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# Innovative Sampling Methods for Focusing the Sub-Slab Soil-Gas Investigation

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August 3, 2012

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## Introduction

Sub-slab soil-gas is critical to vapor intrusion investigations, but spatial heterogeneity in soil-gas can be extremely high. McHugh's investigation<sup>1</sup> on spatial and temporal variability showed that the variability in sub-slab soil gas was equal to that in deeper soil gas and far higher than the variability in indoor air. However, due in part to the difficulty of installing sub-slab sampling points via conventional methods, many investigations probably lack representative soil-gas data. California's vapor intrusion guidance indicates that, "*Collecting as many as eight subsurface samples for a single building, even a large commercial building, both spatially and temporally, is rarely done*".<sup>2</sup>

More extensive sub-slab soil gas sampling is hampered by two factors – the effort and cost required to install sampling points, and the costs of collecting and analyzing soil-gas samples. A typical sub-slab sampling point is described in US EPA's Raymark investigation.<sup>3</sup> Points consisted of either stainless-steel Swagelok® or commonly-available brass plumbing parts. The report recommends using quick-drying cement and, even then, allowing it to cure for a minimum of 24 hours before sampling. DiGiulio, et al. indicated that using this procedure, probes could be installed in as little as 40 minutes. The report goes on to explain that one of the points could not be sampled when it broke loose while making connections. Similarly, Ohio EPA's Vapor Intrusion Guidance<sup>4</sup> provides a Standard Operating Procedure (SOP) for installing sub-slab sampling points using Swagelok® fittings, and includes advice on repairing the assembly if it breaks loose while removing or installing the end plug. The sub-slab points were well designed, given the available hardware, but the time and difficulty of installing them properly is a major limitation.

Simplified means of collecting sub-slab soil gas include the use of "rubber" stoppers with holes pre-drilled for tubing, as described in the Massachusetts vapor intrusion guidance,<sup>5</sup> or jamming modeling clay and tubing into holes in the floor. These alternatives can be useful, but the data they provide may be questionable, and the sample points are generally not useable for repeat sampling. Moreover, short-term cost savings might come at a high cost in data quality, without lowering long-term economic costs.

Cox-Colvin conducts sub-slab soil-gas sampling using rapidly-installed sampling points (Vapor Pins™). The device can be installed with hand-held tools in under ten minutes and requires no cement. Vapor Pins™ can be installed above grade for one time sampling, or below grade for repeat sampling. This presentation highlights an investigation in which we installed and sampled 145 sample points in five days to locate a source of tetrachloroethene (PCE) at a manufacturing facility.

Costs were further reduced by collecting samples into 22-ml glass vials for laboratory analysis by gas chromatography (GC), for approximately a third the cost of TO-15 analysis of samples from canisters. The streamlined procedures and reduced costs enabled the collection of an extensive array of soil-gas samples, allowing us to focus subsequent investigative and remediation efforts. Vapor Pins™ might not comply with some regulatory requirements for vapor intrusion sampling, particularly if barbed fittings are not allowed for tubing connections. Additionally, reporting levels for the glass vials were higher than for evacuated canisters – 10 ppb for PCE – potentially limiting the use of vials to data screening, depending upon data quality objectives.

## **Background**

The investigation was conducted at a manufacturing facility in western Ohio which historically used PCE for cleaning and degreasing. The facility has operated since 1933, but the current owner purchased the property in the 1990s and has a limited understanding of earlier solvent use. PCE had been observed in groundwater at the facility at concentrations as high as 440 ug/L, but declined dramatically following remediation at an area that once held PCE degreasing equipment. A smaller, nearby source of PCE contamination was remediated concurrently using the same techniques, with a similar drop in groundwater PCE.

PCE in groundwater remained elevated in the eastern part of the facility, averaging 18 ug/L in one monitor well. This area contained an aboveground storage tank (AST) that was overtopped with PCE in the 1980s. But because the area was remediated immediately after the release, the spill area was not directly in line with the plume, and groundwater at the spill location was consistently free of PCE, we assumed that the source of PCE was most likely a different AST or former degreaser. The client had us investigate soil and groundwater beneath the eastern building via Geoprobe® direct-push drilling. But soil samples next to the former degreasers and ASTs lacked major contamination, and because the client was pressed to make financial decisions on long-term environmental costs, we were tasked with locating all remaining source areas in a single deployment, and at a limited cost.

## **Experimental Methods**

Having previously located unsuspected sources of VOCs at another Ohio site by prospecting with soil gas, we decided to collect soil gas beneath the building in a grid pattern with 20 ft spacing. In the earlier investigation, soil gas was collected via Geoprobe® from a depth of 5 ft, injected into evacuated 22-ml glass vials, and analyzed by GC in a mobile laboratory by Microseps of Pittsburgh, PA. The more recent investigation was streamlined by collecting soil gas directly through the floor with methods we had since developed for vapor intrusion assessments. Recognizing the limitations of conventional sub-slab soil-gas sampling points, we developed the Vapor Pin™, constructed from a single piece of brass or stainless steel that forms a seal against concrete with a silicone sleeve (Figure 1).

The Vapor Pins™ were installed by drilling 5/8-inch holes through the floor with a hand-held hammer drill. After dusting the holes with a bottle brush, the Vapor Pins™ were hammered into place, capped, and allowed to equilibrate for approximately one hour. At several locations, a second, larger hole was countersunk around the 5/8-inch holes so that the Vapor Pins™ could be installed in a flush-mount configuration and left in place for long-term monitoring (Figure 2).



**Figure 1.** Vapor Pin™ Sub-Slab Samplers.

Following equilibration, soil gas was purged from the sampling points at a rate of 200 ml/minute with a multi-meter equipped with a photo-ionization detector (PID) and oxygen (O<sub>2</sub>) sensor. Purging ended after PID and O<sub>2</sub> levels stabilized – approximately 20 seconds.

Soil gas was collected from the sample points by puncturing the sample tubing with a disposable syringe and withdrawing the plunger. Soil gas was injected through the septum of evacuated glass vials and sent to Microseeps for analysis.

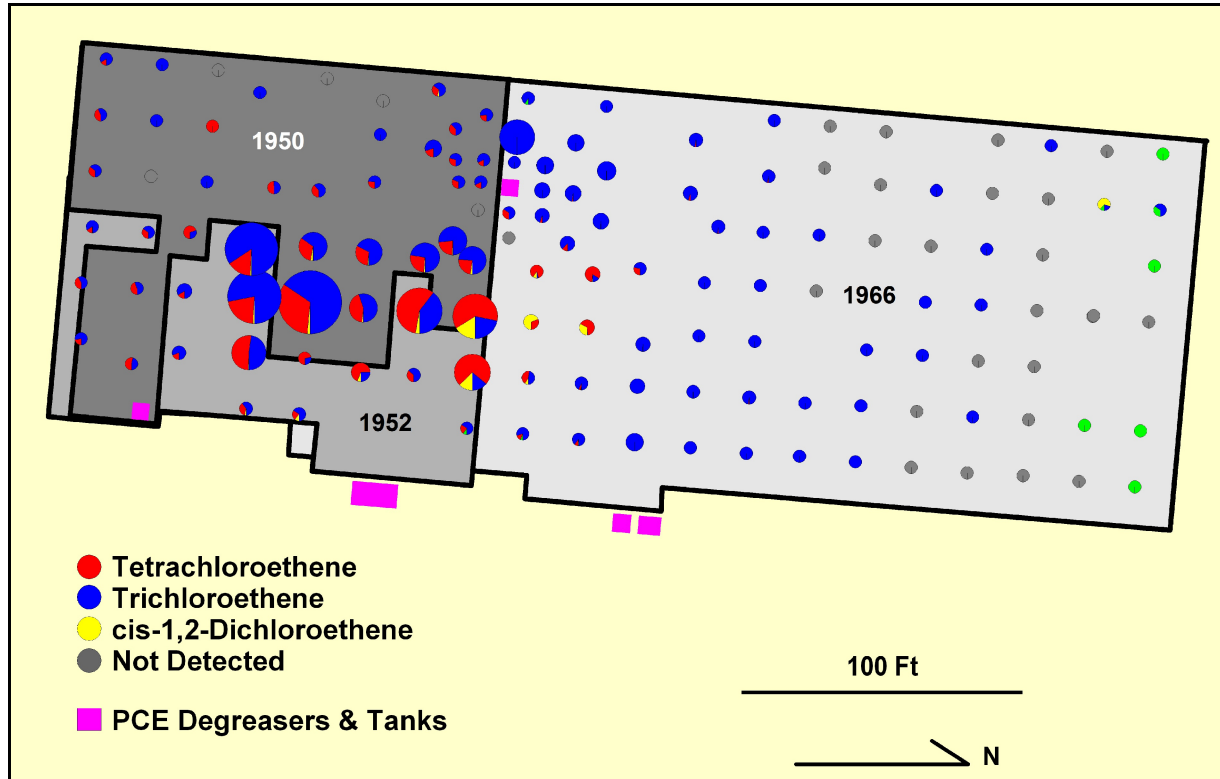
At the end of each shift, the Vapor Pins™ were removed and the holes were plugged with hydraulic cement, allowing daytime plant operations to go uninterrupted. Following each use, the silicone sleeves were stripped from the Vapor Pins™ and discarded, and the pins were decontaminated for reuse.

## Results

Total VOCs in soil gas, as indicated by the field PID, ranged from non-detect to 100,000 ppb (up to 58,000 ppb, corrected for PCE). Total chlorinated solvents in laboratory samples closely resembled PID data, with concentrations ranging from non-detect to 57,000 ppb. VOCs in soil gas did not correspond to expected sources of PCE, i.e., the location of former ASTs or degreasers (Figure 3). Additionally, laboratory results showed a strong correlation with the field-PID data, suggesting that future costs could be further reduced by limiting laboratory analysis to samples with high PID concentrations.



**Figure 2.** Flush-Mount Installation Process.



Soil samples were subsequently collected via Geoprobe® from areas of highly contaminated soil-gas to verify the presence of VOC sources and to provide data on soil properties for the subsequent remediation. Soil samples were sent to a commercial laboratory for analysis for VOCs via gas chromatography/mass spectrometry (GC/MS).

Laboratory results showed high levels of PCE in soil at a depth of approximately 15 ft in the areas of high VOCs in soil gas. Soil data also indicated an area of what appears to be primary contamination by trichloroethene (TCE), which had previously been considered a PCE-degradation product. The soil investigation was followed by the installation of a soil-vapor extraction (SVE) remediation system – approximately nine months after collecting the first soil-gas sample.

## Discussion

As we had seen in previous investigations, most of the contamination was *not* near former degreasing equipment or ASTs. By overlaying the map of soil-gas contamination with historic building outlines, taken from fire insurance maps and aerial photographs, we found that the distribution of PCE and TCE matched the building configuration of 1950 – a time when wastes were routinely dumped or spilled at back doors and loading docks. By 1952, the building completely surrounded the area of PCE contamination.

There are important implications for vapor intrusion. With the cost and effort required to construct sub-slab sample points made of lab-grade stainless hardware, set into concrete mixed with distilled water, and leak testing with ultra-pure helium, one risks collecting a few high-quality samples in the wrong place. The situation is analogous to the argument over Geoprobe® drilling for soil or groundwater in the 1980s. At the time, many argued that direct-push drilling could not provide adequate sample quality for environmental assessment. Experience has proven that while direct-push drilling is not the answer to all sampling needs, the ability to collect more samples in a timely, cost-effective way, enables one to focus efforts on where contamination levels are highest. Likewise, the use of streamlined sampling techniques, including Vapor Pins™, PIDs, and glass vials, allows collecting significantly more data within time and budgetary constraints, potentially reducing problems caused by sample heterogeneity.

## **References**

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## **Key Words**

Vapor Intrusion, Vapor Pin™, Subslab, Sub-Slab, Soil Gas, Volatile Organic Compound, VOC, Tetrachloroethene, Spatial Heterogeneity.