

# Overview of Soil Gas Probe Emplacement & Sampling Methods

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This presentation is an excerpt from the vapor intrusion training that Dr. Blayne Hartman has been presenting to Federal & State regulatory agencies, DOD facilities, consulting groups, and stakeholders around the country.

Lecture notes are at the bottom of each slide so that if played out as a hard-copy, the presentation can be a useful reference document.

# Presentation Summary

- Probe Installation Methods
- Probe Installation Issues
- Sample Collection Methods
- Sample Collection Issues

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This presentation will focus specifically on active soil gas probe installation and sampling methods with some additional issues based upon many years of field experience.

## Active Soil Gas

- Pros:
  - Representative of Subsurface Processes
  - Higher Screening Levels
  - Can Give Real-time Results
- Cons:
  - Mass Transfer Coefficient Unknown
  - Overly Restrictive Default Criteria
  - Protocols still debated

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Measurement of active soil gas is by far the most preferred approach around the country. Actual soil gas data are reflective of subsurface properties, are less expensive than indoor air measurements, and allow real-time results. The screening levels are also higher so there is less chance to be chasing blanks or false positives.

There are some drawbacks, including the lack of knowledge of the vapor transfer rate into the structure, very restrictive screening levels for sub-slab data, and confusion over how & where to collect samples.

## VI Requires Much Lower DLs

- Typical Soil Gas Concentrations
  - MTBE & Benzene near gasoline soil: >100 ug/L
  - PCE under dry cleaner: >100 ug/L
- Soil Gas Levels a Threat to GW:
  - MTBE: >10 ug/L
  - BTEX/PCE: >100 ug/L
- Soil Gas Levels “Failing” VI Criteria
  - Subslab: Benzene: 0.015 ug/L, PCE: 0.040 ug/L
  - At 5’: Benzene: 0.15 ug/L, PCE: 0.40 ug/L

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The biggest difference between sampling soil gas for site assessments and for vapor intrusion is that we are measuring at concentration levels 1,000 to 10,000 times lower. So, the protocols require much greater care. At such low levels, the chances for false positives from equipment blanks are much greater.

## Probe Installation Methods

- Sample Through Rod Methods
  - Aka temporary probes
  - Collect sample while probe rod in ground
  - Less disturbance, less parts in the ground
- Vapor Mini-Wells/Tubing Method
  - Aka semipermanent or permanent probes
  - Bury tubing in the ground
  - Better for repeated sampling

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There are two common ways for collecting active soil gas samples: collection through a probe or rod driven into the ground or collection through a vapor well buried into the ground.

Collection through the probe rod is advantageous if only one sampling round is required. Also, less materials are emplaced in the ground minimizing disturbance of the in-situ vapor and decreasing the potential for blanks from the materials.

Vapor wells consist of small diameter, inert tubing and offer advantages when vertical profiles are desired or when repeated sampling events are likely.

Both methods can give reliable data if done properly.

## Through Rod Method

- Hand Methods (Rotohammer, Slidehammer)
  - Better access
  - Shallower depths (<6' bgs)
  - Internal tubing already connected
  - Better penetration in cobbles
- Direct Push Methods
  - Access more limited
  - Deeper depths
  - Post-run tubing connector can leak
  - Can smear walls in finer grained materials

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Installation of the probe rod is most commonly done by one of two methods: using hand methods or with direct-push systems. Rods can also be installed using rotary, sonic, or percussion drill rigs.

Hand methods are useful in limited access areas for shallow sampling (<6' bgs), but also have a few technical advantages over the direct-push methods. This method can often get better penetration in cobbly soils.

Direct push methods can go deeper, but access is more limited. The post-run tubing can leak at the coupling point inside the rod and smearing of the borehole walls can reduce permeability in finer grained or moist soils.

For either method, seals at the base of the probe at the ground surface are advisable, especially if depths are shallow, soils are coarse grained, and larger volume samples (>1 liter) are collected.

## Hand Methods



Hammering a hand-probe in the ground with a rotohammer.

## Hand Methods



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A hand rod in the ground with collection syringe attached. Note how close the probe is to the house, in this case, a back yard. The roto-hammer used to emplace the probe and the extraction devise also shown.

## PRT Fitting



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Picture of the post-run tubing (PRT) connector used by most direct-push rigs. Fitting can leak if threads not sealed properly. There is no way to tell for sure since the operator can not see the connection.

## Mini-Wells/Tubing Method

- Inexpensive & easy to install/remove
- Allow repeated sampling
- Can “nest” in same bore hole
- Installed multiple ways (DP, hand, rigs)
- Can be better for low permeability soils
- More disturbance to in-situ soil gas
- More parts in the ground – increases blanks

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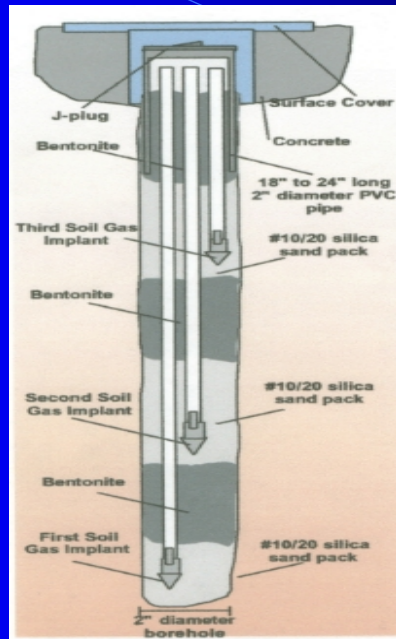
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Vapor wells consist of small diameter, inert tubing and offer advantages when vertical profiles are desired or when repeated sampling events are likely. Multiple tubes can be “nested” in the same borehole. Vapor wells can often times get a sample in low permeability soils when the drive rod methods can not.

Tubes can be installed in a number of ways using simple hand-auger methods, direct-push rigs, or larger drill rigs.

Disadvantages are that more materials are left in the ground increasing the chance for blanks and the burial of the tubes with a sand-pack causes a greater disturbance of the in-situ soil gas.

# Multi-Depth Nested Well



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A schematic of a multi-depth nested vapor well.

## Multi-Depth Nested Well

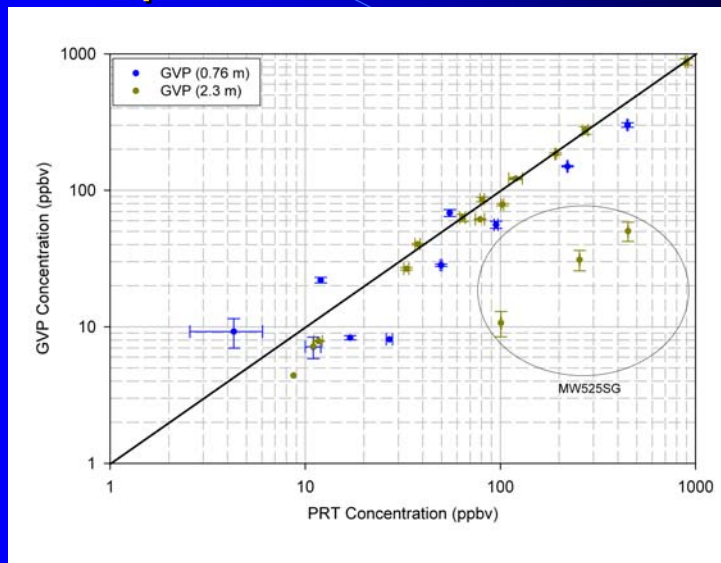


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Soil vapor implants nested in same borehole at three different depths.  
Tubing is 1/8" OD minimizing dead volume.

## Comparison – DP to Hand

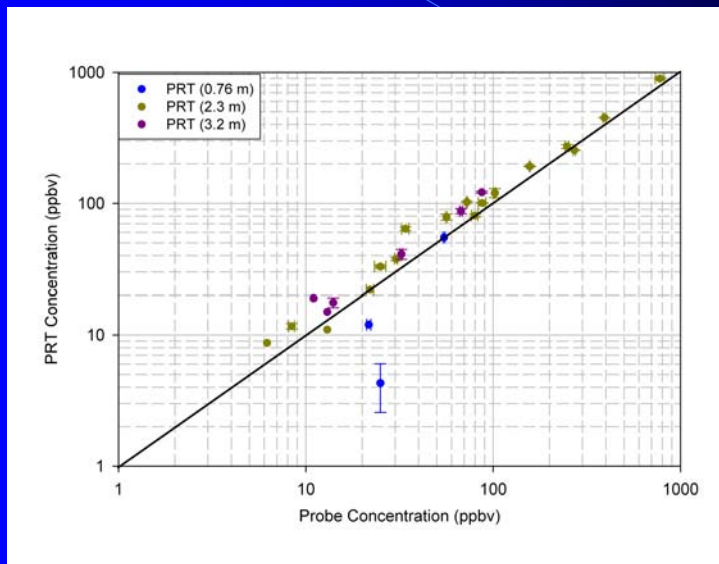


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Comparison data collected by Dom DiGiulio and others shows good agreement between the direct-push and hand methods.

## Comparison – DP to Tubes

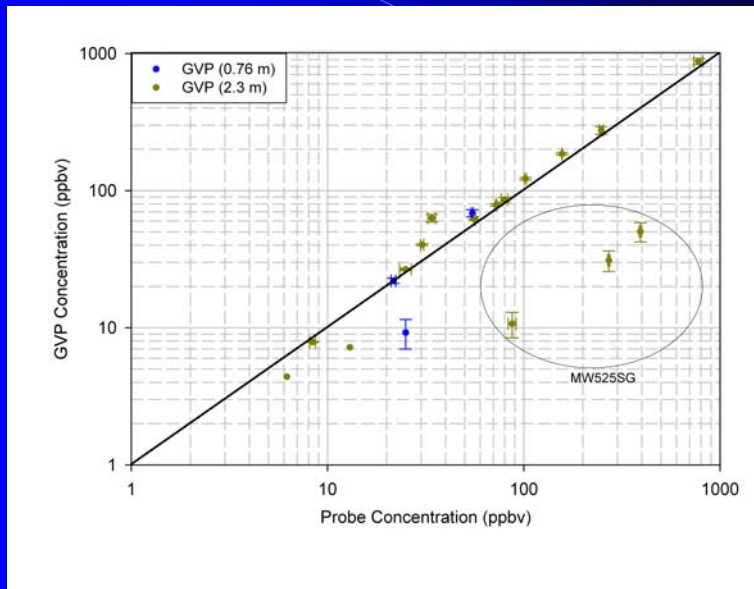


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Comparison data collected by Dom DiGiulio and others shows good agreement between the direct-push method and vapor well method.

# Comparison – Hand to Tubes



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Comparison data collected by Dom DiGiulio and others shows good agreement between the hand probe method and vapor well method.

## Probe Considerations

- **Tubing Type**
  - Rigid wall tubing ok (nylon, teflon, SS)
  - Flexible tubing not (tygon, hardware store)
  - Small diameter best (1/8" or 1/4")
- **Probe Tip**
  - Beware metal tips (may have cutting oils)
- **Equilibration Time**
  - Effects by air knife, rotary, air percussion, sonic
- **Equipment Blanks**
  - Need to collect blank through collection system

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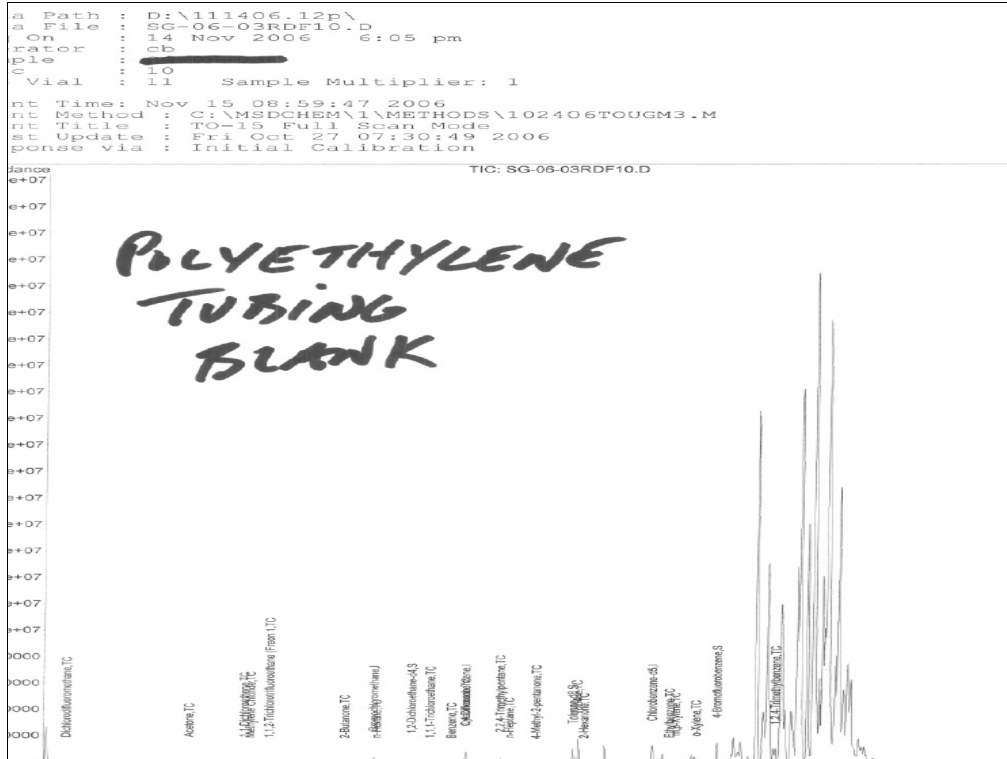
Some of the issues that need to be considered when installing probes include:

**Tubing Type:** Small diameter tubing offers advantages over large PVC pipe. Flexible tubing tends to leak.

**Probe tip:** Metal tips may have blanks due to the cutting process.

**Equilibration time:** How long to wait, especially if air knives are used to clear holes or larger drill rigs are used.

**Equipment blanks:** need to collect blank through the collection system. Trip blanks not enough.



Comparison data collected by Dom DiGiulio and others shows good agreement between the hand probe method and vapor well method.

# Soil Gas Sampling Issues

- How Much to Purge & Collect?
  - Greater the volume, greater the uncertainty
  - Large purge vols require pumps & control
  - How many dead volumes to purge? 3 or more?
- Sample Containers (Don't Chill!!!)
  - Tedlars: easy to fill, no carry-over, 1-2 days max
  - Summas: easy to fill, carry-over, 14 days
  - Syringes: easy to fill, disposable, minutes
  - Gas tight vials: easy to fill, disposable, hrs to days

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Smaller volumes create less headaches and minimize the chances for leakage from the surface and desorption off soil. Larger purge volumes require pumps and flow control which requires more effort and increases chance of errors. Three dead volumes should extract 88% of original air in the system volume, but what about sand pack and surrounding formation?

A variety of sample containers can be used depending upon volume required and storage time. All must be inert, tested clean, and handled properly (no cooling or heat).

# Soil Gas Sampling Issues

- **Tracer/Leak Compound**
  - Gaseous (He) or Liquid (IPA, Freons)
- **Pumps**
  - Collect on upstream side. Watch vacuum applied
- **Rain**
  - How long to wait after a rain event?
- **Time-Integrated Samples?**
  - Existing data does not show large variations

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Tracer/leak compounds are required to ensure sample integrity. Both gaseous (He) and liquid tracers are used. The liquid tracers are operationally simpler and can cover more locations.

If pumps are used, samples should be collected upstream of pump and the applied vacuum should be minimized to avoid leaks.

Does rain influence soil gas concentrations? Probably not for depths greater than 3' and certainly not under paved surfaces.

Are time-integrated samples required ala indoor air samples? Most data do not show large temporal variations in soil gas concentrations.

## The “Key” Sampling Issues

(That Directly Affect the Bottom Line)

- Experience of the Collector/Consultant
  - Have they done this before?
  - Quality/experience of field staff? Sr or Jr?
- Good Hardware
  - Beware the Wal-Mart soil gas lab
- Get Enough Data Near/Around/Under
  - Would you close a site with only 1 boring?

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The most important ingredient for cost effective and efficient VI investigations is the experience of the person/firm doing the collection. Is the collection being done by a firm that has prior experience? Is it a routine part of their services or an occasional part? Do they put experienced people in the field who can think or junior staff who aren't well versed? This applies to the consultant and their subcontractors.

The hardware used is also critical. Bottom line: bad hardware, bad data.

Soil gas, like soil, is not homogenous in most cases. So you need enough data to give decent coverage near, around, or under the receptor. Simpler collection systems with small volumes are advantageous as there is less to go wrong and enable higher production per day (20+ samples per day). Less expensive analytical methods (8021, 8260) enable more analyses for reasonable cost. Real-time data can be extremely helpful to track soil gas contamination laterally and vertically.

All of these issues affect the investigation progress and hence the cost you end up paying (the ultimate bottom line).

## Sample Volumes



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A 6-liter Summa can is about the size of a basketball. A 400 cc mini-can is about the size of a baseball.

Lower volumes give more control on sample location, require less time to collect, and minimize chances of breakthrough from the surface or other sampling zones in nested wells.

Since soil gas concentrations are typically high and required detection limits are relatively high, only small volumes (<100 cc of sample) are typically needed for analysis, so small canisters (<1 liter) are typically sufficient.

## Purging



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For small diameter tubing (1/8" or 1/4" OD), a simple and fast procedure to purge soil vapor probes is to use a disposable gas-tight syringe. Volumes can be carefully measured, the collector can get a feel for the permeability of the sampling zone from the syringe resistance, low vacuums and flow are applied, and no bulky hardware or power is required.

# Purging



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Purging through a collection assembly.

## Sample Collection



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Collection of a soil vapor sample in a mini-Summa (400 cc). Leak/tracer is typically applied prior to sample collection.

## Sample Collection



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Collection of a soil vapor sample in a larger Summa (6000 cc). Leak/tracer is typically applied prior to sample collection. Flow restrictor on top of canister. Note in this set-up, there is no gauge on the canister so the collector has no idea when the canister is filled.

## Sample Collection



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Collection of a soil vapor sample in a tedlar using a syringe. No power required, no complicated fittings. Leak/tracer can be applied prior to sample collection.

Flow rates can be easily controlled by this method and the presence of water also controlled. Once filled, the sample can be sucked into a canister if desired.

## Sample Collection



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Collection of a soil vapor sample in a tedlar using a portable vacuum box. No power required, no complicated fittings. Leak/tracer can be applied prior to sample collection.

Flow rates can be controlled by this method and the presence of water also controlled. Once filled, the sample can be sucked into a canister if desired.

## Sample Transfer



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Soil vapor samples can be easily transferred from a tedlar bag into an evacuated canister in the field for longer holding times or for more security during sample shipping.

## Beware of the Hardware



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The tackle box on the left shows the required hardware to collect soil gas samples in Summas.

The syringe to the right is the only collection device required for on-site analysis of soil gas.

## Beware the Hardware

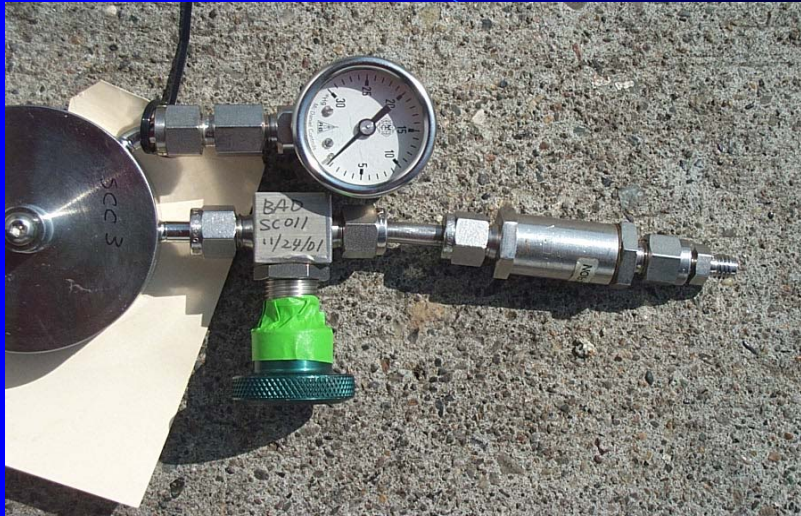


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A soil gas sample collection system used by a consulting firm. Extremely complex, lots of dead-volume for cross contamination, and numerous fittings for potential leaks.

## Beware of the Hardware



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This is a picture of some hardware provided to us by an air lab for a project. Note the label indicating the valve is “bad” and the green tape holding the valve knob in a set position.

Be sure the lab you select has good hardware!

## Some Final Issues (that we often get asked about)

- Certified Clean Canisters
  - Not needed if  $DL > 5 \text{ ug/m}^3$
- Residual Vacuum in Canisters
  - Increases chances of leaks
- Dedicated Flow Restrictors
  - Not necessary if cleaned between samples

A few additional sampling considerations.

## Summary

- Both Probe Installation Methods OK
- Experience Important
- Hardware Important
- Coverage Important
- Extra Careful Procedures Important for VI

A summary of the key points in this presentation.

## VI Samping Documents

- Overview of SV Methods ([www.handpmg.com](http://www.handpmg.com))
  - LustLine Part 1 - Active Soil Gas Method, 2002
  - LustLine Part 3 - FAQs October, 2004
  - LustLine Part 4 – Soil Gas Updates, Sept 2006
- Regulatory Guidance
  - ITRC ITRC VI Guidance - toolkit ([www.itrcweb.org](http://www.itrcweb.org))
  - CA-EPA Soil Gas Advisory ([www.dtsc.ca.gov](http://www.dtsc.ca.gov))
  - MO Soil Gas Document

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A summary of existing documents on soil gas methods can be found at these locations:

## VI Documents

- DiGiulio Articles/Reports
  - EPA-ORD Sub-slab SOP–Draft
  - Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples
  - Comparison of Geoprobe PRT and AMS GVP Soil-Gas Sampling Systems with Dedicated Vapor Probes in Sandy Soils at the Raymark Superfund Site

Available at [www.iavi.rti.org/resources](http://www.iavi.rti.org/resources)

More documents.

## VI Documents

- Soil Gas Sampling SOPs
  - Soil Gas Sampling, Sub-slab Sampling, Vapor Monitoring Wells/Implants, Flux Chambers ([www.handpmg.com](http://www.handpmg.com))
- Other
  - API Soil Gas Document ([www.api.org/bulletins](http://www.api.org/bulletins))

More documents.



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The graphic features a blue arc that starts from a molecular structure icon in the top left and curves down to a silhouette of a person operating a piece of equipment in the bottom right. The text is centered within this arc.