This presentation is an excerpt of the vapor intrusion training that Dr. Hartman has been presenting to Federal & State regulatory agencies, DOD facilities, consulting groups, and stakeholders around the country. As of March 2013, this training has been given to over 30 State Regulatory agencies, EPA-OUST, ITRC, Brazil & Australia. Training has also been given to many PRPs such as the major oil companies, DOD, & numerous consulting groups.

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.
So called “exclusion criteria”, meaning criteria to eliminate sites from further vapor intrusion assessment based upon source concentration and distance between the source & receptor have fundamentally changed the process for investigating the VI pathway at petroleum sites.

**Exclusion Criteria:**  
**A PVI Pathway Game Changer**

- **Step 1: Can Site Be Screened Out?**  
  - Based upon concentration & depth to source  
  - In CA if site is an active fueling station
- **Step 2: Can “Screen-Out Data” be Collected?**
- **Step 3: Do PVI Assessment**

VI Assessments Much Simpler & Less Expensive
EPA-OUST’s soon to be released PVI guidance contained exclusion criteria for soil & groundwater contamination and NAPL in the latest draft.
California released the low threat closure policy (LTCP) last summer (2012). It contains exclusion criteria similar to, but more conservative, than EPA's.
The screening levels for dissolved benzene contamination in the CA-LTCP are 5000 times higher than CA-EPA levels in their VI guidance.

The screening levels for dissolved benzene contamination in the EPA-OUST draft guidance are 5000 times higher than in the EPA-OSWER VI guidance.

Clearly these new policies have major ramifications on the number of PVI sites requiring VI assessments.
Oxygen plays a key role in some State policies. In CA, the presence of oxygen decreases the separation distance by a factor of 2 and increases soil vapor screening levels by 1000 times!
This table summarizes the various soil gas screening levels for benzene in CA. Note:

1) The sub-slab value is lower than ambient levels.

2) The presence of oxygen increases soil gas screening values by 1000 times.

<table>
<thead>
<tr>
<th></th>
<th>RBSL ((\text{ug/m}^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTSC Sub-slab</td>
<td>1.6</td>
</tr>
<tr>
<td>CHHSL</td>
<td>37</td>
</tr>
<tr>
<td>DTSC – Step 5</td>
<td>42</td>
</tr>
<tr>
<td>CA Low-Risk Policy: O2≤4%</td>
<td>85</td>
</tr>
<tr>
<td>CA Low-Risk Policy: O2&gt;4%</td>
<td>85,000</td>
</tr>
</tbody>
</table>

Ambient levels: 1 to 10 \(\text{ug/m}^3\)
The presence of oxygen drops the separation distance in NJ by a factor of 2.
Some sites may not have the soil phase data or oxygen data to screen out. Rather than perform a full VI investigation, an intermediate and less costly step is to collect the additional data to determine if the site can be screened out. These data will be primarily soil phase data and oxygen data. These data are far less expensive to obtain than typical vapor intrusion VOC data.
Step 3: PVI Specific Sampling Issues

- Soil Gas VOC Analysis
  - Benzene, ethylbenzene & naphthalene
  - TPH??
- Might Need to Sample <5’ bgs
  - If samples >5’ bgs exceed allowable levels
  - How to know? On-site analysis best
  - If not, collect samples anyway
- Always Collect Oxygen Data

There are some differences in soil gas sampling for petroleum hydrocarbon VOCs than for chlorinated solvents.

The COCs need to be determined and vary from State to State.

If samples at deeper depths exceed allowable values, shallower samples (<5’ bgs) may need to be collected to document the effect of bioattenuation.

Oxygen data should always be collected to document the presence of the aerobic zone.
This is a plot of data recently collected for an EPA funded study by an automated instrument at Vandenberg AFB site from three probes at the same location but at different depth (3', 8', & 17' bgs). This plot consists of over 500 points per probe collected once per hour over a 4 week period from mid March to mid April 2007. The soil gas concentrations varied by less than 10% over these four days even for probes only 3 feet below the surface.
These are the most common methods used in a vapor intrusion assessment.

- Indoor Air Sampling
- Groundwater Sampling
- Soil Phase Sampling
- Predictive Modeling
- Measure Flux Directly
- Soil Gas Sampling
- Supplemental Tools/Data
The most important ingredient for cost effective and efficient VI investigations is the experience of the people out in the field. Is the consulting firm experienced at VI investigations? Is it a routine part of their services or an occasional part? Do they put experienced staff in the field who can think or junior staff who aren’t experienced?

The same applies to their subcontractors. Does the driller know how to collect soil gas samples? Is the lab experienced at analyzing vapors and does it hold an accreditation?
The 3 most common mistakes made by practitioners in the vapor intrusion arena:
1) Confusing units
2) Using incorrect screening levels
3) Sampling & analysis errors.
Three methods are typically used to determine screening levels. The first method listed gives the lowest (most conservative) levels. The J-E Model gives the highest (least conservative) levels.
By using attenuation factors, one can calculate target levels for soil gas and groundwater starting from the acceptable indoor air concentration. This is the method the EPA guidance allows to determine screening levels in the soil gas or groundwater.
Several models are available that allow you to calculate screening values for groundwater, soil gas, and even soil phase data. The Johnson-Ettinger model/spreadsheet is the most common. API is releasing a version that includes bioattenuation.
A summary of the allowable benzene levels in soil gas shows large variation and illustrates the main points: the new EPA guidance is 50x more restrictive and allowable levels are variable from State to State.

<table>
<thead>
<tr>
<th>State</th>
<th>Alpha</th>
<th>1/Alpha</th>
<th>Risk Based Level (ug/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA Now</td>
<td>0.002</td>
<td>500</td>
<td>155</td>
</tr>
<tr>
<td>EPA 2012?</td>
<td>0.1</td>
<td>10</td>
<td>3.1 (gulp!)</td>
</tr>
<tr>
<td>CA</td>
<td>0.002</td>
<td>500</td>
<td>42</td>
</tr>
<tr>
<td>NJ</td>
<td>0.05</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>MO</td>
<td></td>
<td></td>
<td>118,000</td>
</tr>
<tr>
<td>TN</td>
<td>0.0013</td>
<td>780</td>
<td>2,414</td>
</tr>
<tr>
<td>CT</td>
<td>0.1</td>
<td>10</td>
<td>192</td>
</tr>
</tbody>
</table>
Measuring indoor air might seem to be the most direct and simplest approach, but it has its share of problems. The biggest problem is background sources of contaminants. Many commonly used household products contain some of the target compounds of concern. For example, benzene from consumer products, PCE from dry cleaned clothes, TCE from degreasing cleaners. In addition, the protocols are laborious, intrusive, offer little control, and are expensive. For these reasons, the EPA and many States shy away from this method, especially for PVOCs. However, this method may still be the method of choice if the contaminant of concern is not one commonly found in household products (e.g., 1,1 DCE).
An analysis of Barbasol shaving cream: Benzene & TPH at levels 1000x above indoor air screening levels!
The hidden source of benzene & TPH contamination at many structures.
There are issues that need to be considered when sampling indoor air and when interpreting the data. Sampling issues include the hardware, time period for collection, and things as simple as the type of marker used to label the samples.
Continuous monitoring data of PCE in indoor air from a house. Sensitive chlorine detectors exist to allow this type of data to be collected.

Wouldn’t it be nice to be able to do the same for benzene?
A new instrument being developed by a firm in CA may allow continuous monitoring for selected VOCs.
Note the listed specs for benzene and TCE.

Benzene at 0.03 ug/m³ is below 1e-6 risk level.

TCE at 0.47 ug/m³ in 30 seconds is at the 1e-6 risk level.
Currently the size of a microwave, but expected to shrink.
There are three types of soil gas methods. Active refers to actively withdrawing vapor out of the ground. It gives quantitative values. Passive refers to burying an adsorbent in the ground and letting the vapors passively contact and adsorb onto the collector. It does not give quantitative data and hence can not be used for risk applications, except for screening. Surface flux chambers were discussed previously.

The active method is the one most applicable to risk assessments.
A mobile trailer park with shallow (2’ bgs) ground water. The preferred site for flux chambers.
A typical sampling arrangement used for collection of samples on adsorbants. Note the abundance of fittings and the need for duplicate cartridges for breakthrough. A very complicated set-up, prone to leaks.
New style adsorbent tubes are much smaller than bulky canisters and can’t be broken.
Top photo: A typical sampling arrangement used for collection of samples on adsorbants. Note the abundance of fittings and the need for duplicate cartridges for breakthrough. A very complicated set-up, prone to leaks.

Bottom photo: A much simpler sampling arrangement for adsorbent tubes with better control on actual vapor volumes passed through the adsorbent.
Petroleum compounds of concern vary from State to State. Consult the oversight agencies specifications.
Other Analytical Issues

- 1,3 Butadiene
  - False positive caused by i-butylene
  - Must have lab manually read ion chromatogram
  - Not on most agency soil gas target lists

- Naphthalene
  - 8260, TO-15, TO-17 all used, but …

TO-17 gets PVOCs, TPHg, TPHd in same run!!

Watch out for false detections of 1,3 butadiene.

Also, naphthalene is best analyzed by TO-17.
Parting Thoughts

Upcoming Conferences

• AWMA Annual Conf – Chicago, 6/25/2013
• Cleanup 2013 – Melbourne, Oz  9/16/2013

Looking for a Great PVI Guidance Template?

Look at the Australian PVI Guidance

Upcoming vapor intrusion training.