TO: John Dudley, URS Corporation

FROM: Ruth Custance and Robert Ettinger, GeoSyntec Consultants (GeoSyntec)

DATE: May 3, 2004

SUBJECT: Additional Information Regarding the Commercial Building Vapor Intrusion Modeling

As discussed in last week’s risk assessment call, the one outstanding issue regarding the vapor intrusion modeling was whether a future hypothetical commercial building scenario based on default assumptions was necessary. This type of modeling was proposed by EPA in response to a concern that conducting the modeling based on existing building construction may not adequately represent potential future building construction (e.g. if a warehouse was converted into an office building). Due to the recent agreed upon modifications to the commercial modeling approach regarding the building air exchange rate (AER) and volumetric vapor flow rate (Qsoil) parameters, it was thought that changes in building dimensions (e.g. from a warehouse to office building) may not cause significant differences in predicted indoor air concentrations because these parameters would scale with building size.

To evaluate this hypothesis two model runs were conducted: (1) using site-specific warehouse dimensions from the R.R. Donnelley & Sons warehouse building and (2) using the default office building dimension parameters presented in the earlier vapor modeling memorandum dated March 10, 2004. The Johnson and Ettinger (1991) model (JEM) was used with site-specific soil physical property values. To evaluate whether the different building types impact the modeling of indoor air concentrations, alpha factors were compared from the model runs. If the alpha factors were not appreciably different, then the building dimensions do not significantly impact the vapor intrusion assessment.
The AER and Qsoil values were calculated using the building dimensions of the two building types mentioned above and the equations for calculating the commercial AER and Qsoil values presented below:

Building AER [1/hr] = (Building ventilation rate [0.15 CFM/ft²] * 60 [min/hr] * Floor Area [ft²]) / (Floor Area [ft²] * Ceiling Height [ft])

Q_{soil}^{Commercial} [L/min] = 5 L/min * (Floor Area Commercial [m²] / Floor Area Residential [100 m²])

Table 1 presents the building dimension parameters and the calculated AER and Qsoil values used in the modeling. The resultant alpha factors are presented in the last row. Attachment A presents the model worksheets.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Warehouse</th>
<th>Default Office</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length cm (ft)</td>
<td>15600 (511.5)</td>
</tr>
<tr>
<td></td>
<td>Width cm (ft)</td>
<td>15600 (511.5)</td>
</tr>
<tr>
<td></td>
<td>Ceiling Height cm (ft)</td>
<td>732 (24)</td>
</tr>
<tr>
<td>Air Exchange Rate (hr⁻¹)</td>
<td>0.375</td>
<td>0.9</td>
</tr>
<tr>
<td>Qsoil (L/min)</td>
<td>1216.8</td>
<td>80</td>
</tr>
<tr>
<td>Alpha factor</td>
<td>2.93E-05</td>
<td>2.97E-05</td>
</tr>
</tbody>
</table>

As can be seen in Table 1, there is little difference between the two alpha factors indicating that the building dimension parameters have little effect on the modeling.
results. Therefore, it is proposed that only the current commercial scenario be evaluated in the baseline risk assessment.
### DATA ENTRY SHEET

**Soil Gas Concentration Data**

**ENTER**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>CAS No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil gas</td>
<td>71432</td>
</tr>
<tr>
<td>OR conc.</td>
<td></td>
</tr>
</tbody>
</table>

**Enter Chemical**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Benzene</th>
</tr>
</thead>
</table>

**Enter Soil gas cone.**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>2.00E+01</th>
</tr>
</thead>
</table>

Donnelley Warehouse

**Enter Soil**

- **Depth below grade:** 15 cm
- **Soil gas cone:** 228.75 cm
- **Average soil temperature:** 22°C
- **Soil stratum A:** User-defined
  - **User-defined soil type:** SCS soil vapor permeability
  - **Soil stratum A:**
    - **SCS soil type:** Lookup Soil Parameters
    - **soil dry bulk density:** 1.63 g/cm³
    - **soil total porosity:** 0.3814 (unitless)
    - **soil water-filled porosity:** 0.264 (cm³/cm³)
  - **Soil stratum B:**
    - **SCS soil type:** Lookup Soil Parameters
    - **soil dry bulk density:** 1.5 g/cm³
    - **soil total porosity:** 0.43 (unitless)
    - **soil water-filled porosity:** 0.3 (cm³/cm³)
  - **Soil stratum C:**
    - **SCS soil type:** Lookup Soil Parameters
    - **soil dry bulk density:** 1.5 g/cm³
    - **soil total porosity:** 0.43 (unitless)
    - **soil water-filled porosity:** 0.3 (cm³/cm³)

**Enter Enclosed space floor length:** 40 cm

**Enter Enclosed space floor width:** 15600 cm

**Enter Enclosed space floor height:** 15600 cm

**Enter Floor-wall seam crack width:** 0.1 cm

**Enter Average vapor flow rate into bldg.:** 0.375 (L/min)

**Enter Exposure duration:** 70 yrs

**Enter Exposure frequency:** 30 (days/yr)

**Enter Total time for carcinogens:** 70 yrs

**Enter Total time for noncarcinogens:** 30 yrs

**Enter Averaging time for carcinogens:** 30 yrs

**Enter Averaging time for noncarcinogens:** 30 yrs

**Enter Exposure time for carcinogens:** 360 (days/year)

**Enter Exposure time for noncarcinogens:**
### INTERMEDIATE CALCULATIONS SHEET

#### Donnelley Warehouse

<table>
<thead>
<tr>
<th>Exposure duration, T (sec)</th>
<th>Source-building separation, L (cm)</th>
<th>Stratum A soil air-filled porosity, ( \theta_a^A )</th>
<th>Stratum B soil air-filled porosity, ( \theta_a^B )</th>
<th>Stratum C soil air-filled porosity, ( \theta_a^C )</th>
<th>Stratum A soil total fluid saturation, ( S_w )</th>
<th>Stratum A soil intrinsic permeability, ( k_i )</th>
<th>Stratum A soil relative air permeability, ( k_r )</th>
<th>Stratum A soil effective vapor permeability, ( k_v )</th>
<th>Floor-wall seam, ( X_{seam} ) conc.</th>
<th>Bldg. gas ventilation rate, ( Q_{building} ) (cm'/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.46E+08</td>
<td>213.75</td>
<td>0.117</td>
<td>0.130</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>1.00E+08</td>
<td>62.400</td>
<td>6.72E+04</td>
<td>1.86E+07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area of enclosed space, ( A_e ) (cm^2)</th>
<th>Crack depth, ( Z_{crack} ) (cm)</th>
<th>Enthalpy of vaporization at ave. soil temperature, ( \Delta H_{TS} ) (cal/mol)</th>
<th>Henry's law constant, ( \eta ) (cal/mol)</th>
<th>Henry's law coefficient, ( \eta_{TS} ) (atm-m'/mol)</th>
<th>Henry's law coefficient, ( \eta_{TS} ) (unitless)</th>
<th>Stratum A effective diffusion coefficient, ( D_A' ) (cm'/s)</th>
<th>Stratum B effective diffusion coefficient, ( D_B' ) (cm'/s)</th>
<th>Stratum C effective diffusion coefficient, ( D_C' ) (cm'/s)</th>
<th>Total effective diffusion coefficient, ( D_{eff} ) (cm'/s)</th>
<th>Diffusion path length, ( L_e ) (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.44E+08</td>
<td>2.55E-05</td>
<td>6.122</td>
<td>2.68E-03</td>
<td>1.15E-01</td>
<td>1.75E-04</td>
<td>4.90E-04</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>4.90E-04</td>
<td>213.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Convection source vapor average crack effective Exponent of equivalent foundation indoor source Unit depth, ( L_v ) (cm)</th>
<th>Crack radius, ( r_{crack} ) (cm)</th>
<th>Crack flow rate, ( Q_{crack} ) (cm'/s)</th>
<th>Crack diffusion factor, ( D_{crack} ) (cm'/s)</th>
<th>Area of equivalent foundation, ( A_{equiv} ) (cm^2)</th>
<th>Number of equivalent foundation, ( \nu )</th>
<th>Exponent of equivalent foundation, ( \nu )</th>
<th>Infinite source indoor attenuation factor, ( \alpha )</th>
<th>Infinite source bldg. attenuation factor, ( \alpha_{building} )</th>
<th>Unit risk factor, ( URF ) (mg/m^3)</th>
<th>Reference cone, ( R_fC ) (mg/m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>6.72E+04</td>
<td>0.10</td>
<td>2.03E+04</td>
<td>4.90E-04</td>
<td>6.24E+03</td>
<td>#NUM!</td>
<td>2.93E-05</td>
<td>1.97E+00</td>
<td>7.8E-06</td>
<td>NA</td>
</tr>
</tbody>
</table>

END
## DATA ENTRY SHEET

**Office Building**

### Chemical Data Entry

<table>
<thead>
<tr>
<th>Chemical</th>
<th>CAS No.</th>
<th>Soil Gas Concentration Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>71432</td>
<td>2.00E+01</td>
</tr>
</tbody>
</table>

### Soil Gas Sampling Details

- **Depth Below Grade**
  - Soil Gas Sampling Average: 15 cm
  - Temperature: 228.75°C
- **Soil Gas Sampling Parameters**
  - Soil Type: Stratum A
  - Soil Vapor Permeability: 1.0E-08 cm²
  - Soil Dry Bulk Density: 1.43 g/cm³
  - Soil Total Porosity: 0.3814
  - Soil Water-Filled Porosity: 0.264

### Enclosed Space Details

- **Enclosed Space Floor**
  - Thickness: 10 cm
- **Floor-Wall Seam Crack**
  - Width: 0.15 cm
- **Indoor Air Exchange Rate**
  - Average: 0.9 L/m²

### Averaging Time Details

- **Averaging Time for Carcinogens**
  - ATc: 70 yrs
- **Averaging Time for Noncarcinogens**
  - ATnc: 30 yrs

### Notes

- Use the lookup tool for soil properties.
- Leave blank to calculate if desired.

---

**END**
### Intermediate Calculations Sheet

**Office Building**

<table>
<thead>
<tr>
<th>Exposure duration, sec</th>
<th>Source-building separation, cm</th>
<th>Bldg. ventilation rate, cm³/s</th>
<th>Soil gas cone, Mq/m²</th>
<th>Diffusion path length, cm</th>
<th>Bldg. • ventilation rate, cm³/s</th>
<th>Stratum A soil gas cone, mg/m²</th>
<th>Stratum B soil gas cone, mg/m²</th>
<th>Stratum C soil gas cone, mg/m²</th>
<th>Total overall Diffusion path length, cm</th>
<th>Bldg. ventilation rate, cm³/s</th>
<th>Stratum A soil gas cone, mg/m²</th>
<th>Stratum B soil gas cone, mg/m²</th>
<th>Stratum C soil gas cone, mg/m²</th>
<th>Total overall Diffusion path length, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.46E+08</td>
<td>213.75</td>
<td>16,800</td>
<td>6.72E+04</td>
<td>1.24E+05</td>
<td>1.24E+05</td>
<td>7.8E-06</td>
<td>NA</td>
<td>NA</td>
<td>213.75</td>
<td>NA</td>
<td>7.8E-06</td>
<td>NA</td>
<td>213.75</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Area of enclosed space to-total area ratio.**

<table>
<thead>
<tr>
<th>Stratum A soil air-filled porosity, cm³/cm²</th>
<th>Stratum B soil air-filled porosity, cm³/cm²</th>
<th>Stratum C soil air-filled porosity, cm³/cm²</th>
<th>Stratum A soil intrinsic permeability, cm²/cm²/s</th>
<th>Stratum A soil relative air permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor diffusion coefficient, cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.117</td>
<td>0.130</td>
<td>0.130</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>1.00E-05</td>
<td>16,800</td>
<td>6.72E+04</td>
<td>124E+05</td>
</tr>
</tbody>
</table>

**Crack depth below grade.**

<table>
<thead>
<tr>
<th>Stratum A soil air-filled porosity, cm³/cm²</th>
<th>Stratum B soil air-filled porosity, cm³/cm²</th>
<th>Stratum C soil air-filled porosity, cm³/cm²</th>
<th>Stratum A soil intrinsic permeability, cm²/cm²/s</th>
<th>Stratum A soil relative air permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
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<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>16,800</td>
<td>6.72E+04</td>
<td>1.24E+05</td>
<td>213.75</td>
<td>NA</td>
<td>7.8E-06</td>
<td>NA</td>
<td>213.75</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Exponent of equivalent foundation Peclet number.**

<table>
<thead>
<tr>
<th>Stratum A soil air-filled porosity, cm³/cm²</th>
<th>Stratum B soil air-filled porosity, cm³/cm²</th>
<th>Stratum C soil air-filled porosity, cm³/cm²</th>
<th>Stratum A soil intrinsic permeability, cm²/cm²/s</th>
<th>Stratum A soil relative air permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor diffusion coefficient, cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.84E+105</td>
<td>2.97E+05</td>
<td>2.00E+00</td>
<td>7.8E-06</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>

**Unit risk factor.**

<table>
<thead>
<tr>
<th>Stratum A soil air-filled porosity, cm³/cm²</th>
<th>Stratum B soil air-filled porosity, cm³/cm²</th>
<th>Stratum C soil air-filled porosity, cm³/cm²</th>
<th>Stratum A soil intrinsic permeability, cm²/cm²/s</th>
<th>Stratum A soil relative air permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective vapor diffusion coefficient, cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
<th>Stratum A soil effective vapor permeability, cm²/cm²/s</th>
<th>Stratum A soil effective diffusion coefficient, cm²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.8E-06</td>
<td>NA</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
<td>#N/A</td>
</tr>
</tbody>
</table>
Dear RI/FS Team,

The attached file is a 05/03/04 Memorandum from Ruth Custance and Robbie Ettinger of GeoSyntec Consultants. This Memorandum provides additional information regarding an outstanding issue that was discussed in our last teleconference. The question addressed is whether a future hypothetical commercial building scenario needs to be included in the Baseline Risk Assessment.

We will discuss this Memorandum during our RI/FS teleconference tomorrow, Tuesday, at 10:00 AM. -John

(See attached file: Commercial_Vapor-memo_05_03_04.pdf)

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Santa Barbara, CA 93117
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(805) 964-0259 FAX

Commercial_Vapor-memo_05_03_04.pdf