Appendix N2 – Vapor Intrusion Pathway for Human Health Risk Assessment

Appendix N2 (contained herein) presents results and backup for estimated risks and hazards from the vapor intrusion pathway, i.e., VOCs off-gassing from *in-situ* groundwater to indoor air).

This pathway is considered separately from the HHRA presented in Appendix A, as discussed and approved by USEPA Region 2 (Department of the Army, 2005).

The Johnson and Ettinger (1991) Indoor Air Model (USEPA, 2003) was used to quantify indoor air inhalation risks and hazards. The Johnson and Ettinger model was developed for use as a screening level model and is based on a number of simplifying assumptions. Because most of the inputs to the model are not collected during a typical site characterization, conservative inputs have to be estimated or inferred from available data and other non-site-specific sources of information. Limitations and assumptions associated with the Johnson and Ettinger model are described in the user's guide (USEPA, 2003). These include:

- Contaminant vapors enter the structure primarily through cracks and openings in the walls and foundation.
- Convective transport occurs primarily within the building zone of influence and vapor velocities decrease rapidly with increasing distance from the structure.
- Diffusion dominates vapor transport between the source of contamination and the building zone of influence.
- All vapors originating from below the building will enter the building unless the floors and walls are perfect vapor barriers.
- All soil properties in any horizontal plane are homogeneous.
- The contaminant is homogeneously distributed within the zone of contamination.
- The areal extent of the contamination is greater than that of the building floor in contact with the soil.
- Vapor transport occurs in the absence of convective water movement within the soil column (i.e., evaporation or infiltration), and in the absence of mechanical dispersion.
- The model does not account for transformation processes (e.g., biodegradation, hydrolysis).
- The soil layer is in contact with the structure floor and walls are isotropic with respect to permeability.
- Both the building ventilation rate and the difference in dynamic pressure between the interior of the structure and the soil surface are constant values.

It is also noted in the Johnson and Ettinger model user's guide (USEPA, 2003) that use of measured soil gas concentrations directly beneath a building floor instead of calculated concentrations would reduce uncertainty in the estimation of indoor air concentrations.

Results of the vapor intrusion pathway are summarized in Table N2-1. Backup model inputs and outputs are presented following the references and Table N2-1.

Reference:

Department of the Army, 2005, letter from Mr. Ted Gabel – Project Manager for Environmental Restoration, Picatinny to Mr. William Roach – USEPA Region 2 Project Manager, April 7.

Johnson, P.C. and R.A., Ettinger, 1991, *Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings*, ***Environmental Science & Technology***. 25:1445-1452.

U.S. Environmental Protection Agency (USEPA), 2003, *User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings*. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, June.

Table N2-1
Estimated Risks and Hazards from Vapor Intrusion Pathway
(VOCs Off-Gassing from *In-Situ* Groundwater to Indoor Air)

VOC COPCs	Exposure Point Concentration (ug/L)	Industrial Research Worker		Adult Resident		Child Resident	
		Cancer Risk	Noncancer Hazard	Cancer Risk	Noncancer Hazard	Cancer Risk	Noncancer Hazard
Benzene	0.654	2.2E-07	NA	3.7E-07	NA	7.3E-08	NA
Chloroform	0.625	4.8E-07	NA	8.1E-07	NA	1.6E-07	NA
Chloromethane	0.170	2.0E-08	< 0.001	3.2E-08	< 0.001	6.6E-09	< 0.001
cis-1,2-Dichloroethene	0.563	NA	0.0013	NA	0.0018	NA	0.0018
1,1-Dichloroethane	0.230	NA	< 0.001	NA	< 0.001	NA	< 0.001
1,2-Dichloroethane	0.625	1.4E-07	NA	2.3E-07	NA	4.6E-08	NA
2-Nitrotoluene	0.314	NA	< 0.001	NA	< 0.001	NA	< 0.001
Tetrachloroethene	1.11	3.6E-07	NA	6.0E-07	NA	1.2E-07	NA
Trichloroethene	24.7	1.9E-04	0.12	3.2E-04	0.17	6.4E-05	0.17
	Total:	**1.9E-04**	**0.12**	**3.2E-04**	**0.17**	**6.4E-05**	**0.17**

Exposure point concentrations from Appendix N1 Table 3 (95% UCLs).
Risks and hazards estimated using Johnson and Ettinger Model, run in screening mode, and the following model inputs:
Slab on grad construction (depth below grade to bottom of enclose space floor equal to 15 cm).
Depth to groundwater equal to 1.5 feet (46 cm), based on average depth to groundwater at TCE hotspot in southern area of TCE plume.
Average temperature of groundwater equal to 11^{o}C (New Jersey).
Vadose zone soil type equal to sand.
Note: Worker risks and hazards overestimated due to the fact that the J&E Model assumes 24 hours per day exposure, whereas workers would actually be exposed only 8 hours per day (correction factor of 3-fold may be applied).