Health Consultation

Evaluation of Indoor Air, Soil Gas and Groundwater
Data Sampling Phases 2, 3 and 4 (2001, 2002, 2003)

RAYMARK INDUSTRIES, INCORPORATED

STRATFORD, FAIRFIELD COUNTY, CONNECTICUT

EPA FACILITY ID: CTD001186618

SEPTEMBER 8, 2003

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

As shown in Tables 3 and 4 on pages 11 and 12, follow-up sampling in the nine locations with sub-slab ventilation systems indicates that indoor air concentrations decreased significantly. *This shows that the systems are reducing the levels of contaminants in indoor air.* Post-ventilation system sampling data is discussed further in the Public Health Implications Section on page 15.

Table 3. Summary of Maximum Soil Gas and Indoor Air Concentrations Taken Before and After Sub-Slab Ventilation Systems were Installed in Four Homes/Businesses in 2001, Stratford, CT.

SAMPLE LOCATION	SAMPLE DATE	VOCS in Soil Gas (ppb)		VOCs in Indoor Air (ppb)	
		1,1-DCE	TCE	1,1-DCE	TCE
A	2001	1168	**473**	**12** (first floor) **12** (basement)	**9.6** (first floor) **9** (basement)
A	2002#	151	**530&**	ND [0.28] (basement)	0.18 (basement)
B	2001	101	33	1.2 (first floor) **3.7** (basement)	**0.56** (first floor) **1.7** (basement)
B	2002#	7	19	ND [0.27](first floor) ND [0.3](basement)	0.07 [L] (first floor) 0.18@ (basement)
C	2001	742	**141**	1.1 (first floor) **5.7** (basement)	**3.8** (first floor) **0.68** (basement)
C	2002#	4.4	18	ND [0.27](first floor) ND [0.25](basement)	ND [**0.27**](first floor) 0.06 [L] (basement)
E	2001	591	87	2.1 (first floor) **3.7** (basement)	**2.2** (first floor) **2.5** (basement)
E	2002#	138	122	ND [0.23] (first floor) ND [0.55] (basement)	ND [**0.23**](first floor) ND [**0.55**] (basement)
E	2003	18	20	not tested	not tested
Comparison Value		**1900**	**140**	2.5	**0.19**

Bolded values exceed the comparison value.
Concentration presented is the maximum value detected.
GC/MS results were used rather than TAGA results when available.
[L] is an estimated value below the reporting limit.
Samples were collected after sub-slab ventilation system was installed.
@ This value is the average of the sample and a duplicate. ½ the reporting limit was used for non-detect.
&Sample was collected from public property adjacent to the structure (i.e., sidewalk), not from the foundation.
ND = not detected, with reporting limits in [ ]. A reporting limit is the lowest concentration that can be reliably measured by a particular laboratory instrument and method. The true concentration is somewhere between zero and the reporting limit.

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Data Sampling Phases 2, 3 and 4 (2001, 2002, 2003)

RAYMARK INDUSTRIES, INCORPORATED

STRATFORD, FAIRFIELD COUNTY, CONNECTICUT

EPA FACILITY ID: CTD001186618

Prepared by:

Connecticut Department of Public Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

The conclusions and recommendations in this health consultation are based on the data and information made available to the Connecticut Department of Public Health and the Agency for Toxic Substances and Disease Registry. The Connecticut Department of Public Health and the Agency for Toxic Substances and Disease Registry will review additional information pertinent to this health consultation, should it become available.

BACKGROUND AND STATEMENT OF ISSUE

The Connecticut Department of Public Health (CT DPH) was asked by the U.S. Environmental Protection Agency (EPA) and the Stratford Health Department to evaluate the public health implications of volatile organic compounds (VOCs) off gassing from contaminated groundwater and migrating into buildings in a residential neighborhood in Stratford, Connecticut. The data evaluated by CT DPH in this health consultation are from groundwater, indoor air and soil gas studies conducted by EPA in 2001, 2002 and 2003 in a Stratford neighborhood (neighborhood study area) located immediately southeast of the former Raymark Industries, Inc. facility (Raymark Facility). Figure 1 in Attachment A shows the neighborhood study area. This health consultation is limited to the evaluation of groundwater, soil gas and indoor air data. Environmental data from other media such as soil or biota are outside the scope of this health consultation.

Past disposal practices at the Raymark Facility have polluted the groundwater in the study area with a variety of contaminants. Since 1994, EPA has sampled groundwater at the former Raymark Facility and in the surrounding, downgradient neighborhood study area. Groundwater data indicate the presence of elevated levels of volatile organic compounds (VOC) and several metals in shallow groundwater beneath the neighborhood study area. The presence of VOCs in shallow groundwater beneath homes or businesses is a concern because the VOCs can separate into the gas phase and move into the tiny open spaces between soil particles. This gas, called soil gas, can enter homes or businesses through the basement. The soil gas can enter through crawl spaces, plumbing holes, other floor holes such as sumps and foundation cracks and can contaminate indoor air.

<u>Phase 1</u>

In April 2000, EPA began studying the potential for indoor air impacts from contaminated groundwater by collecting soil gas and indoor air samples from six structures within the neighborhood study area (Phase 1). Data from the Phase 1 study were previously evaluated in a health consultation (ATSDR 2000). The six locations for Phase 1sampling were selected based on a review of groundwater data as well as interviews and basement inspections done at over 50 homes and businesses within the neighborhood study area. The basement inspections identified the presence of cracks and other pathways whereby vapors could enter the basement.

Interviews with residents and workers collected information about potential sources of VOCs within the home or business. The locations with the greatest potential for intrusion of groundwater vapors into indoor air were selected for sampling. Soil gas and indoor air samples were analyzed for the following seven target analytes:

- 1,1-dichloroethylene [1,1-DCE]
- vinyl chloride
- trichloroethylene [TCE]
- benzene
- 1,1,1-trichloroethane [1,1,1-TCA]
- chlorobenzene
- toluene.

These target analytes were selected by EPA based on contaminants found in groundwater and modeling results identifying contaminants with the highest concentrations and the greatest potential to volatilize from groundwater into indoor air. CT DPH, through its cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), previously evaluated EPA's Phase 1 data in a health consultation which concluded that data strongly suggest that VOCs are migrating from groundwater into soil gas and entering indoor air in some homes/businesses in the neighborhood study area. While levels of VOCs in indoor air were not high enough to trigger immediate action (given the standards that were in effect at that time[1]), further sampling was strongly recommended because the data represented exposures at a single point in time and therefore were highly uncertain (ATSDR 2000). As will be discussed in detail later in this document, standards that were in effect in 2000 during the Phase 1 sampling have been revised.

Phase 2

In February/March 2001, EPA conducted a second phase of soil gas and indoor air testing (Phase 2). The purpose of the Phase 2 sampling was to better characterize soil gas and indoor air contamination in the downgradient neighborhood study area. During Phase 2, soil gas samples were collected around building foundations at approximately 105 properties and indoor air testing was done in eight homes/businesses. Soil gas samples were collected at depths of approximately four feet below ground surface using a slam bar (hand-held weight used to pound sampling device into the ground). Indoor air samples were collected if soil gas results indicated concentrations of any of the target analytes at levels greater than 50% of Connecticut's Residential Criteria for Soil Vapor (these criteria are discussed in detail in the "Discussion" section of this document and are presented in Table 1on page 6).

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[1]Since the time that Phase 1 sampling was performed, CT DEP has proposed revisions to its Remediation Standard Regulations, which include groundwater, soil gas, and indoor air standards. These revised standards are discussed later in this document.

For the analysis, soil gas samples were analyzed in EPA's onsite mobile laboratory. Some of the soil gas samples were field confirmed using a gas chromatograph/mass spectrometer (GC/MS). For quality control purposes, replicate soil gas samples were collected in SUMMA canisters and analyzed at the EPA Region I laboratory. For indoor air, real time indoor air monitoring was performed using the EPA Trace Atmospheric Gas Analyzer (TAGA). Eight-hour time-integrated indoor air samples were also collected in SUMMA canisters.

The Phase 2 data support what was indicated by the Phase 1 sampling results. That is, VOCs appear to be migrating from groundwater into soil gas and entering indoor air in some homes/businesses in the neighborhood study area. CT DPH prepared a preliminary interpretation of the Phase 2 data and concluded that *action should be taken in the near term to reduce exposure to indoor air contaminants in four homes/businesses.* Based on CT DPH's evaluation, EPA installed sub-slab ventilation systems in these four locations in 2001 (EPA, 2002). CT DPH also stated that in two structures, another round of soil gas and indoor air sampling should be conducted to better characterize the contamination.

<u>Phase 3</u>

In February/March 2002, EPA conducted a third round (Phase 3) of soil gas and indoor air testing in order to retest homes/businesses that were sampled in 2001 as well as identify additional locations with elevated indoor air levels. EPA followed a sampling and analysis procedure similar to the one it used for the 2001 sampling event. Soil gas samples were collected from locations around the foundation at approximately 35 properties. Soil gas samples were also collected from public property along sidewalks at approximately 38 locations in the neighborhood study area in order to better characterize where elevated areas of soil gas occur. Soil gas samples were collected from depths of 8 to 20 feet below ground surface using a geoprobe. Samples were screened on site and if VOC levels were elevated, indoor air samples were collected. Indoor air samples were collected from 12 homes/businesses. Of these 12, five homes had indoor air concentrations elevated enough to warrant remediation in the short term. Connecticut Department of Environmental Protection (CT DEP), in cooperation with EPA, installed sub-slab ventilation systems in the five homes in November 2002.

As part of the Phase 3 sampling round, EPA resampled indoor air and soil gas from the four structures in which EPA had installed ventilation systems in 2001. The data indicate that the systems are working properly.

<u>Phase 4</u>

In 2003, EPA performed another round of soil gas and indoor air sampling (Phase 4). The Phase 4 sampling occurred in two parts. In January/February 2003, soil gas and indoor air samples were collected at the five homes that received sub-slab ventilation systems in November 2002. The purpose this sampling was to determine whether the systems are reducing indoor levels of VOCs. Sample results indicated that systems are working properly.

The second part of the Phase 4 sampling occurred during March/April 2003. The purpose of the second part of the Phase 4 sampling was to collect additional information about potential exposures to building occupants and to collect data that EPA would need to design sub-slab ventilation systems. Sampling involved collecting soil gas and indoor air samples from 11 homes/businesses within the neighborhood study area that had not previously been sampled. Homes/businesses were selected for sampling based on elevated VOC concentrations in groundwater at nearby monitoring wells. Sampling procedures for this event were slightly different from procedures used by EPA for earlier sampling events. First, soil gas samples were collected from beneath the concrete floor (slab) of the building rather than from next to the foundation. The sub-slab soil gas samples were collected using a probe inserted through holes drilled through the slab. Indoor air samples were collected for 24 hours rather than 8 hours. Phase 4 indoor air sampling results identified three more homes with elevated levels of VOCs.

Demographics of the Neighborhood Study Area

The environmental data evaluated by CT DPH in this health consultation were collected from the residential neighborhood depicted in Figure 1 in Attachment A. The specific portion of the neighborhood that has been identified as the residential area of interest for potential indoor air impacts and that has been targeted by EPA for potential sub slab ventilation systems is identified by the red line. In the portion of the neighborhood within the red line, there are approximately 114 residential structures with approximately 300 people residing.

Site Visits

Prior to installation of sub-slab ventilation systems, CT DPH staff along with EPA, CT DEP and Stratford Health Department staff, visited with residents scheduled to receive systems. The purpose of the visits was to present sampling results, discuss the need to reduce exposures to the elevated VOCs in indoor air and discuss options for reducing exposures. CT DPH addressed health-related questions and concerns that were expressed by residents.

DISCUSSION

Analysis of Exposure Pathways

When determining the public health implications of exposure to hazardous contaminants, CT DPH first considers how people might come into contact with contaminants. The neighborhood study area is primarily a residential area, however there are several businesses present. There are no schools or daycare centers. It should be noted that there are businesses that cater to children (e.g. gymnasium and dance studio). As mentioned in the Background Section, environmental data from the neighborhood study area indicates that groundwater, soil gas and indoor air are contaminated with VOCs.

Ingestion of groundwater contaminants as an exposure pathway of is not a concern. Although groundwater in the area is contaminated, residents receive drinking water from a municipal supply. Other means of direct contact with groundwater from non-potable uses of groundwater such as watering gardens, washing cars and filling swimming pools are unlikely because the known private wells that did exist in the past are no longer in use.

Inhalation of indoor air is a pathway for people to be exposed to VOCs. Adults and children who live or work in the buildings where volatiles have migrated from groundwater to indoor air could be exposed to the contamination by breathing indoor air.

Comparison of Health Protective Screening Values with Sample Data
The next step in determining the public health implications of exposure is to compare contaminant concentrations in environmental media to which there is potential exposure, with health protective comparison values. Health-based comparison values are used as guidelines for evaluating exposures to chemicals. Comparison values are concentrations in environmental media (e.g., indoor air, soil, drinking water) that are not expected to pose adverse health risks, assuming unrestricted, long-term exposure.

In selecting which comparison value to use for a particular chemical, ATSDR follows a general hierarchy whereby ATSDR-derived values are preferred. In the absence of ATSDR values, other relevant and appropriate standards or guidelines, such as state standards, may be used. Typically, the most health protective guideline is selected for the comparison value screening process. The comparison values used in this health consultation are presented in Table 1 on page 6 and consist of values from CT DEP's proposed revised Remediation Standard Regulations (RSRs). CTRSRs were selected because there were the most health protective guideline.

When environmental concentrations of chemicals are below comparison values, we can say with relative certainty that health impacts from exposure to those levels are unlikely. When environmental concentrations exceed comparison values, exposure to the chemical is examined further to determine whether they could pose a health threat.

<u>Comparison Values for Soil Gas</u>
CT DPH compared soil gas data from the neighborhood study area with the Connecticut Residential Soil Vapor Volatilization Criteria from CT DEP's RSRs (see Table 1 on page 6). The Residential Soil Vapor Volatilization Criteria indicate when concentrations of contaminants in soil gas may possibly result in indoor air levels which could potentially pose a health threat, assuming residential exposures. Soil gas concentrations below the Soil Vapor Criteria are not anticipated to pose a significant health threat to people living in residential dwellings.

The Residential Soil Vapor Volatilization Criteria were calculated from health-based Target Indoor Air levels and were developed based upon a revised Johnson and Ettinger model (CT DEP 2003) incorporating both diffusion and advection as the mechanisms of transport of VOCs from groundwater into indoor air. Diffusion is the process whereby soil gas moves from an area of higher concentration to an area of lower concentration. Advection is the process by which soil gas moves according to differences in pressure, temperature or other factors. This modeling approach is recommended in EPA's draft vapor intrusion guidance document (EPA 2002). The model incorporates many parameters including soil characteristics, infiltration rates and dilution factors. CT DEP recently proposed revisions to the Soil Vapor Volatilization Criteria to reflect the revised transport model and additional information about the exposure pathway that has become available since the CT RSRs were formally adopted in 1996 (CT DEP 2003).

Table 1. Health-Based Comparison Values Used to Screen Contaminants Detected in Soil Gas and Indoor air, Stratford, CT.

CONTAMINANT	CT Residential Soil Gas Volatilization Criteria (from draft revisions to CTRSRs*) (ppb/v)^	CT Residential Target Indoor Air Concentrations (from draft revisions to CTRSRs*) (ppb/v)^
1,1-Dichloroethylene	1900	2.5
Trichloroethylene	140	0.19[&]
Vinyl Chloride	41	0.06
1,1,1-Trichloroethane	70,000	92
Benzene	780	1[&]
Toluene	42,000	56
Chlorobenzene	6,100	8

*Draft CT RSRs are newly proposed revisions to CT's Target Air Concentrations, Soil Gas Volatilization Criteria and Groundwater Volatilization Criteria (DEP 2003).
[&] This value is based on a background concentration (see footnote 3 on page 7).
^ppb/v = parts per billion by volume.

Comparison Values for Indoor Air

CT DPH compared indoor air data from the neighborhood study area with the Connecticut Residential Target Indoor Air concentrations (TACs) from CT DEP's revised RSRs (see Table 1above). The Residential TACs are levels that are not expected to pose a health threat, assuming a lifetime of continuous exposures. At levels above the TACs, some form of action to reduce exposure is needed[2]. CT DEP recently proposed revisions to the TACs to reflect new toxicological information and adjustments to inhalation exposure parameters that are better suited to the residential or Industrial/Commercial scenarios (CT DEP 2003).

As will be discussed in the section entitled "Environmental Contaminant Levels", the primary contaminants in soil gas and indoor air within the neighborhood study area are (1,1-Dichloroethylene [1,1-DCE] and Trichloroethylene [TCE]). They were found in soil gas or indoor air at levels exceeding comparison values. Detailed information regarding derivation of the TACs and Soil Vapor Volatilization Criteria for these two chemicals is provided below.

[2]Under the Connecticut Remediation Standard Regulations, enforceability of Target Air Concentrations is provided through the regulatory requirement that volatilization criteria for groundwater and soil vapor be met. When VOCs in groundwater and soil vapor exceed volatilization criteria, there is the possibility that the VOCs could migrate into indoor air at levels that could pose a health risk. Therefore, the regulations require that unless groundwater is cleaned up to meet the groundwater volatilization criteria, an indoor air monitoring program which includes measures to control VOCs in indoor air must be implemented [CGS 22a-133k-3(c)(5)(B)(i)]. As provided in the regulations, the Target Air Concentrations are the levels considered to be protective of public health.

TCE

A new TAC for TCE of 0.19 ppb (1 microgram per cubic meter [ug/m^3]) has been developed by CT DPH for CT DEP because of toxicology reevaluations ongoing at EPA and because of a reevaluation of background TCE levels. The old TAC for TCE (5 ug/m^3 or 0.92 ppb) was based on background[3], using an estimate of upper bound indoor air background levels used by Massachusetts to set its standards (MADEP 1994). However, the central tendency indoor air background level for TCE seen across several studies was 1 ug/m^3 or lower (CT DPH 2002).

Regarding EPA's toxicology reevaluation of TCE, EPA's draft reassessment of TCE highlights recent data which indicate a stronger likelihood of human carcinogenicity of TCE (CT DPH 2002). EPA's reassessment presents a range of new cancer potency factors which are 3.3 to 67 fold higher than the pre-existing value for TCE (0.006 per milligram per kilogram per day [mg/kg/day])[4]. EPA's new draft cancer potency values for TCE are 0.02 to 0.4 per mg/kg/day. EPA recommends that the higher end of the potency range be used for evaluating risks to more sensitive subpopulations such as young children, and people with diabetes, alcohol consumption or ongoing exposure to TCE metabolites from drinking water or other sources. If CT DEP developed a new TAC based on EPA's draft cancer potency factor range, the value would be well below background. Therefore, the new TAC is based on a central tendency estimate of background (0.19 ppb or 1 ug/m^3). A central tendency estimate (median) was chosen to represent background rather than a less conservative upper percentile estimate because of CT DEP's goal to keep total exposures (i.e., exposures from background sources plus exposures originating from groundwater) within the range of the background data distribution. Additionally, there is a desire to keep TCE exposures as low as possible because background levels are already associated with elevated risk.

For evaluations of TCE data in indoor air at the Raymark site, CT DPH has proposed a tiered system of action levels that are based on the TAC (see Table 2 on page 9). At TCE levels in indoor air above 1.9 ppb, immediate mitigation is needed. At levels between 0.19 ppb and 1.9 ppb, mitigation should occur within a short period of time (6 months). This is particularly important in situations where young children or other sensitive subpopulations are exposed. At levels below 0.19 ppb, no action is needed because the levels and risks would be indistinguishable from background.

Soil gas criteria were derived considering: (1) an indoor air concentration that is not expected to pose a health threat and; (2) the relationship between soil gas and indoor air concentrations. The draft revised volatilization criteria for soil vapor of 140 ppb for TCE was developed by CT

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[3]Background levels are defined as normally occurring ambient levels. Using TCE as an example, common sources of TCE in the home may include cleaning products, paints, paint removers and glues. These products contribute to the background levels of TCE in the home.

[4]The pre-existing Cancer Potency Factor for TCE was a provisional value, never formalized on the EPA Integrated Risk Information System (IRIS) (EPA's toxicity and risk database).

DEP based upon the TAC of 0.19 ppb and modeling results using a revised Johnson and Ettinger Model incorporating diffusion and advection as mechanisms of transport of subsurface contamination into indoor air. Concentrations of TCE in soil gas greater than 140 ppb would trigger the need for indoor air monitoring.

1,1-DCE

The new TAC for 1,1-DCE of 2.5 ppb (10 ug/m^3) was developed by CT DPH (for CT DEP) based on EPA's draft reassessment of 1,1-DCE. The old TAC for 1,1-DCE (0.023 ppb or 0.049 ug/m^3) was based on an EPA cancer unit risk factor which was removed from the EPA Integrated Risk Integration System (IRIS) (an EPA toxicity database) on August 13, 2002. The updated IRIS file for 1,1-DCE replaces the 1985 file and includes a revised oral reference dose (RfD)[5] and, for the first time, an inhalation reference concentration (RfC)[6].

EPA's new assessment for 1,1-DCE withdraws the cancer slope factor and the inhalation cancer unit risk for 1,1-DCE from IRIS, because the weight of evidence for cancer is considered to be too limited to support quantitative dose-response assessments.

In May 2002, CT DPH reviewed EPA's draft reassessment of 1,1-DCE and proposed a new TAC, based on a lower inhalation reference concentration than what EPA has developed, to account for the uncertainty surrounding cancer studies (CT DPH 2002). To summarize, CT DPH agrees with EPA's conclusion that the cancer bioassay database for 1,1-DCE is not strong enough to support the estimation of cancer risks in humans. However, CT DPH expanded the size of the Uncertainty Factor by 10 times (from 300 in EPA's derivation to 3000 in CT DPH's derivation) to account for the potential carcinogenicity of 1,1-DCE and the fact that an adequate cancer bioassay does not exist for this VOC. In addition, CT DPH relied on a more sensitive animal study in accordance with ATSDR and California Environmental Protection Agency's assessments (CT DPH 2002). CT DPH's new TAC for 1,1-DCE (2.5 ppb; 10 ug/m^3) is approximately 100 times higher (less stringent) than the old TAC, but is still more stringent than EPA's level in IRIS.

Just as for TCE, CT DPH developed tiered action levels for 1,1-DCE that are based on the new TAC (see Table 2). At indoor air levels of 1,1-DCE greater than 25 ppb, immediate mitigation is needed. At levels in the range of 2.5 to 25 ppb, mitigation is needed within a short period of time (6 months). At levels below 2.5 ppb, no further action is necessary. However, CT DPH recommends that in situations where there is 1,1-DCE in the groundwater beneath a structure and indoor air levels of 1,1-DCE are above background (approximately 0.8 ppb) (DEP 2002),

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[5]A RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily ingestion dose to the human population (including sensitive subgroups) that is likely to be without noticeable harmful health effects.

[6]A RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without noticeable harmful health effects.

that additional monitoring occur. This is a recommended action because of the variability inherent in indoor air testing and the likelihood that concentrations above 0.8 ppb are not due to background VOC sources.

CT DEP also developed a new soil gas volatilization criteria for 1,1-DCE of 1900 ppb based upon the TAC of 2.5 ppb and modeling results using a revised Johnson and Ettinger Model as discussed above. Concentrations of 1,1-DCE in soil gas greater than 1900 ppb would trigger the need for indoor air monitoring.

Table 2. Tiered Action Levels for Indoor Air and Recommended Actions; 1,1-DCE and TCE

CONTAM-INANT	TIER 1	TIER 2	TIER 3
1,1-DCE	**>25 ppb** *Immediate mitigation needed. Hazard Quotient# >10*	**2.5 ppb to 25 ppb** *Mitigation needed in the near term (6 months), particularly where children may be exposed. Hazard Quotient# of 1-10*	**< 2.5 ppb** *No further action needed. Hazard Quotient# <1^*
TCE	**>1.9 ppb** *Immediate mitigation needed. Cancer risks > 1×10^{-3} to 6×10^{-5}@*	**0.19 to 1.9 ppb** *Mitigation needed in the near term (6 months), particularly where children may be exposed. Cancer risk 6×10^{-6} to 1×10^{-3}@*	**<0.19 ppb** *No further action; likely background levels. More monitoring only if soil gas is elevated.*

NOTE: Risk estimates presented in this Table assume continuous lifetime exposure. Calculations for risk estimates are presented in Attachment B. Cancer risks are not calculated for 1,1-DCE because EPA's reevaluation of 1,1-DCE toxicity concludes that there is insufficient data to support development of a cancer potency factor.

#A Hazard Quotient is a measure of the likelihood of noncancer health effects from exposure. A Hazard Quotient equal to one means that the exposure is equal to the "safe level." A Hazard Quotient less than one means that exposure is less than the "safe level" and noncancer health effects are not likely. A Hazard Quotient greater than one means that exposure is greater than the "safe level" and noncancer health effects cannot be ruled out.

@ Cancer risks are provided as a range because they were calculated using the low end and the high end of EPA's draft cancer potency range for TCE. A cancer risk of 1×10^{-3} means a theoretical excess cancer of one in 1000 exposed persons. Cancer risk of 6×10^{-5} means six excess cancers in 100,000 exposed persons. Cancer risk of 6×10^{-6} means six excess cancers in one million exposed persons.

^Additional monitoring may be prudent if 1,1-DCE is present in groundwater beneath a structure and indoor air levels of 1,1-DCE are above background (0.8 ppb).

Environmental Contaminant Levels - Soil Gas and Indoor Air

Tables 3 through 5 provide a summary of Phases 2, 3 and 4 soil gas and indoor air data. The tables include data for only those properties where VOCs were detected in soil gas and/or indoor air at levels exceeding comparison values presented in Table 1. Concentrations presented in the tables are maximum concentrations. Bolded values indicate an exceedance of a comparison value. Table 3 contains data from the four homes/businesses that received ventilation systems in 2001. Table 4 contains data from the five homes that received systems in 2002. Table 5 contains data from the remaining locations with exceedances of comparison values. Soil gas exceedances in Table 5 include samples collected from the foundation, from sidewalk areas and from beneath the slab. Soil gas exceedances presented in Table 5 are foundation samples unless otherwise noted.

Of the seven target analytes, 1,1-DCE and TCE were found in soil gas or indoor air at levels exceeding comparison values.[7] Health-based comparison values used in this evaluation have been discussed and are presented in Table 1. During Phases 2, 3 and 4 of sampling, soil gas samples were collected from around the foundation or beneath the slab of approximately 60 different homes or commercial buildings. Indoor air was sampled in 30 different homes. Soil gas samples exceeded comparison values in only eight of the 60 structures that were sampled. Indoor air exceedances were found in 14 of the 30 structures sampled. Results for all locations with exceedances of comparison values are included in Tables 3 through 5.

Soil gas data from around any particular structure was highly variable. There was as much as a 1000 fold difference between minimum and maximum soil gas concentrations collected from the foundation of a particular structure during one sampling event. Such variability could be explained by differences in seasonal and climate effects, and differences in variables such as soil type and soil moisture. Over the 2001- 2003 sampling rounds, the maximum soil gas concentrations for 1,1-DCE and TCE were 1168 ppb and 658 ppb, respectively. Indoor air concentrations were not as variable as soil gas concentrations. The maximum 1,1-DCE level in indoor air was 12 ppb and the maximum TCE level was 9.6 ppb. In most cases, levels were higher in the basement than on the first floor, a pattern often seen with radon.

Based on the data collected thus far, elevated levels of contaminants in soil gas do not appear to predict elevated levels of contaminants in indoor air. For example, of the 14 homes/businesses with exceedances of indoor air comparison values, only five had soil gas concentrations in exceedance of comparison values. This could be due to the many variables that affect whether and how much VOCs will infiltrate from groundwater into soil gas and indoor air.

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[7]In one home, indoor air levels of vinyl chloride detected by TAGA field screening exceeded the comparison value. However, SUMMA canister samples from the home showed non-detect levels of vinyl chloride. SUMMA canister data is considered more reliable than field screening data. The vinyl chloride exceedance detected by field screening is probably an error, since an elevation was not present in the SUMMA canister results. Therefore, vinyl chloride is not evaluated further.

In two homes, SUMMA canister samples found benzene in basement indoor air at levels 3 to 4 times above the comparison value. Benzene was not detected in the soil gas of these homes. Benzene has been found in shallow groundwater beneath the neighborhood study area but not at extremely elevated levels and it has not been routinely found in soil gas. CT DPH considers it likely that the benzene in indoor air in these two homes are due to sources inside the home rather than groundwater/soil gas. Exposure to benzene in the basement at levels 3 to 4 times above comparison values is not likely to pose a health threat. Therefore, benzene exceedances are not evaluated further.

Table 4. Summary of Maximum Soil Gas and Indoor Air Concentrations Taken Before and After Sub-Slab Ventilation Systems were Installed in Five Homes/Businesses in 2002, Stratford, CT.

SAMPLE LOCATION	SAMPLE DATE	VOCs in Soil Gas (ppb)		VOCs in Indoor Air (ppb)	
		1,1-DCE	TCE	1,1-DCE	TCE
I	2001	12	1.9	not tested	not tested
I	2002	118	84	1.3 (first floor) **6.7** (basement)	**0.83** (first floor) **4** (basement)
I	2003#	ND [0.1]	ND [0.1]	ND [0.1] (first floor) ND [0.1] (basement)	ND [0.1] (first floor) ND [0.1] (basement)
K	2001	ND [1.9]	ND [0.67]	not tested	not tested
K	2002	40	14	ND [0.25] (first floor) 0.26 (basement)	**0.21** [L] (first floor) **0.42** (basement)
K	2003#	0.99	0.145	ND [0.1] (first floor) ND [0.1] (basement)	ND [0.1] (first floor) ND [0.1] (basement)
L	2002	213	86	0.27 (first floor) 0.79 (basement)	ND [**0.21**] (first floor) **0.43** (basement)
L	2003#	ND [0.091]	ND [0.091]	ND [0.086] (first floor) ND [0.091] (basement)	ND [0.086] (first floor) ND [0.091] (basement)
O	2001	6	13	not tested	not tested
O	2002	479	134	0.56 (first floor) 1.5 (basement)	**0.32** (first floor) **0.86** (basement)
O	2003#	0.761	0.359	ND [0.11] (first floor) ND [0.11] (basement)	ND [0.11] (first floor) ND [0.11] (basement)
Q	2001	2.5	ND[0.67]	not tested	not tested
Q	2002	1040	**658**	0.98 (second floor) 0.83 (first floor) 1.7 (basement)	**0.72** (second floor) **0.66** (first floor) **1** (basement)
Q	2003#	959	**658**	ND [0.1] (first floor) ND [0.1] (basement)	ND [0.1] (first floor) ND [0.1] (basement)
Comparison Value		**1900**	**140**	2.5	**0.19**

Bolded values exceed the comparison values.

Concentration presented is the maximum value detected.

GC/MS results were used rather than TAGA results when available.

Samples were collected after sub-slab ventilation system was installed.

[L] is an estimated value below the reporting limit.

ND = not detected, with reporting limits in [ ]. A reporting limit is the lowest concentration that can be reliably measured by a particular laboratory instrument and method. The true concentration is somewhere between zero and the reporting limit.

Table 5. Summary of Maximum Soil Gas and Indoor Air Concentrations (2001, 2002 and 2003), Stratford, CT from Remaining Locations with Exceedances of Comparison Values.

SAMPLE LOCATION	SAMPLE DATE	VOCs in Soil Gas (ppb)		VOCs in Indoor Air (ppb)	
		1,1-DCE	TCE	1,1-DCE	TCE
D	2001	16	3.5	ND (1st floor) 0.2 (basement)	ND (1st floor) **0.28** (basement)
F	2001	66	9.3	ND (1st floor) 0.13 (basement)	ND (1st floor) ND (basement)
F	2002	856	**150**	0.23 (1st floor) ND [0.2] (basement)	ND [**0.2**] (1st floor) ND [**0.2**] (basement)
G	2002	861	15	ND [0.2] (1st floor) ND [0.2] (basement)	**0.31** (1st floor) 0.13 [L] (basement)
G	2003	ND [0.2]	ND [0.2]	not tested	not tested
H	2002	350	**241**&	not tested	not tested
J	2002	982	**688**&	not tested	not tested
M	2002	277	**194**&	not tested	not tested
N	2001	0.97	0.45	not tested	not tested
N	2002	337	**553**&	not tested	not tested
P	2001	3.5	0.11	not tested	not tested
P	2002	899	**208**	ND [0.24] (first floor) ND [0.27] (basement)	ND [0.24](first floor) ND [0.27](basement)
R	2003	**2180**&	**1320**&	not tested	not tested
S	2003	390+	**200**	2 (basement)	**1.1** (basement)
T	2003	513+	**440**+	1.3 (basement)	**0.54** (basement)
U	2003	145+	124+	0.24 (basement)	**0.2** (basement)
V	2003	484+	**192**+	0.12(basement)	ND [0.12](basement)
Comparison Value		**1900**	**140**	**2.5**	**0.19**

Bolded values exceed the comparison value.
Concentration presented is the maximum value detected.
GC/MS results were used rather than TAGA results when available.
[L] is an estimated value below the reporting limit.
ND = not detected, with reporting limits in [ ]. A reporting limit is the lowest concentration that can be reliably measured by a particular laboratory instrument and method. The true concentration is somewhere between zero and the reporting limit.
&Sample was collected from public property adjacent to the structure (i.e., sidewalk), not from the foundation.
+Sample was collected from beneath the slab.

Environmental Contaminant Levels - Groundwater

Groundwater sampling conducted by EPA since the early 1990s indicates that the primary contaminants found in soil gas and indoor air (1,1-DCE and TCE) are also present at high levels in shallow groundwater underlying the neighborhood study area. Average concentrations of 1,1-

DCE and TCE in monitoring wells in the residential area that were sampled in 2003 are 550 ug/L and 667 ug/L, respectively. These *average* concentrations are well above the proposed CT Groundwater Volatilization Criteria of 190 ug/L for 1,1-DCE and 27 ug/L for TCE. Average concentrations of other VOCs did not exceed the Groundwater Volatilization Criteria. CT DPH evaluated average groundwater concentrations from 2003 sampling rather than maximum concentrations because only average levels were available at the time this health consultation was prepared.

The Groundwater Volatilization Criteria are governed by: (1) an indoor air concentration that is not expected to pose a health threat (TAC); (2) the relationship between groundwater and soil gas; and (3) the relationship between soil gas and indoor air. Contaminants present in shallow groundwater at levels exceeding the CT Groundwater Volatilization Criteria may cause exceedances of the health-based indoor air TACs.

A preliminary trend analysis for groundwater concentrations over time has been conducted by TetraTech NUS, Inc. (contractor to EPA) and has tentatively concluded that VOC concentrations in the groundwater are likely to remain the same for a very long time (G. Sturgeon, 2003). This is significant because it indicates that VOCs will remain in groundwater as a continuing source of pollution to indoor air for a long period of time.

Public Health Implications for Children and Adults
As discussed earlier in this document, the focus of this health consultation is groundwater, soil gas and indoor air data. VOCs have been found at elevated levels in groundwater, soil gas and indoor air in the neighborhood study area. Direct contact with groundwater (e.g., ingestion, dermal) is not a concern because groundwater is not currently being used for drinking water or other uses.

Inhalation of indoor air is a pathway for people to be exposed to VOCs in groundwater and soil gas. Adults and children who live or work in the buildings where volatiles have migrated from groundwater to indoor air could be exposed to the contamination by breathing indoor air.

The first step of CT DPH's evaluation of the public health implications from exposure to indoor air consisted of comparing indoor air concentrations with the health-based comparison values in Table 1. The next step involved further evaluating only those VOCs present at levels above comparison values. For comparison values, CT DPH used basement levels of contaminants rather than first floor levels. In most cases, basement levels are higher than first floor levels but exposure is less because residents typically do not spend as much time in the basement as they do on upper floors. Therefore, using basement levels of contaminants to evaluate potential health implications provides a conservative (more health protective) measure of exposure. As shown in Tables 3-5, there are 14 buildings with indoor air levels above comparison values. In nine of these buildings, EPA and CT DEP have installed sub-slab ventilation systems to reduce contaminant levels in indoor air. Tables 3 and 4 show that the systems have significantly reduced VOCs in indoor air[8]. In these nine homes/businesses, inhalation exposures to VOCs from groundwater are not a health concern. As long as the ventilation systems are maintained, future exposures should not be a concern either.

There are five homes/businesses (D, G, S, T and U in Table 5) with indoor air exceedances that do not yet have sub-slab ventilation systems. Three of these five locations were sampled for the first time in 2003. Indoor air exceedances for all five locations are for TCE, with exceedances ranging from 0.2 ppb to 1.1 ppb. These exceedances are in the Tier 2 range indicating that mitigation is warranted in the near term. Despite the fact that data are limited for these five locations, and do not support determination of long-term exposure levels, the data clearly suggest that there is a pathway for vapor intrusion and exposure to elevated levels of TCE in indoor air is occurring.

Table 5 also shows that there are eight locations (F, H, J, M, N, P, R, V in Table 5) where soil gas comparison values were exceeded and indoor air was either not sampled, or limited samples showed no exceedances of indoor air comparison values. In some of these locations, indoor air was not sampled because the soil gas samples were taken from sidewalk areas and there was not necessarily an immediately adjacent home or business to sample. Nevertheless, elevated soil gas indicates a potential pathway into indoor air that should be investigated further.

Regarding past, current and potential future exposures and risks to residents, we are not able to estimate with certainty, the contaminant levels to which people are, were or may be exposed because we do not have enough sampling data. However, we can use the limited data that exist to make conservative estimates of exposure and risk. Using the maximum indoor air levels measured during 2001-2003 in a residence, people could have been exposed to 1,1-DCE at levels as high as 8.3 ug/m^3 (2.1 ppb) on the first floor and 27 ug/m^3 (6.7 ppb) in the basement. As for TCE, exposure levels on the first floor of a home could have been as high as 11.8 ug/m^3 (2.2 ppb) and 21 ug/m^3 (4 ppb) in the basement. Significantly higher levels of TCE and 1,1-DCE were detected in structures currently used for business but exposures in those locations typically would be less than in residences due to the shorter amount of time typically spent at work than at home. However, if the business use of a structure were to change to residential, exposures could be much higher: 47.5 ug/m^3 (12 ppb) for 1,1-DCE and 48 ug/m^3 (9 ppb) for TCE. These data also demonstrate the potential for indoor air concentrations within buildings in this neighborhood to exceed the TAC by 50 times for TCE.

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[8]As noted in Table 3, there were 3 samples (from 2 homes) in which the lowest TCE level that could be reliably quantified (i.e., reporting limit) exceeded the TAC of 0.19 ppb. Reporting limits were as high as 0.55 ppb. Post-remedation samples taken in 2003 from 5 homes receiving ventilation systems had reporting limits that were lower than the TAC for TCE. Post-remediation samples showed that 1,1-DCE and TCE levels were reduced to non-detect levels. These five homes also had radon measurements taken before and after installation of the systems. Radon results confirmed that the systems are effectively reducing radon levels. Although reporting limits from two homes were too high to be useful, the body of data collected after ventilation systems were installed indicates that the systems are reducing VOCs to levels below comparison values.

Based upon the highest VOC concentrations detected in a *current* residence, exposure to 1,1-DCE could result in a Hazard Quotient as high as 2.7. However, if the highest concentration in a business is used, the Hazard Quotient could be as high as 4.7. See Attachment B for the full calculations. A Hazard Quotient is the ratio between a person's estimated exposure level and the "safe" level. A Hazard Quotient greater than one means that a person's exposure is greater than what is considered safe and adverse health effects cannot be ruled out. A Hazard Quotient less than one means that a person's exposure is below the safe level and adverse health effects are not likely.

Relative to cancer risks, exposure to TCE at the highest levels found in a *current* residence could result in cancer risks of 2×10^{-3}. A cancer risk of 2×10^{-3} means an estimated excess of two cancers in 1000 exposed persons. Using the highest TCE level measured in a business, cancer risks could be as high as 5×10^{-3}. A cancer risk of 5×10^{-3} means an estimated excess of five cancers in 1000 exposed persons. CT DPH calculated these cancer risks for TCE using the upper end of EPA's proposed range of cancer potency estimates (EPA cancer potency range for TCE is discussed earlier). These cancer risks represent estimates of the incremental lifetime cancer risk above background cancer risks. According to National Cancer Institute statistics, background rates of cancer in the U.S. are one in 2 or 3 (NCI 2001). This means that in an exposed population of 1,000 background cancer cases would be 330 to 500. See Attachment B for the detailed calculations on cancer and noncancer risks.

The cancer and noncancer risks calculated above represent significant lifetime incremental risks from exposure to 1,1-DCE and TCE. In order to better understand the likelihood that exposed persons would experience adverse health impacts, it is useful to compare estimated exposures to people in the neighborhood study area with levels from the toxicology and epidemiology literature that were seen to produce adverse health effects in people or laboratory animals.

Table 6 presents estimated exposures to people living and working in the affected neighborhood study area with effect levels from human and animal studies. The information provided in Table 6 is technical and very complex. It is included in this document to illustrate the difference between 1,1-DCE and TCE levels people may have been exposed to in the neighborhood study area and levels that have been seen to cause effects in people and laboratory animals.

Table 6 shows estimates of 1,1-DCE and TCE levels that people may have been exposed to in the neighborhood study area. These exposure levels were estimated using very conservative (health protective) assumptions. For example, it was assumed that people would be exposed to the maximum concentration that was detected in the basement and in the first floor of a home. It was further assumed that people would be exposed for 24 hours per day, 365 days per year for 70 years. Based on these very conservative assumptions, Table 6 shows that 1,1-DCE exposures people may have received in the neighborhood study area are approximately 3,700 to12,000 times *lower* than levels seen to produce harmful noncancer effects in laboratory animals. For TCE, levels that people may have been exposed to in the neighborhood study area are 340,000 to 330 times *lower* than cancer effect levels observed in animal and human studies.

Table 6. Estimated 1,1-DCE and TCE exposure levels for people in the neighborhood study area as compared with effect levels from literature studies.

Chemical	Estimated Exposure Level in the affected neighborhood	Comment	Effect Level from the Literature	Comment
1,1-DCE	0.027 mg/m^3 0.008 mg/m^3	Exposure level was calculated from max. concentration in residential basement and 1st fl.	99 mg/m^3^	LOAEL for minimal fatty changes in liver of S-D rats exposed by inhalation for 18 months, 6h/d, 5d/w (Quast et al. 1986 in CT DPH 2002).
TCE	0.006 mg/kg/d 0.003 mg/kg/d	Exposure level was calculated from max. concentration in residential basement and 1st fl., assuming continuous exposure for 70 years	1016 mg/kg-d 724 mg/kg-d 714 mg/kg-d 53-244 mg/kg-d 21.6 to 348.9 mg/kg-d 1.98 mg/kg-d	LADD causing increase of 26% in number of malignant liver tumors in male mice and increase of 7% in female mice (by inhalation). LADD causing increase of 50% in number of malignant liver tumors in male mice (by gavage). LADD causing increase of 22% in number of malignant liver tumors in female mice (by gavage). Range of estimated LED_{01} values based on rat renal tumors. (EPA 2002) Range of estimated LED_{10} values based on mouse liver tumors. (Rhomberg, 2000) LADD associated with SIR of 13.53 for kidney cancer in German cardboard workers exposed by inhalation. (EPA 2002)

^Converted from 25 ppm.
LED_{10} = Lower 95% confidence limit on the effective dose to 10% of the population.
LED_{01} = Lower 95% confidence limit on the effective dose to 1% of the population.
SIR = Standardized Incidence Ratio, ratio of the observed number of cancers in the exposed population and the expected number.
LADD = Lifetime Average Daily Dose.
RR= rate ratio (or odds ratio) is the ratio of cancer incidence among exposed population and unexposed population.

The difference between the effect levels for 1,1-DCE and TCE and the maximum exposure levels suggested by indoor air data in the neighborhood of interest indicate that the exposure levels are well below the range where toxicity and cancer has been seen for 1,1-DCE and TCE in published research studies. However, the TCE concentrations measured in the neighborhood of interest are in a range where estimated cancer risk is elevated and it is often prudent to lower exposures.

This is especially important in the residential scenario due to potential exposure to children. Short-term exposures to carcinogens in early life (within the first one or two years) can result in a similar cancer risk as long-term exposures in adults (Ginsberg 2003, EPA 2002). The most definitive database on early life susceptibility exists for chemicals with a well-accepted genotoxic mode-of-action (e.g., vinyl chloride). Genotoxic means that a chemical can cause DNA damage and/or mutations. Although the genotoxicity profile for TCE indicates that it is not a strong genotoxic agent, there is uncertainty about this as certain TCE metabolites are believed to have a genotoxic mode-of-action in the kidney. The kidney is the best established cancer target for TCE in humans. Further, there is evidence that nongenotoxic compounds might also be more potent in the developing organism, as compared with the adult organism (Ginsberg 2003, SAB 2002). Thus, very young children may have a greater cancer risk from TCE exposure, even if the early life exposure is short-term. This means that the likelihood of adverse health impacts from exposure may be increased when exposure occurs in young children. This would argue for taking action to protect very young children from exposure, even short-term exposure.

In summary, CT DPH has used the limited available data to estimate exposure and risk from TCE and 1,1-DCE. The risks CT DPH has calculated represent a significant incremental risk above background (Hazard Quotient as high as 4.7, cancer risks as high as 5×10^{-3}). Estimated risks are based upon the maximum concentrations detected inside the most contaminated homes/businesses and rely on other conservative assumptions about exposure. *Therefore, the risk estimates are not intended to represent actual risk to an individual, but rather to represent a general upper bound on risk and to help determine the need for action.* A comparison of estimated exposure levels in the neighborhood study area with literature effect levels shows that exposure levels in Stratford are generally below the range where toxicity or cancer has been seen for 1,1-DCE and TCE in the literature. However, these literature effect levels do not account for early life exposures with these VOCs. Short term, early life exposures to carcinogens can result in the accumulation of cancer risks similar to the risks from long-term exposure that occurs in adults only. *Thus, it is important to prevent even short-term exposures in young children.*

For general information purposes, Attachment C includes background information which summarizes the toxicological and epidemiological literature regarding health impacts from 1,1-DCE and TCE exposure.

Community Health Concerns

Community health concerns were collected during the site visits and from the Stratford Health Department. Residents have expressed concern about whether childhood leukemia might be associated with exposure to indoor air contaminants from the Raymark Facility. CT DPH was made aware of one childhood leukemia case in the neighborhood study area. Residents have also expressed concerns about whether other cancers or reproductive health problems could be associated with exposure to indoor air contaminants from the Raymark Facility.

As stated previously, TCE and 1,1-DCE are the only contaminants found in indoor air at levels exceeding health protective screening values. With regard to 1,1-DCE, the highest levels in *living spaces* of homes were in the Tier 3 range which is associated with a Hazard Quotient of less than 1.0. A Hazard Quotient less than one means that exposures are not greater than the "safe level" and noncancer health effects (including reproductive health effects) from exposure to 1,1-DCE in indoor air are not likely. Basement levels were higher but the amount of time one would typically spend in the basement would be less than in the upper floors of the home. It must be stressed however, that measured concentrations in the home represent a single point in time and may not accurately represent exposure levels over time. With regard to cancer risks from 1,1-DCE, there is not sufficient data on which to base a quantitative estimate of cancer risks. However, as discussed previously, the value derived by CT DPH for evaluating noncancer effects includes a safety factor to account for uncertainty relative to cancer effects from exposure to 1,1-DCE.

With regard to TCE, EPA's draft reevaluation of TCE's cancer potency indicates that TCE is a likely human carcinogen (EPA 2001). Exposure to TCE through drinking water has been associated with increased childhood leukemia in studies done in two communities in the U.S., especially among children who were exposed *in utero* (ATSDR 1997). Concentrations of TCE in *living spaces* of homes were as high as the Tier 1 range which is associated with a estimated excess lifetime cancer risk that could be greater than 1×10^{-3}. Again, the TCE concentrations represent maximum levels present in living spaces of homes at the time the sampling occurred (i.e., a single point in time) and may not necessarily represent long term exposures. Moreover, cancer risks have been estimated using conservative estimates of exposure thus could be expected to represent an overestimate of actual risks. Past exposures in Stratford (estimated from recent data) are for the most part, lower than levels observed to cause effects in laboratory animals and in human studies. However, the literature database does not consider potential increased sensitivity of young children from exposure during early life.

In summary, there are large uncertainties in the levels of TCE that residents may have been exposed to over time. There are also many unknowns with respect to individual residents' risk factors for cancer. Therefore it is not possible to draw definitive conclusions regarding whether past TCE exposures are associated with cancer or other adverse health impacts. However, it is prudent to prevent even short periods of exposure above the TAC for TCE, especially with respect to short-term exposures in children.

CONCLUSIONS

Shallow groundwater beneath the neighborhood study area is contaminated with VOCs from the former Raymark Facility at levels greatly exceeding CT Groundwater Volatilization Criteria. Sampling data from some homes and businesses in the neighborhood study area show that TCE and 1,1-DCE in soil gas and indoor air exceed state standards (i.e. CT's Target Air Concentrations and CT's Soil Gas Volatilization Criteria). This means that in some structures, vapors from groundwater are entering indoor air or have the potential to enter indoor air in the future at unacceptable levels. According to CT Remediation Site Regulations, if groundwater and soil vapor criteria are exceeded, action is needed to prevent or reduce exposure to VOCs in indoor air. Variables such as seasonal and climate effects, soil type and soil moisture, basement conditions and the existence of preferential pathways such as utility lines can all affect whether and how much VOCs will infiltrate from groundwater into soil and indoor air.

Based on conservative estimates of exposure, CT DPH estimated cancer and noncancer risks to residents living in homes with elevated VOCs in indoor air. The estimates represent a significant added risk above background risks. In addition, there is evidence that children may have increased risks of cancer when exposure to carcinogens occurs during early life. These factors have prompted CT DPH to conclude that a public health hazard exists and requires action. If action is taken to reduce or eliminate exposures to VOCs migrating from groundwater to indoor air in homes, then the public health hazard will no longer exist. CT DPH's conclusion is based on consideration of all of the following factors:

- A completed exposure pathway exists (i.e., exposure is occurring).
- There are significant estimated incremental cancer and noncancer risks above background.
- There is a large source area in groundwater that presents a threat to indoor air for the foreseeable future.
- There is no current means to prevent exposure.
- It is difficult to adequately monitor or predict which homes will have elevated VOC concentrations in indoor air in the future.
- There is evidence that children have special sensitivity from exposure to carcinogens during early life.

Based on the four rounds of sampling conducted by EPA in the neighborhood study area, nine buildings were identified as having indoor air VOC levels high enough to warrant installation of sub-slab ventilation systems on an expedited basis. The systems are operating in the nine buildings whereby VOC levels have been reduced to levels that do not pose a public health concern. As long as the ventilation systems continue to operate property, there should be no concern in the future. CT DPH fully supports the decision to install sub-slab ventilation systems in these locations and concludes that no further action is needed for these nine homes/businesses.

RECOMMENDATIONS

1. CT DPH recommends that EPA and/or CT DEP take action to reduce exposure (such as installing sub-slab ventilation systems) at the additional five locations with exceedances of CT's Target Air Concentration for TCE (D,G, S, T,U in Table 5).

2. CT DPH recommends that EPA and/or CT DEP take action to reduce exposure (such as installing sub-slab ventilation systems) at each of the remaining residences in the neighborhood study area. Taking action to reduce exposure in each of the residences is a prudent public health

action. It is a proactive step to ensure that in the future, changing groundwater and soil gas conditions do not create conditions that result in unacceptable indoor air exposures, especially where young children live. It also eliminates the need for an extensive, costly ongoing soil gas and indoor air sampling program in the neighborhood study area.

3. Further evaluation of potential VOC migration from groundwater into indoor air of businesses in the neighborhod study area should be undertaken. This further study should include such tasks as comparing groundwater concentrations with Connecticut's TACs for commercial/industrial buildings and gathering more detailed information about exposures to indoor air in the commercial structures (for example, the frequency and duration of exposures, whether young children are present on a regular basis).

4. Following installation of sub-slab ventilation systems, EPA and/or CT DEP should evaluate the performance of each system to ensure that it is operating effectively. Performance could be evaluated by visual inspection, mechanical testing or other appropriate measures. Such performance evaluations should include locations C and E (see Table 3) which had reporting limits in exceedance of the TACs.

5. If widespread installation of sub-slab ventilation systems is determined to be not practicable or feasible, CT DPH recommends that at a minimum, EPA collect additional data on an ongoing basis in order to better understand the potential for vapor intrusion into homes and businesses in the neighborhood study area. The eight locations with soil gas exceedances (F, H, J, M, N, P, R,V) should definitely be included in a plan for additional sampling. Soil gas samples should be collected from around the foundation or through the slab in numbers sufficient to adequately characterize the variability in soil gas levels at a particular property. Indoor air samples should be collected at least during the winter when conditions would be expected to be worst case. Reporting limits for TCE should be lower than the comparison value of 0.19 ppb.

6. EPA should also continue its program of sampling groundwater to better understand the nature, extent and movement of the VOC plume. EPA should also consider measures to reduce, contain or eliminate the VOC source at the former Raymark facility.

PUBLIC HEALTH ACTION PLAN

Actions Planned

1. CT DPH will continue to work with EPA, CT DEP and the Stratford Health Department to respond to public health questions and concerns and provide public health interpretation of environmental data.

2. CT DPH will assist, as needed, in community involvement/health education efforts that may be needed if sub-slab venting systems are offered to large numbers of homes in the neighborhood study area.

3. CT DPH will assist, as needed, in further evaluations of the potential for VOC migration into commercial/industrial structures in the neighborhood study area.

4. CT DPH will prepare a fact sheet summarizing the results of this health consultation for distribution to individuals who work or live in the neighborhood study area, as well as other interested parties.

Actions Taken

1. CT DPH along with the Stratford Health Department, participated in meetings with the four individuals who received sub-slab ventilation systems in 2001 and the five individuals who received systems in the fall 2002. CT DPH provided information as needed, on exposure and health concerns and answered questions about exposure and health risks.

2. CT DPH has assisted EPA, CT DEP and the Stratford Health Department in evaluating data and responding to public health questions and concerns.

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CERTIFICATION

The Health Consultation for Groundwater, Soil Gas, and Indoor Air Data at the Raymark Industries site was prepared by the Connecticut Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.

Greg Ulirsch

Technical Project Officer, SPS,SSAB,DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with its findings.

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ATTACHMENT A

Figure 1

Neighborhood Study Area

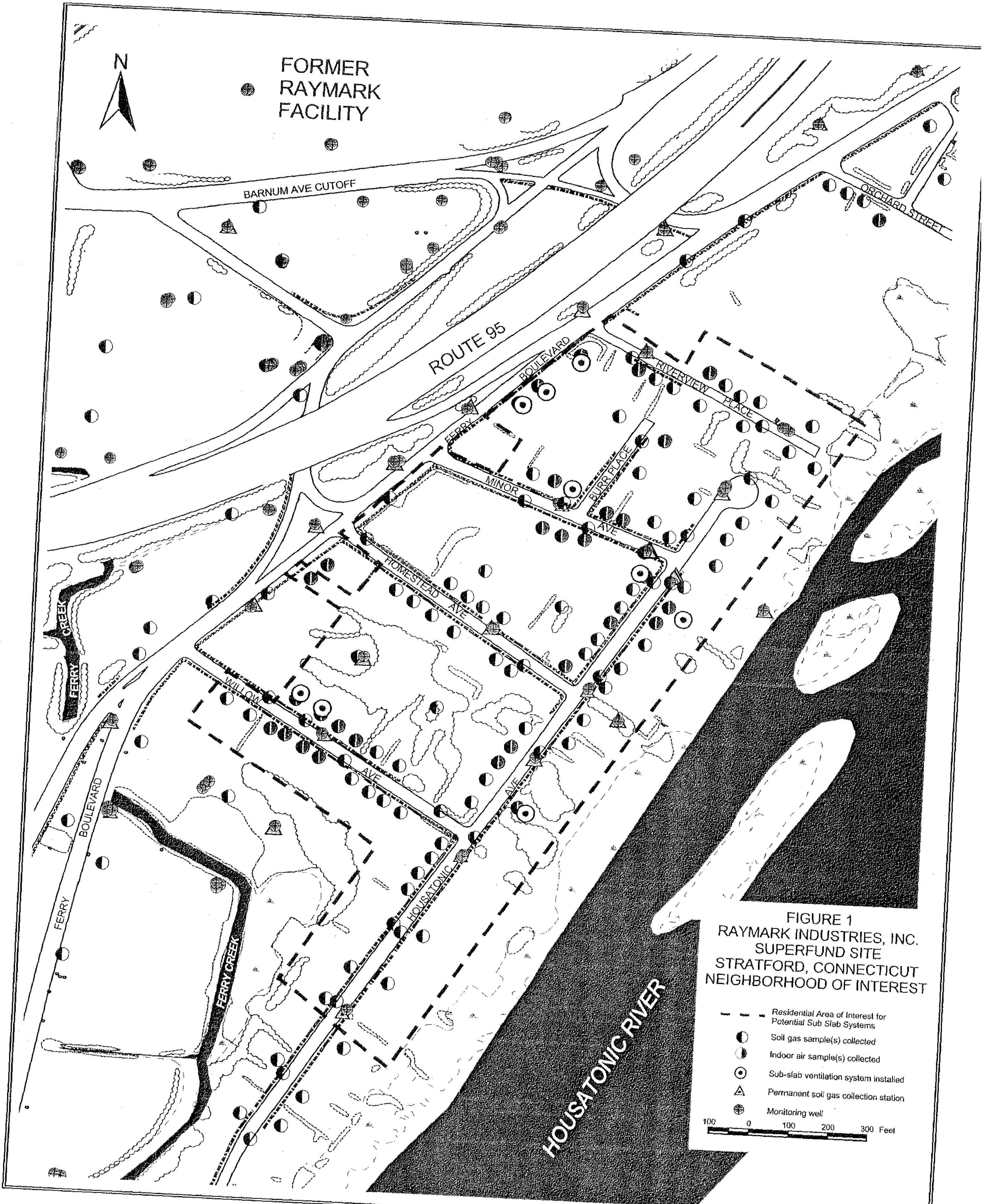

FIGURE 1
RAYMARK INDUSTRIES, INC.
SUPERFUND SITE
STRATFORD, CONNECTICUT
NEIGHBORHOOD OF INTEREST

revised August 19, 2003

ATTACHMENT B

Risk Calculations

Indoor Air Trichloroethylene Risks

Tier 1: 10 ug/m^3 (1.9 ppb)
Cancer Potency Factor Range: 0.02/mg/kg/day to 0.4/mg/kg/day

[10 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d] * 0.02/mg/kg/d = **5.7 E-5**

[10 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d] * 0.4/mg/kg/d = **1.1 E-3**

Tier 2: 1 ug/m^3 (0.19 ppb)

[1 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d] * 0.02/mg/kg/d = **5.7 E-6**

[1 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d] * 0.4/mg/kg/d = **1.1 E-4**

Maximum concentration in a residence (basement): 21 ug/m^3 (4 ppb)

[21 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d]
= 0.006 mg/kg/day * 0.02/mg/kg/d
= **1.2 E-4**

[21 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d]
= 0.006 mg/kg/day * 0.4/mg/kg/d
= **2.4 E-3**

Maximum concentration in a residence (1st floor): 11.8 ug/m^3 (2.2 ppb)
[11.8 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d]
= 0.003 mg/kg/day

Maximum concentration in any structure: 48 ug/m^3 (9 ppb)

[48 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d] * 0.02/mg/kg/d = **2.7 E-4**

[21 ug/m^3 * 20 m^3/day * 365 d/yr * 70 yr * mg/1000 ug / 70 kg * 25550 d] * 0.4/mg/kg/d = **5.4 E-3**

Indoor Air 1,1-DCE Risks

Tier 1: 100 ug/m^3 (25 ppb)
TAC: 10 ug/m^3
100 ug/m^3 / 10 ug/m^3
Hazard Quotient (Index) = 10

Tier 2: 10 ug/m^3 (2.5 ppb)
10 ug/m^3 / 10 ug/m^3
Hazard Index = 1

Maximum concentration in a residence: 27 ug/m^3 (6.7 ppb)
27 ug/m^3 / 10 ug/m^3 = 2.7

Maximum concentration in any structure: 47.5 ug/m^3 (12 ppb)
47.5 ug/m^3 / 10 ug/m^3 = 4.7

ATTACHMENT C

Background Information on Health Effects from Exposure to 1,1-DCE and TCE

Drinking small amounts of trichloroethylene for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear.

Skin contact with trichloroethylene for short periods may cause skin rashes.

How likely is trichloroethylene to cause cancer?

Some studies with mice and rats have suggested that high levels of trichloroethylene may cause liver or lung cancer. Some studies of people exposed over long periods to high levels of trichloroethylene in drinking water or in workplace air have found evidence of increased cancer. However, these results are inconclusive because the cancer could have been caused by other chemicals.

The **International Agency for Research on Cancer (IARC)** has determined that trichloroethylene is probably carcinogenic to humans.

Is there a medical test to show whether I've been exposed to trichloroethylene?

If you have recently been exposed to trichloroethylene, it can be detected in your breath, blood, or urine. The breath test, if it is performed soon after exposure, can tell if you have been exposed to even a small amount of trichloroethylene.

Exposure to larger amounts is assessed by blood and urine tests, which can detect trichloroethylene and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products, so their detection is not absolute proof of exposure to trichloroethylene. This test isn't available at most doctors' offices, but can be done at special laboratories that have the right equipment.

Has the federal government made recommendations to protect human health?

The **EPA** has set a maximum contaminant level for trichloroethylene in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water.

The **EPA** has also developed regulations for the handling and disposal of trichloroethylene.

The **Occupational Safety and Health Administration (OSHA)** has set an exposure limit of 100 parts of trichloroethylene per million parts of air (100 ppm) for an 8-hour workday, 40-hour workweek.

Glossary

Carcinogenicity: The ability of a substance to cause cancer

CAS: Chemical Abstracts Service

Evaporate: To change into a vapor or gas

Milligram (mg): One thousandth of a gram

Nonflammable: Will not burn

PPM: Parts per million

Sediment: Mud and debris that have settled to the bottom of a body of water

Solvent: A chemical that dissolves other substances

Source of Information

This ToxFAQs information is taken from the 1997 Toxicological Profile for Trichloroethylene (update) produced by the Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA.

Animal testing is sometimes necessary to find out how toxic substances might harm people and how to treat people who have been exposed. Laws today protect the welfare of research animals and scientists must follow strict guidelines.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333. Phone: 1-800-447-1544, FAX: 404-639-6359. ToxFAQs Internet address via WWW is http://atsdr1.atsdr.cdc.gov:8080/ToxFAQ.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

TRICHLOROETHYLENE

CAS # 79-01-6

Agency for Toxic Substances and Disease Registry ToxFAQs **September 1997**

This fact sheet answers the most frequently asked health questions (FAQs) about trichloroethylene. For more information, call the ATSDR Information Center at 1-800-447-1544. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Trichloroethylene is a colorless liquid which is used as a solvent for cleaning metal parts. Drinking or breathing high levels of trichloroethylene may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma, and possibly death. Trichloroethylene has been found in at least 852 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is trichloroethylene?

(Pronounced trī-klôr′ō-ĕth′ə-lēn′)

Trichloroethylene (TCE) is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers.

Trichloroethylene is not thought to occur naturally in the environment. However, it has been found in underground water sources and many surface waters as a result of the manufacture, use, and disposal of the chemical.

What happens to trichloroethylene when it enters the environment?

- Trichloroethylene dissolves a little in water, but it can remain in ground water for a long time.
- Trichloroethylene quickly evaporates from surface water, so it is commonly found as a vapor in the air.
- Trichloroethylene evaporates less easily from the soil than from surface water. It may stick to particles and remain for a long time.
- Trichloroethylene may stick to particles in water, which will cause it to eventually settle to the bottom sediment.
- Trichloroethylene does not build up significantly in plants and animals.

How might I be exposed to trichloroethylene?

- Breathing air in and around the home which has been contaminated with trichloroethylene vapors from shower water or household products such as spot removers and typewriter correction fluid
- Drinking, swimming, or showering in water that has been contaminated with trichloroethylene
- Contact with soil contaminated with trichloroethylene, such as near a hazardous waste site
- Contact with the skin or breathing contaminated air while manufacturing trichloroethylene or using it at work to wash paint or grease from skin or equipment

How can trichloroethylene affect my health?

Breathing small amounts may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating.

Breathing large amounts of trichloroethylene may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage.

Drinking large amounts of trichloroethylene may cause nausea, liver damage, unconsciousness, impaired heart function, or death.

1,1-DICHLOROETHENE

Agency for Toxic Substances and Disease Registry — September 1995

This fact sheet answers the most frequently asked health questions about 1,1-dichloroethene. For more information, you may call 404-639-6000. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

SUMMARY: Exposure to 1,1-dichloroethene occurs mainly in the workplace. Breathing high levels of 1,1-dichloroethene can affect the liver, kidney, and central nervous system. This chemical has been found in at least 515 of 1,416 National Priorities List sites identified by the Environmental Protection Agency.

What is 1,1-dichloroethene?

(Pronounced 1,1-dī′klôr′ō ĕth′ēn)

1,1-Dichloroethene is an industrial chemical that is not found naturally in the environment. It is a colorless liquid with a mild, sweet smell. It is also called vinylidene chloride.

1,1-Dichloroethene is used to make certain plastics, such as flexible films like food wrap, and in packaging materials. It is also used to make flame retardant coatings for fiber and carpet backings, and in piping, coating for steel pipes, and in adhesive applications.

What happens to 1,1-dichloroethene when it enters the environment?

- 1,1-Dichloroethene enters the environment from industries that make or use it.
- 1,1-Dichloroethene evaporates very quickly from water and soil to the air.
- In the air, it takes about 4 days for it to break down.
- 1,1-Dichloroethene breaks down very slowly in water.
- It does not accumulate very much in fish or birds.
- In soil, 1,1-dichloroethene is slowly transformed to other less harmful chemicals.

How might I be exposed to 1,1-dichloroethene?

- Workers may be exposed in industries that make or use 1,1-dichloroethene (these industries are mainly in Texas and Louisiana).
- Food that is wrapped in plastic wrap may contain very low levels of 1,1-dichloroethene. The government controls these levels to prevent harm to your health.
- A small percentage (3%) of the drinking water supplies may contain very low levels of 1,1-dichloroethene.
- Air near factories that make or use 1,1-dichloroethene and air near hazardous waste sites may contain low levels of it.

How can 1,1-dichloroethene affect my health?

The main effect from breathing **high levels** of 1,1-dichloroethene is on the central nervous system. Some people lost their breath and fainted after breathing **high levels** of the chemical.

Breathing **lower levels** of 1,1-dichloroethene in air for a long time may damage your nervous system, liver, and lungs. Workers exposed to 1,1-dichloroethene have reported a loss in liver function, but other chemicals were present.

Animals that breathed **high levels** of 1,1-dichloroethene had damaged livers, kidneys, and lungs. The offspring of some of the animals had a higher number of birth defects. We do not know if birth defects occur when people are exposed to 1,1-dichloroethene.

Animals that ingested **high levels** of 1,1-dichloroethene had damaged livers, kidneys, and lungs. There were no birth defects in animals that ingested the chemical.

Spilling 1,1-dichloroethene on your skin or in your eyes can cause irritation.

How likely is 1,1-dichloroethene to cause cancer?

The **Environmental Protection Agency (EPA)** has determined that 1,1-dichloroethene is a possible human carcinogen.

Studies on workers who breathed 1,1-dichloroethene have not shown an increase in cancer. These studies, however, are not conclusive because of the small numbers of workers and the short time studied.

Animal studies have shown mixed results. Several studies reported an increase in tumors in rats and mice, and other studies reported no such effects.

Is there a medical test to show whether I've been exposed to 1,1-dichloroethene?

Tests are available to measure levels of 1,1-dichloroethene in breath, urine, and body tissues. These tests are not usually available in your doctor's office. However, a sample taken in your doctor's office can be sent to a special laboratory if necessary.

Because 1,1-dichloroethene leaves the body fairly quickly, these methods are useful only for finding exposures that have occurred within the last few days. These tests can't tell you if adverse health effects will occur from exposure to 1,1-dichloroethene.

Has the federal government made recommendations to protect human health?

The **EPA** has set a limit in drinking water of 0.007 parts of 1,1-dichloroethene per million parts of drinking water (0.007 ppm). **EPA** requires that discharges or spills into the environment of 5,000 pounds or more of 1,1-dichloroethene be reported.

The **Occupational Safety and Health Administration (OSHA)** has set an occupational exposure limit of 1 ppm of 1,1-dichloroethene in workplace air for an 8-hour workday, 40-hour workweek.

The **National Institute for Occupational Safety and Health (NIOSH)** currently recommends that workers breathe as little 1,1-dichloroethene as possible.

Glossary

Carcinogen: A substance that can cause cancer
Ingesting: Taking food or drink into your body
PPM: Parts per million
Tumor: An abnormal mass of tissue

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1994. Toxicological profile for 1,1-dichloroethene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns. For more information, contact: Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333, Phone: 404-639-6000, FAX: 404-639-6315.

ATTACHMENT D

ATSDR INTERIM PUBLIC HEALTH HAZARD CATEGORIES

CATEGORY / DEFINITION	*DATA SUFFICIENCY*	*CRITERIA*
A. Urgent Public Health Hazard *This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.*	*This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.*	*Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.*
B. Public Health Hazard *This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.*	*This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.*	*Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.*
C. Indeterminate Public Health Hazard *This category is used for sites in which "critical" data are insufficient with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.*	*This determination represents a professional judgement that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.*	*The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.*
D. No Apparent Public Health Hazard *This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.*	*This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.*	*Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.*
E: No Public Health Hazard *This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.*	*Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future*	

*Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.