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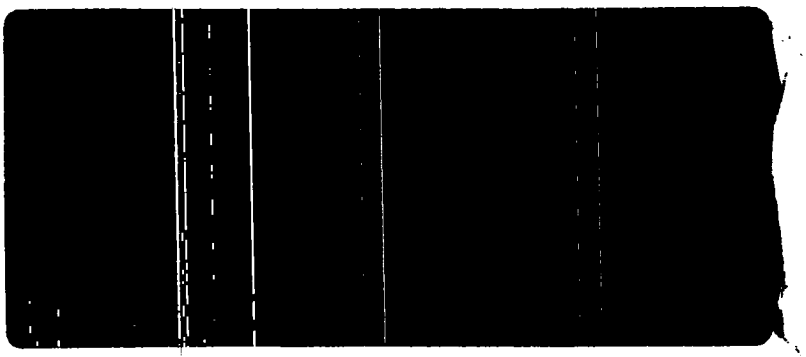

Counsel in Health and Environmental Science

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BASELINE RISK ASSESSMENT FOR THE BELL AEROSPACE TEXTRON FACILITY WHEATFIELD, NEW YORK

Prepared for

Bell Aerospace Textron
Buffalo, New York

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CONTENTS

CONTENTS (continued)

EXECUTIVE SUMMARY

The Bell Aerospace Textron (BAT) facility, located in Wheatfield, New York, has been used for the manufacture and testing of aircraft and aerospace equipment and components since it began operations (as Bell Aircraft Corporation) in 1942. In 1949, an unlined Neutralization Pond was constructed on the site to collect and neutralize waste propellants and fluids containing solvents from rocket engine test firings. Over time, the pond was also used for the disposal of solvents and other materials from other parts of the facility. The pond was closed in 1987 in accordance with a plan approved by the New York State Department of Environmental Conservation (NYSDEC).

Studies conducted in the early 1980s implicated the Neutralization Pond as the source of organic contaminants detected in ground water in the on-site overburden and the underlying bedrock aquifer. The nature and extent of this contamination were further characterized by a five-phase investigation conducted by Golder Associates ("Golder"). According to Golder, the contamination may be characterized as follows:

- A volatile organic contaminant ground water plume present in the on-site overburden, but not extending off-site;
- A dissolved-phase organic contaminant plume present in the upper water-bearing zone ("Zone 1") of the bedrock aquifer. The plume extends off-site and is 4,000-5,000 feet long, and approximately 3,500 feet wide;
- A dense non-aqueous phase liquid (DNAPL) plume located in the Zone 1 hydrostratigraphic unit, which extends east from the Neutralization Pond to Walmore Road, and may go partway beneath Walmore Road; and
- A dissolved-phase organic plume located in the deeper (Zone 3) bedrock aquifer, which appears to be limited to the on-site area beneath the Zone 1 DNAPL plume.

Low levels of 1,2-dichloroethylene have also been detected in water from nearby Bergholtz Creek, which may receive some overburden ground water via sanitary sewer trench discharge (or, less likely, discharge from the Zone 1 bedrock aquifer). In addition,

organic contaminants including PCBs have been detected in on-site soils in the vicinity of the Neutralization Pond.

ENVIRON was retained to perform a baseline (no action) risk assessment of potential current and future exposures to on-site soils by workers at the facility, and to overburden and Zone 1 ground water by area residents. ENVIRON also examined possible impacts on the Niagara River resulting from potential future discharges of contaminated Zone 1 ground water. Although the BAT facility is not a Superfund site, ENVIRON was asked to follow standard procedures for risk assessments under CERCLA (USEPA 1989b).

ENVIRON's risk assessment includes the following potentially affected populations (receptors) and exposure scenarios and routes (comments in parentheses indicate whether these scenarios may currently exist, or may occur in the future):

- On-Site Worker: exposure to soil under ambient conditions (current and future)
  - Incidental soil ingestion
  - Dermal contact
  - Inhalation of vapor and particulates

- On-Site Worker: exposure to soil under conditions of soil disturbance, such as excavation or construction activities (future)
  - Incidental soil ingestion
  - Dermal contact
  - Inhalation of vapor of particulates

- Recreational Users of Bergholtz Creek: Adults, teenagers, older children (current and future)
  - Incidental water ingestion
  - Sediment ingestion
  - Dermal contact with water
  - Dermal contact with sediment
  - Vapor inhalation

- Use of Bergholtz Creek by Dairy Cows (current and future)
  - Human ingestion of cow's milk

- Residential Users of Zone 1 Irrigation Well Water (future)
  - Watering gardens:
    - Incidental water ingestion
    - Dermal contact with water
    - Vapor inhalation
    - Vegetable ingestion
  - Washing cars, use of wading pools:
    - Incidental water ingestion
    - Dermal contact
    - Vapor inhalation

- Impact on Niagara River (future)
  - Comparison of modeled water concentrations with ARARs (Applicable or Relevant and Appropriate Requirements)

A quantitative risk assessment was not performed for potential users of Niagara River water, based upon the projected future *de minimis* impact of ground water discharge on the river water quality. Furthermore, Golder has calculated that it will be over 300 years before the plume reaches the Niagara River if no remediation is implemented. Similarly, the use of Zone 1 ground water wells for domestic purposes (e.g., drinking) also was not considered, based upon the presence of an adequate public surface water supply in the area, the "skunky" odor and poor quality of Zone 1 ground water in the Niagara Falls area, and the results of a home well survey conducted by Golder.

The results of ENVIRON's risk assessment are shown in Tables IV-1 and IV-2, and are summarized in Tables ES-1 and ES-2, below.

Table ES-1 Summary of Carcinogenic Risks					
Exposure Scenario	**Adult Male**	**Adult Female**	**15 year old**	**9 year old**	**4 year old**
Occupational: Construction	1.8×10^{-6}	NA	NA	NA	NA
Occupational: Ambient	1.3×10^{-5}	NA	NA	NA	NA
Bergholtz Creek	1.8×10^{-10}	1.8×10^{-10}	1.6×10^{-10}	2.0×10^{-10}	3.7×10^{-15}
Irrigation Wells	6.7×10^{-6}	7.2×10^{-6}	6.1×10^{-6}	1.7×10^{-5}	1.8×10^{-5}

Table ES-2 Summary of Non-Carcinogenic Hazard Indices					
Exposure Scenario	**Adult Male**	**Adult Female**	**15 year old**	**9 year old**	**4 year old**
Occupational: Construction	1.5×10^{-1}	NA	NA	NA	NA
Occupational: Ambient	1.5×10^{-2}	NA	NA	NA	NA
Bergholtz Creek	2.6×10^{-5}	3.0×10^{-5}	3.4×10^{-5}	5.0×10^{-5}	1.5×10^{-10}
Irrigation Wells	1.8×10^{-1}	2.1×10^{-1}	2.4×10^{-1}	7.7×10^{-1}	1.1

Carcinogenic risk estimates for current exposure scenarios (on-site occupational exposure to ambient conditions and off-site exposure to Bergholtz Creek, including indirect exposure via ingestion of cow's milk) were greatest for the on-site worker. The cancer risk for the on-site worker (ambient) was estimated to be 1.3×10^{-5} (or 1.3 cancer cases per 100,000 people exposed over a lifetime) for all exposure pathways combined. Carcinogenic risks for off-site populations exposed to Bergholtz Creek represent *de minimis* risk with the highest risk, for a 9 year old child, of 2.00×10^{-10} (or 2 cancer cases per 10 billion people exposed). All the carcinogenic risk estimates were within the range identified by USEPA as "acceptable" (10^{-6} to 10^{-4}). Non-carcinogenic hazard indices for all current exposure scenarios were below 1, suggesting no risk of adverse non-carcinogenic health effects.

Carcinogenic risks for future exposure scenarios (on-site hypothetical construction activities, irrigation wells, and indirect exposure via ingestion of vegetables) were greatest for off-site populations. The highest total carcinogenic risks were for the 9 year old and 4

year old child, 1.7×10^{-5} and 1.8×10^{-5} respectively (or approximately 2 cancer cases per 100,000 people exposed over a lifetime). These risks for small children are primarily due to skin contact in wading pools. Ingestion of vegetables represents the largest contributor to risk for adults and the 15 year old teenager. All these risks are within the USEPA range for "acceptable" risk at CERCLA and RCRA waste sites.

Non-carcinogenic hazard indices for the construction worker and all off-site receptors except the 4 year old child were below 1 for all exposure scenarios. The hazard index for the 4 year old (1.1) suggests the possibility of adverse non-carcinogenic effects associated with potential future exposure to ground water from an irrigation well.

The results of ENVIRON's investigation of potential future impacts on the Niagara River are shown in Table IV-3 and summarized in Table ES-3, below. Predicted Zone 1 chemical concentrations in the Niagara River are orders of magnitude lower than federal and New York State drinking water standards, and federal ambient water quality criteria (AWQC). To illustrate this, Table ES-3 summarizes results for the four chemicals with the predicted highest ratios of Niagara River water concentration to AWQC. As this demonstrates, predicted chemical concentrations in the river are 10,000 to 100 million times lower than their respective AWQC for protection of human health; for trichloroethylene and aroclor 1254, ratios are even lower when compared to AWQC for protection of aquatic organisms.

TABLE ES-3
Comparison of Selected Chemical Concentrations in Niagara River with Ambient Water Quality Criteria

Chemical	Concentration in River (mg/l)	Chronic AWQC[a] for Protection of Aquatic Life (mg/l)	AWQC[a] for Human Exposure (mg/l)
1,2-Dichloroethane (total)	2.35×10^{-9}		3.3×10^{-5}
Trichloroethylene	2.15×10^{-7}	21.9	2.7×10^{-3}
Vinyl Chloride	8.21×10^{-11}		2×10^{-3}
Aroclor 1254	7.52×10^{-12}	1.4×10^{-5}	7.9×10^{-8}

[a] AWQC - Ambient Water Quality Criteria

I. INTRODUCTION

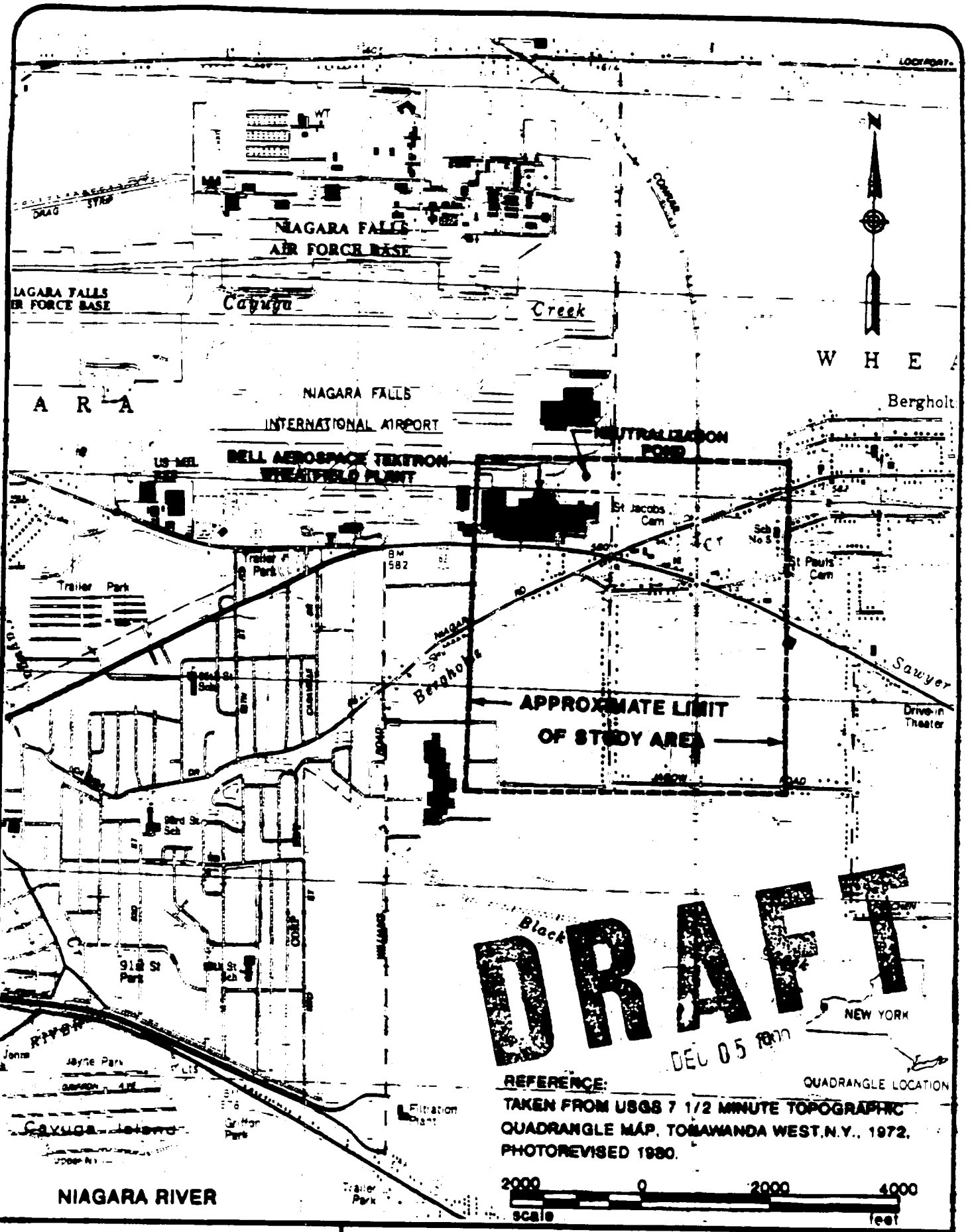
A. Site Location and History

The Bell Aerospace Textron (BAT) facility is located in Wheatfield, New York. It is bounded by the Niagara Falls International Airport to the northwest and west, Niagara Falls Boulevard to the south, Walmore Road to the east, and the Carborundum Abrasives Company facility to the north (see Figure 1). Bergholtz Creek, a tributary to the Niagara River, is located south of the BAT facility.

Bell Aircraft Corporation began operations at the Wheatfield facility in 1942. Textron purchased the military defense business from Bell Aircraft Corporation in 1960 and established the Bell Aerospace Division of Textron (BAT). The facility has been used for manufacture of aircraft and aerospace related equipment, including electronic systems, helicopter components, rocket propulsion hardware and electrical test equipment (Golder Associates 1991).

In 1949 an unlined Neutralization Pond, approximately 100 feet by 60 feet in area, and approximately 9-12 feet deep, was constructed on the site to collect and neutralize waste propellants and associated fluids from rocket engine test firings in the Rocket Test Building. The propellants and fluids consisted mostly of hydrazines and organic chemicals. Based upon records and information provided by BAT employees, the Neutralization Pond was also used for disposal of solvents and fluids from other parts of the facility during the 1950s and 1960s. The use of the pond decreased during the 1970s and 1980s. The last use of the pond was in June 1984; it was closed in 1987 in accordance with a closure plan approved by NYSDEC (Golder Associates 1991).

Overburden studies and limited bedrock studies conducted by Goldberg-Zoino and Associates (GZA) in the early 1980s indicated that organic compounds had been released from the pond to the ground water in the overburden soil and underlying bedrock aquifer. Following these investigations, Golder undertook a five-phase investigation of



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SITE LOCATION MAP
BELL AEROSPACE TEXTRON
(Done By Golder Associates, 1990 a)

Figure
1

hydrogeologic conditions to determine the extent of the ground water contamination. In addition, sampling of on-site soil, water and sediment in Bergholtz Creek, and a door-to-door survey of public and private wells in the area were conducted.

Golder's investigations indicate the presence of: (1) a volatile organic contaminant plume present in the on-site soil overburden but not extending beneath Walmore Road; (2) a dissolved organic contaminant plume located in the upper water-bearing zone of the bedrock Lockport Dolomite aquifer (referred to as the Zone 1 bedrock aquifer by Golder) extending beyond the southern and eastern BAT boundaries (approximately 4,000-5,000 feet in length, and 3,500 feet wide), and passing beneath Bergholtz Creek; and (3) a dense non-aqueous phase liquid (DNAPL) plume in Zone 1 extending approximately 750 feet southeast from the Neutralization Pond, and east to Walmore Road; the DNAPL plume may extend partway beneath Walmore Road. Dissolved-phase organic contaminants were also identified in the deeper bedrock aquifer (Zone 3), but appear to be limited to the area around the pond beneath the Zone 1 DNAPL plume.

Sampling conducted by Golder of Bergholtz Creek water revealed very low levels of 1,2-dichloroethylene at two sampling points, which suggests that water from the overburden via the sanitary sewer trenches (or, less likely, from the Zone 1 bedrock aquifer) is entering the Creek. Golder considered most of the identified sediment contaminants to be unrelated to the BAT facility.

B. Purpose of ENVIRON's Investigation

ENVIRON was retained by BAT to conduct a baseline (no action) risk assessment of the soil and ground water contamination at the BAT facility under both current and possible future conditions of exposure, including potential exposure to on-site workers and off-site populations. The evaluation of on-site soils was limited in scope to those Solid Waste Management Units (SWMUs) surrounding or near the former Neutralization Pond; other SWMUs, which will be remediated, have not been included in ENVIRON's risk assessment. Although the BAT facility is not a Superfund site, ENVIRON was asked to follow standard procedures for risk assessment under CERCLA, as presented in guidance documents from the USEPA (1989b).

C. Risk Assessment Methodology

Risk assessment is the characterization of potential adverse health effects due to human exposure to environmental hazards. The National Academy of Sciences (NAS) has identified four steps essential for a complete risk assessment:

1) Hazard identification - the collection, organization, and evaluation of toxicity data available for the compounds of interest. The primary question addressed in this phase of the risk assessment is, "Is this chemical toxic to humans or the environment?" The quantity and quality of data available vary for each compound; in particular, uncertainty is introduced into the analyses for those compounds that have not been the subject of many toxicological or epidemiological studies.

2) Dose-response assessment - the quantification of the relationship between dose received and the extent of injury or disease. Data are frequently derived from animal studies, but when available, human data are utilized.

3) Exposure assessment - the identification of potentially affected populations (receptors), evaluation of potential routes of exposure, and estimation of the dose received. Exposures can include inhalation, ingestion, and dermal contact, and may involve various environmental media, e.g., water, vapor, dusts or sediments, and food products. Populations at risk can include on-site workers, nearby residents or workers, or larger groups (city-wide, state-wide) who may be potentially exposed.

4) Risk characterization - incorporation of the data obtained in the previous three steps into the quantitative evaluation of the probability of adverse health effects to the populations at risk under the specified conditions of exposure.

Uncertainty is introduced into a risk assessment at several stages in the process. The toxicological evaluation must consider the following sources of uncertainty: extrapolation from animal data to humans, relevance of experimental routes of exposure to conditions of human exposure, extrapolation from high doses used in animal experiments to low doses

experienced by humans, and use of threshold versus no-threshold models. Many uncertainties revolve around conditions of exposure--for example, the use of models to predict chemical concentrations in environmental media when actual measured data are unavailable, and the lack of knowledge as to frequency and magnitude of exposure. Assumptions are generally made as "reasonable maximum estimates" and, where little information is available, assumptions are intended to be conservative and protective of human health.

II. DATA EVALUATION AND HAZARD IDENTIFICATION

A. Ground Water

The ground water contamination was evaluated in both the overburden and the bedrock of Zone 1 and Zone 3. The overburden consists of 15.5 to 17.5 feet of consolidated material (surficial fill, lacustrine clay, lacustrine till and basal till) near the Neutralization Pond. The bedrock surface begins at 15.5 to 17.5 feet below the overburden. ENVIRON's analysis incorporated all ground water monitoring data obtained by Golder (1991). Golder (1991) also provided data on concentrations in on-site soil, and in Bergholtz Creek water and sediments.

1. Overburden

a) Identification of Chemicals of Concern

Analysis of Golder's sampling data revealed a total of 46 compounds that were detected in the overburden ground water. The compounds detected rarely (only once or twice) were eliminated from the evaluation, resulting in a list of 17 compounds, 6 of which were detected in both 1990 and pre-1990 sampling. Of these 17 compounds, 8 were not detected by the most recent Golder sampling, which employed contract laboratory procedures; thus, these compounds were eliminated. Thus, a total of nine compounds from the overburden ground water were evaluated in the risk assessment. All compounds included in the final assessment are listed in Table II-1.

TABLE II-1 Overburden Chemicals of Concern and Concentrations in Bergholtz Creek	
Compounds	**Concentration mg/l**
Acetone	5.67×10^{-8}
Benzene	9.45×10^{-12}
Chloroform	5.18×10^{-6}
1,2 - Dichloroethylene	1.75×10^{-4}
Methylene Chloride	2.52×10^{-4}
Toluene	4.76×10^{-12}
1,1,1 - Trichloroethane	2.00×10^{-7}
Trichloroethylene	4.91×10^{-5}
Vinyl Chloride	6.17×10^{-8}

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b) **Calculation of Concentrations in Bergholtz Creek**

A 36-inch municipal sanitary sewer line runs along Walmore Road. The Walmore Road sewer was constructed of concrete pipe in an overburden trench dug into or very near the bedrock surface. The trench was backfilled with coarse, granular material (Golder 1991). A surface drainage ditch, which also runs along Walmore Road, has been observed to discharge water into the backfill of the sanitary sewer trench. Investigations by Golder have raised the possibility that some overburden ground water may discharge into Bergholtz Creek via the sewer trench. For the purposes of this risk assessment, Golder provided estimates of mass loadings of the overburden chemicals of concern from the overburden to the Walmore Road sewer trench. It was conservatively assumed that 100% of the sewer trench outflow discharges into Bergholtz Creek. The mass loadings (mg/day) from the overburden to the sewer trench were divided by the combined flow rate of the creek and sewer trench (l/day) to determine the chemical concentrations in the creek water, in mg/l (shown in Table II-1; see Appendix A for sample calculations). Although nine compounds were evaluated, sampling of creek water by Golder revealed that only 1,2-dichloroethylene was present above detection limits; six other compounds were identified below the quantitation limits (Golder 1991). Thus, ENVIRON's analysis is conservative in that it includes chemicals not detected in Bergholtz Creek during Golder's sampling program.

2. **Zone 1 Aquifer**

a) **Identification of Chemicals of Concern**

Analysis of Golder's sampling data revealed a total of 29 compounds that were detected in the dissolved-phase Zone 1 ground water plume. The compounds detected rarely (once or twice) were eliminated from the evaluation. The remaining 20 compounds were included in the assessment. Seven compounds were detected in both the pre-1990 and 1990 sampling series. All Zone 1 chemicals that are of concern and were evaluated in this assessment are included in Table II-2.

TABLE II-2 Zone 1 Aquifer Chemicals of Concern and Concentrations	
Compounds	Concentration mg/l
Acetone	2.33×10^{-2}
Benzene	9.70×10^{-3}
Carbon disulfide	2.74×10^{-2}
Chloroethane	2.22×10^{-2}
Chloroform = Trichloromethane	1.24×10^{-2}
Dichloroethane (1,1-)	8.70×10^{-3}
Dichloroethane (1,2-) = Ethylene dichloride	1.01×10^{-3}
Dichloroethylene(1,1-) = Vinylidene chloride	1.60×10^{-2}
Dichloroethylene (trans - 1,2)	2.27×10^{-1}
Lindane = Hexachlorocylohexane, gamma	4.00×10^{-5}
Methyl ethyl ketone (MEK) = 2 - butanone	5.35×10^{-2}
Methylene chloride = Dichloromethane	5.59×10^{-2}
Polychlorinated biphenyls (PCBs)	1.01×10^{-3}
Tetrachloroethane (1,1,2,2)	1.03×10^{-2}
Tetrachloroethylene = Perchloroethylene	5.50×10^{-3}
Toluene = Toluol	1.29×10^{-2}
Trichloroethane (1,1,1-) = Methyl chloroform	2.00×10^{-2}
Trichloroethylene	1.17×10^{-1}
Trichlorofluoromethane	1.58×10^{-2}
Vinyl chloride	3.74×10^{-2}

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b) **Calculation of Concentrations in Irrigation Wells**

Chemical concentrations in Zone 1 ground water were calculated from concentrations detected in monitoring wells within the Zone 1 plume (as defined by Golder) and were conservatively calculated to include measured sample concentrations and assigned values for non-detected samples. For compounds of interest that were not detected in more than 90% of the samples, the geometric mean of data from all Zone 1 wells within the plume was used. The data used to calculate the geometric mean included measured sample concentrations and one-half of the detection limit for samples not detected. Geometric means were used to calculate average water concentrations because arithmetic means were considered to be a poor reflection of the data distribution. For chemicals detected in more than 90% of the samples, concentrations were calculated as the upper 95th percent confidence interval on the geometric mean (with non-detects included at one-half the detection limit). This is a conservative estimate because the standard deviation was very large relative to the mean.

c) **Calculation of Concentrations in the Niagara River**

Golder provided estimates of organic mass loadings of approximately 0.6 lb/day (total) to the Niagara River via potential future discharge of the Zone 1 ground water plume. Golder has calculated that discharge to the river will not occur for over 300 years. ENVIRON divided individual chemical loadings by the average Niagara River flow rate (Gradient/GeoTrans 1988) to obtain estimates of future organic concentrations in the Niagara River resulting from the Zone 1 plume discharge.

B. Bergholtz Creek Sediment

Several compounds were detected in the Bergholtz Creek sediments analyses: acetone, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, indeno(1,2,3-cd)pyrene and pyrene. Golder believes that acetone is a laboratory contaminant and is not site-related, as it was not detected in ground water other than in the immediate vicinity of the Neutralization Pond. Although

acetone was evaluated in ENVIRON's assessment of sediments from Bergholtz Creek, it proved to be a minor contributor to the overall hazard index for exposure to Bergholtz Creek.

According to Golder (1991), "the semivolatile organic constituents detected in stream sediments are not related to the site groundwater chemistry. These compounds are related to coaltar, and asphaltic compounds and are probably derived from the nearby roadways." Furthermore, these compounds were not detected in either overburden ground water or Zone 1 ground water. These compounds were not evaluated in ENVIRON's assessment of risks from Bergholtz Creek sediments.

C. Chemicals of Concern in Soil in Area Around Neutralization Pond

All compounds identified in the soil samples in or near the Neutralization Pond were included in the assessment of the potential risk to workers on-site. Sampling procedures and locations have previously been discussed (Frontier Technical Associates 1990; Golder Associates 1988 and 1990a; ENSECO 1990a and b).

Many of the compounds were detected only once or twice; these chemicals were eliminated from the risk analysis. The arithmetic mean of the measured concentrations and the detection limit concentrations for chemicals that were reported as non-detects was used as a conservative estimate of the soil concentration in the region of the Neutralization Pond. Because of the wide range of concentrations, the arithmetic mean, rather than the geometric mean, was deemed a more conservative estimation of the average soil concentration. A compilation of all compounds detected in soil samples and their respective concentrations used in this risk assessment is presented in Table II-3.

D. Toxicity Assessment of Chemicals of Concern

For each of the compounds identified for inclusion in a risk assessment, toxicity assessments were conducted to evaluate the potential human health effects from exposure to these compounds. Data were gathered on the nature of the toxicity and the dose-response relationship. Although human epidemiological data are preferable, animal data were frequently the only information available for many of these compounds. The

TABLE II-3
Chemicals of Concern and Average Concentrations for Soil Samples

Compound	Soil Concentrations	
	Surface (mg/kg)	All Depths (mg/kg)
Acetone	.144	1.21
Aldrin	.0473	.0321
Anthracene	0.00	.690
Benzo(a)anthracene	1.36	1.04
Benzo(a)pyrene	1.31	.937
Benzo(b)fluoranthene	1.38	1.03
Benzo(ghi)perylene	1.14	.703
Benzo(k)fluoranthene	1.32	.933
Carbon disulfide	0.00	.560
Chrysene	1.38	1.04
Di-n-octyl phthalate	1.39	.792
Dichloroethane (1,1-)	.891	.827
Dichloroethane (1,2-) = Ethylene dichloride	.102	.102
Dichloroethylene (1,1-) = Vinylidene chloride	.0691	.514
Dichloroethylene (trans-1,2-)	1.66	1.27
Ethylbenzene	0.00	.560
Fluoranthene	1.71	1.57
Fluorene	0.00	.682
Hexachlorocyclohexane, beta isomer (beta-HCH)	.0532	.0346
Indeno(1,2,3)perylene	1.15	.728
Methyl ethyl ketone (MEK) = 2-butanone	.117	1.03
Methylene chloride = Dichloromethane	.0673	.647
Phenanthrene	1.31	1.11
Polychlorinated biphenyls (PCBs)	2.14	1.39
Pyrene	1.59	1.38

TABLE II-3 (continued) Chemicals of Concern and Average Concentrations for Soil Samples		
Compound	Soil Concentrations	
	Surface (mg/kg)	All Depths (mg/kg)
Toluene = Toluol	.106	.107
Trichloroethane (1,1,1-) = Methyl chloroform	.394	2.92
Trichloroethane (1,1,2-)	.0561	.464
Trichloroethylene	.0748	.997
Vinyl chloride	.163	.950

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epidemiological or experimental data, in conjunction with safety factors to account for uncertainties in the derivation and use of the data, were used to derive estimates of safe levels of exposure for the non-carcinogenic effects of these compounds. For carcinogens, estimates of carcinogenic risk were determined using a model that assumes some carcinogenic effect exists at any dose (other than zero).

1. Population-Based Toxicity Factors

Non-carcinogenic risks for long-term exposures are characterized by the chronic RfD (Reference Dose), which represents an estimate of daily exposures for the whole population, including sensitive subpopulations, that will not be expected to result in an increased risk of adverse health effects. Chronic RfDs were used as benchmark values for this assessment because all exposure durations were assumed to be long-term for the off-site populations. Table II-4 presents the RfDs used in this assessment. USEPA-published and verified RfDs were used when available; others were developed by ENVIRON from toxicological literature, using the methodology outlined in *Risk Assessment Guidance for Superfund* ("RAGS") (USEPA 1989b).

Carcinogenic risk is characterized by a Cancer Potency Factor (CPF) or slope factor, which represents the level of increased lifetime cancer risk resulting from exposure to 1 mg/kg/day. The CPF is based on a non-threshold model, which assumes that any exposure to a carcinogen, however small, may elicit a carcinogenic response. CPFs are developed for the three highest classes of carcinogens established by IARC (1982):

A - Definite human carcinogen;
B1 - Probable human carcinogen, limited human data available;
B2 - Probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans.

ENVIRON used USEPA-published CPFs for the risk assessment. CPFs have not been published for the various polynuclear aromatic hydrocarbons (PAHs), but they are

TABLE II-4
Population-Based Toxicity Factors:
Reference Doses and Cancer Potency Factors

Compound	RfD (mg/kg/day)	Source	CPF $(mg/kg\text{-}day)^{-1}$	Source
Acetone	$1.00x10^{-1}$	USEPA 1990b	NA	
Aldrin	$3.00x10^{-5}$	USEPA 1990b	17.0	HEAST 3rd 1990b
Anthracene	$3.00x10^{-1}$	IRIS (09/01/90)	NA	
Benzo(a)anthracene	NA		1.67	USEPA 1989a/ CLEMENT 1988
Benzo(a)anthracene (inhalation)	NA		$8.84x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Benzo(a)pyrene	NA		11.5	HEA aci USEPA 1986a
Benzo(a)pyrene (inhalation)	NA		6.10	HEA aci USEPA 1986a
Benzene	$7.00x10^{-4}$	USEPA 1984b-DRAFT	$2.90x10^{-2}$	USEPA 1990b
Benzo(b)fluoranthene	NA		1.61	USEPA 1989a/ CLEMENT 1988
Benzo(b)fluoranthrene (inhalation)	NA		$8.54x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Benzo(ghi)perylene	NA		$2.53x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Benzo(ghi)perylene	NA		$1.34x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Benzo(k)fluoranthene	NA		$7.59x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Benzo(k)fluoranthene (inhalation)	NA		$4.03x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Carbon disulfide	$1.00x10^{-1}$	USEPA 1990b	NA	
Carbon disulfide (inhalation)	$2.86x10^{-3}$	USEPA 1990b	NA	
Chloroethane	$4.30x10^{-1}$	ENVIRON 1989	NA	
Chloroform = Trichloromethane	$1.00x10^{-2}$	USEPA 1990b	$6.10x10^{-3}$	USEPA 1990b
Chloroform = Trichloromethane (inhalation)	$1.00x10^{-2}$	USEPA 1990b	$8.10x10^{-2}$	USEPA 1990b
Chrysene	NA		$5.06x10^{-2}$	USEPA 1989a/ CLEMENT 1988
Chrysene (inhalation)	NA		$2.68x10^{-2}$	USEPA 1989a/ CLEMENT 1988
Di-n-octyl phthalate	$2.00x10^{-2}$	USEPA 1990b	NA	
Dichloroethane (1,1-)	$1.00x10^{-1}$	USEPA 1990b	NA	
Dichloroethane (1,2-) = Ethylene dichloride	$1.20x10^{-1}$	USEPA 1989c	$9.10x10^{-2}$	USEPA 1990b

TABLE II-4 (continued)
Population-Based Toxicity Factors:
Reference Doses and Cancer Potency Factors

Compound	RfD (mg/kg/day)	Source	CPF $(mg/kg\text{-}day)^{-1}$	Source
Dichloroethylene (1,1-) = Vinylidene chloride	$9.00x10^{-3}$	USEPA 1990b	$6.00x10^{-1}$	USEPA 1990b
Dichloroethylene (1,1-) = Vinylidene chloride (inh.)	$9.00x10^{-3}$	USEPA 1990b	1.20	USEPA 1990b
Dichlorethylene (trans-1,2-)	$2.00x10^{-2}$	USEPA 1990b	NA	
Ethylbenzene	$1.00x10^{-1}$	USEPA 1990b	NA	
Fluoranthene	$4.00x10^{-2}$	USEPA 1990b	NA	
Fluorene	$4.00x10^{-2}$	IRIS 1990	NA	
Hexachlorocyclohexane, beta (beta BHC)	$3.00x10^{-4}$	USEPA 1988	1.30	USEPA 1990b
Indeno(1,2,3)perylene	NA		2.67	USEPA 1989a/ CLEMENT 1988
Indeno(1,2,3)perylene (inhalation)	NA		1.42	USEPA 1989a/ CLEMENT 1988
Lindane = Hexachlorocyclohexane, gamma	$3.00x10^{-4}$	USEPA 1990b	1.30	USEPA 1990b
Methyl ethyl ketone (MEK) = 2-butanone	$5.00x10^{-2}$	USEPA 1990b	NA	
Methyl ethyl ketone (MEK) = 2-butanone (inhalation)	$9.00x10^{-2}$	USEPA 1990b	NA	
Methylene chloride = Dichloromethane	$6.00x10^{-2}$	USEPA 1990b	$7.50x10^{-3}$	USEPA 1990b
Methylene chloride = Dichloromethane (inhalation)	$8.67x10^{-1}$	USEPA 1990b	$1.40x10^{-3}$	USEPA 1990b
Phenanthrene	$7.00x10^{-3}$	USEPA 1989a	NA	
Polychlorinated biphenyls (PCBs)	NA		7.70	USEPA 1990b
Pyrene	$3.00x10^{-2}$	USEPA 1990b	$9.31x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Pyrene (inhalation)	$3.00x10^{-2}$	USEPA 1990b	$4.94x10^{-1}$	USEPA 1989a/ CLEMENT 1988
Tetrachloroethane (1,1,2,2-)	$2.50x10^{-3}$	USEPA 1989c	$2.00x10^{-1}$	USEPA 1990b
Tetrachloroethylene = Perchloroethylene	$1.00x10^{-2}$	USEPA 1990b	$5.10x10^{-2}$	USEPA 1990b
Tetrachloroethylene = Perchloroethylene (inhalation)	$1.00x10^{-2}$	USEPA 1990b	$3.30x10^{-3}$	USEPA 1990b
Toluene = Toluol	$3.00x10^{-1}$	USEPA 1990b	NA	
Toluene = Toluol (inhalation)	$5.71x10^{-1}$	USEPA 1990b	NA	
Trichloroethane (1,1,1-) = Methyl chloroform	$9.00x10^{-1}$	USEPA 1990b	NA	
Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	$3.00x10^{-1}$	USEPA 1990b	NA	
Trichloroethylene	NA		$1.10x10^{-2}$	USEPA 1990b

TABLE II-4 (continued)
Population-Based Toxicity Factors:
Reference Doses and Cancer Potency Factors

Compound	RfD (mg/kg/day)	Source	CPF $(mg/kg\text{-}day)^{-1}$	Source
Trichloroethylene (inhalation)	NA		1.70×10^{-2}	USEPA 1990b
Trichlorofluoromethane	7.00×10^{-1}	USEPA 1990b	NA	
Trichlorofluoromethane (inhalation)	2.00	USEPA 1990b	NA	
Vinyl chloride	1.30×10^{-3}	ENVIRON 1989	2.30	USEPA 1990b
Vinyl chloride (inhalation)	NA		2.95×10^{-1}	USEPA 1990b

NA: Not Applicable

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considered to be Class B2 carcinogens. ENVIRON used the CPF value of benzo(a)pyrene (USEPA 1986a) and the relative potency estimates (which indicate the potency of the other carcinogenic PAHs relative to benzo(a)pyrene) developed by Clement Associates (1988) to calculate CPFs for the other PAHs. All CPFs used in this assessment are presented in Table II-4.

2. Occupationally-Based Toxicity Factors

Threshold Limit Values (TLVs) have been developed by the American Conference of Governmental Industrial Hygienists (ACGIH) as guidelines to assist in the control of health hazards in the workplace. TLVs are the airborne concentrations to which most workers can be exposed daily (8 hours per day) without adverse effect. These occupationally-based toxicity factors are based on industrial experience, experimental human and animal studies, or a combination of all three. TLVs which have been developed for compounds assessed at the BAT facility are presented in Table II-5.

Occupational exposures were evaluated and compared to both TLVs and the population-based toxicity factors because of the absence of data for some compounds.

TABLE II-5
Occupationally-Based Toxicity Factors

Compound	TLV[a] mg/m^3
Acetone	1780
Aldrin	0.25
Carbon disulfide	31
1,1-Dichloroethane	810
1,2-Dichloroethane	40
1,1-Dichloroethylene	20
1,2-Dichloroethylene(trans)	793
Ethylbenzene	434
Methyl ethyl ketone	590
Methylene chloride	174
Polychlorinated biphenyls (PCBs)	0.5
Toluene	377
1,1,1-Trichloroethane	1910
1,1,2-Trichloroethane	55
Trichloroethylene	269
Vinyl Chloride	13

[a] American Conference of Governmental Industrial Hygienists (ACGIH). 1990. Threshold Limit Values and Biological Indices for 1990-1991. Cincinnati, OH.

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III. EXPOSURE ASSESSMENT

A. On-site Workers

Exposures involving on-site workers were assessed for two potential exposure scenarios. Under current ambient conditions, workers at the facility could be exposed through normal, everyday occupational activities. In addition, it is possible that construction or maintenance of underground utilities may take place on the site in the future. Both of these scenarios (ambient and construction conditions) create unique exposure conditions, which are discussed below.

1. Construction Activities

Construction activities on the site could involve the excavation of soils and resulting entrainment of dusts and particulates. These activities may result in the following exposure pathways: incidental ingestion of soil, dermal contact with the soil, inhalation of volatiles, and inhalation of particulates. Only on-site workers were assessed for this scenario because they would be receiving the maximum dose and thereby the maximum risk. Off-site populations may incur some risk during construction due to inhalation of dispersed volatiles and/or particulates, but exposures would be significantly lower compared to on-site workers. Because the disturbance of soil could result in exposure to chemicals present at depth, averaged soil concentrations from all sampling depths were used to determine dose to on-site workers.

Although total construction activities can take up to a year or more, it was assumed that the portion of construction involving actual disturbance of soil (e.g., excavation) would occur over a 3-month period, 5 days a week, for a total 60-day exposure period. Incidental soil ingestion was assumed to be 100 mg/day (USEPA 1989c). This is a conservative assumption reflective of dusty conditions at a construction site. The area of dermal contact was assumed to be limited to hands, lower arms, and face. It was

considered reasonable that a construction worker would have heavy boots, long pants, short-sleeved shirt and hard hat as minimum attire. Heavy skin exposures to soil, 1.0×10^{-6} kg/cm^2 (Lepow 1975), were assumed for this scenario. For the inhalation route the assumed contact time was 10 hours per day. These longer work hours seemed reasonable in light of the short construction season.

The emission rate of total suspended particulates (TSP) from the site due to possible future construction was estimated according to the 1985 USEPA compilation of air pollution emission factors (USEPA 1985b). The TSP emission rate during construction activities was found to be 103 mg/m^2-sec. This estimate would overestimate dust emissions for inhalation exposure since only particulates less than 10 microns are considered respirable. Moreover, dust emissions can be significantly reduced by maintaining high moisture content in the soil (USEPA 1989c).

A modified "box" model (Li et al. 1990) was employed to estimate on-site air concentrations for the workers. In this application, dust emissions from the site were assumed to be uniformly distributed across the surface of the area. Atmospheric turbulence would then provide the primary mechanism by which these emissions would be transported into the atmosphere. The base of the box model was defined by the plume trajectory of a release from the upwind edge of the studied area (see Appendix B for the fundamentals of the box model).

For the purpose of the dispersion calculations, the basis of the box for the site was approximated to be 125 m by 90 m. This was based on the size of the Neutralization Pond and measurements by ENVIRON from maps of the surrounding area adjacent to the pond, where soil samples contained organic compounds. The use of a smaller source area would fail to include some areas of contaminated soil; use of a larger source area would result in the inclusion of uncontaminated soil, which would "dilute" the measured soil concentrations (hence, lowering the risk estimate). Thus, ENVIRON's selection of the source size was designed to be conservative. Based on the emission estimates, the calculated on-site airborne particulate concentration during construction activities is 408 mg/m^3.

Emissions of chemical vapors through volatilization were estimated using a model developed by the USEPA (1987). Important assumptions in the model include:

- The soil chemical concentrations are average concentrations sampled at all depths from the site;
- The chemicals are uniformly distributed throughout the soil column;
- The volatilization rate is controlled kinetically by gas-phase diffusion in the soil spaces;
- Equilibrium partitioning exists among the gas, liquid and solid phases;
- No transport of chemicals to the surface occurs via capillary action; and
- Adsorption of the chemical to soil is reversible.

All exposure assumptions used in the on-site construction scenario are presented in Table III-1. The methodology for calculating intakes for soil ingestion, dermal contact with soil, and inhalation of vapors and particulates is described in RAGS (USEPA 1989b).

2. Ambient Conditions

Ambient conditions at the facility may also pose risks to the workers. Exposure pathways include: incidental ingestion of soil, dermal contact with soils, inhalation of volatiles, and inhalation of wind-blown dusts. Because no construction activities would be occurring under this scenario, only soil concentrations from the surface (down to 2 feet) were used for ingestion, dermal contact and modeling of vapor and particulate concentrations.

Exposure time for workers was assumed to be 8 hours/day, 5 days/week, 50 weeks/year for a total of 9 years. According to the USEPA (1989a), US Census data (1983) indicate that the median (50th percentile) number of years in the same home is 9 years. It was assumed that one could have the same job for an equal period of time.

Incidental ingestion of soil was conservatively assumed to be 100 mg/day (USEPA 1989c). Dermal contact was assumed to be limited to the face, lower arms, and hands. The skin exposure to soil was assumed to be 5.00×10^{-7} kg/cm^2 (Lepow 1975). Inhalation of particulates and vapors were limited to a typical work day of 8 hours.

TABLE III-1
Assumptions for On-site Construction Scenario

	ADULT MALE	REFERENCE
DAYS PER LIFETIME (lifetime-days)	25915	USEPA 1989a
YEARS OF EXPOSURE	1	ENVIRON
BODY WEIGHT (kg)	78	USEPA 1989a
BREATHING RATE		
Occupational (m^3/hr)	1.25	NIOSH 1991
TOTAL BODY SURFACE AREA (cm^2)	19400	ICRP 1984
SURFACE AREA OF		
Upper Limbs (cm^2) (18.8%)	3647.2	USEPA 1989a
Head and Neck (cm^2) (7.8%)	1513.2	USEPA 1989a
SCENARIO: INGESTION OF SOIL		
Amount ingested (kg)	$1.00x10^{-4}$	USEPA 1989c
Total time of ingestion (days/yr * yrs exposed)	60	ENVIRON
Fraction of time soil contaminated	100%	ENVIRON
SCENARIO: DERMAL - SOIL - OUTDOORS		
Total contacts (days/wk * wks/yr * yrs exposed)	60	ENVIRON
Days exposed per week	5	ENVIRON
Weeks exposed per year	12	ENVIRON
Soil per surface area of contact (kg/cm^2)	$1.00x10^{-6}$	Lepow 1975
Surface area of contact	3164	ENVIRON
for AM = Face + 2/3 Upper limbs		
Fraction of time soil contaminated	100%	ENVIRON
SCENARIO: INHALATION - VAPORS		
Contact time (hr/day)	10	ENVIRON
Time of inhalation (days) 5 days/wk.	60	ENVIRON
Weeks of exposure per year	12	ENVIRON
SCENARIO: INHALATION - PARTICULATES		
Contact time (hr/day)	10	ENVIRON
Time of inhalation (days) 5 days/week	60	ENVIRON
Weeks of exposure per year	12	ENVIRON

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All assumptions used in the estimation of intakes for ambient conditions on-site are presented in Table III-2. The methodology for calculating intakes from ambient exposures is derived from RAGS (USEPA 1989b).

B. Users of Bergholtz Creek

Golder estimated mass loadings of contaminants from the overburden ground water into Bergholtz Creek, assuming that the Walmore Road sewer trench discharged entirely into the creek. These mass loadings are presented on Table III-3. Chemical concentrations were conservatively estimated from the mass loadings based on the combined flow of the sewer (sewer flow rates also provided by Golder) and the creek. The only flow rate available for Bergholtz Creek was from a USGS survey (Eissler 1979), which indicated a low flow rate in June 1955 of 0.23 cfs. This flow rate was similar to those of other creeks in the area with similar widths and watershed sizes. Average yearly flow was unavailable because Bergholtz Creek is too small to be gauged.

Concentrations in the creek were estimated for nine compounds. These concentrations are presented in Table III-3. A detailed description of the methodology used to calculate these concentrations, and a sample calculation, can be found in Appendix A.

Only one compound, 1,2-dichloroethylene (1,2-DCE), was actually detected in Bergholtz Creek water at concentrations of 6.0 and 7.0 μg/l. None of the other compounds predicted to be present based on modeled overburden discharge into the creek were detected; therefore, the evaluation of these additional compounds provides a conservative estimate of potential human risk. The concentrations of 1,2-DCE detected in the creek were greater than the predicted values. Therefore, to be conservative, the maximum detected concentration of 1,2-DCE (7.0 μg/l) was used in the risk assessment.

1. Human Receptors

Several direct routes of exposure were evaluated for potential risks to human health. The only recreational activity known to take place in or near Bergholtz Creek is the catching of bullfish or crayfish for bait (Kowalski 1990; Mante 1990). This activity is not known to occur in the region of interest; however, to be conservative it

TABLE III-2
Assumptions for On-site Ambient Conditions Scenario

	ADULT MALE	REFERENCE
DAYS PER LIFETIME (lifetime-days)	25915	USEPA 1989a
YEARS OF EXPOSURE	9	ENVIRON
BODY WEIGHT (kg)	78	USEPA 1989a
BREATHING RATE		
Occupational (m^3/hr)	1.25	NIOSH 1991
TOTAL BODY SURFACE AREA (cm^2)	19400	ICRP 1984
SURFACE AREA OF		
Upper Limbs (cm^2) (18.8%)	3647.2	USEPA 1989a
Head and Neck (cm^2) (7.8%)	1513.2	USEPA 1989a
SCENARIO: INGESTION OF SOIL		
Amount ingested (kg)	1.00×10^{-4}	USEPA 1989c
Total time of ingestion (days/yr * yrs exposed)	2250	ENVIRON
Fraction of time soil contaminated	100%	ENVIRON
SCENARIO: DERMAL - SOIL - OUTDOORS		
Total contacts (days/wk * wks/yr * yrs exposed)	2250	ENVIRON
Days exposed per week	5	ENVIRON
Weeks exposed per year	50	ENVIRON
Soil per surface area of contact (kg/cm^2)	5.00×10^{-7}	Lepow 1975
Surface area of contact	3164	ENVIRON
for AM = Face + 2/3 Upper limbs		
Fraction of time soil contaminated	100%	ENVIRON
SCENARIO: INHALATION - VAPORS		
Contact time (hr/day)	8	ENVIRON
Time of inhalation (days) 5 days/wk.	2250	ENVIRON
Weeks of exposure per year	50	ENVIRON
SCENARIO: INHALATION - PARTICULATES		
Contact time (hr/day)	8	ENVIRON
Time of inhalation (days) 5 days/wk.	2250	ENVIRON
Weeks of exposure per year	50	ENVIRON

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TABLE III-3 Mass Loadings for Bergholtz Creek		
Compound	Mass Loading mg/day	Concentration mg/l
Acetone	9.36×10^{-2}	5.67×10^{-8}
Benzene	1.56×10^{-5}	9.45×10^{-12}
Chloroform	857	5.18×10^{-6}
1,2-Dichloroethylene	290	1.75×10^{-4}
Methylene Chloride	416	2.52×10^{-4}
Toluene	7.86×10^{-6}	4.76×10^{-12}
1,1,1-Trichloroethane	3.31×10^{-1}	2.00×10^{-7}
Trichloroethylene	81.2	4.91×10^{-5}
Vinyl chloride	1.02×10^{-1}	6.17×10^{-8}

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was assumed that bait fishing was possible. Given the typical depth of the creek of 2 to 3 feet, it was deemed unlikely that swimming would occur.

Catching of bait fish in the creek presents several potential exposure scenarios: incidental water ingestion, sediment ingestion, dermal contact with the creek water, dermal contact with the sediments, and inhalation of vapors. Several general assumptions for human exposure assessments have been suggested by USEPA (1989a) and were used in this assessment. A summary of these generic assumptions (e.g. length of lifetime, body weight, and inhalation rates) is presented in Table III-4.

No data were available on the frequency and/or duration of bait fishing; therefore, professional judgment was used to develop reasonable assumptions, considering local climatological factors. It was assumed that adults and children aged 6 to 18 years old were potential receptors. Children younger than this would not likely be exposed. Furthermore, a wading pool exposure scenario for small children less than 6 years of age was evaluated using chemical concentrations from irrigation wells, which were at least two orders of magnitude greater than the concentrations in the creek (see Section C 1a); thus, evaluation of exposure of young children to the creek was considered unnecessary in view of the results of the wading risks.

A USEPA-reviewed emission model (USEPA 1987) was employed to calculate the mass transfer rates of volatile constituents from the water surface to the air. The emission estimates were then input to the modified "box" model (Appendix B) to yield air concentration estimates for assessing risks associated with inhalation of chemical vapors.

All receptors were assumed to be bait fishing 2 hours per event, 64 times a year or approximately twice a week, 8 months a year. It was estimated that 50 ml of water could incidentally be ingested while fishing. This is equivalent to the incidental ingestion rate during swimming or showering and is probably an overestimation. It was assumed during fishing that the face, lower arms and hands could be dermally exposed to water and sediments. All assumptions for the five Bergholtz Creek exposure scenarios are presented in Table III-5.

TABLE III-4
General Assumptions for Off-Site Populations

	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old	Reference
DAYS PER LIFETIME (lifetime-days)	25915	28470	25915	25915	25915	USEPA 1989a
YEARS OF EXPOSURE	9	9	6	6	4	ENVIRON
BODY WEIGHT (kg)	78	65	56	31	16	USEPA 1989a
BREATHING RATE (m^3/hr) - USED BY MOST SCENARIOS	0.833	0.833	0.875	0.625	0.333	Adult-USEPA 1986a Kids-ICRP 1984
BREATHING RATE DURING LIGHT ACTIVITY (m^3/hr)	1.2	1.14	1.14	0.78	0.39	ICRP 1984
TOTAL BODY SURFACE AREA (cm^2)	19400	16900	15800	10425	7195	USEPA 1989a
SURFACE AREA OF						
Lower Limbs (cm^2) (37.5%)	7275	6337.5	5925	3909.4	2698.1	USEPA 1989a
Hands (cm^2) (5.2%)	1008.8	878.8	821.6	542.1	374.1	USEPA 1989a
Upper Limbs (cm^2) (18.8%)	3647.2	3177.2	2970.4	1959.9	1352.7	USEPA 1989a
Head and Neck (cm^2) (7.8%)	1513.2	1318.2	1232.4	813.2	561.2	USEPA 1989a

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TABLE III-5
Assumptions for Bergholtz Creek Users

	Adult Male	Adult Female	15 yr old	9 yr old	Reference
SCENARIO: INHALATION - VAPORS, CREEK					
Contact time (hr/day)	2	2	2	2	ENVIRON
Contact time (days/yr * yrs exposed)	576	576	384	384	ENVIRON
SCENARIO: INGESTION OF CREEK WATER					
Amount of water ingested (l/day)	0.05	0.05	0.05	0.05	ENVIRON
Number of contacts total (days/yr * yrs exposed)	576	576	384	384	ENVIRON
SCENARIO: DERMAL - WATER, CREEK					
Hours of contact (per day of contact)	2	2	2	2	ENVIRON
Days spent wading in creek in lifetime (days/yr * yrs exposed)	576	576	384	384	ENVIRON
Days wading per year	64	64	64	64	ENVIRON
Surface area of contact (cm^2) (1/2 head&neck + 2/3 upper limbs)	3188	2777	2596	1713	ENVIRON, USEPA 1989a
SCENARIO: INGESTION OF SEDIMENT, CREEK					
Amount ingested (kg)	0.0001	0.0001	0.0001	0.0001	USEPA 1989c
Total time of ingestion (days/yr * yrs exposed)	576	576	384	384	ENVIRON
Fraction of time soil contaminated	100%	100%	100%	100%	ENVIRON
SCENARIO: DERMAL - SEDIMENT - CREEK					
Number of contacts total (days/wk * wks/yr * yrs exposed)	576	576	384	384	ENVIRON
Days exposed per week	2	2	2	2	ENVIRON
Weeks exposed per year	32	32	32	32	ENVIRON
Amount of soil per surface area of contact (kg/cm^2)	$5.00x10^{-7}$	$5.00x10^{-7}$	$5.00x10^{-7}$	$5.00x10^{-7}$	Lepow 1975
Surface area of contact for AM,AF,15,9 = Face + 2/3 upper limbs	3188	2777	2596	1713	USEPA 1989a/ ENVIRON
Fraction of time soil contaminated	100%	100%	100%	100%	ENVIRON

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2. **Non-Human Receptors**

According to information provided to ENVIRON by BAT, dairy cattle are known to graze near Bergholtz Creek, but not in the region of concern. The cattle are exposed to various media which may contain chemical contaminants; these compounds can bioaccumulate in tissues and be excreted in milk. To be conservative, an indirect human exposure pathway involving ingestion of cow's milk was examined. Cows may be exposed to the creek via several potential exposure pathways: ingestion of the creek water, inhalation of vapors from the creek, and ingestion of sediments in the creek. It was assumed that a cow would be limited to creek exposure during the temperate seasons, conservatively estimated to be 210 days a year. ENVIRON assumed that 10% of a cow's daily water ingestion was received from the creek. It was conservatively assumed that a cow could be in the proximity of the creek 50% of the time inhaling vapors. Exposure by inhalation was estimated using the computed air concentrations directly above the creek, developed from an air dispersion model and an emission model (USEPA 1987; Li et al. 1990). The volume of sediment ingested was estimated based on the water volume ingested and suspended sediment concentrations for a creek of higher flow rate (Archer and LaSala 1968). The estimated volume of sediments ingested from the creek is approximately equal to 25 percent of the typical daily sediment ingestion for cows (Fries and Paustenbach 1990). All exposure assumptions regarding the various cow exposure routes are presented in Table III-6.

C. **Off-site Residents**

1. **Zone 1 Irrigation Wells**

a) **Direct Exposure Pathways**

Zone 1 irrigation wells were assumed to be used for irrigation only and not as a source of potable water. The local area is served by a public surface water supply. The Lockport Dolomite aquifer, the most important aquifer in the Niagara region, is primarily used for industrial purposes. According to Owen (1982), there

TABLE III-6
Dairy Cattle Exposure Assumptions

		Reference
BODY WEIGHT (kg)	450	NRC 1974
INGESTION OF WATER, BERGHOLTZ CREEK		
Volume of water ingested (l/day)	60	NRC 1974
Percent of total volume, ingested from creek	10%	ENVIRON
Time creek water ingested, 210 days/yr	58%	ENVIRON
INGESTION OF SEDIMENTS, BERGHOLTZ CREEK		
Sediment ingested (kg/day)	0.204	ENVIRON
Time creek sediments ingested, 210 days/yr	58%	ENVIRON
INHALATION OF VOLATILES, BERGHOLTZ CREEK		
Volume of air inhaled (m^3/day)	125	Ecologistics 1986
Percent of time spent by creek	50%	ENVIRON
Time spent by creek, 210 days/yr	58%	ENVIRON

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are no known wells used to supply potable water in the area. The quality of the bedrock aquifer is "... very hard and moderately mineralized. The water can be characterized as calcium sulphate or calcium bicarbonate water... NYSDEC classified groundwater in certain portions of the city as being naturally saline. The poor quality of the water, combined with the availability of surface water from the Niagara River, is the primary reason the bedrock aquifer is not used extensively as a supply of groundwater" (Owen 1982). According to the Town of Wheatfield, Niagara County, New York Comprehensive Plan Update (1990), anticipated growth in the area is based in large part on an "... unlimited [surface] water supply."

The non-use of Zone 1 ground water as a potable supply is further supported by the results of the extended private well survey conducted by Golder in the area adjacent to the BAT facility (Golder 1990b). Of 252 properties visited, only seven active wells were located. Only one of these wells was used as a water source; this well was located beyond the limits of the Zone 1 dissolved-phase plume, and so was not impacted by BAT chemicals. This well has since been decommissioned, and the home connected to the public water supply.

Only one of the seven active wells was found to contain volatile organic compounds. This well, which was not used for drinking water, has also been decommissioned. Residents were questioned about the quality of their well water. Several stated that the water was "... dark in color, and smelled and tasted of sulfur" (Golder 1990b).

To further ensure that Zone 1 water is not used by private residences, BAT has requested permission to decommission all exposed (aboveground) and active wells in the study area; 21 wells have been decommissioned to date.

Estimation of the chemical concentrations in the irrigation wells is described in the Data Evaluation Section, II-A. Various uses of irrigation well water may result in direct exposure to chemicals contained in the water. Several potential scenarios for direct exposure to the water were examined: watering of a garden, washing a car, and use of wading pools by children. Each scenario presents multiple exposure pathways for the receptors: inhalation of chemical vapors, incidental ingestion of the water, and dermal contact. The potential receptors for all three scenarios are

adults and teenagers; children, aged 2-6 years old (avg = 4 years old) and 6-12 years old (avg. = 9 years old), were assessed only for the wading pool scenario.

Several parameters for watering a garden were selected as being reasonable estimates of exposure, given the climatological conditions of the Niagara area. It was assumed that watering a garden could occur 1/2 hour per day, 3 times a week during a 5-month growing season. It was also assumed that the receptor would be outdoors watering the garden by hand or in the vicinity while the water was flowing. Inhalation of chemical vapors would occur while chemical constituents volatilized from the wetted surface. An average breathing rate was assumed for individuals watering the garden. Incidental ingestion of water was conservatively estimated to be 50 ml per event. The water is generally described as "skunky," and ingestion may only occur once because of the poor taste of the water. It is possible that a person could water a garden wearing shorts and T-shirt, so dermal exposure was assumed to involve 1/2 the lower limbs, 2/3 of the upper limbs, and the face.

Volatilization of chemical constituents from the wetted surface was calculated using a USEPA emission model (USEPA 1987). An annual average wind speed of 5.5 m/sec at Buffalo, New York (USEPA 1985b) was used in the emission modeling. The area of the wetted surface was assumed to be 50 m^2. Air concentrations were computed using the emission estimates (USEPA 1987) and the air dispersion model described in Appendix B.

The car washing scenario was limited to adults and teens (aged 12-18). It was estimated that washing the car could occur as often as once a week, 8 months of the year. This is a conservative estimate, considering the weather in the Niagara region. ENVIRON assumed that the hose would be running for a maximum of 15 minutes while car washing, during the wetting down and rinsing phases. Inhalation of vapors would occur during this time. A breathing rate of 1.2 m^3/hr was used for the vigorous activity of car washing (ICRP 1984). Dermal contact was limited to the face, arms, and hands. This may overestimate the risk in cooler months, but will underestimate risks in the warmer months if shorts are worn. It was felt that the average exposure would be to the upper limbs and the face. For incidental ingestion of the water, 50 ml per event was assumed. Ingestion may occur on very

hot days, but is less likely in the cooler months, or may not occur at all due to the odor and taste of the water.

Similar parameters were also estimated for a child's exposure to irrigation well water used to fill up a wading pool. It was assumed that the child would be in a wading pool for 2 hours per day, 4 days a week during the 3 months of summer. Inhalation of volatiles was assumed to occur over the same time period with a breathing rate of 0.625 m^3/hr for children aged 6-12 years old, and 0.333 m^3 for children aged 2-6 years old (ICRP 1984). Incidental ingestion of the water was estimated to be 50 ml per day. For risks from dermal exposure it was assumed that the child would be completely immersed (i.e., involvement of 100% of the body surface area) for the entire duration of exposure.

All of the assumptions used in the assessment of risk to off-site residents exposed to the irrigation well water in the various scenarios described above are presented in Table III-7. The methodologies for calculating intakes for the various exposure pathways (e.g. inhalation) are presented in RAGS (USEPA 1989b).

b) Vegetable Intake

One of the exposure scenarios discussed above was the watering of a garden. Therefore, it follows that ingestion of vegetables or fruits grown in the garden is a potential route of exposure for the residents.

Consumption of the following types of vegetables was evaluated:

1) Leafy vegetables - e.g., lettuce and cabbage,
2) Root vegetables - e.g., carrots and potatoes,
3) Non-leafy exposed vegetables - e.g., tomatoes and snap beans,
4) Non-leafy protected vegetables - e.g., corn and peas.

Uptake of chemicals by these vegetables varies by category. For example, exposure of the edible portion of leafy vegetables may be via vapor contact, direct deposition

TABLE III-7
Irrigation Well Exposure Assumptions for Off-site Populations

	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old	Reference
SCENARIO: INGESTION OF WELL WATER, GARDENING						
Amount of water ingested (l/day)	0.05	0.05	0.05			ENVIRON
Number of contacts total (days/yr * yrs exposed)	540	540	540			ENVIRON
SCENARIO: INGESTION OF WELL WATER, CAR WASHING						
Amount of water ingested (l/day)	0.05	0.05	0.05			ENVIRON
Number of contacts total (days/yr * yrs exposed)	288	288	192			ENVIRON
SCENARIO: INGESTION OF WELL WATER, WADING POOLS						
Amount of water ingested (l/day)				0.05	0.05	ENVIRON
Number of contacts total (days/yr * yrs exposed)				288	192	ENVIRON
SCENARIO: INHALATION - VAPORS, GARDENING						
Contact time (hr/day)	0.5	0.5	0.5			ENVIRON
Total time of inhalation (days exposed)	540	540	360			ENVIRON
SCENARIO: INHALATION - VAPORS, CAR WASHING						ENVIRON
Contact time (hr/day)	0.25	0.25	0.25			ENVIRON
Time of inhalation (days/yr * yrs exposed)	288	288	192			ENVIRON
Weeks of exposure per year	32	32	32			
SCENARIO: INHALATION - VAPORS, WADING POOL						
Contact time (hr/day)				2	2	ENVIRON
Total time of inhalation (days exposed)				288	192	ENVIRON
SCENARIO: DERMAL - WATER, GARDENING						
Hours of contact (per day of contact)	0.5	0.5	0.5			ENVIRON
Days spent garden in lifetime (days/yr * yrs exposed)	540	540	360			ENVIRON
Days gardening per year	60	60	60			ENVIRON
Surface area of contact (cm^2)	6826	5946	5559			USEPA 1989a/
AM,AF,15: 1/2 head&neck + 2/3 upper limbs						ENVIRON

TABLE III-7 (continued)
Irrigation Well Exposure Assumptions for Off-site Populations

	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old	Reference
SCENARIO: DERMAL - WATER, CAR WASHING						
Hours of contact (per day of contact)	0.25	0.25	0.25			ENVIRON
Days spent washing car in lifetime (days/yr * yrs exposed)	288	288	192			ENVIRON
Surface area of contact (cm^2)	3188	2777	2596			USEPA 1989a/
AM,AF,15: 1/2 head&neck + 2/3 upper limbs						ENVIRON
SCENARIO: DERMAL - WATER, WADING POOL						
Hours of contact (per day of contact)				2	2	ENVIRON
Days spent wading in lifetime (days/yr * yrs exposed)				288	192	ENVIRON
Surface area of contact (cm^2)				48	48	ENVIRON
Four and nine: Total body				10425	7195	USEPA 1989a

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of water on the leaves, and uptake of water in the soil. The primary route of exposure for the edible portion of root vegetables is root uptake.

Chemical concentrations in the various vegetable classes were estimated using bioconcentration factors based upon modified formulas of Ryan et al. (1988), Bacci et al. (1990), and Baes et al. (1984). These concentrations are estimates for the entire fruit or vegetable. This does not take into account the removal of portions of a vegetable (e.g. peeling a carrot), which reduces the chemical concentration by 95% for some vegetable types (Iwata and Gunther 1976). These concentrations were used as a conservative estimate of concentrations in the edible portion of the vegetable. Formulas and sample calculations are provided in Appendix C.

The dose received by consumption of homegrown vegetables is a function of chemical concentrations in the edible portions, and daily intakes for each vegetable class. Daily intake of all homegrown vegetables is estimated to be 25% of the total vegetable intake, which is approximately 200 g/day; therefore the typical ingestion rate of homegrown vegetables is 50 g/day. It was assumed that homegrown vegetables would be eaten every day during the 5-month growing season, and 3 times per week during the remainder of the year. This would account for canning or freezing of homegrown vegetables and ingestion year-round. These assumptions result in a total ingestion of 11.7 kg of homegrown vegetables per individual per year.

Percentages of each vegetable type grown in a typical garden were estimated: root (9%), leafy (12%), non-leafy exposed (44%), non-leafy protected (35%), based on intake of typical homegrown vegetables and produce typically planted. A detailed description of these estimates is presented in Appendix C. These same percentages were used to estimate the proportion of each vegetable category ingested from the total homegrown vegetable intake of 50 g/day.

The methodology used to calculate chemical intakes from ingestion of vegetables is presented and an example provided in Appendix C. All of the assumptions used in the assessment of risk to off-site residents exposed via vegetable ingestion are presented in Table III-8.

TABLE III-8
Exposure Assumptions for Vegetable Ingestion

	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old	Reference
SCENARIO: INGESTION OF HOMEGROWN VEGETABLES						
Total vegetable intake (g/day)	50	50	50	50	50	USEPA 1989a
Time ingested homegrown vegetables (days/yr)	234	234	234	234	234	ENVIRON
Every day during grow season, 3X's/week otherwise						
SCENARIO: INGESTION OF HOMEGROWN VEGETABLES (LEAFY)						
Total leafy vegetable intake (g/day)	4.5	4.5	4.5	4.5	4.5	USEPA 1989a
Time ingested homegrown leafy vegetables (days/yr)	234	234	234	234	234	ENVIRON
Every day during grow season, 3X's/week otherwise						
SCENARIO: INGESTION OF HOMEGROWN VEGETABLES (ROOT)						
Total root vegetable intake (g/day)	6	6	6	6	6	USEPA 1989a
Time ingested homegrown root vegetables (days/yr)	234	234	234	234	234	ENVIRON
Every day during grow season, 3X's/week otherwise						
SCENARIO: INGESTION OF HOMEGROWN VEGETABLES (NON-LEAFY, EXPOSED)						
Total exposed vegetable intake (g/day)	22	22	22	22	22	USEPA 1989a
Time ingested homegrown exposed vegetables (days/yr)	234	234	234	234	234	ENVIRON
Every day during grow season, 3X's/week otherwise						
SCENARIO: INGESTION OF HOMEGROWN VEGETABLES (NON-LEAFY, PROTECTED)						
Total protected vegetable intake (g/day)	17.5	17.5	17.5	17.5	17.5	USEPA 1989a
Time ingested homegrown protected vegetables (days/yr)	234	234	234	234	234	ENVIRON
Every day during grow season, 3X's/week otherwise						

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2. **Overburden Ground Water: Cow's Milk Ingestion**

Dairy cattle are known to graze near Bergholtz Creek, and the ingestion of cow's milk is thus a possible indirect exposure pathway for local residents.

A description of the cow's exposure as a non-human receptor is presented in Section III-B-2. The combination of all of these exposures provides an estimate of the total chemical concentration in cow's milk.

It is estimated that in farm households 40% of all dairy products ingested are homegrown (USEPA 1989a); this may be an overestimate for the Niagara region. It is unlikely that dairy products other than milk would be produced and ingested on a household level, because of pasteurization laws. Only ingestion of milk was considered in this assessment. The average quantity of milk ingested for adults is 305 g/day (120-450 g/day range) (USEPA 1989a); fresh (local) milk ingestion was estimated to be 122 g/day. The milk ingestion rate for children (5-14 years) ranged between 330-500 g/day (USEPA 1989a); 40% of the average, 415 g/day, results in an ingestion rate of 166 g/day of fresh milk.

All of the assumptions used to calculate risks from ingestion of fresh milk are presented on Table III-9. The methodology used to estimate doses from ingestion of cow's milk is presented in RAGS (USEPA 1989b).

TABLE III-9

Exposure Assumptions for Cow's Milk Ingestion

	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old	Reference
SCENARIO: INGESTION OF HOMEGROWN COW'S MILK						
Total homegrown cow's milk intake, 40% of total (kg/day)	0.122	0.122	0.122	0.166	0.166	USEPA 1989a
Time ingested homegrown cow's milk (days/yr)	365	365	365	365	365	ENVIRON

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IV. RISK CHARACTERIZATION

Both carcinogenic risk and chronic non-carcinogenic hazard indices were quantitatively estimated for each exposure route under each exposure scenario described in Section III - Exposure Assessment. Carcinogenic risk was quantified using the standard USEPA methodology (USEPA 1989b), based on the average daily intake over a lifetime (mg/kg-day) and the CPF or slope factor ($[mg/kg\text{-}day]^{-1}$). The USEPA has defined "acceptable" carcinogenic risk to range between 1.0×10^{-4} (1 excess cancer in ten thousand) and 1.0×10^{-6} (1 excess cancer in one million) (USEPA 1990a, 1990c). Individual chemical risk estimates were summed for each exposure route and route-specific risks were added to obtain the total lifetime cancer risk estimate under each exposure scenario.

The potential for non-carcinogenic adverse effects was evaluated using a chronic hazard quotient, which is the ratio of the average daily exposure level (average daily dose, or ADD) to the RfD (USEPA 1989b). If the ratio is greater than one, there is the potential for non-carcinogenic effects. A chronic hazard index (HI) for each exposure route was calculated by totaling the hazard quotients for each compound. The HIs for each exposure route were added to derive a total HI under each exposure scenario.

A. On-site Workers

Risks were calculated for on-site workers under current ambient conditions and possible future construction conditions. Both lifetime carcinogenic risks and chronic non-carcinogenic hazard indices were evaluated. Total carcinogenic risks for each route of exposure (all chemicals) and total exposure for each scenario are presented in Table IV-1. Individual chemical risk estimates for each exposure route are provided in Appendix D. Inhalation of vapors, soil ingestion, and dermal contact contribute equal portions of risk under ambient conditions. Benzo(a)pyrene (BaP) and polychlorinated biphenyls (PCBs) pose the greatest risks among individual compounds for ambient conditions. Inhalation of

TABLE IV-1
Carcinogenic Risk Estimates for All Exposure Scenarios

Exposure Scenario	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old
Occupational:					
ON-SITE CONSTRUCTION					
Inhalation, vapors	$1.56x10^{-6}$	NA	NA	NA	NA
Inhalation, particulates	$4.31x10^{-10}$	NA	NA	NA	NA
Ingestion, soil	$9.56x10^{-8}$	NA	NA	NA	NA
Dermal, soil	$1.57x10^{-7}$	NA	NA	NA	NA
Total on-site construction: all routes	$1.81x10^{-6}$	NA	NA	NA	NA
Occupational:					
ON-SITE AMBIENT CONDITIONS					
Inhalation, vapors	$4.27x10^{-6}$	NA	NA	NA	NA
Inhalation, particulates	$3.09x10^{-9}$	NA	NA	NA	NA
Ingestion, soil	$4.81x10^{-6}$	NA	NA	NA	NA
Dermal, soil	$3.80x10^{-6}$	NA	NA	NA	NA
Total ambient conditions: all routes	$1.29x10^{-5}$	NA	NA	NA	NA
BERGHOLTZ CREEK					
Direct Exposure:					
Bait fishing					
Inhalation	$7.97x10^{-11}$	$8.71x10^{-11}$	$7.77x10^{-11}$	$1.00x10^{-10}$	NA
Ingestion, water	$3.71x10^{-11}$	$3.80x10^{-11}$	$3.23x10^{-11}$	$4.67x10^{-11}$	NA
Dermal, water	$5.94x10^{-11}$	$5.66x10^{-11}$	$4.50x10^{-11}$	$5.36x10^{-11}$	NA
Ingestion, sediments	0.00	0.00	0.00	0.00	NA
Dermal, sediments	0.00	0.00	0.00	0.00	NA
Total bait fishing: all routes	$1.76x10^{-10}$	$1.82x10^{-10}$	$1.55x10^{-10}$	$2.00x10^{-10}$	NA
Indirect Exposure:					
Ingestion, cow's milk	$1.26x10^{-15}$	$1.37x10^{-15}$	$1.17x10^{-15}$	$2.87x10^{-15}$	$3.70x10^{-15}$
Total Bergholtz Creek: all routes	$1.76x10^{-10}$	$1.82x10^{-10}$	$1.55x10^{-10}$	$2.00x10^{-10}$	$3.70x10^{-15}$

TABLE IV-1 (continued)
Carcinogenic Risk Estimates for All Exposure Scenarios

Exposure Scenario	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old
IRRIGATION WELLS					
Direct Exposure					
Watering Garden					
Inhalation	1.50×10^{-6}	1.64×10^{-7}	1.47×10^{-7}	NA	NA
Ingestion, water	1.45×10^{-6}	1.59×10^{-6}	1.35×10^{-6}	NA	NA
Dermal, water	1.11×10^{-6}	1.05×10^{-6}	8.38×10^{-7}	NA	NA
Total: all routes	2.71×10^{-6}	2.80×10^{-6}	2.34×10^{-6}	NA	NA
Washing Car					
Inhalation	5.78×10^{-8}	5.99×10^{-8}	5.10×10^{-8}	NA	NA
Ingestion, water	7.75×10^{-7}	8.47×10^{-7}	7.20×10^{-7}	NA	NA
Dermal, water	1.38×10^{-7}	1.31×10^{-7}	1.04×10^{-7}	NA	NA
Total: all routes	9.71×10^{-7}	1.04×10^{-6}	8.75×10^{-7}	NA	NA
Wading Pool					
Inhalation	NA	NA	NA	6.06×10^{-7}	4.17×10^{-7}
Ingestion, water	NA	NA	NA	1.95×10^{-6}	2.52×10^{-6}
Dermal, water	NA	NA	NA	9.08×10^{-6}	8.10×10^{-6}
Total: all routes	NA	NA	NA	1.16×10^{-5}	1.10×10^{-5}
Indirect Exposure:					
Ingestion, root produce	6.51×10^{-7}	7.11×10^{-7}	6.05×10^{-7}	1.09×10^{-6}	1.41×10^{-6}
Ingestion, leafy produce	2.57×10^{-7}	2.81×10^{-7}	2.39×10^{-7}	4.32×10^{-7}	5.58×10^{-7}
Ingestion, exposed produce	1.20×10^{-6}	1.31×10^{-6}	1.11×10^{-6}	2.01×10^{-6}	2.60×10^{-6}
Ingestion, protected produce	9.45×10^{-7}	1.03×10^{-6}	8.77×10^{-7}	1.59×10^{-6}	2.05×10^{-6}
Ingestion, total produce	3.05×10^{-6}	3.34×10^{-6}	2.84×10^{-6}	5.12×10^{-6}	6.62×10^{-6}
Total Irrigation Wells: all routes	6.74×10^{-6}	7.18×10^{-6}	6.05×10^{-6}	1.68×10^{-5}	1.77×10^{-5}

Note:
NA: Not Applicable

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vapors contributes the majority of risk for the future construction scenario. Vinyl chloride and 1,1-dichloroethylene pose the greatest risks for exposure during construction activities. The total risk for all routes and all compounds to the on-site worker under ambient conditions is 1.29×10^{-5}, and for the on-site construction worker is 1.81×10^{-6}. Thus for both scenarios, risks to workers fall within the USEPA's range of "acceptable" risks.

Total non-carcinogenic hazard indices for each exposure route under both occupational exposure scenarios are presented on Table IV-2. Individual hazard quotients are presented in Appendix E. Inhalation of vapor contributes most to the hazard index. Carbon disulfide, 1,1-dichloroethylene and 1,2-dichloroethylene (trans-) are the biggest individual chemical contributors to the hazard index. The total hazard index for both occupational scenarios falls well below 1: 0.015 under ambient conditions and 0.15 under future construction conditions. Therefore, workers would not be expected to experience a non-carcinogenic risk associated with contaminated soil in these SWMUs. Appendix E also shows hazard quotients calculated using occupational TLVs (Table E-2b).

B. Users of Bergholtz Creek

Risks were estimated for off-site populations exposed to Bergholtz Creek. Exposure to the creek could occur by direct routes (inhalation, water ingestion, dermal contact with water, ingestion of sediments, and dermal contact with sediments) or by indirect exposure (ingestion of cow's milk from cows exposed to Bergholtz Creek).

Total carcinogenic risks for each of these exposure pathways are presented in Table IV-1. Individual chemical risk estimates are provided in Appendix D. Methylene chloride contributes the largest portion of risk from exposure to the creek by inhalation, ingestion and dermal contact. Trichloroethylene is also a major contributor by dermal contact. Carcinogenic risks for all human receptors are below 2.00×10^{-10} (9 year old) which represents an essentially *de minimis* risk (2 cancer cases per 10 billion people exposed).

Total non-carcinogenic hazard quotients for each exposure route for Bergholtz Creek are presented in Table IV-2. Individual hazard quotients are available in Appendix E. Trans-1,2-dichloroethylene contributes the greatest portion of the hazard index by all routes of exposure. The total HI for the Bergholtz Creek scenario is less than 1 for all human

TABLE IV-2
Non-Carcinogenic Hazard Index Estimates (ADD/RfD Ratios) for All Exposure Scenarios

Exposure Scenario	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old
Occupational:					
ON-SITE CONSTRUCTION					
Inhalation, vapors	1.40×10^{-1}	NA	NA	NA	NA
Inhalation, particulates	2.17×10^{-3}	NA	NA	NA	NA
Ingestion, soil	3.27×10^{-3}	NA	NA	NA	NA
Dermal, soil	5.34×10^{-3}	NA	NA	NA	NA
Total on-site construction: all routes	1.50×10^{-1}	NA	NA	NA	NA
Occupational:					
ON-SITE AMBIENT CONDITIONS					
Inhalation, vapors	1.15×10^{-2}	NA	NA	NA	NA
Inhalation, particulates	4.41×10^{-6}	NA	NA	NA	NA
Ingestion, soil	2.79×10^{-3}	NA	NA	NA	NA
Dermal, soil	8.97×10^{-4}	NA	NA	NA	NA
Total ambient conditions: all routes	1.52×10^{-2}	NA	NA	NA	NA
BERGHOLTZ CREEK					
Direct Exposure:					
Bait fishing					
Inhalation	5.70×10^{-6}	6.84×10^{-6}	8.34×10^{-6}	1.08×10^{-5}	NA
Ingestion, water	8.67×10^{-6}	1.04×10^{-5}	1.21×10^{-5}	2.18×10^{-5}	NA
Dermal, water	1.01×10^{-5}	1.06×10^{-5}	1.15×10^{-5}	1.37×10^{-5}	NA
Ingestion, sediments	7.05×10^{-7}	8.46×10^{-7}	9.82×10^{-7}	1.77×10^{-6}	NA
Dermal, sediments	1.12×10^{-6}	1.17×10^{-6}	1.28×10^{-6}	1.52×10^{-6}	NA
Total bait fishing: all routes	2.63×10^{-5}	2.99×10^{-5}	3.42×10^{-5}	4.96×10^{-5}	NA
Indirect Exposure:					
Ingestion, cow's milk	2.22×10^{-11}	2.67×10^{-11}	3.10×10^{-11}	7.61×10^{-4}	1.48×10^{-10}
Total Bergholtz Creek: all routes	2.63×10^{-5}	2.99×10^{-5}	3.42×10^{-5}	4.96×10^{-5}	1.48×10^{-10}

TABLE IV-2 (continued)
Non-Carcinogenic Hazard Index Estimates (ADD/RfD Ratios) for All Exposure Scenarios

Exposure Scenario	Adult Male	Adult Female	15 yr old	9 yr old	4 yr old
IRRIGATION WELLS					
Direct Exposure					
Watering Garden					
Inhalation	7.48×10^{-3}	8.97×10^{-3}	1.09×10^{-2}	NA	NA
Ingestion, water	4.16×10^{-2}	4.99×10^{-2}	5.79×10^{-2}	NA	NA
Dermal, water	3.33×10^{-2}	3.48×10^{-2}	3.78×10^{-2}	NA	NA
Total: all routes	8.24×10^{-2}	9.37×10^{-2}	1.07×10^{-1}	NA	NA
Washing Car					
Inhalation	5.39×10^{-3}	6.14×10^{-3}	7.13×10^{-3}	NA	NA
Ingestion, water	4.16×10^{-2}	4.99×10^{-2}	5.79×10^{-2}	NA	NA
Dermal, water	7.78×10^{-3}	8.13×10^{-3}	8.83×10^{-3}	NA	NA
Total: all routes	5.48×10^{-2}	6.42×10^{-2}	7.39×10^{-2}	NA	NA
Wading Pool					
Inhalation	NA	NA	NA	5.65×10^{-2}	5.83×10^{-2}
Ingestion, water	NA	NA	NA	1.05×10^{-1}	2.03×10^{-1}
Dermal, water	NA	NA	NA	5.12×10^{-1}	6.85×10^{-1}
Total: all routes	NA	NA	NA	6.74×10^{-1}	9.46×10^{-1}
Indirect Exposure:					
Ingestion, root produce	9.24×10^{-3}	1.11×10^{-2}	1.29×10^{-2}	2.33×10^{-2}	4.51×10^{-2}
Ingestion, leafy produce	3.39×10^{-3}	4.07×10^{-3}	4.73×10^{-3}	8.54×10^{-3}	1.65×10^{-2}
Ingestion, exposed produce	1.60×10^{-2}	1.92×10^{-2}	2.23×10^{-2}	4.03×10^{-2}	7.82×10^{-2}
Ingestion, protected produce	1.24×10^{-2}	1.48×10^{-2}	1.72×10^{-2}	3.11×10^{-2}	6.03×10^{-2}
Ingestion, total produce	3.94×10^{-2}	4.73×10^{-2}	5.49×10^{-2}	9.92×10^{-2}	1.92×10^{-1}
Total Irrigation Wells: all routes	1.77×10^{-1}	2.05×10^{-1}	2.35×10^{-1}	7.72×10^{-1}	1.14

Notes:
ADD: Average Daily Dose
NA: Not Applicable

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receptors; the highest HI is for 9 year olds, 4.96×10^{-5}. Therefore, Bergholtz Creek is not expected to pose a non-carcinogenic risk to recreational users and consumers of milk.

C. Off-site Residents

Risks for off-site residents were evaluated for various uses of irrigation wells and the indirect exposure pathway of ingestion of homegrown vegetables watered from the irrigation wells. Lifetime carcinogenic risks and chronic non-carcinogenic hazard quotients were calculated for each exposure scenario.

Total carcinogenic risks are presented in Table IV-1 for all irrigation well scenarios including the indirect exposure by ingestion of vegetables. Total risk from irrigation well exposure ranges from 6.05×10^{-6} (15 year old) to 1.77×10^{-5} (4 year old). Individual carcinogenic risk estimates can be found in Appendix D. Ingestion of vegetables poses the greatest risk to adult and teenage receptors; wading pool exposure poses the greatest risk for the 9 year old and 4 year old child. Vinyl chloride contributes the greatest portion of risk via vegetable ingestion (78%). PCBs and vinyl chloride contribute the greatest portion of risk via wading pool exposure (81%).

Total non-carcinogenic HI estimates are provided in Table IV-2. Individual chemical hazard quotients are provided in Appendix E. Incidental water ingestion and dermal contact with the irrigation water contribute the most to the non-carcinogenic hazard indices. Benzene, trans-1,2-dichloroethylene, 1,1,2,2-tetrachloroethane, and vinyl chloride were the primary chemical contributors for all irrigation well exposure routes. The highest HI for off-site residents was 1.14 (for the 4 year old child).

D. Estimates of Organic Loadings to Niagara River

Golder estimated future potential loadings of approximately 0.6 lb/day of organic chemicals to the Niagara River, via the Zone 1 ground water plume. Golder Associates has calculated, based on the distance of the present plume boundary from the river, ground water velocity and other factors, that it will take over 300 years for the plume to reach the River. The loadings provided by Golder for individual constituents were divided by the Niagara River flow (Gradient/GeoTrans 1988) to derive concentrations in the River. As

Table IV-3 shows, these concentrations are *de minimis* when compared with AWQC (Ambient Water Quality Criteria) and other ARARs.

The total organic loadings estimated by Golder (approximately 0.6 lb/day) can be considered in the context of estimates of organic loadings from other point sources. Gradient Corp./GeoTrans Inc. (1988) presented detailed calculations of chemical contaminant loadings from ground water to the Niagara River from 33 hazardous waste sites or groups of sites considered to be significant sources. The potential loading from each site was calculated as a function of the total ground water contaminant concentration averaged across the downgradient site boundary, and the average ground water flow leaving the site through the downgradient site boundary. Using the methodology described in the Gradient/GeoTrans report, a best estimate of actual current organic loadings of approximately 394 lb/day was calculated. This agrees reasonably well with previous estimates of contaminant loadings which were based upon differential upstream/downstream organic contaminant concentrations in the river water and suspended sediments. Using this method, the NRTMP River Monitoring Committee estimated organic loadings of 124 lb/day, and Environment Canada estimated organic loadings at 138 lb/day (Gradient/GeoTrans 1988). The Gradient/GeoTrans loading estimates are higher even though only point sources were considered (the NRTMP and Environment Canada analyses presumably incorporated both point and non-point sources into their estimates); however, conservative methods used by Gradient/GeoTrans would tend to bias the results upward. In addition, the analyses by NRTMP and Environment Canada did not account for possible organic losses due to sedimentation.

As Table IV-3 shows, the impact of BAT chemicals from Zone 1 ground water on the Niagara River is *de minimis*. Predicted concentrations are below concentrations of regulatory or public health importance (e.g., drinking water standards, ambient water quality criteria). For this reason, ENVIRON did not conduct a quantitative assessment of risk to users of Niagara River water from potential future ground water discharges to the river.

TABLE IV-3
Organic Loadings to Niagara River from Zone 1 Plume Discharge

Chemical	Loading* (lbs/day)	Loading (mg/day)	Niagara River Flow Rate (l/day)**	Concentration in River (mg/l)	Federal MCLs (mg/l)		New York State Drinking Water Stds (mg/l)	Chronic AWQC for Protection of Aquatic Life (mg/l)	AWQC for Human Exposure (mg/l)
					Current	Proposed			
1,1,1-Trichloroethane	1.08×10^{-2}	4,898.9	4.92×10^{11}	9.96×10^{-9}	2×10^{-1}		5×10^{-3}[c]		18.4
1,1-Dichloroethane	3.61×10^{-6}	1.6	4.92×10^{11}	3.25×10^{-12}			5×10^{-3}[c]		
1,1-Dichloroethylene	9.97×10^{-6}	4.5	4.92×10^{11}	9.15×10^{-12}	7×10^{-3}		5×10^{-3}[c]		3.3×10^{-5}
1,2-Dichloroethylene (total)	2.55×10^{-3}	1,156.7	4.92×10^{11}	2.35×10^{-9}		$7 \times 10^{-2} / 1 \times 10^{-1}$[a]	5×10^{-3}[c]		3.3×10^{-5}
Acetone	3.61×10^{-3}	1,637.5	4.92×10^{11}	3.33×10^{-9}			5×10^{-2}[d]		
Benzene	2.12×10^{-7}	9.6×10^{-2}	4.92×10^{11}	1.95×10^{-13}	5×10^{-3}		5×10^{-3}[c]		6.6×10^{-4}
Carbon disulfide	2.33×10^{-5}	10.6	4.92×10^{11}	2.15×10^{-11}			5×10^{-2}[d]		
Chloroform	6.36×10^{-7}	2.9×10^{-1}	4.92×10^{11}	5.89×10^{-13}			5×10^{-2}[d]	1.24	1.9×10^{-4}
Methylene chloride	2.97×10^{-1}	134,719.2	4.92×10^{11}	2.74×10^{-7}		5×10^{-3}	5×10^{-3}[c]		
Trichloroethylene	2.33×10^{-1}	105,688.8	4.92×10^{11}	2.15×10^{-7}	5×10^{-3}		5×10^{-3}[c]	21.9	2.7×10^{-3}
Toluene	4.24×10^{-7}	1.9×10^{-1}	4.92×10^{11}	3.86×10^{-13}		$2/4 \times 10^{-2}$[b]	5×10^{-3}[c]		14.3
Vinyl chloride	8.91×10^{-5}	40.4	4.92×10^{11}	8.21×10^{-11}	2×10^{-3}		2×10^{-3}		2×10^{-3}
Arochlor-1254	8.06×10^{-6}	3.7	4.92×10^{11}	7.52×10^{-12}		5×10^{-4}	5×10^{-2}[d]	1.4×10^{-5}	7.9×10^{-8}
γ-BHC (Lindane)	7.43×10^{-7}	3.4×10^{-1}	4.92×10^{11}	6.91×10^{-13}	4×10^{-3}	2×10^{-4}	4×10^{-3}		

* From Golder Associates
** From Gradient Corporation and GeoTrans. Inc., 1988
[a] For cis/trans isomers, respectively.
[b] Primary/secondary standard, respectively.
[c] Total for all flagged compounds cannot exceed 5×10^{-3} ppm.
[d] Total for all flagged compounds cannot exceed 5×10^{-2} ppm.

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V. UNCERTAINTIES AND CONCLUSIONS

A. General Uncertainties in Risk Assessment

There often are many inherent uncertainties and data limitations in a risk assessment. First, it is unlikely, no matter how extensive the environmental sampling and analysis, that the actual levels of contaminants in the various environmental media will be known with absolute certainty for the whole site. Second, a number of critical assumptions are required in developing each of the exposure scenarios and predicting the levels of contaminants to which potential receptors are exposed. Finally, the toxicological and dose-response data on the identified chemicals of concern usually are of varying quality and availability, which creates uncertainties in their interpretation.

In addressing such uncertainties, as a matter of conservative public health policy, the USEPA and other regulatory agencies prefer to err on the side of overestimating risk. This is generally accomplished by incorporating into the risk assessment process conservative assumptions that represent the upper bound of reasonably foreseeable exposures.

For the BAT baseline risk assessment, both current and possible future exposure scenarios were evaluated. The on-site occupational exposures under ambient conditions and off-site exposures to contaminants in Bergholtz Creek represent potentially existing exposure conditions. Hypothetical risks were developed for possible future construction activities on-site and potential use of irrigation wells off-site. No active wells currently draw water from the ground water plume; however, in the future, wells might be drilled within the plume as currently defined by Golder, or more distant wells may be affected as the plume spreads if no remedial action is taken. The uncertainties for both current and potential future exposure scenarios are discussed below.

1. Limitations and Uncertainties in Sampling Data

Conservative estimates of media contaminant concentrations were used to calculate risks for the various exposure scenarios. For example, Zone 1 ground water concentrations were assumed to be the 95% confidence interval of the geometric mean for compounds detected in more than 90% of samples. This is a "reasonable worst-case" estimate of Zone 1 ground water concentrations.

Air concentrations were modeled from soil or water concentrations (USEPA 1987; Li, et al. 1990). The concentrations predicted by this air model are known to be in good agreement with direct air measurements (Appendix B).

Mass loadings of the eight overburden compounds of concern to the Walmore Road sewer trench were calculated by Golder. To estimate overburden chemical concentrations in Bergholtz Creek, it was conservatively assumed that 100% of the sewer trench outflow discharges into the creek. Only 1,2-dichloroethylene was actually detected in the creek. Thus, the risks estimated from contamination by all other overburden compounds are likely overestimated.

Hypothetical risks for future exposures were calculated using current data. ENVIRON has not accounted for potential reduction in contamination over time due to dilution, chemical or biological degradation, volatilization or other processes. For example, the Zone 1 ground water concentrations in the hypothetical irrigation wells were based on the concentrations detected in the monitoring wells. The level of contamination of future irrigation wells may be lower due to these processes.

Soil concentrations in the future on-site construction scenario may be reduced over time by volatilization, rainwater runoff, and biodegradation. In some cases, concentrations near the surface could decrease by downward migration of chemicals in rainwater.

2. Limitations and Uncertainties in Exposure Assumptions

In most risk assessments, a large number of assumptions are incorporated into the assessment of potential human exposure. For this risk assessment, exposure assumptions were required for current on-site occupational exposures and off-site population exposures to Bergholtz Creek, and for hypothetical future exposure on-site

(construction) and off-site (irrigation wells). Exposure assumptions established by USEPA (1986a, 1989a, and 1989b) were used when applicable. In some cases (e.g., exposures to dairy cows consuming water from Bergholtz Creek and irrigation well exposures), no published USEPA data were available; therefore, best professional judgment was used to select reasonably conservative assumptions, so that risk was more likely to be overestimated than underestimated.

3. Limitations and Uncertainties in Toxicity Data

Risk assessment involves extrapolation and inference to predict the occurrence of adverse health effects under certain conditions of human exposure to chemicals, based on knowledge of the adverse effects that occur under other conditions of exposure (e.g., at different dose levels, possibly by different routes of exposure, and in different species). Because of this extrapolation, there is some uncertainty in the conclusions that can be reached. Exposure to chemicals usually involves many chemicals at the same time. Interactions resulting from exposure to two or more chemicals may produce toxicological effects that differ from those observed following separate exposures to the individual chemicals. Although there is considerable interest in evaluating the toxicological effects of mixtures, the available information on such toxicological effects is very limited. Since there is not yet a methodology for the evaluation of exposure to mixtures of chemicals, ENVIRON's risk assessment calculated risk from exposure to each of the individual chemicals. In accordance with USEPA guidance, risks were summed to derive total risks from exposure to all chemicals. There is uncertainty as to whether this procedure may overestimate or underestimate risks.

B. Conclusions

1. Current Exposure Scenarios

Risks were estimated for current exposure on-site under ambient occupational conditions, and for off-site exposure to Bergholtz Creek, including indirect exposure via ingestion of cow's milk. Carcinogenic risk is greatest for the on-site worker, 1.29×10^{-5} (or, 1.29 cancer cases per 100,000 people exposed over a lifetime) for all exposure

pathways combined. This risk, largely attributable to inhalation of vapors and dermal contact with the soil, is within the USEPA range of "acceptable" risks (i.e. 10^{-4} to 10^{-6}). Carcinogenic risk for off-site populations exposed to Bergholtz Creek is predominantly due to inhalation, ingestion of water and dermal contact. The highest cancer risk from Bergholtz Creek is for a 9 year old child, 2.00×10^{-10}. This represents essentially *de minimis* risk (2 cancer cases per 10 billion people). Indirect exposure via ingestion of cow's milk resulted in risks five orders of magnitude (100,000 times) lower than those for direct exposure to Bergholtz Creek.

The results indicate no risk of non-carcinogenic adverse effects to on-site workers. An HI of 1.52×10^{-2} was calculated, primarily due to inhalation of vapors. As this is below 1, it suggests no risk of adverse non-carcinogenic effects. The hazard indices for exposure to Bergholtz Creek and indirect exposure via ingestion of cow's milk were several orders of magnitude lower. The highest HI (4.96×10^{-5}) was for a 9 year old child.

2. Potential Future Exposure Scenarios

Potential future exposures included on-site construction and off-site population exposure from irrigation wells, including indirect exposure to vegetables irrigated with water from the irrigation wells.

Carcinogenic risk for the on-site worker during future hypothetical construction activity was 1.81×10^{-6} for all exposure pathways. Carcinogenic risks to off-site populations exposed to the irrigation wells were higher than the risks to workers during construction. Carcinogenic risks for the 9 and 4 year old children were highest, 1.68×10^{-5} and 1.77×10^{-5}, respectively; this includes exposure by wading pools and indirect exposure via ingestion of vegetables. Dermal contact during wading constitutes the greatest portion of risk (54%, 9 year old; 46% 4 year old). Again, these risks fall within the USEPA range of "acceptable" risks for remediation of CERCLA and RCRA sites.

The non-carcinogenic HI for the on-site worker during construction was estimated to be 1.50×10^{-1}, suggesting no adverse effects. Non-carcinogenic HIs for off-site adults (male and female) and the 15 year old and 9 year old children exposed to irrigation

wells were slightly higher (ranging from 0.18 to 0.77), but still were below 1. The highest HI was for the 4 year old child (1.14), for wading pools and ingestion of vegetables. For the 4 year old child, this suggests the possibility of adverse noncarcinogenic effects. The greatest portion of the HI for small children is attributable to dermal contact while wading.

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APPENDIX A
Calculation of Bergholtz Creek Concentrations

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Calculation of Bergholtz Creek Concentrations

The calculation of chemical concentrations in Bergholtz Creek is based on mass loadings from the Walmore Road Sewer and the combined flow rate contributed by the sewer and Bergholtz Creek. Mass loading and sewer flow rates were provided by Golder Associates. The Bergholtz Creek flow rate is 0.023 ft^3/sec (Eissler 1979).

$$X_{conc} = \frac{ML * (CF_{ml})}{(FR_c * CF_{FRC}) + FR_s}$$

where:

X_{conc}	=	Concentration of compound in creek, mg/l
ML	=	Mass loading, lb/day
CF_{ml}	=	Conversion factor for ML, lb/day to mg/day (4.54E+5)
FR_c	=	Flow rate of creek, ft^3/sec
CF_{FRC}	=	Conversion factor for FR_c ft^3/sec to l/day (2.45E+06)
FR_s	=	Flow rate of sewer, 1.09E+06 l/day.

Chloroform

$$X_{conc} = \frac{(1.89E\text{-}05 \text{ lb/day} * 4.54E+05)}{((0.023 \text{ ft}^3\text{/sec} * 2.45E+06) + 1.09E+06 \text{ l/day})}$$

X_{conc} = 7.49E-6 mg/l

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APPENDIX B

Modeling of On-site Air Concentrations

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MODELING OF ON-SITE AIR CONCENTRATIONS AT SUPERFUND SITES

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ABSTRACT

This paper proposes a semi-analytical model to estimate on-site air concentrations, based on the principle of mass conservation, continuous plume behavior, and local meteorological conditions. The predictive scheme is based on the conventional "box" model but is refined to incorporate considerations such as wind shear near the surface, development of plume thickness, and atmospheric stability. The model has been tested against measurements of air concentrations utilizing the measured air emission rates for several Superfund sites. Preliminary findings indicate that the model predictions are in good agreement with direct measurements of on-site air concentrations at these sites. The proposed model is supported by a computer program that incorporates parameters utilized by the USEPA in the UNAMAP6 Gaussian plume models.

INTRODUCTION

The ability to estimate on-site air concentrations with reasonable accuracy has assumed an increasingly prominent role in evaluating potential public health risks associated with activities at contaminated sites. The need for air concentration estimates may arise during: (1) assessment of baseline risks associated with Superfund sites; (2) comparison of the risks associated with different remedial

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alternatives for contaminated site cleanups; (3) evaluation of on-site workers' health risks resulting from the development of contaminated industrial properties; and (4) determination of site cleanup criteria based on a prescribed acceptable public health risk. Errors introduced into the estimates of on-site air concentrations will extend into subsequent estimates of health risks, and thus undermine the usefulness of the modeling effort and subsequent risk analyses. Accurate estimation of on-site air concentrations for a contaminated site is therefore essential to provide meaningful predictions of health risks for decision-makers.

Air emissions at contaminated sites are normally classified as continuous ground-level area-source emissions with negligible buoyancy effect and low source strength. Exposures to such emissions for on-site workers and nearby residents are of particular concern to the public and regulatory agencies. Estimation of the on-site air concentration by applying a conventional diffusion model, Gaussian or non-Gaussian, is inappropriate because the atmospheric dispersion mechanism for short-range dispersion is different from that for long-range dispersion. Taylor's theory of diffusion by continuous movements provides a typical illustration of this fact (1). Furthermore, most dispersion models are derived with the given assumption that an infinite concentration, or some prescribed initial concentration, exists at the source location; these models fail to address the spatial variation of on-site air concentrations.

To address the limitations of applying conventional dispersion modeling techniques to estimation of on-site air concentrations, a

variety of approaches have been considered. The simplest approach to modeling the on-site air concentration is to modify the Gaussian point source solution and apply it to an area source by treating the area emissions as a concentrated point emission located either at the center of the actual source or upwind by a virtual distance. Turner (2) defined the virtual upwind distance by back-calculating the lateral dispersion coefficient from the Pasquill-Gifford curves using a reduced source width. Another similar virtual upwind point source dispersion equation was recommended by the USEPA (3). Both approaches, however, create an unrealistic estimate of the spatial variation of concentrations within the source area, depending on the size of the source.

A second approach is the "box" model which has been widely used in urban air pollution (4,5,6). Gifford and Hanna have proposed a formula with an empirical coefficient to correlate predicted concentrations to field observations. The empirical coefficient was derived from extensive air pollution data (average annual emissions and concentrations of particles for 44 U.S. cities and SO_2 data for 20 U.S. cities). This "box" model approach was greatly simplified in a document published by the USEPA addressing the development of an advisory level for PCB cleanup (7), by assuming a uniform mixing within a 2-meter high virtual box. The "box" model provides a useful tool in estimating the on-site air concentration. Its predictions, however, can be overly conservative if the model is not calibrated and validated by field measurements.

A third approach models short-range air dispersion from area sources based on K-theory (8). K-theory involves application of the atmospheric diffusion equation using empirical eddy diffusivities for the

time-averaged turbulent flux. The approach employs the solution of a two-dimensional atmospheric diffusion equation (9,10). This model is more complicated than a Gaussian model, and the expected improvement in accuracy has yet to be evaluated.

This paper proposes a simple but effective model (11) based on the principle of mass conservation, continuous plume behavior, and local meteorological conditions. The model, referred to as the modified box model, has been developed to estimate the on-site air concentration that most Gaussian air dispersion models are unable to predict. The modified box model is refined from the conventional "box" model to incorporate considerations of wind shear near the surface, development of plume thickness, vertical concentration distribution, and atmospheric stability while at the same time maintaining that model's simplicity. It calculates the on-site or near-field air concentrations from an area source utilizing emission estimates and on-site meteorological observations. The model's predictions have been compared to field observations of air emissions and on-site air concentrations. Preliminary findings indicate that the model predictions are in good agreement with direct measurements of on-site air concentrations at waste sites.

ESTIMATING ON-SITE AIR CONCENTRATIONS

If one represents the contaminated site of interest as a finite area source of strength E, the pollutants emitted can be considered to be contained within an imaginary plume boundary from the upwind edge to the downwind edge of the area as shown in Figure 1. The height of the

imaginary boundary, Z_i, is a function of the downwind distance, oncoming wind velocity, and atmospheric stability. Based on Gaussian distribution, more than 95 percent of the pollutants will be entrapped within a depth of 2.15 σ_z, where σ_z is the standard deviation of the vertical concentration distribution.

If c(z) is the concentration at the downwind edge of the area source and c_a is the ambient concentration beyond the imaginary boundary layer, the conservation of mass states that

$$\int_s (c(z) - c_a) \vec{u}(z) \cdot \vec{n} \, dS = 0, \qquad (1)$$

where:

c(z) is the air concentration at the downwind edge, g/m^3;
$\vec{u}(z)$ is the atmospheric wind velocity at height z, m/sec;
$\vec{n}$ is the unit vector normal to the imaginary boundary; and
S is the surface of the imaginary plume boundary; m.

If the background air concentration, c_a, and the lateral dispersion are neglected, Equation 1 can be rewritten as:

$$\int_A E \, dA = \int_0^{Z_i} \int_0^{W} c(z) \, u(z) \, dy \, dz, \qquad (2)$$

where:

A is the size of the area source, m^2;
W is the width of the area source, m;
E is the area source strength, g/m^2-sec; and
y,z are the rectangular coordinates, with y the cross-wind direction and z the azimuth direction.

The wind profile, u(z), in the above equation can be described by a power-law velocity profile (12):

$$u(z) = u_{10} \left(\frac{z}{10}\right)^{p} \qquad (3)$$

where:

u_{10} is the surface wind speed at 10 m height, m/sec;
z is the height above ground, m; and
p is the wind profile exponent.

It is generally accepted that the vertical concentration distribution in a continuous plume follows the Gaussian distribution such that c(z) can be expressed in terms of the ground-level concentration:

$$c(z) = c_o \exp(-z^2/2\sigma_z^2) \qquad (4)$$

where:

c_o is the ground-level concentration downwind of the source, g/m^3.

By substituting u(z) and c(z) with the relationships illustrated in Equations 3 and 4, respectively, Equation 2 can now be presented as follows:

$$E \cdot \Delta X \cdot W = \int_0^{2.15\sigma_z} \int_0^{W} c_o \cdot \exp(-z^2/2\sigma_z^2) \cdot u_{10} \cdot (z/10)^{p} \, dy \, dz \qquad (5)$$

where:

ΔX is the downwind distance from the upwind edge of the source, m.

The integration can be manipulated and simplified to

$$c_o = [\ u_{10}\ \sigma_z^{p+1}\ I(p)]^{-1}\ E \cdot \Delta X \qquad (6)$$

where:

$$I(p) = \frac{1}{10^p} \int_{\theta=0}^{\theta=2.15} \theta^p \exp(-\theta^2/2)\, d\theta$$

The integration for I(p) can be performed with a simple numerical integration scheme. Figure 2 displays I(p) for various wind profiles. Default values for the wind-profile exponent as recommended by the USEPA (13) can be readily incorporated into this refined "box" model. The standard deviation of the vertical concentration distribution can be defined under site-specific conditions or can be defined in accordance with many standard procedures (13,14,15). A power-law expression for σ_z, which reflects the various atmospheric stabilities, is preferred in the current modeling for mathematical simplicity and consistency with USEPA air dispersion models.

Since Equation 6 takes into consideration the ambient wind speed and atmospheric stability, the real-time meteorological data, and the joint frequency of occurrence of wind-speed and wind-direction classified by the Pasquill-Gifford stability categories [or STAR (17)] can be incorporated to yield an annual average concentration, $\bar{c}$:

$$\bar{c} = \sum_{i=1}^{6} \sum_{j=1}^{6} \sum_{k=1}^{16} f_{ijk} \frac{\Delta X\, E}{(u_{10})_j\, (\sigma_z)_i^{p_i+1}\, I(p_i)} \qquad (7)$$

where:

i is the wind speed category;
j is the atmospheric stability category;
k is the wind direction category; and
f_{ijk} is the frequency of time in a year for specified i, j, and k.

A computer program has been developed to perform the above averaging process.

MODEL COMPARISONS

On-Site Air Concentrations

Field observations of air emission rates were employed in Equation 6 to yield on-site air concentrations at two waste sites under undisturbed conditions. Predictions from the modified box model were then compared to the results of direct on-site air measurements in order to verify the accuracy of the model.

At the first site (Landfill 1), sulfur dioxide (SO_2) and total hydrocarbon (THC) concentrations were reported in a Superfund remedial investigation (17,18). Air samples were collected at 6 inches above the surface at 100 different locations at the site. Data consisting of 32 field observations and 10 background measurements (remaining after quality control on the sampling procedures), were examined in the current assessment.

For SO_2, 8 out of 32 surface samples and 7 out of 10 background samples were below the detection limit of the instrument. The observed background concentrations were all within 1.5 times the detection limit, which indicated that the true background concentration fluctuated around the detection limit. To yield a reasonable arithmetic mean, samples below the detection limit were assigned a value of 0.5 times the detection limit. For THC, all observations were above the detection limit. However, the average background concentration was found to

exceed the average concentration of all surface samples. Table 1 shows the sample statistics for SO_2 and THC. To determine the statistical significance of the observed data, the Wilcoxon Rank Sum Test was conducted in addition to the analysis of variance for both chemical compounds. The average SO_2 concentration was concluded to be statistically significantly different from the background concentration based on the Wilcoxon Rank Sum Test with a p-value of 0.0101. The THC concentrations, however, were concluded to vary insignificantly from the background concentration, since they failed both the analysis of variance and the Wilcoxon Rank Sum Test (p-value >0.5), and were therefore not considered further in this comparison.

Direct emission measurements at the same site were performed using the surface flux chamber technique. The mean SO_2 emission rate computed from 18 measurements was 3.33 $\mu g/m^2$-sec, with a standard deviation of 9.05 $\mu g/m^2$-sec. Considering the inhomogeneity of soil contamination at a large waste landfill, such variation in the emission rate is not unexpected. Both the emission and ambient air measurements were conducted during the day. The annual average wind speed of 3 m/sec, as reported from a nearby weather monitoring station, was employed as the ambient wind speed. Three average atmospheric stabilities were assessed to provide a comparison. Based on an annual mean wind speed of 3.0 m/sec and an atmospheric stability of D class that was considered to characterize the site, Table 2 shows that data for the measured mean SO_2 concentration differs from the modified box model prediction by only 2 percent.

In another recent Superfund site (Landfill 2) remedial investigation (19), limited on-site air samples were taken at an undisturbed waste site

with specified upwind/downwind sampling locations. Downwind samples collected during the day were statistically undistinguishable from the upwind sample. The nighttime samples, however, were distinguishable from the upwind sample and were adopted for the current analysis. Chemical vapor emission rates were also measured using the surface flux chamber technique. The chemical vapor emission rates are summarized from the report (19) and tabulated as follows:

Chemical Constituent	Number of Samples	Emission rate, $\mu g/m^2$-sec	
		Mean	S.D.
Benzene	7	9.98×10^{-3}	2.67×10^{-3}
Toluene	7	1.37×10^{-2}	4.35×10^{-3}
1,1,1-Trichloroethylene	4	1.00×10^{-2}	4.13×10^{-3}

Surface meteorological observations made concurrently with the emission rate measurements indicated that air samples were collected under a near calm condition with an average wind speed of approximately 0.8 m/sec.

The modified box model was used with F stability and a wind speed of 0.8 m/sec to yield on-site air concentrations. The results are presented in Table 3. The modified box model underpredicts the on-site air concentration by a factor ranging from 5 to 8. Given the experimental uncertainty involved in field measurements of emission rates and air concentration, the concentrations estimates are considered to be consistent with the field measurements.

Near-Field Air Concentrations

In addition to estimating on-site air concentrations, the modified box model can be used to estimate the near-field air concentrations provided that the receptor is located within a short distance from the area source (e.g., $\leq$ 2.5 source-widths downwind of a source has been considered an appropriate distance) such that the cross-wind dispersion is insignificant. An examination of the model accuracy was conducted by comparing concentrations predicted by the modified box model with those predicted by a series of other air dispersion models. Ambient air concentrations for a California landfill (Landfill 3) reported in a study by Baker (20) were used as criteria for the comparison.

Ambient vinyl chloride concentrations were measured for five days at two receptor locations, Sites A and B, located within one source-width distance downwind of the landfill. Baker (20) compared the field observations to the predictions of four air dispersion schemes as follows:

(1) The maximum ground-level concentration resulting from a ground-level point source located at the center of the landfill;

(2) The maximum ground-level concentration modified from (1) by utilizing a virtual upwind point source to represent a square area source;

(3) A virtual point source approximation similar to (2) but with modifications of the virtual downwind distance and empirical coefficients; and

(4) A simple "box" model developed for estimation of urban air pollution with adjusted downwind distance.

Hourly surface meteorological observations recorded at a nearby airport were employed to characterize the on-site meteorological conditions. Unfortunately, on-site air emission measurements were not conducted during the Landfill 3 air sampling program, and 30 out of the 120 hours measured at the nearby airport during the experiment were under conditions of no wind. In his model evaluation, Baker assumed that the receptors were directly downwind of the landfill and assigned an ambient wind speed of 1 m/sec for all no-wind conditions. Excluding the hours when winds were not upwind of the landfill, nearly 70 percent of the time that the receptors were assumed to be downwind of the landfill were under no-wind conditions. Although it is a generally accepted approach in air dispersion modeling to assign a wind speed for no-wind conditions, the uncertainty introduced in the concentration estimate by such meteorological adjustments should not be ignored.

Due to the lack of on-site emission measurements, emission estimates were developed from an analytical model (21). The emission estimates were later supported by back-calculated annual average landfill emission rates using the ambient monitoring data, local meteorological data, and the ISCST Gaussian air dispersion model (22). Table 4 presents the measured and predicted vinyl chloride concentrations at receptor sites A and B during the Landfill 3 air study as reported by Baker. Of the four models considered by Baker (Models 1 through 4), Models 1 and 4 were consistently found to perform less effectively than the other models, and are not addressed further in this analysis. Estimates from three other models, a K-theory model (Model 5), a simple box model (Model 6), and the modified box model, are also included in Table 4 for comparison.

For Site A, concentrations predicted from the modified box model differ from the measured concentrations by 3 to 45 percent, as shown in Table 4. (Table 5 summarizes the predicted hourly vinyl chloride concentrations for all 5 days using the proposed model.) The modified box model and the K-theory model appear to provide similar concentration estimates to those estimated by the two virtual-point Gaussian approaches (Models 2 and 3) but with improved accuracy. In contrast, the simple fixed-height box model (Model 6) utilized in the development of EPA's PCB cleanup advisory overpredicts by approximately 20-fold.

For Site B, all models except the K-theory approach performed poorly in predicting the ambient vinyl chloride concentrations. A further examination of the site topography, however, indicated that a ridge north of Site B directs most nighttime draining air and emissions away from this site (20). If one assumes that the air current was obstructed by the ridge during the calm condition and was able to pass over the ridge under other wind conditions, then the dispersion model should predict negligible concentration under the calm conditions. Table 4 presents the model predictions from the three Gaussian models incorporating these screened meteorological conditions. Using this more realistic representation of meteorological conditions, it is apparent that the modified box model performs well in predicting the near-field air concentrations.

DISCUSSION

While the concentrations predicted by the modified box model compare well with measured concentrations at the sites studied, the accuracy of

the model may vary depending on the specific site conditions. While the modified box model resembles the mathematical expression of the boundary-layer technology used in air emission estimation (23), it differs in the vertical representation of the plume dispersion and dependence on the atmospheric conditions.

Figure 3 displays the variation of on-site concentrations in terms of emission source sizes. In general, the model is relatively insensitive to changes in atmospheric stability with the exception of stability classes A and F. Figure 3 shows that the on-site air concentration utilizing the wind-profile exponent for urban environments is almost independent of the source characteristic length (or the downwind distance from the upwind edge of the source) for all atmospheric stabilities except Stability A. The effect of source sizes on the air concentrations becomes more apparent if one normalizes the on-site air concentrations by the concentration calculated for a 50-m long area source (Figure 4). The gradual variation of air concentrations with respect to source characteristic length is a result of the balance between the total emissions (source characteristic length), atmospheric stability (plume thickness) and wind shear. In the modified box model, the plume thickness is represented by a power-law relationship and the wind shear is implicitly conveyed by a power-law velocity profile. In an extremely unstable atmosphere (Stability class A), the power-law formula for σ_z may overestimate the plume thickness as much as 5-fold (based upon the ratio of plume thickness derived from the power-law formula and Briggs equations (14) at a distance of 3000 m). Thus, the modified box

model, may underpredict the air concentration for an area source under Stability A. In an extremely stable atmosphere (Stability Class F), the wind-profile exponent recommended by USEPA, which can be as high as 0.55, may not reflect the actual aerodynamic roughness characterized by the local topography. As a result, more rapid spatial variation of on-site air concentration with downwind distance is observed from the model estimates. More precise determination/selection of the dispersion coefficient (24,25), mixing layer, and wind shear would certainly improve the model's dependence on the source characteristic length.

The on-site or near-field air concentration is determined by on-site emission estimates and prevailing meteorological conditions. While emissions from a contaminated site are insensitive to the atmospheric conditions, the on-site or near-field air concentrations are inevitably affected by the atmospheric mixing. Table 3 shows how an arbitrarily assigned atmospheric stability (e.g., Stability D), which did not represent the observed atmospheric conditions (Stability F) for Landfill 2, underestimated the air concentration by 40- to 60-fold. The extent of this underestimation was substantially reduced when the atmospheric stability was adjusted to reflect the nighttime no-wind conditions (Stability F). Accurate determination of the prevailing meteorological conditions is thus essential to yield a meaningful prediction of the on-site air concentration.

CONCLUSION

A modified box model has been developed to correlate the emission rates and the on-site or near-field air concentrations based on the principle of mass conservation, continuous plume theory, and local meteorological conditions. It has been tested against measurements of air concentrations and emission rates for two Superfund sites and a waste landfill (with estimated emission rate). Preliminary findings indicate that the model results agree well with direct air measurements, and that the model may provide enhanced accuracy over other predictive schemes.

The modified box model can also be used in conjunction with the STAR Summaries and other default values (wind profile exponents and vertical dispersion coefficients) utilized by the USEPA to yield an annual average concentration in the assessment of public health risks.

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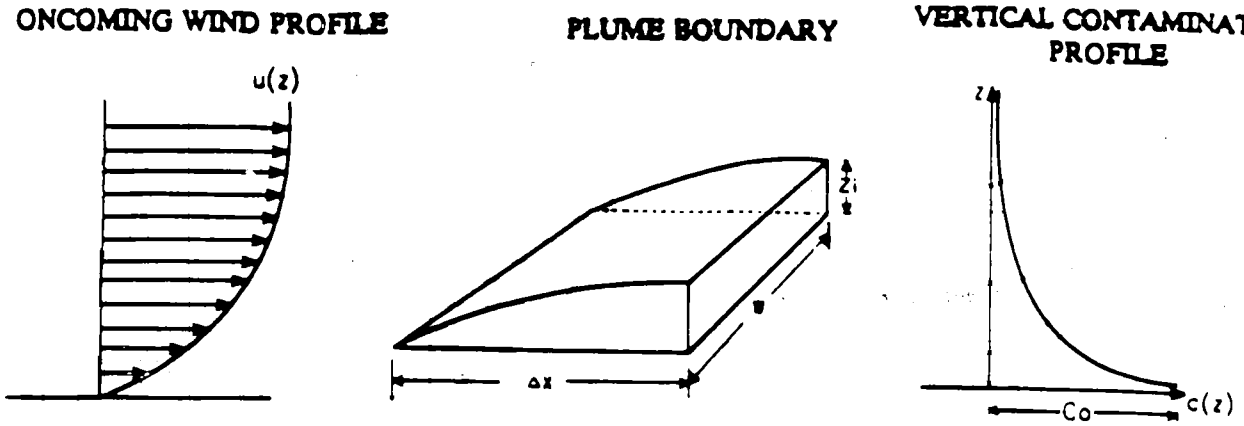

Figure 1. The modified "box" model.

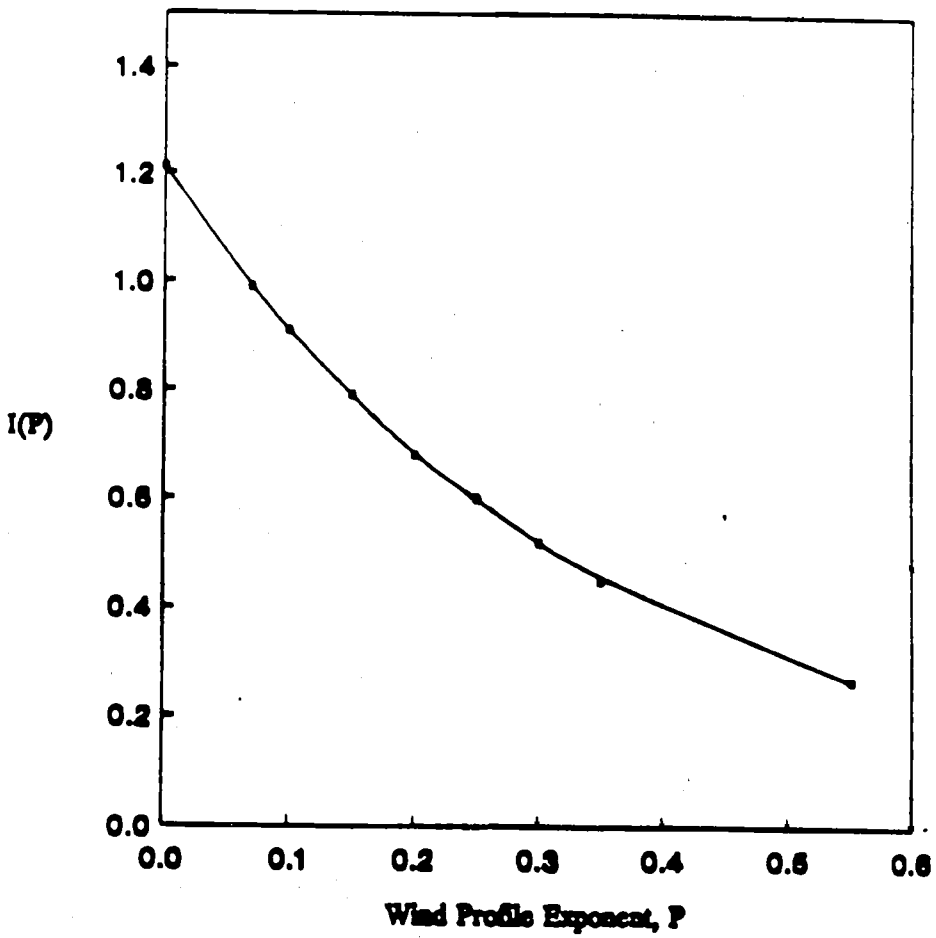

Figure 2. The integration function utilised in Equation 6.

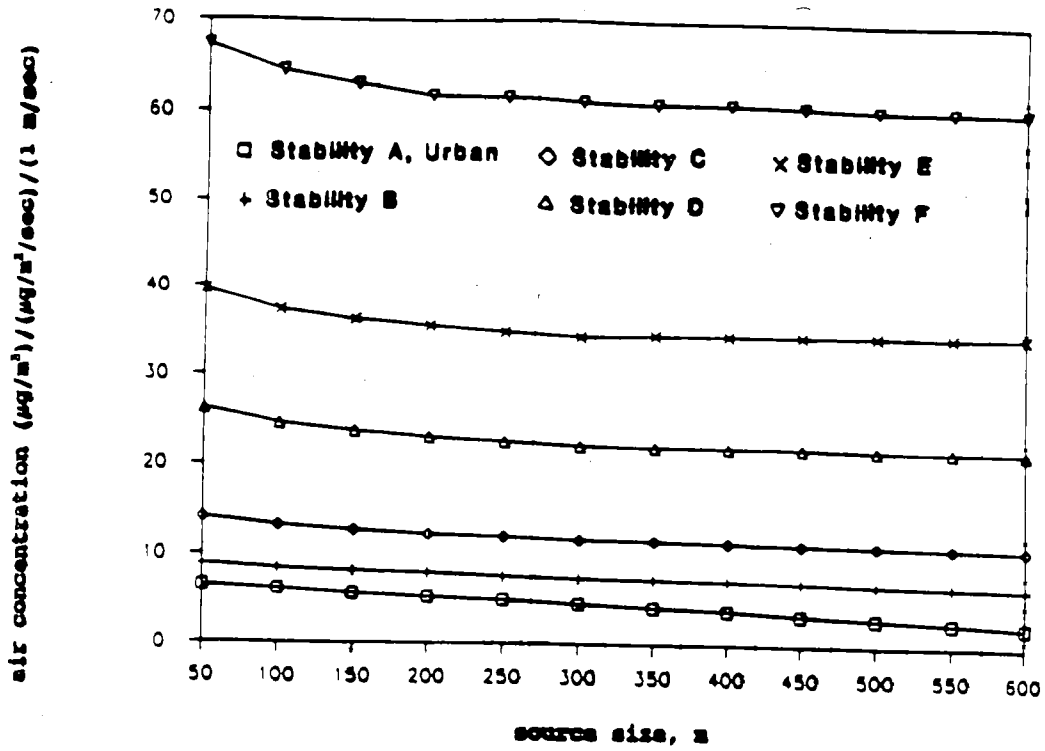

Figure 3 VARIATION OF ON-SITE AIR CONCENTRATION WITH RESPECT TO EMISSION SOURCE SIZE

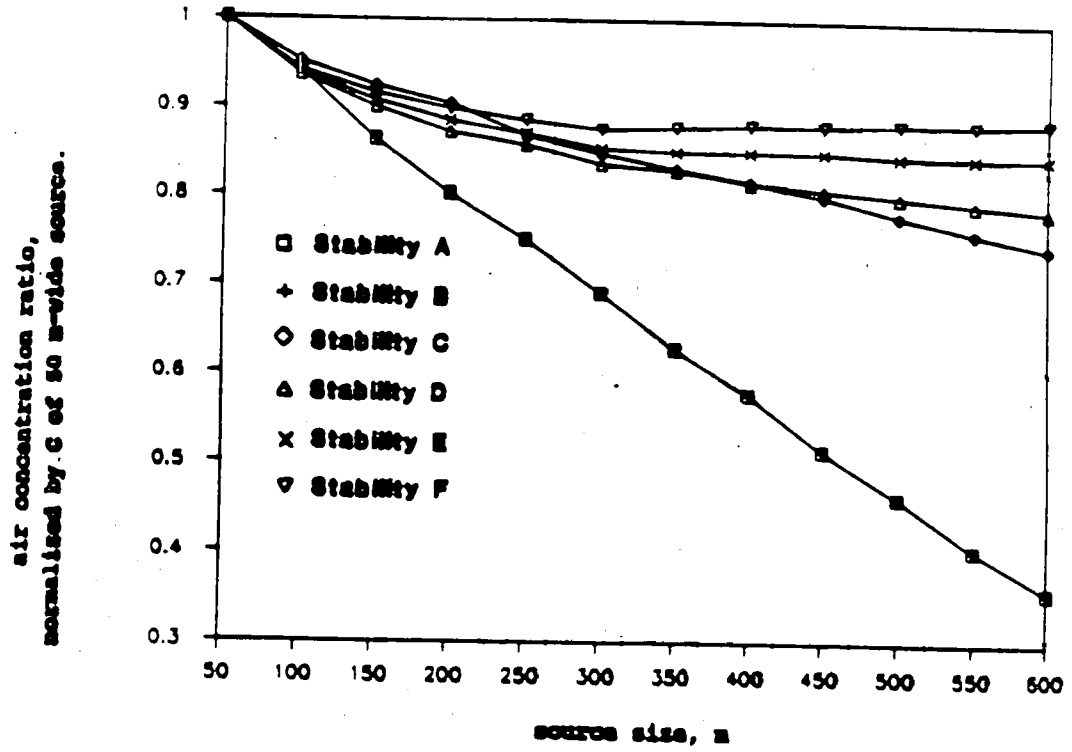

Figure 4 RELATIVE VARIATION OF ON-SITE AIR CONCENTRATION WITH RESPECT TO EMISSION SOURCE SIZE

Table 1 Statistics for air concentration sampled from Landfill 1 (17).

Chemical Constituent	Sulfur dioxide		Total Hydrocarbons	
Sample	Background	Surface	Background	Surface
No. of Samples	10	32	10	32
Data Range, ppmv	<0.01 - 0.015	<0.01 - 0.047	2.2 - 4.2	2.0 - 4.0
Mean	0.0077	0.01703	2.9	2.628
Standard Deviation	0.00637	0.0114	0.611	0.549
Skewness	1.0799	1.0367		
Coefficient of Variance	56.79	67.17	21.07	20.89
P - Value	0.0101		> 0.5	
Summary				
Mean	0.00933 ppmv or 24.88 ug/m^3		undistinguishable ...	

Table 2 Comparison of the predicted and measured SO2 emission rates at Landfill 1 (17).

Atmospheric Stability	Ambient Wind Speed, m/s	Emission rate, ug/m^2-s Measured Mean	Measured High*	Air concentration, ug/m^3 Measured Mean	Measured High*	Predicted Mean	Predicted High*
B	2	3.33	12.38	24.88	55.28	12.99	48.28
B	3	3.33	12.38	24.88	55.28	8.66	32.19
B	4	3.33	12.38	24.88	55.28	6.49	24.14
C	2	3.33	12.38	24.88	55.28	20.08	74.65
C	3	3.33	12.38	24.88	55.28	13.39	49.77
C	4	3.33	12.38	24.88	55.28	10.06	37.39
D	2	3.33	12.38	24.88	55.28	36.63	136.18
D	3	3.33	12.38	24.88	55.28	24.41	90.75
D	4	3.33	12.38	24.88	55.28	18.32	68.09

* : High value is defined as Mean + 1 S.D.

Table 3 Statistics for air samples from Landfill 2 and comparison of the predicted and measured air concentrations (19)

Chemical Constituent	Emission rate (ug/m^2·sec) Mean	High*	Stability	Wind speed (m/sec)	Air Concentration Measured (ppbv)	Measured (ug/m^3)	Predicted (ug/m^3) Mean	High*
Benzene	9.98E-03	0.01265	D	0.5	1.55	5.04	0.22	0.28
			D	0.8			0.18	0.22
			D	1			0.11	0.14
			E	0.5			0.71	0.90
			E	0.8			0.45	0.56
			E	1			0.36	0.45
			F	0.5			1.48	1.87
			F	0.8			0.92	1.17
			F	1			0.74	0.94
Toluene	1.37E-02	0.0181	D	0.5	2.6	9.98	0.30	0.40
			D	0.8			0.24	0.32
			D	1			0.15	0.20
			E	0.5			0.98	1.29
			E	0.8			0.61	0.81
			E	1			0.49	0.65
			F	0.5			2.03	2.68
			F	0.8			1.27	1.68
			F	1			1.02	1.34
1,1,1-trichloroethane	1.00E-02	0.01613	D	0.5	2.4	11.34	0.22	0.31
			D	0.8			0.18	0.25
			D	1			0.11	0.16
			E	0.5			0.71	1.01
			E	0.8			0.45	0.63
			E	1			0.36	0.50
			F	0.5			1.48	2.09
			F	0.8			0.93	1.31
			F	1			0.74	1.05

Table 4 Model estimates and measured vinyl chloride concentrations (ppb) at Landfill 3

Site	Method	March 7-8	March 8-9	August 5-6	August 6-7	August 7-8	Average
A	Measured	12	5	7	12	9	9
	Model 1	25.1	19.4	40.0	45.7	45.5	35.1
	Model 2	9.1	7.3	14.8	16.7	16.9	13.0
	Model 3	4.9	4.0	8.0	9.0	9.1	7.0
	Model 4	45.9	42.8	76.7	81.1	87.3	66.8
	Model 5	6.6	5.1	11.7	11.9	11.9	9.4
	Model 6	116.0	108.2	193.9	205.0	220.6	168.7
	Modified	6.5	4.8	10.7	11.2	10.5	8.8
B	Measured	5	7	2	4	2	4
	Model 1	24.3	13.1	30.4	32.4	32.2	26.5
	Model 2	11.5	6.1	14.2	15.3	15.2	12.5
	Model 3	6.5	3.7	8.4	8.7	8.9	7.2
	Model 4	35.5	28.6	62.8	62.0	66.7	51.1
	Model 5	3.3	2.3	5.7	5.6	5.7	4.5
	Model 6	40.4	32.6	71.5	70.6	76.0	58.2
	Modified	9.3	6.7	15.9	16.7	15.5	12.8
	····· with adjusted meteorological conditions ·····						
B	Measured	5	7	2	4	2	4
	Model 2	7.1	4.5	1.2	0.1	2.2	3.0
	Model 3	3.0	2.5	1.1	0.2	1.4	1.6
	Modified	4.9	4.6	0.9	1.7	2.7	3.8

Measured : Landfill 3 (20)
Model 1 : Ground-level point source (2)
Model 2 : Virtual point source, Turner (2)
Model 3 : Virtual point source, USEPA (3)
Model 4 : Simple box, Urban Air Pollution (6)
Model 5 : K-theory (8)
Model 6 : Simple box, USEPA (7)
Modified : Modified box model

Table 5 Model estimates at Landfill 3 using the modified box model.

Hour	Station A					Station B				
	March 7 - 8	March 8 - 9	August 5 - 6	August 6 - 7	August 7 - 8	March 7 - 8	March 8 - 9	August 5 - 6	August 6 - 7	August 7 - 8
10:00 AM	0	0	0	7.29	0	0	0	0	14.33	0
11:00 AM	5.15	0	0	0	0	9.99	0	0	0	0
12:00 PM	0	0	0	0	0	0	0	0	0	0
1:00 PM	0	1.06	0	0	0	0	0	0	0	0
2:00 PM	0	1.55	0	0	0	0	0	0	0	0
3:00 PM	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	0	0	0	0	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	2.99	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0
8:00 PM	8.64	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	5.05	0	0	0	0
10:00 PM	24.69	0	0	0	0	35.91	0	0	0	0
11:00 PM	24.69	12.35	0	0	34.97	35.91	17.95	0	0	51.52
12:00 AM	9.88	24.69	0	34.97	34.97	14.36	35.91	0	51.52	51.52
1:00 AM	9.88	0	34.97	34.97	34.97	14.36	14.36	51.52	51.52	51.52
2:00 AM	24.69	12.35	34.97	34.97	34.97	35.91	17.95	51.52	51.52	51.52
3:00 AM	9.88	0	34.97	34.97	34.97	14.36	14.36	51.52	51.52	51.52
4:00 AM	9.88	9.88	34.97	34.97	34.97	14.36	14.36	51.52	51.52	51.52
5:00 AM	9.88	9.88	34.97	34.97	13.99	14.36	14.36	51.52	51.52	20.61
6:00 AM	0	12.35	34.97	34.97	13.99	14.36	17.95	51.52	51.52	20.61
7:00 AM	3.51	8.78	34.97	4.97	6.21	5.34	13.34	51.52	7.66	9.57
8:00 AM	0	0	0	0	8.29	0	0	2.29	0	12.76
9:00 AM	5.15	0	12.43	12.43	0	9.99	0	19.15	19.15	0
Average	6.08	4.00	10.72	11.23	10.51	9.34	6.69	15.92	16.74	15.53

APPENDIX C

Estimation of Chemical Concentrations in Produce

APPENDIX C
Estimation of Chemical Concentrations in Produce

Vegetable contaminant concentrations due to watering a garden from irrigation wells were calculated for 4 different types of produce:

1) Leafy vegetables - e.g. lettuce and cabbage
2) Root vegetables - e.g. carrots and potatoes
3) Non-leafy exposed vegetables - e.g. tomatoes and snap beans
4) Non-leafy protected vegetables - e.g. corn and peas

There are several potential exposure pathways for the uptake of contaminants by produce. Topp et al. (1986) theorized that plant uptake is due to the following pathways:

1) Root uptake and translocation
2) Vapor uptake
3) Soil or dust uptake by shoots
4) Oil cell uptake (for oil-containing plants)

Topp et al. (1986) found that total uptake by plants could be correlated with physical/chemical properties assuming that contamination only occurs through root uptake and translocation, and via uptake of vapor from the air. The other two pathways, soil/dust uptake and oil cell uptake were not addressed.

ENVIRON evaluated the uptake of contaminants by the following mechanisms:

1) Root uptake and translocation;
2) Vapor uptake; and
3) Direct deposition on exposed surfaces.

Each type of produce varies in the mechanism of chemical uptake. For example, root uptake is the primary mechanism for bioconcentration in root vegetables. Direct deposition of irrigation water on the edible portion of the plant is not possible, and vapor uptake through the aboveground portion of the plant is considered minimal in comparison to root uptake. For other produce types, direct deposition on the fruit of the plant and vapor uptake from leaves, stems, and the fruit itself may contribute to the contaminant concentration. The pathways considered for each vegetable type are presented on Table C-1.

TABLE C-1 Mechanism of Chemical Uptake by Produce Type	
Produce Type	**Exposure Pathways**
Leafy	Stem, vapor, deposition
Root	Root
Non-leafy Exposed	Stem, vapor, deposition
Non-leafy Protected	Stem, vapor

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The steps for calculating vegetable concentrations for each type of uptake are presented below.

A. Root Uptake and Translocation

1. Estimation of Bioconcentration Factors

The uptake of contaminants from water in soil is via direct uptake by the roots and subsequent translocation to the aboveground portions. For root plants it was assumed that the water used to irrigate the garden was taken up directly by the plant root. The equation used is a modification of plant root uptake from soil (Ryan 1988):

$$BCF_{root} = [10^{(0.77 \log K_{ow} - 1.52)} + 0.82]$$

where:

BCF_{root} = Bioconcentration factor from roots
$\log K_{ow}$ = Octanol-water partition coefficient

Translocation of contaminants may be important for plant types with edible portions aboveground. Translocation of PBCs has been studied in several plants (Iwata and Gunther 1976, Bacci and Gaggi 1985) and it is believed that there is little translocation of PCBs beyond the peel of the root. Translocation of contaminants to the aboveground portions were estimated using a modification of soil uptake by stems (Ryan 1988):

$$BCF_{stem} = [10^{(0.95 \log K_{ow} - 2.05)} + 0.82] * [0.784 * 10^{\{-0.434 [(\log K_{ow} - 1.78)2]/2.44\}}]$$

where:

BCF_{stem} = Bioconcentration factor for stems
$\log K_{ow}$ = Octanol-water partition coefficient

Log K_{ow}s used to derive root and stem BCFs, and the resulting BCFs for roots and stems are presented on Table C-2.

2. Calculation of Contaminant Concentration via Root Uptake

Concentrations of chemicals in produce were estimated using the following equation (Travis et al. 1983):

$$C_{root} = BCF_{root} * C_{H_2O}$$

or,

$$C_{stem} = BCF_{stem} * C_{H_2O}$$

where:

C_{root} = Concentration in produce due to root uptake, (ug/kg)
C_{stem} = Concentration in produce due to root translocation, (ug/kg)
BCF_{root} = Bioconcentration factor for root uptake
BCF_{stem} = Bioconcentration factor for root translocation
C_{H_2O} = Concentration in water, (mg/l)

Root vegetable contaminant concentrations were estimated using the root bioconcentration. Concentrations in the edible portion of all other types of produce are determined by the mechanism of root translocation, therefore the concentrations were estimated using stem bioconcentration. The concentrations due to root uptake and translocation are presented in Table C-3.

TABLE C-2
Log K_{ow}s and BCFs for Root Uptake and Translocation

CHEMICAL	Log K_{ow}	Log K_{ow} Source	ROOT BCF	STEM BCF
Acetone	-2.40E-01	Verschueren 1983	8.40E-01	1.22E-01
Benzene	2.13E+00	USEPA 1979	2.14E+00	1.31E+00
Carbon disulfide	2.16E+00	Hansch&Leo 1979	2.21E+00	1.35E+00
Chloroethane	1.43E+00	Hansch&Leo 1979	1.20E+00	7.63E-01
Chloroform = Trichloromethane	1.97E+00	Hansch&Leo 1979	1.81E+00	1.15E+00
Dichloroethane (1,1-)	1.79E+00	Hansch&Leo 1979	1.54E+00	9.93E-01
Dichloroethane (1,2) = Ethylene dichloride	1.45E+00	Banerjee 1985	1.21E+00	7.74E-01
Dichloroethylene (trans-1,2)	1.48E+00	USEPA 1979	1.24E+00	7.91E-01
Dichloroethylene (1,1-) = Vinylidene chloride	1.48E+00	USEPA 1979	1.24E+00	7.91E-01
Lindane = Hexachlorocyclohexane, gamma	3.24E+00	Hansch&Leo 1979	1.03E+01	3.76E+00
Methyl ethyl ketone (MEK) = 2-butanone	2.60E-01	Verschueren 1983	8.68E-01	2.54E-01
Methylene chloride = Dichloromethane	1.25E+00	Hansch&Leo 1979	1.10E+00	6.69E-01
Polychlorinated biphenyls (PCBs)	6.04E+00	USEPA 1982	6.00E-02	6.00E-03
Tetrachloroethane (1,1,2,2-)	2.39E+00	Banerjee 1985	2.91E+00	1.67E+00
Tetrachloroethylene = Perchloroethylene	2.53E+00	Banerjee 1985	3.50E+00	1.92E+00
Toluene = Toluol	2.69E+00	Hansch&Leo 1979	4.38E+00	2.25E+00
Trichloroethane (1,1,1-) = Methyl chloroform	2.47E+00	Banerjee 1985	3.23E+00	1.81E+00
Trichloroethylene	2.42E+00	USEPA 1982	3.02E+00	1.72E+00
Trichlorofluoromethane	2.53E+00	Hansch&Leo 1979	3.50E+00	1.92E+00
Vinyl chloride	6.00E-01	USEPA 1979	9.07E-01	3.78E-01

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TABLE C-3
Vegetable Concentrations due to Root Uptake and Translocation

Chemical	Concentration in Roots (μg/g fresh)	Concentration in Stems (μg/g fresh)
Acetone	1.96E-02	2.84E-03
Benzene	2.07E-02	1.27E-02
Carbon disulfide	6.06E-02	3.70E-02
Chloroethane	2.67E-02	1.69E-02
Chloroform = Trichloromethane	2.24E-02	1.42E-02
Dichloroethane (1,1-)	1.34E-02	8.64E-03
Dichloroethane (1,2-) = Ethylene dichloride	1.23E-02	7.84E-03
Dichloroethylene (trans-1,2)	3.98E-01	2.55E-01
Dichloroethylene (1,1-) = Vinylidene chloride	1.98E-02	1.27E-02
Lindane = Hexachlorocyclohexane, gamma	4.10E-04	1.50E-04
Methyl ethyl ketone (MEK) =2-butanone	4.64E-02	1.36E-02
Methylene chloride = Dichloromethane	6.14E-02	3.74E-02
Polychlorinated biphenyls (PCBs)	6.06E-05	6.06E-06
Tetrachloroethane (1,1,2,2-)	2.99E-02	1.72E-02
Tetrachloroethylene = Perchloroethylene	1.92E-02	1.05E-02
Toluene = Toluol	5.63E-02	2.89E-02
Trichloroethane (1,1,1) = Methyl chloroform	6.46E-02	3.61E-02
Trichloroethylene	3.54E-01	2.01E-01
Trichlorofluoromethane	5.55E-02	3.04E-02
Vinyl chloride	3.40E-02	1.42E-02

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B. Vapor Uptake

1. Estimation of Vapor-phase Bioconcentration

Vapor uptake can occur from the volatilization of compounds from the irrigation water. The formula to calculate the BCF for vapor has been developed by Bacci et al. (1990):

$$BCF_{vapor} = \frac{10^{(1.95 + 1.14 * \log K_{ow})}}{224.37 * HLC}$$

where:

BCF_{vapor}	=	Bioconcentration factor from vapor
$\log K_{ow}$	=	Octanol-water partition coefficient
HCL	=	Henry's Law Constant (unitless)

Leafy, non-leafy exposed, and non-leafy protected produce uptake from vapor was estimated from the above formula. HLCs used in the calculation, and resulting BCFs are presented in Table C-4.

2. Calculation of Contaminant Concentration via Vapor Uptake

Contaminant concentrations were calculated using the following formula (Bacci et al. 1990):

$$C_{vapor} = BCF_{vapor} * C_{air} * CF$$

where:

C_{vapor}	=	Concentration in leaf due to vapor uptake (μg/g day)
BCF_{vapor}	=	Bioconcentration factor from vapor
C_{air}	=	Concentration in air (mg/m^3)
CF	=	Conversion factor, 1 E-03

Air concentrations were modeled from water concentrations using a USEPA emission model (USEPA 1987) and the air dispersion model described in Appendix B.

TABLE C-4
Produce Vapor Uptake: HLCs, BCFs, and Produce Concentrations

Compounds	Henry's Law Constant (unitless)	Henry's Law Constant (Source)	Vegetable Vapor BCF	Concentration from Vapor (ug/g dry)
Acetone	8.42E-04	Calculated	3.16E-02	1.37E-08
Benzene	2.28E-01	USEPA 1982	5.88E-02	1.51E-08
Carbon disulfide	5.03E-01	Calculated	2.88E-02	2.75E-08
Chloroethane	6.15+00	USEPA 1982	3.47E-04	2.94E-10
Chloroform = Trichloromethane	1.17E-01	Gossett 1987	7.53E-02	2.50E-08
Dichloroethane (1,1-)	1.76E-01	USEPA 1982	3.12E-02	9.67E-09
Dichloroethane (1,2-) = Ethylene dichloride	4.00E-02	USEPA 1982	5.62E-02	1.50E-08
Dichloroethylene (trans-1,2)	2.68E-01	USEPA 1982	9.08E-03	8.08E-08
Dichloroethylene (1,1-) = Vinylidene chloride	1.39E+00	USEPA 1982	1.75E-03	1.04E-09
Lindane = Hexachlorocyclohexane, gamma	3.20E-04	USEPA 1982	7.72E+02	1.99E-07
Methyl ethyl ketone (MEK) =2-butanone	1.12E-03	Calculated	8.84E-02	8.92E-08
Methylene chloride = Dichloromethane	8.29E-02	Gossett 1987	1.61E-02	3.43E-08
Polychlorinated biphenyls (PCBs)	4.37E-02	USEPA 1982	8.54E+04	1.90E-03
Tetrachloroethane (1,1,2,2-)	1.55E-02	USEPA 1982	1.71E+00	4.95E-07
Tetrachloroethylene = Perchloroethylene	1.06+00	Gossett 1987	3.61E-02	4.70E-09
Toluene = Toluol	2.60E-01	USEPA 1982	2.24E-01	7.85E-08
Trichloroethane (1,1,1-)	5.86E-01	Gossett 1987	5.58E-02	2.76E-08
Trichloroethylene	3.72E-01	Gossett 1987	7.71E-02	2.28E-07
Trichlorofluoromethane	4.57E+00	USEPA 1982	8.38E-03	4.53E-09
Vinyl chloride	8.19E-02	USEPA 1982	2.95E-03	4.42E-09

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It was assumed that the leaf concentration was equivalent to the concentration in the edible portion of all non-root produce (e.g. leafy, non-leafy exposed, and non-leafy protected). This is a reasonable assumption for both leafy and non-leafy exposed produce where the edible portions of the plant are directly exposed to vapors and uptake will occur directly to the fruit of the plant. It is a conservative assumption for non-leafy protected produce. In this case, the fruit of the plant is not exposed to the vapor and translocation would have to occur for the contaminant to reach the fruit. Data are not available for all compounds assessed, therefore it was conservatively assumed that vapors could be take up by aboveground portions of a plant and translocated to the edible portions. Dry weight was converted to wet weight concentrations by multiplying dry weight by one minus the wet weight fraction for each produce type. Wet weight fractions used: leafy (0.931), non-leafy exposed (0.892), and non-leafy protected (0.740) (Ecologistics 1984). The resulting concentrations in produce attributable to vapor uptake are presented in Table C-4.

C. Direct Deposition

1. Estimation of Direct Deposition Bioconcentration

When a garden is watered, the water deposits on the aboveground portions of the plant, with a majority of the water running off. Compounds remaining on the leaves or stems can be removed by a number of mechanisms: volatilization, weathering due to precipitation, and photolysis. ENVIRON only included removal by weathering in the estimation of uptake by irrigation water deposited on the aboveground portion of produce.

Travis et al. (1983) developed a formula for calculating total deposition (dry and wet) and the resulting concentrations in produce. This formula was modified to estimate the concentrations only attributable to watering the garden from the irrigation wells:

$$C_{DEP} = \frac{C_{leaf} * [1-e^{-(K_w * S)}]}{Y * CF}$$

where,

C_{DEP} = Concentration in produce, ug/g wet weight
C_{leaf} = Total contaminant deposited on leaf, μg
K_w = Weathering rate loss constant, seconds^{-1}
S = Growing season, seconds
Y = Crop yield, kg
CF = Conversion factor, 1000 g/kg

The total contaminant deposited on the leaf, C_{leaf}, was estimated from the concentration in well water, total water volume (irrigated on garden), amount of water retained on aboveground portions, and interception fractions (portion of garden area covered by plant surface area):

$$M_{leaf} = C_{H2O} * W_T * W_F * I_F * P * CF$$

where

M_{leaf} = Total contaminant deposited on leaf, μg
C_{H2O} = Concentration in well water, mg/l
W_T = Total water volume irrigated, l
W_F = Water fraction remaining on produce
I_F = Interception fraction, unitless
P = Portion of garden allocated for produce type
CF = Conversion factor, 1,000 μg/mg

The total water volume was estimated from the exposure duration for watering the garden (30 min.), and the flow rate for a typical hose (5 gpm) (van der Leeden, Troise, and Todd 1990). The fraction of water remaining on plant surfaces was conservatively estimated to be 5% in absence of any data. This results in an overly conservative estimate of 28 l of water remaining on the surfaces of plants in a garden 325 ft^2. Interception fractions were developed by Baes (1984), based on planting patterns, number of plants per row, number of rows and diameter of the plant. Portions of a typical garden allocated for each produce type were based on homegrown vegetable consumption rates (75th-85th percentile) (USEPA 1989) and vegetables typically grown in a garden.

Produce Type	Portion of Garden
Leafy	9%
Root	12%
Non-Leafy Exposed	44%
Non-Leafy Protected	35%

Assumptions used in the calculation of vegetable concentraion due to direct deposition are presented in Table C-5. The resulting concentrations for leafy and non-leafy exposed produce are presented in Table C-6.

TABLE C-5
Assumptions Used in the Estimation of Produce Concentration Due to Direct Deposition

Assumption	Value	Reference
Time Spent Irrigating (min/day)	30	ENVIRON
Irrigation water volume (L/min)	1.89E+01	van der Leeden 1990
Total water volume (L/day)	567.81	ENVIRON
Weather rate loss constant (15 day half-life)	5.35E-07	Willis et al. 1980
Growing season - 5 months (sec)	1.30E+07	ENVIRON
Leafy vegetables		
Interception fraction	0.15	0.15 Baes et al. 1984
Fraction of garden area	0.09	0.09 ENVIRON/EFH 1989
Water volume remaining on plants (L)	3.83E-01	ENVIRON/Travis 1983
Crop yield (kg)	7.09	ENVIRON
Exposed vegetables		
Interception fraction	0.052	Baes et al. 1984
Fraction of garden area	0.44	ENVIRON/EFH 1989
Water volume remaining on plants (L)	6.50E-01	ENVIRON/Travis 1983
Crop yield (kg)	25.5	ENVIRON

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TABLE C-6 Concentration in Produce Due to Direct Deposition		
Chemical	Leafy Vegetable Concentration (ug/g fresh)	Exposed Vegetable Concentration (ug/g fresh)
Acetone	1.26E-03	5.94E-04
Benzene	5.24E-04	2.47E-04
Carbon disulfide	1.48E-03	6.98E-04
Chloroethane	1.20E-03	5.66E-04
Chloroform = Trichloromethane	6.68E-04	3.15E-04
Dichloroethane (1,1-)	4.70E-04	2.22E-04
Dichloroethane (1,2-) = Ethylene dichloride	5.46E-04	2.58E-04
Dichloroethylene (trans-1,2)	1.74E-02	8.20E-03
Dichloroethylene (1,1-) = Vinylidene chloride	8.64E-04	4.08E-03
Lindane = Hexachlorocyclohexane, gamma	2.16E-06	1.02E-06
Methyl ethyl ketone (MEK) =2-butanone	2.89E-03	1.36E-03
Methylene chloride = Dichloromethane	3.02E-03	1.43E-03
Polychlorinated biphenyls (PCBs)	5.45E-05	2.57E-05
Tetrachloroethane (1,1,2,2-)	5.55E-04	2.62E-04
Tetrachloroethylene = Perchloroethylene	2.97E-04	1.40E-04
Toluene = Toluol	6.94E-04	3.28E-04
Trichloroethane (1,1,1-) = Methyl chloroform	1.08E-03	5.09E-04
Trichloroethylene	6.32E-03	2.98E-03
Trichlorofluoromethane	8.56E-04	4.04E-04
Vinyl chloride	2.02E-03	9.53E-04

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Following is an example of uptake of chloroform by various routes for non-leafy exposed produce.

A) Stem uptake:

$$BCF_{stem} = [10^{(0.95 \log K_{ow} - 2.05)} + 0.82] * [0.784 * 10^{\{-0.434 [(\log Kow - 1.78)^2]/2.44\}}]$$

$$= [10^{(0.95 * 1.97 - 2.05)} + 0.82] * [0.784 * 10^{\{-0.434[(1.97 - 1.78)^2]/2.44\}}]$$

$$= 1.15$$

$$C_{stem} (\mu g/g \text{ wet weight}) = BCF_{stem} * C_{H_2O}$$

$$= 1.15 * 1.24E\text{-}02$$

$$= 1.42E\text{-}02 \ \mu g/g$$

B) Vapor uptake:

$$BCF_{vapor} = \frac{10^{(-1.95 + 1.14 * \text{Log } K_{ow})}}{224.37 * HCL}$$

$$= \frac{10^{(-1.95 + 1.14 * 1.97)}}{224.37 * 0.117}$$

$$= \frac{1.98}{26.25} = 7.53E\text{-}02$$

$$C_{vapor} (\mu g/g \text{ dry weight}) = BCF_{vapor} * C_{air} * CF$$

$$= 7.53E\text{-}02 * 3.32E\text{-}04 * 1E\text{-}03$$

$$= 2.50E\text{-}08 \ \mu g/g \text{ dry weight}$$

Conversion to wet weight:

$$2.50E\text{-}08 * (1\text{-}0.892) = 2.70E\text{-}09 \ \mu g/g \text{ wet weight}$$

C) Direct Deposition

1) Mass contaminant deposited on leaf:

$$M_{leaf} = C_{H_2O} * W_T * W_F * I_F * P * CF$$

$$= 1.24E\text{-}02 * 567.81 * 0.05 * 0.052 * 0.44 * 1000$$

$$= 8.04\ \mu g$$

2) Concentration in exposed produce:

$$C_{DEP} = \frac{C_{leaf} * [1\text{-}e^{-(K_w * S)}]}{Y * 1000}$$

$$= \frac{8.04 * [1 - e^{-(5.35E\text{-}07 * 1.30E+07)}]}{25.5 * 1000}$$

$$= 3.15E\text{-}04\ \mu g/g \text{ wet weight}$$

D) Total concentration in non-leafy exposed produce:

$$C_{Total} = C_{stem} + C_{vapor} + C_{DEP}$$

$$= 1.42E\text{-}02 + 6.5E\text{-}09 + 3.15E\text{-}04$$

$$= 1.45E\text{-}02\ \mu g/g$$

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APPENDIX D
Cancer Risk Tables for Each Exposure Scenario

Table D-1. Lifetime Cancer Risk for Contruction Workers

CHEMICAL	Inhalation Vapor CANCER RISK	Inhalation Particulates CANCER RISK	Ingestion, Soil CANCER RISK	Dermal, Soil CANCER RISK	TOTAL CANCER RISK
Acetone	NA	NA	NA	NA	0.00E+00
Aldrin	3.13E-10	2.09E-11	1.62E-09	5.13E-10	2.47E-09
Anthracene	NA	NA	NA	NA	0.00E+00
Benzo(a)anthracene	NC	NC	5.14E-09	1.63E-09	6.77E-09
Benzo(a)anthracene (inhalation)	3.87E-11	3.51E-11	NC	NC	7.38E-11
Benz(a)pyrene	NC	NC	3.20E-08	1.01E-08	4.21E-08
Benz(a)pyrene (inhalation)	1.36E-10	2.18E-10	NC	NC	3.54E-10
Benzo(b)fluoranthene	NC	NC	4.90E-09	1.55E-08	2.04E-08
Benzo(b)fluoranthene (inhalation)	1.82E-10	3.36E-11	NC	NC	2.15E-10
Benzo(ghi)perylene	NC	NC	5.28E-10	1.67E-10	6.95E-10
Benzo(ghi)perylene (inhalation)	7.27E-13	3.61E-12	NC	NC	4.33E-12
Benzo(k)fluoranthene	NC	NC	2.10E-09	6.65E-10	2.77E-09
Benzo(k)fluoranthene (inhalation)	1.43E-10	1.44E-11	NC	NC	1.58E-10
Carbon disulfide	NC	NC	NA	NA	0.00E+00
Carbon disulfide (inhalation)	NA	NA	NC	NC	0.00E+00
Chrysene	NC	NC	1.57E-10	4.96E-11	2.06E-10
Chrysene (inhalation)	2.95E-12	1.08E-12	NC	NC	4.02E-12
Di-n-octyl phthalate	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,1-)	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	5.17E-09	3.55E-13	2.76E-11	8.73E-11	5.28E-09
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	9.15E-10	2.90E-09	3.81E-09
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	6.50E-07	2.36E-11	NC	NC	6.50E-07
Ethylbenzene	NA	NA	NA	NA	0.00E+00
Floranthene	NA	NA	NA	NA	0.00E+00
Fluorene	NA	NA	NA	NA	0.00E+00
Hexachlorocyclohexane, beta isomer (beta-HCH)	2.21E-11	1.72E-12	1.34E-10	4.23E-10	5.80E-10
Indeno(1,2,3)perylene	NC	NC	5.77E-09	1.83E-09	7.60E-09
Indeno(1,2,3)perylene (inhalation)	1.54E-11	3.95E-11	NC	NC	5.49E-11
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NA	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	NC	1.44E-11	4.56E-11	6.00E-11
Methylene chloride = Dichloromethane (inhl.)	9.97E-09	3.46E-13	NC	NC	9.97E-09
Phenanthrene	NA	NA	NA	NA	0.00E+00
Polychlorinated biphenyls (PCBs)	NAR	NAR	3.19E-08	1.01E-07	1.33E-07
Pyrene	NC	NC	3.83E-09	1.21E-09	5.04E-09
Pyrene (inhalation)	3.76E-10	2.62E-11	NC	NC	4.02E-10
Toluene = Toluol	NC	NC	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NA	NC	NC	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NC	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	NA	NA	NC	NC	0.00E+00
Trichloroethane (1,1,2-)	6.75E-09	1.01E-12	7.85E-11	2.48E-10	7.07E-09
Trichloroethylene	NC	NC	3.26E-11	1.03E-10	1.36E-10
Trichloroethylene (inhalation)	8.39E-09	6.50E-13	NC	NC	8.39E-09
Vinyl chloride	NC	NC	6.48E-09	2.05E-08	2.70E-08
Vinyl chloride (inhalation)	8.78E-07	1.07E-11	NC	NC	8.78E-07
Sum of all chemicals	1.56E-06	4.31E-10	9.56E-08	1.57E-07	1.81E-06

CHEMICAL	Inhalation Vapor CANCER RISK	Inhalation Particulates CANCER RISK	Ingestion, Soil CANCER RISK	Dermal, Soil CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	0.00E+00
Aldrin	8.59E-10	1.76E-10	8.94E-08	1.41E-08	1.05E-07
Anthracene	NA	NC	NC	NC	0.00E+00
Benzo(a)anthracene	NC	NAR	2.53E-07	4.00E-08	2.93E-07
Benzo(a)anthracene (inhalation)	1.05E-10	2.65E-10	NAR	NAR	3.70E-10
Benz(a)pyrene	NC	NAR	1.67E-06	2.65E-07	1.94E-06
Benz(a)pyrene (inhalation)	3.71E-10	1.75E-09	NAR	NAR	2.12E-09
Benzo(b)fluoranthene	NC	NAR	2.48E-07	3.92E-07	6.39E-07
Benzo(b)fluoranthene (inhalation)	4.97E-10	2.59E-10	NAR	NAR	7.56E-10
Benzo(ghi)perylene	NC	NAR	3.22E-08	5.09E-09	3.73E-08
Benzo(ghi)perylene (inhalation)	1.99E-12	3.36E-11	NAR	NAR	3.56E-11
Benzo(k)fluoranthene	NC	NAR	1.11E-07	1.76E-08	1.29E-07
Benzo(k)fluoranthene (inhalation)	3.92E-10	1.17E-13	NAR	NAR	3.92E-10
Carbon disulfide	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NA	NC	NC	NC	0.00E+00
Chrysene	NC	NAR	7.78E-09	1.23E-09	9.01E-09
Chrysene (inhalation)	8.07E-12	8.13E-12	NAR	NAR	1.62E-11
Di-n-octyl phthalate	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,1-)	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	1.42E-08	2.13E-12	1.04E-09	1.64E-09	1.69E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NAR	4.61E-09	7.30E-09	1.19E-08
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	1.78E-06	4.29E-11	NAR	NAR	1.78E-06
Ethylbenzene	NA	NC	NC	NC	0.00E+00
Floranthene	NA	NA	NA	NA	0.00E+00
Fluorene	NA	NC	NC	NC	0.00E+00
Hexachlorocyclohexane, beta isomer (beta-HCH)	6.05E-11	1.52E-11	7.71E-09	1.22E-08	2.00E-08
Indeno(1,2,3)perylene	NC	NAR	3.40E-07	5.38E-08	3.94E-07
Indeno(1,2,3)perylene (inhalation)	4.22E-11	3.57E-10	NAR	NAR	3.99E-10
Methyl ethyl ketone (MEK) = 2-butanone	NC	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NA	NA	NA	0.00E+00
Methylene chloride = Dichloromethane	NC	NAR	5.62E-11	8.89E-11	1.45E-10
Methylene chloride = Dichloromethene (inhl.)	2.73E-08	2.07E-13	NAR	NAR	2.73E-08
Phenanthrene	NA	NA	NA	NA	0.00E+00
Polychlorinated biphenyls (PCBs)	NAR	NAR	1.83E-06	2.90E-06	4.74E-06
Pyrene	NC	NAR	1.65E-07	2.61E-08	1.91E-07
Pyrene (inhalation)	1.03E-09	1.73E-10	NAR	NAR	1.20E-09
Toluene = Toluol	NC	NA	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	NA	NA	NA	NA	0.00E+00
Trichloroethane (1,1,2-)	1.85E-08	7.04E-13	3.56E-10	5.63E-10	1.94E-08
Trichloroethylene	NC	NAR	9.16E-11	1.45E-10	2.36E-10
Trichloroethylene (inhalation)	2.29E-08	2.78E-13	NAR	NAR	2.29E-08
Vinyl chloride	NC	NAR	4.18E-08	6.61E-08	1.08E-07
Vinyl chloride (inhalation)	2.41E-06	1.05E-11	NAR	NAR	2.41E-06
Sum of all chemicals	4.27E-06	3.09E-09	4.81E-06	3.80E-06	1.29E-05

Table D-3. Lifetime Cancer Risks for Adult Males Exposed to Bergholtz Creek

CHEMICAL	Adult Male - Bergholtz Creek Exposure						
	Inhalation CANCER RISK	Ingestion CANCER RISK	Dermal Contact CANCER RISK	Sediment Ingest CANCER RISK	Sediment, Dermal CANCER RISK	Milk Ingest CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	3.43E-18	3.90E-18	1.24E-17	NC	NC	2.56E-22	1.97E-17
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	4.50E-13	1.15E-12	NC	NC	2.05E-17	1.60E-12
Chloroform = Trichloromethane (inhalation)	5.35E-12	NC	NC	NC	NC	NC	5.35E-12
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	NA	NA	NA	NC	NC	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butenone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	2.69E-11	2.31E-11	NC	NC	2.55E-16	5.00E-11
Methylene chloride = Dichloromethane (inhl.)	6.40E-11	NC	NC	NC	NC	NC	6.40E-11
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	NA	NA	NC	NC	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethylene	NC	7.70E-12	3.46E-11	NC	NC	9.76E-16	4.23E-11
Trichloroethylene (inhalation)	1.00E-11	NC	NC	NC	NC	NC	1.00E-11
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	2.02E-12	5.92E-13	NC	NC	4.35E-18	2.61E-12
Vinyl chloride (inhalation)	3.46E-13	NC	NC	NC	NC	NC	3.46E-13
Sum of all chemicals	7.97E-11	3.71E-11	5.94E-11	0.00E+00	0.00E+00	1.26E-15	1.76E-10

Table D-4. Lifetime Cancer Risks for Adult Females Exposed to Bergholtz Creek

CHEMICAL	Adult Female - Bergholtz Creek Exposure						
	Inhalation CANCER RISK	Ingestion CANCER RISK	Dermal Contact CANCER RISK	Sediment Ingest CANCER RISK	Sediment, Dermal CANCER RISK	Milk Ingest CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	3.74E-18	4.00E-18	1.18E-17	NC	NC	2.80E-22	1.95E-17
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	4.61E-13	1.09E-12	NC	NC	2.24E-17	1.55E-12
Chloroform = Trichloromethane (inhalation)	5.84E-12	NC	NC	NC	NC	NC	5.84E-12
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	NA	NA	NA	NC	NC	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	2.76E-11	2.20E-11	NC	NC	2.79E-16	4.96E-11
Methylene chloride = Dichloromethane (inhl.)	6.99E-11	NC	NC	NC	NC	NC	6.99E-11
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	NA	NA	NC	NC	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethylene	NC	7.88E-12	3.29E-11	NC	NC	1.07E-15	4.08E-11
Trichloroethylene (inhalation)	1.09E-11	NC	NC	NC	NC	NC	1.09E-11
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	2.07E-12	5.63E-13	NC	NC	4.75E-18	2.63E-12
Vinyl chloride (inhalation)	3.78E-13	NC	NC	NC	NC	NC	3.78E-13
Sum of all chemicals	8.71E-11	3.80E-11	5.66E-11	0.00E+00	0.00E+00	1.37E-15	1.82E-10

CHEMICAL	15 Year Old - Bergholtz Creek Exposure						
	Inhalation CANCER RISK	Ingestion CANCER RISK	Dermal Contact CANCER RISK	Sediment Ingest CANCER RISK	Sediment, Dermal CANCER RISK	Milk Ingest CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	3.34E-18	3.40E-18	9.34E-18	NC	NC	2.38E-22	1.61E-17
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	3.92E-13	8.69E-13	NC	NC	1.90E-17	1.26E-12
Chloroform = Trichloromethane (inhalation)	5.21E-12	NC	NC	NC	NC	NC	5.21E-12
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	NA	NA	NA	NC	NC	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	2.34E-11	1.75E-11	NC	NC	2.37E-16	4.09E-11
Methylene chloride = Dichloromethane (inhl.)	6.24E-11	NC	NC	NC	NC	NC	6.24E-11
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	NA	NA	NC	NC	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethylene	NC	6.70E-12	2.62E-11	NC	NC	9.06E-16	3.29E-11
Trichloroethylene (inhalation)	9.76E-12	NC	NC	NC	NC	NC	9.76E-12
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	1.76E-12	4.47E-13	NC	NC	4.04E-18	2.21E-12
Vinyl chloride (inhalation)	3.37E-13	NC	NC	NC	NC	NC	3.37E-13
Sum of all chemicals	7.77E-11	3.23E-11	4.50E-11	0.00E+00	0.00E+00	1.17E-15	1.55E-10

Table D-6. Lifetime Cancer Risks for 9 Year Old Exposed to Bergholtz Creek

CHEMICAL	9 Year Old - Bergholtz Creek Exposure						
	Inhalation CANCER RISK	Ingestion CANCER RISK	Dermal Contact CANCER RISK	Sediment Ingest CANCER RISK	Sediment, Dermal CANCER RISK	Milk Ingest CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	4.31E-18	4.91E-18	1.11E-17	NC	NC	5.85E-22	2.04E-17
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	5.66E-13	1.04E-12	NC	NC	4.68E-17	1.60E-12
Chloroform = Trichloromethane (inhalation)	6.73E-12	NC	NC	NC	NC	NC	6.73E-12
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	NA	NA	NA	NC	NC	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	3.39E-11	2.08E-11	NC	NC	5.83E-16	5.47E-11
Methylene chloride = Dichloromethane (inhl.)	8.06E-11	NC	NC	NC	NC	NC	8.06E-11
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	NA	NA	NC	NC	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichloroethylene	NC	9.68E-12	3.12E-11	NC	NC	2.23E-15	4.09E-11
Trichloroethylene (inhalation)	1.26E-11	NC	NC	NC	NC	NC	1.26E-11
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	2.54E-12	5.33E-13	NC	NC	9.93E-18	3.08E-12
Vinyl chloride (inhalation)	4.35E-13	NC	NC	NC	NC	NC	4.35E-13
Sum of all chemicals	1.00E-10	4.67E-11	5.36E-11	0.00E+00	0.00E+00	2.87E-15	2.01E-10

Table D-7. Lifetime Cancer Risks for 4 Year Old Exposed to Bergholtz Creek

CHEMICAL	4 Year Old Milk Ingest CANCER RISK
Acetone	NA
Benzene	7.55E-22
Carbon disulfide	NC
Carbon disulfide (inhalation)	NC
Chloroethane	NC
Chloroform = Trichloromethane	6.05E-17
Chloroform = Trichloromethane (inhalation)	NC
Dichloroethane (1,1-)	NC
Dichloroethane (1,2-) = Ethylene dichloride	NC
Dichloroethylene (trans-1,2)	NA
Dichloroethylene(1,1-) = Vinylidene chloride	NC
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC
Lindane = Hexachlorocyclohexane, gamma	NC
Methyl ethyl ketone (MEK) = 2-butanone	NC
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC
Methylene chloride = Dichloromethane	7.53E-16
Methylene chloride = Dichloromethane (inhl.)	NC
Polychlorinated biphenyls (PCBs)	NC
Tetrachloroethane (1,1,2,2-)	NC
Tetrachloroethylene = Perchloroethylene	NC
Tetrachloroethylene = Perchloroethylene (inhl)	NC
Toluene = Toluol	NA
Toluene = Toluol (inhalation)	NC
Trichloroethane (1,1,1-) = Methyl chloroform	NA
Trichloroethane (1,1,1-) = " = (inhl.)	NC
Trichloroethylene	2.88E-15
Trichloroethylene (inhalation)	NC
Trichlorofluoromethane	NC
Trichlorofluoromethane (inhalation)	NC
Vinyl chloride	1.28E-17
Vinyl chloride (inhalation)	NC

Table D-8. Lifetime Cancer Risks for Adult Male Exposed to Irrigation Wells

CHEMICAL	GARDENING Inhalation CANCER RISK	GARDENING Ingestion CANCER RISK	GARDENING Dermal CANCER RISK	CAR WASHING Inhalation CANCER RISK	CAR WASHING Ingestion CANCER RISK	CAR WASHING Dermal CANCER RISK	Total Produce CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	8.26E-10	3.76E-09	6.36E-09	3.17E-10	2.00E-09	7.92E-10	2.09E-08	3.50E-08
Carbon disulfide	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Carbon disulfide (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Chloroethane	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Chloroform = Trichloromethane	NC	1.01E-09	1.38E-09	NC	5.38E-10	1.71E-10	4.88E-09	7.97E-09
Chloroform = Trichloromethane (inhalation)	2.99E-09	NC	NC	1.15E-09	NC	NC	NAR	4.14E-09
Dichloroethane (1,1-)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	2.69E-09	1.23E-08	7.77E-09	1.03E-09	6.56E-09	9.67E-10	4.05E-08	7.18E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.28E-07	8.49E-08	NC	6.84E-08	1.06E-08	4.30E-07	7.22E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	7.92E-08	NC	NC	3.04E-08	NC	NC	NAR	1.10E-07
Lindane = Hexachlorocyclohexane, gamma	3.73E-11	6.95E-10	3.28E-09	1.43E-11	3.70E-10	4.08E-10	1.23E-08	1.71E-08
Methyl ethyl ketone (MEK) = 2-butanone	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Methylene chloride = Dichloromethane	NC	5.60E-09	2.57E-09	NC	2.99E-09	3.21E-10	1.61E-08	2.76E-08
Methylene chloride = Dichloromethane (inhl.)	3.33E-09	NC	NC	1.28E-09	NC	NC	NAR	4.61E-09
Polychlorinated biphenyls (PCBs)	NA	1.04E-07	7.07E-07	NA	5.54E-08	8.80E-08	1.22E-07	1.08E-06
Tetrachloroethane (1,1,2,2-)	6.43E-09	2.74E-08	6.38E-08	2.47E-09	1.46E-08	7.95E-09	1.96E-07	3.19E-07
Tetrachloroethylene = Perchloroethylene	NC	3.75E-09	1.02E-08	NC	2.00E-09	1.26E-09	3.10E-08	4.82E-08
Tetrachloroethylene = Perchloroethylene (inhl)	4.77E-11	NC	NC	1.83E-11	NC	NC	NAR	6.61E-11
Toluene = Toluol	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Trichloroethylene	NC	1.72E-08	4.13E-08	NC	9.17E-09	5.15E-09	1.27E-07	2.00E-07
Trichloroethylene (inhalation)	5.60E-09	NA	NA	2.15E-09	NA	NA	NAR	7.75E-09
Trichlorofluoromethane	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichlorofluoromethane (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Vinyl chloride	NC	1.15E-06	1.80E-07	NC	6.13E-07	2.24E-08	2.05E-06	4.02E-06
Vinyl chloride (inhalation)	4.92E-08	NC	NC	1.89E-08	NC	NC	NAR	6.81E-08
Sum of all chemicals	1.50E-07	1.45E-06	1.11E-06	5.78E-08	7.75E-07	1.38E-07	3.05E-06	6.74E-06

Table D-9. Lifetime Cancer Risks for Adult Female Exposed to Irrigation Wells

CHEMICAL	GARDENING Inhalation CANCER RISK	GARDENING Ingestion CANCER RISK	GARDENING Dermal CANCER RISK	CAR WASHING Inhalation CANCER RISK	CAR WASHING Ingestion CANCER RISK	CAR WASHING Dermal CANCER RISK	Total Produce CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	9.02E-10	4.10E-09	6.05E-09	3.29E-10	2.19E-09	7.54E-10	2.29E-08	3.72E-08
Carbon disulfide	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Carbon disulfide (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Chloroethane	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Chloroform = Trichloromethane	NC	1.10E-09	1.31E-09	NC	5.87E-10	1.63E-10	5.33E-09	8.49E-09
Chloroform = Trichloromethane (inhalation)	3.27E-09	NC	NC	1.19E-09	NC	NC	NAR	4.46E-09
Dichloroethane (1,1-)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	2.94E-09	1.34E-08	7.39E-09	1.07E-09	7.17E-09	9.21E-10	4.42E-08	7.71E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.40E-07	8.07E-08	NC	7.47E-08	1.01E-08	4.70E-07	7.76E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	8.65E-08	NC	NC	3.16E-08	NC	NC	NAR	1.18E-07
Lindane = Hexachlorocyclohexane, gamma	4.08E-11	7.59E-10	3.12E-09	1.49E-11	4.05E-10	3.89E-10	1.35E-08	1.82E-08
Methyl ethyl ketone (MEK) = 2-butanone	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Methylene chloride = Dichloromethane	NC	6.12E-09	2.45E-09	NC	3.26E-09	3.05E-10	1.76E-08	2.97E-08
Methylene chloride = Dichloromethane (inhl.)	3.64E-09	NC	NC	1.33E-09	NC	NC	NAR	4.97E-09
Polychlorinated biphenyls (PCBs)	NA	1.13E-07	6.72E-07	NA	6.05E-08	8.37E-08	1.33E-07	1.06E-06
Tetrachloroethane (1,1,2,2-)	7.02E-09	3.00E-08	6.07E-08	2.56E-09	1.60E-08	7.56E-09	2.15E-07	3.38E-07
Tetrachloroethylene = Perchloroethylene	NC	4.09E-09	9.66E-09	NC	2.18E-09	1.20E-09	3.39E-08	5.10E-08
Tetrachloroethylene = Perchloroethylene (inhl)	5.21E-11	NC	NC	1.90E-11	NC	NC	NAR	7.12E-11
Toluene = Toluol	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Trichloroethylene	NC	1.88E-08	3.93E-08	NC	1.00E-08	4.90E-09	1.39E-07	2.12E-07
Trichloroethylene (inhalation)	6.12E-09	NA	NA	2.23E-09	NA	NA	NAR	8.35E-09
Trichlorofluoromethane	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichlorofluoromethane (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Vinyl chloride	NC	1.26E-06	1.71E-07	NC	6.70E-07	2.13E-08	2.24E-06	4.36E-06
Vinyl chloride (inhalation)	5.38E-08	NC	NC	1.96E-08	NC	NC	NAR	7.34E-08
Sum of all chemicals	1.64E-07	1.59E-06	1.05E-06	5.99E-08	8.47E-07	1.31E-07	3.34E-06	7.18E-06

Table D-10. Lifetime Cancer Risks for 15 Year Old Exposed to Irrigation Wells

CHEMICAL	GARDENING Inhalation CANCER RISK	GARDENING Ingestion CANCER RISK	GARDENING Dermal CANCER RISK	CAR WASHING Inhalation CANCER RISK	CAR WASHING Ingestion CANCER RISK	CAR WASHING Dermal CANCER RISK	Total Produce CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Benzene	8.06E-10	3.49E-09	4.81E-09	2.80E-10	1.86E-09	5.99E-10	1.94E-08	3.13E-08
Carbon disulfide	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Carbon disulfide (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Chloroethane	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Chloroform = Trichloromethane	NC	9.36E-10	1.04E-09	NC	4.99E-10	1.30E-10	4.53E-09	7.14E-09
Chloroform = Trichloromethane (inhalation)	2.92E-09	NC	NC	1.01E-09	NC	NC	NAR	3.93E-09
Dichloroethane (1,1-)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	2.63E-09	1.14E-08	5.87E-09	9.13E-10	6.09E-09	7.32E-10	3.76E-08	6.52E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.19E-07	6.42E-08	NC	6.35E-08	7.99E-09	4.00E-07	6.54E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	7.72E-08	NC	NC	2.68E-08	NC	NC	NAR	1.04E-07
Lindane = Hexachlorocyclohexane, gamma	3.64E-11	6.45E-10	2.48E-09	1.26E-11	3.44E-10	3.09E-10	1.15E-08	1.53E-08
Methyl ethyl ketone (MEK) = 2-butanone	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Methylene chloride = Dichloromethane	NC	5.20E-09	1.95E-09	NC	2.77E-09	2.42E-10	1.49E-08	2.51E-08
Methylene chloride = Dichloromethane (inhl.)	3.25E-09	NC	NC	1.13E-09	NC	NC	NAR	4.38E-09
Polychlorinated biphenyls (PCBs)	NA	9.65E-08	5.34E-07	NA	5.14E-08	6.66E-08	1.13E-07	8.62E-07
Tetrachloroethane (1,1,2,2-)	6.27E-09	2.55E-08	4.83E-08	2.18E-09	1.36E-08	6.01E-09	1.82E-07	2.84E-07
Tetrachloroethylene = Perchloroethylene	NC	3.48E-09	7.68E-09	NC	1.86E-09	9.56E-10	2.88E-08	4.28E-08
Tetrachloroethylene = Perchloroethylene (inhl)	4.66E-11	NC	NC	1.62E-11	NC	NC	NAR	6.27E-11
Toluene = Toluol	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Trichloroethylene	NC	1.60E-08	3.13E-08	NC	8.51E-09	3.89E-09	1.18E-07	1.77E-07
Trichloroethylene (inhalation)	5.46E-09	NA	NA	1.90E-09	NA	NA	NAR	7.36E-09
Trichlorofluoromethane	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichlorofluoromethane (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Vinyl chloride	NC	1.07E-06	1.36E-07	NC	5.69E-07	1.70E-08	1.91E-06	3.70E-06
Vinyl chloride (inhalation)	4.80E-08	NC	NC	1.67E-08	NC	NC	NAR	6.47E-08
Sum of all chemicals	1.47E-07	1.35E-06	8.38E-07	5.10E-08	7.20E-07	1.04E-07	2.84E-06	6.05E-06

CHEMICAL	Inhalation CANCER RISK	WADING POOL Ingestion CANCER RISK	Dermal CANCER RISK	Total Produce CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	0.00E+00
Benzene	3.33E-09	5.04E-09	5.22E-08	3.51E-08	9.56E-08
Carbon disulfide	NC	NA	NA	NA	0.00E+00
Carbon disulfide (inhalation)	NA	NC	NC	NA	0.00E+00
Chloroethane	NA	NA	NA	NA	0.00E+00
Chloroform = Trichloromethane	NC	1.35E-09	1.13E-08	8.19E-09	2.08E-08
Chloroform = Trichloromethane (inhalation)	1.21E-08	NC	NC	NAR	1.21E-08
Dichloroethane (1,1-)	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	1.08E-08	1.65E-08	6.37E-08	6.79E-08	1.59E-07
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.72E-07	6.96E-07	7.22E-07	1.59E-06
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	3.19E-07	NC	NC	NAR	3.19E-07
Lindane = Hexachlorocyclohexane, gamma	1.50E-10	9.32E-10	2.69E-08	2.07E-08	4.87E-08
Methyl ethyl ketone (MEK) = 2-butanone	NC	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NC	NC	NA	0.00E+00
Methylene chloride = Dichloromethane	NC	7.52E-09	2.11E-08	2.70E-08	5.56E-08
Methylene chloride = Dichloromethane (inhl.)	1.34E-08	NC	NC	NAR	1.34E-08
Polychlorinated biphenyls (PCBs)	NA	1.39E-07	5.79E-06	2.05E-07	6.14E-06
Tetrachloroethane (1,1,2,2-)	2.59E-08	3.68E-08	5.23E-07	3.29E-07	9.15E-07
Tetrachloroethylene = Perchloroethylene	NC	5.03E-09	8.32E-08	5.20E-08	1.40E-07
Tetrachloroethylene = Perchloroethylene (inhl)	1.92E-10	NC	NC	NAR	1.92E-10
Toluene = Toluol	NC	NA	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NA	0.00E+00
Trichloroethylene	NC	2.31E-08	3.39E-07	2.13E-07	5.75E-07
Trichloroethylene (inhalation)	2.25E-08	NA	NA	NAR	2.25E-08
Trichlorofluoromethane	NC	NA	NA	NA	0.00E+00
Trichlorofluoromethane (inhalation)	NA	NC	NC	NA	0.00E+00
Vinyl chloride	NC	1.54E-06	1.48E-06	3.44E-06	6.46E-06
Vinyl chloride (inhalation)	1.98E-07	NC	NC	NAR	1.98E-07
Sum of all chemicals	6.06E-07	1.95E-06	9.08E-06	5.12E-06	1.68E-05

CHEMICAL	Inhalation CANCER RISK	WADING POOL Ingestion CANCER RISK	Dermal CANCER RISK	TOTAL PRODUCE CANCER RISK	Total CANCER RISK
Acetone	NA	NA	NA	NA	0.00E+00
Benzene	2.29E-09	6.51E-09	4.65E-08	4.53E-08	1.01E-07
Carbon disulfide	NC	NA	NA	NA	0.00E+00
Carbon disulfide (inhalation)	NA	NC	NC	NA	0.00E+00
Chloroethane	NA	NA	NA	NA	0.00E+00
Chloroform = Trichloromethane	NC	1.75E-09	1.01E-08	1.06E-08	2.24E-08
Chloroform = Trichloromethane (inhalation)	8.29E-09	NC	NC	NAR	8.29E-09
Dichloroethane (1,1-)	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	7.46E-09	2.13E-08	5.68E-08	8.76E-08	1.73E-07
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	0.00E+00
Dichloroethylene(1,1-) = Vinylidene chloride	NC	2.22E-07	6.20E-07	9.33E-07	1.77E-06
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	2.19E-07	NC	NC	NAR	2.19E-07
Lindane = Hexachlorocyclohexane, gamma	1.03E-10	1.20E-09	2.40E-08	2.67E-08	5.20E-08
Methyl ethyl ketone (MEK) = 2-butanone	NC	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NA	NC	NC	NA	0.00E+00
Methylene chloride = Dichloromethane	NC	9.71E-09	1.88E-08	3.49E-08	6.34E-08
Methylene chloride = Dichloromethane (inhl.)	9.24E-09	NC	NC	NAR	9.24E-09
Polychlorinated biphenyls (PCBs)	NA	1.80E-07	5.16E-06	2.65E-07	5.61E-06
Tetrachloroethane (1,1,2,2-)	1.78E-08	4.76E-08	4.66E-07	4.26E-07	9.57E-07
Tetrachloroethylene = Perchloroethylene	NC	6.49E-09	7.42E-08	6.72E-08	1.48E-07
Tetrachloroethylene = Perchloroethylene (inhl)	1.32E-10	NC	NC	NAR	1.32E-10
Toluene = Toluol	NC	NA	NA	NA	0.00E+00
Toluene = Toluol (inhalation)	NA	NC	NC	NA	0.00E+00
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NA	NA	NA	0.00E+00
Trichloroethane (1,1,1-) = " " (inhl.)	NA	NC	NC	NA	0.00E+00
Trichloroethylene	NC	2.98E-08	3.02E-07	2.75E-07	6.07E-07
Trichloroethylene (inhalation)	1.55E-08	NA	NA	NAR	1.55E-08
Trichlorofluoromethane	NC	NA	NA	NA	0.00E+00
Trichlorofluoromethane (inhalation)	NA	NC	NC	NA	0.00E+00
Vinyl chloride	NC	1.99E-06	1.32E-06	4.45E-06	7.76E-06
Vinyl chloride (inhalation)	1.36E-07	NC	NC	NAR	1.36E-07
Sum of all chemicals	4.17E-07	2.52E-06	8.10E-06	6.62E-06	1.77E-05

CHEMICAL	ROOT CANCER RISK	LEAFY CANCER RISK	EXPOSED CANCER RISK	PROTECTED CANCER RISK	TOTAL PRODUCE CANCER RISK
Acetone	NA	NA	NA	NA	NA
Benzene	3.76E-09	1.80E-09	8.63E-09	6.73E-09	2.09E-08
Carbon disulfide	NA	NA	NA	NA	NA
Carbon disulfide (inhalation)	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA
Chloroform = Trichloromethane	8.55E-10	4.24E-10	2.03E-09	1.58E-09	4.88E-09
Chloroform = Trichloromethane (inhalation)	NAR	NAR	NAR	NAR	NAR
Dichloroethane (1,1-)	NA	NA	NA	NA	NA
Dichloroethane (1,2-) = Ethylene dichloride	6.99E-09	3.58E-09	1.69E-08	1.30E-08	4.05E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA
Dichloroethylene(1,1-) = Vinylidene chloride	7.42E-08	3.80E-08	1.80E-07	1.38E-07	4.30E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NAR	NAR	NAR	NAR	NAR
Lindane = Hexachlorocyclohexane, gamma	3.33E-09	9.30E-10	4.51E-09	3.57E-09	1.23E-08
Methyl ethyl ketone (MEK) = 2-butanone	NA	NA	NA	NA	NA
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NA	NA	NA	NA	NA
Methylene chloride = Dichloromethane	2.88E-09	1.42E-09	6.68E-09	5.12E-09	1.61E-08
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NAR
Polychlorinated biphenyls (PCBs)	2.92E-09	6.93E-09	4.19E-08	7.04E-08	1.22E-07
Tetrachloroethane (1,1,2,2-)	3.74E-08	1.66E-08	7.98E-08	6.26E-08	1.96E-07
Tetrachloroethylene = Perchloroethylene	6.14E-09	2.59E-09	1.25E-08	9.80E-09	3.10E-08
Tetrachloroethylene = Perchloroethylene (inhl	NAR	NAR	NAR	NAR	NAR
Toluene = Toluol	NA	NA	NA	NA	NA
Toluene = Toluol (inhalation)	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) = Methyl chloroform	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) (inhalation)	NA	NA	NA	NA	NA
Trichloroethylene	2.43E-08	1.07E-08	5.15E-08	4.03E-08	1.27E-07
Trichloroethylene (inhalation)	NAR	NAR	NAR	NAR	NAR
Trichlorofluoromethane	NA	NA	NA	NA	NA
Trichlorofluoromethane (inhalation)	NA	NA	NA	NA	NA
Vinyl chloride	4.88E-07	1.74E-07	7.96E-07	5.93E-07	2.05E-06
Vinyl chloride (inhalation)	NAR	NAR	NAR	NAR	NAR
Sum of all chemicals	6.51E-07	2.57E-07	1.20E-06	9.45E-07	3.05E-06

CHEMICAL	ROOT CANCER RISK	LEAFY CANCER RISK	EXPOSED CANCER RISK	PROTECTED CANCER RISK	TOTAL PRODUCE CANCER RISK
Acetone	NA	NA	NA	NA	NA
Benzene	4.11E-09	1.97E-09	9.43E-09	7.36E-09	2.29E-08
Carbon disulfide	NA	NA	NA	NA	NA
Carbon disulfide (inhalation)	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA
Chloroform = Trichloromethane	9.34E-10	4.64E-10	2.21E-09	1.72E-09	5.33E-09
Chloroform = Trichloromethane (inhalation)	NAR	NAR	NAR	NAR	NAR
Dichloroethane (1,1-)	NA	NA	NA	NA	NA
Dichloroethane (1,2-) = Ethylene dichloride	7.64E-09	3.91E-09	1.84E-08	1.42E-08	4.42E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA
Dichloroethylene(1,1-) = Vinylidene chloride	8.11E-08	4.15E-08	1.96E-07	1.51E-07	4.70E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NAR	NAR	NAR	NAR	NAR
Lindane = Hexachlorocyclohexane, gamma	3.64E-09	1.02E-09	4.93E-09	3.90E-09	1.35E-08
Methyl ethyl ketone (MEK) = 2-butanone	NA	NA	NA	NA	NA
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NA	NA	NA	NA	NA
Methylene chloride = Dichloromethane	3.14E-09	1.55E-09	7.29E-09	5.59E-09	1.76E-08
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NAR
Polychlorinated biphenyls (PCBs)	3.19E-09	7.57E-09	4.58E-08	7.69E-08	1.33E-07
Tetrachloroethane (1,1,2,2-)	4.08E-08	1.81E-08	8.72E-08	6.83E-08	2.15E-07
Tetrachloroethylene = Perchloroethylene	6.70E-09	2.83E-09	1.36E-08	1.07E-08	3.39E-08
Tetrachloroethylene = Perchloroethylene (inhl	NAR	NAR	NAR	NAR	NAR
Toluene = Toluol	NA	NA	NA	NA	NA
Toluene = Toluol (inhalation)	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) = Methyl chloroform	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) (inhalation)	NA	NA	NA	NA	NA
Trichloroethylene	2.66E-08	1.17E-08	5.62E-08	4.41E-08	1.39E-07
Trichloroethylene (inhalation)	NAR	NAR	NAR	NAR	NAR
Trichlorofluoromethane	NA	NA	NA	NA	NA
Trichlorofluoromethane (inhalation)	NA	NA	NA	NA	NA
Vinyl chloride	5.33E-07	1.90E-07	8.70E-07	6.48E-07	2.24E-06
Vinyl chloride (inhalation)	NAR	NAR	NAR	NAR	NAR
Sum of all chemicals	7.11E-07	2.81E-07	1.31E-06	1.03E-06	3.34E-06

CHEMICAL	ROOT CANCER RISK	LEAFY CANCER RISK	EXPOSED CANCER RISK	PROTECTED CANCER RISK	TOTAL PRODUCE CANCER RISK
Acetone	NA	NA	NA	NA	NA
Benzene	3.49E-09	1.67E-09	8.01E-09	6.25E-09	1.94E-08
Carbon disulfide	NA	NA	NA	NA	NA
Carbon disulfide (inhalation)	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA
Chloroform = Trichloromethane	7.94E-10	3.94E-10	1.88E-09	1.46E-09	4.53E-09
Chloroform = Trichloromethane (inhalation)	NAR	NAR	NAR	NAR	NAR
Dichloroethane (1,1-)	NA	NA	NA	NA	NA
Dichloroethane (1,2-) = Ethylene dichloride	6.49E-09	3.32E-09	1.57E-08	1.21E-08	3.76E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA
Dichloroethylene(1,1-) = Vinylidene chloride	6.89E-08	3.53E-08	1.67E-07	1.29E-07	4.00E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NAR	NAR	NAR	NAR	NAR
Lindane = Hexachlorocyclohexane, gamma	3.10E-09	8.64E-10	4.19E-09	3.31E-09	1.15E-08
Methyl ethyl ketone (MEK) = 2-butanone	NA	NA	NA	NA	NA
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NA	NA	NA	NA	NA
Methylene chloride = Dichloromethane	2.67E-09	1.32E-09	6.20E-09	4.75E-09	1.49E-08
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NAR
Polychlorinated biphenyls (PCBs)	2.71E-09	6.44E-09	3.89E-08	6.53E-08	1.13E-07
Tetrachloroethane (1,1,2,2-)	3.47E-08	1.54E-08	7.41E-08	5.81E-08	1.82E-07
Tetrachloroethylene = Perchloroethylene	5.70E-09	2.41E-09	1.16E-08	9.10E-09	2.88E-08
Tetrachloroethylene = Perchloroethylene (inhl	NAR	NAR	NAR	NAR	NAR
Toluene = Toluol	NA	NA	NA	NA	NA
Toluene = Toluol (inhalation)	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) = Methyl chloroform	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) (inhalation)	NA	NA	NA	NA	NA
Trichloroethylene	2.26E-08	9.93E-09	4.78E-08	3.75E-08	1.18E-07
Trichloroethylene (inhalation)	NAR	NAR	NAR	NAR	NAR
Trichlorofluoromethane	NA	NA	NA	NA	NA
Trichlorofluoromethane (inhalation)	NA	NA	NA	NA	NA
Vinyl chloride	4.53E-07	1.62E-07	7.39E-07	5.51E-07	1.91E-06
Vinyl chloride (inhalation)	NAR	NAR	NAR	NAR	NAR
Sum of all chemicals	6.05E-07	2.39E-07	1.11E-06	8.77E-07	2.84E-06

CHEMICAL	ROOT CANCER RISK	LEAFY CANCER RISK	EXPOSED CANCER RISK	PROTECTED CANCER RISK	TOTAL PRODUCE CANCER RISK
Acetone	NA	NA	NA	NA	NA
Benzene	6.31E-09	3.02E-09	1.45E-08	1.13E-08	3.51E-08
Carbon disulfide	NA	NA	NA	NA	NA
Carbon disulfide (inhalation)	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA
Chloroform = Trichloromethane	1.43E-09	7.12E-10	3.40E-09	2.64E-09	8.19E-09
Chloroform = Trichloromethane (inhalation)	NAR	NAR	NAR	NAR	NAR
Dichloroethane (1,1-)	NA	NA	NA	NA	NA
Dichloroethane (1,2-) = Ethylene dichloride	1.17E-08	6.00E-09	2.83E-08	2.18E-08	6.79E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA
Dichloroethylene(1,1-) = Vinylidene chloride	1.24E-07	6.38E-08	3.01E-07	2.32E-07	7.22E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NAR	NAR	NAR	NAR	NAR
Lindane = Hexachlorocyclohexane, gamma	5.59E-09	1.56E-09	7.57E-09	5.98E-09	2.07E-08
Methyl ethyl ketone (MEK) = 2-butanone	NA	NA	NA	NA	NA
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NA	NA	NA	NA	NA
Methylene chloride = Dichloromethane	4.83E-09	2.38E-09	1.12E-08	8.58E-09	2.70E-08
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NAR
Polychlorinated biphenyls (PCBs)	4.89E-09	1.16E-08	7.03E-08	1.18E-07	2.05E-07
Tetrachloroethane (1,1,2,2-)	6.27E-08	2.79E-08	1.34E-07	1.05E-07	3.29E-07
Tetrachloroethylene = Perchloroethylene	1.03E-08	4.35E-09	2.09E-08	1.64E-08	5.20E-08
Tetrachloroethylene = Perchloroethylene (inhl	NAR	NAR	NAR	NAR	NAR
Toluene = Toluol	NA	NA	NA	NA	NA
Toluene = Toluol (inhalation)	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) = Methyl chloroform	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) (inhalation)	NA	NA	NA	NA	NA
Trichloroethylene	4.08E-08	1.79E-08	8.63E-08	6.77E-08	2.13E-07
Trichloroethylene (inhalation)	NAR	NAR	NAR	NAR	NAR
Trichlorofluoromethane	NA	NA	NA	NA	NA
Trichlorofluoromethane (inhalation)	NA	NA	NA	NA	NA
Vinyl chloride	8.19E-07	2.93E-07	1.34E-06	9.95E-07	3.44E-06
Vinyl chloride (inhalation)	NAR	NAR	NAR	NAR	NAR
Sum of all chemicals	1.09E-06	4.32E-07	2.01E-06	1.59E-06	5.12E-06

CHEMICAL	ROOT CANCER RISK	LEAFY CANCER RISK	EXPOSED CANCER RISK	PROTECTED CANCER RISK	TOTAL PRODUCE CANCER RISK
Acetone	NA	NA	NA	NA	NA
Benzene	8.15E-09	3.91E-09	1.87E-08	1.46E-08	4.53E-08
Carbon disulfide	NA	NA	NA	NA	NA
Carbon disulfide (inhalation)	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA
Chloroform = Trichloromethane	1.85E-09	9.19E-10	4.39E-09	3.41E-09	1.06E-08
Chloroform = Trichloromethane (inhalation)	NAR	NAR	NAR	NAR	NAR
Dichloroethane (1,1-)	NA	NA	NA	NA	NA
Dichloroethane (1,2-) = Ethylene dichloride	1.52E-08	7.75E-09	3.66E-08	2.82E-08	8.76E-08
Dichloroethylene (trans-1,2)	NA	NA	NA	NA	NA
Dichloroethylene(1,1-) = Vinylidene chloride	1.61E-07	8.24E-08	3.89E-07	3.00E-07	9.33E-07
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NAR	NAR	NAR	NAR	NAR
Lindane = Hexachlorocyclohexane, gamma	7.22E-09	2.02E-09	9.78E-09	7.73E-09	2.67E-08
Methyl ethyl ketone (MEK) = 2-butanone	NA	NA	NA	NA	NA
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NA	NA	NA	NA	NA
Methylene chloride = Dichloromethane	6.23E-09	3.08E-09	1.45E-08	1.11E-08	3.49E-08
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NAR
Polychlorinated biphenyls (PCBs)	6.32E-09	1.50E-08	9.08E-08	1.52E-07	2.65E-07
Tetrachloroethane (1,1,2,2-)	8.10E-08	3.60E-08	1.73E-07	1.36E-07	4.26E-07
Tetrachloroethylene = Perchloroethylene	1.33E-08	5.61E-09	2.70E-08	2.12E-08	6.72E-08
Tetrachloroethylene = Perchloroethylene (inhl	NAR	NAR	NAR	NAR	NAR
Toluene = Toluol	NA	NA	NA	NA	NA
Toluene = Toluol (inhalation)	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) = Methyl chloroform	NA	NA	NA	NA	NA
Trichloroethane (1,1,1-) (inhalation)	NA	NA	NA	NA	NA
Trichloroethylene	5.27E-08	2.32E-08	1.12E-07	8.74E-08	2.75E-07
Trichloroethylene (inhalation)	NAR	NAR	NAR	NAR	NAR
Trichlorofluoromethane	NA	NA	NA	NA	NA
Trichlorofluoromethane (inhalation)	NA	NA	NA	NA	NA
Vinyl chloride	1.06E-06	3.78E-07	1.73E-06	1.29E-06	4.45E-06
Vinyl chloride (inhalation)	NAR	NAR	NAR	NAR	NAR
Sum of all chemicals	1.41E-06	5.58E-07	2.60E-06	2.05E-06	6.62E-06

APPENDIX E
Non-Carcinogenic Hazard Index Tables for Each Exposure Scenario

Table E-1. Non-Carcinogenic Hazard Quotients for Construction Workers: ADD/RfD

CHEMICAL	Inhalation Vapor ADD / RfD	Inhalation Particulates ADD / RfD	Ingestion, Soil ADD / RfD	Dermal, Soil ADD / RfD	TOTAL ADD / RfD
Acetone	1.02E-03	9.54E-06	1.55E-05	4.90E-05	1.10E-03
Aldrin	2.65E-04	8.49E-04	1.37E-03	4.34E-04	2.92E-03
Anthracene	1.16E-05	1.82E-06	2.95E-06	9.33E-07	1.73E-05
Benzo(a)anthracene	NC	NA	NA	NA	0.00E+00
Benzo(a)anthracene (inhalation)	NA	NA	NA	NA	0.00E+00
Benz(a)pyrene	NC	NA	NA	NA	0.00E+00
Benz(a)pyrene (inhalation)	NA	NA	NA	NA	0.00E+00
Benzo(b)fluoranthene	NC	NA	NA	NA	0.00E+00
Benzo(b)fluoranthene (inhalation)	NA	NA	NA	NA	0.00E+00
Benzo(ghi)perylene	NC	NA	NA	NA	0.00E+00
Benzo(ghi)perylene (inhalation)	NA	NA	NA	NA	0.00E+00
Benzo(k)fluoranthene	NC	NA	NA	NA	0.00E+00
Benzo(k)fluoranthene (inhalation)	NA	NA	NA	NA	0.00E+00
Carbon disulfide	NC	NAR	7.18E-06	2.27E-05	2.99E-05
Carbon disulfide (inhalation)	8.80E-02	1.55E-04	NAR	NAR	8.81E-02
Chrysene	NC	NA	NA	NA	0.00E+00
Chrysene (inhalation)	NA	NA	NA	NA	0.00E+00
Di-n-octyl phthalate	6.46E-05	3.13E-05	5.07E-05	1.61E-05	1.63E-04
Dichloroethane (1,1-)	2.79E-08	6.55E-06	1.06E-05	3.35E-05	5.07E-05
Dichloroethane (1,2-) = Ethylene dichloride	2.04E-04	6.73E-07	1.09E-06	3.45E-06	2.10E-04
Dichloroethylene (trans-1,2)	1.98E-02	5.04E-05	8.17E-05	2.58E-04	2.02E-02
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NAR	7.32E-05	2.32E-04	3.05E-04
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	2.60E-02	4.52E-05	NAR	NAR	2.60E-02
Ethylbenzene	3.17E-04	4.44E-06	7.18E-06	2.27E-05	3.52E-04
Floranthene	4.33E-06	3.12E-05	5.03E-05	1.59E-05	1.02E-04
Fluorene	3.30E-05	1.35E-04	2.18E-05	6.91E-06	1.97E-04
Hexachlorocyclohexane, beta isomer (beta-HCH)	2.45E-05	9.15E-05	1.48E-04	4.68E-04	7.32E-04
Indeno(1,2,3)perylene	NC	NA	NA	NA	0.00E+00
Indeno(1,2,3)perylene (inhalation)	NA	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NAR	2.64E-05	8.35E-05	1.10E-04
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	7.25E-04	9.06E-06	NAR	NAR	7.34E-04
Methylene chloride = Dichloromethane	NC	NAR	1.38E-05	4.37E-05	5.75E-05
Methylene chloride = Dichloromethane (inhl.)	3.55E-04	5.91E-07	NAR	NAR	3.55E-04
Phenanthrene	3.53E-04	1.26E-04	2.04E-04	6.45E-05	7.47E-04
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	0.00E+00
Pyrene	NC	NAR	5.91E-05	1.87E-05	7.78E-05
Pyrene (inhalation)	1.10E-05	3.67E-05	NAR	NAR	4.76E-05
Toluene = Toluol	NC	NAR	4.58E-07	1.45E-06	1.91E-06
Toluene = Toluol (inhalation)	2.57E-05	1.48E-07	NAR	NAR	2.59E-05
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NAR	4.15E-05	1.31E-04	1.73E-04
Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	2.40E-03	7.69E-06	NAR	NAR	2.41E-03
Trichloroethane (1,1,2-)	NAR	NAR	1.49E-04	4.70E-04	6.19E-04
Trichloroethylene	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	0.00E+00
Vinyl chloride	NC	5.79E-04	9.37E-04	2.96E-03	4.48E-03
Vinyl chloride (inhalation)	NA	NA	NA	NA	0.00E+00
Sum of all chemicals	1.40E-01	2.17E-03	3.27E-03	5.34E-03	1.50E-01

CAS NUMBER	CHEMICAL	Inhalation Vapor ADD / TLV	Inhalation Particulates ADD / TLV	Ingestion, Soil ADD / TLV	Dermal, Soil ADD / TLV	TOTAL ADD / TLV
67-64-1	Acetone	3.59E-07	6.97E-11	7.07E-09	2.24E-08	3.89E-07
309-00-2	Aldrin	1.99E-07	1.32E-08	1.34E-06	4.23E-07	1.97E-06
120-12-7	Anthracene	NA	NA	NA	NA	0.00E+00
56-55-3	Benzo(a)anthracene	NC	NC	NA	NA	0.00E+00
56-55-3	Benzo(a)anthracene (inhalation)	NA	NA	NC	NC	0.00E+00
50-32-8	Benz(a)pyrene	NC	NC	NA	NA	0.00E+00
50-32-8	Benz(a)pyrene (inhalation)	NA	NA	NC	NC	0.00E+00
205-99-28	Benzo(b)fluoranthene	NC	NC	NA	NA	0.00E+00
205-99-28	Benzo(b)fluoranthene (inhalation)	NA	NA	NC	NC	0.00E+00
191-24-2	Benzo(ghi)perylene	NC	NC	NA	NA	0.00E+00
191-24-2	Benzo(ghi)perylene (inhalation)	NA	NA	NC	NC	0.00E+00
207-08-9	Benzo(k)fluoranthene	NC	NC	NA	NA	0.00E+00
207-08-9	Benzo(k)fluoranthene (inhalation)	NA	NA	NC	NC	0.00E+00
75-15-0	Carbon disulfide	NC	NC	1.88E-07	5.96E-07	7.84E-07
75-15-0	Carbon disulfide (inhalation)	5.06E-05	1.86E-09	NC	NC	5.06E-05
218-01-9	Chrysene	NC	NC	NA	NA	0.00E+00
218-01-9	Chrysene (inhalation)	NA	NA	NC	NC	0.00E+00
117-84-0	Di-n-octyl phthalate	NA	NA	NA	NA	0.00E+00
75-34-3	Dichloroethane (1,1-)	2.15E-11	1.05E-10	1.06E-08	3.36E-08	4.44E-08
107-06-2	Dichloroethane (1,2-) = Ethylene dichloride	3.82E-06	2.62E-10	2.66E-08	8.42E-08	3.94E-06
156-60-5	Dichloroethylene (trans-1,2)	3.11E-06	1.65E-10	1.67E-08	5.29E-08	3.18E-06
75-35-4	Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	2.68E-07	8.47E-07	1.11E-06
75-35-4	Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	7.30E-05	2.64E-09	NC	NC	7.30E-05
100-41-4	Ethylbenzene	4.56E-07	1.33E-10	1.34E-08	4.25E-08	5.12E-07
206-44-0	Floranthene	NA	NA	NA	NA	0.00E+00
86-73-7	Fluorene	NA	NA	NA	NA	0.00E+00
319-85-7	Hexachlorocyclohexane, beta isomer (beta-HCH)	NA	NA	NA	NA	0.00E+00
193-39-5	Indeno(1,2,3)perylene	NC	NC	NA	NA	0.00E+00
193-39-5	Indeno(1,2,3)perylene (inhalation)	NA	NA	NC	NC	0.00E+00
78-93-3	Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	1.82E-08	5.75E-08	7.57E-08
78-93-3	Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	6.90E-07	1.80E-10	NC	NC	6.90E-07
75-09-2	Methylene chloride = Dichloromethane	NC	NC	3.87E-08	1.23E-07	1.61E-07
75-09-2	Methylene chloride = Dichloromethane (inhl.)	1.10E-05	3.83E-10	NC	NC	1.10E-05
85-01-8	Phenanthrene	NA	NA	NA	NA	0.00E+00
1336-36-3	Polychlorinated biphenyls (PCBs)	2.42E-05	2.87E-07	2.90E-05	9.19E-05	1.45E-04
129-00-0	Pyrene	NC	NC	NA	NA	0.00E+00
129-00-0	Pyrene (inhalation)	NA	NA	NC	NC	0.00E+00
108-88-3	Toluene = Toluol	NC	NC	2.96E-09	9.37E-09	1.23E-08
108-88-3	Toluene = Toluol (inhalation)	2.43E-07	2.92E-11	NC	NC	2.43E-07
71-55-6	Trichloroethane (1,1,1-) = Methyl chloroform	NC	NC	1.59E-08	5.03E-08	6.62E-08
71-55-6	Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	2.36E-06	1.57E-10	NC	NC	2.36E-06
79-00-5	Trichloroethane (1,1,2-)	5.80E-06	8.69E-10	8.78E-08	2.78E-07	6.17E-06
79-01-6	Trichloroethylene	NC	NC	3.86E-08	1.22E-07	1.61E-07
79-01-6	Trichloroethylene (inhalation)	4.94E-06	3.83E-10	NC	NC	4.94E-06
75-01-4	Vinyl chloride	NC	NC	7.61E-07	2.41E-06	3.17E-06
75-01-4	Vinyl chloride (inhalation)	6.17E-04	7.52E-09	NC	NC	6.17E-04
xxx-xx-x	Sum of all chemicals	7.98E-04	3.15E-07	3.19E-05	9.70E-05	9.27E-04

Table E-2. Non-Carcinogenic Hazard Quotients Under Ambient Conditions: ADD/RfD

CHEMICAL	Inhalation Vapor ADD / RfD	Inhalation Particulates ADD / RfD	Ingestion, Soil ADD / RfD	Dermal, Soil ADD / RfD	Total ADD / RfD
Acetone	7.49E-05	2.91E-09	1.85E-06	2.92E-06	7.96E-05
Aldrin	1.94E-05	3.18E-06	2.02E-03	3.19E-04	2.36E-03
Anthracene	8.46E-07	NC	NC	NC	8.46E-07
Benzo(a)anthracene	NC	NA	NA	NA	0.00E+00
Benzo(a)anthracene (inhalation)	NA	NA	NA	NA	0.00E+00
Benz(a)pyrene	NC	NA	NA	NA	0.00E+00
Benz(a)pyrene (inhalation)	NA	NA	NA	NA	0.00E+00
Benzo(b)fluoranthene	NC	NA	NA	NA	0.00E+00
Benzo(b)fluoranthene (inhalation)	NA	NA	NA	NA	0.00E+00
Benzo(ghi)perylene	NC	NA	NA	NA	0.00E+00
Benzo(ghi)perylene (inhalation)	NA	NA	NA	NA	0.00E+00
Benzo(k)fluoranthene	NC	NA	NA	NA	0.00E+00
Benzo(k)fluoranthene (inhalation)	NA	NA	NA	NA	0.00E+00
Carbon disulfide	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	6.41E-03	NC	NC	NC	6.41E-03
Chrysene	NC	NA	NA	NA	0.00E+00
Chrysene (inhalation)	NA	NA	NA	NA	0.00E+00
Di-n-octyl phthalate	4.71E-06	1.40E-07	8.88E-05	1.40E-05	1.08E-04
Dichloroethane (1,1-)	2.04E-04	1.79E-08	1.14E-05	1.81E-05	2.33E-04
Dichloroethane (1,2-) = Ethylene dichloride	1.50E-05	1.79E-09	1.09E-06	1.73E-06	1.78E-05
Dichloroethylene (trans-1,2)	1.44E-03	1.68E-07	1.07E-04	1.69E-04	1.72E-03
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NAR	9.84E-06	1.56E-05	2.54E-05
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	1.89E-03	3.66E-08	NAR	NAR	1.89E-03
Ethylbenzene	2.32E-05	NC	NC	NC	2.32E-05
Floranthene	3.16E-07	8.67E-08	5.49E-05	8.69E-06	6.40E-05
Fluorene	2.36E-06	NC	NC	NC	2.36E-06
Hexachlorocyclohexane, beta isomer (beta-HCH)	NA	NA	NA	NA	0.00E+00
Indeno(1,2,3)perylene	NC	NA	NA	NA	0.00E+00
Indeno(1,2,3)perylene (inhalation)	NA	NA	NA	NA	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NAR	2.99E-06	4.73E-06	7.73E-06
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	5.30E-05	2.62E-09	NAR	NAR	5.30E-05
Methylene chloride = Dichloromethane	NC	NAR	1.44E-06	2.27E-06	3.71E-06
Methylene chloride = Dichloromethane (inhl.)	2.59E-04	1.57E-09	NAR	NAR	2.59E-04
Phenanthrene	2.58E-05	3.78E-07	2.40E-04	3.79E-05	3.04E-04
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	0.00E+00
Pyrene	NC	NAR	6.81E-05	1.08E-05	7.88E-05
Pyrene (inhalation)	7.99E-07	1.07E-07	NAR	NAR	9.06E-07
Toluene = Toluol	NC	NAR	4.52E-07	7.16E-07	1.17E-06
Toluene = Toluol (inhalation)	1.88E-06	3.75E-10	NAR	NAR	1.88E-06
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NAR	5.62E-06	8.89E-06	1.45E-05
Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	1.76E-04	2.66E-09	NAR	NAR	1.76E-04
Trichloroethane (1,1,2-)	9.33E-04	2.85E-08	1.80E-05	2.84E-05	9.79E-04
Trichloroethylene	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	0.00E+00
Vinyl chloride	NC	2.53E-07	1.61E-04	2.54E-04	4.16E-04
Vinyl chloride (inhalation)	NA	NA	NA	NA	0.00E+00
Sum of all chemicals	1.15E-02	4.41E-06	2.79E-03	8.97E-04	1.52E-02

CHEMICAL	Inhalation Vapor ADD / TLV	Inhalation Particulates ADD / TLV	Ingestion, Soil ADD / TLV	Dermal, Soil ADD / TLV	Total ADD / TLV
Acetone	3.28E-08	1.60E-12	8.43E-10	1.33E-09	3.50E-08
Aldrin	1.82E-08	3.72E-09	1.97E-06	3.11E-07	2.30E-06
Anthracene	NA	NC	NC	NC	0.00E+00
Benzo(a)anthracene	NC	NC	NA	NA	0.00E+00
Benzo(a)anthracene (inhalation)	NA	NA	NC	NC	0.00E+00
Benz(a)pyrene	NC	NC	NA	NA	0.00E+00
Benz(a)pyrene (inhalation)	NA	NA	NC	NC	0.00E+00
Benzo(b)fluoranthene	NC	NC	NA	NA	0.00E+00
Benzo(b)fluoranthene (inhalation)	NA	NA	NC	NC	0.00E+00
Benzo(ghi)perylene	NC	NC	NA	NA	0.00E+00
Benzo(ghi)perylene (inhalation)	NA	NA	NC	NC	0.00E+00
Benzo(k)fluoranthene	NC	NC	NA	NA	0.00E+00
Benzo(k)fluoranthene (inhalation)	NA	NA	NC	NC	0.00E+00
Carbon disulfide	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	4.61E-06	NC	NC	NC	4.61E-06
Chrysene	NC	NC	NA	NA	0.00E+00
Chrysene (inhalation)	NA	NA	NC	NC	0.00E+00
Di-n-octyl phthalate	NA	NA	NA	NA	0.00E+00
Dichloroethane (1,1-)	1.96E-07	2.16E-11	1.15E-08	1.81E-08	2.26E-07
Dichloroethane (1,2-) = Ethylene dichloride	3.50E-07	5.25E-11	2.66E-08	4.21E-08	4.19E-07
Dichloroethylene (trans-1,2)	2.84E-07	4.14E-11	2.19E-08	3.46E-08	3.40E-07
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	3.60E-08	5.69E-08	9.29E-08
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	6.65E-06	1.60E-10	NC	NC	6.65E-06
Ethylbenzene	4.17E-08	NC	NC	NC	4.17E-08
Floranthene	NA	NA	NA	NA	0.00E+00
Fluorene	NA	NC	NC	NC	0.00E+00
Hexachlorocyclohexane, beta isomer (beta-HCH)	NA	NA	NA	NA	0.00E+00
Indeno(1,2,3)perylene	NC	NC	NA	NA	0.00E+00
Indeno(1,2,3)perylene (inhalation)	NA	NA	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	2.06E-09	3.26E-09	5.32E-09
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	6.31E-08	3.90E-12	NC	NC	6.31E-08
Methylene chloride = Dichloromethane	NC	NC	4.03E-09	6.37E-09	1.04E-08
Methylene chloride = Dichloromethane (inhl.)	1.01E-06	7.64E-12	NC	NC	1.01E-06
Phenanthrene	NA	NA	NA	NA	0.00E+00
Polychlorinated biphenyls (PCBs)	2.21E-06	8.42E-08	4.46E-05	7.05E-05	1.17E-04
Pyrene	NC	NC	NA	NA	0.00E+00
Pyrene (inhalation)	NA	NA	NC	NC	0.00E+00
Toluene = Toluol	NC	NC	2.93E-09	4.63E-09	7.55E-09
Toluene = Toluol (inhalation)	2.22E-08	5.54E-12	NC	NC	2.22E-08
Trichloroethane (1,1,1-) = Methyl chloroform	NC	NC	2.15E-09	3.40E-09	5.55E-09
Trichloroethane (1,1,1-) = Methyl chloroform (inhl.)	2.15E-07	4.07E-12	NC	NC	2.15E-07
Trichloroethane (1,1,2-)	5.29E-07	2.02E-11	1.06E-08	1.68E-08	5.57E-07
Trichloroethylene	NC	NC	2.90E-09	4.58E-09	7.48E-09
Trichloroethylene (inhalation)	4.50E-07	5.46E-12	NC	NC	4.50E-07
Vinyl chloride	NC	NC	1.31E-07	2.07E-07	3.37E-07
Vinyl chloride (inhalation)	5.64E-05	2.47E-10	NC	NC	5.64E-05
Sum of all chemicals	7.31E-05	8.85E-08	4.68E-05	7.12E-05	1.91E-04

Table E-3. Non-Carcinogenic Hazard Quotients for Adult Males Exposed to Bergholtz Creek

CHEMICAL	Adult Male - Bergholtz Creek Exposure						
	Inhalation ADD / RfD	Ingestion ADD / RfD	Dermal Contact ADD / RfD	Sediment Ingest ADD / RfD	Sediment, Dermal ADD / RfD	Milk Ingest ADD / RfD	Total ADD / RfD
Acetone	2.07E-10	3.63E-10	2.54E-11	7.05E-07	1.12E-06	4.62E-13	1.83E-06
Benzene	7.60E-12	8.65E-12	2.74E-11	NC	NC	9.95E-17	4.36E-11
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	3.32E-07	8.47E-07	NC	NC	2.65E-12	1.18E-06
Chloroform = Trichloromethane (inhalation)	2.97E-07	NC	NC	NC	NC	NC	2.97E-07
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	5.17E-06	5.61E-06	6.93E-06	NC	NC	1.46E-11	1.77E-05
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	2.69E-06	2.31E-06	NC	NC	4.48E-12	5.00E-06
Methylene chloride = Dichloromethane (inhl.)	2.37E-07	NC	NC	NC	NC	NC	2.37E-07
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	1.02E-14	6.03E-14	NC	NC	4.18E-19	7.04E-14
Toluene = Toluol (inhalation)	4.34E-15	NC	NC	NC	NC	NC	4.34E-15
Trichloroethane (1,1,1-) = Methyl chloroform	NC	1.42E-09	6.76E-09	NC	NC	3.54E-14	8.19E-09
Trichloroethane (1,1,1-) = " " (inhl.)	3.52E-10	NC	NC	NC	NC	NC	3.52E-10
Trichloroethylene	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	3.04E-08	8.90E-09	NC	NC	1.15E-14	3.93E-08
Vinyl chloride (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Sum of all chemicals	5.70E-06	8.67E-06	1.01E-05	7.05E-07	1.12E-06	2.22E-11	2.63E-05

Table E-4. Non-Carcinogenic Hazard Quotients for Adult Females Exposed to Bergholtz Creek

CHEMICAL	Adult Female - Bergholtz Creek Exposure						
	Inhalation ADD / RfD	Ingestion ADD / RfD	Dermal Contact ADD / RfD	Sediment Ingest ADD / RfD	Sediment, Dermal ADD / RfD	Milk Ingest ADD / RfD	Total ADD / RfD
Acetone	2.48E-10	4.36E-10	2.65E-11	8.46E-07	1.17E-06	5.54E-13	2.02E-06
Benzene	9.12E-12	1.04E-11	2.86E-11	NC	NC	1.19E-16	4.81E-11
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	3.98E-07	8.86E-07	NC	NC	3.18E-12	1.28E-06
Chloroform = Trichloromethane (inhalation)	3.56E-07	NC	NC	NC	NC	NC	3.56E-07
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	6.20E-06	6.73E-06	7.25E-06	NC	NC	1.75E-11	2.02E-05
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	3.23E-06	2.42E-06	NC	NC	5.37E-12	5.65E-06
Methylene chloride = Dichloromethane (inhl.)	2.85E-07	NC	NC	NC	NC	NC	2.85E-07
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	1.22E-14	6.30E-14	NC	NC	5.01E-19	7.52E-14
Toluene = Toluol (inhalation)	5.21E-15	NC	NC	NC	NC	NC	5.21E-15
Trichloroethane (1,1,1-) = Methyl chloroform	NC	1.71E-09	7.07E-09	NC	NC	4.25E-14	8.78E-09
Trichloroethane (1,1,1-) = " " (inhl.)	4.23E-10	NC	NC	NC	NC	NC	4.23E-10
Trichloroethylene	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	3.65E-08	9.31E-09	NC	NC	1.38E-14	4.58E-08
Vinyl chloride (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Sum of all chemicals	6.84E-06	1.04E-05	1.06E-05	8.46E-07	1.17E-06	2.67E-11	2.98E-05

Table E-5. Non-Carcinogenic Hazard Quotients for 15 Year Old Exposed to Bergholtz Creek

15 Year Old - Bergholtz Creek Exposure

CHEMICAL	Inhalation ADD / RfD	Ingestion ADD / RfD	Dermal Contact ADD / RfD	Sediment Ingest ADD / RfD	Sediment, Dermal ADD / RfD	Milk Ingest ADD / RfD	Total ADD / RfD
Acetone	3.02E-10	5.06E-10	2.88E-11	9.82E-07	1.28E-06	6.43E-13	2.26E-06
Benzene	1.11E-11	1.21E-11	3.11E-11	NC	NC	1.39E-16	5.42E-11
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	4.63E-07	9.61E-07	NC	NC	3.70E-12	1.42E-06
Chloroform = Trichloromethane (inhalation)	4.34E-07	NC	NC	NC	NC	NC	4.34E-07
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	7.56E-06	7.81E-06	7.87E-06	NC	NC	2.03E-11	2.32E-05
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	3.75E-06	2.62E-06	NC	NC	6.24E-12	6.37E-06
Methylene chloride = Dichloromethane (inhl.)	3.47E-07	NC	NC	NC	NC	NC	3.47E-07
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	1.42E-14	6.84E-14	NC	NC	5.82E-19	8.25E-14
Toluene = Toluol (inhalation)	6.35E-15	NC	NC	NC	NC	NC	6.35E-15
Trichloroethane (1,1,1-) = Methyl chloroform	NC	1.98E-09	7.67E-09	NC	NC	4.93E-14	9.66E-09
Trichloroethane (1,1,1-) = " " (inhl.)	5.16E-10	NC	NC	NC	NC	NC	5.16E-10
Trichloroethylene	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	4.24E-08	1.01E-08	NC	NC	1.60E-14	5.25E-08
Vinyl chloride (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Sum of all chemicals	8.34E-06	1.21E-05	1.15E-05	9.82E-07	1.28E-06	3.10E-11	3.41E-05

Table E-6. Non-Carcinogenic Hazard Quotients for 9 Year Old Exposed to Bergholtz Creek

9 Year Old - Bergholtz Creek Exposure

CHEMICAL	Inhalation ADD / RfD	Ingestion ADD / RfD	Dermal Contact ADD / RfD	Sediment Ingest ADD / RfD	Sediment, Dermal ADD / RfD	Milk Ingest ADD / RfD	Total ADD / RfD
Acetone	3.90E-10	9.15E-10	3.43E-11	1.77E-06	1.52E-06	1.58E-12	3.30E-06
Benzene	1.43E-11	2.18E-11	3.70E-11	NC	NC	3.41E-16	7.31E-11
Carbon disulfide	NC	NC	NC	NC	NC	NC	0.00E+00
Carbon disulfide (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroethane	NC	NC	NC	NC	NC	NC	0.00E+00
Chloroform = Trichloromethane	NC	8.35E-07	1.15E-06	NC	NC	9.08E-12	1.98E-06
Chloroform = Trichloromethane (inhalation)	5.60E-07	NC	NC	NC	NC	NC	5.60E-07
Dichloroethane (1,1-)	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethane (1,2-) = Ethylene dichloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene (trans-1,2)	9.76E-06	1.41E-05	9.38E-06	NC	NC	5.00E-11	3.32E-05
Dichloroethylene(1,1-) = Vinylidene chloride	NC	NC	NC	NC	NC	NC	0.00E+00
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC	NC	NC	NC	NC	NC	0.00E+00
Lindane = Hexachlorocyclohexane, gamma	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone	NC	NC	NC	NC	NC	NC	0.00E+00
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC	NC	NC	NC	NC	NC	0.00E+00
Methylene chloride = Dichloromethane	NC	6.77E-06	3.12E-06	NC	NC	1.53E-11	9.90E-06
Methylene chloride = Dichloromethane (inhl.)	4.48E-07	NC	NC	NC	NC	NC	4.48E-07
Polychlorinated biphenyls (PCBs)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethane (1,1,2,2-)	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene	NC	NC	NC	NC	NC	NC	0.00E+00
Tetrachloroethylene = Perchloroethylene (inhl)	NC	NC	NC	NC	NC	NC	0.00E+00
Toluene = Toluol	NC	2.56E-14	8.15E-14	NC	NC	1.43E-18	1.07E-13
Toluene = Toluol (inhalation)	8.19E-15	NC	NC	NC	NC	NC	8.19E-15
Trichloroethane (1,1,1-) = Methyl chloroform	NC	3.58E-09	9.15E-09	NC	NC	1.21E-13	1.27E-08
Trichloroethane (1,1,1-) = " " (inhl.)	6.65E-10	NC	NC	NC	NC	NC	6.65E-10
Trichloroethylene	NC	NA	NA	NC	NC	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane	NC	NC	NC	NC	NC	NC	0.00E+00
Trichlorofluoromethane (inhalation)	NC	NC	NC	NC	NC	NC	0.00E+00
Vinyl chloride	NC	7.66E-08	1.20E-08	NC	NC	3.93E-14	8.86E-08
Vinyl chloride (inhalation)	NA	NC	NC	NC	NC	NC	0.00E+00
Sum of all chemicals	1.08E-05	2.18E-05	1.37E-05	1.77E-06	1.52E-06	7.61E-11	4.95E-05

CHEMICAL	Milk Ingest ADD / RfD
Acetone	3.06E-12
Benzene	6.60E-16
Carbon disulfide	NC
Carbon disulfide (inhalation)	NC
Chloroethane	NC
Chloroform = Trichloromethane	1.76E-11
Chloroform = Trichloromethane (inhalation)	NC
Dichloroethane (1,1-)	NC
Dichloroethane (1,2-) = Ethylene dichloride	NC
Dichloroethylene (trans-1,2)	9.68E-11
Dichloroethylene(1,1-) = Vinylidene chloride	NC
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	NC
Lindane = Hexachlorocyclohexane, gamma	NC
Methyl ethyl ketone (MEK) = 2-butanone	NC
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	NC
Methylene chloride = Dichloromethane	2.97E-11
Methylene chloride = Dichloromethane (inhl.)	NC
Polychlorinated biphenyls (PCBs)	NC
Tetrachloroethane (1,1,2,2-)	NC
Tetrachloroethylene = Perchloroethylene	NC
Tetrachloroethylene = Perchloroethylene (inhl)	NC
Toluene = Toluol	2.77E-18
Toluene = Toluol (inhalation)	NC
Trichloroethane (1,1,1-) = Methyl chloroform	2.35E-13
Trichloroethane (1,1,1-) = " " (inhl.)	NC
Trichloroethylene	NA
Trichloroethylene (inhalation)	NC
Trichlorofluoromethane	NC
Trichlorofluoromethane (inhalation)	NC
Vinyl chloride	7.62E-14
Vinyl chloride (inhalation)	NC
Sum of all chemicals	1.48E-10

Table E-8. Non-Carcinogenic Hazard Quotients for Adult Male Exposed to Irrigation Wells

CHEMICAL	GARDENING Inhalation ADD / RfD	GARDENING Ingestion ADD / RfD	GARDENING Dermal ADD / RfD	CAR WASHING Inhalation ADD / RfD	CAR WASHING Ingestion ADD / RfD	CAR WASHING Dermal ADD / RfD	Total Produce ADD / RfD	Total ADD / RfD
Acetone	2.32E-05	1.50E-04	5.59E-06	1.67E-05	1.50E-04	1.31E-06	3.35E-05	3.79E-04
Benzene	1.95E-03	8.88E-03	1.50E-02	1.41E-03	8.88E-03	3.51E-03	1.27E-02	5.24E-02
Carbon disulfide	NC	1.76E-04	3.09E-04	NC	1.76E-04	7.22E-05	2.58E-04	9.91E-04
Carbon disulfide (inhalation)	1.78E-03	NC	NC	1.28E-03	NC	NC	NA	3.06E-03
Chloroethane	1.05E-05	3.31E-05	2.03E-05	7.58E-06	3.31E-05	4.73E-06	2.75E-05	1.37E-04
Chloroform = Trichloromethane	NC	7.93E-04	1.08E-03	NC	7.93E-04	2.53E-04	9.85E-04	3.91E-03
Chloroform = Trichloromethane (inhalation)	1.77E-04	NC	NC	1.28E-04	NC	NC	NA	3.05E-04
Dichloroethane (1,1-)	1.66E-05	5.58E-05	5.90E-05	1.19E-05	5.58E-05	1.38E-05	6.00E-05	2.73E-04
Dichloroethane (1,2-) = Ethylene dichloride	1.18E-05	5.41E-05	3.41E-05	8.53E-06	5.41E-05	7.97E-06	4.56E-05	2.16E-04
Dichloroethylene (trans-1,2)	2.38E-03	7.28E-03	4.82E-03	1.71E-03	7.28E-03	1.13E-03	8.88E-03	3.35E-02
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.14E-03	7.54E-04	NC	1.14E-03	1.76E-04	9.81E-04	4.19E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	3.52E-04	NC	NC	2.53E-04	NC	NC	NA	6.05E-04
Lindane = Hexachlorocyclohexane, gamma	4.59E-06	8.55E-05	4.03E-04	3.31E-06	8.55E-05	9.42E-05	3.90E-04	1.07E-03
Methyl ethyl ketone (MEK) = 2-butanone	NC	6.86E-04	6.03E-05	NC	6.86E-04	1.41E-05	2.36E-04	1.68E-03
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	5.99E-05	NC	NC	4.32E-05	NC	NC	NA	1.03E-04
Methylene chloride = Dichloromethane	NC	5.98E-04	2.75E-04	NC	5.98E-04	6.41E-05	4.40E-04	1.97E-03
Methylene chloride = Dichloromethane (inhl.)	1.32E-05	NC	NC	9.49E-06	NC	NC	NA	2.27E-05
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Tetrachloroethane (1,1,2,2-)	6.17E-04	2.63E-03	6.12E-03	4.45E-04	2.63E-03	1.43E-03	4.83E-03	1.87E-02
Tetrachloroethylene = Perchloroethylene	NC	3.53E-04	9.55E-04	NC	3.53E-04	2.23E-04	7.48E-04	2.63E-03
Tetrachloroethylene = Perchloroethylene (inhl)	6.94E-05	NC	NC	5.00E-05	NC	NC	NA	1.19E-04
Toluene = Toluol	NC	2.75E-05	8.71E-05	NC	2.75E-05	2.03E-05	6.92E-05	2.32E-04
Toluene = Toluol (inhalation)	2.95E-06	NC	NC	2.12E-06	NC	NC	NA	5.07E-06
Trichloroethane (1,1,1-) = Methyl chloroform	NC	1.42E-04	3.62E-04	NC	1.42E-04	8.45E-05	2.84E-04	1.01E-03
Trichloroethane (1,1,1-) = " " (inhl.)	8.81E-06	NC	NC	6.35E-06	NC	NC	NA	1.52E-05
Trichloroethylene	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Trichlorofluoromethane	NC	1.45E-05	3.93E-05	NC	1.45E-05	9.18E-06	3.08E-05	1.08E-04
Trichlorofluoromethane (inhalation)	1.44E-06	NC	NC	1.04E-06	NC	NC	NA	2.48E-06
Vinyl chloride	NC	1.85E-02	2.89E-03	NC	1.85E-02	6.75E-04	8.45E-03	4.89E-02
Vinyl chloride (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Sum of all chemicals	7.48E-03	4.16E-02	3.33E-02	5.39E-03	4.16E-02	7.78E-03	3.94E-02	1.77E-01

Table E-9. Non-Carcinogenic Hazard Quotients for Adult Female Exposed to Irrigation Wells

CHEMICAL	GARDENING Inhalation ADD / RfD	GARDENING Ingestion ADD / RfD	GARDENING Dermal ADD / RfD	CAR WASHING Inhalation ADD / RfD	CAR WASHING Ingestion ADD / RfD	CAR WASHING Dermal ADD / RfD	Total Produce ADD / RfD	Total ADD / RfD
Acetone	2.78E-05	1.79E-04	5.84E-06	1.90E-05	1.79E-04	1.36E-06	4.02E-05	4.53E-04
Benzene	2.34E-03	1.07E-02	1.57E-02	1.60E-03	1.07E-02	3.67E-03	1.52E-02	5.99E-02
Carbon disulfide	NC	2.11E-04	3.23E-04	NC	2.11E-04	7.55E-05	3.09E-04	1.13E-03
Carbon disulfide (inhalation)	2.14E-03	NC	NC	1.46E-03	NC	NC	NA	3.60E-03
Chloroethane	1.26E-05	3.97E-05	2.12E-05	8.65E-06	3.97E-05	4.95E-06	3.30E-05	1.60E-04
Chloroform = Trichloromethane	NC	9.52E-04	1.13E-03	NC	9.52E-04	2.64E-04	1.18E-03	4.48E-03
Chloroform = Trichloromethane (inhalation)	2.13E-04	NC	NC	1.46E-04	NC	NC	NA	3.58E-04
Dichloroethane (1,1-)	1.99E-05	6.69E-05	6.17E-05	1.36E-05	6.69E-05	1.44E-05	7.20E-05	3.15E-04
Dichloroethane (1,2-) = Ethylene dichloride	1.42E-05	6.49E-05	3.57E-05	9.72E-06	6.49E-05	8.33E-06	5.47E-05	2.52E-04
Dichloroethylene (trans-1,2)	2.85E-03	8.74E-03	5.04E-03	1.95E-03	8.74E-03	1.18E-03	1.07E-02	3.91E-02
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.37E-03	7.88E-04	NC	1.37E-03	1.84E-04	1.18E-03	4.88E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	4.22E-04	NC	NC	2.89E-04	NC	NC	NA	7.11E-04
Lindane = Hexachlorocyclohexane, gamma	5.51E-06	1.03E-04	4.22E-04	3.77E-06	1.03E-04	9.85E-05	4.67E-04	1.20E-03
Methyl ethyl ketone (MEK) = 2-butanone	NC	8.23E-04	6.31E-05	NC	8.23E-04	1.47E-05	2.83E-04	2.01E-03
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	7.19E-05	NC	NC	4.92E-05	NC	NC	NA	1.21E-04
Methylene chloride = Dichloromethane	NC	7.17E-04	2.87E-04	NC	7.17E-04	6.70E-05	5.28E-04	2.32E-03
Methylene chloride = Dichloromethane (inhl.)	1.58E-05	NC	NC	1.08E-05	NC	NC	NA	2.66E-05
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Tetrachloroethane (1,1,2,2-)	7.41E-04	3.16E-03	6.40E-03	5.07E-04	3.16E-03	1.50E-03	5.80E-03	2.13E-02
Tetrachloroethylene = Perchloroethylene	NC	4.23E-04	9.98E-04	NC	4.23E-04	2.33E-04	8.98E-04	2.98E-03
Tetrachloroethylene = Perchloroethylene (inhl)	8.33E-05	NC	NC	5.70E-05	NC	NC	NA	1.40E-04
Toluene = Toluol	NC	3.30E-05	9.11E-05	NC	3.30E-05	2.13E-05	8.30E-05	2.61E-04
Toluene = Toluol (inhalation)	3.53E-06	NC	NC	2.42E-06	NC	NC	NA	5.95E-06
Trichloroethane (1,1,1-) = Methyl chloroform	NC	1.71E-04	3.78E-04	NC	1.71E-04	8.84E-05	3.40E-04	1.15E-03
Trichloroethane (1,1,1-) = " " (inhl.)	1.06E-05	NC	NC	7.23E-06	NC	NC	NA	1.78E-05
Trichloroethylene	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Trichlorofluoromethane	NC	1.74E-05	4.11E-05	NC	1.74E-05	9.60E-06	3.70E-05	1.23E-04
Trichlorofluoromethane (inhalation)	1.73E-06	NC	NC	1.19E-06	NC	NC	NA	2.92E-06
Vinyl chloride	NC	2.21E-02	3.02E-03	NC	2.21E-02	7.06E-04	1.01E-02	5.81E-02
Vinyl chloride (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Sum of all chemicals	8.97E-03	4.99E-02	3.48E-02	6.14E-03	4.99E-02	8.13E-03	4.73E-02	2.05E-01

Table E-10. Non-Carcinogenic Hazard Quotients for 15 Year Old Exposed to Irrigation Wells

CHEMICAL	GARDENING Inhalation ADD / RfD	GARDENING Ingestion ADD / RfD	GARDENING Dermal ADD / RfD	CAR WASHING Inhalation ADD / RfD	CAR WASHING Ingestion ADD / RfD	CAR WASHING Dermal ADD / RfD	Total Produce ADD / RfD	Total ADD / RfD
Acetone	3.39E-05	2.08E-04	6.34E-06	2.21E-05	2.08E-04	1.48E-06	4.66E-05	5.27E-04
Benzene	2.86E-03	1.24E-02	1.71E-02	1.86E-03	1.24E-02	3.98E-03	1.77E-02	6.82E-02
Carbon disulfide	NC	2.45E-04	3.51E-04	NC	2.45E-04	8.19E-05	3.59E-04	1.28E-03
Carbon disulfide (inhalation)	2.61E-03	NC	NC	1.70E-03	NC	NC	NA	4.30E-03
Chloroethane	1.54E-05	4.61E-05	2.30E-05	1.00E-05	4.61E-05	5.37E-06	3.84E-05	1.84E-04
Chloroform = Trichloromethane	NC	1.10E-03	1.23E-03	NC	1.10E-03	2.87E-04	1.37E-03	5.10E-03
Chloroform = Trichloromethane (inhalation)	2.59E-04	NC	NC	1.69E-04	NC	NC	NA	4.28E-04
Dichloroethane (1,1-)	2.42E-05	7.77E-05	6.69E-05	1.58E-05	7.77E-05	1.56E-05	8.35E-05	3.61E-04
Dichloroethane (1,2-) = Ethylene dichloride	1.73E-05	7.53E-05	3.87E-05	1.13E-05	7.53E-05	9.04E-06	6.35E-05	2.90E-04
Dichloroethylene (trans-1,2)	3.48E-03	1.01E-02	5.47E-03	2.26E-03	1.01E-02	1.28E-03	1.24E-02	4.51E-02
Dichloroethylene(1,1-) = Vinylidene chloride	NC	1.59E-03	8.55E-04	NC	1.59E-03	2.00E-04	1.37E-03	5.60E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	5.15E-04	NC	NC	3.35E-04	NC	NC	NA	8.50E-04
Lindane = Hexachlorocyclohexane, gamma	6.72E-06	1.19E-04	4.58E-04	4.38E-06	1.19E-04	1.07E-04	5.43E-04	1.36E-03
Methyl ethyl ketone (MEK) = 2-butanone	NC	9.56E-04	6.85E-05	NC	9.56E-04	1.60E-05	3.29E-04	2.32E-03
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	8.77E-05	NC	NC	5.71E-05	NC	NC	NA	1.45E-04
Methylene chloride = Dichloromethane	NC	8.32E-04	3.11E-04	NC	8.32E-04	7.27E-05	6.13E-04	2.66E-03
Methylene chloride = Dichloromethane (inhl.)	1.93E-05	NC	NC	1.26E-05	NC	NC	NA	3.18E-05
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Tetrachloroethane (1,1,2,2-)	9.03E-04	3.67E-03	6.95E-03	5.88E-04	3.67E-03	1.62E-03	6.73E-03	2.41E-02
Tetrachloroethylene = Perchloroethylene	NC	4.91E-04	1.08E-03	NC	4.91E-04	2.53E-04	1.04E-03	3.36E-03
Tetrachloroethylene = Perchloroethylene (inhl)	1.02E-04	NC	NC	6.62E-05	NC	NC	NA	1.68E-04
Toluene = Toluol	NC	3.83E-05	9.88E-05	NC	3.83E-05	2.31E-05	9.64E-05	2.95E-04
Toluene = Toluol (inhalation)	4.31E-06	NC	NC	2.81E-06	NC	NC	NA	7.12E-06
Trichloroethane (1,1,1-) = Methyl chloroform	NC	1.98E-04	4.11E-04	NC	1.98E-04	9.59E-05	3.95E-04	1.30E-03
Trichloroethane (1,1,1-) = " " (inhl.)	1.29E-05	NC	NC	8.40E-06	NC	NC	NA	2.13E-05
Trichloroethylene	NC	NA	NA	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA	NA	NA	0.00E+00
Trichlorofluoromethane	NC	2.02E-05	4.46E-05	NC	2.02E-05	1.04E-05	4.29E-05	1.38E-04
Trichlorofluoromethane (inhalation)	2.11E-06	NC	NC	1.38E-06	NC	NC	NA	3.49E-06
Vinyl chloride	NC	2.57E-02	3.28E-03	NC	2.57E-02	7.66E-04	1.18E-02	6.72E-02
Vinyl chloride (inhalation)	NA	NC	NC	NA	NC	NC	NA	0.00E+00
Sum of all chemicals	1.09E-02	5.79E-02	3.78E-02	7.13E-03	5.79E-02	8.83E-03	5.49E-02	2.35E-01

Table E-11. Non-Carcinogenic Hazard Quotients for 9 Year Old Exposed to Irrigation Wells

CHEMICAL	WADING POOL Inhalation ADD / RfD	WADING POOL Ingestion ADD / RfD	WADING POOL Dermal ADD / RfD	Total Produce ADD / RfD	Total ADD / RfD
Acetone	1.75E-04	3.76E-04	8.59E-05	8.43E-05	7.21E-04
Benzene	1.47E-02	2.24E-02	2.31E-01	3.19E-02	3.00E-01
Carbon disulfide	NC	4.42E-04	4.75E-03	6.49E-04	5.84E-03
Carbon disulfide (inhalation)	1.35E-02	NC	NC	NA	1.35E-02
Chloroethane	7.95E-05	8.33E-05	3.11E-04	6.93E-05	5.44E-04
Chloroform = Trichloromethane	NC	2.00E-03	1.67E-02	2.48E-03	2.11E-02
Chloroform = Trichloromethane (inhalation)	1.34E-03	NC	NC	NA	1.34E-03
Dichloroethane (1,1-)	1.25E-04	1.40E-04	9.07E-04	1.51E-04	1.32E-03
Dichloroethane (1,2-) = Ethylene dichloride	8.94E-05	1.36E-04	5.25E-04	1.15E-04	8.65E-04
Dichloroethylene (trans-1,2)	1.79E-02	1.83E-02	7.41E-02	2.23E-02	1.33E-01
Dichloroethylene(1,1-) = Vinylidene chloride	NC	2.87E-03	1.16E-02	2.47E-03	1.69E-02
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	2.66E-03	NC	NC	NA	2.66E-03
Lindane = Hexachlorocyclohexane, gamma	3.47E-05	2.15E-04	6.20E-03	9.80E-04	7.43E-03
Methyl ethyl ketone (MEK) = 2-butanone	NC	1.73E-03	9.28E-04	5.94E-04	3.25E-03
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	4.53E-04	NC	NC	NA	4.53E-04
Methylene chloride = Dichloromethane	NC	1.50E-03	4.22E-03	1.11E-03	6.83E-03
Methylene chloride = Dichloromethane (inhl.)	9.95E-05	NC	NC	NA	9.95E-05
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	0.00E+00
Tetrachloroethane (1,1,2,2-)	4.66E-03	6.63E-03	9.41E-02	1.22E-02	1.18E-01
Tetrachloroethylene = Perchloroethylene	NC	8.87E-04	1.47E-02	1.88E-03	1.75E-02
Tetrachloroethylene = Perchloroethylene (inhl)	5.24E-04	NC	NC	NA	5.24E-04
Toluene = Toluol	NC	6.91E-05	1.34E-03	1.74E-04	1.58E-03
Toluene = Toluol (inhalation)	2.22E-05	NC	NC	NA	2.22E-05
Trichloroethane (1,1,1-) = Methyl chloroform	NC	3.58E-04	5.56E-03	7.14E-04	6.64E-03
Trichloroethane (1,1,1-) = " " (inhl.)	6.65E-05	NC	NC	NA	6.65E-05
Trichloroethylene	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	0.00E+00
Trichlorofluoromethane	NC	3.65E-05	6.04E-04	7.75E-05	7.18E-04
Trichlorofluoromethane (inhalation)	1.09E-05	NC	NC	NA	1.09E-05
Vinyl chloride	NC	4.64E-02	4.44E-02	2.13E-02	1.12E-01
Vinyl chloride (inhalation)	NA	NC	NC	NA	0.00E+00
Sum of all chemicals	5.65E-02	1.05E-01	5.12E-01	9.92E-02	7.72E-01

Table E-12. Non-Carcinogenic Hazard Quotients for 4 Year Old Exposed to Irrigation Wells

CHEMICAL	WADING POOL Inhalation ADD / RfD	WADING POOL Ingestion ADD / RfD	WADING POOL Dermal ADD / RfD	Total Produce ADD / RfD	Total ADD / RfD
Acetone	1.81E-04	7.29E-04	1.15E-04	1.63E-04	1.19E-03
Benzene	1.52E-02	4.33E-02	3.09E-01	6.18E-02	4.29E-01
Carbon disulfide	NC	8.57E-04	6.36E-03	1.26E-03	8.47E-03
Carbon disulfide (inhalation)	1.39E-02	NC	NC	NA	1.39E-02
Chloroethane	8.21E-05	1.61E-04	4.16E-04	1.34E-04	7.94E-04
Chloroform = Trichloromethane	NC	3.87E-03	2.23E-02	4.80E-03	3.09E-02
Chloroform = Trichloromethane (inhalation)	1.38E-03	NC	NC	NA	1.38E-03
Dichloroethane (1,1-)	1.29E-04	2.72E-04	1.21E-03	2.92E-04	1.91E-03
Dichloroethane (1,2-) = Ethylene dichloride	9.23E-05	2.64E-04	7.02E-04	2.22E-04	1.28E-03
Dichloroethylene (trans-1,2)	1.85E-02	3.55E-02	9.90E-02	4.33E-02	1.96E-01
Dichloroethylene(1,1-) = Vinylidene chloride	NC	5.56E-03	1.55E-02	4.78E-03	2.58E-02
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.)	2.74E-03	NC	NC	NA	2.74E-03
Lindane = Hexachlorocyclohexane, gamma	3.58E-05	4.17E-04	8.29E-03	1.90E-03	1.06E-02
Methyl ethyl ketone (MEK) = 2-butanone	NC	3.34E-03	1.24E-03	1.15E-03	5.74E-03
Methyl ethyl ketone (MEK) = 2-butanone (inhl.)	4.67E-04	NC	NC	NA	4.67E-04
Methylene chloride = Dichloromethane	NC	2.91E-03	5.64E-03	2.15E-03	1.07E-02
Methylene chloride = Dichloromethane (inhl.)	1.03E-04	NC	NC	NA	1.03E-04
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	0.00E+00
Tetrachloroethane (1,1,2,2-)	4.81E-03	1.28E-02	1.26E-01	2.36E-02	1.67E-01
Tetrachloroethylene = Perchloroethylene	NC	1.72E-03	1.96E-02	3.65E-03	2.50E-02
Tetrachloroethylene = Perchloroethylene (inhl)	5.41E-04	NC	NC	NA	5.41E-04
Toluene = Toluol	NC	1.34E-04	1.79E-03	3.37E-04	2.26E-03
Toluene = Toluol (inhalation)	2.30E-05	NC	NC	NA	2.30E-05
Trichloroethane (1,1,1-) = Methyl chloroform	NC	6.94E-04	7.44E-03	1.38E-03	9.52E-03
Trichloroethane (1,1,1-) = " " (inhl.)	6.87E-05	NC	NC	NA	6.87E-05
Trichloroethylene	NC	NA	NA	NA	0.00E+00
Trichloroethylene (inhalation)	NA	NA	NA	NA	0.00E+00
Trichlorofluoromethane	NC	7.08E-05	8.08E-04	1.50E-04	1.03E-03
Trichlorofluoromethane (inhalation)	1.13E-05	NC	NC	NA	1.13E-05
Vinyl chloride	NC	9.00E-02	5.94E-02	4.12E-02	1.91E-01
Vinyl chloride (inhalation)	NA	NC	NC	NA	0.00E+00
Sum of all chemicals	5.83E-02	2.03E-01	6.85E-01	1.92E-01	1.14E+00

Table E-13. Adult Male Non-Carcinogenic Hazard Quotients from Ingestion of Vegetables

CHEMICAL	ROOT ADD/RfD	LEAFY ADD/RfD	EXPOSED ADD/RfD	PROTECTED ADD/RfD	TOTAL PRODUCE ADD/RfD
Acetone	1.51E-05	2.36E-06	9.68E-06	6.37E-06	3.35E-05
Benzene	2.28E-03	1.09E-03	5.23E-03	4.08E-03	1.27E-02
Carbon disulfide	4.66E-05	2.22E-05	1.06E-04	8.29E-05	2.58E-04
Carbon disulfide (inhalation)	NAR	NAR	NAR	NAR	NA
Chloroethane	4.77E-06	2.43E-06	1.15E-05	8.84E-06	2.75E-05
Chloroform = Trichloromethane	1.73E-04	8.56E-05	4.09E-04	3.18E-04	9.85E-04
Chloroform = Trichloromethane (inhalation)	NA	NA	NA	NA	NA
Dichloroethane (1,1-)	1.03E-05	5.26E-06	2.50E-05	1.94E-05	6.00E-05
Dichloroethane (1,2-) = Ethylene dichloride	7.88E-06	4.03E-06	1.90E-05	1.46E-05	4.56E-05
Dichloroethylene (trans-1,2)	1.53E-03	7.85E-04	3.71E-03	2.86E-03	8.88E-03
Dichloroethylene(1,1-) = Vinylidene chloride	1.69E-04	8.67E-05	4.09E-04	3.16E-04	9.81E-04
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NA	NA	NA	NA	NA
Lindane = Hexachlorocyclohexane, gamma	1.05E-04	2.94E-05	1.42E-04	1.13E-04	3.90E-04
Methyl ethyl ketone (MEK) = 2-butanone	7.14E-05	1.90E-05	8.45E-05	6.11E-05	2.36E-04
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NAR	NAR	NAR	NAR	NA
Methylene chloride = Dichloromethane	7.87E-05	3.89E-05	1.83E-04	1.40E-04	4.40E-04
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NA
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA
Tetrachloroethane (1,1,2,2-)	9.20E-04	4.09E-04	1.97E-03	1.54E-03	4.83E-03
Tetrachloroethylene = Perchloroethylene	1.48E-04	6.25E-05	3.01E-04	2.36E-04	7.48E-04
Tetrachloroethylene = Perchloroethylene (inhl	NA	NA	NA	NA	NA
Toluene = Toluol	1.44E-05	5.69E-06	2.75E-05	2.16E-05	6.92E-05
Toluene = Toluol (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethane (1,1,1-) = Methyl chloroform	5.52E-05	2.38E-05	1.15E-04	9.00E-05	2.84E-04
Trichloroethane (1,1,1-) (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethylene	NA	NA	NA	NA	NA
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA
Trichlorofluoromethane	6.10E-06	2.57E-06	1.24E-05	9.73E-06	3.08E-05
Trichlorofluoromethane (inhalation)	NAR	NAR	NAR	NAR	NA
Vinyl chloride	2.01E-03	7.18E-04	3.28E-03	2.44E-03	8.45E-03
Vinyl chloride (inhalation)	NA	NA	NA	NA	NA
Sum of all chemicals	7.65E-03	3.39E-03	1.60E-02	1.24E-02	3.94E-02

Table E-14. Adult Female Non-Carcinogenic Hazard Quotients from Ingestion of Vegetables

CHEMICAL	ROOT ADD/RfD	LEAFY ADD/RfD	EXPOSED ADD/RfD	PROTECTED ADD/RfD	TOTAL PRODUCE ADD/RfD
Acetone	1.81E-05	2.84E-06	1.16E-05	7.64E-06	4.02E-05
Benzene	2.74E-03	1.31E-03	6.28E-03	4.90E-03	1.52E-02
Carbon disulfide	5.59E-05	2.66E-05	1.27E-04	9.95E-05	3.09E-04
Carbon disulfide (inhalation)	NAR	NAR	NAR	NAR	NA
Chloroethane	5.73E-06	2.92E-06	1.38E-05	1.06E-05	3.30E-05
Chloroform = Trichloromethane	2.07E-04	1.03E-04	4.90E-04	3.82E-04	1.18E-03
Chloroform = Trichloromethane (inhalation)	NA	NA	NA	NA	NA
Dichloroethane (1,1-)	1.24E-05	6.31E-06	3.00E-05	2.33E-05	7.20E-05
Dichloroethane (1,2-) = Ethylene dichloride	9.46E-06	4.84E-06	2.28E-05	1.76E-05	5.47E-05
Dichloroethylene (trans-1,2)	1.84E-03	9.42E-04	4.45E-03	3.43E-03	1.07E-02
Dichloroethylene(1,1-) = Vinylidene chloride	2.03E-04	1.04E-04	4.91E-04	3.79E-04	1.18E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NA	NA	NA	NA	NA
Lindane = Hexachlorocyclohexane, gamma	1.26E-04	3.52E-05	1.71E-04	1.35E-04	4.67E-04
Methyl ethyl ketone (MEK) = 2-butanone	8.57E-05	2.28E-05	1.01E-04	7.33E-05	2.83E-04
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NAR	NAR	NAR	NAR	NA
Methylene chloride = Dichloromethane	9.44E-05	4.67E-05	2.19E-04	1.68E-04	5.28E-04
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NA
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA
Tetrachloroethane (1,1,2,2-)	1.10E-03	4.90E-04	2.36E-03	1.85E-03	5.80E-03
Tetrachloroethylene = Perchloroethylene	1.78E-04	7.50E-05	3.61E-04	2.84E-04	8.98E-04
Tetrachloroethylene = Perchloroethylene (inhl	NA	NA	NA	NA	NA
Toluene = Toluol	1.73E-05	6.83E-06	3.30E-05	2.59E-05	8.30E-05
Toluene = Toluol (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethane (1,1,1-) = Methyl chloroform	6.62E-05	2.86E-05	1.38E-04	1.08E-04	3.40E-04
Trichloroethane (1,1,1-) (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethylene	NA	NA	NA	NA	NA
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA
Trichlorofluoromethane	7.31E-06	3.09E-06	1.49E-05	1.17E-05	3.70E-05
Trichlorofluoromethane (inhalation)	NAR	NAR	NAR	NAR	NA
Vinyl chloride	2.41E-03	8.61E-04	3.93E-03	2.93E-03	1.01E-02
Vinyl chloride (inhalation)	NA	NA	NA	NA	NA
Sum of all chemicals	9.17E-03	4.07E-03	1.92E-02	1.48E-02	4.73E-02

Table E-15. 15 Year Old Non-Carcinogenic Hazard Quotients from Ingestion of Vegetables

CHEMICAL	ROOT ADD/RfD	LEAFY ADD/RfD	EXPOSED ADD/RfD	PROTECTED ADD/RfD	TOTAL PRODUCE ADD/RfD
Acetone	2.10E-05	3.29E-06	1.35E-05	8.87E-06	4.66E-05
Benzene	3.18E-03	1.52E-03	7.29E-03	5.69E-03	1.77E-02
Carbon disulfide	6.49E-05	3.09E-05	1.48E-04	1.15E-04	3.59E-04
Carbon disulfide (inhalation)	NAR	NAR	NAR	NAR	NA
Chloroethane	6.65E-06	3.39E-06	1.60E-05	1.23E-05	3.84E-05
Chloroform = Trichloromethane	2.40E-04	1.19E-04	5.69E-04	4.43E-04	1.37E-03
Chloroform = Trichloromethane (inhalation)	NA	NA	NA	NA	NA
Dichloroethane (1,1-)	1.44E-05	7.32E-06	3.48E-05	2.70E-05	8.35E-05
Dichloroethane (1,2-) = Ethylene dichloride	1.10E-05	5.61E-06	2.65E-05	2.04E-05	6.35E-05
Dichloroethylene (trans-1,2)	2.13E-03	1.09E-03	5.17E-03	3.98E-03	1.24E-02
Dichloroethylene(1,1-) = Vinylidene chloride	2.36E-04	1.21E-04	5.70E-04	4.40E-04	1.37E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NA	NA	NA	NA	NA
Lindane = Hexachlorocyclohexane, gamma	1.47E-04	4.09E-05	1.98E-04	1.57E-04	5.43E-04
Methyl ethyl ketone (MEK) = 2-butanone	9.95E-05	2.65E-05	1.18E-04	8.51E-05	3.29E-04
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NAR	NAR	NAR	NAR	NA
Methylene chloride = Dichloromethane	1.10E-04	5.42E-05	2.54E-04	1.95E-04	6.13E-04
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NA
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA
Tetrachloroethane (1,1,2,2-)	1.28E-03	5.69E-04	2.74E-03	2.14E-03	6.73E-03
Tetrachloroethylene = Perchloroethylene	2.06E-04	8.71E-05	4.19E-04	3.29E-04	1.04E-03
Tetrachloroethylene = Perchloroethylene (inhl	NA	NA	NA	NA	NA
Toluene = Toluol	2.01E-05	7.92E-06	3.83E-05	3.01E-05	9.64E-05
Toluene = Toluol (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethane (1,1,1-) = Methyl chloroform	7.69E-05	3.32E-05	1.60E-04	1.25E-04	3.95E-04
Trichloroethane (1,1,1-) (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethylene	NA	NA	NA	NA	NA
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA
Trichlorofluoromethane	8.49E-06	3.58E-06	1.73E-05	1.36E-05	4.29E-05
Trichlorofluoromethane (inhalation)	NAR	NAR	NAR	NAR	NA
Vinyl chloride	2.80E-03	1.00E-03	4.56E-03	3.40E-03	1.18E-02
Vinyl chloride (inhalation)	NA	NA	NA	NA	NA
Sum of all chemicals	1.06E-02	4.73E-03	2.23E-02	1.72E-02	5.49E-02

Table E-16. 9 Year Old Non-Carcinogenic Hazard Quotients from Ingestion of Vegetables

CHEMICAL	ROOT ADD/RfD	LEAFY ADD/RfD	EXPOSED ADD/RfD	PROTECTED ADD/RfD	TOTAL PRODUCE ADD/RfD
Acetone	3.79E-05	5.95E-06	2.44E-05	1.60E-05	8.43E-05
Benzene	5.74E-03	2.75E-03	1.32E-02	1.03E-02	3.19E-02
Carbon disulfide	1.17E-04	5.58E-05	2.67E-04	2.09E-04	6.49E-04
Carbon disulfide (inhalation)	NAR	NAR	NAR	NAR	NA
Chloroethane	1.20E-05	6.13E-06	2.89E-05	2.23E-05	6.93E-05
Chloroform = Trichloromethane	4.34E-04	2.15E-04	1.03E-03	8.00E-04	2.48E-03
Chloroform = Trichloromethane (inhalation)	NA	NA	NA	NA	NA
Dichloroethane (1,1-)	2.60E-05	1.32E-05	6.29E-05	4.88E-05	1.51E-04
Dichloroethane (1,2-) = Ethylene dichloride	1.98E-05	1.01E-05	4.79E-05	3.69E-05	1.15E-04
Dichloroethylene (trans-1,2)	3.85E-03	1.98E-03	9.33E-03	7.19E-03	2.23E-02
Dichloroethylene(1,1-) = Vinylidene chloride	4.25E-04	2.18E-04	1.03E-03	7.94E-04	2.47E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NA	NA	NA	NA	NA
Lindane = Hexachlorocyclohexane, gamma	2.65E-04	7.39E-05	3.58E-04	2.83E-04	9.80E-04
Methyl ethyl ketone (MEK) = 2-butanone	1.80E-04	4.79E-05	2.13E-04	1.54E-04	5.94E-04
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NAR	NAR	NAR	NAR	NA
Methylene chloride = Dichloromethane	1.98E-04	9.78E-05	4.59E-04	3.52E-04	1.11E-03
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NA
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA
Tetrachloroethane (1,1,2,2-)	2.31E-03	1.03E-03	4.94E-03	3.87E-03	1.22E-02
Tetrachloroethylene = Perchloroethylene	3.73E-04	1.57E-04	7.58E-04	5.95E-04	1.88E-03
Tetrachloroethylene = Perchloroethylene (inhl	NA	NA	NA	NA	NA
Toluene = Toluol	3.63E-05	1.43E-05	6.91E-05	5.44E-05	1.74E-04
Toluene = Toluol (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethane (1,1,1-) = Methyl chloroform	1.39E-04	6.00E-05	2.89E-04	2.26E-04	7.14E-04
Trichloroethane (1,1,1-) (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethylene	NA	NA	NA	NA	NA
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA
Trichlorofluoromethane	1.53E-05	6.47E-06	3.12E-05	2.45E-05	7.75E-05
Trichlorofluoromethane (inhalation)	NAR	NAR	NAR	NAR	NA
Vinyl chloride	5.06E-03	1.81E-03	8.25E-03	6.14E-03	2.13E-02
Vinyl chloride (inhalation)	NA	NA	NA	NA	NA
Sum of all chemicals	1.92E-02	8.54E-03	4.03E-02	3.11E-02	9.92E-02

Table E-17. 4 Year Old Non-Carcingoenic Hazard Quotients from Ingestion of Vegetables

CHEMICAL	ROOT ADD/RfD	LEAFY ADD/RfD	EXPOSED ADD/RfD	PROTECTED ADD/RfD	TOTAL PRODUCE ADD/RfD
Acetone	7.35E-05	1.15E-05	4.72E-05	3.10E-05	1.63E-04
Benzene	1.11E-02	5.33E-03	2.55E-02	1.99E-02	6.18E-02
Carbon disulfide	2.27E-04	1.08E-04	5.18E-04	4.04E-04	1.26E-03
Carbon disulfide (inhalation)	NAR	NAR	NAR	NAR	NA
Chloroethane	2.33E-05	1.19E-05	5.60E-05	4.31E-05	1.34E-04
Chloroform = Trichloromethane	8.41E-04	4.17E-04	1.99E-03	1.55E-03	4.80E-03
Chloroform = Trichloromethane (inhalation)	NA	NA	NA	NA	NA
Dichloroethane (1,1-)	5.03E-05	2.56E-05	1.22E-04	9.45E-05	2.92E-04
Dichloroethane (1,2-) = Ethylene dichloride	3.84E-05	1.96E-05	9.27E-05	7.14E-05	2.22E-04
Dichloroethylene (trans-1,2)	7.47E-03	3.83E-03	1.81E-02	1.39E-02	4.33E-02
Dichloroethylene(1,1-) = Vinylidene chloride	8.24E-04	4.23E-04	2.00E-03	1.54E-03	4.78E-03
Dichloroethylene(1,1-)=Vinylidene chlor.(inh.	NA	NA	NA	NA	NA
Lindane = Hexachlorocyclohexane, gamma	5.13E-04	1.43E-04	6.94E-04	5.49E-04	1.90E-03
Methyl ethyl ketone (MEK) = 2-butanone	3.48E-04	9.28E-05	4.12E-04	2.98E-04	1.15E-03
Methyl ethyl ketone (MEK) = 2-butanone (inhl.	NAR	NAR	NAR	NAR	NA
Methylene chloride = Dichloromethane	3.83E-04	1.90E-04	8.90E-04	6.82E-04	2.15E-03
Methylene chloride = Dichloromethane (inhal.)	NAR	NAR	NAR	NAR	NA
Polychlorinated biphenyls (PCBs)	NA	NA	NA	NA	NA
Tetrachloroethane (1,1,2,2-)	4.48E-03	1.99E-03	9.58E-03	7.51E-03	2.36E-02
Tetrachloroethylene = Perchloroethylene	7.22E-04	3.05E-04	1.47E-03	1.15E-03	3.65E-03
Tetrachloroethylene = Perchloroethylene (inhl	NA	NA	NA	NA	NA
Toluene = Toluol	7.04E-05	2.77E-05	1.34E-04	1.05E-04	3.37E-04
Toluene = Toluol (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethane (1,1,1-) = Methyl chloroform	2.69E-04	1.16E-04	5.59E-04	4.39E-04	1.38E-03
Trichloroethane (1,1,1-) (inhalation)	NAR	NAR	NAR	NAR	NA
Trichloroethylene	NA	NA	NA	NA	NA
Trichloroethylene (inhalation)	NA	NA	NA	NA	NA
Trichlorofluoromethane	2.97E-05	1.25E-05	6.04E-05	4.74E-05	1.50E-04
Trichlorofluoromethane (inhalation)	NAR	NAR	NAR	NAR	NA
Vinyl chloride	9.80E-03	3.50E-03	1.60E-02	1.19E-02	4.12E-02
Vinyl chloride (inhalation)	NA	NA	NA	NA	NA
Sum of all chemicals	3.73E-02	1.65E-02	7.82E-02	6.02E-02	1.92E-01

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