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TECHNICAL MEMORANDUM OF RISK ASSESSMENT EVALUATION
for
SITE 1 GROUNDWATER (OU 3)

Naval Air Station Joint Reserve Base
Willow Grove, Pennsylvania

Engineering Field Activity Northeast
Naval Facilities Engineering Command
Contract Number N62472-94-03-D-0057
Contract Task Order 003

August 2005

TETRA TECH NUS, INC.

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TECHNICAL MEMORANDUM OF RISK ASSESSMENT EVALUATION for SITE 1 - GROUNDWATER (OU 3)

NAVAL AIR STATION JOINT RESERVE BASE WILLOW GROVE, PENNSYLVANIA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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EXECUTIVE SUMMARY

This technical memorandum presents a review and limited update of the human health risk assessment (HHRA) of groundwater originally prepared in 1997 as part of the Remedial Investigation Report for Site 1 - Privet Road Compound (TtNUS, 2002). The review identifies changes in the risk assessment methodology since the 1997 HHRA was prepared and discusses, in general, the impact the changes would have on the risk estimates presented in the 1997 HHRA. The review concentrates on the changes in the methodology for evaluating risks to hypothetical residents since these receptors were identified as the critical receptors in the 1997 HHRA. Therefore, changes in risk assessment methodology and the impact of these changes on the risk estimates for hypothetical residents hypothetically exposed to groundwater are discussed in detail in the following subsections. In addition, the risk estimates for hypothetical residents exposed to groundwater are re-calculated following current risk assessment guidance.

Review of 1997 HHRA Methodology Versus Current HHRA Methodology

The following items summarize the major differences between the 1997 HHRA methodology and the methodology used to prepare the updated HHRA of groundwater:

- The protocol used to select chemical of potential concern (COPC) for the updated HHRA is the same as the protocol used in the 1997 HHRA and it considered current Region 3 risk-based concentrations (RBCs) and USPEA Maximum Contaminant Levels (MCLs) in the toxicity screening used to select COPCs. The list of COPCs evaluated in the updated HHRA includes all COPCs identified in the 1997 HHRA except beryllium; however, carbon tetrachloride and chloroform were added to the list of COPCs.

- The most significant changes in the exposure assessment protocol (1997 versus current) are those associated with the calculation of the exposure point concentration (EPC). EPCs calculated per current methodology are higher for most COPCs than those calculated for the 1997 HHRA.

- Significant changes in toxicity criteria (i.e., reference doses, cancer slope factors) were noted for beryllium and tetrachloroethene between the 1997 HHRA and the updated HHRA. Beryllium was evaluated as a carcinogen in the 1997 HHRA. In 1998 USEPA withdrew the oral cancer slope factor for beryllium and as a result beryllium is no longer evaluated as a carcinogen for the ingestion and dermal contact exposure pathways. The cancer slope factor for tetrachloroethene increased by an order of magnitude. As a result of these changes, the risk estimates in this updated HHRA are lower than those presented in the 1997 HHRA.

Updated Risk Estimates for Hypothetical Future Residents Exposed to Groundwater

Risk estimates for the hypothetical future resident exposed to groundwater were recalculated and presented in this technical memorandum.

The cancer risk estimates for the hypothetical future lifelong resident under the RME scenario in this evaluation (2×10^{-4}) are lower than those estimated in the 1997 HHRA (4×10^{-4}) because of the aforementioned changes in the toxicity criteria for beryllium. Arsenic and beryllium were the major contributors to the risk estimates presented in the 1997 HHRA while tetrachloroethene and arsenic were the major contributors to the risk estimates in this updated HHRA. It should be noted that concentrations of arsenic were less than the USEPA MCL while concentrations of tetrachloroethene exceeded the USEPA MCL.

Target-organ specific non-cancer risk estimates (hazard indices [HIs]) calculated for both this evaluation and the 1997 evaluation do not exceed 1 for the hypothetical future child and adult resident. These results indicate that adverse non-carcinogenic health effects are not anticipated under the conditions established for this HHRA. HIs for child and adult residents estimated in this evaluation are slightly lower than those presented in the 1997 HHRA. The slight differences in the HIs between this evaluation and those presented in the 1997 HHRA are a consequence of the changes in exposure assumptions, exposure point concentrations, and toxicity criteria.

1.0 INTRODUCTION

This technical memorandum presents a review and limited update of the human health risk assessment (HHRA) of Site 1 groundwater originally prepared in 1997 as part of the Remedial Investigation Report for Site 1-Privet Road Compound (TtNUS, 2002). The review identifies changes in the risk assessment methodology since the 1997 HHRA was prepared and discusses, in general, the impact the changes would have on the risks estimates presented in the 1997 HHRA. The review concentrates on the changes in the methodology for evaluating risks to hypothetical residents since these receptors were identified as the critical receptors in the 1997 HHRA. Therefore, changes in risk assessment methodology and the impact of these changes on the risk estimates for hypothetical residents hypothetically exposed to groundwater are discussed in detail in the following subsections. In addition, the risk estimates for hypothetical residents exposed to groundwater are re-calculated following current risk assessment guidance.

2.0 REVIEW OF THE 1997 RISK ASSESSMENT

The 1997 HHRA for groundwater at Site 1 was reviewed to evaluate if the use of current risk assessment methodology (versus the methodology available in 1997) would significantly impact the risk assessment results presented in the 1997 HHRA. For example, after the 1997 HHRA was prepared the USEPA extensively revised the guidance for evaluating the dermal route of exposure (USEPA, 2004a) and for calculating exposure point concentrations (EPCs) (USEPA, 2002a; Singh et. al., 2004). In addition, USEPA updated some of the toxicity criteria (Reference Doses [RfDs] and cancer slope factors [CSFs]) used in quantitative risk assessment and the toxicity screening criteria used to select the chemicals of potential concern (COPCs). The impacts of these changes on the risks estimates presented in the 1997 HHRA are discussed below.

2.1 TOXICITY SCREENING CRITERIA AND SELECTION OF COPCS

USEPA Region 3 Risk-Based Concentrations (RBCs) available in 1997 were used as the basis of the COPC toxicity screening levels in the 1997 HHRA. USEPA Region 3 updates its RBC table twice a year; consequently the RBC table has undergone numerous revisions since the 1997 HHRA. An updated COPC selection table for groundwater is presented in Attachment A. USEPA Region 3 RBCs (USEPA, 2005a) for tap water and USEPA MCLs (USEPA, 2004b) were used to select COPCs for groundwater. A chemical was retained as a COPC in groundwater if the maximum detected concentration exceeded the lesser of the USEPA Region 3 RBC and USEPA MCL. No background groundwater samples were collected at Site 1; consequently chemicals were not eliminated as COPCs based on a comparison of site concentrations to background concentrations.

Tetrachloroethene, trichloroethene, arsenic, barium, beryllium, lead, and manganese were retained as COPCs for groundwater in the 1997 HHRA for Site 1. Table 2.1 in Attachment A presents the updated COPC selection table for direct contact exposures to groundwater. The following chemicals were detected in groundwater at maximum concentrations exceeding toxicity screening levels based on the current USEPA Region 3 RBCs for tap water and current USEPA MCLs and were selected as COPCs for groundwater at Site 1.

- VOCs [carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene]
- Inorganics [arsenic, barium, chromium, lead, and manganese]

Concentrations of carbon tetrachloride, chloroform, arsenic, barium, chromium, and manganese exceeded the USEPA Region 3 RBCs but were less than the USEPA MCLs.

2.2 EXPOSURE FACTOR ASSUMPTIONS

Tables 1 through 4 present a comparison of the exposure assumptions for child residents and adult residents used in the 1997 HHRA versus those currently recommended by USEPA guidance. The most significant change in the exposure assumptions are those used to evaluate the dermal route of exposure. The exposure assumptions used in the 1997 HHRA were based on recommendations provided in USEPA's Dermal Exposure Assessment: Principles and Applications, January 1992 and USEPA Region 3's Assessing Dermal Contact with Soil, December 1995. The updated dermal exposure assumptions are based on recommendations in USEPA's Supplemental Guidance for Dermal Risk Assessment, July 2004 and USEPA Region 3's Updated Dermal Exposure Assessment Guidance, June 2003.

In the 1997 HHRA, the surface area (SA) for the child resident was a weighted value calculated for the exposure duration of the receptor (743.8 cm^2-yr/kg). The current guidance recommends a value of 6,600 cm^2 as the total body surface area of a child. For the adult resident, a SA of 18,150 cm^2 was used for the total body surface area in the 1997 HHRA. Current guidance recommends a value of 18,000 cm^2 for the total body surface area.

The equations used to estimate the absorbed dose per event (DA_{event}) for organics have been updated since the 1997 HHRA was prepared. The most significant change to the equations is the addition of a fraction absorbed (FA) term to the equations. This term accounts for the slow absorption rates of high molecular weight chemicals. For the chemicals retained as COPCs in groundwater in the 1997 HHRA, all have a FA equal to 1. Consequently, the absorbed doses for dermal contact with groundwater calculated using the new dermal guidance would not be significantly different than those calculated using the old dermal guidance.

The 1997 HHRA did not evaluate the child resident for risks from inhalation exposures to chemicals volatilizing from groundwater. Current guidance recommends evaluating the inhalation pathway for both child and adult residents. Consequently, the evaluation of the inhalation pathway for both child and adult residents results in higher inhalation pathway risks for the lifelong resident.

2.3 TOXICITY VALUES

Tables 5 and 6 present a comparison of the RfDs and CSFs used in the 1997 HHRA versus current values. Significant changes in oral and/or inhalation toxicity values are noted for trichloroethene, tetrachloroethene, and beryllium.

Toxicity criteria for trichloroethene are not currently published on the U.S. EPA's Integrated Risk Information System (IRIS) database. The 1997 HHRA was prepared using a provisional oral RfD and inhalation CSF and a withdrawn oral CSF for trichloroethene. The USEPA has published draft toxicity values based on the USEPA's Trichloroethylene Health Risk Assessment: Synthesis and Characterization (USEPA, 2001a). However, these values are still undergoing peer review. The toxicity criteria developed by the California EPA (CA EPA, 2002) were used for trichloroethene in this updated HHRA because the draft USEPA criteria have not been finalized. The current CA EPA oral RfD for trichloroethene is 0.5 mg/kg/day; the oral RfD used in the 1997 HHRA was 0.006 mg/kg/day. Previously an inhalation RfD was not available for trichloroethene, however, the current CA EPA published value is 0.17 mg/kg/day. For noncarcinogenic exposures, these changes in toxicity values result in higher non-cancer risk estimates for trichloroethene exposure via inhalation and lower risk estimates for trichloroethene exposure via ingestion and dermal contact. The current oral and inhalation CA EPA CSFs for trichloroethene are 0.013 $(mg/kg/day)^{-1}$ and 0.007 $(mg/kg/day)^{-1}$, respectively. The oral and inhalation CSFs used in the 1997 HHRA were 0.011 $(mg/kg/day)^{-1}$ and 0.006 $(mg/kg/day)^{-1}$, respectively. Overall these changes do not significantly impact the risk estimates presented for trichloroethene in the 1997 HHRA.

Beryllium was evaluated as a carcinogen via the oral and dermal routes of exposure in the 1997 HHRA. However, in 1998 USEPA withdrew the oral cancer slope factor for beryllium and, as a result, the EPA Region 3 RBC for tap water increased significantly. Consequently, beryllium was not selected as a COPC for this updated HHRA. An inhalation RfD of 0.000057 mg/kg/day is also now available for beryllium (USEPA, 2005b). However, beryllium is not a volatile chemical; the availability of an inhalation RfD has no impact on the HHRA evaluation of beryllium concentrations in groundwater.

The oral CSF for tetrachloroethene was revised from 0.052 $(mg/kg/day)^{-1}$ to 0.54 $(mg/day/day)^{-1}$, and the inhalation CSF has changed from 0.002 $(mg/day/day)^{-1}$ to 0.02 $(mg/day/day)^{-1}$. Also an inhalation RfD of 0.14 mg/kg/day is now available for tetrachloroethene (USEPA, 2005a). Consequently, cancer and non-cancer risk estimates for tetrachloroethene presented in this updated HHRA exceed those presented in the 1997 HHRA, in part because of these changes.

The RfD for hexavalent chromium has changed; the oral RfD was revised from 0.005 mg/kg/day to 0.003 mg/kg/day (USEPA, 2005b). In addition, the recommended oral absorption efficiency for hexavalent chromium was revised from 0.01 to 0.025 (USEPA, 2004a) which results in the new dermal RfD of 0.000075 mg/kg/day. Also an inhalation RfD of 0.00003 mg/kg/day is now available for hexavalent chromium (USEPA, 2005b). These changes indicate that chromium is considered slightly more toxic for exposures via the incidental ingestion and inhalation routes of exposure and slightly less toxic via the dermal contact route of exposure than previously determined. Overall these changes do not significantly

impact the risk estimates presented for chromium in the 1997 HHRA. Chromium is not a volatile chemical; the availability of an inhalation RfD has no impact on the HHRA evaluation of chromium concentrations in groundwater.

The recommended oral absorption efficiency values for arsenic, barium, and manganese have also been changed resulting in the revised dermal toxicity values presented in Tables 5 and 6. However, only the changes presented for the dermal values for manganese are significant.

2.4 METHODOLOGY USED TO ESTIMATE EXPOSURE POINT CONCENTRATIONS

Exposure point concentrations (EPCs) in the 1997 HHRA were calculated following USEPA's Supplemental Guidance to Risk Assessment Guidance for Superfund (RAGS): Calculating the Concentration Term (USEPA, 1992b). In accordance with this guidance the Student-t upper confidence limit (UCL) was used as the EPC if the data was normally distributed and the H-statistic based UCL (H-UCL) was used as the EPC if the data was lognormally distributed. If the distribution of the data could not be determined then the data was assumed to be lognormally distributed and the H-UCL was selected as the EPC. USEPA has updated the guidance for calculating EPCs (USEPA, 2002a; Singh et. al., 2004). The updated guidance continues to recommend the Student-t UCL for normally distributed data and the H-UCL for lognormally distributed data but also includes EPC recommendations for data that follow a gamma distribution and for cases where the data distribution can not be determined (i.e., the non parametric case). Table 7 presents a comparison of the EPCs presented in the 1997 HHRA, calculated in accordance with the old EPC guidance, and the EPCs calculated following the new EPC guidance. The EPCs for tetrachloroethene, trichloroethene, and arsenic calculated according to the new EPC guidance are higher than the values calculated using the old guidance. The EPCs for lead and manganese calculated according to the new EPC guidance are lower than the values calculated using the old guidance.

3.0 UPDATED RISK CHARACTERIZATION

The cancer risks and hazard indices were recalculated for child residents and adult residents exposed to groundwater incorporating the changes in risk assessment methodology and exposure assumptions discussed in Section 2. Incremental lifetime cancer risks (ILCRs) and hazard indices (HIs) under the RME and CTE scenarios are summarized in Tables 8 and 9. The results of the risk assessment in RAGS Part D format (USEPA, 2001b) are included in Attachment A and sample calculations are included in Attachment B.

3.1 NONCARCINOGENIC RISKS

The HI for adult residents (HI = 1) exposed to the COPCs in groundwater under the RME scenario is equal to the acceptable level of 1. The HI for child residents exposed to COPCs in groundwater (HI = 3) under the RME scenario exceeded unity although the HIs for the individual target organs were all less than or equal to unity.

The HI for adult residents (HI = 0.6) exposed to groundwater under the CTE scenario is less than the acceptable level of 1. The HI for child residents exposed to groundwater (HI = 2) under the CTE scenario exceeded unity although the HQs for the individual target organs were all less than unity.

These results indicate that adverse non-carcinogenic health effects are not anticipated under the conditions considered in the exposure assessment.

3.2 CARCINOGENIC RISKS

The ILCR under the RME for child residents (ILCR = 8×10^{-5}) is within USEPA's target risk range of 10^{-4} to 10^{-6} while the ILCR for adult residents (ILCR = 1×10^{-4}) is equal to the upper bound of the target risk range. The ILCR for lifelong residents (ILCR = 2×10^{-4}) exceeds the target risk range. Arsenic (ILCR = 5×10^{-5}) and tetrachloroethene (ILCR = 1×10^{-4}) are the major contributors to the ILCRs for lifelong residents.

ILCRs for the child resident (ILCR = 2×10^{-5}), adult resident (ILCR = 2×10^{-5}), and lifelong resident (4×10^{-5}) under the CTE scenario are within the USEPA's target risk range of 10^{-4} to 10^{-6}.

It should be noted that concentrations of arsenic were less than the USEPA MCL while concentrations of tetrachloroethene exceeded the USEPA MCL.

3.3 RISKS FROM LEAD

Lead was identified as a COPC in groundwater at Site 1. The maximum detected concentration of lead in groundwater (18 µg/L) exceeded the 15 µg/L Federal Action Level promulgated under the Safe Drinking Water Act.

Hypothetical future residential exposures to lead in groundwater were evaluated using the IEUBK lead model (USEPA, 2002b). As recommended by the IEUBK model, the average lead concentration of 21.3 mg/kg in surface soil and 2.57 µg/L in groundwater were used as the EPCs. Default values were used for the rest of the model input parameters. IEUBK model outputs are included in Attachment C. The lead concentrations of 21.3 mg/kg in surface soil and 2.57 µg/L in groundwater results in 0.007 percent of hypothetical child residents having a blood lead level greater than 10 µg/dL and results in a geometric mean blood lead level of 1.7 µg/dL. These lead modeling results do not exceed the USEPA goal as described in the 1994 OSWER Directive of no more than 5 percent of children exceeding a 10 µg/dL blood lead level.

3.4 COMPARISON OF RESULTS

Table 10 presents a comparison of the cancer risks and hazard indices from the 1997 HHRA and those calculated in this evaluation. ILCRs for lifelong residents are lower in this evaluation (ILCR = 2×10^{-4}) as compared to those estimated in the 1997 HHRA (ILCR = 4×10^{-4}). The main reason for the decrease in the ILCR is the changes in the toxicity criteria for beryllium. Beryllium was evaluated as a carcinogen in the 1997 HHRA. In 1998 USEPA withdrew the oral cancer slope factor for beryllium and as a result beryllium is no longer evaluated as a carcinogen for the ingestion and dermal contact exposure pathways. Beryllium was not selected as a COPC for this updated HHRA.

HIs for child and adult residents estimated in this evaluation are slightly lower than those presented in the 1997 HHRA. The slight differences in the HIs between this evaluation and those presented in the 1997 HHRA are a consequence of the changes in exposure assumptions, exposure point concentrations, and toxicity criteria.

3.5 UNCERTAINTY ASSOCIATED WITH TOXICITY CRITERIA FOR TRICHLOROETHENE

As noted in Section 2.3, toxicity criteria (i.e., RfDs, CSFs) for trichloroethene are not currently published on the USEPA's IRIS database or in USEPA's Health Effects Assessment Summary Tables (HEAST). The toxicity criteria developed by the California EPA (CA EPA, 2002) were used to evaluate trichloroethene in this risk assessment because the USEPA draft toxicity values published in a recent

technical document (USEPA, 2001a) are currently undergoing peer review. A range of CSFs [0.02-0.4 $(mg/kg/day)^{-1}$], as opposed to a single recommended value, is presented in this recent draft guidance. The draft CSFs are 2 to 30 times higher than the CA EPA CSF [0.013 $(mg/kg/day)^{-1}$]. The draft oral RfD is 0.0003 mg/kg/day as compared to the CA EPA RfD of 0.5 mg/kg/day. ILCRs and HIs for exposures to trichloroethene in groundwater under the RME and CTE scenarios were within acceptable levels (i.e., did not exceed the upper bound of the USEPA target cancer risk range or an HI of 1) for hypothetical child and adult residents evaluated using the CA EPA toxicity criteria. For exposures to trichloroethene in groundwater under the RME scenario, ILCRs for hypothetical lifelong residents and HIs for hypothetical child and adult residents would exceed acceptable levels if the upper range of the draft USEPA toxicity values were used in the calculations. Under the CTE scenario, the HI for the hypothetical child resident would exceed acceptable levels while the ILCR for hypothetical lifelong residents and HI for hypothetical adult residents would be within acceptable levels if the upper range of the draft USEPA toxicity values were used in the calculations.

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USEPA, 2004b. 2004 Edition of the Drinking Water Standards and Health Advisories, Office of Water, EPA 822-R-04-005, Washington, DC, Winter.

USEPA, 2005a. Region III Risk Based Concentration Table (RBC) April 7, 2005 Update. EPA Region III, Philadelphia PA.

USEPA, 2005b. Integrated Risk Information System (IRIS) On-line Data Base. June.

TABLES

TABLE 1
COMPARISON OF EXPOSURE ASSUMPTIONS
CHILD RESIDENTS EXPOSED TO GROUNDWATER - REASONABLE MAXIMUM EXPOSURES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Parameter Code	Parameter Definition	Old Value[1]	Rationale/ Reference	New Value	Rationale/ Reference
Ingestion					
IR-GW	Ingestion Rate of Groundwater (L/day)	1	USEPA, 1991	1	USEPA, 1991
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	6	USEPA, 1989 USEPA, 1991	6	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	15	USEPA, 1989 USEPA, 1991	15	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	2190	USEPA, 1989	2190	USEPA, 1989
Dermal Contract					
DAevent	Dermally Absorbed Dose per Event (mg/cm^2-event)	Chemical Specific	USEPA, 1992	Chemical Specific	USEPA, 2004
SA	Skin Surface Available for Contact	2728 cm^2-yr/kg	USEPA, 1989	6600 cm^2	USEPA, 2004
EV	Event Frequency (events/day)	1	USEPA, 1992	1	USEPA, 2004
ET	Exposure Time (hours/day)	0.33	USEPA, 1992	0.33	USEPA, 2004
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	6	USEPA, 1989 USEPA, 1991	6	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	15	USEPA, 1989 USEPA, 1991	15	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	2190	USEPA, 1989	2190	USEPA, 1989
Inhalation					
IR	Inhalation Rate (m^3/hr)	Not Evaluated		0.6	USEPA, 1989
Ra	Air Exchange Rate (1/min)			0.017	Foster & Chrostowski 1987
Ds	Shower Duration (min)			15	Professional Judgment
Dt	Total Time in Bathroom (min)			20	Professional Judgment
EF	Exposure Frequency (days/year)			350	USEPA, 1991
ED	Exposure Duration (years)			6	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)			15	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)			25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)			2190	USEPA, 1989

Notes:
1 - Old values are from the Remedial Investigation Report for Site 2 Antenna Field Landfill, October 2004, Table 3-24.
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Values that have changed from the previous HHRA are shaded.

TABLE 2
COMPARISON OF EXPOSURE ASSUMPTIONS
CHILD RESIDENTS EXPOSED TO GROUNDWATER - CENTRAL TENDENCY EXPOSURES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Parameter Code	Parameter Definition	Old Value[1]	Rationale/ Reference	New Value	Rationale/ Reference
Ingestion					
IR-GW	Ingestion Rate of Groundwater (L/day)	0.7	USEPA, 1991	0.7	USEPA, 1997
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	2	USEPA, 1989 USEPA, 1991	2	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	15	USEPA, 1989 USEPA, 1991	15	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	730	USEPA, 1989	730	USEPA, 1989
Dermal Contract					
DAevent	Dermally Absorbed Dose per Event (mg/cm^2-event)	Chemical Specific	USEPA, 1992	Chemical Specific	USEPA, 2004
SA	Skin Surface Available for Contact	**850 cm^2-yr/kg**	USEPA, 1989	**6600 cm^2**	USEPA, 2004
EV	Event Frequency (events/day)	1	USEPA, 1992	1	USEPA, 2004
ET	Exposure Time (hours/day)	0.33	USEPA, 1992	0.33	USEPA, 2004
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	2	USEPA, 1989 USEPA, 1991	2	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	15	USEPA, 1989 USEPA, 1991	15	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	730	USEPA, 1989	730	USEPA, 1989
Inhalation					
IR	Inhalation Rate (m^3/hr)	Not Evaluated		**0.6**	USEPA, 1989
Ra	Air Exchange Rate (1/min)			**0.017**	Foster & Chrostowski 1987
Ds	Shower Duration (min)			**15**	Professional Judgment
Dt	Total Time in Bathroom (min)			**20**	Professional Judgment
EF	Exposure Frequency (days/year)			**350**	USEPA, 1991
ED	Exposure Duration (years)			**2**	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)			**15**	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)			**25550**	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)			**730**	USEPA, 1989

Notes:
1 - Old values are from the Remedial Investigation Report for Site 2 Antenna Field Landfill, October 2004, Table 3-25.
Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.
USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
USEPA, 1992: Supplemental Guidance to RAGS: Calculating the Concentration Term. PB92-963373.
USEPA, 1997: Exposure Factors Handbook. EPA/600/8-95/002FA.
USEPA, 2002: Supplement Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Values that have changed from the previous HHRA are shaded.

TABLE 3
COMPARISON OF EXPOSURE ASSUMPTIONS
ADULT RESIDENTS EXPOSED TO GROUNDWATER - REASONABLE MAXIMUM EXPOSURES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Parameter Code	Parameter Definition	Old Value[1]	Rationale/ Reference	New Value	Rationale/ Reference
Ingestion					
IR-GW	Ingestion Rate of Groundwater (L/day)	2	USEPA, 1991	2	USEPA, 1991
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	24	USEPA, 1989 USEPA, 1991	24	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	70	USEPA, 1989 USEPA, 1991	70	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	8760	USEPA, 1989	8760	USEPA, 1989
Dermal Contract					
DAevent	Dermally Absorbed Dose per Event (mg/cm^2-event)	Chemical Specific	USEPA, 1992	Chemical Specific	USEPA, 2004
SA	Skin Surface Available for Contact (cm^2)	18150	USEPA, 1989	18000	USEPA, 2004
EV	Event Frequency (events/day)	1	USEPA, 1992	1	USEPA, 2004
ET	Exposure Time (hours/day)	0.25	USEPA, 1992	0.25	USEPA, 2004
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	24	USEPA, 1989 USEPA, 1991	24	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	70	USEPA, 1989 USEPA, 1991	70	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	8760	USEPA, 1989	8760	USEPA, 1989
Inhalation					
IR	Inhalation Rate (m^3/hr)	0.83	USEPA, 1989	0.6	USEPA, 1989
Ra	Air Exchange Rate (1/min)	0.017	Foster & Chrostowski 1987	0.017	Foster & Chrostowski 1987
Ds	Shower Duration (min)	15	Professional Judgment	15	Professional Judgment
Dt	Total Time in Bathroom (min)	20	Professional Judgment	20	Professional Judgment
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	24	USEPA, 1989 USEPA, 1991	24	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	70	USEPA, 1989 USEPA, 1991	70	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	8760	USEPA, 1989	8760	USEPA, 1989

Notes:
1 - Old values are from the Remedial Investigation Report for Site 2 Antenna Field Landfill, October 2004, Table 3-24.
Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.
USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
USEPA, 1992: Supplemental Guidance to RAGS: Calculating the Concentration Term. PB92-963373.
USEPA, 2002: Supplement Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Values that have changed from the previous HHRA are shaded.

TABLE 4
COMPARISON OF EXPOSURE ASSUMPTIONS
ADULT RESIDENTS EXPOSED TO GROUNDWATER - CENTRAL TENDENCY EXPOSURES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Parameter Code	Parameter Definition	Old Value[1]	Rationale/ Reference	New Value	Rationale/ Reference
Ingestion					
IR-GW	Ingestion Rate of Groundwater (L/day)	1.4	USEPA, 1991	1.4	USEPA, 1991
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	7	USEPA, 1989 USEPA, 1991	7	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	70	USEPA, 1989 USEPA, 1991	70	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	2555	USEPA, 1989	2555	USEPA, 1989
Dermal Contract					
DAevent	Dermally Absorbed Dose per Event (mg/cm^2-event)	Chemical Specific	USEPA, 1992	Chemical Specific	USEPA, 2004
SA	Skin Surface Available for Contact (cm^2)	**18150**	USEPA, 1989	**18000**	USEPA, 2004
EV	Event Frequency (events/day)	1	USEPA, 1992	1	USEPA, 2004
ET	Exposure Time (hours/day)	0.25	USEPA, 1992	0.25	USEPA, 2004
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	7	USEPA, 1989 USEPA, 1991	7	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	70	USEPA, 1989 USEPA, 1991	70	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	2555	USEPA, 1989	2555	USEPA, 1989
Inhalation					
IR	Inhalation Rate (m^3/hr)	**0.83**	USEPA, 1989	**0.6**	USEPA, 1989
Ra	Air Exchange Rate (1/min)	0.017	Foster & Chrostowski 1987	0.017	Foster & Chrostowski 1987
Ds	Shower Duration (min)	15	Professional Judgment	15	Professional Judgment
Dt	Total Time in Bathroom (min)	20	Professional Judgment	20	Professional Judgment
EF	Exposure Frequency (days/year)	350	USEPA, 1991	350	USEPA, 1991
ED	Exposure Duration (years)	7	USEPA, 1989 USEPA, 1991	7	USEPA, 1989 USEPA, 1991
BW	Body Weight (kg)	70	USEPA, 1989 USEPA, 1991	70	USEPA, 1989 USEPA, 1991
AT-C	Averaging Time (Cancer) (days)	25550	USEPA, 1989	25550	USEPA, 1989
AT-N	Averaging Time (Non-Cancer) (days)	2555	USEPA, 1989	2555	USEPA, 1989

Notes:
1 - Old values are from the Remedial Investigation Report for Site 2 Antenna Field Landfill, October 2004, Table 3-25.
Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.
USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
USEPA, 1992: Supplemental Guidance to RAGS: Calculating the Concentration Term. PB92-963373.
USEPA, 2002: Supplement Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Values that have changed from the previous HHRA are shaded.

TABLE 5
COMPARISON OF REFERENCE DOSES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW, GROVE PENNSYLVANIA

Chemical of Potential Concern	Oral Absorption Efficiency for Dermal		Oral RfD		Dermal RfD[2]		Inhalation RfD	
	Old	New[1]	Old mg/kg/day	New mg/kg/day	Old mg/kg/day	New mg/kg/day	Old mg/kg/day	New mg/kg/day
Volatiles Organic Compounds								
Tetrachloroethene	1	1	1.0E-02 I	1.0E-02 I	1.0E-02	1.0E-02	NA	1.4E-01 E
Trichloroethene	1	1	6.0E-03 E	5.0E-01 CA	6.0E-03	5.0E-01	NA	1.7E-01 CA
Inorganics								
Arsenic	0.95	1	3.0E-04 I	3.0E-04 I	3.16E-04	3.0E-04	NA	NA
Barium	1	0.7	7.0E-02 I	7.0E-02 I	7.0E-02	4.9E-02	1.43E-04 A	1.4E-04 A
Beryllium	0.01	0.007	5.0E-03 I	2.0E-03 I	5.0E-01	1.4E-05	NA	5.7E-06 I
Chromium	0.01	0.025	5.0E-03 I	3.0E-03 I	5.0E-01	7.5E-05	NA	3.0E-05 I
Lead	1	1	NA	NA	NA	NA	NA	NA
Manganese (Water)	1	0.04	2.3E-02 I	2.4E-02 I	2.3E-02	9.6E-04	NA	NA
Manganese (Food)	1	0.04	1.4E-01 I	1.4E-01 I	1.4E-01	5.6E-03	1.43E-05 I	1.4E-05 I

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.

CA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
E = NCEA Provisional value.
I = Integrated Risk Information System (IRIS), June 2005.

Values that have changed from the previous HHRA are shaded.

TABLE 6
COMPARISON OF CANCER SLOPE FACTORS
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW, GROVE PENNSYLVANIA

Chemical of Potential Concern	Oral Absorption Efficiency for Dermal		Oral CSF		Dermal CSF[2]		Inhalation CSF	
	Old	New[1]	Old (mg/kg/day)$^{-1}$	New (mg/kg/day)$^{-1}$	Old (mg/kg/day)$^{-1}$	New (mg/kg/day)$^{-1}$	Old (mg/kg/day)$^{-1}$	New (mg/kg/day)$^{-1}$
Volatiles Organic Compounds								
Tetrachloroethene	1	1	5.2E-02 E	5.4E-01 E	5.2E-02	5.4E-01	2.0E-03 E	2.0E-02 E
Trichloroethene	1	1	1.1E-02 W	1.3E-02 CA	1.1E-02	1.3E-02	6.0E-03 E	7.0E-03 CA
Inorganics								
Arsenic	0.95	1	1.5E+00 I	1.5E+00 I	1.43E+00	1.5E+00	1.5E+01 I	1.5E+01 I
Barium	1	0.7	NA	NA	NA	NA	NA	NA
Beryllium	0.01	0.007	4.3E+00 I	NA	4.3E-02	NA	8.4E+00 I	8.4E+00 I
Chromium	0.01	0.025	NA	NA	NA	NA	4.2E+01 I	4.2E+01 I
Lead	1	1	NA	NA	NA	NA	NA	NA
Manganese (Water)	1	0.04	NA	NA	NA	NA	NA	NA
Manganese (Food)	1	0.04	NA	NA	NA	NA	NA	NA

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor x Oral Absorption Efficiency for Dermal.
3 - U.S. EPA, Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, July 1993, EPA/600/R-93/089.
4 - U.S. EPA, PCBs: Cancer Dose-Response Assessment and Applications to Environmental Mixtures, September 1996, EPA/600/P-96/001F.

CA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
E = NCEA Provisional value.
I = Integrated Risk Information System (IRIS), June 2005.
W = Withdrawn from IRIS or HEAST.

Values that have changed from the previous HHRA are shaded.

TABLE 7
COMPARISON OF EXPOSURE POINT CONCENTRATIONS
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW, GROVE PENNSYLVANIA

Chemical	Exposure Point Concentrations	
	Old Value[1]	New Value[2]
Carbon Tetrachloride	NA	5.74[5]
Chloroform	NA	5.78[5]
Tetrachloroethene	7.49[4]	11.7[5]
Trichloroethene	11.1[4]	22.4[6]
Arsenic	1.95[4]	2.35[5]
Barium	287[4]	221[7]
Chromium	NA	8.18[5]
Lead	5.85[4]	2.57[8]
Manganese	981[4]	362[9]

Notes:
All concentrations are in ug/L.
NA - This chemical was not identified as a COPC in the previous risk assessment.
1 - Old values are from the Remedial Investigation Report for Site 1 - Privet Road Compound, February 2002, Appendix J.
2 - Calculated according to USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.
3 - Maximum detected concentration.
4 - Land's H-UCL.
5 - 95% Chebyshev(Mean, Std) UCL.
6 - 99% Chebyshev(Mean, Std) UCL.
7 - Approximate Gamma 95% UCL.
8 - Arithmetic mean.
9 - Adjusted Gamma 95% UCL.
UCL = Upper Confidence Limit.
COPC = Chemical of Potential Concern.

TABLE 8

SUMMARY OF CANCER RISKS AND HAZARD INDICES
REASONABLE MAXIMUM EXPOSURES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an HI > 1
Child Residents	Groundwater	Ingestion	6E-05	--	Tetrachloroethene, Arsenic	Carbon Tetrachloride, Trichloroethene	2	--
		Dermal Contact	1E-05	--	--	Tetrachloroethene	0.2	--
		Inhalation	3E-06	--	--	--	0.03	--
		Total	8E-05	--	Tetrachloroethene, Arsenic	Carbon Tetrachloride, Trichloroethene	3	--
Adult Residents	Groundwater	Ingestion	1E-04	--	Tetrachloroethene, Arsenic	Carbon Tetrachloride, Trichloroethene	1	--
		Dermal Contact	3E-05	--	Tetrachloroethene	--	0.09	--
		Inhalation	--	--	--	--	0.005	--
		Total	1E-04	--	Tetrachloroethene, Arsenic	Carbon Tetrachloride, Trichloroethene	1	--
Lifelong Residents (Child and Adult)	Groundwater	Ingestion	2E-04	--	Tetrachloroethene, Arsenic	Carbon Tetrachloride, Trichloroethene	NA	--
		Dermal Contact	4E-05	--	Tetrachloroethene	Carbon Tetrachloride	NA	--
		Inhalation	--	--	--	Chloroform	NA	--
		Total	2E-04	--	Tetrachloroethene, Arsenic	Carbon Tetrachloride, Chloroform, Trichloroethene	NA	--

TABLE 9

SUMMARY OF CANCER RISKS AND HAZARD INDICES
CENTRAL TENDENCY EXPOSURES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an HI > 1
Child Residents	Groundwater	Ingestion	1E-05	--	--	Tetrachloroethene, Arsenic	2	--
		Dermal Contact	4E-06	--	--	Tetrachloroethene	0.2	--
		Inhalation	6E-07	--	--	--	0.01	--
		Total	2E-05	--	--	Tetrachloroethene, Arsenic	2	--
Adult Residents	Groundwater	Ingestion	1E-05	--	--	Tetrachloroethene, Arsenic	0.5	--
		Dermal Contact	4E-06	--	--	Tetrachloroethene	0.05	--
		Inhalation	8E-07	--	--	--	0.005	--
		Total	2E-05	--	--	Tetrachloroethene, Arsenic	0.6	--
Lifelong Residents (Child and Adult)	Groundwater	Ingestion	3E-05	--	Tetrachloroethene	Carbon Tetrachloride, Arsenic	NA	--
		Dermal Contact	8E-06	--	--	Tetrachloroethene	NA	--
		Inhalation	1E-06	--	--	--	NA	--
		Total	4E-05	--	Tetrachloroethene	Carbon Tetrachloride, Arsenic	NA	--

TABLE 10
COMPARISON OF CANCER RISKS AND HAZARD INDICES
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE

Receptor Group	Cancer Risk		Hazard Index	
	Old Value[1]	New Value	Old Value[1]	New Value
Child Resident	NR	8E-05	4	3
Adult Resident	NR	1E-04	2	1
Lifelong Resident	4E-04	2E-04	NA	NA

Notes:
NR - Not reported, only results for the lifelong resident were presented in the RI report.
NA - Not applicable for this receptor.
1 - Old values are from the Remedial Investigation Report for Site 1 Privet Road Compound, July 2002, Table 4-25 & 4-27.

ATTACHMENT A

RAGS PART D TABLES

LIST OF TABLES
RAGS PART D TABLE 2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Table No.

2.1 Groundwater

TABLE 2.1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Sample with Maximum Concentration	Frequency of Detection	Range of Nondects[2]	Concentration Used for Screening[3]	Above Background Concentration[4]	EPA Region 3 RBCs for Tap Water[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Site 1	Volatile Organic Compounds														
	71-55-6	1,1,1-Trichloroethane	0.5 J	6	ug/L	10MW27	2/25	10	6	NA	320 N	200	MCL	No	BSL
	75-34-3	1,1-Dichloroethane	0.2 J	0.8 J	ug/L	10MW27-D	2/25	10	0.8	NA	90 N	NA	NA	No	BSL
	75-35-4	1,1-Dichloroethene	0.1 J	4	ug/L	10MW27	2/25	10	4	NA	35 N	7	MCL	No	BSL
	56-23-5	Carbon Tetrachloride	0.2 J	0.2 J	ug/L	10MW27-D	1/25	1 - 10	0.2	NA	0.16 C	5	MCL	Yes	ASL
	67-66-3	Chloroform	0.1 J	0.2 J	ug/L	10MW27, 10MW28	2/25	10	0.2	NA	0.15 C	80	MCL	Yes	ASL
	127-18-4	Tetrachloroethene	2 J	36	ug/L	01MWNW1_19970708	8/25	1 - 10	36	NA	0.1 C	5	MCL	Yes	ASL
	540-59-0	Total 1,2-Dichloroethene	0.2 J	5 J	ug/L	01MW07I_19970627	3/25	1 - 10	5	NA	5.5 N	NA	NA	No	BSL
	79-01-6	Trichloroethene	0.1 J	37	ug/L	01MW07I_19970627	16/25	10	37	NA	0.026 C	5	MCL	Yes	ASL
	Semi-Volatile Organic Compounds														
	117-81-7	Bis(2-Ethylhexyl)Phthalate	2 J	2 J	ug/L	10MW28	1/2	6 - 9	2	NA	4.8 C	6	MCL	No	BSL
	Inorganics														
	7429-90-5	Aluminum	19.1	3430	ug/L	01MW05S_19910923-F	6/18	8.6 - 135	3430	NA	3700 N	NA	NA	No	BSL
	7440-36-0	Antimony	0.81 K	0.98	ug/L	10MW27	2/18	45	0.98	NA	1.5 N	6	MCL	No	BSL
	7440-38-2	Arsenic	3.6	4.2	ug/L	01MWNW1B_19911007	2/18	0.85 - 3.2	4.2	NA	0.045 C	10	MCL	Yes	ASL
	7440-39-3	Barium	15	474	ug/L	10MW28	15/18	20 - 155	474	NA	260 N	2000	MCL	Yes	ASL
	7440-41-7	Beryllium	0.16	4	ug/L	5 SAMPLES	7/18	0.05 - 9	4	NA	7.3 N	4	MCL	No	BSL
	7440-70-2	Calcium	12300	56500	ug/L	10MW28	18/18	---	56500	NA	NA	NA	NA	No	NUT
	7440-47-3	Chromium	1.3	18	ug/L	01MW05I_19910923-F	3/18	7 - 11	18	NA	11 N[9]	100	MCL[9]	Yes	ASL
	7440-48-4	Cobalt	10	17	ug/L	01MW05S_19910923-F	2/18	0.15 - 10	17	NA	73 N	NA	NA	No	BSL
	7440-50-8	Copper	0.49	37	ug/L	01MW05S_19910923-F	3/18	6 - 35	37	NA	150 N	1300	MCL[10]	No	BSL
	7439-89-6	Iron	23.6	576 J	ug/L	01MW02I_19910924	4/18	14.6 - 177	576	NA	1100 N	NA	NA	No	BSL
	7439-92-1	Lead	1	18	ug/L	01MW04I_19910923	11/18	0.5 - 1	18	NA	15 [11]	15	MCL[10]	Yes	ASL
	7439-95-4	Magnesium	3780	27500	ug/L	01MWNW1A_19911007-D	18/18	---	27500	NA	NA	NA	NA	No	NUT
	7439-96-5	Manganese	2.3	981	ug/L	01MW05S_19910923-F	14/18	1 - 2	981	NA	73 N[12]	NA	NA	Yes	ASL
	7440-02-0	Nickel	3.1	26	ug/L	01MW04S_19910923-F	4/18	12 - 26	26	NA	73 N	NA	NA	No	BSL
	7440-09-7	Potassium	1490 J	38700	ug/L	01MW05I_19910923-F	11/18	2140	38700	NA	NA	NA	NA	No	NUT
	7782-49-2	Selenium	1.1	1.2	ug/L	10MW27-D	2/16	0.85 - 20	1.2	NA	18 N	50	MCL	No	BSL
	7440-23-5	Sodium	9840	28500	ug/L	01MW06S_19910924-F	18/18	---	28500	NA	NA	NA	NA	No	NUT
	7440-62-2	Vanadium	0.58	0.58	ug/L	10MW28	1/9	0.12 - 4	0.58	NA	3.7 N	NA	NA	No	BSL
	7440-66-6	Zinc	2	187	ug/L	10MW27	7/18	2 - 47	187	NA	1100 N	NA	NA	No	BSL

Footnotes

1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - No background data are available for groundwater.
5 - The EPA Region 3 tap water screening level is presented. Value represents the risk based tap water screening level divided by 10 to correspond to a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag), or an incremental cancer risk of 1.0E-6 for carcinogens (denoted with a "C" flag) (USEPA Region III, April 2005).
6 - USEPA Primary Drinking Water Standard (USEPA, Winter 2004). The values presented are based on MCLs or SMCLs and are presented for reference purposes only.
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level. Chemicals selected as COPCs are indicated by shaded chemical names.
8 - The RBC for tap water for hexavalent chromium is presented. The RBC for trivalent chromium is 55,000 ug/L.
9 - Value presented is for total chromium.
10 - The MCL for this parameter is actually a treatment technique. The SDWA action level (at the tap) has been presented.
11 - No RBC is available. The Action Level promulgated under the Safe Drinking Water Act is used for screening purposes.
12 - The RBC for tap water calculated using the RfDo for manganese nonfood is presented.

Associated Samples

01MW01I_19970707	01MW02S_19970627	01MW05I_19970627	01MW07I_19910924	01MWNW2A_19910927
01MW01S_19910924	01MW03I_19970707	01MW05S_19910923	01MW07I_19910924-F	01MWNW2B_19910927
01MW01S_19910924-F	01MW03I_19970707-D	01MW05S_19910923-F	01MW07I_19970627	01MWNW2_19970708
01MW01S_19970627	01MW03S_19910924	01MW05S_19970627	01MW07S_19910924	01MWWW1_19970709
01MW01SO_19970627	01MW03S_19970627	01MW06I_19910924	01MW07S_19910924-F	01MWWW1_19970709-D
01MW02I_19910924	01MW04I_19910923	01MW06I_19910924-F	01MW07S_19970627	01MWWW1B_19970709
01MW02I_19970627	01MW04I_19970627	01MW06I_19970627	01MW08I_19970707	01MWWW2_19970709
01MW02I_19970627-D	01MW04S_19910923	01MW06S_19910924	01MW08S_19970630	01MWWW3_19970708
01MW02S_19910924	01MW04S_19910923-F	01MW06S_19910924-D	01MWNW1A_19911007	10MW27
01MW02S_19910924-D	01MW04S_19970627	01MW06S_19910924-F	01MWNW1A_19911007-D	10MW27-D
01MW02S_19910924-F	01MW05I_19910923	01MW06S_19910924-F-D	01MWNW1B_19911007	10MW28
01MW02S_19910924-F-D	01MW05I_19910923-F	01MW06S_19970627	01MWNW1_19970708	

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirements To Be Considered
C = Carcinogen
COPC = Chemical Of Potential Concern
J = Estimated value
K = Value estimated with a high bias
MCL = Maximum Contaminant Level
N = Noncarcinogen
NA = Not Applicable/Not Available
RBC = Risk Based Concentration

Rationale Codes:
For selection as a COPC:
ASL = Above Screening Level and site background.

For elimination as a COPC:
BSL = Below Screening Level
NUT = Essential Nutrient

LIST OF TABLES
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MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

Table No.

Reasonable Maximum/Central Tendency Exposures

3.1.RME Groundwater

TABLE 3.1 RME
EXPOSURE POINT CONCENTRATION SUMMARY
REASONABLE MAXIMUM EXPOSURE
NASJRB WILLOW GROVE

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Site 1	Carbon Tetrachloride	ug/L	4.63	5.74 (NP)	0.35 J	5.74	ug/L	95% Chebyshev(Mean, Std) UCL	W-, A-D, & K-S Test (1)
	Chloroform	ug/L	4.61	5.78 (NP)	0.2 J	5.78	ug/L	95% Chebyshev(Mean, Std) UCL	W-, A-D, & K-S Test (1)
	Tetrachloroethene	ug/L	6.10	11.7 (NP)	36	11.7	ug/L	95% Chebyshev(Mean, Std) UCL	W-, A-D, & K-S Test (1)
	Trichloroethene	ug/L	6.85	22.4 (NP)	37	22.4	ug/L	99% Chebyshev(Mean, Std) UCL	W-, A-D, & K-S Test (2)
	Arsenic	ug/L	1.32	2.35 (NP)	4.2	2.35	ug/L	95% Chebyshev(Mean, Std) UCL	W-, A-D, & K-S Test (1)
	Barium	ug/L	137	221 (G)	474	221	ug/L	Approximate Gamma 95% UCL	A-D, & K-S Test (3)
	Chromium	ug/L	4.56	8.18 (NP)	18	8.18	ug/L	95% Chebyshev(Mean, Std) UCL	W-, A-D, & K-S Test (1)
	Lead	ug/L	2.57	5.35 (L)	18	2.57	ug/L	Arithmetic Mean	(4)
	Manganese	ug/L	139	362 (G)	981	362	ug/L	Adjusted Gamma 95% UCL	A-D, & K-S Test (5)

For non-detects, 1/2 sample quantitation limit was used as a proxy concentration; for duplicate sample results, the average value was used in the calculation.
G = Gamma
L = Lognormal
NP = Non-parametric
1 - The Shapiro-Wilks, Anderson-Darling, and Kolmogorov-Smirnov tests indicate that the data is non-parametric. The ProUCL guidance recommends that the 95% Chebyshev(Mean, Std) UCL be used as the exposure point concentration.
2 - The Shapiro-Wilks, Anderson-Darling, and Kolmogorov-Smirnov tests indicate that the data is non-parametric. The ProUCL guidance recommends that the 95% Chebyshev(Mean, Std) UCL be used as the exposure point concentration.
3 - The Anderson-Darling and Kolmogorov-Smirnov tests indicate that the data follows a gamma distribution. The ProUCL guidance recommends that the approximate gamma UCL be used as the exposure point concentration.
4 - Mean concentration is used as exposure point concentration for evaluating exposures to lead.
U.S. EPA, 1994:Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for lead in Children
5 - The Anderson-Darling and Kolmogorov-Smirnov tests indicate that the data follows a gamma distribution. The ProUCL guidance recommends that the adjusted gamma UCL be used as the exposure point concentration.

Exposure point concentrations for the RME scenarios are also the exposure point concentrations for the CTE scenarios.

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VALUES USED FOR DAILY INTAKE CALCULATIONS

Table No.

Reasonable Maximum Exposures

4.1.RME Child Residents Exposed to Groundwater
4.2.RME Child Residents Exposed to Volatile Emissions from Groundwater
4.3.RME Adult Residents Exposed to Groundwater
4.4.RME Adult Residents Exposed to Volatile Emissions from Groundwater

Central Tendency Exposures

4.1.CTE Child Residents Exposed to Groundwater
4.2.CTE Child Residents Exposed to Volatile Emissions from Groundwater
4.3.CTE Adult Residents Exposed to Groundwater
4.4.CTE Adult Residents Exposed to Volatile Emissions from Groundwater

TABLE 4.1 RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Child	Site 1	CGW	Chemical Concentration in Groundwater	Max or 95% UCL	mg/kg	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	1	L/day	USEPA, 1991	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 1991	BW x AT
				ED	Exposure Duration	6	years	USEPA, 1989, 1991	
				BW	Body Weight	15	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
Dermal	Residents	Child	Site 1	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				SA	Skin Surface Available for Contact	6,600	cm2	USEPA, 2004	
				EV	Event Frequency	1	events/day	USEPA, 2004	DAevent x EV x EF x ED x SA
				ET	Exposure Time	0.33	hours/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	350	days/year	USEPA, 1991	
				ED	Exposure Duration	6	years	USEPA, 1989, 1991	See text for calculation of DAevent.
				BW	Body Weight	15	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual; Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 5.48E-06

Noncancer Ingestion Intake = 6.39E-05

Cancer Dermal Intake = 3.62E+01

Noncancer Dermal Intake = 4.22E+02

TABLE 4.2 RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Child	Site 1	S	Volatile Chemical Generation Rate	Derived	mg/m3-min shower	Foster&Chrostowski 1987	Intake (mg/kg/day) =
				IRsh	Inhalation Rate of volatiles in shower	0.6	m3/hr	USEPA, 1989	
				EF	Exposure Frequency	350	days/year	USEPA, 1991	S x IR x K x EF x ED
				K	Masss Transfer Coefficient	Derived	min	Foster&Chrostowski 1987	BW x AT x Ra x CF
				ED	Exposure Duration	6	years	USEPA, 1989, 1991	
				BW	Body Weight	15	kg	USEPA, 1989, 1991	
				Ra	Air Exchange Rate	0.017	min-1	Foster&Chrostowski 1987	
				CF	Conversion Factor	60	min/hr		
				Ds	Shower Duration	15	min	Professional judgment	
				Dt	Total Time in Bathroom	20	min	Professional judgment	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Noncancer)	2,190	days	USEPA, 1989	

Sources

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.

Unit Intake Calculations

Inhalation Intake = (IRsh x EF x ED)/(BW x AT x Ra x CF)

Cancer Inhalation Intake = 3.29E-03 Noncancer Inhalation Intake = 3.84E-02

TABLE 4.3 RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 1	CGW	Chemical Concentration in Groundwater	95% UCL or Max	ug/L	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	–	
				IR-GW	Ingestion Rate of Groundwater	2	L/day	USEPA, 1991	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 1991	BW x AT
				ED	Exposure Duration	24	years	USEPA, 1989, 1991	
				BW	Body Weight	70	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Residents	Adult	Site 1	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				SA	Skin Surface Available for Contact	18,000	cm2	USEPA, 2004	
				EV	Event Frequency	1	events/day	USEPA, 2004	DAevent x EV x EF x ED x SA
				ET	Exposure Time	0.25	hours/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	350	days/year	USEPA, 1991	
				ED	Exposure Duration	24	years	USEPA, 1989, 1991	See text for calculation of DAevent.
				BW	Body Weight	70	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 9.39E-06

Noncancer Ingestion Intake = 2.74E-05

Cancer Dermal Intake = 8.45E+01

Noncancer Dermal Intake = 2.47E+02

TABLE 4.4 RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Residents	Adult	Site 1	S	Volatile Chemical Generation Rate	Derived	mg/m3-min shower	Foster&Chrostowski 1987	Chronic Daily Intake (CDI) (mg/kg-day)=
				IRsh	Inhalation Rate of volatiles in shower	0.6	m3/hr	USEPA, 1989	
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$\frac{S \times IRsh \times K \times EF \times ED}{BW \times AT \times Ra \times CF}$
				K	Masss Transfer Coefficient	Derived	min	Foster&Chrostowski 1987	
				ED	Exposure Duration	24	years	USEPA, 1989, 1991	
				BW	Body Weight	70	kg	USEPA, 1989, 1991	
				Ra	Air Exchange Rate	0.017	min-1	Foster&Chrostowski 1987	
				CF	Conversion Factor	60	min/hr		
				Ds	Shower Duration	15	min	Professional judgment	
				Dt	Total Time in Bathroom	20	min	Professional judgment	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Noncancer)	8760	days	USEPA ,1989	

Sources

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.

Unit Intake Calculations

Inhalation Intake = (IRsh x EF x ED)/(BW x AT x Ra x CF)

Cancer Inhalation Intake = 2.82E-03 Noncancer Inhalation Intake = 8.22E-03

TABLE 4.1 CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Child	Site 1	CGW	Chemical Concentration in Groundwater	Max or 95% UCL	mg/kg	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	0.7	L/day	USEPA, 1997	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 1991	BW x AT
				ED	Exposure Duration	2	years	USEPA, 1993	
				BW	Body Weight	15	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
Dermal	Residents	Child	Site 1	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				SA	Skin Surface Available for Contact	6,600	cm2	USEPA, 2004	
				EV	Event Frequency	1	events/day	USEPA, 2004	DAevent x EV x EF x ED x SA
				ET	Exposure Time	0.33	hours/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	350	days/year	USEPA, 1991	
				ED	Exposure Duration	2	years	USEPA, 1993	See text for calculation of DAevent.
				BW	Body Weight	15	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.28E-06

Noncancer Ingestion Intake = 4.47E-05

Cancer Dermal Intake = 1.21E+01

Noncancer Dermal Intake = 4.22E+02

TABLE 4.2 CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Child	Site 1	S	Volatile Chemical Generation Rate	Derived	mg/m3-min shower	Foster&Chrostowski 1987	Intake (mg/kg/day) =
				IRsh	Inhalation Rate of volatiles in shower	0.6	m3/hr	USEPA, 1989	
				EF	Exposure Frequency	350	days/year	USEPA, 1991	S x IR x K x EF x ED
				K	Masss Transfer Coefficient	Derived	min	Foster&Chrostowski 1987	BW x AT x Ra x CF
				ED	Exposure Duration	2	years	USEPA, 1993	
				BW	Body Weight	15	kg	USEPA, 1989, 1991	
				Ra	Air Exchange Rate	0.017	min-1	Foster&Chrostowski 1987	
				CF	Conversion Factor	60	min/hr		
				Ds	Shower Duration	10	min	Professional judgment	
				Dt	Total Time in Bathroom	15	min	Professional judgment	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Noncancer)	730	days	USEPA, 1989	

Sources

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.

Unit Intake Calculations

Inhalation Intake = (IRsh x EF x ED)/(BW x AT x Ra x CF)

Cancer Inhalation Intake = 1.10E-03 Noncancer Inhalation Intake = 3.84E-02

TABLE 4.3 CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 1	CGW	Chemical Concentration in Groundwater	95% UCL or Max	ug/L	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	–	
				IR-GW	Ingestion Rate of Groundwater	1.4	L/day	USEPA, 1991	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	234	days/year	USEPA, 1991	BW x AT
				ED	Exposure Duration	7	years	USEPA, 1993	
				BW	Body Weight	70	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Residents	Adult	Site 1	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				SA	Skin Surface Available for Contact	18,000	cm2	USEPA, 2004	
				EV	Event Frequency	1	events/day	USEPA, 2004	DAevent x EV x EF x ED x SA
				ET	Exposure Time	0.17	hours/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	234	days/year	USEPA, 1991	
				ED	Exposure Duration	7	years	USEPA, 1989, 1991	See text for calculation of DAevent.
				BW	Body Weight	70	kg	USEPA, 1989, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.28E-06

Noncancer Ingestion Intake = 1.28E-05

Cancer Dermal Intake = 1.65E+01

Noncancer Dermal Intake = 1.65E+02

TABLE 4.4 CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Residents	Adult	Site 1	S	Volatile Chemical Generation Rate	Derived	mg/m3-min shower	Foster&Chrostowski 1987	Chronic Daily Intake (CDI) (mg/kg-day)=
				IRsh	Inhalation Rate of volatiles in shower	0.6	m3/hr	USEPA, 1989	
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$\frac{S \times IRsh \times K \times EF \times ED}{BW \times AT \times Ra \times CF}$
				K	Masss Transfer Coefficient	Derived	min	Foster&Chrostowski 1987	
				ED	Exposure Duration	7	years	USEPA, 1993	
				BW	Body Weight	70	kg	USEPA, 1989, 1991	
				Ra	Air Exchange Rate	0.017	min-1	Foster&Chrostowski 1987	
				CF	Conversion Factor	60	min/hr		
				Ds	Shower Duration	15	min	Professional judgment	
				Dt	Total Time in Bathroom	20	min	Professional judgment	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Noncancer)	2555	days	USEPA ,1989	

Sources

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposure to Volatile Organic Contaminants in the Shower.

Unit Intake Calculations

Inhalation Intake = (IRsh x EF x ED)/(BW x AT x Ra x CF)

Cancer Inhalation Intake = 8.22E-04 Noncancer Inhalation Intake = 8.22E-03

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5-1 Non-Cancer Toxicity Data - Oral/Dermal
5-2 Non-Cancer Toxicity Data - Inhalation

TABLE 5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
NASJRB WILLOW GROVE, PENNSYLVANIA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds										
Carbon Tetrachloride	Chronic	7.0E-04	mg/kg/day	1	7.0E-04	mg/kg/day	Liver	1000/1	IRIS	6/7/2005
Chloroform	Chronic	1.0E-02	mg/kg/day	1	1.0E-02	mg/kg/day	Liver	1000/1	IRIS	6/7/2005
Tetrachloroethene	Chronic	1.0E-02	mg/kg/day	1	1.0E-02	mg/kg/day	Liver	1000/1	IRIS	6/7/2005
Trichloroethene	Chronic	5.0E-01	mg/kg/day	1	5.0E-01	mg/kg/day	Liver	NA	CA EPA	12/2002
Metals										
Arsenic	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Skin, CVS	3/1	IRIS	6/7/2005
Barium	Chronic	7.0E-02	mg/kg/day	0.07	4.9E-03	mg/kg/day	Kidney	3/1	IRIS	6/7/2005
Chromium VI	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	Fetotoxicity, GS, Bone	300/3	IRIS	6/7/2005
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	2.4E-02	mg/kg/day	0.04	9.6E-04	mg/kg/day	CNS	3/1	IRIS	6/7/2005

Notes:

1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.

Definitions:

CNS = Central Nervous System

CVS = Cardiovascular System

EPA 3 = USEPA Region 3 Risk-Based Concentration Table, April 7, 2005.

GS = Gastrointestinal System

IRIS = Integrated Risk Information System

NA = Not Applicable

NCEA = National Center for Environmental Assessment - USEPA Region 3 RBC Table, April 7, 2005.

CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors,

TABLE 5.2
NON-CANCER TOXICITY DATA -- INHALATION
NASJRB WILLOW GROVE, PENNSYLVANIA

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[1]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds									
Carbon Tetrachloride	Chronic	1.8E-01	mg/m^3	5.0E-02	(mg/kg/day)	Liver	NA	EPA 3	4/7/2005
Chloroform	Chronic	4.9E-02	mg/m^3	1.4E-02	(mg/kg/day)	Liver	NA	NCEA	4/7/2005
Tetrachloroethene	Chronic	4.9E-01	mg/m^3	1.4E-01	(mg/kg/day)	Liver	NA	NCEA	4/7/2005
Trichloroethene	Chronic	6.0E-01	mg/m^3	1.7E-01	(mg/kg/day)	Liver	NA	CA EPA	12/2002
Metals									
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	Chronic	5.0E-04	mg/m^3	1.4E-04	(mg/kg/day)	Fetotoxicity	1000/1	HEAST	7/1997
Chromium VI	Chronic	1.0E-04	mg/m^3	2.9E-05	(mg/kg/day)	Lungs	300/1	IRIS	6/7/2005
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	5.0E-05	mg/m^3	1.4E-05	(mg/kg/day)	CNS	1000/1	IRIS	6/7/2005

Notes:

1 - Extrapolated RfD = RfC *20m ^{3}/day / 70 kg

Definitions:

CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.

CNS = Central Nervous System

HEAST = Health Effects Assessment Summary Tables, July 1997.

IRIS = Integrated Risk Information System

NCEA = National Center for Environmental Assessment

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CANCER TOXICITY DATA

Table No.

6-1 Cancer Toxicity Data - Oral/Dermal
6-2 Cancer Toxicity Data - Inhalation

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
NASJRB WILLOW GROVE, PENNSYLVANIA

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds								
Carbon Tetrachloride	1.3E-01	$(mg/kg/day)^{-1}$	1	1.3E-01	$(mg/kg/day)^{-1}$	B2	IRIS	6/7/2005
Chloroform	NA	NA	NA	NA	NA	B2	IRIS	6/7/2005
Tetrachloroethene	5.4E-01	$(mg/kg/day)^{-1}$	1	5.4E-01	$(mg/kg/day)^{-1}$	NA	EPA 3	4/7/2005
Trichloroethene	1.3E-02	$(mg/kg/day)^{-1}$	1	1.3E-02	$(mg/kg/day)^{-1}$	C	CA EPA	12/2002
Metals								
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	6/7/2005
Barium	NA	NA	NA	NA	NA	D	IRIS	6/7/2005
Chromium VI	NA	NA	NA	NA	NA	D	IRIS	6/7/2005
Lead	NA	NA	NA	NA	NA	B2	IRIS	6/7/2005
Manganese	NA	NA	NA	NA	NA	D	IRIS	6/7/2005

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral Absorption Efficiency for Dermal.

EPA Group:
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.
E - Evidence of noncarcinogenicity.

EPA 3 = U.S. EPA Region 3 RBC Table, April 7, 2005.

HEAST= Health Effects Assessment Summary Tables

IRIS = Integrated Risk Information System.

NA = Not Available.

CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.

TABLE 6.2
CANCER TOXICITY DATA -- INHALATION
NASJRB WILLOW GROVE, PENNSYLVANIA

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor[1]		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds							
Carbon Tetrachloride	1.5E-02	$(mg/m^3)^{-1}$	5.3E-02	$(mg/kg/day)^{-1}$	B2	IRIS	6/7/2005
Chloroform	2.3E-02	$(mg/m^3)^{-1}$	8.1E-02	$(mg/kg/day)^{-1}$	B2	IRIS	6/7/2005
Tetrachloroethene	5.7E-03	$(mg/m^3)^{-1}$	2.0E-02	$(mg/kg/day)^{-1}$	NA	EPA 3	4/7/2005
Trichloroethene	2.0E-03	$(mg/m^3)^{-1}$	7.0E-03	$(mg/kg/day)^{-1}$	C	CA EPA	12/2002
Metals							
Arsenic	4.3E+00	$(mg/m^3)^{-1}$	1.5E+01	$(mg/kg/day)^{-1}$	A	IRIS	6/7/2005
Barium	NA	NA	NA	NA	D	IRIS	6/7/2005
Chromium VI	1.2E+01	$(mg/m^3)^{-1}$	4.2E+01	$(mg/kg/day)^{-1}$	A	IRIS	6/7/2005
Lead	NA	NA	NA	NA	B2	IRIS	6/7/2005
Manganese	NA	NA	NA	NA	D	IRIS	6/7/2005

Notes:

1 - Inhalation CSF = Unit Risk * 70 kg / $20m^3$/day.

Definitions:

EPA 3 = U.S. EPA Region 3 RBC Table, April 7, 2005.

HEAST= Health Effects Assessment Summary Tables

IRIS = Integrated Risk Information System.

NA = Not Available.

NCEA = National Center for Environmental Assessment

EPA Group:

A - Human carcinogen.

B1 - Probable human carcinogen - indicates that limited human data are available.

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .

C - Possible human carcinogen.

D - Not classifiable as a human carcinogen.

E - Evidence of noncarcinogenicity.

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CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

Table No.

REASONABLE MAXIMUM EXPOSURES

7.1.RME Child Residents
7.2.RME Adult Residents

CENTRAL TENDENCY EXPOSURES

7.1.CTE Child Residents
7.2.CTE Adult Residents

TABLE 7.1 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe:
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site 1	Ingestion	Carbon Tetrachloride	5.74	ug/L	3.1E-05	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	4.1E-06	3.7E-04	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.5
				Chloroform	5.78	ug/L	3.2E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.7E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.04
				Tetrachloroethene	11.7	ug/L	6.4E-05	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	3.5E-05	7.5E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.07
				Trichloroethene	22.4	ug/L	1.2E-04	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	1.6E-06	1.4E-03	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.003
				Arsenic	2.35	ug/L	1.3E-05	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	1.9E-05	1.5E-04	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.5
				Barium	221	ug/L	1.2E-03	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.4E-02	(mg/kg/day)	7.0E-02	(mg/kg/day)	0.2
				Chromium	8.18	ug/L	4.5E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	5.2E-04	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.2
				Lead	2.57	ug/L	1.4E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.6E-04	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	2.0E-03	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.3E-02	(mg/kg/day)	2.4E-02	(mg/kg/day)	1.0
			Exp. Route Total								6.0E-05					2.5
			Dermal	Carbon Tetrachloride	5.74	ug/L	4.7E-06	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	6.2E-07	5.5E-05	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.08
				Chloroform	5.78	ug/L	1.6E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.9E-05	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.002
				Tetrachloroethene	11.7	ug/L	2.1E-05	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	1.2E-05	2.5E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.02
				Trichloroethene	22.4	ug/L	1.1E-05	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	1.5E-07	1.3E-04	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.0003
				Arsenic	2.35	ug/L	2.8E-08	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	4.2E-08	3.3E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.001
				Barium	221	ug/L	2.6E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.1E-05	(mg/kg/day)	4.9E-03	(mg/kg/day)	0.006
				Chromium	8.18	ug/L	2.0E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.3E-06	(mg/kg/day)	7.5E-05	(mg/kg/day)	0.03
				Lead	2.57	ug/L	3.1E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.6E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	4.3E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	5.0E-05	(mg/kg/day)	9.6E-04	(mg/kg/day)	0.05
			Exp. Route Total								1.2E-05					0.2
		Exposure Point Total									7.2E-05					2.7
	Exposure Medium Total										7.2E-05					2.7
	Air	Site 1	Inhalation	Carbon Tetrachloride	0.005	mg/m3	1.6E-05	(mg/kg/day)	5.3E-02	(mg/kg/day)$^{-1}$	8.7E-07	1.9E-04	(mg/kg/day)	5.0E-02	(mg/kg/day)	0.004
				Chloroform	0.005	mg/m3	1.7E-05	(mg/kg/day)	8.1E-02	(mg/kg/day)$^{-1}$	1.4E-06	2.0E-04	(mg/kg/day)	1.4E-02	(mg/kg/day)	0.01
				Tetrachloroethene	0.010	mg/m3	3.2E-05	(mg/kg/day)	2.0E-02	(mg/kg/day)$^{-1}$	6.4E-07	3.8E-04	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.003
				Trichloroethene	0.020	mg/m3	6.7E-05	(mg/kg/day)	7.0E-03	(mg/kg/day)$^{-1}$	4.7E-07	7.8E-04	(mg/kg/day)	1.7E-01	(mg/kg/day)	0.005
				Arsenic	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	1.5E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Barium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-04	(mg/kg/day)	--
				Chromium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	4.2E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	2.9E-05	(mg/kg/day)	--
				Lead	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-05	(mg/kg/day)	--
			Exp. Route Total								3.4E-06					0.03
		Exposure Point Total									3.4E-06					0.03
	Exposure Medium Total										3.4E-06					0.03
Medium Total											7.5E-05					2.7
										Total of Receptor Risks Across All Media	7.5E-05				Total of Receptor Hazards Across All Media	2.7

TABLE 7.2 RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe:
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site 1	Ingestion	Carbon Tetrachloride	5.74	ug/L	5.4E-05	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	7.0E-06	1.6E-04	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.2
				Chloroform	5.78	ug/L	5.4E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.6E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.02
				Tetrachloroethene	11.7	ug/L	1.1E-04	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	5.9E-05	3.2E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.03
				Trichloroethene	22.4	ug/L	2.1E-04	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	2.7E-06	6.1E-04	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.001
				Arsenic	2.35	ug/L	2.2E-05	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	3.3E-05	6.4E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.2
				Barium	221	ug/L	2.1E-03	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	6.1E-03	(mg/kg/day)	7.0E-02	(mg/kg/day)	0.09
				Chromium	8.18	ug/L	7.7E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.2E-04	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.07
				Lead	2.57	ug/L	2.4E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	7.0E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	3.4E-03	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	9.9E-03	(mg/kg/day)	2.4E-02	(mg/kg/day)	0.4
			Exp. Route Total								1.0E-04					1.1
			Dermal	Carbon Tetrachloride	5.74	ug/L	9.6E-06	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	1.3E-06	2.8E-05	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.04
				Chloroform	5.78	ug/L	3.3E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	9.5E-06	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.0009
				Tetrachloroethene	11.7	ug/L	4.4E-05	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	2.3E-05	1.3E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.01
				Trichloroethene	22.4	ug/L	2.3E-05	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	3.0E-07	6.8E-05	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.0001
				Arsenic	2.35	ug/L	5.0E-08	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	7.5E-08	1.4E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0005
				Barium	221	ug/L	4.7E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.4E-05	(mg/kg/day)	4.9E-03	(mg/kg/day)	0.003
				Chromium	8.18	ug/L	3.5E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.0E-06	(mg/kg/day)	7.5E-05	(mg/kg/day)	0.01
				Lead	2.57	ug/L	5.4E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.6E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	7.7E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.2E-05	(mg/kg/day)	9.6E-04	(mg/kg/day)	0.02
			Exp. Route Total								2.5E-05					0.09
		Exposure Point Total									1.3E-04					1.2
	Exposure Medium Total										1.3E-04					1.2
	Air	Site 1	Inhalation	Carbon Tetrachloride	0.005	mg/m3	1.4E-05	(mg/kg/day)	5.3E-02	(mg/kg/day)$^{-1}$	7.4E-07	4.1E-05	(mg/kg/day)	5.0E-02	(mg/kg/day)	0.0008
				Chloroform	0.005	mg/m3	1.5E-05	(mg/kg/day)	8.1E-02	(mg/kg/day)$^{-1}$	1.2E-06	4.3E-05	(mg/kg/day)	1.4E-02	(mg/kg/day)	0.003
				Tetrachloroethene	0.010	mg/m3	2.8E-05	(mg/kg/day)	2.0E-02	(mg/kg/day)$^{-1}$	5.5E-07	8.1E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0006
				Trichloroethene	0.020	mg/m3	5.7E-05	(mg/kg/day)	7.0E-03	(mg/kg/day)$^{-1}$	4.0E-07	1.7E-04	(mg/kg/day)	1.7E-01	(mg/kg/day)	0.001
				Arsenic	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	1.5E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Barium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-04	(mg/kg/day)	--
				Chromium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	4.2E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	2.9E-05	(mg/kg/day)	--
				Lead	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-05	(mg/kg/day)	--
			Exp. Route Total								2.9E-06					0.005
		Exposure Point Total									2.9E-06					0.005
	Exposure Medium Total										2.9E-06					0.005
Medium Total											1.3E-04					1.2
										Total of Receptor Risks Across All Media	1.3E-04				Total of Receptor Hazards Across All Media	1.2

TABLE 7.1 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe:
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site 1	Ingestion	Carbon Tetrachloride	5.74	ug/L	7.3E-06	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	9.5E-07	2.6E-04	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.4
				Chloroform	5.78	ug/L	7.4E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.6E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.03
				Tetrachloroethene	11.7	ug/L	1.5E-05	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	8.1E-06	5.2E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.05
				Trichloroethene	22.4	ug/L	2.9E-05	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	3.7E-07	1.0E-03	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.002
				Arsenic	2.35	ug/L	3.0E-06	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	4.5E-06	1.1E-04	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.4
				Barium	221	ug/L	2.8E-04	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	9.9E-03	(mg/kg/day)	7.0E-02	(mg/kg/day)	0.1
				Chromium	8.18	ug/L	1.0E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.7E-04	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.1
				Lead	2.57	ug/L	3.3E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.2E-04	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	4.6E-04	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.6E-02	(mg/kg/day)	2.4E-02	(mg/kg/day)	0.7
			Exp. Route Total								1.4E-05					1.7
			Dermal	Carbon Tetrachloride	5.74	ug/L	1.6E-06	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	2.1E-07	5.5E-05	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.08
				Chloroform	5.78	ug/L	5.3E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.9E-05	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.002
				Tetrachloroethene	11.7	ug/L	7.1E-06	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	3.8E-06	2.5E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.02
				Trichloroethene	22.4	ug/L	3.8E-06	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	4.9E-08	1.3E-04	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.0003
				Arsenic	2.35	ug/L	9.3E-09	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	1.4E-08	3.3E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.001
				Barium	221	ug/L	8.8E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.1E-05	(mg/kg/day)	4.9E-03	(mg/kg/day)	0.006
				Chromium	8.18	ug/L	6.5E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.3E-06	(mg/kg/day)	7.5E-05	(mg/kg/day)	0.03
				Lead	2.57	ug/L	1.0E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.6E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	1.4E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	5.0E-05	(mg/kg/day)	9.6E-04	(mg/kg/day)	0.05
			Exp. Route Total								4.1E-06					0.2
		Exposure Point Total									1.8E-05					1.9
	Exposure Medium Total										1.8E-05					1.9
	Air	Site 1	Inhalation	Carbon Tetrachloride	0.003	mg/m3	3.0E-06	(mg/kg/day)	5.3E-02	(mg/kg/day)$^{-1}$	1.6E-07	1.0E-04	(mg/kg/day)	5.0E-02	(mg/kg/day)	0.002
				Chloroform	0.003	mg/m3	3.2E-06	(mg/kg/day)	8.1E-02	(mg/kg/day)$^{-1}$	2.6E-07	1.1E-04	(mg/kg/day)	1.4E-02	(mg/kg/day)	0.008
				Tetrachloroethene	0.005	mg/m3	5.9E-06	(mg/kg/day)	2.0E-02	(mg/kg/day)$^{-1}$	1.2E-07	2.1E-04	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.001
				Trichloroethene	0.011	mg/m3	1.2E-05	(mg/kg/day)	7.0E-03	(mg/kg/day)$^{-1}$	8.6E-08	4.3E-04	(mg/kg/day)	1.7E-01	(mg/kg/day)	0.003
				Arsenic	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	1.5E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Barium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-04	(mg/kg/day)	--
				Chromium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	4.2E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	2.9E-05	(mg/kg/day)	--
				Lead	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-05	(mg/kg/day)	--
			Exp. Route Total								6.2E-07					0.01
		Exposure Point Total									6.2E-07					0.01
	Exposure Medium Total										6.2E-07					0.01
Medium Total											1.9E-05					1.9
										Total of Receptor Risks Across All Media	1.9E-05				Total of Receptor Hazards Across All Media	1.9

TABLE 7.2 CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe:
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Site 1	Ingestion	Carbon Tetrachloride	5.74	ug/L	7.4E-06	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	9.6E-07	7.4E-05	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.1
				Chloroform	5.78	ug/L	7.4E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	7.4E-05	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.007
				Tetrachloroethene	11.7	ug/L	1.5E-05	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	8.1E-06	1.5E-04	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.02
				Trichloroethene	22.4	ug/L	2.9E-05	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	3.7E-07	2.9E-04	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.0006
				Arsenic	2.35	ug/L	3.0E-06	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	4.5E-06	3.0E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.1
				Barium	221	ug/L	2.8E-04	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	2.8E-03	(mg/kg/day)	7.0E-02	(mg/kg/day)	0.04
				Chromium	8.18	ug/L	1.0E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.0E-04	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.03
				Lead	2.57	ug/L	3.3E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	3.3E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	4.6E-04	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	4.6E-03	(mg/kg/day)	2.4E-02	(mg/kg/day)	0.2
			Exp. Route Total								1.4E-05					0.5
			Dermal	Carbon Tetrachloride	5.74	ug/L	1.6E-06	(mg/kg/day)	1.3E-01	(mg/kg/day)$^{-1}$	2.0E-07	1.6E-05	(mg/kg/day)	7.0E-04	(mg/kg/day)	0.02
				Chloroform	5.78	ug/L	5.2E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	5.2E-06	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.0005
				Tetrachloroethene	11.7	ug/L	7.0E-06	(mg/kg/day)	5.4E-01	(mg/kg/day)$^{-1}$	3.8E-06	7.0E-05	(mg/kg/day)	1.0E-02	(mg/kg/day)	0.007
				Trichloroethene	22.4	ug/L	3.7E-06	(mg/kg/day)	1.3E-02	(mg/kg/day)$^{-1}$	4.9E-08	3.7E-05	(mg/kg/day)	5.0E-01	(mg/kg/day)	0.00007
				Arsenic	2.35	ug/L	6.6E-09	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	9.9E-09	6.6E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0002
				Barium	221	ug/L	6.2E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	6.2E-06	(mg/kg/day)	4.9E-03	(mg/kg/day)	0.001
				Chromium	8.18	ug/L	4.6E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	4.6E-07	(mg/kg/day)	7.5E-05	(mg/kg/day)	0.006
				Lead	2.57	ug/L	7.2E-09	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	7.2E-08	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	362	ug/L	1.0E-06	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.0E-05	(mg/kg/day)	9.6E-04	(mg/kg/day)	0.01
			Exp. Route Total								4.0E-06					0.05
		Exposure Point Total									1.8E-05					0.5
	Exposure Medium Total										1.8E-05					0.5
	Air	Site 1	Inhalation	Carbon Tetrachloride	0.005	mg/m3	4.1E-06	(mg/kg/day)	5.3E-02	(mg/kg/day)$^{-1}$	2.2E-07	4.1E-05	(mg/kg/day)	5.0E-02	(mg/kg/day)	0.0008
				Chloroform	0.005	mg/m3	4.3E-06	(mg/kg/day)	8.1E-02	(mg/kg/day)$^{-1}$	3.5E-07	4.3E-05	(mg/kg/day)	1.4E-02	(mg/kg/day)	0.003
				Tetrachloroethene	0.010	mg/m3	8.1E-06	(mg/kg/day)	2.0E-02	(mg/kg/day)$^{-1}$	1.6E-07	8.1E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0006
				Trichloroethene	0.020	mg/m3	1.7E-05	(mg/kg/day)	7.0E-03	(mg/kg/day)$^{-1}$	1.2E-07	1.7E-04	(mg/kg/day)	1.7E-01	(mg/kg/day)	0.001
				Arsenic	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	1.5E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Barium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-04	(mg/kg/day)	--
				Chromium	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	4.2E+01	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	2.9E-05	(mg/kg/day)	--
				Lead	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	0.0E+0	mg/m3	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	0.0E+00	(mg/kg/day)	1.4E-05	(mg/kg/day)	--
			Exp. Route Total								8.5E-07					0.005
		Exposure Point Total									8.5E-07					0.005
	Exposure Medium Total										8.5E-07					0.005
Medium Total											1.9E-05					0.6
										Total of Receptor Risks Across All Media	1.9E-05				Total of Receptor Hazards Across All Media	0.6

LIST OF TABLES
RAGS PART D TABLE 9
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

Table No.

REASONABLE MAXIMUM EXPOSURES

9.1.RME Child Residents
9.2.RME Adult Residents
9.3.RME Lifelong Residents

CENTRAL TENDENCY EXPOSURES

9.1.CTE Child Residents
9.2.CTE Adult Residents
9.3.CTE Lifelong Residents

TABLE 9.1 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 1	Carbon Tetrachloride	4E-06	--	6E-07	--	5E-06	Liver	0.5	--	0.08	0.6
			Chloroform	--	--	--	--	--	Liver	0.04	--	0.002	0.04
			Tetrachloroethene	3E-05	--	1E-05	--	5E-05	Liver	0.07	--	0.02	0.10
			Trichloroethene	2E-06	--	1E-07	--	2E-06	Liver	0.003	--	0.0003	0.003
			Arsenic	2E-05	--	4E-08	--	2E-05	Skin, CVS	0.5	--	0.001	0.5
			Barium	--	--	--	--	--	Kidney	0.2	--	0.006	0.2
			Chromium	--	--	--	--	--	Fetotoxicity, GS, Bone	0.2	--	0.03	0.2
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	1.0	--	0.05	1
			Chemical Total	6E-05	--	1E-05	--	7E-05		2	--	0.2	3
		Exposure Point Total						7E-05					3
	Exposure Medium Total							7E-05					3
	Groundwater	Site 1	Carbon Tetrachloride	--	9E-07	--	--	9E-07	Liver	--	0.004	--	0.004
			Chloroform	--	1E-06	--	--	1E-06	Liver	--	0.01	--	0.01
			Tetrachloroethene	--	6E-07	--	--	6E-07	Liver	--	0.003	--	0.003
			Trichloroethene	--	5E-07	--	--	5E-07	Liver	--	0.005	--	0.005
			Arsenic	--	--	--	--	--	NA	--	--	--	--
			Barium	--	--	--	--	--	Fetotoxicity	--	--	--	--
			Chromium	--	--	--	--	--	Lungs	--	--	--	--
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	--	--	--	--
			Chemical Total	--	3E-06	--	--	3E-06		--	0.03	--	0.03
		Exposure Point Total						3E-06					0.03
	Exposure Medium Total							3E-06					0.03
Medium Total								8E-05					3
Receptor Total							Receptor Risk Total	8E-05				Receptor HI Total	3

Total CNS HI	1
Total CVS HI	0.5
Total GS HI	0.2
Total Kidney HI	0.2
Total Liver HI	0.8
Total Skin HI	0.5
Total Fetotoxicity HI	0.2
Total Bone HI	0.2

TABLE 9.2 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 1	Carbon Tetrachloride	7E-06	--	1E-06	--	8E-06	Liver	0.2	--	0.04	0.3
			Chloroform	--	--	--	--	--	Liver	0.02	--	0.0009	0.02
			Tetrachloroethene	6E-05	--	2E-05	--	8E-05	Liver	0.03	--	0.01	0.04
			Trichloroethene	3E-06	--	3E-07	--	3E-06	Liver	0.001	--	0.0001	0.001
			Arsenic	3E-05	--	7E-08	--	3E-05	Skin, CVS	0.2	--	0.0005	0.2
			Barium	--	--	--	--	--	Kidney	0.09	--	0.003	0.09
			Chromium	--	--	--	--	--	Fetotoxicity, GS, Bone	0.07	--	0.01	0.09
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	0.4	--	0.02	0.4
			Chemical Total	1E-04	--	3E-05	--	1E-04		1	--	0.09	1
		Exposure Point Total						1E-04					1
	Exposure Medium Total							1E-04					1
	Groundwater	Site 1	Carbon Tetrachloride	--	7E-07	--	--	7E-07	Liver	--	0.0008	--	0.0008
			Chloroform	--	1E-06	--	--	1E-06	Liver	--	0.003	--	0.003
			Tetrachloroethene	--	6E-07	--	--	6E-07	Liver	--	0.0006	--	0.0006
			Trichloroethene	--	4E-07	--	--	4E-07	Liver	--	0.001	--	0.001
			Arsenic	--	--	--	--	--	NA	--	--	--	--
			Barium	--	--	--	--	--	Fetotoxicity	--	--	--	--
			Chromium	--	--	--	--	--	Lungs	--	--	--	--
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	--	--	--	--
			Chemical Total	--	3E-06	--	--	3E-06		--	0.005	--	0.005
		Exposure Point Total						3E-06					0.005
	Exposure Medium Total							3E-06					0.005
Medium Total								1E-04					1
Receptor Total							Receptor Risk Total	1E-04				Receptor HI Total	1

Total CNS HI	0.4
Total CVS HI	0.2
Total GS HI	0.09
Total Kidney HI	0.09
Total Liver HI	0.3
Total Skin HI	0.2
Total Fetotoxicity HI	0.09
Total Bone HI	0.09

TABLE 9.3 RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 1	Carbon Tetrachloride	1E-05	--	2E-06	--	1E-05					
			Chloroform	--	--	--	--	--					
			Tetrachloroethene	9E-05	--	4E-05	--	1E-04					
			Trichloroethene	4E-06	--	5E-07	--	5E-06					
			Arsenic	5E-05	--	1E-07	--	5E-05					
			Barium	--	--	--	--	--					
			Chromium	--	--	--	--	--					
			Lead	--	--	--	--	--					
			Manganese	--	--	--	--	--					
			Chemical Total	2E-04	--	4E-05	--	2E-04					
		Exposure Point Total						2E-04					
	Exposure Medium Total							2E-04					
	Groundwater	Site 1	Carbon Tetrachloride	--	2E-06	--	--	2E-06					
			Chloroform	--	3E-06	--	--	3E-06					
			Tetrachloroethene	--	1E-06	--	--	1E-06					
			Trichloroethene	--	9E-07	--	--	9E-07					
			Arsenic	--	--	--	--	--					
			Barium	--	--	--	--	--					
			Chromium	--	--	--	--	--					
			Lead	--	--	--	--	--					
			Manganese	--	--	--	--	--					
			Chemical Total	--	6E-06	--	--	6E-06					
		Exposure Point Total						6E-06					
	Exposure Medium Total							6E-06					
Medium Total								2E-04					
Receptor Total							Receptor Risk Total	2E-04					

TABLE 9.1 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 1	Carbon Tetrachloride	1E-06	--	2E-07	--	1E-06	Liver	0.4	--	0.08	0.4
			Chloroform	--	--	--	--	--	Liver	0.03	--	0.002	0.03
			Tetrachloroethene	8E-06	--	4E-06	--	1E-05	Liver	0.05	--	0.02	0.08
			Trichloroethene	4E-07	--	5E-08	--	4E-07	Liver	0.002	--	0.0003	0.002
			Arsenic	5E-06	--	1E-08	--	5E-06	Skin, CVS	0.4	--	0.001	0.4
			Barium	--	--	--	--	--	Kidney	0.1	--	0.006	0.1
			Chromium	--	--	--	--	--	Fetotoxicity, GS, Bone	0.1	--	0.03	0.2
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	0.7	--	0.05	0.7
			Chemical Total	1E-05	--	4E-06	--	2E-05		2	--	0.2	2
		Exposure Point Total						2E-05					2
	Exposure Medium Total							2E-05					2
	Groundwater	Site 1	Carbon Tetrachloride	--	2E-07	--	--	2E-07	Liver	--	0.002	--	0.002
			Chloroform	--	3E-07	--	--	3E-07	Liver	--	0.008	--	0.008
			Tetrachloroethene	--	1E-07	--	--	1E-07	Liver	--	0.001	--	0.001
			Trichloroethene	--	9E-08	--	--	9E-08	Liver	--	0.003	--	0.003
			Arsenic	--	--	--	--	--	NA	--	--	--	--
			Barium	--	--	--	--	--	Fetotoxicity	--	--	--	--
			Chromium	--	--	--	--	--	Lungs	--	--	--	--
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	--	--	--	--
			Chemical Total	--	6E-07	--	--	6E-07		--	0.01	--	0.01
		Exposure Point Total						6E-07					0.01
	Exposure Medium Total							6E-07					0.01
Medium Total								2E-05					2
Receptor Total							Receptor Risk Total	2E-05				Receptor HI Total	2

Total CNS HI	0.7
Total CVS HI	0.4
Total GS HI	0.2
Total Kidney HI	0.1
Total Liver HI	0.6
Total Skin HI	0.4
Total Fetotoxicity HI	0.2
Total Bone HI	0.2

TABLE 9.2 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 1	Carbon Tetrachloride	1E-06	--	2E-07	--	1E-06	Liver	0.1	--	0.02	0.1
			Chloroform	--	--	--	--	--	Liver	0.007	--	0.0005	0.008
			Tetrachloroethene	8E-06	--	4E-06	--	1E-05	Liver	0.02	--	0.007	0.02
			Trichloroethene	4E-07	--	5E-08	--	4E-07	Liver	0.0006	--	0.00007	0.0006
			Arsenic	5E-06	--	1E-08	--	5E-06	Skin, CVS	0.1	--	0.0002	0.1
			Barium	--	--	--	--	--	Kidney	0.04	--	0.001	0.04
			Chromium	--	--	--	--	--	Fetotoxicity, GS, Bone	0.03	--	0.006	0.04
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	0.2	--	0.01	0.2
			Chemical Total	1E-05	--	4E-06	--	2E-05		0.5	--	0.05	0.5
		Exposure Point Total						2E-05					0.5
	Exposure Medium Total							2E-05					0.5
	Groundwater	Site 1	Carbon Tetrachloride	--	2E-07	--	--	2E-07	Liver	--	0.0008	--	0.0008
			Chloroform	--	4E-07	--	--	4E-07	Liver	--	0.003	--	0.003
			Tetrachloroethene	--	2E-07	--	--	2E-07	Liver	--	0.0006	--	0.0006
			Trichloroethene	--	1E-07	--	--	1E-07	Liver	--	0.0010	--	0.0010
			Arsenic	--	--	--	--	--	NA	--	--	--	--
			Barium	--	--	--	--	--	Fetotoxicity	--	--	--	--
			Chromium	--	--	--	--	--	Lungs	--	--	--	--
			Lead	--	--	--	--	--	NA	--	--	--	--
			Manganese	--	--	--	--	--	CNS	--	--	--	--
			Chemical Total	--	8E-07	--	--	8E-07		--	0.005	--	0.005
		Exposure Point Total						8E-07					0.005
	Exposure Medium Total							8E-07					0.005
Medium Total								2E-05					0.6
Receptor Total							Receptor Risk Total	2E-05				Receptor HI Total	0.6

Total CNS HI	0.2
Total CVS HI	0.1
Total GS HI	0.04
Total Kidney HI	0.04
Total Liver HI	0.2
Total Skin HI	0.1
Total Fetotoxicity HI	0.04
Total Bone HI	0.04

TABLE 9.3 CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 1	Carbon Tetrachloride	2E-06	--	4E-07	--	2E-06					
			Chloroform	--	--	--	--	--					
			Tetrachloroethene	2E-05	--	8E-06	--	2E-05					
			Trichloroethene	7E-07	--	1E-07	--	8E-07					
			Arsenic	9E-06	--	2E-08	--	9E-06					
			Barium	--	--	--	--	--					
			Chromium	--	--	--	--	--					
			Lead	--	--	--	--	--					
			Manganese	--	--	--	--	--					
			Chemical Total	3E-05	--	8E-06	--	4E-05					
		Exposure Point Total						4E-05					
	Exposure Medium Total							4E-05					
	Groundwater	Site 1	Carbon Tetrachloride	--	4E-07	--	--	4E-07					
			Chloroform	--	6E-07	--	--	6E-07					
			Tetrachloroethene	--	3E-07	--	--	3E-07					
			Trichloroethene	--	2E-07	--	--	2E-07					
			Arsenic	--	--	--	--	--					
			Barium	--	--	--	--	--					
			Chromium	--	--	--	--	--					
			Lead	--	--	--	--	--					
			Manganese	--	--	--	--	--					
			Chemical Total	--	1E-06	--	--	1E-06					
		Exposure Point Total						1E-06					
	Exposure Medium Total							1E-06					
Medium Total								4E-05					
Receptor Total							Receptor Risk Total	4E-05					

ATTACHMENT B

SAMPLE CALCULATIONS

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM INGESTION OF GROUNDWATER ADULT RESIDENT		
BASED ON: U.S. EPA, DECEMBER 1989		
BY: R. JUPIN	CHECKED BY:	DATE: 06/08/2005

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from ingestion of groundwater.

EQUATION:

$$IEX = \frac{Cgw \times CF \times IF \times EF \times ED}{BW \times AT}$$

Where:

IEX	=	estimated exposure intake (mg/kg/day)
Cgw	=	exposure point concentration in groundwater (ug/L)
CF	=	conversion factor (1.0E-3 mg/ug)
IR	=	ingestion rate (L/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
CSFo	=	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$)
RfDo	=	oral noncarcinogenic reference dose (mg/kg/day)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFo (mg/kg/day)-1
HQ (Noncarcinogens) = Intake (mg/kg/day) / RFDo (mg/kg/day)

ASSUMPTIONS:

Cgw	=	22.4	ug/L	Chemical: Trichloroethene
IR	=	2	L/day	
CF	=	1.0E-03	mg/ug	
EF	=	350	days/year	
ED	=	24	years	
BW	=	70	kg	
ATc	=	25550	days	
ATnc	=	8760	days	
CSFo	=	1.3E-02	$(mg/kg/day)^{-1}$	
RfDo	=	5.0E-01	(mg/kg/day)	

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM INGESTION OF GROUNDWATER ADULT RESIDENT		
BASED ON: U.S. EPA, DECEMBER 1989		
BY: R. JUPIN	CHECKED BY: J. Jackson	DATE: 06/08/2005

EXAMPLE CARCINOGENIC CALCULATION

$$IEXc = \frac{22.4\ ug/L \times 0.001\ mg/ug \times 2\ L/day \times 350\ days/year \times 24\ years}{70\ kg \times 25550\ days}$$

IEXc = 2.10E-04 mg/kg/day

ILCR = 2.10E-04 mg/kg/day x 1.30E-02 (mg/kg/day)-1 = Incremental Lifetime Cancer Risk

ILCR = 2.7E-06

EXAMPLE NONCARCINOGENIC CALCULATION

$$IEXnc = \frac{22.4\ ug/L \times 0.001\ mg/ug \times 2\ L/day \times 350\ days/year \times 24\ years}{70\ kg \times 8760\ days}$$

IEXnc = 6.14E-04 mg/kg/day

$$HQ = \frac{6.14E\text{-}04\ mg/kg/day}{5.0E\text{-}01\ (mg/kg/day)} = \text{Hazard Quotient}$$

HQ = 0.0012

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH GROUNDWATER ADULT RESIDENT		
BASED ON: U.S. EPA, DECEMBER 1989, JULY 2004		
BY: R. JUPIN	CHECKED BY:	DATE: 06/08/2005

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from dermal contact with groundwater.

EQUATION:

$$DAD = \frac{DAevent \times EV \times ED \times EF \times A}{BW \times AT}$$

Where:

DAD	=	dermally absorbed dose (mg/kg/day)
DAevent	=	absorbed does per event (mg/cm^2/event)
EV	=	event frequency (events/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
A	=	skin surface available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days)
CSFo	=	oral carcinogenic slope factor ((mg/kg/day)$^{-1}$)
RfDo	=	oral noncarcinogenic reference dose (mg/kg/day)

RISKS:

ILCR (Carcinogens) = DAD (mg/kg/day) x CSFd (mg/kg/day)-1
HQ (Noncarcinogens) = DAD (mg/kg/day) / RFDd (mg/kg/day)

EQUATIONS for DAevent:

For Inorganics:

DAevent = Kp x Cw x CF x tevent

For Organics:

$$\text{If } tevent \le t^*, \text{ then: } DAevent = 2 \times FA \times Kp \times Cw \times CF \times \sqrt{\frac{6 \times tau \times tevent}{\pi}}$$

$$\text{If } tevent > t^*, \text{ then: } DAevent = FA \times Kp \times Cw \times CF \times \left[\frac{tevent}{1+B} + 2 \times tau \times \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH GROUNDWATER ADULT RESIDENT		
BASED ON: U.S. EPA, DECEMBER 1989, JULY 2004		
BY: R. JUPIN	CHECKED BY:	DATE: 06/08/2005

Where:

Kp	=	permeability coefficient from water (cm/hr)
Cgw	=	concentration of chemical in groundwater (mg/L)
tevent	=	duration of event (hr/event)
CF	=	conversion factor (0.001 L/cm^3)
t*	=	time it takes to reach steady-state (hr/event)
τ	=	lag time (hr/event)
B	=	Bunge Model Constant (dimensionless)

EXAMPLE CALCULATION OF DAevent

ASSUMPTIONS:

Cgw	=	0.0224	mg/L	Chemical: Trichloroethene
Kp	=	1.16E-02	cm/hr	
FA	=	1	unitless	
tevent	=	0.25	hr/event	
CF	=	0.001	L/cm^3	
t*	=	1.39	hr/event	
τ	=	0.58	hr/event	
B	=	0.051		

tevent < t*, therefore,

$$DAevent = (2 \times 0.0116\ cm/hr)\ (1)\ (0.0224\ mg/L)\ (0.001\ L/cm3) \times \sqrt{\frac{6 \times 0.581\ hr/event \times 0.25\ hr/event}{\pi}}$$

DAevent = 2.74E-07 mg/cm^2-event

RISK CALCULATIONS

ASSUMPTIONS:

A	=	18000	cm^2/day
EV	=	1	event/day
ED	=	24	years
EF	=	350	days/year
BW	=	70	kg
ATc	=	25550	days
ATnc	=	8760	days
CSFd	=	1.3E-02	(mg/kg/day)$^{-1}$
RfDd	=	5.0E-01	(mg/kg/day)

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH GROUNDWATER ADULT RESIDENT		
BASED ON: U.S. EPA, DECEMBER 1989, JULY 2004		
BY: R. JUPIN	CHECKED BY:	DATE: 06/08/2005

EXAMPLE CARCINOGENIC CALCULATION

$$DADc = \frac{2.74E\text{-}07 \text{ mg/cm2-event} \times 1 \text{ event/day} \times 24 \text{ years} \times 350 \text{ days/year} \times 18000 \text{ cm2/day}}{70 \text{ kg} \times 25550 \text{ days}}$$

DADc = 2.31E-05 mg/kg/day

DADc = 2.31E-05 mg/kg/day x 1.30E-02 (mg/kg/day)-1 = Incremental Lifetime Cancer Risk

ILCR = 3.0E-07

EXAMPLE NONCARCINOGENIC CALCULATION

$$DADnc = \frac{2.74E\text{-}07 \text{ mg/cm2-event} \times 1 \text{ event/day} \times 24 \text{ years} \times 350 \text{ days/year} \times 18000 \text{ cm2/day}}{70 \text{ kg} \times 8760 \text{ days}}$$

DADnc = 6.75E-05 mg/kg/day

HQ = 6.75E-05 mg/kg/day / 5.00E-01 (mg/kg/day) = Hazard Quotient

HQ = 0.00013

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF VOLATILES WHILE SHOWERING BY AN ADULT RESIDENT		
BASED ON: U.S. EPA, 1989 AND FOSTER AND CHROSTOWSKI, 1987		
BY: R. JUPIN	CHECKED BY:	DATE: 06/08/2005

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from inhalation of volatiles while showering by an adult resident.

EQUATIONS:

$$\text{Intake} = \frac{S \times IRsh \times K \times EF \times ED}{BW \times AT \times Ra \times CF}$$

Where:

$$K = Ds + \frac{\exp(-Ra \times Dt) - \exp[Ra \times (Ds - Dt)]}{Ra}$$

$S = Cwd \times FR/SV$ $\quad$ $Cwd = Cw \times [1-\exp(-Kal \times ts/60d)]$

$Kal = Kl \times [(T1 \times Us)/(Ts \times U1)^{-0.5}$ $\quad$ $Kl = 1/[1/k1 + RT/(H \times kg)]$

$k1 = 20\ cm/hr \times (44/MW)^{0.5}$ $\quad$ $kg = 3000\ cm/hr \times (18/MW)^{0.5}$

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFi (mg/kg/day)-1
HQ (Noncarcinogens) = Intake (mg/kg/day) / RFDi (mg/kg/day)

Where:

Intake	=	estimated exposure intake (mg/kg/day)
S	=	volatile chemical generation rate (mg/m3-min - shower)
IRsh	=	inhalation rate (m3/hr)
EF	=	exposure frequency (showers/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
Ra	=	air exchange rate (1/min)
Ds	=	shower duration (min)
Dt	=	total time in bathroom (min)
FR	=	shower water flow rate (L/min)
SV	=	shower room air volume (m3)
ts	=	shower droplet drop time (sec)
d	=	shower droplet diameter (mm)
MW	=	molecular weight of compound (g/mole)
H	=	Henry's Law constant (atm-m3/mole)
T1	=	calibration water temperature (K)
Ts	=	shower water temperature (K)
U1	=	water viscosity at T1 (cp)
Us	=	water viscosity at Ts (cp)
CSFi	=	inhalation carcinogenic slope factor ($(mg/kg/day)^{-1}$)
RfDi	=	inhalation noncarcinogenic reference dose (mg/kg/day)

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF VOLATILES WHILE SHOWERING BY AN ADULT RESIDENT		
BASED ON: U.S. EPA, 1989 AND FOSTER AND CHROSTOWSKI, 1987		
BY: R. JUPIN	CHECKED BY: T. Jackson	DATE: 06/08/2005

ASSUMPTIONS: Chemical: Trichloroethene

IRsh	=	0.6	m3/hr
EF	=	350	showers/year
ED	=	24	years
BW	=	70	kg
ATc	=	25550	days
Atn	=	8760	days
Ra	=	0.0167	1/min
CF	=	60	min/hr
Ds	=	15	min
Dt	=	20	min
FR	=	10	L/min
SV	=	12	m3
Cw	=	0.0224	mg/L
ts	=	2	sec
d	=	1	mm
MW	=	131.4	g/mole
H	=	1.03E-02	atm-m3/mole
RT	=	2.40E-02	atm-m3/mole
T1	=	293	K
Ts	=	320	K
U1	=	0.982	centipoise
Us	=	0.616	centipoise
CSFi	=	7.00E-03	(mg/kg/day)-1
RfDi	=	1.70E-01	(mg/kg/day)

EXAMPLE CALCULATION:

k1 = 20 cm/hr x (44 g/mole / 131.4 g/mole)^0.5

k1 = **11.57 cm/hr**

kg = 3000 cm/hr x (18 g/mole / 131.4 g/mole)^0.5

kg = **1110.35 cm/hr**

Kl = 1/[1/11.6 cm/hr + 2.40E-02 atm-m3/mole/(1.03E-02 atm-m3/mole x 1110.3 cm/hr)]

Kl = **1.13E+01 cm/hr**

CLIENT: WILLOW GROVE, PENNSYLVANIA		JOB NUMBER: 2192
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF VOLATILES WHILE SHOWERING BY AN ADULT RESIDENT		
BASED ON: U.S. EPA, 1989 AND FOSTER AND CHROSTOWSKI, 1987		
BY: R. JUPIN	CHECKED BY: T. Jackson	DATE: 06/08/2005

Kal = 1.13E+01 cm/hr x [(293 K x 0.616 centipoise)/(320 K x 0.982 centipoise)]^0.5

Kal = **14.9 cm/hr**

Cwd = 0.0224 mg/L x [1 - exp((-14.9 cm/hr x 2 sec)/(60 x 1 mm))]

Cwd = **8.77E-03 mg/L**

S = 8.77E-03 mg/L x 10 L/min / 12 m3

S = **7.31E-03 mg/m3-min-shower**

$$K = 15\text{ min} + \frac{\exp(-0.0167\text{ 1/min} \times 20\text{ min}) - \exp[0.0167\text{ 1/min} \times (15\text{ min} - 20\text{ min})]}{0.0167\text{ 1/min}}$$

K = **2.79 min**

CARCINOGENIC INTAKE:

$$\text{Intake} = \frac{7.31\text{E-03 mg/m3-min-shower} \times 0.6\text{ m3/hr} \times 2.79\text{ min} \times 350\text{ showers/year} \times 24\text{ years}}{70\text{ kg} \times 25550\text{ days} \times 0.0167\text{ 1/min} \times 60\text{ min/hr}}$$

intake = **5.74E-05 mg/kg-day**

Risk = 0.007 (mg/kg/day)-1 x 5.74E-05 mg/kg-day

Risk = **4.0E-07**

NONCARCINOGENIC INTAKE:

$$\text{Intake} = \frac{7.31\text{E-03 mg/m3-min-shower} \times 0.6\text{ m3/hr} \times 2.79\text{ min} \times 350\text{ showers/year} \times 24\text{ years}}{70\text{ kg} \times 8760\text{ days} \times 0.0167\text{ 1/min} \times 60\text{ min/hr}}$$

intake = **1.68E-04 mg/kg-day**

HQ = 1.68E-04 mg/kg-day / 1.70E-01 (mg/kg/day)

HQ = **0.0010**

ATTACHMENT C

IEUBK LEAD MODEL RESULTS

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 261 (Page 1 of 3)
Location: NASJRB Willow Grove, Pennsylvania
Site Name: Site 1
Date: 6/10/2005
Run Mode: Site Risk Assessment

Soil/Dust Data
Average concentration of lead in surface soil = 21.3 mg/kg.
Water Data
Average concentration of lead in groundwater = 2.57 ug/L.

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The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 2.570 ug Pb/L

Model Version: 1.0 Build 261
Location: NASJRB Willow Grove, Pennsylvania
Site Name: Site 1
Date: 6/10/2005
Run Mode: Site Risk Assessment

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 24.910 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	21.300	24.910
1-2	21.300	24.910
2-3	21.300	24.910
3-4	21.300	24.910
4-5	21.300	24.910
5-6	21.300	24.910
6-7	21.300	24.910

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

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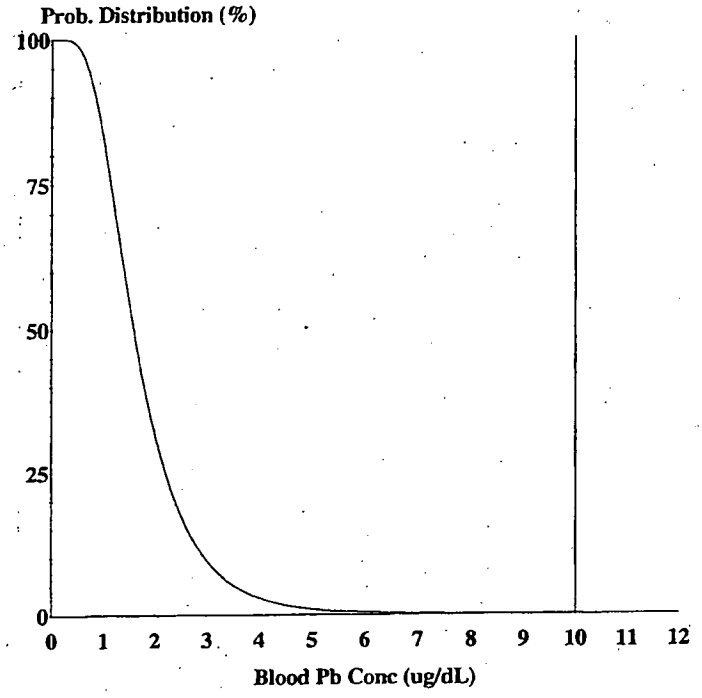
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.658	0.000	0.247
1-2	0.034	2.783	0.000	0.619
2-3	0.062	3.134	0.000	0.645
3-4	0.067	3.030	0.000	0.662
4-5	0.067	2.935	0.000	0.690
5-6	0.093	3.103	0.000	0.729
6-7	0.093	3.427	0.000	0.742

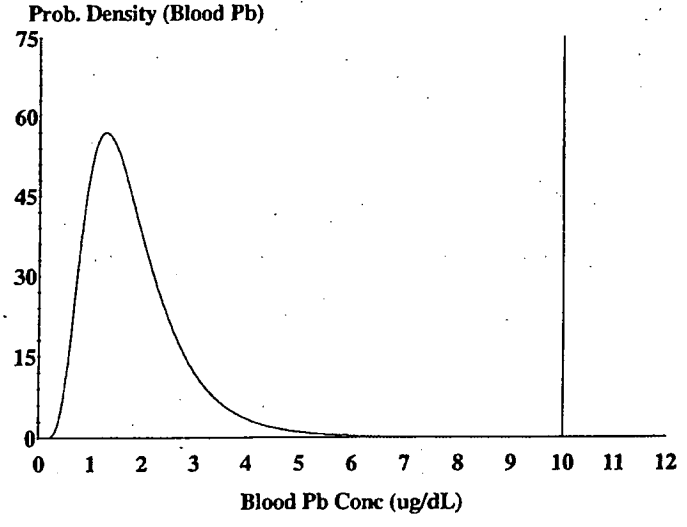
Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	0.571	3.497	1.9
1-2	0.908	4.345	1.9
2-3	0.911	4.753	1.8
3-4	0.916	4.675	1.7
4-5	0.682	4.375	1.5
5-6	0.615	4.541	1.4
6-7	0.581	4.844	1.4

Model Version: 1.0 Build 261
Location: NASJRB Willow Grove, Pennsylvania
Site Name: Site 1
Date: 6/10/2005
Run Mode: Site Risk Assessment



Cutoff = 10.000 ug/dl
Geo Mean = 1.660
GSD = 1.600
% Above = 0.007

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Site Risk Assessment
Comment = Site 1



Cutoff = 10.000 ug/dl
Geo Mean = 1.660
GSD = 1.600
% Above = 0.007
% Below = 99.993

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Site Risk Assessment
Comment = Site 1