Appendix B

Development of Action Levels for the HWMA/RCRA Closure of Tanks WM-184, WM-185, and WM-186

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The Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm Facility (TFF) Tanks WM-184, WM-185, and WM-186 are to be closed under HWMA/RCRA (State of Idaho 1983; 42 U.S. Code [USC] 6901, 1976) by removal of the waste currently contained in the tanks and decontamination of the internal tank surfaces. Compliance with the performance standard for closure of tank systems (40 CFR 265.111 and 265.197) is to be demonstrated for the tanks by sampling the final rinsate solutions from the decontamination efforts and comparing the resulting analytical data with action levels developed in this appendix. The action levels for the HWMA/RCRA closure of Tanks WM-184, WM-185, and WM-186 have been developed to ensure that the tanks, subsequent to completion of closure activities, will be left in a state that is protective of human health and the environment. This appendix was prepared to present the methodology used to develop action levels specific to the HWMA/RCRA closure of Tanks WM-184, WM-185, and WM-186. Action levels were developed by defining the acceptable excess cancer risk and hazard quotient thresholds and calculating corresponding action levels based upon these risk and hazard thresholds. Finally, the excess cancer risk and hazard for all pathways and contaminants at the developed action levels are presented. The technique for calculation of action levels described in this appendix will be applied to any additional COCs identified during the course of closure activities for Tanks WM-184, WM-185, and WM-186.

This analysis considers two pathways: soil inhalation and soil ingestion to an occupational receptor. Performing the analysis considering these pathways is very conservative. Environmental Protection Agency (EPA) guidance (EPA 1989) states that the soil inhalation and soil ingestion pathways are appropriate for soil contamination not greater than 10 feet in depth. While the potential soil contamination resulting from liquid contacting the internal tank surfaces will be greater than 40 feet in depth, these pathways were retained to ensure the protectiveness of the action level development methodology. In developing the conceptual site model for this risk assessment, the following assumptions were made:

1. Liquid infiltration contacts the internal tank surfaces

2. Contacting liquid then exits the tank system with all COCs present at action level concentrations

3. Each liter of contaminated liquid contaminates 1 kg of soil (thus each part per million of contaminant in the liquid is equivalent to one part per million of contaminant in the soil).

Assumption No. 1 is conservative due to the planned grouting of the tank system. Once the tanks have been grouted, it is highly unlikely that water infiltration will contact the internal tank surfaces. Assumption No. 2 is conservative because it assumes immediate release of liquid contacting the internal tank surfaces from the tank to the soil (should such liquid/tank surface contact be possible, which is unlikely due to grouting). In reality, liquid contacting the internal tank surfaces will remain contained within the stainless steel tanks and concrete vaults. Assumption No. 3 is conservative for three reasons. First, assuming an average bulk soil density of 1.3 kg/L, and an average soil porosity of 0.45, the void volume in a typical kilogram of soil is approximately 350 mL. Thus, although the assumption has been made that each liter of contaminated liquid contaminates 1 kg of soil, in reality, it is only physically possible for 350 mL of the contaminated liquid to contaminate each kilogram of soil. Second, it is assumed that the liquid and soil are in contact for sufficient time to allow mass transfer equilibrium to be reached between the soil column and the liquid, whereas in reality, the water will be flowing through the

soil column and equilibrium will not be reached. Finally, it is assumed that 100% of the contaminant is transferred to the soil without regard for partitioning of the contaminant between the soil column and the water. In reality, a fraction of each of the contaminants will remain contained within the contaminated liquid.

Step 1: Define the Total Allowable Excess Cancer Risk and Hazard Quotient to the Future Occupational Receptor

As stated in the assumptions above, the liquid that may come into contact with the closed tank system and subsequently contaminate surrounding soil is assumed to exit the tank system and enter the surrounding soil at the action level concentration. The surrounding soil is then assumed to be contaminated at equivalent parts per million concentrations. Consequently, risk-based media cleanup standards are appropriate to establish the allowable excess cancer risk and hazard quotient. Protective media cleanup standards for human health means constituent concentrations that result in the total residual risk from a medium to an individual exposed over a lifetime falling within a range from 10^{-4} to 10^{-6}, with a cumulative carcinogenic risk range. For noncarcinogenic effects, EPA generally interprets protective cleanup standards to mean constituent concentration that an individual could be exposed to on a daily basis without appreciable risk of deleterious effect during a lifetime; the hazard index generally should not exceed 1 (55 FR 46, 1990; 55 FR 145, 1990); 61 FR 85, 1996). To ensure protectiveness of human health, the most conservative threshold for excess cancer risk, 1.0E–06, will be used for Tanks WM-184, WM-185, and WM-186. Therefore

- Total allowable risk threshold = 1.0E–06
- Total allowable hazard quotient threshold = 1.0.

Step 2: Define Receptors and Pathways

The pathways considered for developing action levels include

- Occupational receptor ingestion of contaminated soil
- Occupational receptor inhalation of contaminated soil.

Step 3: Define Contaminants of Concern and Toxicity Parameters

The contaminant of concern (COC) list was developed by defining all HWMA/RCRA-regulated constituents that meet either of the following criteria:

1. The HWMA/RCRA-regulated constituent was detected during sampling and analysis of the waste currently contained within the tanks ***and*** the constituent is listed in the United States EPA Region 9 Preliminary Remediation Goal (PRG) Table (EPA 2003)[a]

2. The HWMA/RCRA-regulated constituent was determined to be part of the INTEC liquid waste stream as described in *A Regulatory Analysis and Reassessment of U.S. Environmental Protection*

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a. One constituent, 2-hexanone, while not listed in the EPA Region 9 PRG Table, was listed in the EPA Region III Risk-based Concentration Table (EPA 2002). This constituent was retained in the COC list, and toxicity information from the Region III document was used to determine constituent-specific action levels for 2-hexanone.

Agency Listed Hazardous Waste Number for Applicability to the INTEC Liquid Waste System (Gilbert and Venneman 1999).

Applying the two criteria defined above allows definition of the complete COC list for HWMA/RCRA closure of Tanks WM-184, WM-185, and WM-186. The complete list of COCs is provided in Table B-1. As stated in criterion No. 1, above, detected constituents that are not listed in the EPA Region 9 PRG Table were excluded from the COC list. Constituents excluded for this reason were calcium, chloride, magnesium, nitrate, phosphate, and sulfate.

Reference doses and slope factors for each of the contaminants of concern are provided in Table B-1. This information was obtained from the United States EPA Region 9 PRG Table (EPA 2003). Toxicity information for 2-hexanone was obtained from the EPA Region III Risk-based Concentration Table (EPA 2002). The EPA Region 9 PRG Table does not include inhalation reference doses for antimony, arsenic, cadmium, and chromium. As requested by the Idaho Department of Environmental Quality (DEQ), the ingestion reference doses for these four metals were used as both ingestion and inhalation reference doses. Toxicity information is available for all COCs listed in Table B-1 with the exception of lead. While there is no specific toxicity information currently available for lead, separate EPA guidance was used to develop the action level for lead (see Step 8).

The COC list for this closure includes Phenol, which was detected during confirmation sampling of Tank WM-182. Phenol was added to the action level list and included in the calculation of action levels.

Table B-1. COCs and toxicity parameters as provided in the EPA Region 9 PRG Table (EPA 2003).

COC	Oral Slope Factor 1/(mg/kg-d)	Oral Reference Dose (mg/kg-d)	Inhalation Slope Factor 1/(mg/kg-d)	Inhalation Reference Dose (mg/kg-d)
1,1,1-trichloroethane	—	0.02	—	0.29
2,4-dinitrophenol	—	0.002	—	0.002
2-hexanone[a]	—	0.04	—	0.0014
Acetone	—	0.1	—	0.1
Aluminum	—	1	—	0.0014
Antimony	—	0.0004	—	0.0004[b]
Aroclor-1260	2	—	2	—
Arsenic	1.5	0.0003	15	0.0003[b]
Barium	—	0.07	—	0.00014
Benzene	0.055	0.003	0.027	0.0017
Beryllium	—	0.002	8.4	0.0000057
Bromomethane	—	0.0014	—	0.0014
Cadmium	—	0.0005	6.3	0.0005[b]
Carbon disulfide	—	0.1	—	0.2
Carbon tetrachloride	0.13	0.0007	0.053	0.0007
Chloroethane	0.0029	0.4	0.0029	2.9
Chloromethane	0.013	—	0.0063	0.086
Chromium	—	0.003	290	0.003[b]
Cobalt	—	0.06	—	—
Copper	—	0.037	—	—
Cyclohexane	—	5.7	—	5.7
Cyclohexanone	—	5	—	5
Ethyl acetate	—	0.9	—	0.9
Ethyl benzene	—	0.1	—	0.29
Fluoride	—	0.06	—	—
Iron	—	0.3	—	—
Lead	—	—	—	—
Manganese	—	0.024	—	0.000014
Mercury	—	0.0003	—	0.000086
Methanol	—	0.5	—	0.5
Methyl ethyl ketone	—	0.6	—	0.29
Methyl isobutyl ketone	—	0.08	—	0.023
Methylene chloride	0.0075	0.06	0.0016	0.86
Nickel	—	0.02	—	—
N-nitrosodimethylamine	51	—	49	—
Phenol	—	0.6	—	0.6
Pyridine	—	0.001	—	0.001
Selenium	—	0.005	—	—
Silver	—	0.005	—	—
Tetrachloroethylene	0.052	0.01	0.002	0.11
Thallium	—	0.000066	—	—
Toluene	—	0.2	—	0.11
Trichloroethylene	0.011	0.006	0.006	0.006
Vanadium	—	0.007	—	—
Xylene	—	2	—	0.2
Zinc	—	0.3	—	—

a. The toxicity information was obtained from the EPA Region III Risk-based Concentration Table (EPA 2002).

b. The ingestion reference dose is used as the inhalation reference dose although no inhalation reference dose is provided in the EPA Region 9 PRG Table (EPA 2003).

Step 4: Define Percentage of Risk and Hazard to be Applied to Ingestion and Inhalation Scenario

The total allowable excess cancer risk and hazard quotient must be split into the fraction that is allowable for the ingestion pathway and the fraction that is allowable for the inhalation pathway. Experience indicates that the ingestion pathway will drive the risk and hazard for the occupational receptor. Consequently, the majority (99.5%) of the allowable risk and hazard defined in Step 1 above was assigned to the ingestion pathway as shown in Table B-2.

Table B-2. Pathway-specific allowable risk and hazard.

	Total	Ingestion (%)	Inhalation (%)	Ingestion Fraction	Inhalation Fraction
Risk	1.00E!06	99.5	0.5	9.95E!07	5.00E!09
Hazard quotient	1.00E+00	99.5	0.5	9.95E!01	5.00E!03

Step 5: Calculate the COC-Specific Allowable Risk and Hazard Quotient for Each Pathway

Back calculation of action levels for COCs requires determination of allowable risk for each COC.[b] The sum of all allowable risks must be less than 1.0E–06. To determine the allowable risk for each COC, the total allowable risk must be apportioned among the COCs. There are several techniques for apportioning allowable risk among COCs.

The simplest technique for apportioning allowable risk is to distribute allowable risk equally among the COCs. Using this technique, the allowable risk is divided by the total number of carcinogenic COCs and the result is used as the allowable risk for each COC. The problem with this approach is that it makes no differentiation among COCs with respect to carcinogenic threat to human health. In the case of the action level determination for the HWMA/RCRA closure of Tanks WM-184, WM-185, and WM-186, the same allowable risk is assigned to a COC that is extremely carcinogenic (N-nitrosodimethylamine [slope factor 51 $(mg/kg\text{-}d)^{-1}$]) and a contaminant that is minimally carcinogenic (chloroethane [slope factor 0.0029 $(mg/kg\text{-}d)^{-1}$]). Using this approach results in action levels that are extremely low (below detection levels in many instances) for the highly carcinogenic compounds and action levels that are excessively high for minimally carcinogenic compounds. This approach results in decontamination efforts being driven by the need to meet a single action level for the most carcinogenic component. The actual COC concentrations for the less carcinogenic components will be reduced far below action levels, resulting in a total residual risk far below the threshold of 1.0E!06. While extremely conservative, this approach results in action levels that may prove impossible to achieve during closure (particularly those below detection limits).

A second approach uses slope factor normalization to apportion allowable risk among the COCs. The slope factors for all carcinogenic COCs are summed, and the percent slope factor contribution to the total is used to determine the percent of the allowable risk that is apportioned to each COC. In this way, the majority of the allowable risk is assigned to the COCs that are the most highly carcinogenic. This

b. While this discussion of apportioning risk among COCs is written with respect to determination of action levels using carcinogenic contaminants and risk-based back-calculation, it applies equally to determination of action levels using non-carcinogenic contaminants and hazard-based back-calculation.

technique is superior to the equal distribution technique described above because it results in action levels for highly-carcinogenic contaminants that are above detection limits and realistically achievable, while still maintaining the overall allowable risk below the regulatory threshold. The problem with this approach for the purposes of determining action levels for the closure of Tanks WM-184, WM-185, and WM-186 is the presence of the extremely carcinogenic N-nitrosodimethylamine. This contaminant is extremely carcinogenic with respect to the other COCs present in the tank system. Using the normalization approach, consequently, results in the majority of the allowable risk being assigned to this contaminant. This results in greatly reduced action levels for moderately carcinogenic contaminants such as heavy metals. This approach results in decontamination efforts being driven by the need to meet action levels for the metals. Due to the chemistry associated with the contents of the tanks, and the relative ease of decontaminating organic contaminants versus metals, decontamination to meet the action levels for metals will result in actual concentrations of organic constituents that will be far below the action levels for these constituents. This would result in a total residual risk far below the threshold of 1.0E!06. This approach results in action levels for various metals that may prove impossible to achieve during closure.

While both approaches described above result in action levels that are compliant with the need to reduce risk below 1.0E!06, the first approach results in an impracticable action level for the highly carcinogenic N-nitrosodimethylamine. The second approach results in impracticable action levels for a variety of heavy metals. A compromise approach balancing the action levels for the amine and the metals to achievable, yet protective, levels was developed. This third approach uses logarithmic slope factor normalization to apportion allowable risk among the COCs. A normalizing power of 0.5 was selected via trial and error that resulted in achievable, yet compliant action levels for all COCs. Each of the slope factors was raised to the power of 0.5. These slope factors were then summed, and the percent contribution to this sum of each slope factor was determined. This percent contribution was then used to assign allowable risk to all carcinogenic COCs.

The three approaches above are alternate methods for assigning allowable risk to each COC. The sum of the allowable risk for each approach is the same, at 1.0E!06. Selection of the third technique provides action levels that are technically practicable. The true risk resulting from each COC is calculated in Step 7 of this methodology. This true risk is calculated at 9.2E!07, demonstrating that the selected action levels are compliant with the regulatory threshold of 1.0E!06. The calculation of true residual risk is independent of the apportioning of allowable risk performed in this step.

As discussed above, allowable risk and hazard quotients for each COC for each pathway were normalized logarithmically against their expected percent contribution to the overall risk and hazard for each pathway. For carcinogenic risk, the square root of the slope factor for each COC was determined. The normalized slope factor percentage was determined by dividing the square root of the slope factor for each COC by the sum of the square root of the slope factors for all COCs for a given pathway. This percent contribution was then multiplied by the total pathway-specific allowable risk to calculate the COC- and pathway-specific allowable risk. To increase the conservativeness of the design, correction factors (discussed below) were applied to COCs, as necessary, to reduce the total allowable risk for each COC. The resulting COC pathway-specific allowable risks for ingestion and inhalation are listed in Table B-3.

For non-carcinogenic hazard, the square root of the inverse of the reference dose for each COC was determined. The normalized inverse reference dose percentage was determined by dividing the square root of the inverse reference dose for each COC by the sum of the square root of the inverse reference doses for all COCs for a given pathway. This percent contribution was then multiplied by the total pathway-specific allowable hazard to calculate the COC- and pathway-specific allowable hazard. To increase the conservativeness of the design, correction factors (discussed below) were applied to COCs,

as necessary, to reduce the total allowable hazard for each COC. The resulting COC pathway-specific allowable hazard for ingestion and inhalation are listed in Table B-3.

Table B-3. COC-specific allowable risk and hazard for the soil ingestion and inhalation pathways.

COC	Effective Allowable Ingestion Risk	Effective Allowable Inhalation Risk	Effective Allowable Ingestion Hazard	Effective Allowable Inhalation Hazard
1,1,1-Trichloroethane	—	—	1.08E!02	7.18E!06
2,4-Dinitrophenol	—	—	3.43E!02	8.65E!05
2-Hexanone	—	—	7.67E!03	1.03E!04
Acetone	—	—	4.85E!03	1.22E!05
Aluminum	—	—	1.53E!03	1.03E!04
Antimony	—	—	7.67E!02	1.93E!04
Aroclor-1260	1.28E!07	2.00E!10	1.08E!03	2.74E!06
Arsenic	1.11E!07	5.47E!10	8.85E!02	2.23E!04
Barium	—	—	5.80E!04	3.27E!05
Benzene	3.55E!09	3.87E!12	4.67E!03	1.56E!05
Berylium	—	4.09E!10	3.43E!02	1.62E!03
Bromomethane	—	—	4.10E!02	1.03E!04
Cadmium	—	3.54E!11	6.86E!03	1.73E!05
Carbon disulfide	—	—	4.85E!03	8.65E!06
Carbon tetrachloride	6.54E!09	6.50E!12	1.16E!02	2.92E!05
Chloroethane	4.89E!09	7.60E!12	2.43E!03	2.27E!06
Chloromethane	1.03E!08	1.12E!11	0.00E+00	1.32E!05
Chromium	—	2.40E!09	2.80E!02	7.06E!05
Cobalt	—	—	6.26E!03	0.00E+00
Copper	—	—	7.97E!03	0.00E+00
Cyclohexane	—	—	6.42E!04	1.62E!06
Cyclohexanone	—	—	6.86E!04	1.73E!06
Ethyl Acetate	—	—	1.62E!03	4.08E!06
Ethyl Benzene	—	—	4.85E!03	7.18E!06
Flouride	—	—	6.26E!03	0.00E+00
Iron	—	—	2.80E!03	0.00E+00
Lead	—	—	0.00E+00	0.00E+00
Manganese	—	—	9.90E!03	1.03E!03
Mercury	—	—	2.53E!04	1.19E!06
Methanol	—	—	2.17E!03	5.47E!06
Methyl ethyl ketone	—	—	1.32E!04	4.79E!07
Methyl isobutyl ketone	—	—	5.42E!03	2.55E!05
Methylene chloride	7.86E!09	5.65E!12	6.26E!03	4.17E!06
Nickel	—	—	1.08E!02	0.00E+00
N-Nitrosodimethylamine	6.48E!07	9.88E!10	0.00E+00	0.00E+00
Phenol	—	—	1.98E!03	4.99E!06
Pyridine	—	—	2.11E!03	5.32E!06
Selenium	—	—	8.68E!05	0.00E+00
Silver	—	—	2.89E!04	0.00E+00
Tetrachloroethylene	4.14E!09	1.26E!12	3.07E!03	2.33E!06
Thallium	—	—	1.89E!01	0.00E+00
Toluene	—	—	3.43E!03	1.17E!05
Trichloroethylene	7.93E!10	9.11E!13	1.65E!03	4.16E!06
Vanadium	—	—	1.83E!02	0.00E+00
Zinc	—	—	2.80E!03	0.00E+00
Total	9.26E!07	4.62E!09	6.48E!01	3.76E!03

Correction factors were used in the risk calculations to lower the action levels of contaminants to meet regulatory thresholds. Risk calculations alone would produce concentrations greater than the maximum concentration of contaminants for the toxicity characteristic. Correction factors, therefore, were used to augment the risk number to ensure hazardous waste is not left in place. Removing hazardous waste is the first criteria for achieving clean closure for the tank system.

In an effort to develop action levels at appropriate concentrations and meet project goals for protection of the public and the environment, correction factors were developed on a case-by-case basis and may vary for different tank systems. Systems that are fairly accessible and with contamination that can be removed to low concentrations will have different correction factors than those used for tanks systems that are not easily accessible and where effective decontamination may be more difficult to achieve. Two important points should be recognized:

- Correction factors are not intended to be the same for all closure actions. Therefore, the Department of Energy can develop action levels as conservative as possible on a project basis.

- Action levels will always be protective of human health and the environment based on the calculated risks and hazard index.

The use of correction factors is performed to lower action levels to concentrations below regulatory thresholds while accounting for project-specific challenges to clean closure. The correction factors are not used to adjust for the uncertainty of any closure project. The difference between the use of correction factors and accounting for uncertainty is clearly established by the following explanation.

Using conservative assumptions when calculating the risk and hazard quotient negates uncertainties associated with meeting the performance standard for clean closure. Examples of the conservative assumptions used in action level calculation are listed below:

- Risk and hazard indices are based on the total number of constituents that may be detected in the unit. Actually, some of these constituents (particularly organic compounds) will not be present after waste removal and decontamination. For example N-nitrosodimethylamine is a significant contributor to risk. However, it is likely that this compound will not be detected during final sampling. The total risk will then be reduced by the amount contributed by N-nitrosodimethylamine. The calculated risk for N-nitrosodimethylamine from soil ingestion and inhalation is 6.48E!07. This is the greatest potential risk contributor in Tanks WM-184, WM-185, and WM-186.

- The probability of detecting N-nitrosodimethylamine after decontamination is based on the decontamination factor that is necessary to reduce the maximum detected concentration to one that is below the detection limit. This decontamination factor is approximately 15. While the decontamination factor for reducing the concentration of mercury to below the action level is more than 100. The relationship between the two decontamination factors indicates N-nitrosodimethylamine will likely be completely removed.

Step 6: Calculate the COC- and Pathway-Specific Action Levels from Allowable Risk and Hazard Calculated in Step 5

The equations used to relate risk, intake factor, and slope factor or reference dose to excess cancer risk or hazard quotient are given in Step 7. These equations were obtained from EPA guidance (EPA 1989). The risk-based COC-specific action levels were calculated from COC-specific allowable risk by

dividing the COC-specific allowable risk (Table B-3) by the intake factor coefficient (see Step 7) and the COC-specific slope factor (Table B-1). The hazard-based COC-specific action levels were calculated from COC-specific allowable hazard quotients by dividing the COC-specific allowable hazard quotient (Table B-3) by the intake factor coefficient (see Step 7) and multiplying by the reference dose (Table B-1). The COC-specific action levels for the ingestion and inhalation pathways resulting from COC-specific allowable risk and COC-specific allowable hazard are listed in Table B-4. To be conservative, the minimum pathway-specific action level was used as the overall action level. The final effective action levels are provided in the right-hand column of Table B-4.

Table B-4. Pathway-specific and effective action levels for each COC.

COC	Action Level (mg/Kg) Ingestion Risk	Action Level (mg/Kg) Inhalation Risk	Action Level (mg/Kg) Ingestion Hazard	Action Level (mg/Kg) Inhalation Hazard	Effective Action Level (mg/Kg)
1,1,1-Trichloroethane	—	—	4.4E+02	8.1E+04	4.4E+02
2,4-Dinitrophenol	—	—	1.4E+02	6.7E+03	1.4E+02
2-Hexanone	—	—	6.3E+02	5.6E+03	6.3E+02
Acetone	—	—	9.9E+02	4.8E+04	9.9E+02
Aluminum	—	—	3.1E+03	5.6E+03	3.1E+03
Antimony	—	—	6.3E+01	3.0E+03	6.3E+01
Aroclor-1260	3.7E!01	1.1E+01	1.3E+03	6.4E+04	3.7E!01
Arsenic	4.2E!01	4.0E+00	5.4E+01	2.6E+03	4.2E!01
Barium	—	—	8.3E+01	1.8E+02	8.3E+01
Benzene	3.7E!01	1.6E+01	2.9E+01	1.0E+03	3.7E!01
Berylium	—	5.3E+00	1.4E+02	3.6E+02	5.3E+00
Bromomethane	—	—	1.2E+02	5.6E+03	1.2E+02
Cadmium	—	6.1E!01	7.0E+00	3.4E+02	6.1E!01
Carbon disulfide	—	—	9.9E+02	6.7E+04	9.9E+02
Carbon tetrachloride	2.9E!01	1.3E+01	1.7E+01	8.0E+02	2.9E-01
Chloroethane	9.6E+00	2.8E+02	2.0E+03	2.6E+05	9.6E+00
Chloromethane	4.5E+00	1.9E+02	—	4.4E+04	4.5E+00
Chromium	—	9.0E!01	1.7E+02	8.2E+03	9.0E!01
Cobalt	—	—	7.7E+02	—	7.7E+02
Copper	—	—	6.0E+02	—	6.0E+02
Cyclohexane	—	—	7.5E+03	3.6E+05	7.5E+03
Cyclohexanone	—	—	7.0E+03	3.4E+05	7.0E+03
Ethyl Acetate	—	—	3.0E+03	1.4E+05	3.0E+03
Ethyl Benzene	—	—	9.9E+02	8.1E+04	9.9E+02
Flouride	—	—	7.7E+02	—	7.7E+02
Iron	—	—	1.7E+03	—	1.7E+03
Lead	—	—	—	—	0.0E+00
Manganese	—	—	4.9E+02	5.6E+02	4.9E+02
Mercury	—	—	1.6E-01	4.0E+00	1.6E!01
Methanol	—	—	2.2E+03	1.1E+05	2.2E+03
Methyl ethyl ketone	—	—	1.6E+02	5.4E+03	1.6E+02
Methyl isobutyl ketone	—	—	8.9E+02	2.3E+04	8.9E+02
Methylene chloride	6.0E+00	3.8E+02	7.7E+02	1.4E+05	6.0E+00
Nickel	—	—	4.4E+02	—	4.4E+02
N-Nitrosodimethylamine	7.3E!02	2.2E+00	—	—	7.3E!02
Phenol	—	—	2.4E+03	1.2E+05	2.4E+03
Pyridine	—	—	4.3E+00	2.1E+02	4.3E+00
Selenium	—	—	8.9E-01	—	8.9E!01
Silver	—	—	3.0E+00	—	3.0E+00
Tetrachloroethylene	4.5E!01	6.9E+01	6.3E+01	1.0E+04	4.5E!01
Thallium	—	—	2.5E+01	—	2.5E+01
Toluene	—	—	1.4E+03	5.0E+04	1.4E+03
Trichloroethylene	4.1E!01	1.7E+01	2.0E+01	9.7E+02	4.1E!01
Vanadium	—	—	2.6E+02	—	2.6E+02
Zinc	—	—	1.7E+03	—	1.7E+03

a. The action level for lead cannot be determined using a risk-based approach, as there are currently no established toxicity parameters for lead. The action level for lead was developed as described in Step 8.

Step 7: Determine the True Excess Cancer Risk and Hazard Quotient Resulting in the Action Levels Calculated in Step 7

Soil concentrations resulting from the calculated action levels were used as a starting point to assess the risk and hazard to the occupational receptor via the soil ingestion and inhalation pathways. The results of this analysis are provided in Table B-5 below. The table also includes the cumulative risk and hazard posed by both pathways. The calculation spreadsheets are shown on the following pages in Equations (B-1) through (B-9) and Tables B-6 through B-9.

Table B-5. Cumulative excess cancer risk resulting from soil ingestion and soil inhalation pathways to an occupational receptor from contaminated soil at the effective action levels presented in Table B-4.

COC	Risk (Ingestion Pathway)	Risk (Inhalation Pathway)	Total Risk	Hazard Quotient (Ingestion Pathway)	Hazard Quotient (Inhalation Pathway)	Total Hazard Quotient
1,1,1-Trichloroethane	—	—	—	1.08E!02	3.93E!08	1.08E!02
2,4-Dinitrophenol	—	—	—	3.43E!02	1.80E!06	3.43E!02
2-Hexanone	—	—	—	—	—	—
Acetone	—	—	—	4.85E!03	2.55E!07	4.85E!03
Aluminum	—	—	—	1.53E!03	5.76E!05	1.59E!03
Antimony	—	—	—	7.67E!02	4.03E!06	7.67E!02
Aroclor-1260	1.28E!07	6.75E!12	1.28E!07	—	1.77E!09	1.77E!09
Arsenic	1.11E!07	5.84E!11	1.11E!07	6.90E!04	3.63E!08	6.90E!04
Barium	—	—	—	5.80E!04	1.52E!05	5.95E!04
Benzene	3.55E!09	9.16E!14	3.55E!09	6.01E!05	5.57E!09	6.01E!05
Berylium	—	4.09E!10	4.09E!10	1.29E!03	2.39E!05	1.32E!03
Bromomethane	—	—	—	4.10E!02	2.16E!06	4.10E!02
Cadmium	—	3.54E!11	3.54E!11	5.98E!04	3.14E!08	5.98E!04
Carbon disulfide	—	—	—	4.85E!03	1.28E!07	4.85E!03
Carbon tetrachloride	6.54E!09	1.40E!13	6.55E!09	2.01E!04	1.06E!08	2.01E!04
Chloroethane	4.89E!09	2.57E!13	4.89E!09	1.18E!05	8.53E!11	1.18E!05
Chloromethane	1.03E!08	2.64E!13	1.03E!08	—	1.36E!09	1.36E!09
Chromium	—	2.40E!09	2.40E!09	1.47E!04	7.72E!09	1.47E!04
Cobalt	—	—	—	6.26E!03	—	6.26E!03
Copper	—	—	—	7.97E!03	—	7.97E!03
Cyclohexane	—	—	—	6.42E!04	3.38E!08	6.42E!04
Cyclohexanone	—	—	—	6.86E!04	3.61E!08	6.86E!04
Ethyl Acetate	—	—	—	1.62E!03	8.50E!08	1.62E!03
Ethyl Benzene	—	—	—	4.85E!03	8.79E!08	4.85E!03
Flouride	—	—	—	6.26E!03	—	6.26E!03
Iron	—	—	—	2.80E!03	—	2.80E!03
Lead	—	—	—	—	—	—
Manganese	—	—	—	9.90E!03	8.92E!04	1.08E!02
Mercury	—	—	—	2.53E!04	4.64E!08	2.53E!04
Methanol	—	—	—	2.17E!03	1.14E!07	2.17E!03
Methyl ethyl ketone	—	—	—	1.32E!04	1.44E!08	1.32E!04
Methyl isobutyl ketone	—	—	—	5.42E!03	9.92E!07	5.42E!03
Methylene chloride	7.86E!09	8.82E!14	7.86E!09	4.88E!05	1.79E!10	4.88E!05
Nickel	—	—	—	1.08E!02	—	1.08E!02
N-Nitrosodimethylamine	6.48E!07	3.27E!11	6.48E!07	—	—	—
Phenol	—	—	—	1.98E!03	1.04E!07	1.98E!03
Pyridine	—	—	—	2.11E!03	1.11E!07	2.11E!03
Selenium	—	—	—	8.68E!05	—	8.68E!05
Silver	—	—	—	2.89E!04	—	2.89E!04
Tetrachloroethylene	4.14E!09	8.37E!15	4.14E!09	2.22E!05	1.06E!10	2.22E!05
Thallium	—	—	—	1.89E!01	—	1.89E!01
Toluene	—	—	—	3.43E!03	3.28E!07	3.43E!03
Trichloroethylene	7.93E!10	2.28E!14	7.93E!10	3.36E!05	1.77E!09	3.36E!05
Vanadium	—	—	—	1.83E!02	—	1.83E!02
Zinc	—	—	—	2.80E!03	—	2.80E!03
Total	9.26E!07	2.95E!09	9.29E!07	4.55E!01	1.00E!03	4.56E!01

Occupational Soil Ingestion

$$Intake\ Factor = \left(\frac{C \times FI \times EF \times CF}{AT}\right) \times \left(\frac{IR \times ED}{BW}\right) \quad \text{(B-1)}$$

where

C	=	contaminant concentration (mg/kg) (contaminant dependent)
FI	=	fraction ingested from source = 1
EF	=	exposure frequency (day/year) = 250
CF	=	conversion factor (kg/mg) = 1.00E!06
AT	=	averaging time (day) = 2.55E+04
IR	=	ingestion rate (mg/day) = 50
ED	=	exposure duration (year) = 25
BW	=	body weight (kg) = 70

Assumption: Each liter of leachate contaminates 1 kg of soil.

$$Risk = Intake\ Factor \times Slope\ Factor \quad \text{(B-2)}$$

Table B-6. Calculation of excess cancer risk for an occupational soil ingestion scenario using the action levels provided in Table B-4.

Constituent	C (mg/Kg)	Intake Factor/C (1/day)	Intake Factor (mg/Kg-day)	Slope Factor (Kg-day/mg)	Risk	Risk Percentage
1,1,1-Trichloroethane	4.44E+02	1.75E!07	7.77E!05	0.00E+00	—	—
2,4-Dinitrophenol	1.40E+02	1.75E!07	2.46E!05	0.00E+00	—	—
2-Hexanone	6.27E+02	1.75E!07	1.10E!04	0.00E+00	—	—
Acetone	9.92E+02	1.75E!07	1.74E!04	0.00E+00	—	—
Aluminum	3.14E+03	1.75E!07	5.49E!04	0.00E+00	—	—
Antimony	6.27E+01	1.75E!07	1.10E!05	0.00E+00	—	—
Aroclor-1260	3.67E!01	1.75E!07	6.42E!08	2.00E+00	1.28E!07	13.86%
Arsenic	4.23E!01	1.75E!07	7.41E!08	1.50E+00	1.11E!07	12.01%
Barium	8.30E+01	1.75E!07	1.45E!05	0.00E+00	—	—
Benzene	3.68E!01	1.75E!07	6.45E!08	5.50E!02	3.55E!09	0.38%
Berylium	5.29E+00	1.75E!07	9.26E!07	0.00E+00	—	—
Bromomethane	1.17E+02	1.75E!07	2.05E!05	0.00E+00	—	—
Cadmium	6.11E!01	1.75E!07	1.07E!07	0.00E+00	—	—
Carbon disulfide	9.92E+02	1.75E!07	1.74E!04	0.00E+00	—	—
Carbon tetrachloride	2.88E!01	1.75E!07	5.03E!08	1.30E!01	6.54E!09	0.71%
Chloroethane	9.63E+00	1.75E!07	1.69E!06	2.90E!03	4.89E!09	0.53%
Chloromethane	4.55E+00	1.75E!07	7.96E!07	1.30E!02	1.03E!08	1.12%
Chromium	9.01E!01	1.75E!07	1.58E!07	0.00E+00	—	—
Cobalt	7.68E+02	1.75E!07	1.35E!04	0.00E+00	—	—
Copper	6.03E+02	1.75E!07	1.06E!04	0.00E+00	—	—
Cyclohexane	7.49E+03	1.75E!07	1.31E!03	0.00E+00	—	—
Cyclohexanone	7.01E+03	1.75E!07	1.23E!03	0.00E+00	—	—
Ethyl Acetate	2.98E+03	1.75E!07	5.21E!04	0.00E+00	—	—
Ethyl Benzene	9.92E+02	1.75E!07	1.74E!04	0.00E+00	—	—
Flouride	7.68E+02	1.75E!07	1.35E!04	0.00E+00	—	—
Iron	1.72E+03	1.75E!07	3.01E!04	0.00E+00	—	—
Lead	0.00E+00	1.75E!07	0.00E+00	0.00E+00	—	—
Manganese	4.86E+02	1.75E!07	8.51E!05	0.00E+00	—	—
Mercury	1.55E!01	1.75E!07	2.72E!08	0.00E+00	—	—
Methanol	2.22E+03	1.75E!07	3.88E!04	0.00E+00	—	—
Methyl ethyl ketone	1.62E+02	1.75E!07	2.84E!05	0.00E+00	—	—
Methyl isobutyl ketone	8.87E+02	1.75E!07	1.55E!04	0.00E+00	—	—
Methylene chloride	5.99E+00	1.75E!07	1.05E!06	7.50E!03	7.86E!09	0.85%
Nickel	4.44E+02	1.75E!07	7.77E!05	0.00E+00	—	—
N-Nitrosodimethylamine	7.26E!02	1.75E!07	1.27E!08	5.10E+01	6.48E!07	70.01%
Phenol	2.43E+03	1.75E!07	4.25E!04	0.00E+00	—	—
Pyridine	4.31E+00	1.75E!07	7.55E!07	0.00E+00	—	—
Selenium	8.87E!01	1.75E!07	1.55E!07	0.00E+00	—	—
Silver	2.96E+00	1.75E!07	5.18E!07	0.00E+00	—	—
Tetrachloroethylene	4.55E!01	1.75E!07	7.96E!08	5.20E!02	4.14E!09	0.45%
Thallium	2.55E+01	1.75E!07	4.46E!06	0.00E+00	—	—
Toluene	1.40E+03	1.75E!07	2.46E!04	0.00E+00	—	—
Trichloroethylene	4.12E!01	1.75E!07	7.21E!08	1.10E!02	7.93E!10	0.09%
Vanadium	2.62E+02	1.75E!07	4.59E!05	0.00E+00	—	—
Zinc	1.72E+03	1.75E!07	3.01E!04	0.00E+00	—	—
				Total	9.26E!07	100.00%

Occupational Soil Inhalation

$$Intake\ Factor = \left(\frac{C \times IR \times EF \times ET \times ED}{BW \times AT \times PEF} \right) \tag{B-3}$$

where

C	=	soil contaminant concentration (mg/kg) (contaminant dependent)
IR	=	inhalation rate (m^3/hr) = 0.83
EF	=	exposure frequency (day/year) = 250
ET	=	exposure time (hour/day) = 8
ED	=	exposure duration (year) = 25
BW	=	body weight (kg) = 70
AT	=	averaging time (day) = 2.55E+04
PEF	=	particulate emission factor (m^3/kg) (calculated)

$$PEF = \frac{LS \times 5.8\text{E} + 10}{A} \left(\frac{m^4}{kg} \right) \tag{B-4}$$

where

LS	=	prevailing wind field dimension (m) = 49.65
A	=	area of contamination (m^2) = 1140.15

Assumption: Each liter of leachate contaminates 1 kg of soil.

$$Risk = Intake\ Factor \times Slope\ Factor \tag{B-5}$$

Table B-7. Calculation of excess cancer risk for an occupational soil inhalation scenario using the action levels provided in Table B-4.

Constituent	C (mg/Kg)	Intake Factor/C (1/day)	Intake Factor (mg/Kg-day)	Slope Factor (Kg-day/mg)	Risk	Risk Percentage
1,1,1-Trichloroethane	4.44E+02	9.21E-12	4.08E-09	0.00E+00	—	—
2,4-Dinitrophenol	1.40E+02	9.21E-12	1.29E-09	0.00E+00	—	—
2-Hexanone	6.27E+02	9.21E-12	5.77E-09	0.00E+00	—	—
Acetone	9.92E+02	9.21E-12	9.13E-09	0.00E+00	—	—
Aluminum	3.14E+03	9.21E-12	2.89E-08	0.00E+00	—	—
Antimony	6.27E+01	9.21E-12	5.77E-10	0.00E+00	—	—
Aroclor-1260	3.67E-01	9.21E-12	3.37E-12	2.00E+00	6.75E-12	0.23%
Arsenic	4.23E-01	9.21E-12	3.90E-12	1.50E+01	5.84E-11	1.98%
Barium	8.30E+01	9.21E-12	7.64E-10	0.00E+00	—	—
Benzene	3.68E-01	9.21E-12	3.39E-12	2.70E-02	9.16E-14	0.00%
Berylium	5.29E+00	9.21E-12	4.87E-11	8.40E+00	4.09E-10	13.88%
Bromomethane	1.17E+02	9.21E-12	1.08E-09	0.00E+00	—	—
Cadmium	6.11E-01	9.21E-12	5.62E-12	6.30E+00	3.54E-11	1.20%
Carbon disulfide	9.92E+02	9.21E-12	9.13E-09	0.00E+00	—	—
Carbon tetrachloride	2.88E-01	9.21E-12	2.65E-12	5.30E-02	1.40E-13	0.00%
Chloroethane	9.63E+00	9.21E-12	8.86E-11	2.90E-03	2.57E-13	0.01%
Chloromethane	4.55E+00	9.21E-12	4.19E-11	6.30E-03	2.64E-13	0.01%
Chromium	9.01E-01	9.21E-12	8.29E-12	2.90E+02	2.40E-09	81.56%
Cobalt	7.68E+02	9.21E-12	7.07E-09	0.00E+00	—	—
Copper	6.03E+02	9.21E-12	5.55E-09	0.00E+00	—	—
Cyclohexane	7.49E+03	9.21E-12	6.89E-08	0.00E+00	—	—
Cyclohexanone	7.01E+03	9.21E-12	6.46E-08	0.00E+00	—	—
Ethyl Acetate	2.98E+03	9.21E-12	2.74E-08	0.00E+00	—	—
Ethyl Benzene	9.92E+02	9.21E-12	9.13E-09	0.00E+00	—	—
Flouride	7.68E+02	9.21E-12	7.07E-09	0.00E+00	—	—
Iron	1.72E+03	9.21E-12	1.58E-08	0.00E+00	—	—
Lead	0.00E+00	9.21E-12	0.00E+00	0.00E+00	—	—
Manganese	4.86E+02	9.21E-12	4.47E-09	0.00E+00	—	—
Mercury	1.55E-01	9.21E-12	1.43E-12	0.00E+00	—	—
Methanol	2.22E+03	9.21E-12	2.04E-08	0.00E+00	—	—
Methyl ethyl ketone	1.62E+02	9.21E-12	1.49E-09	0.00E+00	—	—
Methyl isobutyl ketone	8.87E+02	9.21E-12	8.17E-09	0.00E+00	—	—
Methylene chloride	5.99E+00	9.21E-12	5.51E-11	1.60E-03	8.82E-14	0.00%
Nickel	4.44E+02	9.21E-12	4.08E-09	0.00E+00	—	—
N-Nitrosodimethylamine	7.26E-02	9.21E-12	6.68E-13	4.90E+01	3.27E-11	1.11%
Phenol	2.43E+03	9.21E-12	2.24E-08	0.00E+00	—	—
Pyridine	4.31E+00	9.21E-12	3.97E-11	0.00E+00	—	—
Selenium	8.87E-01	9.21E-12	8.17E-12	0.00E+00	—	—
Silver	2.96E+00	9.21E-12	2.72E-11	0.00E+00	—	—
Tetrachloroethylene	4.55E-01	9.21E-12	4.19E-12	2.00E-03	8.37E-15	0.00%
Thallium	2.55E+01	9.21E-12	2.35E-10	0.00E+00	—	—
Toluene	1.40E+03	9.21E-12	1.29E-08	0.00E+00	—	—
Trichloroethylene	4.12E-01	9.21E-12	3.79E-12	6.00E-03	2.28E-14	0.00%
Vanadium	2.62E+02	9.21E-12	2.42E-09	0.00E+00	—	—
Zinc	1.72E+03	9.21E-12	1.58E-08	0.00E+00	—	—
				Total	2.95E-09	100.00%

Occupational Soil Ingestion

$$Intake\ Factor = \left(\frac{C \times FI \times EF \times CF}{AT}\right) \times \left(\frac{IR \times ED}{BW}\right) \quad \text{(B-6)}$$

where

C	=	contaminant concentration (mg/kg) (contaminant dependent)
FI	=	fraction ingested from source = 1
EF	=	exposure frequency (day/year) = 250
CF	=	conversion factor (kg/mg) = 1.00E!06
AT	=	averaging time (day) = 9.13E+03
IR	=	ingestion rate (mg/day) = 50
ED	=	exposure duration (year) = 25
BW	=	body weight (kg) = 70

Assumption: Each liter of leachate contaminates 1 kg of soil.

$$Hazard = Intake\ Factor/Reference\ Dose \quad \text{(B-7)}$$

Table B-8. Calculation of hazard quotient for an occupational soil ingestion scenario using the action levels provided in Table B-4.

Constituent	C (mg/kg)	Intake Factor/C (1/day)	Intake Factor (mg/kg/day)	Reference Dose (mg/kg/day)	Hazard Quotient	Hazard Quotient (%)
1,1,1-trichloroethane	4.445E+02	4.890E!07	2.173E!04	2.000E!02	1.087E!02	2.35
2,4-dinitrophenol	1.406E+02	4.890E!07	6.873E!05	2.000E!03	3.436E!02	7.42
2-hexanone	6.286E+02	4.890E!07	3.074E!04	4.000E!02	7.684E!03	1.66
Acetone	9.939E+02	4.890E!07	4.860E!04	1.000E!01	4.860E!03	1.05
Aluminum	3.143E+03	4.890E!07	1.537E!03	1.000E+00	1.537E!03	0.33
Antimony	6.286E+01	4.890E!07	3.074E!05	4.000E!04	7.684E!02	16.59
Aroclor-1260	3.67E-01	4.890E!07	8.417E!04	0.000E+00	—	—
Arsenic	4.860E!01	4.890E!07	2.376E!07	3.000E!04	7.921E!04	0.17
Barium	8.315E+01	4.890E!07	4.066E!05	7.000E!02	5.808E!04	0.13
Benzene	4.230E!01	4.890E!07	2.068E!07	3.000E!03	6.894E!05	0.01
Beryllium	5.512E+00	4.890E!07	2.695E!06	2.000E!03	1.348E!03	0.29
Bromomethane	1.176E+02	4.890E!07	5.750E!05	1.400E!03	4.107E!02	8.87
Cadmium	6.365E!01	4.890E!07	3.112E!07	5.000E!04	6.224E!04	0.13
Carbon disulfide	9.939E+02	4.890E!07	4.860E!04	1.000E!01	4.860E!03	1.05
Carbon tetrachloride	3.302E!01	4.890E!07	1.614E!07	7.000E!04	2.306E!04	0.05
Chloroethane	1.105E+01	4.890E!07	5.404E!06	4.000E!01	1.351E!05	0.00
Chloromethane	5.220E+00	4.890E!07	2.553E!06	0.000E+00	—	—
Chromium	9.381E!01	4.890E!07	4.587E!07	3.000E!03	1.529E!04	0.03
Cobalt	7.699E+02	4.890E!07	3.764E!04	6.000E!02	6.274E!03	1.35
Copper	6.045E+02	4.890E!07	2.956E!04	3.700E!02	7.989E!03	1.72
Cyclohexane	7.504E+03	4.890E!07	3.669E!03	5.700E+00	6.437E!04	0.14
Cyclohexanone	7.028E+03	4.890E!07	3.436E!03	5.000E+00	6.873E!04	0.15
Ethyl acetate	2.982E+03	4.890E!07	1.458E!03	9.000E!01	1.620E!03	0.35
Ethyl benzene	9.939E+02	4.890E!07	4.860E!04	1.000E!01	4.860E!03	1.05
Fluoride	7.699E+02	4.890E!07	3.764E!04	6.000E!02	6.274E!03	1.35
Iron	1.721E+03	4.890E!07	8.417E!04	3.000E!01	2.806E!03	0.61
Lead	0.000E+00	4.890E!07	0.000E+00	0.000E+00	—	—
Manganese	4.869E+02	4.890E!07	2.381E!04	2.400E!02	9.920E!03	2.14
Mercury	1.555E!01	4.890E!07	7.605E!08	3.000E!04	2.535E!04	0.05
Methanol	2.222E+03	4.890E!07	1.087E!03	5.000E!01	2.173E!03	0.47
Methyl ethyl ketone	1.623E+02	4.890E!07	7.936E!05	6.000E!01	1.323E!04	0.03
Methyl isobutyl ketone	8.889E+02	4.890E!07	4.347E!04	8.000E!02	5.433E!03	1.17
Methylene chloride	6.873E+00	4.890E!07	3.361E!06	6.000E!02	5.601E!05	0.01
Nickel	4.445E+02	4.890E!07	2.173E!04	2.000E!02	1.087E!02	2.35
N-nitrosodimethylamine	8.335E!02	4.890E!07	4.075E!08	0.000E+00	—	—
Phenol	2.43E+03	4.890E-07	1.19E-03	6.00E-01	1.98E-03	0.43
Pyridine	4.321E+00	4.890E!07	2.113E!06	1.000E!03	2.113E!03	0.46
Selenium	8.889E!01	4.890E!07	4.347E!07	5.000E!03	8.693E!05	0.02
Silver	2.963E+00	4.890E!07	1.449E!06	5.000E!03	2.898E!04	0.06
Tetrachloroethylene	5.220E!01	4.890E!07	2.553E!07	1.000E!02	2.553E!05	0.01
Thallium	2.553E+01	4.890E!07	1.248E!05	6.600E!05	1.892E!01	40.83
Toluene	1.406E+03	4.890E!07	6.873E!04	2.000E!01	3.436E!03	0.74
Trichloroethylene	4.729E!01	4.890E!07	2.312E!07	6.000E!03	3.854E!05	0.01
Vanadium	2.630E+02	4.890E!07	1.286E!04	7.000E!03	1.837E!02	3.96
Xylene	4.445E+03	4.890E!07	2.173E!03	2.000E+00	1.087E!03	0.23
Zinc	1.721E+03	4.890E!07	8.417E!04	3.000E!01	2.806E!03	0.61
Total					**4.63E!01**	**100.00**

Occupational Soil Inhalation

$$Intake\ Factor = \left(\frac{C \times IR \times EF \times ET \times ED}{BW \times AT \times PEF} \right) \quad \text{(B-8)}$$

where

C	=	soil contaminant concentration (mg/kg) (contaminant dependent)
IR	=	inhalation rate (m^3/hr) = 0.83
EF	=	exposure frequency (day/year) = 250
ET	=	exposure time (hour/day) = 8
ED	=	exposure duration (year) = 25
BW	=	body weight (kg) = 70
AT	=	averaging time (day) = 9.13E+03
PEF	=	particulate emission factor (m^3/kg) (calculated)

$$PEF = \frac{LS \times 5.8\text{E} + 10}{A} \left(\frac{m^4}{kg} \right)$$

where

LS	=	prevailing wind field dimension (m) = 49.65
A	=	area of contamination (m^2) = 1140.15

Assumption: Each liter of leachate contaminates 1 kg of soil.

Hazard = Intake Factor/Reference Dose (B-9)

Table B-9. Calculation of hazard quotient for an occupational soil inhalation scenario using the action levels provided in Table B-4.

Constituent	C (mg/kg)	Intake Factor/C (1/day)	Intake Factor (mg/kg-day)	Reference Dose (mg/kg/day)	Hazard Quotient	Hazard Quotient (%)
1,1,1-trichloroethane	4.445E+02	2.571E!11	1.143E!08	2.900E!01	3.940E!08	0.00
2,4-dinitrophenol	1.406E+02	2.571E!11	3.614E!09	2.000E!03	1.807E!06	0.18
2-hexanone	6.286E+02	2.571E!11	1.616E!08	1.400E!03	1.154E!05	1.14
Acetone	9.939E+02	2.571E!11	2.555E!08	1.000E!01	2.555E!07	0.03
Aluminum	3.143E+03	2.571E!11	8.080E!08	1.400E!03	5.772E!05	5.69
Antimony	6.286E+01	2.571E!11	1.616E!09	4.000E!04	4.040E!06	0.40
Aroclor-1260	3.67E-01	2.571E!11	4.426E!08	0.000E+00	—	—
Arsenic	4.860E!01	2.571E!11	1.249E!11	3.000E!04	4.165E!08	0.00
Barium	8.315E+01	2.571E!11	2.138E!09	1.400E!04	1.527E!05	1.51
Benzene	4.230E!01	2.571E!11	1.088E!11	1.700E!03	6.397E!09	0.00
Beryllium	5.512E+00	2.571E!11	1.417E!10	5.700E!06	2.486E!05	2.45
Bromomethane	1.176E+02	2.571E!11	3.023E!09	1.400E!03	2.160E!06	0.21
Cadmium	6.365E!01	2.571E!11	1.636E!11	5.000E!04	3.273E!08	0.00
Carbon disulfide	9.939E+02	2.571E!11	2.555E!08	2.000E!01	1.278E!07	0.01
Carbon tetrachloride	3.302E!01	2.571E!11	8.488E!12	7.000E!04	1.213E!08	0.00
Chloroethane	1.105E+01	2.571E!11	2.842E!10	2.900E+00	9.799E!11	0.00
Chloromethane	5.220E+00	2.571E!11	1.342E!10	8.600E!02	1.561E!09	0.00
Chromium	9.381E!01	2.571E!11	2.412E!11	3.000E!03	8.040E!09	0.00
Cobalt	7.699E+02	2.571E!11	1.979E!08	0.000E+00	—	—
Copper	6.045E+02	2.571E!11	1.554E!08	0.000E+00	—	—
Cyclohexane	7.504E+03	2.571E!11	1.929E!07	5.700E+00	3.384E!08	0.00
Cyclohexanone	7.028E+03	2.571E!11	1.807E!07	5.000E+00	3.614E!08	0.00
Ethyl acetate	2.982E+03	2.571E!11	7.666E!08	9.000E!01	8.517E!08	0.01
Ethyl benzene	9.939E+02	2.571E!11	2.555E!08	2.900E!01	8.811E!08	0.01
Fluoride	7.699E+02	2.571E!11	1.979E!08	0.000E+00	—	—
Iron	1.721E+03	2.571E!11	4.426E!08	0.000E+00	—	—
Lead	0.000E+00	2.571E!11	0.000E+00	0.000E+00	—	—
Manganese	4.869E+02	2.571E!11	1.252E!08	1.400E!05	8.941E!04	88.14
Mercury	1.555E!01	2.571E!11	3.999E!12	8.600E!05	4.650E!08	0.00
Methanol	2.222E+03	2.571E!11	5.714E!08	5.000E!01	1.143E!07	0.01
Methyl ethyl ketone	1.623E+02	2.571E!11	4.173E!09	2.900E!01	1.439E!08	0.00
Methyl isobutyl ketone	8.889E+02	2.571E!11	2.285E!08	2.300E!02	9.937E!07	0.10
Methylene chloride	6.873E+00	2.571E!11	1.767E!10	8.600E!01	2.055E!10	0.00
Nickel	4.445E+02	2.571E!11	1.143E!08	0.000E+00	—	—
N-nitrosodimethylamine	8.335E!02	2.571E!11	2.143E!12	0.000E+00	—	—
Phenol	2.43E+03	2.57E-11	6.25E-08	6.00E-01	1.04E!07	0.1
Pyridine	4.321E+00	2.571E!11	1.111E!10	1.000E!03	1.111E!07	0.01
Selenium	8.889E!01	2.571E!11	2.285E!11	0.000E+00	—	—
Silver	2.963E+00	2.571E!11	7.618E!11	0.000E+00	—	—
Tetrachloroethylene	5.220E!01	2.571E!11	1.342E!11	1.100E!01	1.220E!10	0.00
Thallium	2.553E+01	2.571E!11	6.564E!10	0.000E+00	—	—
Toluene	1.406E+03	2.571E!11	3.614E!08	1.100E!01	3.285E!07	0.03
Trichloroethylene	4.729E!01	2.571E!11	1.216E!11	6.000E!03	2.026E!09	0.00
Vanadium	2.630E+02	2.571E!11	6.760E!09	0.000E+00	—	—
Xylene	4.445E+03	2.571E!11	1.143E!07	2.000E!01	5.714E!07	0.06
Zinc	1.721E+03	2.571E!11	4.426E!08	0.000E+00	—	—
Total					**1.014E!03**	**100.00**

Step 8: Determine an Action Level for Lead

Of the COCs currently applicable to Tanks WM-184, WM-185, and WM-186, only lead does not have a reference dose or a slope factor. The following discussion offers an approach for establishing an action level for lead. Soil screening guidance (EPA 2001) suggests a lead soil concentration of 400 mg/kg based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA 1994). The liquid lead concentration is calculated using the definition of K_d. The K_d value is the ratio of the soil concentration to the liquid concentration. Thus, the action level is calculated by dividing the suggested soil concentration for lead by the K_d. The K_d of lead is 100 cm^3/g (EPA 1996). With these values, lead action level is calculated at 4 mg/L.

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