Trichloroethylene (TCE): Deriving Cleanup Levels under the Model Toxics Control Act (MTCA)

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Summary table of standard MTCA Methods B and C cleanup levels

This table lists default TCE cleanup levels. Not all of these cleanup levels are based on calculations using the MTCA Methods B and C equations. Some values are based on state and/or federal laws, as required by the MTCA regulation. A list of acronyms used in this guidance is found on the last page.

Method	Default Cleanup Level (1)	Regulatory Basis
Groundwater Method A	5 µg/L	MTCA Method A Table 720-1
Groundwater Method B	4 µg/L	Adjusted EPA/State Maximum Contaminant Level
Groundwater Method C	5 µg/L	EPA/State Maximum Contaminant Level
Fresh Surface Water Methods B and C	0.3 µg/L	Human health consumption of water and organisms. EPA 40 CFR 131.45[1]
Marine Surface Water Methods B and C	0.7 µg/L	Human health consumption of organisms. EPA 40 CFR 131.45
Soil Method A Unrestricted	0.03 mg/kg	MTCA Method A Table 740-1
Soil Method A Industrial	0.03 mg/kg	MTCA Method A Table 745-1
Soil Method B	12 mg/kg	MTCA Equation 740-2 adjusted for mutagenic effects
Soil Method C	1,800 mg/kg	MTCA Equation 740-2 adjusted for Method C
Soil Protective of Groundwater as drinking water (unsaturated)	0.025 mg/kg	MTCA Equation 747-1
Soil Protective of Groundwater as drinking water (saturated)	0.0015 mg/kg	MTCA Equation 747-1 adjusted for saturated zone
Air Method B	0.33 µg/m^3	MTCA Equation 750-2 adjusted for mutagenic effects
Air Method C	2 µg/m^3	MTCA Equation 750-1 adjusted for Method C

(1) These are not necessarily final cleanup levels. These values may need to be adjusted for additive risk, Practical Quantitation Limits (PQLs), and natural background per WAC 173-340-720(7); -730(5); -740(5); -745(6); -750(5).

[1] The National Toxics Rule (NTR; 40 CFR 131.36) no longer applies to Washington state. EPA's federally promulgated water quality standards for Washington state are contained in 40 CFR 131.45 – EPA's revision of certain federal water quality criteria applicable to Washington. These are human health criteria only.

I. Determining cleanup levels for TCE - Introduction

Calculating MTCA Method B cleanup levels based on the carcinogenic effects of TCE is not as straightforward as that for most other chemicals. This document describes the reasons for the added complexity and shows the detailed calculations below and in **Tables 1 through 8** (***located at the end of the document***). When a calculated value is not used (for example, when a state or federal standard is an Applicable or Relevant and Appropriate Requirement [ARAR] that is more protective than the calculated value), the rationale for the selection of each cleanup level is provided. A list of acronyms used in this guidance is provided on the last page.

II. MTCA cleanup levels for TCE based on cancer risk: Why some of the calculations are more complicated than normal

In 2011, after 20 years of review of relevant scientific data, the United States Environmental Protection Agency (EPA) updated information about TCE toxicity in its Integrated Risk Information System (IRIS) on-line database. When available, Ecology uses toxicity information from IRIS to calculate cleanup levels for hazardous substances. EPA reported two findings related to the carcinogenicity of TCE that increased the complexity of MTCA cleanup level calculations.

1. First, while most toxicity values are based on a single "critical" effect, EPA developed its cancer values by adding together the increased risks of three separate types of cancer (kidney cancer, liver cancer, and non-Hodgkin lymphoma [NHL]).

2. Second, when children are exposed to TCE, EPA assigns a greater weight to the kidney cancer portion of the value than the liver cancer and NHL portions. EPA determined that TCE causes kidney cancer (but not liver cancer or NHL) through a mutagenic mode of action. Studies suggest that exposure to mutagens early in life are associated with a greater risk of cancer than exposure to the same amount as an adult. Since the oral slope factor and inhalation unit risk for TCE are based on adult exposure, EPA recommends adjusting the portion associated with a mutagenic mode of action (kidney cancer) to account for increased early-life susceptibility when children are exposed. The adjusted kidney cancer potency factor is combined with the unadjusted liver and NHL potency factors to calculate cleanup levels for time periods when children are exposed. These adjustments are applied to cleanup level calculations for:

    - Method B Groundwater (MTCA Equation 720-2, which also applies to potable surface water).
    - Method B Soil for unrestricted land use (MTCA Equations 740-2 and 740-5).
    - Method B Soil concentrations for groundwater protection as a drinking water source (MTCA Equation 747-1).
    - Method B surface water concentrations for the consumption of fish (MTCA Equation 730-2).
    - Method B Air (MTCA Equation 750-2).

The adjustments are not made for:

- Method A determinations.
- Method C cleanup level calculations (which are based on adult exposure – see paragraph below)

MTCA Method C cleanup equations are based on adult exposure and do not incorporate early-life exposure adjustments. However, if a non-industrial site qualifies for setting a Method C cleanup level (for groundwater, surface water, or air) based on the criteria in WAC 173-340-706(1)(a), then the Method C cleanup level will need to be adjusted lower to account for early-life exposure. This is further discussed in the sections below describing Method B cleanup level calculations for the various media.

TCE cancer potency factors and methods to adjust for increased early-life susceptibility are described in the text and in **Table 1** (for ingestion exposure) and **Table 2** (for inhalation exposure) located at the end of this document. The adjustment methods are based on information in EPA document EPA/630/R-03/003F, "Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens" published in March 2005.

III. Cleanup levels for TCE based on noncancer effects

EPA developed both oral and inhalation noncancer toxicity values for TCE based mostly on findings of increased heart malformations in the developing fetus and on immune system effects. Supporting studies on kidney toxicity were also considered in EPA's assessment. Calculating cleanup levels for TCE based on noncancer effects are straightforward, using the MTCA noncancer equations without adjustments for early-life susceptibility. Noncancer toxicity values are shown in **Table 3**.

IV. Important terminology

1. The names for 3 of the 4 toxicity parameters are different between the MTCA regulation and EPA:

   - MTCA Oral Cancer Potency Factor (CPFo) = EPA Oral Cancer Slope Factor (SFO).
   - MTCA Oral Reference Dose (RfDo) = EPA Oral Reference Dose (RfDo).
   - MTCA Inhalation Cancer Potency Factor (CPFi) = EPA Inhalation Unit Risk (IUR). ***See 2 below***.
   - MTCA Inhalation Reference Dose (RfDi) = EPA Reference Concentration (RfC). ***See 2 below***.

2. MTCA and EPA use different units for the inhalation toxicity parameters. EPA identifies the RfC and IUR, and does not present conversions to an inhalation RfD (RfDi) or inhalation cancer potency factor (CPFi). For calculating cleanup levels based on inhalation exposure, MTCA expresses inhalation toxicity data as an inhaled dose or intake expressed as a RfDi or a CPFi – based on adjustments for body weight (70 kilograms) and breathing rate (20 m^3/day). The conversion formulas are presented below.

   - CPFi (kg-day/mg) = (IUR [m^3/µg] x 70 kg) ÷ (20 m^3/day x 0.001 mg/µg).
   - RfDi (mg/kg-day) = (RfCi [mg/m^3] ÷ 70 kg) x 20 m^3/day.

3. In the calculations below, two terms relate to adjustments used when children are exposed to TCE:

Age-Dependent Adjustment Factor (ADAF) (as shown in **Tables 1 and 2**) – This is a multiplier for the TCE kidney cancer potency factor that accounts for the increased susceptibility to TCE-induced kidney cancer in children (compared to equally-exposed adults). This adjustment is applied because EPA determined that kidney cancer (but not liver cancer or NHL) is caused by TCE through a mutagenic mode of action. Studies suggest that exposure to mutagens early in life are associated with a greater risk of cancer than exposure to the same amount as an adult.

Early-Life Exposure (ELE) Adjustment Factor - A factor used to calculate age-adjusted cleanup levels for each cancer type by combining the following age-specific parameters, as shown in **Tables 1 and 2**:

- Age-Dependent Adjustment Factor (ADAF) for kidney cancer. There is no ADAF parameter for NHL or liver cancer.
- Toxicity adjustment factor. This is used to adjust the total cancer potency factor (CPFo or CPFi) for the combined three cancer effects to the corresponding CPFo or CPFi for the individual types of cancer (i.e., kidney cancer, liver cancer, and NHL).
- Exposure duration.
- Body weight.
- One of the following, depending the environmental medium.
    - Drinking water ingestion rate (for groundwater and potable surface water).
    - Fish consumption rate (for surface waters that support or have the potential to support fish or shellfish populations)
    - Soil ingestion rate (for soil).
    - Breathing rate (for air).

V. Method B groundwater calculations

In September 2011, EPA published an oral cancer slope factor (MTCA calls it a cancer potency factor) for TCE of 0.046 $(mg/kg\text{-}day)^{-1}$ which was derived by route-to-route extrapolation from the Inhalation Unit Risk (IUR). The IUR was based on the carcinogenic effects of TCE on 3 separate tissues, and EPA back-calculated oral slope factors for each of the 3 tissues (which, when added together equal the combined slope factor of 0.046 $[mg/kg\text{-}day]^{-1}$). The oral cancer potency factor for each of the individual cancer types is provided below.

- Kidney cancer = 0.00933 $(mg/kg\text{-}day)^{-1}$
- Non-Hodgkin lymphoma = 0.0216 $(mg/kg\text{-}day)^{-1}$
- Liver cancer = 0.0155 $(mg/kg\text{-}day)^{-1}$

These values are based on adult exposure. When children are exposed to TCE, EPA assigns a greater weight to the kidney cancer portion of the value (but not to the liver cancer and NHL portions). This adjustment is applied because EPA determined that TCE causes kidney cancer (but not liver cancer or NHL) through a mutagenic mode of action, and studies suggest that exposure to mutagens early in life are associated with a greater risk of cancer than exposure to the same amount as an adult. Since the oral slope factor and inhalation unit risk for TCE are based on adult exposure, EPA recommends adjusting the portion associated with a mutagenic mode of action (kidney cancer) to account for increased early-life susceptibility when children are exposed. The adjusted kidney cancer potency factor is combined with the unadjusted liver and NHL potency factors to calculate cleanup levels for time periods when children are exposed. Specifically, the ability of TCE to cause kidney cancer in children less than 2 years of age is assumed to be 10 times greater than in adults, meaning that the kidney cancer portion of the cancer potency factor is multiplied by a 10-fold Age-Dependent Adjustment Factor (ADAF) for risk calculations and cleanup level calculations that include exposure to children up to 2 years of age. Similarly, the ability of TCE to cause kidney cancer in children from their second through sixteenth birthday is assumed to be 3 times greater than in adults and the kidney cancer potency factor is multiplied by an ADAF of 3 when children in that age range are exposed. Early-life exposure age adjustment factors applied to the groundwater, soil, and surface water pathways are provided in the following table.

Early-Life Exposure Age Adjustment Factors for Carcinogens – Groundwater, Soil, Surface Water Pathways					
Parameter	**Parameter Definition**	**Exposure Parameters for Early-Life Exposure**			
		Age Groupings			
		0 to 2 years	**2 to 6 years**	**6 to 16 years**	**16 to 30 years**
ADAF (1)	Age-dependent adjustment factor, unitless	10	3	3	1
MAF	Toxicity adjustment factor for mutagens - kidney cancer	Same for each age: CPFo Kidney ÷ Total CPFo = 0.00933 ÷ 0.046			
CAF	Toxicity adjustment factor for carcinogens (non-mutagens) - NHL/Liver (2)	Same for each age: (CPFo NHL + CPFo Liver) ÷ Total CPFo = 0.0371 ÷ 0.046			
ED	Exposure duration, years	2	4	10	14
BW	Body weight, kg	16	16	70	70
DWIR	Drinking water ingestion rate, L/d	1	1	2	2
SIR (3)	Soil Ingestion rate, mg/day	200	200	50	50
FCR (4)	Fish consumption rate, grams/day	54	54	54	54

(1) ADAFs only apply to early-life adjustments for kidney cancer.

(2) NHL = non-Hodgkin lymphoma.

(3) The Method B cancer soil cleanup level is based on child exposure (Equation 740-2). Therefore, exposure to age groups beyond 6 years old was not incorporated into the ELE cleanup equation for soil

(4) The MTCA regulation does not include a default child-specific FCR. As such, the FCR for the child was conservatively assumed to be equal to that of the adult.

The cleanup level for groundwater (and potable surface water) is calculated using MTCA Equation 720-2, but modified to include the age-specific exposure durations, toxicity adjustments, body weights, drinking water ingestion rates, and ADAFs (for only the kidney cancer portion of the cancer potency factor). Here's how it's done.

1. An Early-Life Exposure (ELE) adjustment factor is calculated by adding early-life adjustments for kidney to early-life adjustments made for combined NHL/Liver. Early-life adjustments are made by combining the age-specific values in each column in the above table ((ADAF x Toxicity Adjustments x Exposure Duration x Drinking Water Ingestion Rate)/Body Weight) for each of the four age ranges:

   - **Total ELE adjustment factor =**

     Kidney Cancer – $(((ADAF_{0\text{-}2} \times MAF \times ED_{0\text{-}2} \times DWIR_{0\text{-}2})/BW_{0\text{-}2}) + ((ADAF_{2\text{-}6} \times MAF \times ED_{2\text{-}6} \times DWIR_{2\text{-}6})/BW_{2\text{-}6}) + ((ADAF_{6\text{-}16} \times MAF \times ED_{6\text{-}16} \times DWIR_{6\text{-}16})/BW_{6\text{-}16}) + ((ADAF_{16\text{-}30} \times MAF \times ED_{16\text{-}30} \times DWIR_{16\text{-}30})/BW_{16\text{-}30}))$

     +

     NHL + Liver Cancer – $(((CAF \times ED_{0\text{-}2} \times DWIR_{0\text{-}2})/BW_{0\text{-}2}) + ((CAF \times ED_{2\text{-}6} \times DWIR_{2\text{-}6})/BW_{2\text{-}6}) + ((CAF \times ED_{6\text{-}16} \times DWIR_{6\text{-}16})/BW_{6\text{-}16}) + ((CAF \times ED_{16\text{-}30} \times DWIR_{16\text{-}30})/BW_{16\text{-}30}))$

     = 1.516 liter-year/kg-day

A difference in the kidney and NHL/liver calculations is that ADAFs are used in the calculations for kidney cancer, but not for NHL or liver cancer. Another way to look at it is that all the ADAFs for NHL and liver cancer are all equal to 1. The calculations also apply different toxicity adjustments (i.e., MAF for kidney and CAF for NHL/liver).

2. The cleanup level is calculated with a modified MTCA Equation 720-2 by incorporating the ELE adjustment factor which accounts for ADAFs, toxicity adjustments, exposure duration, drinking water ingestion rate, and body weight.

The modified equation is: (Risk x Averaging Time x Unit Conversion Factor [UCF])/(Total CPFo x Total ELE Adjustment Factor x Inhalation Correction Factor x Drinking Water Fraction) and the cleanup level is:

- **Groundwater cleanup level** = (0.000001 x 75 years x 1,000 µg/mg)/(0.046 [mg/kg-day]$^{-1}$ x 1.516 liter-year/kg-day x 2 x 1) = **0.54 µg/L**

The Method B groundwater cleanup level of 0.54 µg/L accounts for the additive cancer risk from each of the cancer types. That is, the cleanup level is protective against the cumulative risk (not to exceed 10^{-6} risk) that is contributed by each cancer type.

Note that for non-industrial sites that may qualify for setting a Method C groundwater cleanup level based on the criteria in WAC 173-340-706(1)(a), the Method C groundwater cancer cleanup level is calculated the same as above except that the target cancer risk is 1 x 10^{-5}. In this case, the Method C calculated groundwater cancer cleanup level adjusted for ELE is 5.4 µg/L. In the absence of meeting the criteria set forth in WAC 173-340-706(1)(a), the Method C calculated groundwater cancer cleanup level is 9.5 µg/L based on adult exposure (MTCA Equation 720-2 adjusted for Method C).

VI. Method B soil calculations

The cleanup level for soil is calculated using MTCA Equation 740-2 and is modified to include the age-specific exposure durations, toxicity adjustments, body weights, soil ingestion rates, and ADAFs (for only the kidney cancer portion of the cancer potency factor). Equation 740-2 is based on child exposure and a total exposure duration of 6 years is used. Here's how it's done.

1. An Early-Life Exposure (ELE) adjustment factor is calculated by adding early-life adjustments for kidney to early-life adjustments made for combined NHL/Liver. Early-life adjustments are made by combining the age-specific values in each column in the table on Page 5 ((ADAF x Toxicity Adjustments x Exposure Duration x Soil Ingestion Rate)/Body Weight) for age ranges up to 6 years old:

   - **Total ELE adjustment factor =**

     Kidney Cancer – $(((ADAF_{0\text{-}2} \times MAF \times ED_{0\text{-}2} \times SIR_{0\text{-}2})/BW_{0\text{-}2}) + ((ADAF_{2\text{-}6} \times MAF \times ED_{2\text{-}6} \times SIR_{2\text{-}6})/BW_{2\text{-}6}))$

     +

     NHL + Liver Cancer – $(((CAF \times ED_{0\text{-}2} \times SIR_{0\text{-}2})/BW_{0\text{-}2}) + ((CAF \times ED_{2\text{-}6} \times SIR_{2\text{-}6})/BW_{2\text{-}6}))$

     = 141.619 mg-year/kg-day

2. The cleanup level is calculated with a modified MTCA Equation 740-2 by incorporating the ELE adjustment factor which accounts for ADAFs, toxicity adjustments, exposure duration, soil ingestion rate, and body weight.

The modified equation is: (Risk x Averaging Time x UCF)/(Total CPFo x Total ELE Adjustment Factor x AB1) and the cleanup level is:

- **Soil cleanup level** = (0.000001 x 75 years x 1,000,000 mg/kg)/(0.046 [mg/kg-day]$^{-1}$ x 141.619 mg-year/kg-day x 1) = **11.5 mg/kg or 12 mg/kg rounded to 2 significant figures.**

Note that Method C soil cleanup levels may only be established where the person conducting the cleanup action can demonstrate that the area under consideration is an industrial property (WAC 173-340-706(1)(c)). As such, the Method C calculated soil cleanup level is based on adult exposure and does not include an adjustment for ELE. The Method C calculated soil cleanup level based on cancer is 2,900 mg/kg (MTCA Equation 745-2).

VII. Method B surface water calculations

The cleanup level for surface water is calculated using MTCA Equation 730-2 and is modified to include the age-specific exposure durations, toxicity adjustments, body weights, fish consumption rates, and ADAFs (for only the kidney cancer portion of the cancer potency factor). Here's how it's done.

1. An Early-Life Exposure (ELE) adjustment factor is calculated by adding early-life adjustments for kidney to early-life adjustments made for combined NHL/Liver. Early-life adjustments are made by combining the age-specific values in each column in the table on Page 5 ((ADAF x Toxicity Adjustments x Exposure Duration x Fish Consumption Rate)/Body Weight) for each of the four age ranges:

   - **Total ELE adjustment factor =**

     Kidney Cancer – $(((ADAF_{0\text{-}2} \times MAF \times ED_{0\text{-}2} \times FCR_{0\text{-}2})/BW_{0\text{-}2}) + ((ADAF_{2\text{-}6} \times MAF \times ED_{2\text{-}6} \times FCR_{2\text{-}6})/BW_{2\text{-}6}) + ((ADAF_{6\text{-}16} \times MAF \times ED_{6\text{-}16} \times FCR_{6\text{-}16})/BW_{6\text{-}16}) + ((ADAF_{16\text{-}30} \times MAF \times ED_{16\text{-}30} \times FCR_{16\text{-}30})/BW_{16\text{-}30}))$

     +

     NHL + Liver Cancer – $(((CAF \times ED_{0\text{-}2} \times FCR_{0\text{-}2})/BW_{0\text{-}2}) + ((CAF \times ED_{2\text{-}6} \times FCR_{2\text{-}6})/BW_{2\text{-}6}) + ((CAF \times ED_{6\text{-}16} \times FCR_{6\text{-}16})/BW_{6\text{-}16}) + ((CAF \times ED_{16\text{-}30} \times FCR_{16\text{-}30})/BW_{16\text{-}30}))$

     = 60.054 gram-year/kg-day

2. The cleanup level is calculated with a modified MTCA Equation 730-2 by incorporating the ELE adjustment factor which accounts for ADAFs, toxicity adjustments, exposure duration, fish consumption rate, and body weight.

The modified equation is: (Risk x Averaging Time x UCF1 x UCF2)/(Total CPFo x Total ELE Adjustment Factor x Bioconcentration Factor [BCF] x Fish Diet Fraction [FDF]) and the cleanup level is:

Surface water cleanup level = (0.000001 x 75 years x 1,000 µg/mg x 1,000 grams/kg)/(0.046 [mg/kg-day]$^{-1}$ x 60.054 grams-year/kg-day x 11 liters/kg x 0.5) = **4.9 µg/L.**

Note that for non-industrial sites that may qualify for setting a Method C surface water cleanup level based on the criteria in WAC 173-340-706(1)(a), the Method C surface water cleanup level is calculated the same as above except that the target cancer risk is 1 x 10^{-5} and the fish diet fraction is 0.2. In this case, the Method C calculated surface water cleanup level adjusted for ELE is 120 µg/L. In the absence of meeting the criteria set forth in WAC 173-340-706(1)(a), the Method C calculated surface water cleanup level is 320 µg/L based on adult exposure (MTCA Equation 730-2 adjusted for Method C).

VIII. Method B air calculations

The cleanup level for air accounts for exposure via inhalation rather than oral exposure. The TCE Inhalation Unit Risk (IUR) identified in EPA's IRIS for the sum of the three individual cancer types is 4.1 x 10^{-6} $m^3/\mu g$. This equates to a MTCA inhalation cancer potency factor (CPFi) of 0.0144 $(mg/kg\text{-}day)^{-1}$ using the conversion formula on Page 3. IUR's identified in IRIS for the separate cancer types along with conversions to MTCA CPFi's are provided below.

- Kidney cancer = IUR – 1 x 10^{-6} $m^3/\mu g$; CPFi – 0.0035 $(mg/kg\text{-}day)^{-1}$
- Non-Hodgkin lymphoma = IUR – 2 x 10^{-6} $m^3/\mu g$; CPFi – 0.007 $(mg/kg\text{-}day)^{-1}$
- Liver cancer = IUR – 1 x 10^{-6} $m^3/\mu g$; CPFi – 0.0035 $(mg/kg\text{-}day)^{-1}$

Early-life exposure age adjustment factors applied to the air pathway are provided in the table below.

Early-Life Exposure Age Adjustment Factors for Carcinogens – Air Pathway					
Parameter	**Parameter Definition**	**Exposure Parameters for Early-Life Exposure**			
		Age Groupings			
		0 to 2 years	**2 to 6 years**	**6 to 16 years**	**16 to 30 years**
ADAF (1)	Age-dependent adjustment factor, unitless	10	3	3	1
MAF	Toxicity adjustment factor for mutagens - kidney cancer	Same for each age: CPFi Kidney ÷ Total CPFi = 0.0035 ÷ 0.0144			
CAF	Toxicity adjustment factor for carcinogens (non-mutagens) - NHL/Liver (2)	Same for each age: (CPFi NHL + CPFi Liver) ÷ Total CPFi = 0.0105 ÷ 0.0144			
ED	Exposure duration, years	2	4	10	14
BW	Body weight, kg	16	16	70	70
BR	Breathing rate, m^3/day	10	10	20	20

(1) ADAFs only apply to early-life adjustments for kidney cancer.

(2) NHL = non-Hodgkin lymphoma

The cleanup level for air is calculated using MTCA Equation 750-2, but modified to include the age-specific exposure durations, toxicity adjustments, body weights, breathing rates, and ADAFs (for only the kidney cancer portion of the cancer potency factor). Here's how it's done.

1. An Early-Life Exposure (ELE) adjustment factor is calculated by adding early-life adjustments for kidney to early-life adjustments made for combined NHL/Liver. Early-life adjustments are made by combining the age-specific values in each column in the above table ((ADAF x Toxicity Adjustments x Exposure Duration x Breathing Rate)/Body Weight) for each of the four age ranges:

   - **Total ELE adjustment factor =**

     Kidney Cancer – $(((ADAF_{0\text{-}2} \times MAF \times ED_{0\text{-}2} \times BR_{0\text{-}2})/BW_{0\text{-}2}) + ((ADAF_{2\text{-}6} \times MAF \times ED_{2\text{-}6} \times BR_{2\text{-}6})/BW_{2\text{-}6}) + ((ADAF_{6\text{-}16} \times MAF \times ED_{6\text{-}16} \times BR_{6\text{-}16})/BW_{6\text{-}16}) + ((ADAF_{16\text{-}30} \times MAF \times ED_{16\text{-}30} \times BR_{16\text{-}30})/BW_{16\text{-}30}))$

     +

     NHL + Liver Cancer – $(((CAF \times ED_{0\text{-}2} \times BR_{0\text{-}2})/BW_{0\text{-}2}) + ((CAF \times ED_{2\text{-}6} \times BR_{2\text{-}6})/BW_{2\text{-}6}) + ((CAF \times ED_{6\text{-}16} \times BR_{6\text{-}16})/BW_{6\text{-}16}) + ((CAF \times ED_{16\text{-}30} \times BR_{16\text{-}30})/BW_{16\text{-}30}))$

     = 15.651 m^3-year/kg-day

2. The cleanup level is calculated with a modified MTCA Equation 750-2 by incorporating the Total ELE adjustment factor which accounts for ADAFs, toxicity adjustments, exposure duration, breathing rate, and body weight.

The modified equation is: (Risk x Averaging Time x UCF)/(Total CPFi x ELE Adjustment Factor x Inhalation Absorption Fraction [ABS]) and the cleanup level is:

- **Air cleanup level** = (0.000001 x 75 years x 1,000 µg/mg)/(0.0144 [mg/kg-day]$^{-1}$ x 15.651 m^3-year/kg-day x 1) = **0.33 µg/m^3**

For non-industrial sites that may qualify for setting a Method C air cleanup level based on the criteria in WAC 173-340-706(1)(a), the Method C cleanup level is calculated the same as above except that the target cancer risk is 1 x 10^{-5}. In this case, the Method C calculated air cleanup level adjusted for ELE is 3.3 µg/m^3. In the absence of meeting the criteria set forth in WAC 173-340-706(1)(a), the Method C calculated air cleanup level is 6.1 µg/m^3 based on adult exposure (MTCA Equation 750-2 adjusted for Method C).

Table 1: Trichloroethylene (TCE) Oral Cancer Potency (Slope) Factors [1]
(Used for calculating, soil, groundwater and surface water cleanup levels)

Toxicity Value Based on Kidney Cancer With A Mutagenic Mode of Action & Potential for Early-Life Exposure (ELE)	Toxicity Value Based on Non-Hodgkin Lymphoma (NHL)	Toxicity Value Based on Liver Cancer
9.33E-03 (mg/kg-day)$^{-1}$	**2.16E-02 (mg/kg-day)$^{-1}$**	**1.55E-02 (mg/kg-day)$^{-1}$**
ELE Adjustment Factor For groundwater = **0.661 liter-yr/kg-day (a)** For soil = **81.13 mg-yr/kg-day (b)** For surface water = **28.79 gram-yr/kg-day (c)**	**ELE Adjustment Factor** For groundwater = **0.855 liter-yr/kg-day (a)** For soil = **60.489 mg-yr/kg-day (b)** For surface water = **31.264 gram-yr/kg-day (c)**	

IRIS also provides the sum of the three individual cancer types, resulting in a **total oral Cancer Potency Factor of 4.6E-02 per mg/kg-day**. This cancer potency factor is used for calculation of Method C cleanup levels.

(a) Groundwater The kidney cancer early-life exposure (ELE) adjustment factor for drinking water was determined using the following equation:

$$\text{ELE Adj. Factor} = \frac{(ADAF \times MAF \times ED \times DWIR)}{BW}(0\text{-}2\text{ y}) + \frac{(ADAF \times MAF \times ED \times DWIR)}{BW}(2\text{-}6\text{ y}) + \frac{(ADAF \times MAF \times ED \times DWIR)}{BW}(6\text{-}16\text{ y}) + \frac{(ADAF \times MAF \times ED \times DWIR)}{BW}(16\text{-}30\text{ y})$$

The non-Hodgkin lymphoma (NHL) and liver cancer early-life exposure (ELE) adjustment factors for drinking water were determined using similar equations without the ADAFs:

$$\text{ELE Adj. Factor} = \frac{(CAF \times ED \times DWIR)}{BW}(0\text{-}2\text{ y}) + \frac{(CAF \times ED \times DWIR)}{BW}(2\text{-}6\text{ y}) + \frac{(CAF \times ED \times DWIR)}{BW}(6\text{-}16\text{ y}) + \frac{(CAF \times ED \times DWIR)}{BW}(16\text{-}30\text{ y})$$

Total ELE Adjustment Factor (Kidney + NHL/Liver) = 1.516 liter-yr/kg-day

(b) Soil The kidney cancer early-life exposure (ELE) adjustment factor for soil ingestion was determined using the following equation [2]

$$\text{ELE Adj. Factor} = \frac{(ADAF \times MAF \times ED \times SIR)}{BW}(0\text{-}2\text{ y}) + \frac{(ADAF \times MAF \times ED \times SIR)}{BW}(2\text{-}6\text{ y})$$

The non-Hodgkin lymphoma and liver cancer early-life exposure (ELE) adjustment factors for soil ingestion were determined using similar equations without the ADAFs [2]

$$\text{ELE Adj. Factor} = \frac{(CAF \times ED \times SIR)}{BW}(0\text{-}2\text{ y}) + \frac{(CAF \times ED \times SIR)}{BW}(2\text{-}6\text{ y})$$

Total ELE Adjustment Factor (Kidney + NHL/Liver) = 141.619 mg-yr/kg-day

(c) Surface Water The kidney cancer early-life exposure (ELE) adjustment factor for surface water fish consumption was determined using the following equation:

$$\text{ELE Adj. Factor} = \frac{(ADAF \times MAF \times ED \times FCR)}{BW}(0\text{-}2\text{ y}) + \frac{(ADAF \times MAF \times ED \times FCR)}{BW}(2\text{-}6\text{ y}) + \frac{(ADAF \times MAF \times ED \times FCR)}{BW}(6\text{-}16\text{ y}) + \frac{(ADAF \times MAF \times ED \times FCR)}{BW}(16\text{-}30\text{ y})$$

The non-Hodgkin lymphoma and liver cancer early-life exposure (ELE) adjustment factors for surface water fish consumption were determined using similar equations without the ADAFs:

$$\text{ELE Adj. Factor} = \frac{(CAF \times ED \times FCR)}{BW}(0\text{-}2\text{ y}) + \frac{(CAF \times ED \times FCR)}{BW}(2\text{-}6\text{ y}) + \frac{(CAF \times ED \times FCR)}{BW}(6\text{-}16\text{ y}) + \frac{(CAF \times ED \times FCR)}{BW}(16\text{-}30\text{ y})$$

Total ELE Adjustment Factor (Kidney + NHL/Liver) = 60.054 gram-yr/kg-day

The assumptions used for the various age ranges in the ELE equations above are presented below.

Early-Life Exposure Age Adjustment Assumptions					
Parameter		**<2 yrs**	**2 to <6 yrs**	**6 to <16 yrs**	**16 to 30 yrs**
ADAFs	Age Dependent Adjustment Factor (unitless)	10	3	3	1
MAF	Toxicity adjustment factor for mutagens - kidney	Same for each age: CPFo Kidney ÷ Total CPFo = 0.00933 ÷ 0.046			
CAF	Toxicity adjustment factor for carcinogens (non-mutagens) – NHL/Liver	Same for each age: (CPFo NHL + CPFo Liver) ÷ Total CPFo = 0.0371 ÷ 0.046			
ED	Exposure Duration (years)	2	4	10	14
BW	Body Weight (kg)	16	16	70	70
DWIR	Drinking Water Ingestion Rate (liters/day)	1	1	2	2
SIR	Soil Ingestion Rate (mg/day)	200	200	50	50
FCR	Fish consumption rate, grams/day	54	54	54	54

Source of toxicity information: EPA's IRIS: http://www.epa.gov/iris/subst/0199.htm

[1] MTCA uses the term "Cancer Potency Factor", abbreviated here as CPF; EPA uses the term (cancer) "Slope Factor" in the Integrated Risk Information System (IRIS). The units are $(mg/kg\text{-}day)^{-1}$ or risk per mg/kg-day.
[2] Adjusted for only 6 years since MTCA uses a 6 year exposure scenario for soil ingestion of carcinogens.

Table 2: Trichloroethylene (TCE) Inhalation Unit Risk Factors (IUR) and Inhalation Cancer Potency (Slope) Factors (CPFi)[1] (Used for calculating air cleanup levels)

Toxicity Value Based on Kidney Cancer With A Mutagenic Mode of Action & Potential for Early Life-Exposure (ELE)	Toxicity Value Based on Non-Hodgkin Lymphoma (NHL)	Toxicity Value Based on Liver Cancer
IUR = 1E-06 $(\mu g/m^3)^{-1}$	IUR = 2E-06 $(\mu g/m^3)^{-1}$	IUR = 1E-06 $(\mu g/m^3)^{-1}$
Converted to CPFi (a) = 3.5E-03 $(mg/kg\text{-}day)^{-1}$	**Converted to CPFi (a) = 7.0E-03 $(mg/kg\text{-}day)^{-1}$**	**Converted to CPFi (a) = 3.5E-03 $(mg/kg\text{-}day)^{-1}$**
ELE Adjustment Factor (b) 7.917 m^3-yr/kg-day	**ELE Adjustment Factor (b) 7.734 m^3-yr/kg-day**	

IRIS also provides the sum of the three individual cancer types, resulting in **total inhalation unit risk factor of 4.1E-06 $(\mu g/m^3)^{-1}$ or CPFi of 1.44E-02 $(mg/kg\text{-}day)^{-1}$**. This cancer potency factor is used for calculation of Method C air cleanup levels.

(a) The following equation was used to convert the EPA cancer unit risk factor (IUR) to an inhalation cancer potency (slope) factor: CPFi (kg-day/mg) = (IUR [$m^3/\mu g$] × 70 kg) ÷ (20 m^3/day × 0.001 mg/µg)

(b) The kidney cancer early-life exposure (ELE) adjustment factor was determined using the following equation:

$$\text{ELE Adj. Factor} = \frac{(ADAF \times MAF \times ED \times BR)}{BW}(0\text{-}2\,y) + \frac{(ADAF \times MAF \times ED \times BR)}{BW}(2\text{-}6\,y) + \frac{(ADAF \times MAF \times ED \times BR)}{BW}(6\text{-}16\,y) + \frac{(ADAF \times MAF \times ED \times BR)}{BW}(16\text{-}30\,y)$$

The non-Hodgkin lymphoma (NHL) and liver cancer early-life exposure (ELE) adjustment factors were determined using similar equations without the ADAFs:

$$\text{ELE Adj. Factor} = \frac{(CAF \times ED \times BR)}{BW}(0\text{-}2\,y) + \frac{(CAF \times ED \times BR)}{BW}(2\text{-}6\,y) + \frac{(CAF \times ED \times BR)}{BW}(6\text{-}16\,y) + \frac{(CAF \times ED \times BR)}{BW}(16\text{-}30\,y)$$

Total ELE Adjustment Factor (Kidney + NHL/Liver) = 15.651 m^3-yr/kg-day

Early-Life Exposure Age Adjustment Assumptions

Parameter		<2 yrs	2 to <6 yrs	6 to <16 yrs	16 to 30 yrs
ADAFs	Age Dependent Adjustment Factor (unitless)	10	3	3	1
MAF	Toxicity adjustment factor for mutagens - kidney	Same for each age: CPFi Kidney ÷ Total CPFi = 0.0035 ÷ 0.0144			
CAF	Toxicity adjustment factor for cancer – NHL/Liver	Same for each age: (CPFi NHL + CPFi Liver) ÷ Total CPFi = 0.0105 ÷ 0.0144			
ED	Exposure Duration (years)	2	4	10	14
BR	Breathing Rate (cubic meters/day)	10	10	20	20
BW	Body Weight (kg)	16	16	70	70

Source of information: U.S. EPA's Integrated Risk Information System (IRIS) http://www.epa.gov/iris/subst/0199.htm

[1] EPA uses the term "Inhalation Unit Risk" in risk calculations for the air exposure pathway. The MTCA rule uses the term "Cancer Potency Factor". Until the MTCA rule is updated to incorporate this EPA approach, the IUR must be converted to a cancer potency factor so the current MTCA equations can be used to calculate cleanup levels.

Table 3: Trichloroethylene (TCE) Non-Cancer Toxicity Values	
Oral Reference Dose (RfDo)	**Inhalation Reference Dose (RfDi)**
5.0E-04 mg/kg-day	**5.71E-04 mg/kg-day (a)**
(a) The following equation was used to convert the EPA inhalation reference concentration (RfC) of 2.0E-03 mg/m^3 to the inhalation reference dose (RfDi): RfDi = (RfC [mg/m^3] ÷ 70 kg) × 20 m^3/day	
Source of toxicity information: U.S. EPA's Integrated Risk Information System (IRIS): http://www.epa.gov/iris/subst/0199.htm	

Table 4: MTCA Standard Method B and C Groundwater Cleanup Levels (CUL) for Trichloroethylene (TCE) for Drinking Water (potable groundwater and surface water) [*see* WAC 173-340-720(4) & (5)] (a)				
Toxicity Values from Tables 1 and 3	**MTCA Method B (µg/L)**		**MTCA Method C (µg/L)**	
	Eqn 720-1 Non-Cancer (@ HQ=1)	**Eqn 720-2 Cancer (@Risk = 10^{-6})**	**Eqn 720-1 (mod) Non-Cancer (@ HQ=1)**	**Eqn 720-2 Cancer (@Risk = 10^{-5})**
Using CPF_0's (for 3 cancer types)	--------	0.54 **(b)**	--------	9.5 **(d)**
Using RfD_0	4	--------	8.8 **(c)**	--------
Applicable State and Federal Law: State & Federal MCL = 5.0 µg/L; Federal drinking water standards located at: http://water.epa.gov/drink/contaminants/index.cfm				
TCE Potable Groundwater Cleanup Levels (e)				
	MTCA Method B		**MTCA Method C**	
	4 µg/L		**5 µg/L**	
(a) All cleanup levels calculated using an inhalation correction factor (INH) = 2.				
(b) Method B (cancer) groundwater cleanup level (CUL) Equation = (Risk x AT x UCF)/(Total CPFo x Total ELE adjustment factor x INH x Drinking Water Fraction)[1] Groundwater CUL = (0.000001 x 75 years x 1,000 µg/mg)/(0.046 [mg/kg-day]$^{-1}$ x 1.516 liter-year/kg-day x 2 x 1) = **0.54 µg/L**				
(c) Method C (non-cancer) groundwater CUL calculated using equation 720-1 modified for an adult exposure scenario by changing the body weight to 70 kg and the drinking water intake rate to 2 liters/day per WAC 173-340-720(5).				
(d) Method C (cancer) groundwater CUL calculated using Equation 720-2, a cancer risk of 10^{-5} and a CPFo = 4.6E-02 mg/kg-day (sum of 3 CPFo's with no ELE adjustment).				
(e) Under Method B, the MCL of 5 µg/L exceeds a hazard quotient of 1. Therefore, under WAC 173-340-720 (7)(b), the MCL must be adjusted downward to 4 µg/L, so that the Method B cleanup level will not exceed a hazard quotient of 1. Thus, 4 µg/L is used as the Method B groundwater cleanup level. Because the MCL does not exceed either a hazard quotient of 1 or a cancer risk of $1x10^{-5}$ under Method C, the MCL can be used as the Method C cleanup level. **NOTE**: These are not necessarily final cleanup levels. These values may need to be adjusted for additive risk, PQLs and natural background per WAC 173-340-720(7). Note that they are already adjusted for ARARs. Also, if contaminants in the groundwater are likely to discharge to a surface water, surface water CULs may need to be considered when determining a final CUL (*see* **Table 5**).				

[1] See WAC 173-340-720(4) for definitions of terms in this equation. Because the age-adjusted cancer potency factor already takes into account body weight, drinking water ingestion rate, and exposure duration, these factors are left out of this equation when calculating this cleanup level.

Table 5: MTCA Standard Method B and C Surface Water Cleanup Levels (CUL) for Trichloroethylene (TCE) [*see* WAC 173-340-730(3) & (4)]

Toxicity Values from Tables 1 and 3	MTCA Method B (µg/L)		MTCA Method C (µg/L)	
	Eqn 730-1 Non-Cancer (@ HQ=1)	Eqn 730-2 Cancer (@Risk = 10^{-6})	Eqn 730-1 (mod) Non-Cancer (@ HQ=1)	Eqn 730-2 Cancer (@Risk = 10^{-5})
Using CPF_0's (for 3 cancer types)	--------	4.9 **(a)**	--------	320 **(b)**
Using RfD_0	120	--------	290 **(c)**	--------

Applicable State and Federal Law: 40 CFR 131.45 Human Health Protection Standards = 0.3 µg/L (water & organisms); 0.7 µg/L (organisms only).

U.S. EPA's 40 CFR 131.45 web location: https://www.epa.gov/wqs-tech/water-quality-standards-regulations-washington#fed

TCE Surface Water Cleanup levels (d)		
	Fresh Water Methods B and C	**Marine Water Methods B and C**
	0.3 µg/L	**0.7 µg/L**

(a) Method B (cancer) surface water cleanup level (CUL) Equation = (Risk x AT x UCF1 x UCF2)/(Total CPFo x Total ELE Adjustment Factor x BCF x FDF)[1]

Surface Water CUL = (0.000001 x 75 years x 1,000 µg/mg x 1,000 grams/kg)/(0.046 [mg/kg-day]$^{-1}$ x 60.054 grams-year/kg-day x 11 liters/kg x 0.5) = **4.9 µg/L**

(b) Method C (cancer) surface water CUL calculated using Equation 730-2, cancer risk of 10^{-5}, BCF = 11 L/kg, FDF = 0.2, per WAC 173-340-730(4), and a CPFo of 4.6E-02 mg/kg-day (sum of 3 CPFo's with no ELE adjustment).

(c) Method C (non-cancer) surface water CULs calculated using Equation 730-1, a BCF = 11 L/kg, and FDF = 0.2, per WAC 173-340-730(4).

(d) MTCA requires CULs to comply with ARARs, which in this case includes both federal and state water quality criteria. This includes consideration of both the survivability of the organisms and risk to humans eating fish and shellfish. It also includes consideration of whether or not the surface water has drinking water as a designated beneficial use under state law.

The most stringent ARARs for TCE are the Federal Water Quality Criteria in 40 CFR 131.45, and thus these criteria govern the cleanup levels in this case.

NOTE: These are not necessarily final cleanup levels. These values may need to be adjusted for additive risk, PQLs and natural background per WAC 173-340-730(5). The values are already adjusted for ARARs.

[1] See WAC 173-340-730(3) for definitions of terms in this equation. Because the age-adjusted cancer potency factor already takes into account body weight, fish consumption rate, and exposure duration, these factors are left out of this equation when calculating this cleanup level.

Table 6: MTCA Standard Method B and C Soil Cleanup Levels (CUL) for Trichloroethylene (TCE) Protective of the Soil Ingestion Pathway
(*see* WAC 173-340-740(3)(b)(iii)(B) & 173-340-745(5)(b)(iii)(B))

Toxicity Values from Table 2	MTCA Method B (mg/kg)		MTCA Method C (mg/kg)	
	Eqn 740-1 Non-Cancer (@ HQ=1)	Eqn 740-2 Cancer (@Risk = 10^{-6})	Eqn 745-1 Non-Cancer (@ HQ=1)	Eqn 745-2 Cancer (@Risk = 10^{-5})
Using CPF_0's (for 3 cancer types)	--------	12 **(a)**	--------	2,900 **(b)**
Using RfD_0	40	--------	1,800	--------
New TCE Soil Cleanup Levels for the Soil Ingestion Pathway (c)				
	MTCA Method B		**MTCA Method C**	
	12 mg/kg		**1,800 mg/kg**	

(a) Method B (cancer) soil CUL = (Risk x AT x UCF)/(Total CPFo x Total ELE Adjustment Factor x AB1)[1]

Soil CUL = (0.000001 x 75 years x 1,000,000 mg/kg)/(0.046 [mg/kg-day]$^{-1}$ x 141.619 mg-year/kg-day x 1) = **11.5 mg/kg or 12 mg/kg rounded to 2 significant figures**

(b) Method C (cancer) soil CUL calculated using equation 745-2, and a CPFo = 4.6E-02 mg/kg-day (sum of 3 CPFo's with no ELE adjustment)

(c) **NOTE**: These are not necessarily final cleanup levels. These values may need to be adjusted for additive risk, PQLs and natural background per WAC 173-340-740(5) and 745(6). There are no known ARARs, so there is no adjustment for ARARs.

Also, this is just the soil ingestion exposure pathway. Other pathways such as leaching (*see* **Table 7**), dermal, and vapors may need to be considered when determining a final cleanup level.

[1] See WAC 173-340-740(3) for definitions of terms in this equation. Because the age-adjusted cancer potency factor already takes into account body weight, soil ingestion rate and exposure duration, these factors are left out of this equation when calculating this cleanup level.

Table 7: MTCA Soil Cleanup Levels for Trichloroethylene (TCE) Protective of Potable Groundwater through the Soil Leaching Pathway [*see* WAC 173-340-747(4)]

Target Groundwater Cleanup Level	Based on Protection of Potable Groundwater		Based on Protection of Surface Water	
	Method B Drinking Water (see Table 4)	**Method C Drinking Water (See Table 4)**	**Freshwater (see Table 5)**	**Marine (see Table 5)**
	4.0 µg/L	5.0 µg/L	0.3 µg/L	0.7 µg/L
TCE Soil Cleanup Level for Leaching Pathway (Unsaturated Zone Soil) (a)	**0.025 mg/kg**	**0.031 mg/kg**	**0.0019 mg/kg**	**0.0044 mg/kg**
TCE Soil Cleanup Level for Leaching Pathway (Saturated Zone Soil) (a)	**0.0015 mg/kg**	**0.0019 mg/kg**	**0.00011 mg/kg**	**0.00027 mg/kg**

(a) Calculated using Equation 747-1 (3-phase model), default assumptions for the following TCE specific properties: Koc = 94 L/kg; Henry's Law Constant (Hcc) @ 13 degrees C = 0.239 (unitless).

NOTE: These are not necessarily final cleanup levels. These values may need to be adjusted for additive risk, PQLs and natural background per WAC 173-340-740(5) and 745(6). There are no known ARARs, so there is no adjustment needed for ARARs.

Table 8: MTCA Standard Method B and C Air Cleanup Levels (CUL) for Trichloroethylene (TCE) [WAC 173-340-750(3)and (4)]				
Toxicity Values from Table 2 and 3	**MTCA Method B ($\mu g/m^3$)**		**MTCA Method C ($\mu g/m^3$)**	
	Eqn 750-1 Non-Cancer (@ HQ = 1)	**Eqn 750-2 Cancer (@ Risk = 10^{-6})**	**Eqn 750-1 (mod) Non-Cancer (@ HQ = 1)**	**Eqn 750-2 Cancer (@ Risk = 10^{-5})**
Using CPF_i's (for 3	--------	0.33 **(a)**	--------	6.1 **(b)**
Using RfD_i	0.91	--------	2 **(c)**	--------
New TCE Air Cleanup Levels (CULs) (d)				
	MTCA Method B		**MTCA Method C**	
	0.33 $\mu g/m^3$		**2.0 $\mu g/m^3$**	

(a) Method B (cancer) Air CUL = (Risk x AT x UCF)/(Total CPFi x Total ELE Adjustment Factor x Inhalation Absorption Fraction[ABS])[1]

Air CUL = (0.000001 x 75 years x 1,000 µg/mg)/(0.0144 [mg/kg-day]$^{-1}$ x 15.651 m^3-yr/kg-day x 1) = **0.33 $\mu g/m^3$**

(b) Method C (cancer) air CUL calculated using equation 750-2, a cancer risk of 10^{-5}, and a CPFi = 0.0144 (mg/kg-day)$^{-1}$ (sum of 3 CPFi's with no ELE adjustment).

(c) Method C (non-cancer) air CUL calculated using equation 750-1 modified for an adult exposure scenario by changing the body weight to 70 kg and the breathing rate to 20 m^3/day per WAC 173-340-750(4).

(d) These are not necessarily final cleanup levels. These values may need to be adjusted for ARARs, additive risk, PQLs and natural background per WAC 173-340-750(5).

[1] See WAC 173-340-750(3) for definitions of terms in this equation. Because the age-adjusted cancer potency factor already takes into account body weight, breathing rate, and exposure duration, these factors are left out of this equation when calculating this cleanup level.

Acronyms and Abbreviations

Acronym or Abbreviation	Definition
ABS	Inhalation Absorption Fraction
ADAF	Age-Dependent Adjustment Factor
ARAR	Applicable or Relevant and Appropriate Requirement
AT	Averaging Time
BCF	Bioconcentration Factor
BR	breathing rate
BW	body weight
CAF	toxicity adjustment factor for carcinogens (non-mutagens)
CFR	Code of Federal Regulations
CLARC	Cleanup Levels and Risk Calculation
CPFi	Inhalation Cancer Potency Factor
CPFo	Oral Cancer Potency Factor
CUL	cleanup level
degrees C	degrees Celsius
DWIR	drinking water ingestion rate
Ecology	Washington State Department of Ecology
ED	exposure duration
ELE	Early-Life Exposure
EPA	United States Environmental Protection Agency
Eqn	equation
FCR	Fish Consumption Rate
FDF	Fish Diet Fraction
Hcc	Henry's Law Constant Dimensionless (unitless)
HQ	hazard quotient
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
Koc	soil organic carbon-water partition coefficient
MAF	toxicity adjustment factor for mutagens
MCL	Maximum Contaminant Level
µg /kg µg /L µg/m^3	Micrograms per kilogram Micrograms per liter Micrograms per cubic meter
MTCA	Model Toxics Control Act
NHL	non-Hodgkin lymphoma also known as non-Hodgkin's lymphoma
NTR	National Toxic Rule
PQL	Practical Quantitation Limit
RfC	Reference Concentration

Acronym or Abbreviation	Definition
RfDi	Inhalation Reference Dose
RfDo	Oral Reference Dose
SIR	soil ingestion rate
TCE	Trichloroethylene
UCF	Unit Conversion Factor
WAC	Washington Administrative Code
yr	year