

Polycyclic Aromatic Hydrocarbons and Benzo[a]pyrene: Changes to MTCA Default Cleanup Levels for 2017

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Summary

In January 2017, the U.S. Environmental Protection Agency (EPA) published several changes to the toxicity values for benzo[a]pyrene in its Integrated Risk Information System (IRIS) database. EPA also determined that benzo[a]pyrene (which is sometimes known as BaP) has a mutagenic mode of action, and therefore recommends using Age-Dependent Adjustment Factors (ADAFs) to address increased childhood sensitivity (compared to adults) to its carcinogenic (cancer-causing) effects.

These changes affect some Model Toxics Control Act (MTCA) Method B cleanup levels for benzo[a]pyrene and for carcinogenic polycyclic aromatic hydrocarbons (cPAHs). MTCA Method C cleanup equations are based on adult exposure and do not incorporate early-life exposure (ELE) adjustments using ADAFs. 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 using ADAFs to account for early life exposure. This is further discussed in the sections below describing MTCA cleanup level calculations for the various media.

Method B and Method C default cleanup level equations are found in the MTCA regulation, Chapter 173-340 WAC, available at <https://apps.leg.wa.gov/WAC/default.aspx?cite=173-340>. This memorandum describes the updated toxicity values for benzo[a]pyrene and how they affect default MTCA cleanup levels. A list of acronyms used in this guidance is provided on the last page. **Table 1** below lists updated default MTCA cleanup levels for cPAH mixtures and benzo[a]pyrene.

Table 1: Updated default MTCA cleanup levels for cPAH mixtures and benzo[a]pyrene

Method	Default Cleanup Level (1)	Regulatory Basis
Groundwater Method A	0.1 µg/L	MTCA Method A Table 720-1
Groundwater Method B (2)	0.2 µg/L	EPA/State Maximum Contaminant Level
Groundwater Method C (2)	0.2 µg/L	EPA/State Maximum Contaminant Level
Surface Water Method B	1.6E-05 µg/L Fresh and Marine Water	EPA 40 CFR 131.45 ¹
Surface Water Method C	1.6E-05 µg/L Fresh and Marine Water	EPA 40 CFR 131.45
Soil Method A Unrestricted	0.1 mg/kg	MTCA Method A Table 740-1
Soil Method A Industrial	2 mg/kg	MTCA Method A Table 745-1
Soil Method B	0.19 mg/kg	MTCA Equation 740-2
Soil Method C	130 mg/kg	MTCA Equation 740-2 adjusted for Method C
Soil Protective of Groundwater (vadose)	3.9 mg/kg	MTCA Equation 747-1
Soil Protective of Groundwater (saturated)	0.19 mg/kg	MTCA Equation 747-1 adjusted for saturated zone
Air Method B (3)	1.1E-03 µg/m ³	MTCA Equation 750-2
Air Method C (3)	4.2E-02 µg/m ³	MTCA Equation 750-2 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).
- (2) The state and federal maximum contaminant level (MCL) of 0.2 µg/L for benzo[a]pyrene does not exceed a lifetime excess cancer risk of one in one hundred thousand or a noncancer hazard quotient of 1 and is considered sufficiently protective.
- (3) For benzo[a]pyrene as an individual compound, the air cleanup levels based on noncancer effects are lower than the values in **Table 1** above: 9.1E-04 µg/m³ for Method B and 2E-03 µg/m³ for Method C. These levels should be used as the default air cleanup level for benzo(a)pyrene as an individual compound. There is currently no MTCA method for evaluating the noncancer effects of PAH mixtures.

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. EPA's changes to toxicity values for Benzo[a]pyrene

For the carcinogenic effects of benzo[a]pyrene, EPA:

- Determined that benzo[a]pyrene has a mutagenic mode of action and recommended using Age-Dependent Adjustment Factors (ADAFs) to address the increased sensitivity of children (compared to adults) to its carcinogenic effects.
- Lowered the oral cancer slope factor from $7.3 \text{ (mg/kg-day)}^{-1}$ to $1 \text{ (mg/kg-day)}^{-1}$. The MTCA regulation refers to the "oral cancer slope factor" as the "oral cancer potency factor" but the toxicity numbers are the same.
- Added an inhalation unit risk (IUR) of $6 \times 10^{-4} \text{ (}\mu\text{g/m}^3\text{)}^{-1}$. Note that MTCA and EPA use different units for the inhalation toxicity parameters. For cancer, EPA identifies the IUR, and does not present conversions to an inhalation cancer potency factor (CPF_i). For calculating cleanup levels based on inhalation exposure for carcinogens, MTCA expresses inhalation toxicity data as an inhaled dose or intake expressed as a CPF_i – based on adjustments for body weight (70 kilograms) and breathing rate (20 m³/day). The conversion formula is presented below.
 - $\text{CPF}_i \text{ (kg-day/mg)} = (\text{IUR [m}^3/\mu\text{g]} \times 70 \text{ kg}) \div (20 \text{ m}^3/\text{day} \times 0.001 \text{ mg}/\mu\text{g})$.

These changes also affect MTCA cleanup levels for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) because benzo[a]pyrene is the reference chemical used to calculate cPAH cleanup levels. MTCA methods to evaluate human health toxicity of cPAH mixtures using toxicity equivalency factors are described in the MTCA regulation (WAC 173-340-708(8)(e)) and in more detail in Toxics Cleanup Program's Implementation Memorandum 10, *Evaluating the Human Health Toxicity of Carcinogenic PAHs (cPAHs) Using Toxicity Equivalency Factors (TEFs)*, Washington State Department of Ecology publication no. 15-09-049, available at <https://fortress.wa.gov/ecy/publications/SummaryPages/1509049.html>

For the noncancer effects of benzo[a]pyrene, EPA:

- Added an oral reference dose of $3 \times 10^{-4} \text{ mg/kg-day}$.
- Added an inhalation reference concentration (RfC) of $2 \times 10^{-6} \text{ mg/m}^3$. For noncancer, EPA identifies the RfC, and does not present conversions to an inhalation reference dose (RfDi). For calculating cleanup levels based on inhalation exposure for noncarcinogenic endpoints, MTCA expresses inhalation toxicity data as an inhaled dose or intake expressed as a RfDi – based on adjustments for body weight (70 kilograms) and breathing rate (20 m³/day). The conversion formula is presented below.
 - $\text{RfDi (mg/kg-day)} = (\text{RfCi [mg/m}^3] \div 70 \text{ kg}) \times 20 \text{ m}^3/\text{day}$.

II. How the MTCA default cleanup levels for cPAHs and Benzo[a]pyrene were determined

Framework for Cleanup Level Determination

Cleanup levels for MTCA sites are selected from among several possible options, including:

- Applicable state and federal laws (ARARs);
- MTCA risk-based cleanup level equations, table values, and adjustments;
- Ecological risk assessment determinations;
- Background concentrations; and
- Practical quantitation limits (PQLs).

Selection of a site's appropriate cleanup level is influenced by the specific hazardous substance, the existence of applicable laws, the environmental medium that is contaminated, and site-specific factors. As shown in **Table 1**, depending on the environmental medium and choice of MTCA Method, the default cleanup levels for benzo[a]pyrene and cPAH mixtures will be based on ARARs, numbers in tables in the MTCA regulation, or risk-based values calculated using the MTCA equations.

Adjustments for Early-Life Exposure to Mutagenic Hazardous Substances

As noted above, EPA has determined that benzo[a]pyrene has a mutagenic mode of action and recommends using Age-Dependent Adjustment Factors (ADAFs) to address the increased sensitivity of children (compared to adults) to its carcinogenic effects. This affects the calculation of Method B cleanup levels using the MTCA equations, resulting in lower cleanup levels compared to standard calculations. Previously, Ecology used this approach to calculate cleanup levels for trichloroethylene, a mutagenic hazardous substance. The adjustment methods are based on information in EPA's March 2005 document, *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens*, publication no. EPA/630/R-03/003F.

As recommended by EPA, the ability of a mutagen (such as benzo[a]pyrene) to cause cancer in children less than 2 years of age is assumed to be 10 times greater than in adults. In practice, the cancer potency factor is multiplied by a 10-fold ADAF for cleanup level calculations that include exposure to children up to 2 years of age. Similarly, the ability of a mutagen to cause cancer in children from their second through sixteenth birthday is assumed to be 3 times greater than in adults, and the cancer potency factor is multiplied by an ADAF of 3 when children in that age range are exposed.

To calculate an **Early-Life Exposure (ELE) adjustment**, the ADAF is combined with certain exposure parameters that can change with age in the MTCA cleanup level equations (e.g., intake rate for soil, water, or air; body weight; exposure duration). This ELE is substituted into the MTCA equations for those exposure parameters to derive a cleanup level. The calculations start with the MTCA Equations for carcinogens for potable surface water and groundwater (720-2), surface water (730-2), soil (740-2), and air (750-2). Depending on the environmental medium (soil, groundwater, surface water, or air), age-specific adjustments are made to the equations, based on the parameters in **Table 2** below.

Table 2: Age-specific adjustments for early-life exposure

Early-Life Exposure Age Adjustment Factors for Carcinogens – Soil, Groundwater, Surface Water, and Air 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
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 (2)	Soil Ingestion rate, mg/day	200	200	50	50
FCR (3)	Fish consumption rate, grams/day	54	54	54	54
BR	Breathing rate, m ³ /day	10	10	20	20

- (1) ADAFs only apply to early-life adjustments for kidney cancer.
- (2) 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.
- (3) 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.

Detailed calculations for ELEs and cleanup levels for the various environmental media are described in the sections below.

III. Method B soil calculations

MTCA soil calculations for benzo[a]pyrene and cPAHs

Step 1 of 2. Without the ELE adjustment, the MTCA Method B Equation 740-2 is normally used to calculate Soil Cleanup levels for carcinogens (from WAC 173-340-740):

$$\text{Soil Cleanup Level} \left(\frac{\text{mg}}{\text{kg}} \right) = \frac{\text{RISK} \times \text{ABW} \times \text{AT} \times \text{UCF}}{\text{CPFo} \times \text{SIR} \times \text{AB1} \times \text{ED} \times \text{EF}}$$

Table 3: Default parameters for Equation 740-2

Parameter	Abbreviation	Default Value	Units
Acceptable Cancer Risk	RISK	1 x 10 ⁻⁶	unitless
Average Body Weight	ABW	16	kilograms
Averaging Time	AT	75	years
Unit Conversion Factor	UCF	1 x 10 ⁶	milligrams/kilogram
Oral Cancer Potency Factor	CPFo	Chemical-specific*	kilogram-day/milligram
Soil Ingestion Rate	SIR	200	milligrams/day
Absorption Fraction	AB1	1	unitless
Exposure Duration	ED	6	years
Exposure Frequency	EF	1	unitless

*For benzo[a]pyrene, the CPFo = 1 kilogram-day/milligram.

Step 2 of 2.

The soil cleanup level equation is based on exposures that occur during the first 6 years of life (birth through the 6th birthday). However, since the ADAF is reduced from 10 to 3 at the second birthday, two separate calculations are needed; one from birth to age 2, and another from age 2 to age 6. The exposure duration is also changed to be consistent with the ADAF age ranges. The ELE adjustment is calculated as follows:

$$\begin{aligned} \text{ELE (soil)} &= ((\text{ADAF}_{<2\text{yr}} \times \text{ED}_{<2\text{yr}} \times \text{SIR}_{<2\text{yr}}) / \text{BW}_{<2\text{yr}}) + ((\text{ADAF}_{2-6\text{yr}} \times \text{ED}_{2-6\text{yr}} \times \text{SIR}_{2-6\text{yr}}) / \text{BW}_{2-6\text{yr}}) = \\ &= ((10 \times 2 \text{ yr} \times 200 \text{ mg/day}) / 16 \text{ kg}) + ((3 \times 4 \text{ yr} \times 200 \text{ mg/day}) / 16 \text{ kg}) = \\ &= \mathbf{400 \text{ (milligram-year)/(kilogram-day)}} \end{aligned}$$

This is substituted into the soil cleanup level equation, replacing the equivalent parameters:

$$\begin{aligned} \text{Soil Cleanup Level} \left(\frac{\text{mg}}{\text{kg}} \right) &= \frac{\text{RISK} \times \text{AT} \times \text{UCF}}{\text{CPFo} \times \text{AB1} \times \text{EF} \times \text{ELE}} \\ &= \frac{0.000001 \times 75 \text{ yr} \times 1,000,000 \text{ mg/kg}}{1 \frac{(\text{kg} - \text{day})}{\text{mg}} \times 1 \times 1 \times 400 \frac{\text{mg} - \text{yr}}{\text{kg} - \text{day}}} \\ &= \mathbf{0.1875 \text{ mg/kg (rounded to 0.19 mg/kg)}} \end{aligned}$$

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 130 mg/kg (MTCA Equation 745-2).

IV. Method B groundwater calculations

MTCA groundwater calculations for benzo[a]pyrene and cPAHs

Step 1 of 2. Without the ELE adjustment, the MTCA Method B Equation 720-2 is normally used to calculate Groundwater Cleanup levels for carcinogens (from WAC 173-340-720):

$$\text{Groundwater Cleanup Level } \left(\frac{\mu\text{g}}{\text{L}}\right) = \frac{\text{RISK} \times \text{ABW} \times \text{AT} \times \text{UCF}}{\text{CPFo} \times \text{DWIR} \times \text{ED} \times \text{INH} \times \text{DWF}}$$

Table 4: Default parameters for Equation 720-2

Parameter	Abbreviation	Default Value	Units
Acceptable Cancer Risk	RISK	1 x 10 ⁻⁶	unitless
Average Body Weight	ABW	70	kilograms
Averaging Time	AT	75	years
Unit Conversion Factor	UCF	1 x 10 ³	micrograms/milligram
Oral Cancer Potency Factor	CPFo	Chemical-specific*	kilogram-day/milligram
Drinking Water Ingestion Rate	DWIR	2	liters/day
Exposure Duration	ED	30	years
Inhalation Correction Factor	INH	1	unitless
Drinking Water Fraction	DWF	1	unitless

*For benzo[a]pyrene, the CPFo = 1 kilogram-day/milligram.

Step 2 of 2.

The groundwater cleanup level equation is based on exposures that occur during the first 30 years of life (birth through the 30th birthday). The ADAF changes from 10 to 3 at the second birthday, and from 3 to 1 at age 16. Also, the body weight and drinking water ingestion rate change at age 6. The calculation of the ELE adjustment requires four separate calculations; one from birth to age 2, one from age 2 to age 6, one from age 6 to age 16, and one from age 16 through age 30. The ELE adjustment is calculated as follows:

$$\begin{aligned} \text{ELE (groundwater)} = & ((\text{ADAF}_{<2\text{yr}} \times \text{ED}_{<2\text{yr}} \times \text{DWIR}_{<2\text{yr}}) / \text{BW}_{<2\text{yr}}) + ((\text{ADAF}_{2-6\text{yr}} \times \text{ED}_{2-6\text{yr}} \times \text{DWIR}_{2-6\text{yr}}) / \text{BW}_{2-6\text{yr}}) + \\ & ((\text{ADAF}_{6-16\text{yr}} \times \text{ED}_{6-16\text{yr}} \times \text{DWIR}_{6-16\text{yr}}) / \text{BW}_{6-16\text{yr}}) + ((\text{ADAF}_{16-30\text{yr}} \times \text{ED}_{16-30\text{yr}} \times \text{DWIR}_{16-30\text{yr}}) / \text{BW}_{16-30\text{yr}}) = \\ & ((10 \times 2 \text{ yr} \times 1 \text{ L/day}) / 16 \text{ kg}) + ((3 \times 4 \text{ yr} \times 1 \text{ L/day}) / 16 \text{ kg}) + ((3 \times 10 \text{ yr} \times 2 \text{ L/day}) / 70 \text{ kg}) + ((1 \times 14 \text{ yr} \times 2 \\ & \text{L/day}) / 70 \text{ kg}) = \end{aligned}$$

$$\mathbf{3.26 \text{ (liter-year)/(kilogram-day)}}$$

This is substituted into the groundwater cleanup level equation, replacing the equivalent parameters:

$$\begin{aligned} \text{Groundwater Cleanup Level } \left(\frac{\mu\text{g}}{\text{L}} \right) &= \frac{\text{RISK} \times \text{AT} \times \text{UCF}}{\text{CPF}_0 \times \text{INH} \times \text{DWF} \times \text{ELE}} \\ &= \frac{0.000001 \times 75 \text{ yr} \times 1,000 \mu\text{g}/\text{mg}}{1 \frac{(\text{kg} - \text{day})}{\text{mg}} \times 1 \times 1 \times 3.26 \frac{\text{L} - \text{yr}}{\text{kg} - \text{day}}} \\ &= \mathbf{0.023 \mu\text{g}/\text{L}} \end{aligned}$$

Note that the EPA and Washington State Maximum Contaminant Levels (MCL) for drinking water are both 0.2 µg/L. Since this MCL is an applicable federal and state law and is associated with a lifetime excess cancer risk of less than one in one hundred thousand and a hazard quotient of 1, it is considered sufficiently protective and is the appropriate default MTCA Method B groundwater cleanup level. See the MTCA regulation (WAC 173-340-720(7)(b)).

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 cleanup level is calculated the same as above except that the target cancer risk is 1×10^{-5} . In this case, the Method C calculated groundwater cleanup level adjusted for ELE is 0.23 µg/L. In the absence of meeting the criteria set forth in WAC 173-340-706(1)(a), the Method C calculated groundwater cleanup level is 0.88 µg/L based on adult exposure (MTCA Equation 720-2 adjusted for Method C). As noted above, the MCL of 0.2 µg/L is sufficiently protective and is the appropriate default MTCA Method C groundwater cleanup level.

V. Method B surface water calculations

MTCA surface water calculations for benzo[a]pyrene and cPAHs

Step 1 of 2. Without the ELE adjustment, the MTCA Method B Equation 730-2 is normally used to calculate Surface Water Cleanup levels for carcinogens (from WAC 173-340-730):

$$\text{Surface Water Cleanup Level } \left(\frac{\mu\text{g}}{\text{L}} \right) = \frac{\text{RISK} \times \text{ABW} \times \text{AT} \times \text{UCF1} \times \text{UCF2}}{\text{CPFo} \times \text{BCF} \times \text{FCR} \times \text{FDF} \times \text{ED}}$$

Table 5: Default parameters for Equation 730-2

Parameter	Abbreviation	Default Value	Units
Acceptable Cancer Risk	RISK	1 x 10 ⁻⁶	unitless
Average Body Weight	ABW	70	kilograms
Averaging Time	AT	75	years
Unit Conversion Factor 1	UCF1	1 x 10 ³	micrograms/milligram
Unit Conversion Factor 2	UCF2	1 x 10 ³	grams/kilogram
Oral Cancer Potency Factor	CPFo	Chemical-specific*	kilogram-day/milligram
Bioconcentration Factor	BCF	30	liters/kilogram
Fish Consumption Rate	FCR	54	grams/day
Fish Diet Fraction	FDF	0.5	unitless
Exposure Duration	ED	30	years

*For benzo[a]pyrene, the CPFo = 1 kilogram-day/milligram.

Step 2 of 2.

The surface water cleanup level equation is based on exposures that occur during the first 30 years of life (birth through the 30th birthday). The ADAF changes from 10 to 3 at the second birthday, and from 3 to 1 at age 16. Also, the body weight changes at age 6. This requires four separate calculations; one from birth to age 2, one from age 2 to age 6, one from age 6 to age 16, and one from age 16 through age 30.

$$\begin{aligned} \text{ELE (surface water)} &= ((\text{ADAF}_{<2\text{yr}} \times \text{ED}_{<2\text{yr}} \times \text{FCR}_{<2\text{yr}}) / \text{BW}_{<2\text{yr}}) + ((\text{ADAF}_{2-6\text{yr}} \times \text{ED}_{2-6\text{yr}} \times \text{FCR}_{2-6\text{yr}}) / \text{BW}_{2-6\text{yr}}) + \\ & ((\text{ADAF}_{6-16\text{yr}} \times \text{ED}_{6-16\text{yr}} \times \text{FCR}_{6-16\text{yr}}) / \text{BW}_{6-16\text{yr}}) + ((\text{ADAF}_{16-30\text{yr}} \times \text{ED}_{16-30\text{yr}} \times \text{FCR}_{16-30\text{yr}}) / \text{BW}_{16-30\text{yr}}) = \\ & ((10 \times 2 \text{ yr} \times 54 \text{ g/day}) / 16 \text{ kg}) + ((3 \times 4 \text{ yr} \times 54 \text{ g/day}) / 16 \text{ kg}) + ((3 \times 10 \text{ yr} \times 54 \text{ g/day}) / 70 \text{ kg}) + ((1 \times 14 \text{ yr} \times \\ & 54 \text{ g/day}) / 70 \text{ kg}) = \\ & \mathbf{141.9 \text{ (gram-year)/(kilogram-day)}} \end{aligned}$$

This is substituted into the surface water cleanup level equation, replacing the equivalent parameters:

$$\begin{aligned} \text{Surface Water Cleanup Level } \left(\frac{\mu\text{g}}{\text{L}} \right) &= \frac{\text{RISK} \times \text{AT} \times \text{UCF1} \times \text{UCF2}}{\text{CPFo} \times \text{BCF} \times \text{FDF} \times \text{ELE}} \\ &= \frac{0.000001 \times 75 \text{ yr} \times 1,000 \frac{\mu\text{g}}{\text{mg}} \times 1,000 \frac{\text{g}}{\text{kg}}}{1 \frac{(\text{kg} - \text{day})}{\text{mg}} \times 30 \frac{\text{L}}{\text{kg}} \times 0.5 \times 141.9 \frac{\text{g} - \text{yr}}{\text{kg} - \text{day}}} \\ &= \mathbf{0.035 \mu\text{g/L}} \end{aligned}$$

The EPA Quality criterion listed in 40 CFR 131.45 is 0.000016 µg/L for both fresh water and marine water. Since this is an applicable federal law and is lower than the level calculated above, the appropriate Method B cleanup level for both fresh water and marine water is 0.000016 µg/L.

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 1×10^{-5} and the fish diet fraction is 0.2. In this case, the Method C calculated surface water cleanup level adjusted for ELE is 0.88 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 5.4 µg/L based on adult exposure (MTCA Equation 730-2 adjusted for Method C). As noted above, the federal human health criterion of 0.000016 µg/L is sufficiently protective and is the appropriate default MTCA Method C surface water cleanup level.

VI. Method B air calculations

MTCA air calculations for benzo[a]pyrene and cPAHs

Step 1 of 1. Without the ELE adjustment, the MTCA Method B Equation 750-2 is normally used to calculate Air Cleanup levels for carcinogens (from WAC 173-340-750):

$$\text{Air Cleanup Level} \left(\frac{\mu\text{g}}{\text{m}^3} \right) = \frac{\text{RISK} \times \text{ABW} \times \text{AT} \times \text{UCF}}{\text{CPF}_i \times \text{BR} \times \text{ABS} \times \text{ED} \times \text{EF}}$$

Table 6: Default parameters for Equation 750-2

Parameter	Abbreviation	Default Value	Units
Acceptable Cancer Risk	RISK	1 x 10 ⁻⁶	unitless
Average Body Weight	ABW	70	kilograms
Averaging Time	AT	75	years
Unit Conversion Factor	UCF	1 x 10 ³	micrograms/milligram
Inhalation Cancer Potency Factor	CPF _i	Chemical-specific*	kilogram-day/milligram
Breathing Rate	BR	20	cubic meters/day
Inhalation Absorption Fraction	ABS	1	unitless
Exposure Duration	ED	30	years
Exposure Frequency	EF	1	unitless

*For benzo[a]pyrene, the CPF_i = 2.1 kilogram-day/milligram.

Step 2 of 2.

The air cleanup level equation is based on exposures that occur during the first 30 years of life (birth through the 30th birthday). The ADAF changes from 10 to 3 at the second birthday, and from 3 to 1 at age 16. Also, the body weight and breathing rate change at age 6. The calculation of the ELE adjustment requires four separate calculations; one from birth to age 2, one from age 2 to age 6, one from age 6 to age 16, and one from age 16 through age 30. The ELE adjustment is calculated as follows:

$$\begin{aligned} \text{ELE (air)} &= ((\text{ADAF}_{<2\text{yr}} \times \text{ED}_{<2\text{yr}} \times \text{BR}_{<2\text{yr}})/\text{BW}_{<2\text{yr}}) + ((\text{ADAF}_{2-6\text{yr}} \times \text{ED}_{2-6\text{yr}} \times \text{BR}_{2-6\text{yr}})/\text{BW}_{2-6\text{yr}}) + \\ &((\text{ADAF}_{6-16\text{yr}} \times \text{ED}_{6-16\text{yr}} \times \text{BR}_{6-16\text{yr}})/\text{BW}_{6-16\text{yr}}) + ((\text{ADAF}_{16-30\text{yr}} \times \text{ED}_{16-30\text{yr}} \times \text{BR}_{16-30\text{yr}})/\text{BW}_{16-30\text{yr}}) = \\ &((10 \times 2 \text{ yr} \times 10 \text{ m}^3/\text{day})/16 \text{ kg}) + ((3 \times 4 \text{ yr} \times 10 \text{ m}^3/\text{day})/16 \text{ kg}) + ((3 \times 10 \text{ yr} \times 20 \text{ m}^3/\text{day})/70 \text{ kg}) + ((1 \times 14 \\ &\text{ yr} \times 20 \text{ m}^3/\text{day})/70 \text{ kg})= \end{aligned}$$

32.6 (cubic meters-year)/(kilogram-day)

$$\begin{aligned} \text{Air Cleanup Level } \left(\frac{\mu\text{g}}{\text{m}^3}\right) &= \frac{\text{RISK} \times \text{AT} \times \text{UCF}}{\text{CPF}_i \times \text{ABS} \times \text{EF} \times \text{ELE}} \\ \text{Air Cleanup Level } \left(\frac{\mu\text{g}}{\text{m}^3}\right) &= \frac{0.000001 \times 75 \text{ yr} \times 1000 \mu\text{g}/\text{mg}}{2.1 \frac{(\text{kg} - \text{d})}{\text{mg}} \times 1 \times 1 \times 32.6 \frac{\text{m}^3 - \text{yr}}{\text{kg} - \text{day}}} \\ &= \mathbf{0.0011 \mu\text{g}/\text{m}^3} \end{aligned}$$

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 1×10^{-5} . In this case, the Method C calculated air cleanup level adjusted for ELE is $0.011 \mu\text{g}/\text{m}^3$. In the absence of meeting the criteria set forth in WAC 173-340-706(1)(a), the Method C calculated air cleanup level is $0.042 \mu\text{g}/\text{m}^3$ based on adult exposure (MTCA Equation 750-2 adjusted for Method C)

Acronyms and Abbreviations

Acronym or Abbreviation	Definition
ABW	average body weight
ABS	Inhalation Absorption Fraction
ADAF	Age-Dependent Adjustment Factor
ARAR	Applicable or Relevant and Appropriate Requirement
AT	averaging time
BaP	Benzo[a]pyrene
BCF	Bioconcentration Factor
BR	breathing rate
BW	body weight
CFR	Code of Federal Regulations
CLARC	Cleanup Levels and Risk Calculation
cPAH	Carcinogenic Polycyclic Aromatic Hydrocarbons
CPFi	Inhalation Cancer Potency Factor
CPFo	Oral Cancer Potency Factor
Ecology	Washington State Department of Ecology
ED	exposure duration
ELE	Early-Life Exposure
EPA	United States Environmental Protection Agency
FCR	Fish Consumption Rate
FDF	Fish Diet Fraction
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
MCL	Maximum Contaminant Level
µg /kg	Micrograms per kilogram
µg /L	Micrograms per liter
µg/m ³	Micrograms per cubic meter
MTCA	Model Toxics Control Act
NTR	National Toxics Rule
PQL	Practical Quantitation Limit
RfC	Reference Concentration
RfDi	Inhalation Reference Dose
RISK	Acceptable cancer risk level (1 in 1,000,000) (unitless)
TEF	Toxicity Equivalent Factor
UCF	unit conversion factor
WAC	Washington Administrative Code