

# Soil Cleanup Levels to Protect Groundwater

## Protecting Groundwater from Contaminants in Soil

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Under the Model Toxics Control Act (MTCA) Cleanup Rule ([Chapter 173-340 WAC](#)),<sup>1</sup> when selecting a cleanup level for a chemical contaminant in soil, one criterion to consider is the potential for the contaminant to leach from soil into groundwater. Specifically, the concentrations of hazardous substances in soil should not cause contamination of groundwater that exceeds cleanup levels established under [WAC 173-340-720](#),<sup>2</sup> including surface water beneficial uses under [WAC 173-340-730](#).<sup>3</sup> These pathways are considered in addition to the direct-contact criterion that is based on ingestion of soil (and dermal absorption for Modified Methods B and C evaluations).

## Default Soil Concentrations Protective of Groundwater

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[WAC 173-340-747](#)<sup>4</sup> presents several methods for establishing soil concentrations that are considered protective of groundwater. Most of the options require a site-specific evaluation based on data collected from the site. However, one method uses default values to derive soil cleanup levels protective of groundwater (for any hazardous substance) and does not require site-specific data. Ecology used this “fixed parameter three-phase partitioning model” (described in [WAC 173-340-747\(4\)](#) and based on [MTCA Equation 747-1](#)<sup>5</sup>) to calculate default soil cleanup levels protective of potable groundwater, and groundwater that may discharge to surface water (fresh or marine waters). These results are listed in CLARC. We listed concentrations for both unsaturated (i.e., vadose zone) and groundwater-saturated zone soils in the CLARC tables to provide protective concentrations that are easy to use without site-specific data and calculations. Where available, we used unitless Henry’s law constants at 13 degrees Celsius in the calculations based on typical groundwater temperatures in Washington state. If chemical-specific data was not available to derive a Henry’s law constant at 13 degrees Celsius, a Henry’s law constant at 25 degrees Celsius was used in the calculation if available.

[Ecology’s Implementation Memo #10](#)<sup>6</sup> provides guidance on evaluating the potential for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in soil to impact groundwater. The MTCA Cleanup Rule requires that the physical and chemical properties of individual cPAHs be considered ([WAC 173-340-](#)

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<sup>1</sup> <https://app.leg.wa.gov/wac/default.aspx?cite=173-340>

<sup>2</sup> <https://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720> (Groundwater cleanup standards.)

<sup>3</sup> <https://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-730> (Surface water cleanup standards.)

<sup>4</sup> <https://app.leg.wa.gov/wac/default.aspx?cite=173-340-747> (Deriving soil concentrations for groundwater protection.)

<sup>5</sup> <https://app.leg.wa.gov/wac/default.aspx?cite=173-340-747>

<sup>6</sup> <https://apps.ecology.wa.gov/publications/SummaryPages/1509049.html>

[708\(8\)\(e\)\(iv\)](#)<sup>7</sup> when evaluating soil impacts to groundwater. This involves evaluating both the toxicity and mobility of the individual cPAHs to develop a Total Toxic Mobility Equivalent Concentration (Total TMEQ) for the cPAH mixture. The Total TMEQ for the cPAH mixture is then compared to the soil concentration protective of groundwater for benzo(a)pyrene as provided in CLARC.

## Importance of the Target Groundwater Concentration

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A critical parameter for soil-to-groundwater calculations is the target groundwater cleanup level. A target surface water cleanup level is used to evaluate the groundwater to surface water pathway (i.e., when groundwater may discharge to nearby surface water). The soil cleanup level depends on back-calculating from the target cleanup level (i.e., potable groundwater, fresh surface water, or marine surface water). The selection of potable and nonpotable groundwater cleanup levels is discussed in WAC 173-340-720, and the selection of surface water cleanup levels is discussed in WAC 173-340-730. The soil-to-groundwater cleanup levels listed in CLARC are based on protection of groundwater (as a potable source) and surface water (protection of human health and aquatic life) to appropriate standard Method B concentrations.

## Selecting the Appropriate Potable Groundwater Cleanup Level Target

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The general framework for selecting standard Method B potable groundwater cleanup levels is described in WAC 173-340-720(4)(b) and WAC 173-340-720(7). Briefly, there are three sets of numbers to consider when you are selecting standard Method B cleanup levels for potable groundwater:

1. **Groundwater cleanup levels calculated with [MTCA Equation 720-1](#) (for noncarcinogens) and [MTCA Equation 720-2](#)<sup>8</sup> (for carcinogens).** These are available in CLARC.
2. **Concentrations established under applicable state and federal laws such as Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs).** These are also referred to as applicable, relevant, and appropriate requirements (ARARs). These are available in CLARC.
3. **Adjustments to the ARARs, as described in WAC 173-340-720(7)(b).** Specifically, you may have to adjust cleanup levels based on ARARs to lower concentrations to ensure that the Aexcess cancer risk associated with exposure to the chemical in groundwater is no more than one in one hundred thousand ( $1 \times 10^{-5}$ ) and the hazard quotient is no more than one (1).

To derive the target groundwater cleanup levels for the soil-to-groundwater pathway, we used the following procedure, which is consistent with the MTCA Cleanup Rule:

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<sup>7</sup> <https://apps.leg.wa.gov/wac/default.aspx?cite=173-340-708> (Human health risk assessment procedures.)

<sup>8</sup> <https://app.leg.wa.gov/wac/default.aspx?cite=173-340-720> (Groundwater cleanup standards.)

- **If a chemical does not have an ARAR:** The groundwater Method B cleanup level is calculated using MTCA Equations 720-1 (for noncarcinogens) and 720-2 (for carcinogens), whichever concentration is lower. These are available in CLARC.
- **If a chemical has an ARAR:** The groundwater Method B cleanup level is the lower of these values, unless it requires adjustment (see below).
- **Check to see if the ARAR should be adjusted downward.** If an ARAR is associated with an excess cancer risk of greater than one in one hundred thousand ( $1 \times 10^{-5}$ ) or a hazard quotient of more than one (1), as calculated using MTCA Equations 720-1 or 720-2, then the groundwater Method B cleanup level must be adjusted downward from the ARAR concentration so that the excess cancer risk is no greater than one in one hundred thousand ( $1 \times 10^{-5}$ ) and the hazard quotient is no more than one (1)<sup>9</sup>. See WAC 173-340-720(7)(b).

## Selecting the Appropriate Surface Water Cleanup Level Target

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The general framework for selecting standard Method B surface water cleanup levels is described in WAC 173-340-730(3)(b) and WAC 173-340-730(5), and separate cleanup levels are derived for fresh and marine surface water. There are four sets of numbers to consider when you are selecting standard Method B cleanup levels for fresh and marine surface water:

1. **Surface water cleanup levels calculated with [MTCA Equations 730-1](#) (for noncarcinogens) and [MTCA Equation 730-2](#)<sup>10</sup> (for carcinogens).** These are based on the protection of human fish consumption and are available in CLARC. These apply to both fresh and marine surface water. Bioconcentration factors (BCFs) provided in CLARC are used in the equations to estimate the uptake of the contaminant from ambient water to fish. The BCF values provided in CLARC are those used by the U.S. Environmental Protection Agency (EPA) to establish ambient water quality criteria. See WAC 173-340-708(9).
2. **Fresh and marine surface water concentrations that are protective of human health and are established under applicable state ([173-201A-240 WAC](#))<sup>11</sup> and federal laws ([Section 304 of the](#)**

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<sup>9</sup> You may need to make further adjustments to ARARs to account for multiple hazardous substances and multiple exposure pathways at the site.

<sup>10</sup> <https://app.leg.wa.gov/wac/default.aspx?cite=173-340-730> (Groundwater cleanup standards.)

<sup>11</sup> <https://apps.leg.wa.gov/wac/default.aspx?cite=173-201A-240> (Toxic substances.)

[Clean Water Act \[CWA\]](#)<sup>12</sup>; [40 CFR Subpart D 131.45](#)<sup>13</sup>). These values are applied as ARARs in the development of surface water cleanup levels. Values for fresh water are based on combined effects from consumption of surface water as a potable source and consumption of organisms (e.g., fish and shellfish). Values for marine water are based solely on consumption of organisms. These values are applied as ARARs in the development of surface water cleanup levels.

3. **Fresh and marine surface water concentrations that are protective of aquatic life under acute and chronic exposure conditions and are established under applicable state (WAC 173-201A) and federal laws (Section 304 of the CWA).** These values are applied as ARARs in the development of surface water cleanup levels.
4. **Adjustments to the ARARs, as described in WAC 173-340-730(5)(b).** Specifically, you may have to adjust cleanup levels based on ARARs to lower concentrations to ensure that the excess cancer risk associated with exposure to the chemical in groundwater is no more than one in one hundred thousand ( $1 \times 10^{-5}$ ) and the hazard quotient is no more than one (1).

To derive the target fresh and marine surface water cleanup levels for the soil-to-groundwater pathway, we used the following procedure, which is consistent with the MTCA Cleanup Rule:

- **If a chemical does not have an ARAR:** The surface water Method B cleanup level is calculated using MTCA Equations 730-1 (for noncarcinogens) and 730-2 (for carcinogens), whichever concentration is lower. These are available in CLARC.
- **If a chemical has an ARAR:** The surface water Method B cleanup level is the lower of these values, unless it requires adjustment (see below).
- **Check to see if the ARAR should be adjusted downward.** If an ARAR is associated with an excess cancer risk of greater than one in one hundred thousand ( $1 \times 10^{-5}$ ) or a hazard quotient of more than one (1), as calculated using MTCA Equations 730-1 or 730-2, then the surface water Method B cleanup level must be adjusted downward from the ARAR concentration so that the excess cancer risk is no greater than one in one hundred thousand ( $1 \times 10^{-5}$ ) and the hazard quotient is no more than one (1)<sup>14</sup>. See WAC 173-340-730(5)(b).

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<sup>12</sup> <https://www.epa.gov/wqc>

<sup>13</sup> <https://ecfr.io/Title-40/Section-131.45>. For guidance applying the 40 CFR Subpart D 131.45 values, see TCP Interim Policy 730: Taking into Account Federal Human Health Surface Water Quality Criteria under MTCA at <https://apps.ecology.wa.gov/publications/SummaryPages/2009059.html>

<sup>14</sup> You may need to make further adjustments to ARARs to account for multiple hazardous substances and multiple exposure pathways at the site.

## Soil Protective of Potable Groundwater, Fresh Surface Water, and Marine Surface Water Cleanup Levels in CLARC

As shown in the following screenshot, the [CLARC Method B Soil Table](#)<sup>15</sup> (which is also found in the [Master Table](#)<sup>16</sup>) has information related to the soil-to-groundwater pathway as a potable source, and the pathway where groundwater discharges to nearby surface water (Groundwater→SW).

<b>Soil</b> Protective of Groundwater Vadose @ 13 degrees C (Eq. 747-1) <a href="#">see guidance</a> (mg/kg)	<b>Soil</b> Protective of Groundwater Saturated (Eq. 747-1) <a href="#">see guidance</a> (mg/kg)	<b>Soil</b> Protective of Groundwater→SW Vadose @ 13 degrees C <b>Fresh Water</b> (Eq. 747-1) <a href="#">see guidance</a> (mg/kg)	<b>Soil</b> Protective of Groundwater→SW Saturated <b>Fresh Water</b> (Eq. 747-1) <a href="#">see guidance</a> (mg/kg)	<b>Soil</b> Protective of Groundwater→SW Vadose @ 13 degrees C <b>Marine Water</b> (Eq. 747-1) <a href="#">see guidance</a> (mg/kg)	<b>Soil</b> Protective of Groundwater→SW Saturated <b>Marine Water</b> (Eq. 747-1) <a href="#">see guidance</a> (mg/kg)	<b>Ground Water</b> WA State Maximum Contaminant Level 246-290 WAC (µg/L)	<b>Ground Water</b> Target Cleanup Level for Soil to Ground Water Pathway <a href="#">see guidance</a> (µg/L)	<b>Surface Water</b> Target Cleanup Level for Soil to Surface Water Pathway <b>Fresh Water</b> <a href="#">see guidance</a> (µg/L)	<b>Surface Water</b> Target Criterion <b>Fresh Water</b> <a href="#">see guidance</a>	<b>Surface Water</b> Target Cleanup Level for Soil to Surface Water Pathway <b>Marine Water</b> <a href="#">see guidance</a> (µg/L)	<b>Surface Water</b> Target Criterion <b>Marine Water</b> <a href="#">see guidance</a>
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- The first six columns are **soil concentrations that are protective of groundwater as a potable source, as fresh surface water, and as marine surface water**. Protective concentrations in soil are provided for both unsaturated (i.e., vadose zone) and groundwater-saturated zone soils. These were calculated using the fixed parameter three-phase partitioning model provided in MTCA Equations 747-1 and 747-2. Ecology used default values listed in the equations (i.e., separate defaults for vadose<sup>17</sup> and saturated<sup>18</sup> soil conditions) along with chemical-specific values for the distribution coefficient ( $K_d$ ) and Henry's law, as provided in CLARC. We recommend that site managers use the cleanup levels calculated with Henry's law constants at 13° Celsius, which reflects typical groundwater temperatures in Washington state.
- The second set provides the **target groundwater cleanup levels (based on potable use)** used to generate the calculations, along with the criterion that formed the basis of the selected target level. Abbreviations for target criterion found in the table are:
  - N** = Noncarcinogen, Method B calculation using MTCA Equation 720-1.
  - C** = Carcinogen, Method B calculation using MTCA Equation 720-2.
  - MCL or MCLG** = Federal drinking water maximum contaminant level or maximum contaminant level goal. These are the current ARARs identified in CLARC.

<sup>15</sup>[https://www.ezview.wa.gov/Portals/\\_1987/Documents/Documents/CLARC\\_SoilMethodABandGWP\\_unrestricted.pdf](https://www.ezview.wa.gov/Portals/_1987/Documents/Documents/CLARC_SoilMethodABandGWP_unrestricted.pdf)

<sup>16</sup> [https://www.ezview.wa.gov/Portals/\\_1987/Documents/Documents/CLARC\\_Master.pdf](https://www.ezview.wa.gov/Portals/_1987/Documents/Documents/CLARC_Master.pdf)

<sup>17</sup> Soil-to-groundwater cleanup levels for vadose zone soil were not calculated for organic chemicals that have a  $K_d$  value, but lack a Henry's law value in CLARC. With the exception of mercury, we used a Henry's law of zero in the calculation for metals.

<sup>18</sup> A Henry's law value is not needed to calculate soil-to-groundwater cleanup levels for saturated zone soil since the air-filled soil porosity is assumed to be zero.

- **MCL C ADJ or MCLG C ADJ** = MCL or MCLG adjusted to a lower concentration so that the excess cancer risk is one in one hundred thousand ( $1 \times 10^{-5}$ ). See WAC 173-340-720(7)(b).
  - **MCL N ADJ or MCLG N ADJ** = MCL or MCLG adjusted to a lower concentration so that the noncancer hazard index is no greater than one (1). See WAC 173-340-720(7)(b).
  - **Background** = For example, we used the Washington groundwater background concentration for arsenic as referenced in MTCA Table 720-1.
3. The third set provides the **target surface water cleanup levels (fresh and marine)** used to generate the calculations, along with the criterion that formed the basis of the selected target level. Abbreviations for target criterion found in the table are:
- **N** = Noncarcinogen, Method B calculation using MTCA Equation 730-1.
  - **C** = Carcinogen, Method B calculation using MTCA Equation 730-2.
  - **WQC\_HH** = Lowest Water Quality Criteria (WQC) ARAR (state or federal) in CLARC based on protection of surface water for potable use and consumption of organisms (applicable for fresh water), or based on consumption of organisms only (applicable for marine water).
  - **WQC\_AL** = Lowest ARAR (state or federal) in CLARC based on protection of aquatic life under acute and chronic conditions.
  - **WQC C ADJ** = WQC adjusted to a lower concentration so that the excess cancer risk is one in one hundred thousand ( $1 \times 10^{-5}$ ). See WAC 173-340-730(5)(b).
  - **WQC N ADJ** = WQC adjusted to a lower concentration so that the noncancer hazard index is no greater than one (1). See WAC 173-340-730(5)(b).
  - **Background** = For example, we used the Washington groundwater background concentration for arsenic as referenced in MTCA Table 720-1. A groundwater background value was selected because the pathway is soil leaching to groundwater.

## Soil-to-Groundwater Cleanup Levels in CLARC for Ionizing Organics: Additional Steps

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As listed in MTCA Table 747-2, nine chemicals have carbon-water partitioning coefficients (Koc) that vary as a function of soil pH:

- benzoic acid (CAS # 65-85-0)
- 2-chlorophenol (CAS # 95-57-8)
- 2,4-dichlorophenol (CAS # 120-83-2)
- 2,4-dinitrophenol (CAS # 51-28-5)
- pentachlorophenol (CAS # 87-86-5)

- 2,3,4,5-Tetrachlorophenol (CAS # 4901-51-3)<sup>19</sup>
- 2,3,4,6-Tetrachlorophenol (CAS # 58-90-2)
- 2,4,5-trichlorophenol (CAS # 95-95-4)
- 2,4,6-trichlorophenol (CAS # 88-06-2)

Default soil-to-groundwater cleanup levels for vadose zone soil and groundwater-saturated zone soil are provided in CLARC for these pH dependent chemicals, which are calculated using the fixed parameter three-phase partitioning model (MTCA Equations 747-1 and 747-2) and Koc at pH 6.8 (as listed in MTCA Table 747-2). Table 747-2 also provides Koc values for pH conditions of 4.9 and 8.0 which can be used to calculate site-specific soil-to-groundwater cleanup levels based on these pH conditions (using MTCA Equations 747-1 and 747-2). If the soil pH falls between those listed in Table 747-2, you can calculate the cleanup level by interpolating between the Koc values in MTCA Table 747-2. Then using that Koc, you can calculate the cleanup level with MTCA Equations 747-1 and 747-2. See WAC 173-340-747(4)(c)(i)(B).

## Cautions and Limitations

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As noted above, the generic soil-to-groundwater cleanup levels listed in the CLARC table:

- Have been calculated using only one of several possible methods.
- Are based on the assumption that the groundwater is either potable, or is discharging to surface water (fresh or marine).
- Do not address Method C groundwater cleanup levels.
- Do not consider site-specific factors.

Depending on conditions at the site, one of the other approaches described in WAC 173-340-747 may be more appropriate. Further, the generic values in the CLARC table may need to be adjusted to account for multiple hazardous substances, multiple exposure pathways, soil background concentrations, or practical quantitation limits.

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<sup>19</sup> 2,3,4,5-Tetrachlorophenol is not listed in CLARC due to the lack of available toxicity data and levels established under applicable state and federal laws.