

Preliminary Cleanup Level Workbook Supplemental Information

This supplemental information paper provides background information and instructions for using the Preliminary Cleanup Level (PCUL) workbook. PCULs apply to upland MTCA sites in Ecology's Northwest Region that have environmental transport pathways to surface water. The PCULs cover transport pathways to surface water as well as additional pathways not related to surface water to support complete MTCA cleanup actions.

The PCUL document is not intended to be used to establish discharge limits for permitted or unpermitted discharges at any site or water quality criteria for any surface water body.

A version of the PCUL workbook specific to the Lower Duwamish Waterway (LDW) site is posted on Ecology's LDW website¹. This version includes sediment cleanup levels (CULs) and remedial action levels (RALs) from EPA's (2014) record of decision (ROD) for the LDW. This version of the workbook can be modified for marine sites outside the LDW by eliminating the CULs and RALs specific to the LDW and making additional modifications from site-specific parameter values to default parameter values. Ask Priscilla Tomlinson or Kim Wooten for assistance in modifying the PCUL workbook for marine sites outside the LDW.

There is also a version of the PCUL workbook specific to the South Lake Union (SLU) area, which includes freshwater sediment and surface water. Ask Priscilla Tomlinson or Kim Wooten to access this version. The SLU version of the workbook is generic and can be used at any freshwater site.

The PCUL document implements the technical approach in an Ecology (2016a) policy memo regarding ground water CULs for the LDW by expanding it to more chemicals and additional transport pathways and by updating applicable or relevant and appropriate requirements (ARARs). The policy memo provides detailed discussions of the following issues that are not repeated here:

- Beneficial uses of the LDW
- Applicability of state and federal WQC for conventional parameters
- Rationale for using Method B CULs
- Descriptions of literature references used to estimate water concentrations protective of aquatic life.

The PCULs are calculated consistent with the Model Toxics Control Act (MTCA, 173-340 WAC), the Sediment Management Standards (SMS, 173-204 WAC), and guidance associated with both of these regulations.

The PCUL workbook has undergone quality assurance checks. Nevertheless, users are advised to perform their own quality assurance checks. Please notify Priscilla Tomlinson at priscilla.tomlinson@ecy.wa.gov or 425-324-0732 if potential errors are identified.

¹ <https://apps.ecology.wa.gov/cleanupsearch/site/1643#site-documents>.

Purpose of PCULs

The PCULs in the workbook are intended to be used for two purposes during the cleanup process:

- Remedial investigation: Initial screening of environmental chemical concentrations to identify chemicals and transport and exposure pathways of concern
- Feasibility study and cleanup action plan (CAP): Starting point for developing final, site-specific CULs and remediation levels (RELs, WAC 173-340-355).

The comparison of site contaminant concentrations to PCULs may be used to identify chemicals of potential concern (COPCs). In addition, if environmental concentrations of a chemical in a receiving medium do not exceed its PCUL for that medium, these data may be used to support an empirical demonstration that the applicable transport pathway is not occurring. Additional information concerning length of time the contamination has been present and anticipated future site conditions must also be considered in the empirical demonstration per WAC 173-340-747(9) and Implementation Memo 15 (Ecology 2016b).

For example, ground water concentrations in compliance with the ground water PCUL for a specific chemical could support a proposal to eliminate the leaching pathway from the soil PCUL for that chemical. Similarly, sediment concentrations in compliance with the sediment PCUL could support a proposal to eliminate protection of sediment from the ground water PCUL for that chemical. The Ecology cleanup project manager (site manager) will determine whether an empirical demonstration has been met.

The PCUL document should be the starting point for developing final CULs for LDW sites. Final CULs may be different from PCULs for reasons including, but not necessarily limited to, the following:

- Commercial or industrial land use (soil or air only)
- Exclusion from the terrestrial ecological evaluation (TEE) or qualification to use the simplified TEE
- Elimination of a transport pathway due to an empirical demonstration
- Consideration of natural attenuation during environmental transport
- Availability of biological data that over-ride the results of chemical testing (e.g., whole effluent toxicity test, benthic toxicity bioassay)
- Use of site-specific modeling (e.g., Reible sediment model, site-specific modeling of ground water transport)
- Adjustments based on practical quantitation limits (PQLs)
- Adjustments to consider additive noncancer hazards and cancer risks due to multiple chemicals and multiple exposure pathways.

Some of these issues are discussed later in this document.

Contents of Workbook

PCULs are calculated for a variety of environmental transport and exposure pathways. Soil PCULs are labeled SL-1 through SL-10; ground water PCULs are labeled GW-1 through GW-5; air PCULs are labeled AR-1; and soil gas PCULs are labeled SG-1. A full list is provided below.

The environmental transport pathways to surface water that are addressed in the PCUL document include the following (Figure 1):

- Transport of contaminated ground water to surface water (GW-2)
- Partitioning of ground water contamination to sediment (GW-3)
- Leaching of soil contaminants to potable ground water from the vadose zone (SL-2) or the saturated zone (SL-5)
- Leaching of soil contaminants from the vadose zone (SL-3) or the saturated zone (SL-6) to ground water followed by transport to surface water
- Leaching of soil contaminants from the vadose zone (SL-4) or the saturated zone (SL-7) to ground water followed by partitioning to sediment
- Erosion of contaminated soil directly to sediment (SL-8)
- Transport of soil into a storm water pipe that outfalls to the river (SL-8)
- Infiltration of soil (SL-8) or ground water (GW-2) into a storm water pipe that outfalls to the river.

Liquid and solid materials in a storm drain system are regulated by the Water Quality Program via their permitting process, not by the Toxics Cleanup Program. The PCUL document does not address the water portion of the surface runoff pathway, either the flow that directly enters a waterbody or the flow that enters a storm drain with an outfall to the waterbody. However, if soil is protective of the leaching pathway (SL-2 through SL-7), it is expected that the water in surface runoff will be protective of the waterbody.

Similarly, the solid materials in a storm drain with an outfall to a waterbody are not addressed by the PCUL document. However, if soil is protective of bank erosion (SL-8), it is expected that any soil entering the storm drain system will be protective of the waterbody. Other pathways for contaminant transport to the waterbody, such as atmospheric deposition or spills directly to the waterbody, should be discussed with the site manager.

The PCUL document includes the following media and pathways that do not directly involve a waterbody:

- Upland soil contamination (SL-1 and SL-9)
- Ground water contamination in a potable aquifer (GW-1)
- Intrusion of soil vapors (SG-1) or vapors from ground water (GW-4) into a building.

The environmental exposure pathways and potential receptors addressed in the PCUL document include the following (Figure 2):

Medium	Exposure Pathway	Human Receptors	Ecological Receptors
Soil	Direct contact	SL-1	SL-9 (terrestrial)
Ground water	Potable use	GW-1	--

Medium	Exposure Pathway	Human Receptors	Ecological Receptors
Air	Inhalation	AR-1	--
Surface water	Direct contact	--	GW-2 (aquatic)
	Seafood consumption	GW-2	--
Sediment	Direct contact	GW-3	GW-3 (benthic)
	Seafood consumption	GW-3	GW-3 (higher trophic level)

The most stringent PCULs are identified for residential land use. PCULs for industrial land use are also available and may be substituted if the site manager agrees that a site qualifies for industrial land use. The CULs for many chemicals are dominated by the leaching pathway; these CULs are not expected to be affected by land use.

The following individual PCULs are provided in the workbook.

PCUL Number	PCUL Name
SL-1	Direct contact under unrestricted land use
SL-2	Vadose zone protection of drinking water
SL-3	Vadose zone protection of surface water via ground water
SL-4	Vadose zone protection of sediment via ground water
SL-5	Saturated zone protection of drinking water
SL-6	Saturated zone protection of surface water via ground water
SL-7	Saturated zone protection of sediment via ground water
SL-8	Protection of sediment via soil erosion
SL-9	Site-specific TEE for unrestricted land use
SL-10	Natural background concentration
GW-1	Drinking water
GW-2	Protection of surface water
GW-3	Protection of sediment
GW-4	Protection of indoor air
GW-5	Natural background concentration
AR-1	Air cleanup level
SG-1	Soil gas screening level for protection of indoor air

The workbook contains the following groups of pages that contain sets of related information. In the freshwater version, some page names have the suffix 'FW' because they contain information specific to fresh surface water or sediment and must be distinguished in the master workbook from pages with information specific to marine surface water and sediment.

Category	Page	Contents
--	Mod	History of modifications
Media Summaries	SL, SL-FW	Most conservative soil PCULs
	GW, GW-FW	Most conservative ground water PCULs
	Sed, SedFW	Sediment PCULs and, in the LDW version, CULs and RALs from the LDW ROD
	AR	PCULs for air and soil gas

Category	Page	Contents
Background Information	Chem	Chemical names, CAS numbers, and synonyms
	Param	Chemical and toxicological parameters
	Eqtn	Equations for calculating PCULs and non-chemical-specific parameter values for input to equations
Soil Calculation Support	SL-Det	Equation values for soil contact, table values for the TEE, and the TSCA ² ARAR value for PCBs
	SL-Eq	Calculations for MTCA Equations 740-1, 740-2, 745-1, and 745-2 (soil contact)
	Leach, LeachFW	Calculations for MTCA Equation 747-1 (soil leaching to ground water)
Ground Water Calculation Support	PW	ARARs and MTCA equation values for potable water and ground water screening levels for vapor intrusion
	SW, SW-FW	ARARs for surface water and MTCA equation values for ingestion of fish
	GW-Eq	Calculations for MTCA Equations 720-1 and 720-2 (drinking water) and 730-1 and 730-2 (surface water)
	Partit, PartitFW	Calculations for modified MTCA Equation 747-1, used to model partitioning between ground water and sediment
	VI	Calculations for ground water screening levels for protection of indoor air
Sediment Calculation Support	Sed-Eq, Sed-EqFW	Calculations for SMS Equations 9-1 and 9-2 for three sediment contact scenarios
	SedMMA, SedMMA-FW	Calculations for three sediment contact scenarios with considerations for mutagenic mode of action
Air Calculation Support	AR-Det	Equation values for air cleanup levels and soil gas screening levels
	AR-Eq	Calculations for MTCA Equations 750-1 and 750-2 (air inhalation)

Detailed notes on individual chemicals and on the contents of each page are provided in Tables 1 and 2, respectively. Table 3 provides definitions of acronyms. Within the workbook, when the value for an individual chemical is obtained from a different source or represents a different endpoint from the other chemicals in the same column, this is explained in a comment inserted into the cell.

The PCULs in the workbook are calculated using ARARs; the equations in MTCA, SMS, and associated guidance; input parameters describing exposure or transport; and, for some chemicals, literature values for aquatic toxicity. The LDW version includes some site-specific parameter values (see Assumptions Specific to the LDW). Such parameters should be reset to default

² CUL is for self-implementing cleanups, consistent with Method A.

values for marine sites outside the LDW. The SLU version includes only default parameter values.

PCUL values are not copied directly from Ecology's Cleanup Levels and Risk Calculation (CLARC) website but are calculated within the workbook. Some PCULs differ from the values presented in CLARC due to either site-specific assumptions or slight differences in rounding.

The chemicals included in the workbook are those that are commonly analyzed at MTCA sites. The chemical list does not imply that these are the only chemicals that should be analyzed at MTCA sites. All chemicals listed in CLARC that are suspected of being present based on-site history should be analyzed. If a detected analyte is not listed in the PCUL workbook, request Ecology to develop PCULs for the analyte. The site manager must approve PCULs for chemicals not listed in the workbook.

On the soil and ground water summary pages (SL and GW), the most stringent PCUL is identified from among multiple pathway specific PCULs. If the most stringent PCUL falls below the natural background concentration, it is adjusted up to the natural background concentration. To address the possibility that one or more pathways are not applicable at a site, a column is provided for the user to define a PCUL that excludes one or more pathways listed on the summary page. PCULs in the workbook are not adjusted for PQLs (see Practical Quantitation Limits).

On the far-right side of some pages is a matrix showing the basis for the most stringent PCUL for informational purposes. For example, the most stringent PCUL might be based on an ARAR, an adjusted ARAR, a value calculated using a Method B equation, a value calculated using the three-phase model, or natural background.

PCULs do not contain information related to point of compliance. For information on this topic, refer to the applicable sections of MTCA and SMS. Points of compliance must be approved by the site manager.

The PCUL workbook is a living document. Updates to parameters or criteria are incorporated into periodic revisions.

Assumptions Specific to the LDW

The LDW version of the workbook includes the following site-specific information:

- The receiving surface water and sediments are marine, and the surface water is nonpotable.
- The fish consumption rate is 97.5 grams/day³, based on the LDW human health risk assessment (LDWG 2010).
- The scenarios for human contact with sediment are from the LDW human health risk assessment (LDWG 2010).

³ Note that the state water quality criteria for human health are based on a fish consumption rate of 175 g/day. The evaluation of the protectiveness of these ARARs is discussed under Adjustments to ARARs.

- Sediment natural background levels for total PCB congeners, total PCB toxicity equivalents (TEQ), total dioxin/furan TEQ, arsenic, and total cPAH TEQ are from the ROD.
- The natural background concentration of arsenic in ground water is based on Ecology (2022a) for the Puget Sound Basin.
- Soil natural background levels for metals are from Ecology (1994) for the Puget Sound region.
- Ground water PCULs for protection of sediment are calculated using a modified version of the MTCA three-phase model (Equations 747-1 and 747-2), using LDW-specific parameter values for fraction organic carbon, porosity, and particle density (Ecology 2016a). Site-specific modeling approaches may be proposed to the site manager.

Cautions on Modifications to the Workbook

The user of this workbook is advised to exercise caution when making changes because of the possibility of introducing errors. Always check the source of cell contents before editing a cell. The following workbook features should be considered before making any changes.

Many cells contain formulas linking to other cells or other pages within the workbook. For example, values on the media summary pages (SL, GW, Sed, and AR) are linked to the media detail pages (e.g., SL-Det, PW, SW, and AR-Det). Many of the values on the detail pages are linked to the various equation calculation pages (e.g., SL-Eq, GW-Eq, Sed-Eq, VI, Leach, and Partit), which in turn link to the chemical-specific parameters page (Param) and the equations page (Eqtn).

Chemicals are listed in the same order on each page. Do not move chemicals from one row to another on any of the pages. Changes to the lists of chemicals on one page could result in confusion and potentially incorrect linkage among pages. New chemicals may be added, but care must be exercised to insert each chemical in the same order on all pages.

If changes are made to input parameters used in equations, these changes should be made to cells without formulas in the 'Param' page or the 'Eqtn' page. If the modification is made to the correct cell, the modification will be propagated correctly throughout the workbook.

The site manager will determine whether modifications to the workbook are warranted. All changes made to the workbook must be accompanied by a complete explanation of what was changed and why the change was appropriate.

Adjustments to ARARs

WQC and maximum contaminant levels (MCLs) constitute ARARs under MTCA. The site manager will determine whether ground water at a site is considered potable and thus subject to MCLs. ARARs are evaluated in the workbook to determine if any adjustments are required according to WAC 173-340-720(7)(b) and -730(5)(b). The adjustments discussed in this section pertain to individual ARARs. PCULs are not adjusted to account for multiple chemicals or multiple exposure pathways; such adjustments should be performed when developing final CULs for the feasibility study or CAP.

The derivation of the ground water PCUL for protection of potable water (GW-1) involves identifying MCLs and calculating ground water CULs per MTCA Equations 720-1 and 720-2 using the toxicity values in the CLARC database (Figure 3). If the ratio of the minimum MCL to the Equation 720-1 value does not exceed 1, then the hazard quotient associated with the MCL does not exceed 1 and the MCL constitutes the PCUL. If the ratio exceeds 1, the MCL is adjusted down to the Equation 720-1 value to achieve a hazard quotient of 1 and this constitutes the PCUL.

If the ratio of the minimum MCL to the Equation 720-2 value does not exceed 10, then the cancer risk associated with the MCL does not exceed 1×10^{-5} and the MCL constitutes the PCUL. If the ratio exceeds 10, the MCL is adjusted down to 10 times the Equation 720-2 value to achieve a cancer risk of 1×10^{-5} and this constitutes the PCUL.

If an MCL is available but no oral toxicity values are available to evaluate it (e.g., lead), the MCL is used as the PCUL. If no MCL is available but an oral toxicity value is available, the minimum of the values from Equations 720-1 and 720-2 is used as the PCUL. If a chemical has no toxicity values and no MCL, there is no PCUL for potable water.

Similarly, the derivation of the ground water PCUL for protection of surface water (GW-2) involves identifying WQC and calculating ground water CULs per MTCA Equations 730-1 and 730-2 using the toxicity values in the CLARC database (Figure 4)⁴. Similar ratios are calculated and adjustments made, if needed, as described above for MCLs. The fish consumption rate in Equations 730-1 and 730-2 is adjusted to 97.5 g/day and the fish diet fraction⁵ is adjusted to 1 (Ecology 2016a), consistent with both the LDW ROD and common tribal fish consumption patterns. For all sites outside the LDW that lie within the usual and accustomed fishing area for one or more tribes, consult the tribes on the appropriate fish consumption rate.

For ease of calculation, the literature values for protection of aquatic life are included in the determination of minimum WQC, though they are not actually ARARs because they are not promulgated regulations. This placement of the literature values is unlikely to affect the final PCULs.

Notes on Specific Parameters

Chemical Properties

Values for chemical properties (e.g., Kow, Hcc, BCF) are obtained from Ecology's CLARC database. PCULs that are dependent on chemical properties (e.g., leaching) are not calculated for chemicals without chemical property values in CLARC.

⁴ A small number of State or Federal WQC require adjustment because of differences in toxicity values used between TCP and WQP. TCP uses the toxicity values from IRIS and EPA's regional screening levels workbook, developed for Superfund cleanup work. WQP generally uses the toxicity values from EPA's Clean Water Act Section 304(a) criteria documents for the National Recommended WQC.

⁵ Proportion of the total fish diet obtained from the affected waterbody.

Practical Quantitation Limits

If a final CUL needs to be adjusted to a PQL, the PQL must be approved by the site manager. Because PQLs can vary depending on the analytical method, instrumentation, and site conditions, the workbook does not provide PQLs for soil, ground water, or air. However it is necessary to have sediment PQLs to allow calculation of sediment PCULs for bioaccumulative chemicals. The process for developing sediment PCULs is explained below in Sediment PCULs.

Sediment PQLs are from the Sediment Cleanup User's Manual (SCUM) Tables 11-1 and D-1 and represent mid-range values. The values in Table 11-1 are derived by eliminating the minimum and maximum values reported in a survey of accredited laboratories and taking the median of the remaining values. Sediment PQL data are reported for additional chemicals in Table D-1, but the amount of data available was considered insufficient to derive median values so average values are reported instead. For some chemicals in Table D-1, PQL values are available from only one or two laboratories. The average PQLs in Table D-1 are associated with a much higher level of uncertainty than the median values in Table 11-1.

Natural Background Concentrations

Natural background concentrations are provided for soil, ground water, and sediment where available. Potentially liable parties (PLPs) may propose natural background concentrations for additional chemicals per WAC 173-340-709.

Natural soil background concentrations are based on the 90th percentile, the 80th percentile, or four times the median of the data set of natural background concentrations, depending on the shape of the distribution. In Ecology's (1994) background soil evaluation, non-detected values in the data sets were replaced with half the detection limits.

Natural sediment background concentrations for most chemicals are based on the upper 90 percent tolerance limit on the 90th percentile (90/90 UTL) of the background data set, as reported in Table 10-1 of SCUM. Non-detected values in the background data sets were handled using the Kaplan-Meier approach.

The natural background concentration of arsenic in groundwater (8 µg/L) is based on the 90/90 UTL of the data set for the Puget Sound region (Ecology 2022a). Natural background concentrations for Island County (13.3 µg/L) or parts of Snohomish County (13.6 µg/L) may be substituted where appropriate.

In the LDW version of the workbook, the natural sediment background values for total PCB congeners, total dioxin/furan TEQ, and arsenic are taken from the ROD to be consistent with EPA's sediment cleanup. The values in the ROD are based on the upper 95 percent confidence limit (95UCL) on the mean of the background data set.

Washington State Water Quality Criteria for Human Health

The ground water PCUL for protection of surface water (GW-2) considers State and Federal WQC for protection of aquatic life and humans consuming fish and shellfish. The State WQC

for protection of human health (Ecology 2016c) are shown in the column titled ‘WA State WQC, Human Health, Consumption of Organisms’. EPA partially approved and partially disapproved of the Washington State WQC for human health. EPA’s WQC for Washington State, referred to as the Washington Toxics Rule, are in the column titled ‘WA Toxics Rule, Protection of Human Health, Consumption of Organisms’. The minimum ARAR for surface water considers the values in both of these columns, as well as values from the National Recommended Water Quality Criteria (NRWQC) for protection of human health and values from the State and NRWQC for protection of aquatic life.

Water Quality Criteria for Aquatic Life

Water quality criteria for protection of aquatic life are available for many chemicals from EPA and Washington State. When aquatic life criteria are not available, the following literature sources may be used to estimate concentrations protective of aquatic life [WAC 173-340-730(3)(b)(ii)]:

- Risk Assessment Information System (University of Tennessee 2013)
- NOAA (2008) screening quick reference tables (SQuiRT)
- Verbruggen et al. (2008)
- De Rooij et al. (2004)
- EPA’s EcoTox database.

Values from these literature sources have been included for some commonly encountered chemicals (Ecology 2016a), but not for all chemicals in the PCUL workbook. The site manager will determine whether these or other literature sources should be consulted for other chemicals without aquatic life criteria.

Sediment PCULs

In the SLU version of the workbook, sediment PCULs are developed according to Ecology’s guidance for freshwater sediment in SCUM. These sediment PCULs may be used at any freshwater sediment site.

In the LDW version of the workbook, the minimum sediment CULs in the ROD are the preferred values for the sediment PCULs. For chemicals not listed in the ROD, the sediment PCULs are developed consistent with the SCUM guidance for lower tier sediment cleanup objectives (SCOs) for marine sediments (Figure 5). SMS cleanup screening levels (CSLs, also referred to as upper tier) and the RALs in the ROD are also provided. The CSLs and RALs are not used for developing PCULs but are provided for potential use when developing site-specific CULs or RELs.

The LDW ROD lists six different CULs and 13 different RALs covering four different remedial action objectives and multiple depth horizons. All of the CULs and RALs are provided in the PCUL workbook. The minimum CULs are used for developing PCULs. For some sites, the site manager may determine that the minimum CULs are not applicable. In these cases, the applicable CULs or RALs can be identified in a user-defined sediment PCUL column.

To develop PCULs for marine sites outside the LDW, multiple adjustments must be made to the LDW version of the workbook. The CULs and RALs from the ROD should be eliminated from the 'Sed' page. Site-specific values for sediment parameters on the 'Eqtn' page should be adjusted back to default values. Additional adjustments are also needed. Please contact Priscilla Tomlinson or Kim Wooten to develop PCULs for marine sites outside the LDW.

Some of the benthic criteria for marine sediment are expressed in terms of organic carbon (OC) normalized concentrations. OC normalized criteria are not comparable to sediment CULs expressed in dry weight. Groundwater-sediment partitioning cannot be calculated using OC normalized values. For chemicals with OC normalized benthic criteria, the lowest apparent effects thresholds (LAET) values, which are expressed as dry weight, are used for calculating groundwater PCULs to protect sediment. However, when presenting the benthic criteria for these chemicals in the feasibility study and CAP, the OC normalized form should be used.

Chapter 9 of SCUM provides two methods for establishing sediment CULs for bioaccumulative chemicals. If data for sediment and aquatic tissue concentrations are available, a site-specific biota-to-sediment accumulation factor (BSAF) can be determined. This method requires a large level of effort. In many cases, the sediment CUL calculated using a site-specific BSAF is below the natural background concentration or the PQL. Thus, a simpler approach is to set the sediment CUL to the maximum of natural background and the PQL. The PCUL workbook is designed on a generic basis, so the simplified background/PQL approach is used. If site-specific BSAFs are developed, site-specific sediment PCULs can be hand-entered in the columns for upper and lower tier risk-based concentrations for bioaccumulatives on the 'Sed' or 'SedFW' page.

For the SLU version of the workbook, a chemical is considered bioaccumulative if it occurs on either of the following lists of bioaccumulative chemicals:

- Persistent bioaccumulative toxins (WAC 173-333-310) (43 analytes)
- Primary (List 1) and candidate (List 2) bioaccumulative contaminants of concern (DMMP 2018) (24 analytes).

Due to overlap between the two lists, a total of 59 analytes are identified as bioaccumulative chemicals.

In the LDW version of the workbook, a chemical is considered bioaccumulative if it occurs on either of the two lists of bioaccumulative chemicals shown above **and** there is evidence that the chemical is present in LDW seafood at concentrations of potential concern. Chemicals present in LDW seafood at levels of potential concern are identified from the following two lists:

- Chemicals of concern (COCs) for human consumption of seafood from the LDW (LDWG 2010, Table B.7-1) (18 analytes)
- COCs for higher trophic level receptors in the LDW (LDWG 2010, Table A.8-1) (5 analytes).

Due to overlap between the two lists, a total of 21 analytes are identified as present in LDW seafood at levels of potential concern.

The following analytes are identified as bioaccumulative in the LDW version of the workbook because they fit both criteria (bioaccumulative chemicals *and* present in LDW tissues at levels of potential concern):

- Total PCB Aroclors, total PCB congeners, and total PCB TEQ
- 2,3,7,8-TCDD and total dioxin/furan TEQ
- Arsenic and mercury
- Tributyltin
- Carcinogenic PAH TEQ
- Hexachlorobenzene and pentachlorophenol
- Aldrin, all forms of chlordane, total DDTs, 4,4'-DDT, dieldrin, heptachlor, and heptachlor epoxide.

The list of bioaccumulative chemicals in the SLU version of the workbook is longer.

The SCO (lower tier) concentration for a bioaccumulative chemical is set to the higher of natural background and the PQL. The CSL (upper tier) concentration for a bioaccumulative chemical is set to the higher of regional background and the PQL. If neither a background concentration nor a numerical PQL value is available, the sediment PCUL is indicated as the text entry “PQL”.

When the sediment PCUL for a chemical is listed as the text entry “PQL” rather than a numerical value, it is not possible for the workbook to calculate numerical ground water or soil PCULs for protection of sediment. In these cases, the ground water and soil PCULs are listed as “TBD” (to be determined). Until a numerical sediment PQL is entered, the workbook will ignore non-numerical entries when identifying the most stringent soil and ground water PCULs. If a numerical sediment PQL is entered in the ‘PQL’ column on the ‘Sed’ or ‘SedFW’ page, all of the downstream calculations will self-populate throughout the workbook.

Additional Details for Identification of Bioaccumulative Chemicals in LDW

LDWG (2010) eliminated some of the chemicals identified as COCs in their human health and ecological risk assessments from the final list of indicator chemicals based on considerations of frequency of detection, frequency of exceedance, analytical interference, and contribution to overall risk. For the reasons discussed below, Ecology assumed that all of the chemicals on LDWG’s lists of COCs are potentially present in LDW seafood.

Although bis(2-ethylhexyl)phthalate (BEHP) and pentachlorophenol are listed as COCs for human consumption of seafood in RI Table B.7-1, LDWG eliminated them from the list of indicator chemicals (i.e., risk drivers) for human health because of small contribution to overall risk and low frequency of detection. LDWG eliminated tributyltin and vanadium as indicator chemicals because the associated hazard quotients are only slightly above 1 for only one seafood consumption scenario. LDWG eliminated eleven organochlorine pesticides for three reasons: low contribution to overall risk; analytical interference due to high PCB concentrations in the samples that likely biased the pesticide results high; and, in some cases, low frequency of detection. Each of these issues could manifest differently on the small scale of individual upland cleanup sites, so Ecology did not eliminate any of these chemicals from consideration as being potentially present in LDW seafood. However, BEHP, vanadium, and three of the pesticides are

not present on the lists of bioaccumulative chemicals and so are not treated as bioaccumulative for that reason.

The higher trophic level species evaluated in LDWG's ecological risk assessment included crabs, great blue herons, ospreys, river otters, and harbor seals. Chemical exposures for these receptors are dominated by their seafood diets. Total PCB exposures to crabs and otters exceeded their lowest observed adverse effect levels (LOAELs) and LDWG retained total PCBs as an indicator chemical for ecological receptors. PCB TEQ, arsenic, mercury, and zinc exposures exceeded the no observed adverse effect levels for crabs, otters, or osprey. LDWG eliminated these chemicals as risk drivers because exposures did not exceed the LOAELs. However, chemical concentrations associated with individual upland cleanup sites may be different from the river-wide exposure concentrations considered in LDWG's ecological risk assessment. Ecology considered all of the listed chemicals to be potentially present in LDW seafood. All of these chemicals are also considered bioaccumulative and so they are treated as bioaccumulative for the purpose of deriving sediment PCULs.

Soil PCULs to Protect Ground Water

MTCA Equation 747-1, shown below, is used to calculate soil PCULs protective of ground water via the leaching pathway (SL-2 through SL-7, Figure 6) on the 'Leach' and 'LeachFW' pages of the workbook. All parameter values are default values provided in MTCA.

$$C_{soil} = C_{gw} \times UCF \times DF \left[K_d + \frac{\theta_w + \theta_a \times H_{cc}}{\rho_b} \right]$$

Where:

- C_{soil} = Soil PCUL for protection of ground water (mg/kg) (chemical-specific)
- C_{gw} = Ground water PCUL ($\mu\text{g/L}$) (chemical-specific)
- UCF = Unit conversion factor (1 mg/1,000 μg)
- DF = Dilution factor (unitless) (20 for vadose zone, 1 for saturated zone)
- K_d = Soil-water distribution coefficient (L/kg) (chemical-specific) (K_d for organic chemicals is calculated per MTCA Equation 747-2 below)
- θ_w = Water-filled porosity (0.3 ml/ml for vadose zone, 0.43 ml/ml for saturated zone)
- θ_a = Air-filled porosity (0.13 ml/ml for vadose zone, 0 ml/ml for saturated zone)
- H_{cc} = Henry's law constant (unitless) (chemical-specific)
- ρ_b = Dry soil bulk density (1.5 kg/L).

MTCA Equation 747-2, shown below, is used to calculate K_d for organic chemicals:

$$K_d = K_{oc} \times f_{oc}$$

Where:

- K_d = Soil-water distribution coefficient (L/kg) (chemical-specific)
- K_{oc} = Soil organic carbon-water partitioning coefficient (ml/g) (chemical-specific)
- f_{oc} = Soil fraction of organic carbon (0.001 g/g).

Site-specific values may be used for f_{oc} , θ_w , θ_a , and ρ_b if approved by the site manager.

Soil PCULs for protection of ground water are calculated separately for the vadose and the saturated zones because of different default assumptions for DF, θ_w , and θ_a . Because ground water is shallow near the LDW, and because sea level rise could make it shallower, the use of soil PCULs for the vadose zone must be approved by the site manager.

When no Henry's law constant (H_{cc}) is available for a chemical, it is assigned a value of 0 to allow the calculation to proceed. Chemical loss due to volatilization is not a major driver in the three-phase partitioning model.

Ground Water PCULs to Protect Sediment

The following modified version of the MTCA three-phase model is used to calculate ground water PCULs protective of sediment on the 'Partit' and 'PartitFW' pages of the workbook. The equation below is based on an Ecology (2016a) memorandum, but the sediment PCULs have been updated to LAET values (see Sediment PCULs above). The ground water PCULs for protection of sediment supersede the CULs published in the 2016 memorandum. Parameter values are default values provided in MTCA unless noted otherwise.

$$C_{gw} = \frac{C_{sed}}{UCF \times DF \left[K_d + \frac{\theta_w}{\rho_b} \right]}$$

Where:

C_{gw} = Ground water PCUL for protection of sediment ($\mu\text{g/L}$) (chemical-specific)

C_{sed} = Sediment PCUL (mg/kg) (chemical-specific)

UCF = Unit conversion factor (1 $\text{mg}/1,000 \mu\text{g}$)

DF = Dilution factor (unitless) (1 for saturated sediment)

K_d = Soil-water distribution coefficient (L/kg) (chemical-specific) (K_d for organic chemicals is calculated per MTCA Equation 747-2 above)

θ_w = Water-filled porosity (0.615 ml/ml for LDW [LDWG 2010], 0.43 ml/ml for other sites)

ρ_b = Dry sediment bulk density (1.02 kg/L for LDW [Ecology 2016a]), 1.5 kg/L for other sites)

For the LDW version of the workbook, a value of 0.019 g/g is used for f_{oc} in Equation 747-2, based on the remedial investigation (RI) report (LDWG 2010). For the SLU version of the workbook, the default value of 0.001 g/g is used. Site-specific values may be used for f_{oc} , θ_w , and ρ_b if approved by the site manager.

When developing CULs for the FS or CAP, if some of the sediment CULs are expressed as OC normalized (see Sediment PCULs above), the K_d value in the equation above should be replaced by K_{oc} and the term θ_w/ρ_b should be eliminated. The elimination of this term will have negligible impact on the result.

It should be noted that the three-phase model is a simple mass-balance equation calculated independently for each contaminant in soil. It was developed for soil subsurface conditions and uses mass-balance between soil grains, air pore-space, and associated aqueous phases. The mass balance among the three phases is based on two chemical factors: K_d and Henry's Law constant. In the sediment environment, sediment and water physicochemical conditions (e.g. salinity, pH, hardness, dissolved oxygen, alkalinity, and multiple solutes) and dynamic physical conditions (e.g. currents; waves; temperature changes; and light intensity) are significantly different from, and more complex than, soil conditions. Hence, the model results for the transition zone between ground water and surface water do not fully account for the complexity of this environment.

These differing physicochemical sediment/water conditions have diverse impacts upon various chemical classes and their ionic forms and partial charges, which in turn, impact bioavailability and toxicity. For example, metals are often significantly affected by the physicochemical properties (e.g., pH, alkalinity, salinity) of the water. Marine or estuarine water can significantly impact pH due to its high buffering capacity. High sulfide conditions within the marine environment can also significantly affect formations of metal-sulfide complexes. Changes in pH in the near shoreline transition zone between fresh ground water and saline marine water can regulate dissolution of the metal solids in upland soil leachate.

Nonpolar organics, on the other hand, are less affected by these conditions because their nonpolar properties restrict the chemical response to water conditions. However, light-intensity has a greater impact on non-polar organics due to their photoactivation properties and this significantly affects reactivity and toxicity.

With approval from the site manager, other models developed specifically for sediment and water may be used on a site-specific basis with site-specific modifications, such as the Reible Two-Layer Sediment Cap and Steady State Analytical⁶. The Two-Layer model was developed to predict sediment cap effectiveness and is a two-layer steady state model that predicts concentrations and fluxes in a chemical isolation layer or in the near surface biologically active zone (bioturbation layer).

The Steady State model uses input parameters that incorporate a significant number of variables that may be important in improving overall model accuracy in predicting effectiveness. Some of these variables include depositional velocity, conventional and active cap decay rates, and carbon fractions within conventional and active cap layers. The model determines concentrations and fluxes in a two-layer sediment cap at steady-state, using various sediment, water and chemical factors assuming advection, diffusion, dispersion, deposition/erosion, sorption onto colloidal organic matter, and boundary layer mass transfer. This is normally used to estimate migration through an active layer (lower layer) and a conventional cap layer (upper layer). Unlike the Two-Layer model, however, the Steady State model does not consider a bioturbation layer.

The Two-Layer Sediment Cap and the Steady State Analytical models cannot be used for the PCULs because they require site-specific data. The modified version of the MTCA three-phase model was used instead because it can be run on a general, default scenario. However, the modified three-phase model is likely to be conservative when applied to ground water-sediment

⁶ Available at: <https://www.depts.ttu.edu/cweb/groups/reiblesgroup/downloads.html>.

partitioning. It will overestimate contaminant adsorption to sediments and thus provide a ground water PCUL that is lower (more protective) than necessary.

Soil PCULs to protect sediment are derived by using two modeling steps in tandem. First the ground water PCUL to protect sediment (GW-3) is calculated using the modified version of Equation 747-1. Then soil PCULs (SL-4 and SL-7) are calculated using the standard version of Equation 747-1. The use of two models in tandem introduces a higher level of uncertainty than the use of either model alone.

The soil and ground water PCULs for protection of sediment are useful for screening purposes, but professional judgement should be used when setting final CULs to protect sediment. For example, if bulk sediment concentrations do not exceed their sediment PCULs, the site manager may consider the ground water to be protective of sediment regardless of the predictions of the partitioning model (i.e., empirical demonstration). Sediment bioassays and alternative partitioning models, such as those discussed above, can provide additional lines of evidence. The use of bioassays or alternative models must be approved by the site manager. The complete weight of evidence, including the empirical relationships between soil, ground water, and sediment concentrations, should be considered when developing final soil and ground water CULs for protection of sediment.

PCULs for Industrial/Commercial Land Use

Method C PCULs for soil and air at industrial sites are provided on detail pages in the workbook. These include soil PCULs for worker contact, site-specific and simplified TEE soil concentrations for industrial/commercial sites, air PCULs for industrial sites, and soil gas and ground water screening levels for protection of indoor air at industrial sites. These PCULs are not intended to be used for initial screening of soil and ground water data. They are provided for potential use when developing site-specific soil CULs or RELs at sites that qualify for commercial or industrial land use per WAC 173-340-706(1), -745(1), -745(2), and -7490(3)(c) as determined by the site manager. Note that soil CULs for many chemicals are likely to be based on the leaching pathway, which is not affected by the designation of a site as industrial.

Method C PCULs for drinking water and protection of surface water are not included in the workbook because industrial land use does not qualify a site for Method C in these media (Ecology 2016a). The criteria that must be met to use Method C for groundwater or surface water (WAC 173-340-706(1)(a)) are rarely met.

Air, soil gas, and groundwater PCULs are provided for vapor intrusion at commercial sites. These PCULs are calculated consistent with Ecology's (2022) *Guidance for Evaluating Vapor Intrusion in Washington State*. They may not be used as CULs but they may be used as RELs that are protective of workers during the time it takes for the cleanup to achieve the CULs.

Screening Levels for Terrestrial Ecological Evaluation

The TEE screening levels provided for initial screening of soil data are the minima of the values for protection of plants, soil biota, and wildlife in the site-specific TEE under unrestricted land use. Screening levels for site-specific TEEs under industrial/commercial land use and screening

levels for simplified TEEs (unrestricted or industrial/commercial land use) are provided on the soil detail page for developing site-specific soil CULs or RELs. The site manager will determine if a site qualifies for the simplified TEE.

Note that if a site undergoes a site-specific TEE, PCULs for the TEE are needed for all detected chemicals, not just the chemicals listed in MTCA Table 749-3. On the other hand, if a site undergoes a simplified TEE, only the chemicals listed in MTCA Table 749-2 need to be evaluated in the TEE.

If the site manager determines that a site qualifies for exclusion from the TEE, SL-9 may be eliminated from consideration.

Short-Term Action Levels for Trichloroethene (TCE)

Short-term inhalation of TCE in indoor air may cause serious heart defects in a developing fetus. The damage can occur early in pregnancy, possibly before the pregnancy is recognized. Vapor assessments must be conducted quickly at sites with TCE to protect women of childbearing age. For additional information on this issue, refer to Appendix A of Ecology's (2022) *Guidance for Evaluating Vapor Intrusion in Washington State*.

Short-term action levels for air are provided in the PCUL workbook for both unrestricted land use and commercial/industrial land use. If air concentrations exceed the action levels, rapid response is necessary to collect additional data and possibly mitigate exposures. Short-term screening levels for soil gas and groundwater are also provided. If soil gas or groundwater concentrations exceed the screening levels, additional data should be collected quickly to verify whether the exposure pathway is complete.

The short-term action levels and screening levels are higher than the chronic air CULs and soil gas and groundwater screening levels. They are used to ensure that women of childbearing age are not overexposed during the time it takes for the final remedy to be implemented. The short-term action levels and screening levels may not be used as CULs but they might be used as RELs at some sites. The site manager will determine the appropriate CULs and RELs for TCE.

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