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Revision 1

STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-BC-1 and 100-BC-2 Source Operable Units

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

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Environmental Calculation File

STOMP 1-D Modeling for Determination of Unit-Length Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-BC-1 and 100-BC-2 Source Operable Units

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Terms

ARARs	applicable regulations and requirements
AWQL	applicable water quality standards
CHPRC	CH2M HILL Plateau Remediation Company
COPC	contaminant of potential concern
CPK	peak groundwater concentration
DF	dilution factor
ECF	environmental calculation file
EPC	exposure point concentration
EQL	estimated quantitation limit
FEPs	features, events, and processes
HEIS	Hanford Environmental Information System (environmental database)
HISI	Hanford Information System Inventory (software database)
HSU	hydrostratigraphic unit
MCL	maximum contaminant level
POCal	point of calculation
PRG	preliminary remediation goal
OU	Operable Unit
RAG	remedial action goal
RESRAD	RESidual RADiation (modeling software)
RUM	Ringold upper mud
SSL	soil screening level
STOMP	Subsurface Transport Over Multiple Phases (modeling software)
SZ	saturated zone
VZ	vadose zone
WAC	Washington Administrative Code
WQS	water quality standard

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1 Purpose

The objective of this environmental calculation file (ECF) is to provide unit-length soil screening levels (SSLs) and unit-length preliminary remediation goals (PRGs) protective of surface water and protective of groundwater in the 100-BC-1 and 100-BC-2 source operable units (collectively referred to as the 100-BC Area or 100-BC OUs herein). This calculation is performed with models implemented in the STOMP©[1] (Subsurface Transport Over Multiple Phases) fate and transport simulation software (PNNL-11216, *STOMP Subsurface Transport Over Multiple Phases: Application Guide*; PNNL-12030, *STOMP Subsurface Transport Over Multiple Phases: Theory Guide*; PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases: Version 4.0: User's Guide*). This calculation follows the approach set forth in DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection.* Detailed information on the development and basis of the models implemented in STOMP for this calculation is provided in SGW-50776, *Model Package Report: Vadose Zone Model for the River Corridor*. The model framework used in this analysis is identical to that used in ECF-HANFORD-11-0063, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*. As discussed in Sections 5.3 and 6.2, the results of the 100-D/100-H modeling were considered representative for determining that site-specific modeling and sensitivity analyses are not needed for the 100-BC Area.

SSLs are used to identify areas needing further investigation. PRGs represent soil concentration or radionuclide activity that can remain in the vadose zone at a site without causing an exceedance of groundwater, or surface water, quality standards. Unit-length SSLs and PRGs are provided because SSLs and PRGs are inherently dimensional values that depend on the extent of the contaminated soil in the direction of groundwater flow. Hence, unit-length values are provided that are readily scalable to the length of waste sites in the general direction of groundwater flow. Based on numerical flow and solute transport simulations developed using a number of conservative assumptions, unit-length SSLs and PRGs specific to the 100-BC source OUs were calculated for 190 non-radionuclides and 25 radionuclides in groundwater and 190 non-radionuclides in surface water (specifically, the Columbia River). The approach used here is to calculate unit-length SSLs in the same manner as unit-length PRGs but using a more conservative recharge rate based on an irrigated farming scenario (recognizing this is not the planned land use for the 100-BC Area). This approach honors the primary importance of recharge as parameter influencing breakthrough rates for vadose zone contamination into groundwater, and uses irrigation recharge rates to provide an upper bound on this parameter for screening purposes. The resulting unit-length SSL and PRG values are only applicable to the 100-BC Area waste sites where the assumptions and conditions described in this ECF are representative.

Conceptual and numerical models of flow and solute transport under variably saturated conditions were developed for conditions representative of the lithology and hydrology observed at various waste sites within the 100-BC source OUs. Conditions specific to the larger 100 Area, or specific to the 100-BC Area, include time-varying recharge rates specific to the 100 Area, 100-BC-Area-specific vadose zone thickness and lithology, 100-BC-Area-specific 100-BC-Area-specific specific hydraulic properties, and 100-BC-Area-specific specific aquifer fluxes. Numerical assumptions include that liquid-phase water flow and solute transport under variably saturated conditions are adequately described by the Richards equation and the advection-dispersion equation with radioactive decay and linear sorption and no volatilization or hydrodynamic dispersion, respectively.

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[1] Battelle Memorial Institute (Battelle) retains copyright on all versions, revisions, and operational modes of the Subsurface Transport Over Multiple Phases (STOMP) software simulator, as permitted by the U.S. Department of Energy. STOMP is used here under a limited government use license.

Contaminant migration from waste sites in the 100-BC OUs through the vadose zone to the underlying aquifer is controlled by the driving forces, interactions between water and sediments, and interactions between the contaminants and the sediments. The hydraulic driving forces include gravity; matric potential gradients; recharge, which is the net result of competition between precipitation, evaporation, transpiration, infiltration, run-off, and run-on; and artificial (anthropogenic) discharges, such as those from liquid discharges to septic tank leach fields, ponds, lagoons, pipe and tank leaks, and by irrigation. The types, thicknesses, and properties of the sediments can all affect the rate and direction of solute and water movement to the aquifer. A contaminant's concentration in the groundwater and its concentration in the downgradient Columbia River, including the peak concentration, are dependent on the solute flux from the vadose zone; aquifer thickness, properties, and flux rates; travel distance; groundwater and river water mixing; and the location sampled. Each contaminant's propensity to sorb to vadose zone or aquifer materials can also be important controlling factors on the groundwater concentration determination.

The STOMP-W operational mode of STOMP (which solves for water mass conservation and dilute species mass conservation) was used to solve the Richards equation and the advection-dispersion equation that govern water flow and solute transport, respectively, under variably saturated conditions in porous media. The governing equations solved by the STOMP software are well documented in PNNL-12030. Numerical simulations generated using STOMP provided predictions of groundwater concentration and time to reach the breakthrough of the maximum concentrations for a list of contaminants based on a range of recharge rates, sediment types, vadose-zone thicknesses, and properties appropriate to the 100-BC OUs. The peak concentration within 1000 years was used in calculating unit-length SSLs and PRGs. The 1000-year limit was based on regulatory comment.

2 Methodology

Fate and transport simulations performed with the STOMP code were used to calculate peak groundwater concentrations resulting from a bounding representation of initial contaminant source in the vadose zone. The peak groundwater values obtained from those simulations were used to derive unit-length SSL and PRG values protective of groundwater, and protective of surface water, for the 100-BC source OUs. The STOMP code was selected to perform the simulations on the basis of its ability to adequately simulate the vadose zone features, events, and processes (FEPs) relevant to calculating SSLs and PRGs in the 100-BC OU and to satisfy the other code criteria and attributes identified in DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*, a document that describes the approach and provides the regulatory basis for using STOMP in this type of evaluation. Detailed information on the development and basis of the models used in this calculation are provided in SGW-50776, *Model Package Report: Vadose Zone Model for the River Corridor*.

Many of the methodologies, model inputs, and assumptions for computing SSLs and PRGs were developed to determine remedial action goals (RAGs) as part of DOE/RL-96-17 Rev.6, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*. Although the calculation methods are similar, the RAGs were calculated with the RESRAD (RESidual RADiation) model (ANL/EAD-4, *User's Manual for RESRAD Version 6*) and the SSLs and PRGs in this calculation were calculated with the STOMP software. A notable difference in approach is that the RAGs were developed as single values based on an assumed waste site dimension, whereas the SSLs and PRGs in this claucaiton are provided on a unit-length basis appropriate for direct scaling for evalaution of waste sites by site-specific representative dimensions.

2.1 Definition of Soil Screening Levels and Preliminary Remediation Goals

SSLs are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data (EPA/540/F095/041, *Soil Screening Guidance: Fact Sheet*). EPA provides a methodology for calculation of risk-based, site-specific SSLs for contaminants in soil that may be used to identify areas needing further investigation at National Priorities List sites. The approach used here is to derive SSLs in the same manner as PRGs (see below) but using a more conservative recharge rate based on an irrigated farming scenario. This approach recognizes the primary importance of recharge as parameter influencing breakthrough rates for vadose zone contamination into groundwater, and uses the irrigation based recharge rates as an upper bound on this parameter for screening purposes.

PRGs represent the maximum quantity, whether soil concentration or radionuclide activity, of a contaminant of potential concern (COPC) that can remain in the vadose zone without causing an exceedance of applicable regulatory standards. PRGs can be defined for protection of groundwater or protection of surface water simply by the choice of the applicable standard used in the calculation. The PRG calculation in this ECF is evaluated based on the peak release of a COPC under a native vegetation recharge scenario that is consistent with the land use plans for the 100-BC-1 and 100-BC-2 source OUs (Section 3.2.1.1). In contrast, the SSL calculation is based on a conservative (bounding) irrigation recharge scenario (Section 2.6). The value of a SSL or of a PRG for a particular COPC depends on a number of key factors:

- Waste site characteristics, specifically, source mass distribution and distance to the water table;
- Land cover condition and the associated net recharge rate;
- Interactions between the vadose zone geology and water movement;
- Interactions between the vadose zone geology and contaminant chemistry.

The unit-length SSLs and PRGs presented in this ECF are calculated for a unit-length source term and should not be applied at any given waste site without scaling by the appropriate length dimension, in the general direction of groundwater flow under the waste site to be evaluated. As described in Section 2.6, waste-site SSL and PRG values used for evaluation of exposure point concentrations (EPCs) are to be calculated by dividing the unit-length SSL or PRG value by the representative length of the waste site decision unit in the general direction of groundwater flow.

Model simulations were carried out for the non-radionuclide COPCs identified in ECF-HANFORD-10-0442 Rev. 1, *Calculation of Nonradiological Soil Concentrations Protective of Groundwater Using the Fixed Parameter 3-Phase Equilibrium Partitioning Equation for the 100 Areas and 300 Area*, and radionuclide COPCs identified in ECF-HANFORD-10-0429, *Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Report.* Unit-length SSLs and PRGs protective of groundwater were calculated for all COPCs (radionuclide and non-radionuclide) and unit-length SSLs and PRGs protective of surface water were calculated for all non-radionuclide COPCs.

2.2 Identification of Representative Stratigraphic Columns

Borehole data were used to identify representative stratigraphic columns for 100-BC source OUs. Only two lithologic units are present in the 100-BC vadose zone: the gravel-dominated Hanford formation and the Ringold Formation's E unit, which contains a slightly smaller percentage of coarse-grained sediments and a higher percentage of finer-grained sediments than the Hanford formation (SGW-44022 Rev. 1, *Geohydrologic Data Package in Support of 100-BC-5 Modeling*; SGW-46279, *Conceptual Framework*

and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model). Using the June 2008 water table elevations to represent the highest annually occurring water table, a conservative (smaller) thickness of the vadose zone was computed for each well and borehole. The borehole data were also used to estimate the thicknesses of each lithologic unit within the vadose zone and within the aquifer. The boreholes were divided into groups based on the proportion of each lithologic unit and total vadose zone thickness. A representative stratigraphic column was selected for each borehole group within the 100-BC source OUs, resulting in seven stratigraphic columns to be used in the STOMP simulations (refer to Section 3.1 below).

The water table elevations of June 2008 were selected to provide representative (not extreme) high water table conditions; the month of June is typically when the highest river stages occur in this reach of the Columbia River. Use of water table elevations from the high water stage period (represented by June 2008 data) result in a conservative (smaller) thickness of the vadose zone for each well and borehole to develop the representative stratigraphic profiles. Imposing conservative bias towards a smaller thickness was made to reduce the travel distance for contaminants in the vadose zone, and thereby bias the resulting peak groundwater concentration calculated to arrive sooner and have greater magnitude – resulting in more restrictive SSL and PRG values than otherwise would be calculated. These well and borehole data were used to estimate the thicknesses of each lithologic unit in each representative stratigraphic column.

The lowest portion of each representative stratigraphic column is used to represent the upper 5 meters (m) of the unconfined aquifer, such that the water flux through this downgradient aquifer boundary of the model domain represents a 5-m monitoring well screen. This representation is consistent with the requirements for accounting for the aquifer mixing zone thickness specified in the Washington Administrative Code (WAC), specifically WAC 173-340-747[5][f][i], which stipulates that the aquifer mixing zone thickness shall not exceed 5 m in depth. Aquifer dilution is thus directly simulated in the STOMP solution, based on the OU-specific hydraulic gradient imposed as a boundary condition across those nodes representing the aquifer portion of the representative stratigraphic column.

2.3 STOMP Flow and Transport Simulation

Peak groundwater concentrations in the aquifer at the downgradient edge of the modeled waste site within each of the representative stratigraphic columns were calculated using STOMP to solve the governing equations for flow and solute transport under variably saturated conditions (Sections 3 and 5). Peak concentrations of selected COPCs (Attachment A) were calculated for two different initial contaminant source distributions (Section 3.2.4) with two different recharge scenarios for each representative stratigraphic column (Section 3.1).

2.4 Calculation of Peak Groundwater Concentration within 1000 Years

Peak groundwater concentrations within 1000 years were calculated for each model time step along a portion of the domain's downgradient boundary corresponding to the top 5 m of the aquifer. Using the upper 5 m of the aquifer is consistent with the requirements for aquifer mixing zone thickness in WAC 173-340-747[5][f][i]. The concentration was conservatively estimated by calculating it in the aquifer beneath the downgradient edge of the waste site footprint. These groundwater concentrations and the year that they occurred were tabulated to find the peak concentration of contaminant in groundwater and its year of occurrence.

2.5 Point of Calculation, Point of Compliance, and Protectiveness Criteria

In accordance with risk assessment guidelines, the determination of soil contamination impacts to groundwater and surface water also requires the definition and rationale for (1) the point of calculation

(POCal) i.e., the place/point in the groundwater domain where modeled groundwater concentrations are to be assessed for potential impacts and protectiveness (resulting from soil contamination at the point of compliance), and (2) the protectiveness metric, i.e., the groundwater and surface water metric(s) to be used in the assessment of protectiveness at the POCal (DOE/RL-2011-50).

The POCal for the protection of groundwater and surface water is related to the "exposure point" in the context of conventional human health risk assessments (EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume 1, Human Health Evaluation Manual [Part A]*) in federal and state regulations and guidelines (DOE/RL-2011-50).

The "point of compliance" under the WAC is the soil throughout the vadose zone (WAC-173-340-740(6)(b)). The POCal is the point where the peak groundwater concentration resulting from the uniform initial contaminant concentration in the soil is calculated in the forward calculation. This peak groundwater concentration is then used to back-calculate the maximum allowable soil concentration at the point of compliance (all soil in the vadose zone) to determine the maximum soil contamination level that will not result in exceedance of groundwater or surface water protection levels.

The representative columns are represented in STOMP as a single vertical column of computational grid blocks. For this calculation, the POCal is the outflow (downgradient) edge those grid blocks that correspond to the topmost 5 m of the aquifer, representing the screened portion of a monitoring well. The peak value of concentration within the topmost 5 m of the aquifer was scaled by the appropriate regulatory compliance criteria in a back-calculation step to determine unit-length SSL and PRG values for the point of compliance (vadose zone soil). The protectiveness criteria are the applicable water quality standards for groundwater and surface water (e.g., applicable regulations and requirements [ARARs], maximum contaminant levels [MCLs], or applicable water quality standards [AWQLs]) values for each contaminant. The applicable water quality standard for each contaminant for protectiveness of groundwater and surface water in the 100-BC Area are listed in the tables of unit-length SSL values in Attachment A, and in the tables of unit-length PRG values in Attachment B, of this ECF.

2.6 Calculation of Unit-Length Soil Screening Level and Unit-Length Preliminary Remediation Goal Values

A simple calculation was employed to compute unit-length SSL and PRG values by scaling the peak concentration values against the regulatory compliance criteria and the initial soil concentration. As a measure of allowable quantity of contaminant in the soil, evaluation SSLs and PRGs are expressed as contaminant mass per mass of soil for non-radionuclides or as contaminant activity per mass of soil for radionuclides. Unit-length SSLs and PRGs are expressed as the product of length in the general direction of groundwater flow and either the contaminant mass per mass of soil for non-radionuclides or contaminant activity per mass of soil for radionuclides.

The unit-length SSL for each COPC is computed as:

$$SSL_{unit-length} = C_I \frac{WQS}{CPK} \tag{1a}$$

where,

$SSL_{unit-length} \equiv$ unit-length soil screening level $\left[\frac{\text{mg}}{\text{kg}}\cdot\text{m or } \frac{\text{pCi}}{\text{g}}\cdot\text{m}\right]$

C_I ≡ initial soil mass, or activity, concentration $\left[\frac{\text{mg}}{\text{kg}}\cdot\text{m or } \frac{\text{pCi}}{\text{g}}\cdot\text{m}\right]$

WQS ≡ water quality standard $\left[\frac{\text{mg}}{\text{L}} \text{or } \frac{\text{pCi}}{\text{L}}\right]$

CPK ≡ peak groundwater mass, or activity, concentration $\left[\frac{\text{mg}}{\text{L}} \text{or } \frac{\text{pCi}}{\text{L}}\right]$

Similarly, the unit-length PRG for each COPC is computed as:

$$PRG_{unit-length} = C_I \frac{WQS}{CPK} \tag{1b}$$

where,

$PRG_{unit-length}$

≡ unit-length preliminary remediation goal $\left[\frac{\text{mg}}{\text{kg}}\cdot\text{m or } \frac{\text{pCi}}{\text{g}}\cdot\text{m}\right]$

C_I ≡ initial soil mass, or activity, concentration $\left[\frac{\text{mg}}{\text{kg}}\cdot\text{m or } \frac{\text{pCi}}{\text{g}}\cdot\text{m}\right]$

WQS ≡ water quality standard $\left[\frac{\text{mg}}{\text{L}} \text{or } \frac{\text{pCi}}{\text{L}}\right]$

CPK ≡ peak groundwater mass, or activity, concentration $\left[\frac{\text{mg}}{\text{L}} \text{or } \frac{\text{pCi}}{\text{L}}\right]$

Peak groundwater concentrations (*CPK*) used in Equations (1a) and (1b) are obtained from the conservative irrigation recharge scenario simulations (Section 2.6) and the native vegetation recharge scenario simulations (Section 3.2.1.1), respectively.

Unit-length SSLs and PRGs are derived for protection of either surface water or of groundwater by using the applicable water quality standard as the *WQS* variable in Equations (1a) and (1b).

The unit-length SSL and PRG values are specified in terms of unit length to provide for direct scaling to representative waste site dimension in the general direction of groundwater flow ($L_{\parallel GW}$, expressed in meters) to obtain evaluation SSL and PRG values appropriate to evalaution of EPC values using Equations 2a and 2b, respectively:

$$SSL_{evaluation} = \frac{SSL_{unit-length}}{L_{\parallel GW}} \tag{2b}$$

$$PRG_{evaluation} = \frac{PRG_{unit-length}}{L_{\parallel GW}} \tag{2b}$$

The values of $SSL_{unit\text{-}length}$ and $PRG_{unit\text{-}length}$ calculated using Equations (1a) and (1b), respectively, are derived from model simulations representative of a soil column that extends a distance of one meter along the general direction of groundwater flow (Section 3.1). To determine waste-site values, the unit-length values are divided by the representative length of the waste site. To illustrate this concept, assume that the calculated $SSL_{unit\text{-}length}$ for some COPC is $1.0\,\frac{\text{mg}}{\text{kg}}\cdot\text{m}$ (Figure 2-1a). That means that a concentration of 1.0 mg/kg of the COPC in the vadose zone of a one-meter wide soil column results an outflow from that column of groundwater with a concentration equal to the MCL. Suppose, however, that the waste site

under consideration has a representative length of 5 m – i.e., extends 5 m in the general direction of groundwater flow. This situation can be represented as five one-meter-wide soil columns assembled in series along the direction of groundwater flow (Figure 2-1b). In this case, the contamination from each individual column contributes to the outflow concentration in groundwater, so the five-meter effective SSL for evaluation of this specific waste site ($SSL_{evaluation}$) would be

$$SSL_{evaluation} = \frac{SSL_{unit-length}}{L_{\|GW}} = \frac{1\ \frac{mg}{kg}\cdot m}{5\ m} = 0.2\frac{mg}{kg}$$

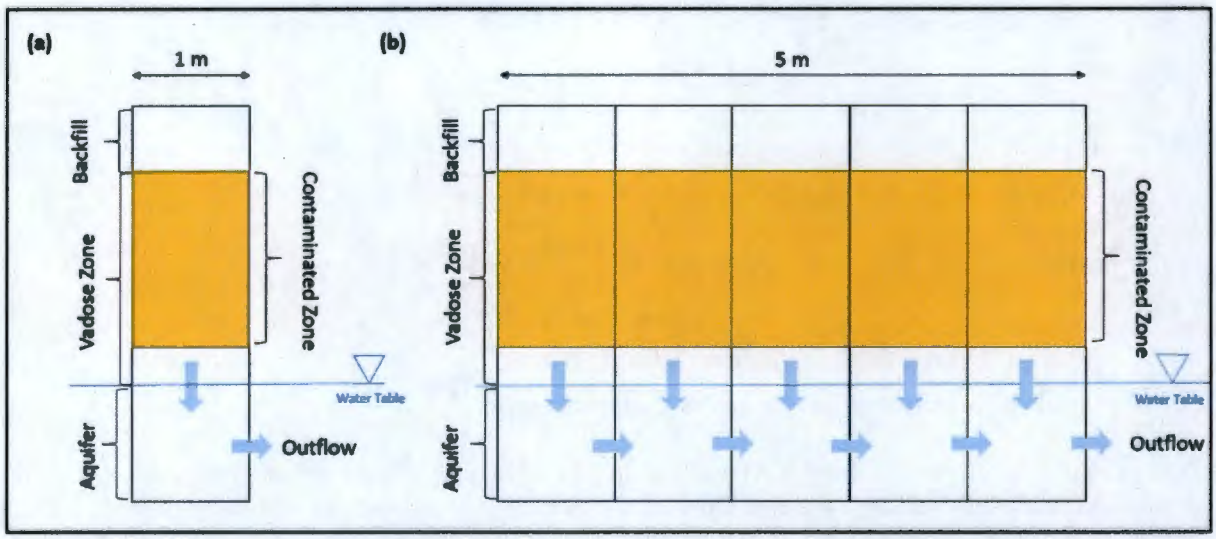


Figure 2-1. Example of Application of Unit-Length SSL or PRG to a Waste Site Decision Unit

When scaling the unit-length SSL or PRG values for use in comparison to EPC values, two additional checks are required;

1. It is possible that scaling by the representative waste site decision unit dimension could result in evaluation SSL or PRG values that are less than the background level for a given COPC; in these cases, the EPC will not be considered to exceed the evaluation (scaled) SSL or PRG values; and
2. It is possible that scaling by the representative waste site decision unit dimension could result in evaluation SSL or PRG values that are less than the estimated quantification limit (EQL); in these cases, the EPC will not be considered to exceed the evaluation (scaled) SSL or PRG values.

2.6.1 Lower Threshold of Numerical Significance for Peak Groundwater Concentrations

Breakthrough is assumed not to occur in cases where the simulated peak groundwater concentration within the 1000-year limit does not exceed 0.0001 µg/L for non-radionuclide COPCs and 0.0001 pCi/m^3 for radionuclide COPCs. This breakthrough threshold is used to set a minimum level of numerical significance for groundwater peak concentrations reported by the numerical model. Use of values less than this breakthrough threshold would result in extremely high unit-length SSL or PRG values that would not constitute a meaningful limit on residual soil contamination. Consequently, where breakthrough does not occur under this assumption, the unit-length **SSL or PRG value is encoded "NR" to** signify a non-representative result.

2.6.2 Lower Threshold of Estimated Quantitation Limit for Unit-Length Soil Screening Levels and Preliminary Remediation Goals

If the unit-length SSL or PRG calculated for a given COPC is below the estimated quantitation limit (EQL) for the soil concentration of that COPC, then the EQL is substituted for the unit-length SSL or PRG value as a lower bound. The soil EQL represents the lowest concentration that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions. EQLs are normally arbitrarily set rather than explicitly determined; for this calculation, EQLs are those specified in Appendix A of DOE/RL-2009-44, *Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study*.

2.6.3 Upper Threshold of Pore Space Maximum Contaminant Mass Capacity for Non-radionuclide Unit-Length Soil Screening Level and Unit-Length Preliminary Remediation Goal Values

Unit-length SSL and PRG values were calculated from the peak groundwater concentrations using Equations (1a) and (1b), respectively, and the applicable surface water and groundwater regulatory standards. Where simulated peak groundwater concentrations were very small, application of Equations (1a) and (1b) would yield physically unrealistic soil concentrations, e.g., 10 kg of aluminum per 1 kg of soil. Listing such unphysical protection levels is not meaningful, so an upper physical bound for unit-length SSL and PRG values is specified here that is derived based on considering the extreme of total contaminant mass that can occupy the soil pore space within a unit mass (1.0 kg) of bulk soil. The bulk density (ρ_b) of 100 Area soils is 1930 kg/m^3, so the total volume (V_T) of this soil (sum of soil and pore space) is calculated as

$$V_T = \frac{m_{soil}}{\rho_b} = \frac{1\ \text{kg}}{1930\,\frac{\text{kg}}{\text{m}^3}} = 5.18 \times 10^{-4}\ \text{m}^3 \tag{3}$$

At maximum, COPC mass is assumed to occupy the total porosity fully. Therefore, the maximum mass of COPC in the soil is calculated as

$$m_{max,p} = n_T \times V_T \times \rho_p \tag{4}$$

where n_T is the total porosity and ρ_p is the particle density of the COPC. In the 100 Area, the highest total porosity of the Hanford formation or of the Ringold Formation is 0.28. The particle density of the COPC is assumed equal the highest particle density of the Hanford formation or of the Ringold Formation, which is 2680 kg/m^3 for the Hanford formation (PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses*). Substituting into Equation (4), the maximum mass of COPC in 1.0 kg soil is then calculated as

$$m_{max,p} = (0.28) \times \left(5.18 \times 10^{-4}\ \text{m}^3\right) \times \left(2680\ \frac{\text{kg}}{\text{m}^3}\right) = 0.389\ \text{kg} \times \left(\frac{1{,}000{,}000\ \text{mg}}{1\ \text{kg}}\right)$$
$$= 389{,}000\ \text{mg}$$

Thus, the maximum unit-length SSL or PRG value for non-radionuclides is 389,000 mg·m per kg of soil. Therefore, unit-length SSL or PRG values that exceed this physical upper bound are truncated at physical upper bound value 389,000 mg·m/kg. Note that this physical upper bound is not applied to radionuclide unit-length SSL or PRG values because these are expressed in terms of activity rather than mass.

A similar threshold was presented for maximum radioactivity in soil in SGW-50776. However, it was redundant to apply that limit here because a value for that would exceed that limit would also exceed the lower threshold of numerical significance for peak groundwater concentrations (Section 2.6.1).

2.6.4 Cleanup Levels for Hexavalent Chromium based on Limitation of Sorption Data

ECF-HANFORD-11-0165, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area*, provides quantitative evaluations of leach test results and the derivation of a conservative-basis K_d for hexavalent chromium for evaluation of future fate and transport of residual vadose zone contamination after interim remedial actions have been implemented for source waste sites in the vadose zone. These evaluations were based on the results of leaching studies conducted on soil samples from a large number (about 200) of leach studies for vadose zone soils across the River Corridor, including both high concentration/low volume waste sites, low concentration effluent waste sites, and boreholes not associated with a waste site. The soil concentration data for which the K_d value was derived had a maximum value of 6.0 mg/kg, and hence there is no basis to infer greater soil cleanup levels for hexavalent chromium based on the limited range of these data. These leach test data also indicate that for hexavalent chromium at concentrations below 6.0 mg/kg are highly non-leachable. Therefore, the SSL and PRG values for hexavalent chromium using the K_d recommended in ECF-HANFORD-11-0165 (0.8 mg/L) are set to a soil concentration value of 6.0 mg/kg, consistent with the data range and leaching test results. This value is not scaled by the representative dimension in the general direction of groundwater flow because the basis for the K_d value are bounding results for intentionally aggressive leaching methods that showed Cr(VI) concentrations below 6 mg/kg in the vadose zone are highly non-leachable – a result that is not dependent on the dimensionality of the model. Additionally, note that the soil PRG values for protection of groundwater and surface water for hexavalent chromium is not based on the results of fate and transport modeling, but rather on interim cleanup actions (originally based on the "100 times rule) which assigns the more restrictive value of 2.0 mg/kg.

3 Assumptions and Inputs

Two sequential STOMP simulations were used to determine peak groundwater concentrations. The first stage, termed the historic pre-2010 simulation, modeled flow through the representative columns for a 2010-year period prior to the commencement of predictive modeling. The purpose of this arbitrarily long simulation period is merely to achieve equilibrium (steady state) in the flow conditions in the model domain. Review of the first-stage matric potential and volumetric water content values over the last 100 years confirmed that fluxes in the column had reached equilibrium conditions at the end of the simulation.

The second stage, termed the predictive post-2010 simulation, modeled flow and transport for a 1000-year period commencing in calendar year 2010, a year selected to represent the present. Denoting the starting year as 2010 is done to allow consistency with PRG and SSL calculations for other river corridor evaluations.

Results from the historic pre-2010 simulations established the initial aqueous pressure conditions for the 1000-year-long second-stage simulation, the predictive post-2010 simulation, which solved for both flow and solute transport. The predictive solute transport simulations tracked the fate of contaminants with COPC-specific distribution coefficients and radioactive decay constants through the vadose zone and into the aquifer. These results were used to identify the peak groundwater concentrations (within 1000 years) and year the peak concentration occurs.

STOMP estimates of peak groundwater concentration depend on the model inputs and assumptions. Inputs to the models and their underlying assumptions are presented in the following categories:

- Model domains

- Boundary conditions and initial conditions
- Hydraulic and transport parameters
- Contaminant source term

Each of these input categories is discussed in the sub-sections that follow.

3.1 Model Domain

Conceptually, the model represents a column of sediments that comprise a vadose zone underlain by an aquifer (referred to herein as the saturated zone). Recharge-driven flow moves downward through the vadose zone, where it encounters contamination that is eventually transported to an underlying aquifer, across which a pressure gradient drives horizontal flow. At the start of each predictive simulation, the vadose zone comprises a cover of clean fill with constant thickness as well as contaminated and uncontaminated sediments of varying thickness. The saturated zone constitutes the base of the column.

3.1.1 Representative Stratigraphic Columns

Within the 100-BC source OUs, the lithology of both vadose and saturated zones is composed of Hanford formation and Ringold Unit E soils in varying abundances. These are represented in the model by layers of discrete materials defined by material-specific hydraulic and mechanical properties. If present, the contact between the Ringold unit E and the Ringold Upper Mud unit forms the bottom of the aquifer.

Thickness and lithologic composition of the vadose zone of the saturated zone were determined using borehole data from the Hanford Environmental Information System (HEIS) borehole database. Boreholes from 100-BC source OUs were divided into groups that represent the range of vadose zone thicknesses and lithologic composition. The objective was to create a limited number of representative stratigraphic columns so that the number of STOMP simulations could be minimized while maintain fidelity with conditions in the field. This was accomplished by grouping the 100-BC Area boreholes into seven different intervals of vadose zone thickness and then identifying one representative lithologic composition for each interval as given in Table 3-1 and shown in Figure 3-1. Note that Table 3-1 shows the thickness of both the representative stratigraphic columns and of their implementation in the STOMP model, in which the thickness of the representative columns are rounded to the nearest multiple of 0.25 m to accommodate the model gridding (Section 3.1.2). A conservative (thinner) estimate of vadose zone thickness was calculated by taking the difference between ground surface elevation and the June 2008 water table elevation, which is representative of the seasonal high water table elevation. The relevant data for all the boreholes were compiled for each source OU. In the 100-BC Area, vadose zone thickness ranges between 12 m and 29 m with an average of 18.0 m, whereas saturated zone thickness ranges between 28.7 m and 48.0 m, with an average of 32.9 m. Each column was assumed to contain clean backfill in the top 15 ft. of each column to represent conditions following interim remediation.

3.1.2 Model Implementation

The model coordinate system is Cartesian, with the vertical (z) axis aligned with the direction of gravitational acceleration and the first horizontal (x) axis aligned with the general direction of groundwater flow. The second horizontal (y) axis is represented numerically by the STOMP simulator, but effectively no water flow or solute transport occurs in this direction because the boundary conditions on (y) axis cell faces are all assigned default no-flow conditions to represent an infinite extent of the waste site in the direction perpendicular to the general direction of groundwater flow.

The model domain consists of a vertical column of grid blocks intersected by a water table. Grid blocks above the water table comprise the vadose zone (VZ). Grid blocks below the water table comprise the

Table 3-1: Vadose Zone Thickness and Geology for 100-BC Source Operable Units

Model Column Index	Model VZ[a] Thickness (m)	Model VZ Composition	Model Thickness of Backfill in VZ (m)	Model Thickness of Hanford in VZ (m)	Model Thickness of Ringold E in VZ (m)	Corresponding Wells	Representative VZ Thickness (m)	Representative VZ Composition	Representative Thickness of Backfill in VZ (m)	Representative Thickness of Hanford in VZ (m)	Representative Thickness of Ringold E in VZ (m)	Representative Aquifer Thickness (m)	Representative SZ[b] Composition
1	14.75	30% Backfill 62% Hanford 8% Ringold E	4.5	9.0	1.25	199-B3-2	15.0	31% Backfill 61% Hanford 9% Ringold E	4.6	9.1	1.3	31.6	100% Ringold E
2	23.0	20% Backfill 80% Hanford	4.5	18.5	0.0	699-71-77	23.1	20% Backfill 80% Hanford	4.6	18.5	0.0	28.7	15% Hanford 85% Ringold E
3	14.0	32% Backfill 68% Hanford	4.5	9.5	0.0	199-B5-5	14.1	33% Backfill 67% Hanford	4.6	9.5	0.0	48.0	100% Ringold E
4	29.25	15% Backfill 85% Hanford	4.5	24.75	0.0	199-B8-9	29.4	16% Backfill 84% Hanford	4.6	24.8	0.0	35.1	41% Hanford 59% Ringold E
5	22.0	20% Backfill 80% Hanford	4.5	17.5	0.0	199-B3-50 199-B5-6	22.1	21% Backfill 79% Hanford	4.6	17.5	0.0	33.0	15% Hanford 85% Ringold E
6	12.0	38% Backfill 62% Ringold E	4.5	7.5	0.0	199-B2-12	12.1	38% Backfill 62% Ringold E	4.6	7.5	0.0	33.5	100% Ringold E
7	13.0	35% Backfill 46% Hanford 19% Ringold E	4.5	6.0	2.5	199-B2-14	13.1	35% Backfill 46% Hanford 19% Ringold E	4.6	6.0	2.5	30.75	100% Ringold E

a. VZ = Vadose Zone

b. SZ = Saturated Zone

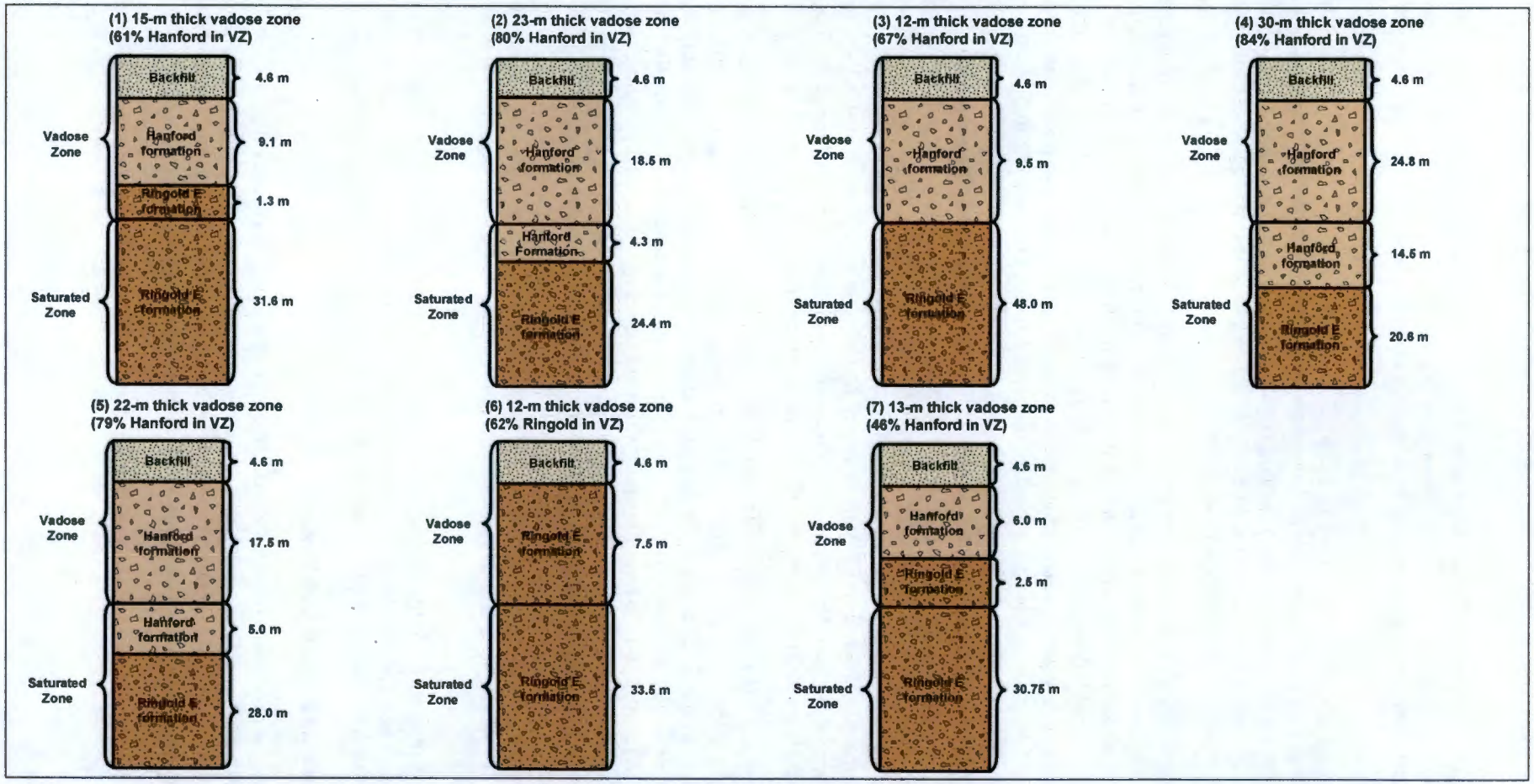


Figure 3-1. Representative Stratigraphic Columns for 100-BC Source Areas

saturated zone (SZ). The location of the water table is assigned in the initial configuration of the model and does not move up or down during simulations. Grid blocks are uniformly 0.25 m in height and 10 m in length throughout the model domain, with an arbitrarily assigned thickness of 1 m in the the effectively unused *y*-direction.

The thickness of the saturated zone was set to 5 m in all models to represent the screened well interval at the POCal (Section 2.5). Confirmatory simulations were performed to evaluate if using greater thicknesses for the saturated zone while evaluating concentration at the POCal (uppermost 5 m of saturated zone). The results confirmed that modeling saturated zone thicknesses greater than 5 m did not affect the concentration reported at the POCal.

The vertical dimension (*z*) of the model grid blocks were selected to provide appropriate resolution to represent the the hydrostratigraphy and the contaminant source distribution, while also minimizing both the model run times and any undesirable numerical dispersion effects. The horizontal dimension in the general direction of groundwater flow (*x*) of the model grid blocks was selected to minimize potential numerical artifacts in simulated concentrations within saturated grid blocks. Numerical dispersion is a modeling artifact that can arise when the advective transport distance exceeds the grid block size within a single model time step. Numerical dispersion can be constrained to acceptable levels by setting limits on the minimum grid block size and/or the minimum model time step. Choosing limits that yield a Courant number value on the order of unity will minimize numerical dispersion (Huyakorn and Pinder, 1983). The Courant number is the dimensionless ratio of advective transport distance – defined as the product of groundwater velocity and the model time step, to grid block size (Huyakorn and Pinder, 1983). All simulations for this calculation used STOMP's Courant limitation scheme that automatically subdivides transport time steps within each time step for the flow solution to ensure that the Courant number for each grid block does not exceed the Courant limit (1.0) throughout the computational mesh.

Unit-length PRGs and SSLs are defined for a unit-length source term, which requires an effective horizontal (*x*) grid block length of 1 m. Such a small grid block length, when used in combination with values of saturated hydraulic conductivity or saturated head gradient, could force the Courant limitation scheme to adopt extremely short time steps. To complete simulations in reasonable times, the grid block length was therefore set to 10 m to limit run times while still ensuring numerical dispersion was minimized. This tenfold increase in the grid block horizontal (*x*) length increased the source term area from a unit value to a value of ten. Therefore, based on the linearity of the concentration with the horizontal distance, the simulated contaminant aqueous concentration value was divided by ten to yield the value appropriate for calculating unit-length PRG and SSL values. The accuracy of this methodology was verified with confirmatory simulations to compare how simulated aqueous concentrations varied with grid block size.

Grid block Courant numbers for the aquifer grid blocks, in which flow is horizontal under fully saturated conditions, were all less 1.0. Grid block Courant numbers for the vadose zone grid blocks, in which flow is vertical under variably saturated conditions, were all less 1.0 for all recharge scenarios.

3.2 Boundary and Initial Conditions

Solving the governing equations for variably saturated flow and transport requires stipulation of boundary and initial conditions. A complete set of boundary and initial conditions must be stipulated for each governing equation for input to STOMP. The boundary condition specifications for this model discussed in this section are graphically summarized in Figure 3-2.

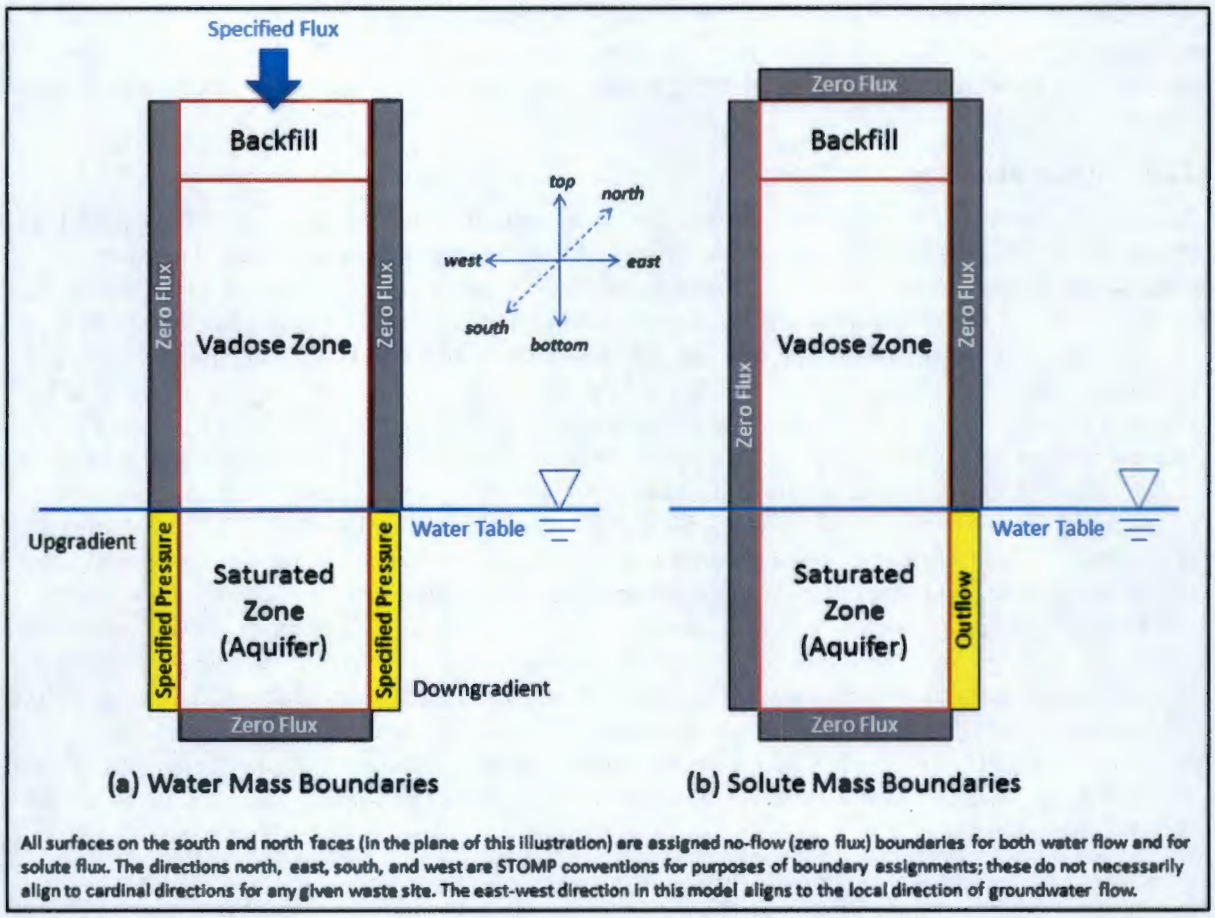


Figure 3-2. Boundary Conditions for (a) Water Mass and (b) Solute Mass Conservation Equations

For the water mass conservation equation, flow boundary conditions were specified to represent one-dimensional vertical flow in vadose zone resulting from recharge through the top boundary, and lateral flow in the saturated zone in response to the hydraulic gradient. A Neumann-type (specified flux) boundary condition was applied at the top surface to simulate effective recharge; the flux rate was varied, stepwise constant, to represent different recharge rates over time. Neumann-type boundary conditions with no flow (zero flux) were assigned to all the vertical boundaries (east, west, south, and north) of the vadose zone to maintain one-dimensional, vertical flow. The bottom boundary of the model domain was assigned a Neumann-type boundary condition with no-flow (zero flux) to constrain the aquifer to a 5-m thickness (Figure 3-2a). The east and west boundaries of the saturated zone portion of the domain was assigned a hydraulic gradient boundary condition to maintain the specified lateral flow rate in the aquifer, while the north and south boundaries were assigned Neumann-type boundary conditions with no flow (zero flux) to constrain the aquifer flow to one horizontal direction. Note here that in discussing lateral boundaries, the directions east, west, north, and south are conventions used in the STOMP code. For this model, these direction references do not (necessarily) align to cardinal directions for any given actual waste site. Rather, the west-east (x) dimension in this STOMP representation is intended to align to the direction of groundwater flow for any waste site.

For the solute mass conservation equation, specified zero-flux boundaries were applied at the top of the model domain, along both edges of the vadose zone, along the upgradient edges of the aquifer grid blocks, and the bottom of the aquifer (Figure 3-2b). The downgradient edges of the aquifer grid blocks

were assigned STOMP's outflow solute type boundary condition (see page 6.21 of PNNL-12030, and page 4.4 of PNNL-15782), which transports solute mass out of the domain according to the advective flux term in the solute mass conservation governing equation but does not allow solute to enter back into the domain.

3.2.1 Upper Boundary Conditions

For water flow, a time-varying Neumann-type (specified water flux) boundary condition was applied at the top surface (Figure 3-2a) to represent net infiltration (destined to become recharge). The net infiltration into the vadose zone, which is used in the model to represent the recharge into the aquifer, is driven by the competition between precipitation (including snow), potential evaporation, transpiration, run-off and run-on. In an arid or semi-arid climate, the net downward flux that results from these fluxes are episodic and usually infrequent. This effect is typically damped towards a nearly constant rate with increasing depth, however, as soil moisture variability with depth measured at Hanford Site lysimeters shows (PNNL-17841, *Compendium of Data for the Hanford Site (Fiscal Years 2004 to 2008) Applicable to Estimation of Recharge Rates*). This is the basis for representing recharge in the vadose zone model using a constant rate applicable to a given soil type and vegetation cover (DOE/RL-2011-50). A number of studies have been carried out at the Hanford Site to ascertain representative long-term averages of the episodic fluxes, i.e., recharge rates, such as those compiled by Pacific Northwest National Laboratory (PNNL) in PNNL-14702 Rev. 1, *Vadose Zone Hydrology Data Package for Hanford Assessments*) for the 100 Areas. The 100 Area specific recharge rates reported in PNNL-14702 Rev. 1 vary with surface soil type, providing an estimate of the range of possible recharge rates for various land uses. The three surface soil types were the Ephrata sandy loam or stony loam, Burbank sandy loam and Rupert sand. Additionally, PNNL-14702 Rev. 1 also provides recharge rates for disturbed soil conditions; the disturbed soil rates representing backfill were selected for use in calculation of unit-length SSLs and PRGs for the 100-BC source OUs.

Each calculation of a unit-length SSL or PRG with STOMP requires a pair of simulations; the first is a simulation of water flow only for historic recharge conditions, needed to obtain the soil moisture conditions throughout the model domain at the start time for the second simulation. The second is a coupled simulation of water flow and contaminant transport, starting from the assumed initial contaminant distribution (100:0 or 70:30 models) and the initial moisture distribution provided by the first simulation. Calendar year 2010 was set as the time when the first, historic (pre-2010) simulation ends and the second, predictive (post-2010) simulation begins. Recharge rates were conservatively simulated in STOMP as a specified flux boundary condition applied to the top boundary of the model (Figure 3-2a) for each recharge scenario and each soil type. Rates were assumed to change over time in step function-fashion for each recharge scenario.

For the historic (pre-2010) simulations, land use and recharge rates were assumed to transition from native vegetation (mature shrub-steppe) during pre-settlement conditions, to a historic irrigation period for 1880 to 1944, to a Hanford Site operational period with bare soil from 1944 to 2010. The pre-settlement phase was assumed to begin in calendar year 1, an arbitrary date that was selected merely to ensure steady-state moisture conditions are achieved in the solution for the applicable recharge rate by the 1880 year of transition to historic irrigation (1880). Historic irrigation is included in the historic period because some land areas adjacent to and slightly overlapping the 100-BC area were used for irrigated agriculture prior to construction of the Hanford Site. The historic irrigation period is conservatively assumed to commence in 1880, and is further conservatively assumed applicable to all waste sites in the 100-BC source OUs. The Hanford Site operational period is conservatively assumed to consist of bare soil conditions, maintained vegetation free, for all waste sites. The recharge rates for each historic phase

(pre-settlement with native vegetation, historic irrigation, Hanford operations) are applied to the top boundary as a constant rate within each phase.

For the predictive simulations (post-2010), two different recharge scenarios were evaluated, representing different future land uses. The native vegetation recharge scenario represents DOE's planned land use with restoration and maintenance of a native shrub-steppe plant community. The irrigation recharge scenario represents a bounding condition of irrigated agriculture.

For solute transport, specified zero-contaminant-flux boundaries were applied at the top of the model domain, along both edges of the vadose zone, along the upgradient edges of the aquifer grid blocks, and the bottom of the aquifer (Figure 3-2b). The downgradient edges of the aquifer grid blocks were assigned STOMP's outflow solute boundary condition (see page 6.21 of PNNL-12030, and also page 4.4 of PNNL-15782), which transports solute out of the domain according to the advective flux term in the governing equation and does not allow solute to enter back into the domain (Figure 3-2b).

3.2.1.1 Native Vegetation Recharge Scenario

The native vegetation recharge scenario (Table 3-2; Figure 3-3) is used for calculation of unit-length PRG values. This recharge scenario represents DOE's planned land use with restoration and maintenance of a native shrub-steppe plant community. The scenario is comprised of three historic phases discussed previously and four future phases that represent recharge rates changes corresponding to postulated future land use/cover transitions. The first future phase (2010 to 2015) represents the period of continued bare soil cover. The second future phase (2015 to 2020) represents an invasive cheatgrass cover. The third phase represents grasses and developing shrubs as vegetation matures during a 30-year transition (transition period duration from DOE/RL-2011-50). The final phase is mature shrub steppe that lasts for the remainder of the simulation. Recharge rates diminish in each successive phase for this scenario. Revegetation of waste sites following remediation is assumed in this scenario, consistent with revegetation that is occurring in the 100 Areas accordance with the *Hanford Biological Resources Management Plan* (DOE/RL-96-32 Rev. 1). Revegetation has been successfully conducted in the 100 Area following other remediation activities (for examples, refer to annual issues of the *River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, including WCH-299 (2008), WCH-362 (2009), WCH-428 (2010), WCH-512 (2011), and WCH-554 (2012).

3.2.1.2 Irrigation Recharge Scenario

The irrigation recharge scenario (Table 3-3; Figure 3-4) is used for calculation of unit-length SSL values. This recharge scenario represents an upper bound based on recharge rates from irrigated agriculture land use. This recharge scenario is comprised of transition from bare soil conditions to long-term irrigation farming. Although this recharge scenario is inconsistent with DOE land use plans, it is used here to represent an upper bound on recharge rates for screening purposes. The bounding nature of this recharge scenario is reinforced further by the assumption that irrigated agriculture commences five years in the future, much sooner than is reasonable given that Hanford Site remediation activities are expected to continue for decades to come and constrain land use accordingly.

Recharge rates for the irrigation phases of this recharge scenario were estimated using the same approach used to assess interim remediation at 100 Area waste sites (DOE/RL-96-17) following Washington Department of Health guidance (WDOH/320-015, *Hanford Guidance for Radiological Cleanup*). These previous site assessments used Remedial Action Goals (RAGs) calculated from RESRAD simulations that assumed total recharge was a combination of irrigation and native vegetation (base case) recharge scenario rates. As the base case rates used in the RESRAD simulations were differ from those adopted for the native vegetation recharge scenario (from PNNL-14702), the RESRAD equation for total recharge was back-solved to ascertain the recharge rate attributable to irrigation alone.

Table 3-2. Native Vegetation Recharge Scenario Phases and Recharge Rates (mm/yr)

Surface Soil Type	Historic Simulation (pre-2010) (calculation of initial hydraulic conditions)			Predictive Simulation (post-2010) (calculation of peak groundwater concentration)			
	Pre-Settlement (< 1880)	Historic Irrigation [a] (1880-1944)	Hanford Operations (1944-2010)	Bare Soil (2010-2015)	Cheatgrass (2015-2020)	Developing Shrub-Steppe (2020-2050)	Mature Shrub-Steppe (> 2050)
Hanford sand, disturbed	4.0 [b]	72.4 [c]	63.0 [d]	63.0 [d]	31.5 [e]	8.0 [f]	4.0 [g]

a. Irrigated agriculture was present adjacent to and slightly overlapping the 100-BC Area prior to Hanford Site construction; irrigation was conservatively assumed applicable to all 100-BC sites from calendar years 1880 through 1944.

b. Source: PNNL-14702 Rev. 1, Table 4-15, all areas with soils disturbed by excavations; shrub steppe.

c. Recharge rates for historic irrigation phase is that from the long-term irrigation rate (Irrigation II) under the irrigation recharge scenario (Table 3-3).

d. Source: PNNL-14702 Rev. 1, Table 4-15, all areas with soils disturbed by excavations; no vegetation.

e. Source: PNNL-14702 Rev. 1, Table 4-15, all areas with soils disturbed by excavations; cheatgrass.

f. Source: PNNL-14702 Rev. 1, Table 4-15, all areas with soils disturbed by excavations; young shrub steppe.

g. Source: PNNL-14702 Rev. 1, Table 4-15, all areas with soils disturbed by excavations; shrub steppe.

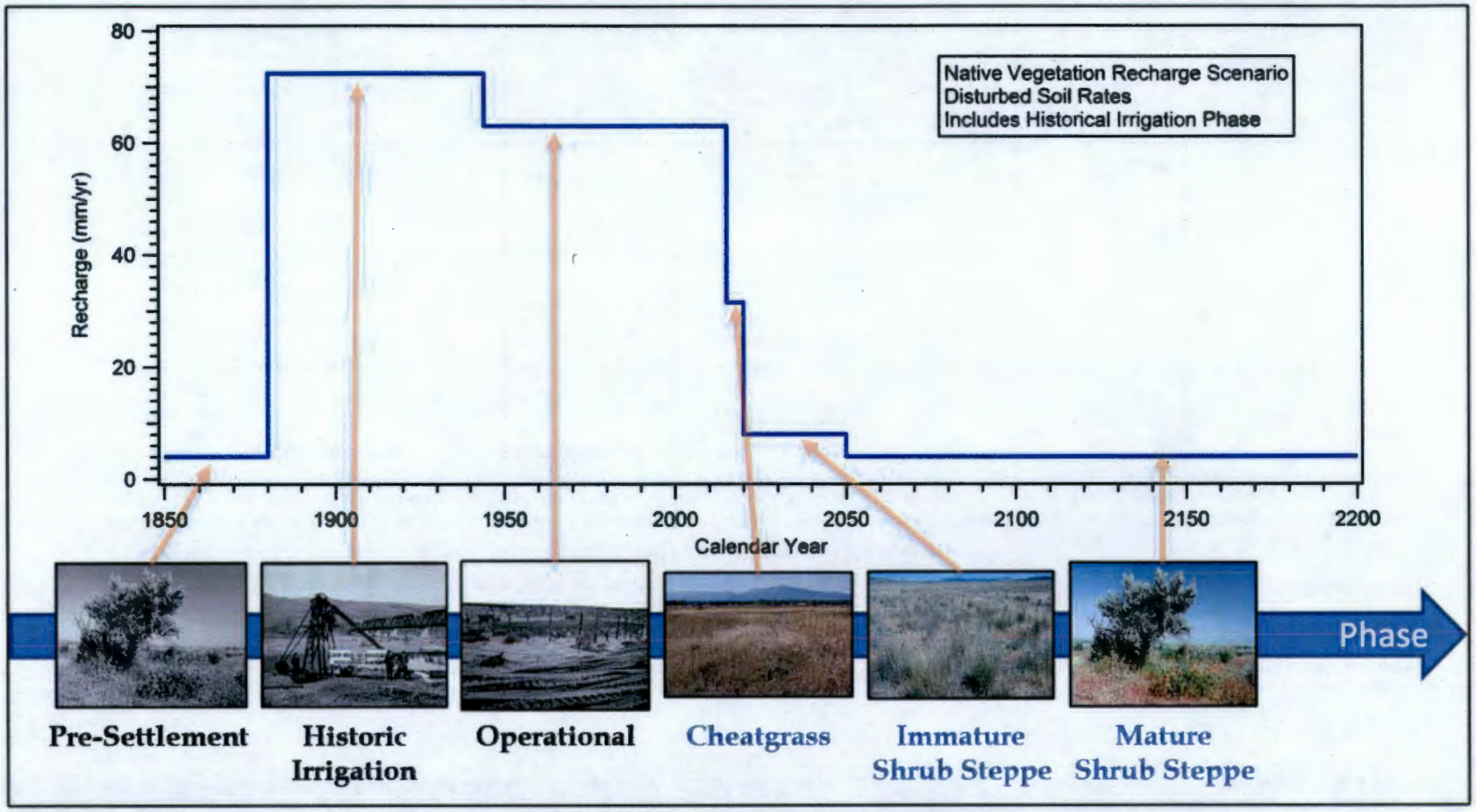


Figure 3-3. Native Vegetation Recharge Scenario

Table 3-3. Irrigation Recharge Scenario Phases and Recharge Rates (mm/yr)

	Historic Simulation (pre-2010) (calculation of initial hydraulic conditions)			Predictive Simulation (post-2010) (calculation of peak groundwater concentration)		
Surface Soil Type	Pre-Settlement (< 1880)	Historic Irrigation [a] (1880-1944)	Hanford Operations (1944-2010)	Bare Soil (2010-2015)	Irrigation I (2015-2045)	Irrigation II (> 2045)
Hanford sand, disturbed	4.0 [b]	72.4 [c]	63.0 [d]	63.0 [d]	76.4 [e]	72.4 [e]

a. Irrigated agriculture was present adjacent to and slightly overlapping the 100-BC Area prior to Hanford Site construction; irrigation was conservatively assumed applicable to all 100-BC sites from calendar years 1880 through 1944.

b. Source: PNNL-14702 Table 4-15, all areas with soils disturbed by excavations; shrub steppe.

c. Recharge rates for historic irrigation phase is that from the long-term irrigation rate (Irrigation II phase).

d. Source: PNNL-14702 Table 4-15, all areas with soils disturbed by excavations; no vegetation.

e. Recharge rates for future irrigation phases represent incremental increases over corresponding undisturbed native vegetation recharge rates, based on WDOH guidance (WDOH/320-015, *Hanford Guidance for Radiological Cleanup*). The recharge increment attributable to irrigation alone is 68.4 mm/yr. This increment is added to the corresponding rate for immature shrub steppe (8.0 mm/yr) and mature shrub steppe (4.0 mm/yr) phases of the native vegetation recharge scenario (Table 3-2) to obtain the total recharge rate.

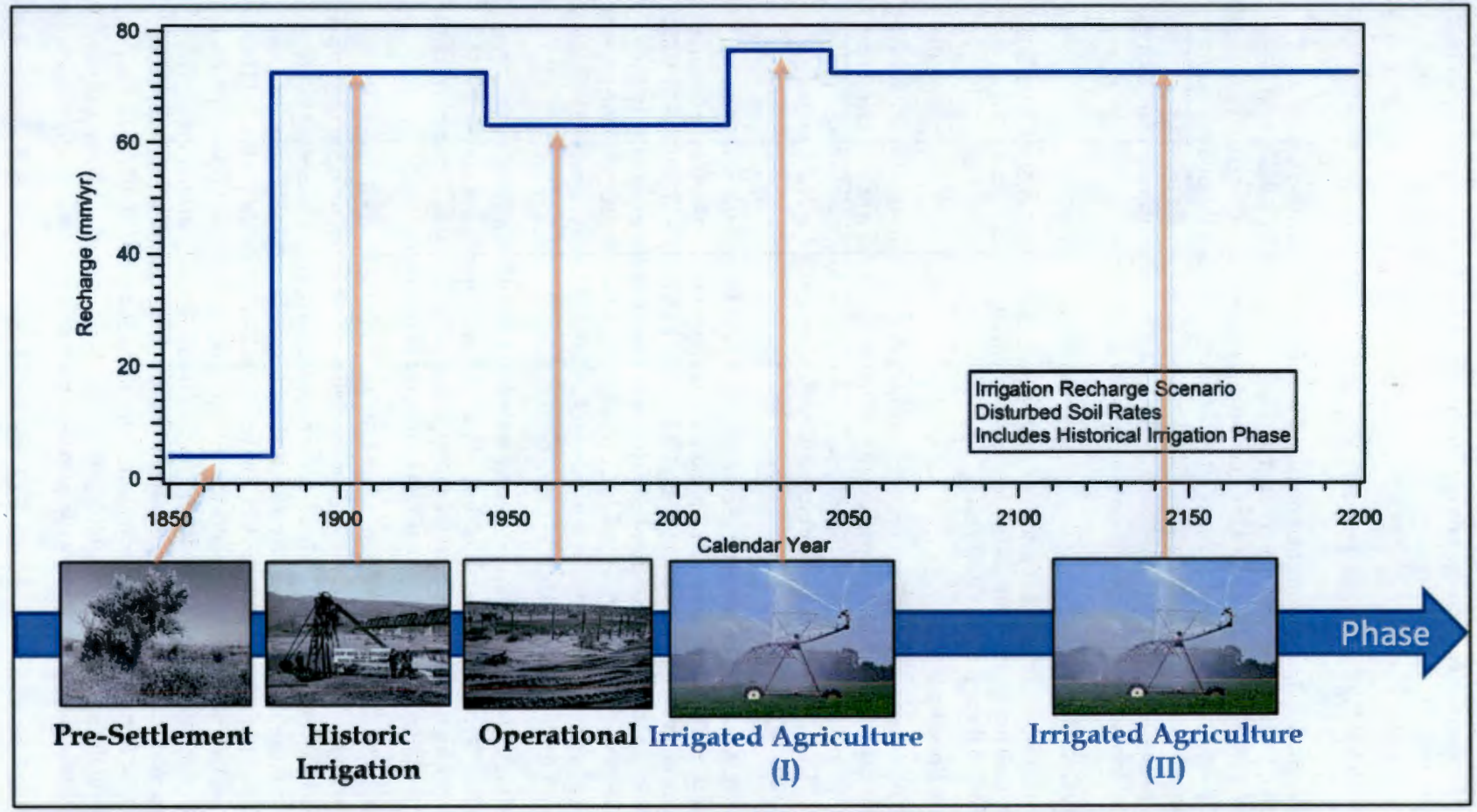


Figure 3-4. Irrigation Recharge Scenario

According to the RESRAD manual, total recharge rate is a function of precipitation, evapotranspiration, run-off, and applied irrigation and is defined as:

$$I = (1 - C_e)[(1 - C_r)P_r + I_{rr}] \quad (5)$$

where I = annual recharge rate (LT^{-1}), C_e = evapotranspiration coefficient (dimensionless), C_r = runoff coefficient (dimensionless), P_r = annual precipitation rate (LT^{-1}), and I_{rr} = annual irrigation rate (LT^{-1}). Using Equation (5) with the DOE/RL-96-17 RESRAD values for these parameters, $C_e = 0.91$, $C_r = 0.2$, $P_r = 0.16$ m/yr, and $I_{rr} = 0.76$ m/yr, yielded a total recharge rate of 80 mm/yr. Solving Equation (5) again with $I_{rr} = 0$ yielded the non-irrigation total recharge rate of 11.5 mm/yr. Therefore, the recharge attributable to irrigation alone was 68.4 mm/yr. This rate was then added to the native vegetation recharge rates for disturbed soils to determine a rate for the irrigation phases (Table 3-3).

3.2.2 Lower Boundary Conditions

The bottom of the model domain is assigned a constant zero-flux boundary condition for both water mass and contaminant mass (solute) transport (Figure 3-2). This boundary condition limits the aquifer representation in this model to the appropriate thickness.

3.2.3 Lateral Boundary Conditions

For the portion of the model domain in the vadose zone (Figure 3-2) a constant zero-flux lateral boundary condition for both water transport and solute transport is assigned to restrict (with respect to arrival time of peak solute concentration and peak magnitude) the representation in the vadose zone to one-dimensional vertical flow. This is a conservative representation with respect to the arrival time and the magnitude of the peak concentration.

For the portion of the model domain in the saturated zone, a constant Dirichlet type (specified head) boundary condition is specified for water transport at opposite edges aligned to the hydraulic gradient to represent the water table at the desired elevation and impose the desired hydraulic gradient. The hydraulic gradients values assigned to the edges of the saturated aquifer model cells were based on ECF-100BC5-12-0027, *Hydraulic Gradients in 100-BC-5, 2010 and 2011*, which divided the 100-BC area into northern and southern subregions and presented measurements of water levels and statistical analyses of hydraulic gradients and groundwater flow in these subregions.

In the northern portion of the 100-BC Area, where the water table drops into the Ringold Unit E formation near the Columbia River, the magnitude of the hydraulic gradient ranged from a low of 6.1E-04 measured in March 2011 to a high of 3.2E-03 measured in September 2010. The statistical tests indicated a good fit to the data and p-values were <0.05, giving high confidence in the results.

In the southern portion of the 100-BC Area, where the water table occurs in the Hanford formation, the water table is very flat, making measurement of the gradient very difficult. Over the course of the six field campaigns documented in ECF-100BC5-12-0027, head differences were within measurement error on three occasions. In the remaining three occasions, the magnitude of the gradient ranged from 6.9E-05 in March 2011 to 1.3E-04 in both July 2010 and June 2011. However, the p-value for the gradient calculated from the March 2011 measurements was 0.121, greater than the conventionally accepted cutoff value of 0.05 for rejection of the null-hypothesis that the hydraulic gradient is indistinguishable from zero. The p-value of the gradient calculated from the June 2011 measurements was 0.064, just above the cutoff level and the lowest value obtained from any set of measurements made in the southern 100-BC Area. No p-value could be calculated for the gradient calculated from the July 2010 measurements, as that calculation was made on the basis of heads measured in three wells, provide a perfect fit to a plane.

The estimates of the hydraulic gradient in the southern portion of the 100-BC Area have greater uncertainty than those from the north. Nevertheless, the values from the south were selected as the basis for setting lateral hydraulic gradients in the unit-length PRG and SSL calculations described herein, because the southern 100-BC Area is more representative of the waste sites under investigation. In addition, the lower lateral hydraulic gradients result in less dilution (Section 5.1.3), providing a more conservative estimate of peak concentrations. The lateral hydraulic gradient was set to 1.3E-04, corresponding to the mean and mode of gradient estimates from the southern portion of the 100-BC Area.

For solute transport, the upgradient edge of the portion of the model domain in the aquifer and all edges of the model domain in the vadose zone portion of the model domain are assigned zero-flux boundary conditions (Figure 3-2b). The downgradient edges (Figure 3-2b) of the aquifer grid blocks were assigned STOMP's outflow solute boundary condition (see page 6.21 of PNNL-12030; also page 4.4 of PNNL-15782). This boundary condition provides for transport of solute out of the domain according to the advective flux term in the governing equation, but does not allow solute to enter back into the domain.

3.2.4 Initial Conditions

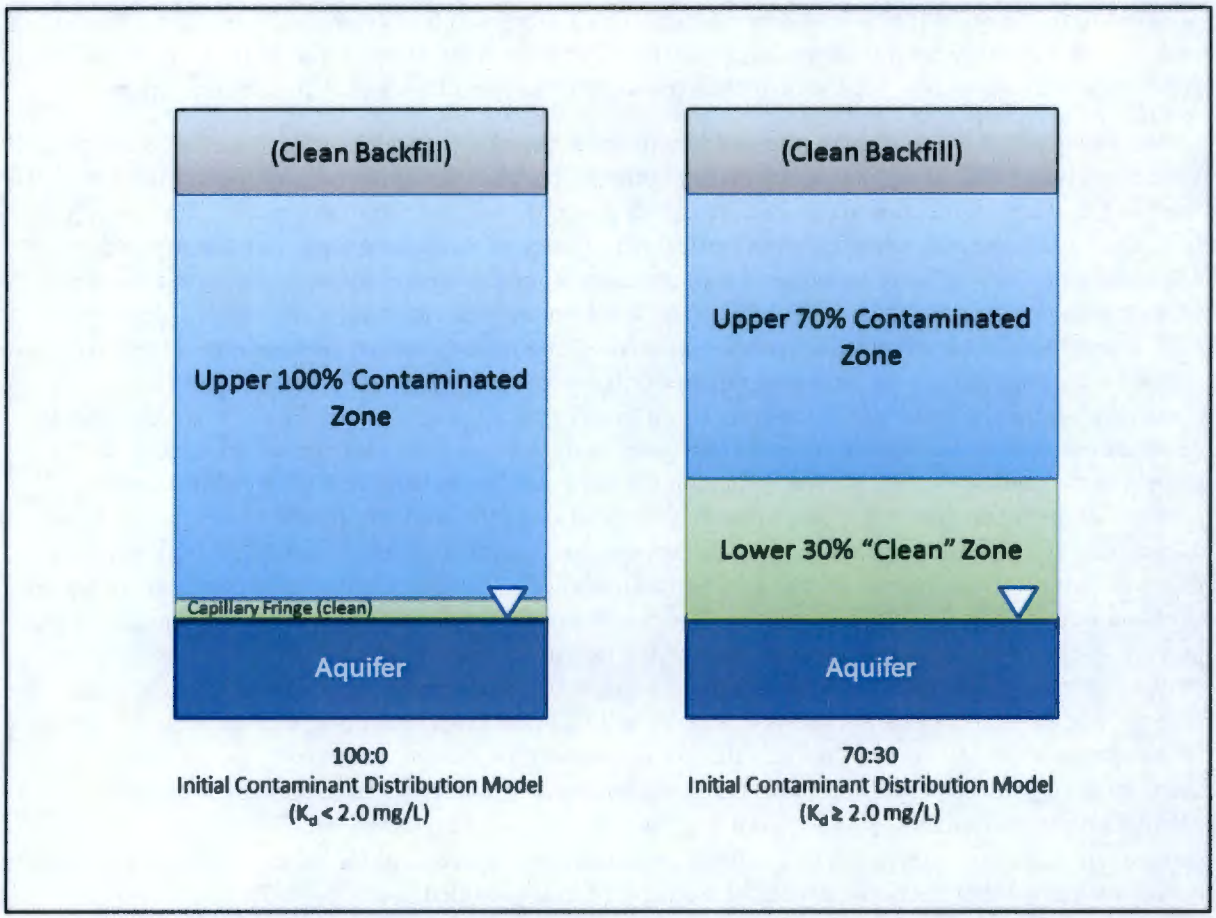
For hydraulic initial conditions, an arbitrary value was assigned as the initial pressure for the historic (pre-2010) flow simulations. A value of 86,656.7 Pa, approximately equivalent to –1.5 m matric potential, was assigned to the nodes in the vadose zone whereas the aquifer grid blocks were assigned values that matched the boundary condition pressures. Final pressures from the historic (pre-2010) simulations were used as the initial pressures for the predictive (post-2010) coupled flow and transport simulations.

Contaminant initial conditions are imposed based on the objective and methodology of the calculation. Determination of SSL and PRG values is accomplished in a two-step calculation process: first, STOMP is used in a forward calculation step to calculate peak groundwater concentration resulting from a uniform initial concentration over an appropriate vertical depth range of the vadose zone. For this forward calculation step, the initial concentration applied is a unit concentration (1.0 mg/kg for nonradionuclide COPCs, or 1.0 pCi/kg for radionuclide COPCs). The second, back-calculation step using Equation (1a) or (1b), is where the peak groundwater concentration resulting from the initial uniform unit concentration is scaled by the appropriate regulatory compliance criterion to determine the maximum initial soil concentration that could be present and not result in an exceedance of that criterion. The maximum value obtained from this back-calculation step is assigned as the SSL or PRG value (these differ only with respect to the recharge scenario used; irrigation for SSLs versus native vegetation for PRGs). As a measure of maximum allowable contaminant concentration in the soil, unit-length SSLs and PRGs are expressed as contaminant mass times unit distance in the general direction of groundwater flow per mass of soil for non-radionuclides (e.g., mg/kg). For radionuclides, these are expressed as contaminant activity times unit distance in the general direction of groundwater flow per mass of soil for radionuclides (e.g., pCi/g). The use of a unit initial concentration in the forward-calculation step with STOMP is therefore only a convenience to support calculation of unit-length SSLs and PRGs in the back-calculation step. The peak groundwater concentration that is calculated with STOMP will be proportional to the initial soil concentration value. Hence, any initial value for soil concentration could be used in the forward-calculation step, and when scaled against the resulting peak groundwater concentration in the back-calculation step in Equation (1a) or (1b) will yield the same unit-length SSL or PRG. The unit concentration, therefore, is not to be confused as constituting an actual observed waste site residual soil concentration. Further detail on this calculation approach is provided in SGW-50776.

Based on SGW-51818, *Conceptual Basis for Distribution of Highly Sorbed Contaminants in 100 Areas Vadose Zone*, and the analysis reported below (in Section 5.1.4), all contaminants were grouped into two groups, one with lower distribution coefficients in the range $K_d < 2$ mL/g, and other with the higher distribution coefficients in the range ≥ 2 mL/g.

For the lower K_d contaminants ($K_d < 2$ mL/g), a uniform concentration of 1.0 mg/kg was applied in the entire vadose zone, from below the clean backfill down to 0.5 m (two simulation grid blocks) above the water table. This is termed the 100:0 initial source distribution (Figure 3-5). Initial concentration in the 0.5-m-zone above the water table was not applied due to the presence of capillary fringe and water table movement in the periodically rewetted zone that would result from river stage fluctuations. Placing the initial mass at the water table can also result in unrepresentative large peak releases in the simulation start because of the extreme concentration gradients created by the application of this initial condition.

For the higher K_d contaminants ($K_d \geq 2$ mL/g), based on information presented in SGW-51818, the conservative assumption of contamination throughout the full thickness of the vadose zone is modified. For these contaminants, the upper 70% of the vadose zone below the clean backfill was assumed contaminated while the lower 30% is treated as uncontaminated; this is termed the 70:30 initial source distribution (Figure 3-5). The 70:30 initial source distribution assumption is deemed conservative for the high K_d contaminants, with respect to peak groundwater concentration, based on observed limited vertical extent of such contaminants. Where borehole measurements of deeper contamination of higher K_d contaminants but of limited vertical extent are found, this conservatism can be tested using those data.



Note: Strontium-90 (K_d = 25 mL/g) is an exception, simulated with 100:0 model; see text for explanation.

Figure 3-5. 100:0 and 70:30 Initial Contaminant Distribution Models

A notable exception to the K_d based assignment of an initial source distribution was made for the COPC strontium-90. Because field data revealed that this COPC was found throughout the vadose zone at several sites, use of a 70:30 initial source distribution for this COPC would clearly be non-conservative. Accordingly, unit-length SSL and PRG values were calculated for strontium-90 using the 100:0 initial source distribution at all sites. Strontium-90 is distributed throughout the vadose zone despite its relatively high K_d value for reasons having to do with historic discharge practices and conditions that no longer dominate the subsurface. A complete discussion of this is provided in the nature and extent of contamination discussion found in Chapter 4 of the remedial investigation/feasibility study report for the 100-BC OUs. This exception might be considered as a site-specific treatment, but was applied to all sites for this COPC only in the first-level modeling under the graded approach (DOE/RL-2011-50).

3.3 Hydraulic Parameters

To the extent possible, OU-specific hydraulic and transport parameter values were used in the STOMP simulations. Hydraulic parameters were measured for backfill, Hanford formation, and Ringold E soils in multiple areas along the Columbia River Corridor. Some of the hydraulic parameters measured for the Hanford formation in the 100-BC area exhibit a large range of variability. To assess the impact of this variability over a range of plausible hydraulic parameters for the Hanford formation, simulations were performed using two hydraulic parameter sets: one drawn from samples collected in the 100-D/H Area and the other from samples collected in 100-BC Area. Comparsion of the resulting unit-length SSL and PRG values for each set are presented in an uncertainty evaluation in Section 5.2. The outcome of that analysis was that the hydraulic parameters drawn from 100-D/H resulted in higher peak groundwater concentrations of all COPCs, and therefore yielded lower (more conservative) unit-length SSL/PRG values. Based on this uncertainty evalaution, the more conservative parameter set was selected for use in calculating unit-length SSLs and PRGs.

Based on previous Hanford studies and on the fact that all available measurements of hydraulic properties made the same assumption, the sediments were assumed to follow the van Genuchten (1980) moisture retention constitutive relation and the Mualem –van Genuchten relative permeability constitutive relation (Mualem, 1976), thus requiring values to be specified in STOMP for each lithologic unit for:

- K_s saturated hydraulic conductivity, (LT^{-1});
- n_T total porosity (L^3L^{-3});
- n_D saturated volumetric water content, called diffusive porosity in STOMP (L^3L^{-3});
- s_r residual saturation (dimensionless), equal to the residual volumetric water content divided by the saturated volumetric water content;
- van Genuchten fitting parameter α (L^{-1}), proportional to the inverse of the air entry matric potential;
- van Genuchten exponential fitting parameter n (dimensionless).

Mualem-van Genuchten for Hanford formation and Ringold E soils in the 100-BC and 100-D/H areas based on RPP-20621, *Far-Field Hydrology Data Package for the Integrated Disposal Facility Performance Assessment* are presented in Table 3-4. These form the basis for estimates of Mualem-van Genuchten used in this calculation. Hydraulic parameters used in this calculation are shown in Table 3-5 with discussion of the basis of these parameters below.

Table 3-4. Mualem-van Genuchten Hydraulic Parameters for the 100 Area Vadose Zone [a,b]

Sample	HSU [c]	Source Area	Well Number	Depth (m)	% Gravel	θ_s *Saturated Volumetric Moisture Content* (cm^3/cm^3)	θ_r *Residual Volumetric Moisture Content* (cm^3/cm^3)	α van Genuchten Inverse Air Entry Head Fitting Parameter (1/cm)	n van Genuchten Exponential Fitting Parameter (-)	Fitted K_s Fitted Saturated Hydraulic Conductivity [d,e] (cm/s)
2-1307	Ringold	100-HR-3	199-D5-14	18.90	43	0.236	0.0089	0.0130	1.447	1.29E-04
2-1308	Ringold	100-HR-3	199-D5-14	30.64	58	0.120	0.0208	0.0126	1.628	6.97E-05
2-1318	Hanford	100-HR-3	199-D8-54A	15.54	60	0.124	0.0108	0.0081	1.496	1.67E-04
2-2663	Hanford	100-BC-5	199-B2-12	8.20	61	0.135	0.0179	0.0067	1.527	6.73E-05
2-2664	Ringold	100-BC-5	199-B2-12	24.84	73	0.125	0.0136	0.0152	1.516	1.12E-04
2-2666	Hanford	100-BC-5	199-B4-9	21.49	71	0.138	0.00	0.0087	1.284	1.02E-04
2-2667	Hanford	100-BC-5	199-B4-9	23.93	75	0.094	0.00	0.0104	1.296	1.40E-04
3-0570	Hanford	100-KR-1	116-KE-4A	3.50	60	0.141	0.00	0.0869	1.195	2.06E-02
3-0577	Hanford	100-FR-3	199-F5-43B	7.16	66	0.107	0.00	0.0166	1.359	2.49E-04
3-0686	Hanford	100-FR-1	116-F-14	6.49	55	0.184	0.00	0.0123	1.600	5.93E-04
3-1702	Hanford	100-DR-2	199-D5-30	9.78	68	0.103	0.00	0.0491	1.260	1.30E-03
4-1086	Ringold	100-K	199-K-110A	12.77	65	0.137	0.00	0.1513	1.189	5.83E-02
4-1090	Hanford	100-K	199-K-111A	8.20	50	0.152	0.0159	0.0159	1.619	4.05E-04
4-1118	Hanford	100-K	199-K-109A	10.30	66	0.163	0.00	0.2481	1.183	3.89E-02
4-1120	Ringold	100-K	199-K-109A	18.90	63	0.131	0.0070	0.0138	1.501	2.85E-04

Table 3-4. Mualem-van Genuchten Hydraulic Parameters for the 100 Area Vadose Zone [a,b]

Sample	HSU [c]	Source Area	Well Number	Depth (m)	% Gravel	θ_s *Saturated Volumetric Moisture Content* (cm^3/cm^3)	θ_r *Residual Volumetric Moisture Content* (cm^3/cm^3)	α van Genuchten Inverse Air Entry Head Fitting Parameter (1/cm)	n van Genuchten Exponential Fitting Parameter (-)	Fitted K_s Fitted Saturated Hydraulic Conductivity [d,e] (cm/s)

a. Source: RPP-20621

b. Moisture retention data were measured on the non-gravel sediment fraction (< 2mm size) and corrected for gravel fraction.

c. HSU = hydrostratigraphic unit

d. Assumed to represent vertical hydraulic conductivity

e. Hydraulic conductivities were measured on the bulk samples that included the gravel fraction using the constant-head permeameter method for saturated hydraulic conductivity (K_s) and the unit gradient method for unsaturated hydraulic conductivity.

Table 3-5. Hydraulic Parameters obtained from the 100 Source Area

			n_T	n_D	α	n	s_r	$K_{s/h}$	$K_{s/v}$
Geographic Area	Zone	Unit	Total Porosity	Diffusive Porosity	van Genuchten Air Entry Fitting Parameter	van Genuchten Exponential Fitting Parameter	Residual Saturation [a]	Horizontal Saturated Hydraulic Conductivity	Vertical Saturated Hydraulic Conductivity
			(cm^3/cm^3)	(cm^3/cm^3)	(1/cm)	(-)	(-)	(cm/s)	(cm/s)
100-BC	Backfill	Hanford	0.276 [b]	0.262 [b]	0.019 [b]	1.400 [b]	0.373 [b]	5.98E-04 [b]	5.98E-04 [b]
	Vadose	Hanford	0.280 [c]	0.247 [c]	0.0086 [d]	1.369 [d]	0.0242 [e]	9.87E-04 [f]	9.87E-05 [f]
	Vadose	Ringold E	0.293 [g]	0.267 [g]	0.0152 [h]	1.516 [h]	0.0509 [h]	1.12E-03 [i]	1.12E-04 [i]
	Saturated	Hanford	0.280 [c]	0.247 [c]	0.0086 [d]	1.369 [d]	0. 0242 [e]	6.9E+00 [j]	6.9E-01 [j]
	Saturated	Ringold E	0.293 [g]	0.267 [g]	0.0152 [h]	1.516 [h]	0. 0509 [h]	1.0E-02 [k]	1.0E-03 [k]
100-D/H	Backfill	Hanford	0.276 [b]	0.262 [b]	0.019 [b]	1.400 [b]	0.373 [b]	5.98E-04 [b]	5.98E-04 [b]
	Vadose	Hanford	0.280 [c]	0.247 [c]	0.029 [l]	1.378 [l]	0.022 [l]	4.66E-03 [m]	4.66E-04 [m]
	Vadose	Ringold E	0.293 [g]	0.267 [g]	0.013 [n]	1.538 [n]	0.057 [n]	9.48E-04 [o]	9.48E-05 [o]
	Saturated	Hanford	0.280 [c]	0.247 [c]	0.029 [l]	1.378 [l]	0.022 [l]	6.9E+00 [j]	6.9E-01 [j]
	Saturated	Ringold E	0.293 [g]	0.267 [g]	0.013 [n]	1.538 [n]	0.057 [n]	1.0E-02 [k]	1.0E-03 [k]

Table 3-5. Hydraulic Parameters obtained from the 100 Source Area

			n_T	n_D	α	n	s_r	$K_{s\|h}$	$K_{s\|v}$
Geographic Area	Zone	Unit	Total Porosity	Diffusive Porosity	van Genuchten Air Entry Fitting Parameter	van Genuchten Exponential Fitting Parameter	Residual Saturation [a]	Horizontal Saturated Hydraulic Conductivity	Vertical Saturated Hydraulic Conductivity
			(cm^3/cm^3)	(cm^3/cm^3)	(1/cm)	(-)	(-)	(cm/s)	(cm/s)

a. Residual saturation is defined as the ratio of the residual moisture content (θ_r) to the diffusive porosity.

b. Source: arithmetic mean of hydraulic parameters for backfill calculated for six samples that were collected within the Hanford Site (hydraulic conductivity assumed isotropic for backfill) reported in PNNL-18564, Table A.12 (these are also the site-wide values for backfill listed in PNNL-14702, Table 4.5)

c. Source: PNNL-18564, Tables 6.3 and 6.4, values for total and effective porosity for Hanford gravelly sand (Hgs), site-wide. Note the saturated volumetric moisture content values listed in Table 3-4 were determined by applying a gravel correction factor to the values determined in the laboratory on the < 2 mm fraction. However, these values appeared to be underestimated and were inconsistent with the high K_s values estimated, so this site-wide estimate was used.

d. Source: computed arithmetic mean of values for three Hanford formation samples from 100-BC-5 (Table 3-4, samples 2-2663, 2-666, and 2.667).

e. Source: value for Hanford Formation sample with non-zero residual saturation from 100-BC-5 (Table 3-4, samples 2-2663)

f. Source: computed geometric mean of values for three Hanford formation samples from 100-BC-5 (Table 3-4, samples 2-2663, 2-666, and 2.667) for vertical value; horizontal value computed based on assumed anisotropic ratio of 0.1.

g. Source: PNNL-18564, Tables 6.3 and 6.4, values for total and effective porosity for Ringold gravel (Rg), site-wide.

h. Source: value for Ringold Formation sample from 100-BC-5 (Table 3-4, sample 2-2664).

i. Source: value for Ringold Formation sample from 100-BC-5 (Table 3-4, sample 2-2664); horizontal value computed based on assumed anisotropic ratio of 0.1.

j. Source: summary of hydraulic conductivity estimates from constant-rate injection tests in 100-C-7:1 wells conducted in Aug. 2012 reported in PNNL-21845, Table 12

k. Source: horizontal saturated hydraulic conductivity for saturated zone units was calculated as the geometric mean of aquifer test measurements for the Ringold formation in the 100-BC areas of data reported in SGW-40781, Table 7-1; see Table 5-2.

l. Source: computed arithmetic mean of values for two Hanford formation samples from 100-D and 100-H (Table 3-4, samples 2-1318 and 3-1702).

m. Source: computed geometric mean of values for two Hanford formation samples from 100-D and 100-H (Table 3-4, samples 2-1318 and 3-1702) for vertical value; horizontal value computed based on assumed anisotropic ratio of 0.1.

n. Source: computed arithmetic mean of values for two Ringold Formation samples from 100-D and 100-H (Table 3-4, samples 2-1307 and 2-1308).

o. Source: computed geometric mean of values for two Ringold Formation samples from 100-D and 100-H (Table 3-4, samples 2-1307 and 2-1308); horizontal value computed based on assumed anisotropic ratio of 0.1.

The Mualem-van Genuchten hydraulic properties for the Hanford formation were estimated for the 100-BC and 100-DH Areas by averaging the individual parameter values for all formation-specific samples collected in those respective areas:

- Three Hanford formation samples collected in the 100-BC Area (2-2663, 2-2666, and 2-2667; Table 3-4) were selected to estimate mean hydraulic properties for the Hanford formation in the 100-BC Area.
- Two Hanford formation samples collected in the 100-D/H Area (2-1307, 2-1308; Table 3-4) were selected to estimate mean hydraulic properties for the 100-D/H Area.

Vertical saturated hydraulic conductivity of the Hanford formation was averaged using the geometric mean of the selected measurements for Hanford formation samples in each respective area, whereas the other parameters were averaged using the arithmetic mean. Horizontal hydraulic conductivity was calculated by assuming an anisotropy ratio of 0.1.

Determination of the saturated volumetric water content (called θ_s in the van Genuchten moisture retention relation and called diffusive porosity in STOMP input) included the use of a gravel correction factor. The θ_s values in Table 3-4 were determined by applying a gravel correction factor to the values determined in the laboratory on the < 2 mm fraction. The absence of the gravels may have resulted in underestimation of the void volume available for flow because it is very hard to reconcile the high K_s values with such small porosity values. Therefore, the Hanford-wide estimate of 0.25 was used for the saturated volumetric water content.

The Mualem-van Genuchten hydraulic properties for the Ringold formation were estimated for the 100-BC and 100-DH Areas by averaging the individual parameter values for all formation-specific samples collected in those respective areas:

- A single Ringold Formation sample collected in the 100-BC Area (2-2664; Table 3-4) was selected to estimate mean hydraulic properties for the Ringold Formation in the 100-BC Area.
- Two Ringold Formation samples (2-1318 and 3-1702; Table 3-4) were selected to estimate mean hydraulic properties for the Ringold Formation in the 100-DH Area.

Vertical saturated hydraulic conductivity of the Ringold Formation was averaged using the geometric mean (where multiple samples were available) for Ringold Formations samples in each respective area. Horizontal hydraulic conductivity was calculated by assuming an anisotropy ratio of 0.1.

In the absence of more site-specific data, Hanford-wide mean parameter values for the backfill were used. Mean hydraulic parameters for six samples of backfill that were collected within the Hanford site (PNNL-18564) were selected to represent these units within the 100 Area. The backfill parameters used for the 100 Area simulations were also used in flow and transport simulations under variably-saturated conditions at other waste sites, such as the 200-MW-1 and PW-1/3/6 waste sites in the 200 Area (Table 8 in ECF-200MW1-10-0080, *200-MW-1 Contaminant Fate and Transport Model to Evaluate Impacts to Groundwater in Support of DOE/RL-2008-38 Decision Draft*; Table 11 in ECF-200PW1/3/6-10-0326, *Screening Process and Contaminant Fate and Transport Model to Evaluate Impacts to Groundwater in Support of DOE/RL-2007-27 DRAFT B*).

3.3.1 Vadose Zone

The van Genuchten m fitting parameter was assumed to be fixed and equal to $(n - 1)/n$ and the Mualem β exponent was assumed to be fixed at 0.5 (Mualem 1976; RPP-20621, *Far-Field Hydrology Data Package for the Integrated Disposal Facility Performance Assessment*). Hanford and Ringold E units are well to

poorly sorted sandy gravels or sandy silty gravels whereas the backfill consists of poorly sorted sand and gravel with varying fractions of eolian loess and silt (RPP-20621; SGW-44022; SGW-46279; PNNL-18564). Within the 100-BC source OU, the Hanford formation tends to be coarser grained than the Ringold E. The former tends to contain larger gravel clasts than the latter, and the Ringold E unit in the 100-BC vadose zone consists of semi-indurated clay, silt, fine- to coarse-grained sand, and pebble to cobble-size gravel (SGW-44022). Where present, the Ringold upper mud (RUM) was assumed to act as a lower bound (aquitard) for the aquifer (SGW-46279) and so was not directly included in the STOMP simulations.

OU-specific values for several Mualem-van Genuchten hydraulic parameters were obtained for the Hanford formation from data packages SGW-44022 (applicable to the 100-BC and 100-D/H Areas) and SGW-46279 (applicable to the entire 100 Area). The first data package cites the data table for the unsaturated hydraulic properties of 15 samples of sandy gravels from the 100 Area operable units, which were originally described in RPP-20621. These 100 Area sediments are dominated by the gravel fraction (> 2-mm size), with gravel clasts accounting for 43 to 75% of the total sample mass (RPP-20621). Moisture retention data were measured on the non-gravel sediment fraction (< 2mm size) and corrected for gravel fraction, whereas hydraulic conductivities were measured on the bulk samples that included the gravel fraction using the constant-head permeameter method for saturated hydraulic conductivity (K_s) and the unit gradient method for unsaturated hydraulic conductivity (RPP-20621). The fitted K_s estimates were assumed to represent vertical hydraulic conductivity.

3.3.2 Saturated Zone

Direct measurements of K_s for Hanford formation (as opposed to values calculated with the van Genuchten equation) in the saturated zone at 100-BC are presented in PNNL-21845, *Investigation of Hexavalent Chromium Flux to Groundwater at the 100-C-7: 1 Excavation Site*. This document reports the average horizontal K_s measured in the saturated zone is 6.0E+03 m/day (6.9E+00 cm/s) for the 100-BC Area.

The horizontal K_s for Ringold E in the saturated zone is based on the geometric mean of six slug tests conducted in the 100-BC Area (SGW-40781, *100-HR-3 Remedial Process Optimization Modeling Data Package*) which resulted in a value of 8.7E+00 m/day (1.0E-02 cm/s).

Following convention for Hanford sediments (SGW-44022; and SGW-46279), an anisotropy ratio of vertical to horizontal saturated hydraulic conductivity of 0.1 was applied to obtain vertical hydraulic conductivity values from the horizontal values discussed above. However, comparison of the aquifer horizontal K_s values in Table 3-5 with the vertical K_s values in Table 3-4 for the same unit revealed differences of one or more orders of magnitude. For example, the aquifer horizontal K_s for the Hanford unit in 100-BC is 6.90E+00 cm/s (Table 3-5), whereas the vertical K_s values for the 100-BC OU vary between 6.73E-05 to 1.40E-04 cm/s (Table 3-4), a difference of four to five orders of magnitude. Possible explanations include the differences in sample scale between the large-scale aquifer test relative to the laboratory-scale Table 3-4 samples, the potential effects of sample disturbance or repacking prior to the Table 3-4 K_s measurements, and the limitations of the Mualem-van Genuchten relative permeability functions to represent hydraulic conductivity adequately across the range of matric potential values.

3.4 Contaminant Transport Parameters

The contaminant transport parameters required by STOMP are the particle density of each unit, dispersion coefficients, half-lives for each radiological COPC, and the distribution coefficient for each COPC.

The particle density (ρ_P) values of the backfill, Hanford, and Ringold units can be calculated using the bulk density (ρ_B) and porosity. Bulk density is needed for retardation scaling factor calculations. Estimates of bulk density for Hanford and Ringold units were obtained from PNNL-14702, which gave 1.91 g/cm^3 for the Hanford and 1.90 g/cm^3 for the Ringold. The bulk density estimate of 1.94 g/cm^3 for backfill was obtained from PNNL-18564.

Hydrodynamic dispersion was conservatively assumed negligible, so dispersivity values were all set to zero. Note, however, that diffusion was included. Setting dispersivity values to zero yields higher peak groundwater concentrations than would be obtained using non-zero values. This, therefore, is a conservative assumption with respect to unit-length SSL and PRG values. (Numerical dispersion is a separate consideration; steps taken to minimize numerical dispersion in the STOMP code calculations are discussed in Section 3.1.)

The distribution coefficient, K_d, for the chemicals were taken from ECF-HANFORD-10-0442 and for the radionuclides K_d and half-life values were taken from ECF-HANFORD-10-0429. The values are listed in Attachments A and B for each COPC. One exception to this is the K_d value for hexavalent chromium (Cr(VI)). The K_d value of Cr(VI), 0.8 mL/g, was estimated in ECF-HANFORD-11-0165, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area.*

STOMP accounts for contaminant first-order decay in the solute mass conservation equation (PNNL-12030). Half-life values ($t_{1/2}$) for radionuclide COPCs were obtained from ECF-HANFORD-10-0429. These values are listed in those tables pertaining to radionuclides in Attachments A and B of this ECF for each radionuclide COPC. Chain decay is not accounted for in this calculation because no radionuclide COPC evaluated has significant daughter products.

Biodegradation is neglected in this calculation, which is generally a conservative assumption because the result is to overstate the persistence of a COPC by neglecting its biodegradation. However, in some circumstances this may be nonconservative where biodegradation products are also COPCs. For example, COPCs such as chloroform can degrade to methylene chloride and chloromethane, which have higher cancer slope factors. Dichloroethylene can eventually degrade to vinyl chloride, which has a higher cancer slope factor than dichloroethylene.

Volatilization and gas phase transport is conservatively neglected in this calculation to maximize the peak groundwater concentration predicted by the model.

Predictive (post-2010) simulations of water flow and contaminant transport were run for 1000 years to produce peak groundwater concentrations for each COPC based on its K_d values, and accounting for radioactive decay for radionuclide COPCs, using the K_d values and half-lives listed in the tables in Attachments A and B of this ECF.

3.5 Simulation Duration

A 1000-year limit was established for purposes of unit-length SSL and PRG calculation by agreement with regulatory agencies. Accordingly, the peak concentration within the 1000-year predictive (post-2010) simulation was used to calculate the unit-length SSL and PRG values.

The time of occurrence for peak groundwater concentration may be after the 1000-year limit for contaminants subject to high sorption. Because of the 1000-year limit, however, only the peak groundwater concentration within 1000 years is used as the basis for unit-length SSL or PRG values. Typically, breakthrough at numerically significant levels is not simulated within 1000 years for contaminants with high sorption values, although the threshold for breakthrough will depend on the

recharge scenario used. These cases commonly result in an "NR" (non-representative) coding assigned for the unit-length SSL or PRG (Section 2.6.1).

3.6 Uncertainties, Assumptions, and Conservatism

Potential sources of uncertainty in risk assessments are primarily in the categories of (1) model uncertainties, (2) scenario uncertainties, and (3) parameter uncertainties. Model uncertainty pertaining to the equations used as numerical representations of the natural processes is expected to be relatively small (DOE/RL-2011-50).

STOMP has been shown through comparison to analytical solutions, benchmarking against other codes, and field validation to solve the governing equations it incorporates for flow and transport processes correctly, but that the representativeness of any given model implemented using STOMP is inherently limited by the accuracy of the conceptual representation and the representativeness of the parameterization.

DOE/RL-2011-50 provides a summary evaluation of the comparisons of field data and field test results to corresponding model results obtained using the STOMP code, and the evaluation indicates that the equations used in STOMP adequately simulate the natural processes. The technical basis regarding scenario and parameter selection and the evaluation of uncertainty and variability is also documented in DOE/RL-2011-50. Documentation is provided in DOE/RL-2011-50 on (1) dominant model factors, (2) model parameter values and plausible ranges of parameter values, (3) model assumptions and effects on model results, and (4) model limitations.

Application of the unit-length SSL and PRG values calculated herein requires an understanding of which assumptions and modeling choices were conservative and which were not. Conservative assumptions and modeling choices include:

- Recharge was represented in the numerical model by uniform flux rates specified over particular periods so that vadose zone flow is always downward. In contrast, recharge in an arid vadose zone occurs only as often as the combination of precipitation and antecedent moisture conditions allow, i.e., sporadically or infrequently, so that there can be long periods when shallow vadose-zone pore water movement is controlled more by evaporation and transpiration near the surface than gravity, resulting in upward movement or reduced downward seepage velocity.
- The model implementation in a single column forces all contamination through the vadose zone down to the aquifer, whereas infiltrating water and solutes tend to migrate laterally as the wetting front redistributes following an infiltration event.
- The recharge rates for the native vegetation scenario used to calculate unit-length PRGs uses bounding native vegetation rates based on numerous lysimeter and tracer recharge studies (PNNL-17841).
- The unit-length SSL values to be used for screening calculated for bounding recharge rates postulated in the irrigation recharge scenario. This is not the expected land use, and the irrigation is assumed to commence much sooner than is reasonable.
- The initial condition (either the 100:0 or 70:30 model) represents a bounding initial condition that effectively assumes the maximum residual soil contamination level is uniformly present over the entire applicable vadose zone thickness (a peak or maximum concentration level would not be expected to occur over the entire depth range).

- The vadose zone thicknesses for the representative stratigraphic columns were minimized by using water tables from a typical high-water month when developing the stratigraphic columns for use in an average annual model; this minimizes contaminant transport time, thereby resulting in higher and earlier groundwater peak concentrations.
- Dilution upon mixing of groundwater with Columbia River water is assumed negligible.
- Hydrodynamic dispersion is assumed negligible, which leads to larger peak concentrations than if dispersion had been included.
- Volatile organic compounds are assumed to have negligible volatilization so that the resulting peak concentrations are larger than if volatilization had been included.
- Geometric means of measured aquifer horizontal hydraulic conductivity values are lower, and thus more conservative, than arithmetic means because the values typically span several orders of magnitude. Lower hydraulic conductivities yield lower aquifer fluxes and thus larger peak concentrations.
- A more conservative set of hydraulic parameters with respect to determintation of unit-length SSL and PRG were applied based on an uncertainty evaluation of area-specific hydraulic parameter sets for 100-BC and 100-DH Areas.

Assumptions that may or may not be conservative include:

- The median aquifer hydraulic gradient value for each source area may be too large by several-fold for waste sites near the Columbia River and may be several times too large for waste sites that are far inland from the river. Larger hydraulic gradients yield higher aquifer fluxes and lower peak concentrations.

4 Software Applications

STOMP was the primary software used for this calculation; as approved software, the information required is provided in this section.

Microsoft Excel® spreadsheets were used to calculate contaminant inventory values and approximate contaminant solute concentrations, back-calculate unit-length SSL and PRG values, and evaluate the results produced by STOMP. These calculations were performed on a desktop with ID INTERA-00465. The hardware is a Dell®[2] Precision E7200 with a 3.07-GHz Intel® Core2™ i7 processor and 6.0 GB of RAM loaded with the Windows®[3] 7 64-bit operating system.

4.1 Approved Software

The vadose zone fate and transport calculations are performed using CHPRC Build 4 of the STOMP software, registered in the Hanford Information System Inventory (HISI) under identification number 2471. STOMP use by CHPRC is managed under the following software lifecycle documents: CHPRC-00222, STOMP *Functional Requirements Document*; CHPRC-00176, *STOMP Software Management Plan*; CHPRC-00211, *STOMP Software Test Plan*; CHPRC-00515, STOMP *Acceptance Test Report*; and CHPRC-00269, STOMP *Requirements Traceability Matrix*.

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[2] Dell® and PowerEdge® are registered trademarks of Dell Products, Inc.

[3] Excel® and Windows® are registered trademarks of Microsoft Corporation in the U.S. and other countries.

4.1.1 Description

The following required information for the STOMP software package used for this calculation is provided here:

- Software Title: STOMP
- Software Version: CHPRC Build 4
- HISI Identification Number: 2471
- Workstation type and property number (from which software is run): STOMP was executed on the INTERA Richland GREEN Linux®[4] Cluster that is owned and managed by INTERA, Inc., a pre-selected subcontractor to CHPRC. The computer property tag for the front-end node is #469 at INTERA's office in Richland, Washington. This node is a Dell® PowerEdge® R510 with two 6-core Intel®[5] Xeon X5660 processors @ 2.80GHz and 48 GB of RAM. As given by the command "uname –a", the operating system details are

```
Linux green 3.2.0-54-generic #82-Ubuntu SMP Tue Sep 10 20:08:42 UTC
2013 x86_64 GNU/Linux
```

4.1.2 Software Installation and Checkout

A copy of the *Software Installation and Checkout Form* for the STOMP installation used for this calculation is provided in Attachment C to this ECF.

4.1.3 Statement of Valid Software Application

DOE/RL-2011-50 contains a summary of the main model attributes and code selection criteria that serve as the basis for the demonstration of the adequacy of the STOMP code for use in vadose zone modeling at Hanford. The results of the evaluation in DOE/RL-2011-50 show that the STOMP code is capable of meeting or exceeding the identified attributes and criteria. The comparison of the code selection criteria to the STOMP code capabilities indicates the STOMP code is capable of simulating all of the necessary FEPs, and that STOMP meets all of the other required code selection criteria. Section 6.4.1 of DOE/RL-2011-50 addresses code selection criteria, including quality assurance documentation of verification studies for specific model attributes (e.g., unsaturated flow, solute transport, infiltration, and drainage), and includes a discussion of other code related criteria (i.e., inter-code comparisons, hardware requirements, solution methodology, dimensionality, and output capability).

The results of CHPRC acceptance testing (CHPRC-00515) demonstrate that the STOMP software is acceptable for its intended use. Installations of the software are operating correctly, as demonstrated by the INTERA GREEN Linux® Cluster system producing the same results as those presented for installation tests conducted and documented in accordance with the approved software test plan (CHPRC-00211).

5 Calculation

STOMP simulations were created and run using the representative stratigraphic columns, boundary conditions, initial conditions, and parameter values described in Section 3. A description of the

[4] Linux® is the registered trademark of Linus Torvalds in the U.S. and other countries.

[5] Intel® is a registered trademark of Intel Corporation.

calculation of unit-length SSL and PRG values is described in Section 5.1. Site-specific modeling evaluations are described in Section 5.3.

5.1 Calculation of Soil Screening Levels and Preliminary Remediation Goals

The source-area-specific unit-length SSL values for the 100-BC source OUs are presented in Attachment A of this ECF. The source-area-specific unit-length PRG values are presented for the 100-BC source OUs in Attachment B of this ECF. Details of this calculation are provided below.

5.1.1 Time Step and Solution Control

The STOMP simulator solves a wide variety of nonlinear, single- or multiphase flow and transport problems for variably saturated geologic media. Partial differential conservations equations for component mass, energy, and solute mass comprise the fundamental equations for the simulator. STOMP solves flow and transport problems in the subsurface environment in one, two, or three dimensions. STOMP solves the fundamental equations for flow using an integral volume finite difference approach with the nonlinearities in the discretized equations resolved through Newton-Raphson iteration. The fundamental equation for solute transport are discretized to algebraic form following the integrated finite difference method of Patankar (1980) that is implicit using backward Euler time differencing, or by other techniques available in STOMP (e.g., TVD). STOMP solves the linear systems of equations that result from the Newton-Raphson linearization or the solute transport solution using either a direct, banded matrix solver or an indirect conjugate gradient-based solver.

For this calculation, the STOMP-W operational mode (solving for water mass and solute mass conservation) with the direct, banded matric solver was used for all simulations. The Patankar (1980) technique was used for solute transport simulation.

For solution control, the maximum time step permitted for predictive transport simulations was 0.01 years. The selected grid dimension of 10.0 m in the horizontal direction by 0.25 m in the vertical direction were also deliberately specified to maintain grid Courant numbers below the threshold of 1.0 to minimize numerical dispersion in the saturated zone (3.1.2). STOMP's automatic Courant limitation feature was used to control numerical dispersion in the unsaturated nodes: this feature further sub-divided transport solution time steps within the time steps allowed for the flow solution to maintain the Courant limit and thereby control numerical dispersion.

The aqueous concentrations calculated using STOMP was scaled down to unit horizontal grid (x-direction) length (1.0 m) by dividing the aqueous concentrations by 10. The accuracy of this methodology was verified through simulation of varying grid dimensions (details not presented in this ECF).

5.1.2 Peak Groundwater Concentration Calculation

STOMP was used to simulate groundwater concentration for each model time step along a portion of the domain's downgradient boundary corresponding to the top 5 m of the aquifer for the following set of simulations:

- → Two recharge scenarios, each for:
  - → Seven stratigraphic columns (Figure 3-1), each for:
    - → All COPCs with their respective K_d values and decay half-lives (Attachments A and B of this ECF)

Fluxes through the downgradient boundary were written to a surface flux file, one of STOMP's standard output options. For each time step, STOMP writes the water mass and solute mass flux rates passing

through the surface as well as the cumulative water and solute mass that have passed through the surface. Groundwater concentration within the 5-m-long surface was estimated by calculating it at the aquifer edge beneath the downgradient edge of the waste site footprint. The solute mass flux per unit time was divided by the water volume flux per unit time to yield a groundwater concentration at each time step.

5.1.3 Dilution Factor

Dilution of vadose zone contaminant release in the aquifer is directly accounted for within the STOMP simulation because the aquifer is directly represented in the model domain as a function of the aquifer thickness and the hydraulic gradient. Consequently, an aquifer dilution factor is not applied to scale the concentrations reported by STOMP, but rather it is implicit in the concentrations reported by STOMP in this formulation. For comparison purposes, the effective dilution factor in this model can be calculated. The dilution factor is calculated as the ratio of the combined aquifer and vadose zone water fluxes to the vadose zone water flux (WAC 173-340-747):

$$DF = \frac{Q_{VZ} + Q_A}{Q_{VZ}} \tag{6}$$

where DF is the dilution factor (dimensionless), Q_{VZ} equals the volumetric flux from the vadose zone into the aquifer (L^3T^{-1}) and Q_A represents the volumetric flux through the topmost 5 m of the aquifer (L^3T^{-1}). Volumetric flux rates used in Equation (6) are shown in Table 5-1.

Table 5-1. Volumetric Flux Rates

Area	Aquifer Formation	Q_A Aquifer Volumetric Flux Rates (m^3/yr)	Q_{VZ} Vadose Zone Volumetric Flux Rates by Recharge Scenario Phase (m^3/yr)			
Native Vegetation Recharge Scenario		All Soil/Vegetation Conditions	Bare Soil (2010-2015) 63 mm/yr	Cheatgrass (2015-2020) 31.5 mm/yr	Developing Shrub-Steppe (2020-2050) 8.0 mm/yr	Mature Shrub-Steppe (2050 >) 4.0 mm/yr
100-BC	Hanford	1,420	0.63	0.315	0.08	0.04
	Ringold	2.05	0.63	0.315	0.08	0.04
Irrigation Recharge Scenario		All Soil/Irrigation Conditions	Bare Soil (2010-2015) 63 mm/yr	Irrigation I (2015-2045) 76.4 mm/yr		Irrigation II (2045 >) 72.4 mm/yr
100-BC	Hanford	1,420	0.63	0.764		0.724
	Ringold	2.05	0.63	0.764		0.724

The effective dilution factors calculated using Equation (6) for recharge rates for each recharge phase in the predictive period (treated as steady-state values) are listed in Table 5-2. These factors are calculated using the recharge rates for each scenario and phase (Table 3-2; Table 3-3), median hydraulic gradients (Section 3.2.3), and aquifer saturated hydraulic conductivities (Table 3-5), along with dimensions of the STOMP model domain (Section 3.1). The dilution factors are substantially higher where the aquifer is comprised of Hanford formation than where the aquifer is comprised of Ringold Formation because the

higher hydraulic conductivity in the Hanford formation results in greater fluxes for a similar gradient. The dilution factors presented in Table 5-2 provide an indication of the magnitude of dilution calculated by STOMP. It is emphasized here, however, that these factors were not explicitly applied to STOMP results. Rather, dilution is actually calculated within the STOMP solution using the calculated instantaneous water fluxes in the model domain, time step by time step. Thus, dilution is implicitly accounted for within the model results, rather than applied explicitly in a post-calculation step to model results.

Table 5-2. Effective Dilution Factors[a]

Area	Aquifer Formation	Effective Dilution Factors by Recharge Scenario Phase			
Native Vegetation Recharge Scenario		Bare Soil (2010-2015) 63 mm/yr	Cheatgrass (2015-2020) 31.5 mm/yr	Developing Shrub-Steppe (2020-2050) 8.0 mm/yr	Mature Shrub-Steppe (2050 >) 4.0 mm/yr
100-BC	Hanford	2.26E+03	4.52E+03	1.78E+04	3.56E+04
	Ringold	4.26E+00	7.51E+00	2.66E+01	5.23E+01
Irrigation Recharge Scenario		Bare Soil (2010-2015) 63 mm/yr	Irrigation I (2015-2045) 76.4 mm/yr		Irrigation II (2045 >) 72.4 mm/yr
100-BC	Hanford	2.26E+03	1.87E+03		1.97E+03
	Ringold	4.26E+00	3.68E+00		3.83E+00

a. Dilution factors calculated per Washington Administrative Code (WAC 173-340-747); calculation of dilution is for the steady-state recharge rate in each recharge phase. Instantaneous dilution in STOMP varies as a function of the instantaneous water flux from the vadose zone entering the aquifer at the water table, which changes in response to time-varying recharge rates.

For context, if the default fixed parameter three-phase partition model (WAC 173-340-747(3)(a)) were used to establish soil concentrations for groundwater protection, the default groundwater dilution factor is 20 for unsaturated zone soil. However, this default is not applicable to this calculation, because it uses alternative fate and transport models (WAC 173-340-747(8)) and not the default parameter three-phase partition model. Where alternative fate and transport models are used, the WAC requires that dilution "be based on site-specific measurements or estimated using a model incorporating site-specific characteristics". This requirement is met in this calculation by using STOMP to model the aquifer with the appropriate aquifer thickness and a median hydraulic gradient based on site-specific measurements.

The WAC requires the following with regard to the dilution factor where upgradient contamination is present for use of alternative fate and transport models:

> **WAC 173-340-747 (8)(b)(vi)**: Dilution. Dilution shall be based on site-specific measurements or estimated using a model incorporating site-specific characteristics. If detectable concentrations of hazardous substances are present in upgradient groundwater, then the dilution factor may need to be adjusted downward in proportion to the background (upgradient) concentration.

Adjustments to the dilution factor are not warranted in this case because these values were applied to establish soil contamination levels protective of groundwater for the post-remedy period. There is no natural background level of Cr(VI) contamination in groundwater in the 100-BC area; the present plume is anthropogenic in origin and is being addressed by an interim remedy that will address any vadose zone

sources that leach to groundwater during the remedy implementation period. The interim or final remedy will continue until contamination levels in groundwater have achieved cleanup levels. Hence, the unit-length SSLs and PRGs protective of groundwater and of surface water that were calculated without adjustment for upgradient (background) concentration are protective for the post-remedial period.

5.1.4 Calculation of Soil Screening Levels and Preliminary Remediation Goals

In post-processing of the STOMP surface flux files, the peak groundwater concentration within 1000 years for the predictive simulations (Section 5.1.2) was identified for each simulation. For each COPC the maximum of the peak concentrations simulated for the representative stratigraphic columns for that source area (Figure 3-1) was selected as the basis for calculation of the unit-length SSL (if the irrigation recharge scenario) or PRG (if the native vegetation recharge scenario). This process of using the maximum groundwater concentration result provided an additional bounding aspect to this calculation, because unit-length SSL and PRG values for all waste sites in a given source area are based on results for the stratigraphic column that is most protective for the range of stratigraphic columns representative of that source area.

Evaluation of unit-length SSL and PRG calculations for the full set of representative stratigraphic columns developed for all 100 Area source OUs indicates that the K_d threshold value (the K_d value at which the peak groundwater concentration does not exceed the breakthrough concentration threshold) is strongly influenced by the vadose zone thickness as well as the recharge scenario. Generally, for 70:30 initial source distributions, thicker vadose zone columns result in smaller K_d threshold values. The K_d threshold is denoted in Attachments A and B tabulations of unit-length SSL and PRG values that are presented in ascending K_d order (Tables A-1, A-3, and A-5 for unit-length SSLs; Tables B-1, B-3, and B-5 for unit-length PRGs), by a bold red line at the point where "NR" values result. Note the same unit-length SSL and PRG values are also tabulated in analyte-name ascending order for lookup by COPC convenience in Attachments A and B (Tables A-2, A-4, and A-6 for unit-length SSLs; Tables B-2, B-4, and B-6 for unit-length PRGs).

5.2 Uncertaintly Analysis

Measured hydraulic parameters were available for multiple groundwater interest areas in the 100 Area (Section 0). In order to assess the impact of the range of plausible hydraulic parameters, simulations were performed using values obtained from sampling of the 100-BC and 100-D/H Areas. The parameters tested are for each of these areas are shown in Table 3-5.

Evaluation of the two sets of hydraulic parameters was accomplished through comparison of the peak concentrations of COPCs in groundwater for the unit-concentration scenarios used to calculate unit-length SSL and PRG values. Recall from Equations (1a) and (1b) that the unit-length SSL and PRG values, respectively, vary inversely with the peak concentration. This leads to the intuitive conclusion that, in comparing hydraulic parameters, the model that results in a higher peak groundwater concentration is more conservative – that is, it leads to deriving a more restrictive unit-length SSL or PRG value.

For the sake of simplicity, the comparison is shown for unit-length SSL and PRG simulations of all K_d values for the non-radionuclide COPCs. However, the results also apply for site-specific non-radionuclide and radionuclide COPC simulations.

Figure 5-1 shows the simulated peak groundwater concentration as a function of K_d for both the 100-BC and 100-D/H parameter sets in the irrigation recharge scenario (unit-length SSL basis) simulations. It is evident that the peak groundwater concentrations are uniformly lower for the 100-BC parameter set than for the 100-D/H parameter set. Similarly, Figure 5-2 shows peak groundwater concentration as a function of K_d for both the 100-BC and 100-D/H parameters in the native vegetation recharge scenario (unit-length

PRG basis) simulations, with the identical result. In Figure 5-1 and Figure 5-2, the range of K_d values displayed extends only to up to 1.0 mg/ml, for the sake of clarity. Differences are most pronounced with lower K_d values.

This outcome can be observed across the full range of K_d values in Figure 5-3 and Figure 5-4. These figures show scatter plot comparisons of the peak groundwater concentrations simulated for the 100-BC and 100-D/H parameter sets under the irrigation (unit-length SSL basis) and native vegetation (unit-length PRG basis) recharge scenarios, respectively. Again, it is observed that the 100-BC parameter set results in uniformly lower peak groundwater concentrations than the 100-D/H parameter set. Therefore, use of the 100-D/H parameter set will result in the derivation of more conservative (i.e., more protective) unit-length SSL and PRG values.

Based on the results of this uncertainty analysis, the 100-D/H hydraulic parameter set was adopted for determination of 100-BC unit-length SSL and PRG values as an additional conservatism in this calculation.

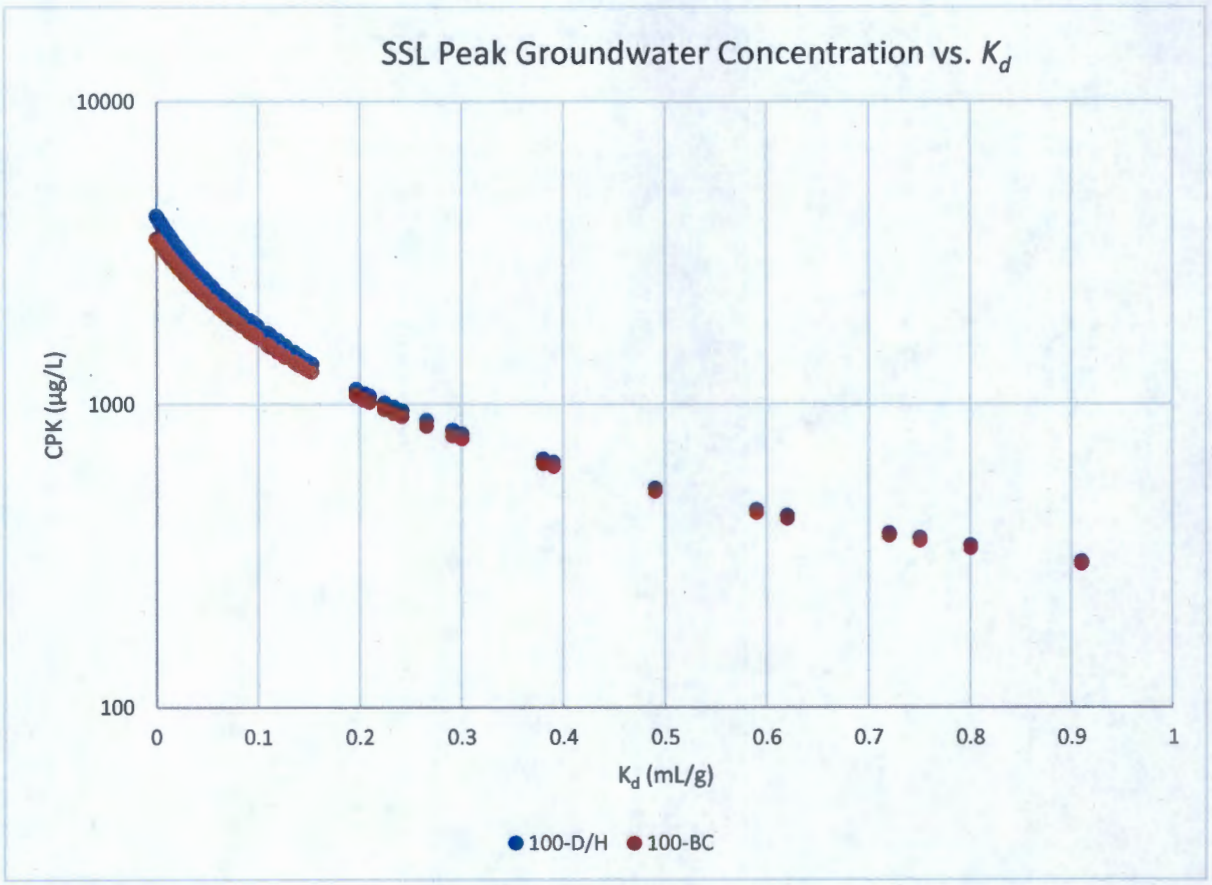

Figure 5-1. Uncertainty Analysis: Peak Groundwater Concentration as a Function of K_d for Irrigation Recharge Scenario (unit-length SSL basis) Simulations for 100-D/H and 100-BC Parameter Sets

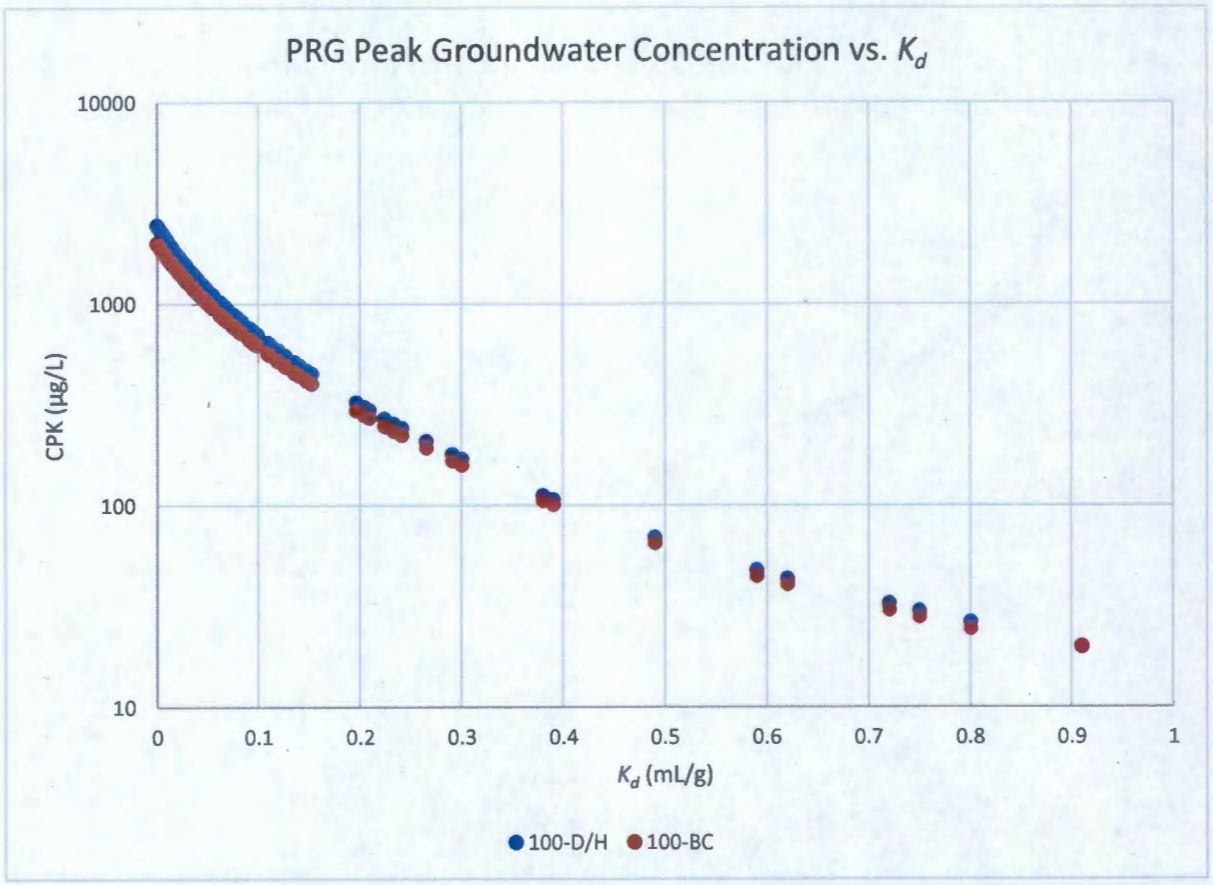

Figure 5-2. Uncertainty Analysis: Peak Groundwater Concentration as a Function of K_d for Native Vegetation Recharge Scenario (unit-length PRG basis) Simulations for 100-D/H and 100-BC Parameter Sets

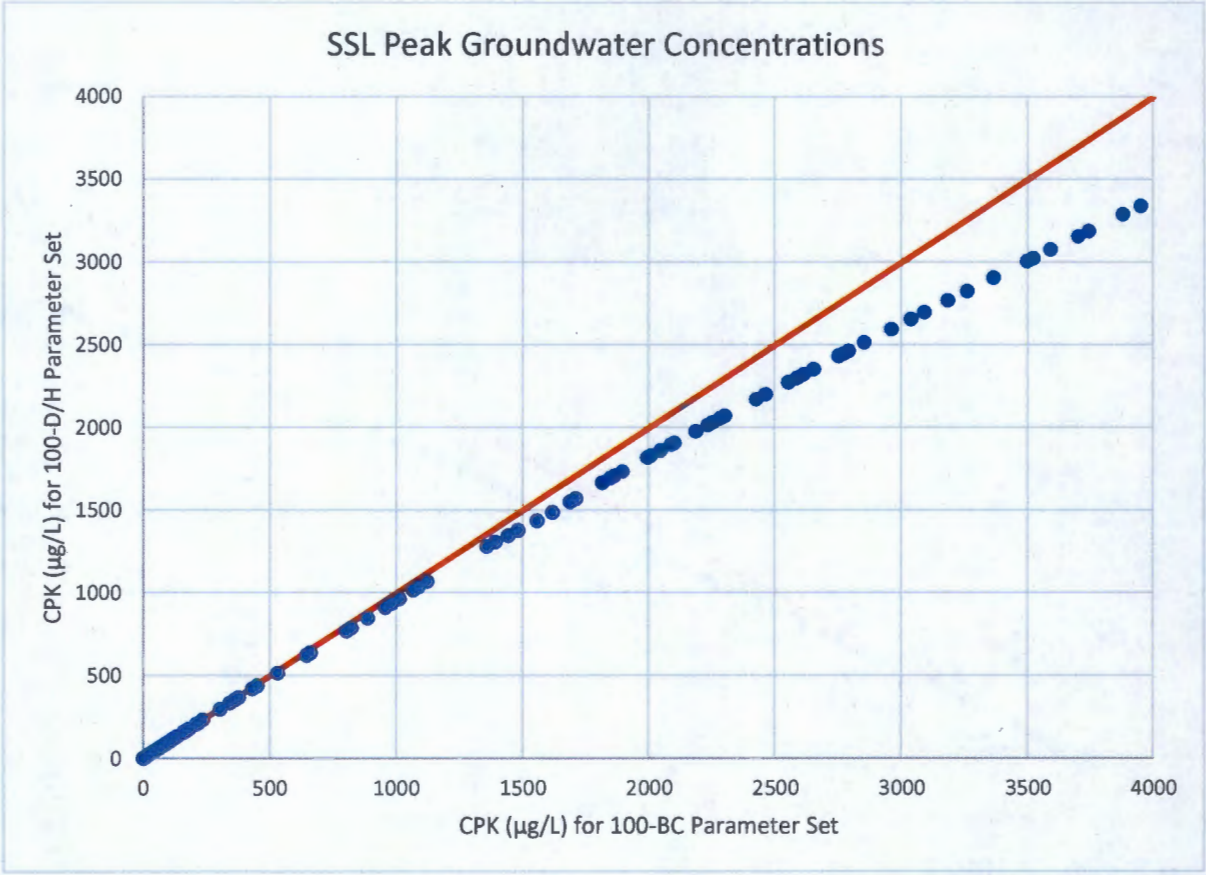

Figure 5-3. Uncertainty Analysis: Irrigation Recharge Scenario (unit-length SSL basis) Simulation Peak Groundwater Concentration Scatter Plot for 100-BC versus 100-D/H Hydraulic Parameter Sets

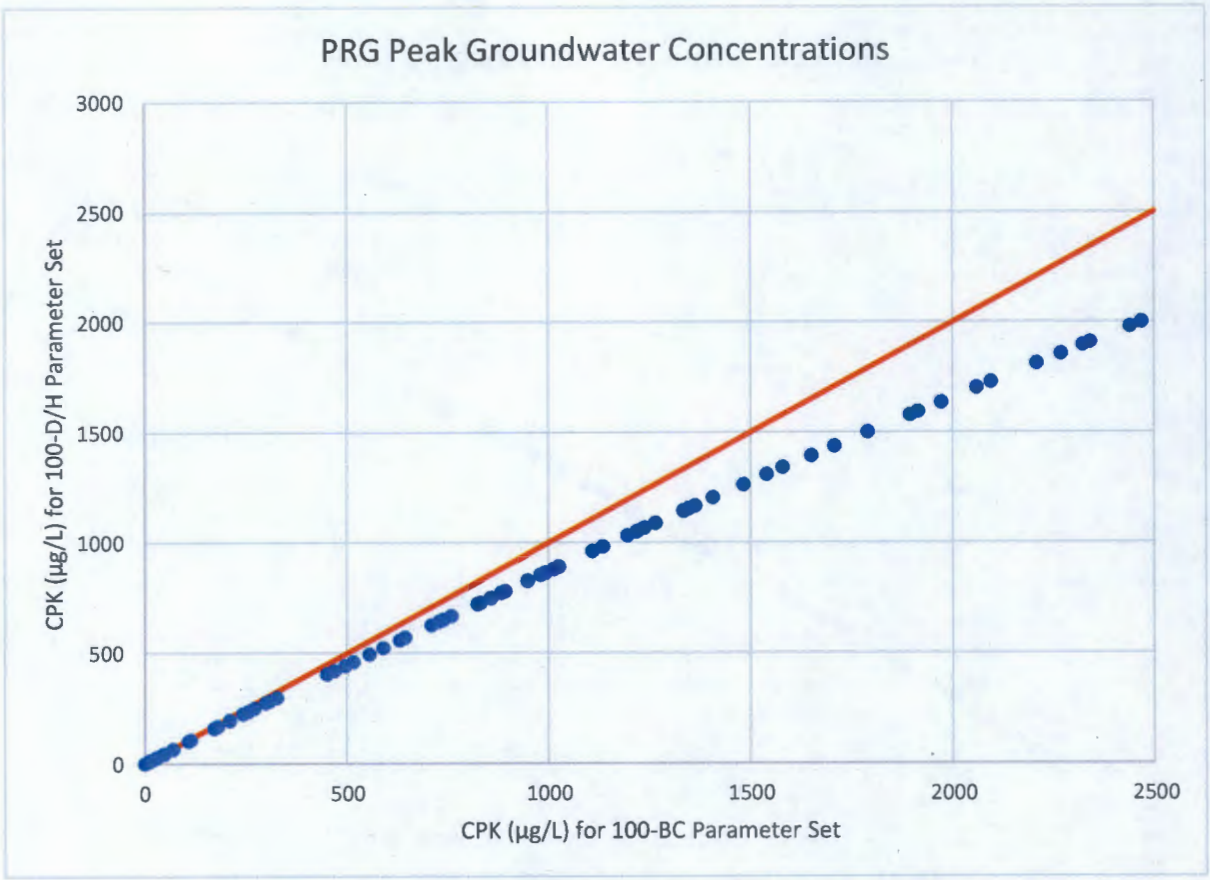

Figure 5-4. Uncertainty Analysis: Native Vegetation Recharge Scenario (unit-length PRG basis) Simulation Peak Groundwater Concentration Scatter Plot for 100-BC versus 100-D/H Hydraulic Parameter Sets

5.3 Site-Specific Modeling

DOE-RL/2011-50 provides a graded approach for calculation of unit-length SSL and PRG values. Under this graded approach, for which the first-level, generalized model is non-representative, or in cases where the bounding assumptions merit reconsideration for specific site conditions, the waste site may be evaluated further using a site-specific modeling approach. This approach combines the efficiency of a generalized modeling approach (first level) with the judicious use of site-specific modeling (second level) only where the additional modeling is merited.

5.3.1 Site-Specific Tritium SSL and PRG for 118-B-1

Characterization of the 118-B-1 Burial Ground (CVP-2007-00006, *Cleanup Verification Package for the 118-B-1, 105-B Solid Waste Burial Ground*) showed residual tritium contamination in exceedance of both evaluation SSL and evaluation PRG values at a borehole denoted A2-3, which was advanced from the floor of an excavation denoted Area 1 (Figure 5-5). Depth-discrete tritium concentrations sampled at A2-3 are shown in Table 5-3. Based on these observations, a site-specific model was developed to assess the impact on tritium in groundwater within the 118-B-1 Burial Ground.

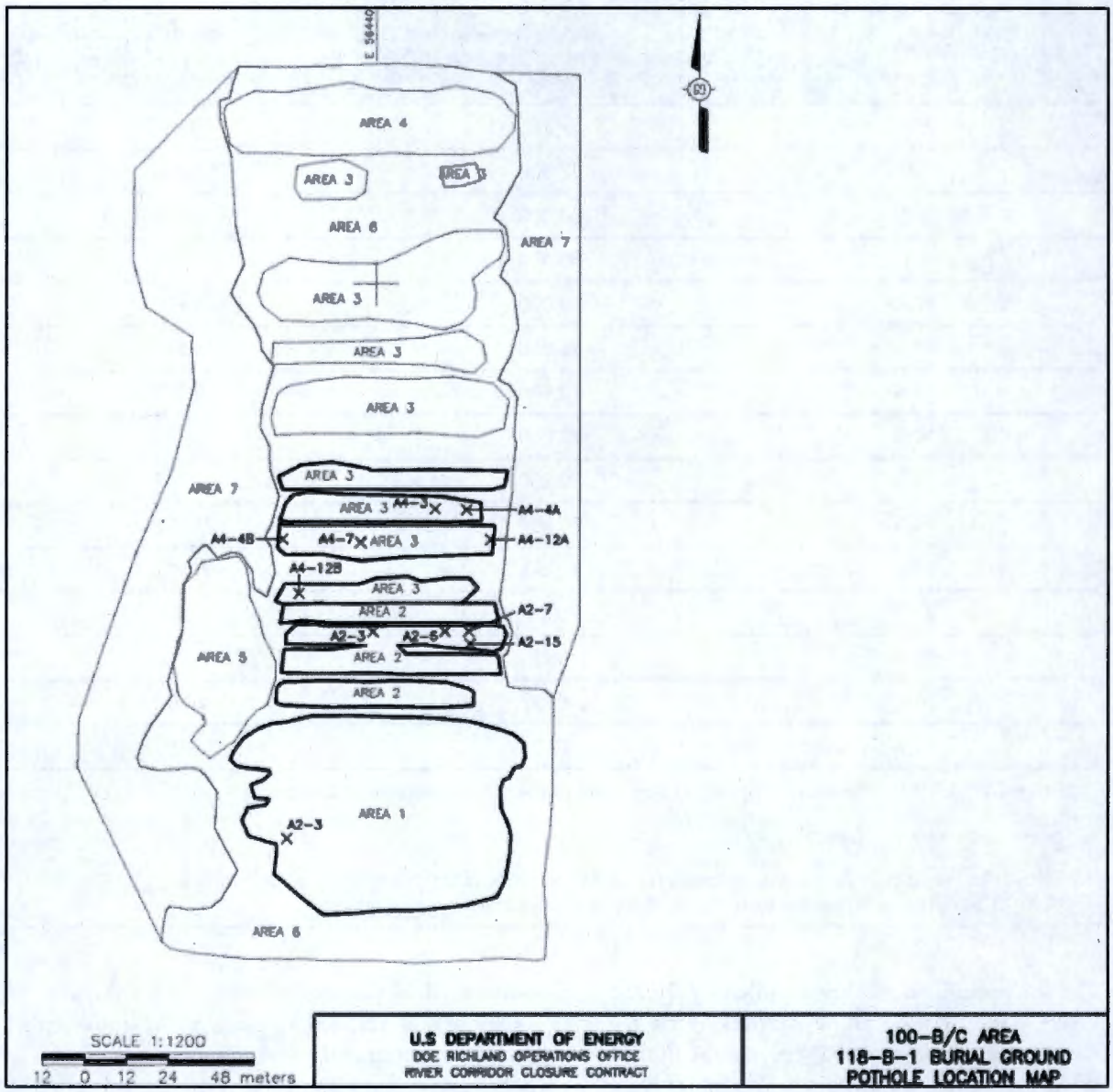

Figure 5-5. 118-B-1 Burial Ground Excavation and Borehole Locations (Appendix D, *Cleanup Verification Package for the 118-B-1, 105-B Solid Waste Burial Ground*, CVP-2007-00006)

Table 5-3. Borehole A2-3 Tritium Concentrations

Depth[1] (m bgs[2])	Measured Tritium Concentration[1] (pCi/g)	Decay Adjusted (3-year) Measured Tritium Concentration (pCi/g)[3]
6.1	494	418
7.0	37,500	31,689
8.2	36,300	30,675
9.1	33,400	28,224
10.4	29,000	24,506
11.9	15,800	13,352
13.4	19,100	16,140
14.9	23,800	20,112
17.0	39,900	33,717
18.3	26,600	22,478
20.0	9,050	7,648
21.3	2,800	2,366
23.0	936	791
24.4	563	476
26.1	42.3	36

1: From CVP-2007-00006, Rev. 0, Appendix D: Tritium Plume Characterization Sampling Results, Table D-1

2: bgs = below ground surface

3: These data were collected between June and December 2006 and the transport model starts in 2010.Ttherefore, a 3-year decay to the observed soil concentration was applied.

The site-specific model has a similar structure to the models used for calculating unit-length SSLs and PRGs, but differs in four key respects. First, a unique column was developed to represent the lithology at the 118-B-1 Burial Ground. Second, the initial concentration of tritium in the soil column is specified using the depth discrete data shown in Table 5-3, with decay correction from the year of data collection (2007) to the predictive model start year (2011), as shown in Table 5-3. Third, rather than a unit-length column, the actual flow length was incorporated directly into the site-specific model, allowing downgradient groundwater concentrations to be forecast without scaling. Fourth, information from the cleanup verification report was used to constrain the representative dimension in the direction of groundwater flow to one appropriate to the focus of the borehole at A2-3.

5.3.1.1 118-B-1 Site-Specific Model Representative Stratigraphic Column

A representative stratigraphic column corresponding to borehole A2-3 was developed using data from CVP-2007-00006, *Cleanup Verification Package for the 118-B-1, 105-B Solid Waste Burial Ground*, and from ECF-HANFORD-13-0020, *100-Area Geologic Framework Model*.

CVP-2007-00006 indicates that the floor of the Area 1 excavation was 6.1 m below ground surface (bgs) and that the water table is 25.2 m bgs. Based on ECF-HANFORD-13-0020, Hanford formation materials near borehole A2-3 comprise the full thickness of the vadose zone and extend 2.5 m below the water table where it meets the Ringold E formation. The site-specific stratigraphic column (Figure 5-6) was created by modifying Stratigraphic Column 2 (Figure 3-1) to reflect these dimensions. This included specifying:

- Backfill as extending from ground surface to 6.0 m bgs;
- Hanford formation as occupying 19.25 m from contact with backfill to the water table (for a total vadose zone thickness of 25.25 m) and extending 2.5 m into the saturated zone; and
- Ringold E formation as comprising the bottommost 2.5 m of the model domain.

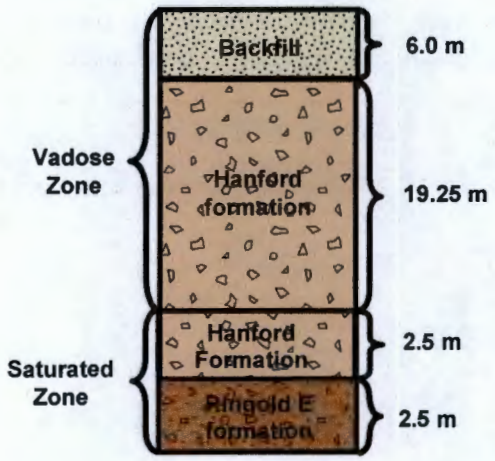

Figure 5-6. Model Column for 118-B-1

5.3.1.2 118-B-1 Site-Specific Model Initial Conditions

Unlike the tritium models used for unit-length SSL and PRG calculations, in which a uniform unit concentration initial condition was applied throughout the vadose zone, initial tritium concentration conditions were set in the site-specific model using the depth-discrete sample data shown in Table 5-3. Concentration values were interpolated using a nearest-neighbor approach. Observed data, after decay correction (Table 5-3) were populated onto model grid center using nearest neighbor approach. Backfill and SZ were assumed to be clean at the beginning of the transport simulation.

5.3.1.3 118-B-1 Site-Specific Model Boundary Conditions

The boundary conditions applied to the site-specific model were identical to those applied to the general unit-length SSL and PRG models. However, for the sake of clarity, the boundary conditions used for calculating unit-length SSLs were denoted "Irrigation Scenario" in reference to the site-specific model and those used for calculating unit-length PRGs were denoted "Native Vegetation".

5.3.1.4 118-B-1 Site-Specific Model Dimensions

The site-specific tritium model used the same 0.25 m vertical discretization as the unit-length SSL and PRG models. However, unlike those models, the length of the site-specific model in the direction of groundwater flow was set according to the actual dimensions of the waste site. These dimensions were calculated in ECF-100BC5-15-0119, *Determination of Lineal Dimensions for 100BC Operable Unit Waste Site Decision Units for Use in Soil Screening Levels and Preliminary Remediation Goal*

Comparisons to Exposure Point Concentrations. The A2-3 borehole is located within the "118-B-1 Shallow 1" Decision Unit, which is 34.7 m long along the direction of groundwater flow.

However, focused sampling revealed tritium soil contamination at the 118-B-1 Solid Waste Burial Ground in Areas 1, 2, and 3 as well as at caches of tritium tubes, with the highest detection occurring in Area 1. Further sampling via test excavations was done within Area 1 to determine the contaminated zone, which was located within area A2 (Figure 5-7); concentrations are shown in Table 5-4. Within A2, sampling node 3 had the highest test tritium soil concentration (Table 5-5), and characterization borehole A2-3 was completed there. Sampling node A2-6 also had measurable tritium. Waste-site length for the site-specific model in the direction of groundwater flow is estimated as 5 m from sampling node A2-3 dimensions. Node A2-6 may also affect groundwater, but because its dimension in the direction of groundwater flow is similar to that as A2-3 and it is adjacent, not up or downgradient, to A2-3 its affects are not additive. Node A2-3, with the highest soil concentrations can be conservatively use to estimate impacts from A2-6. As a conservatism, the effective lineal representative dimension for this location is assumed to be 10 m, double the dimension (5 m) inferred from this review of the sampling results.

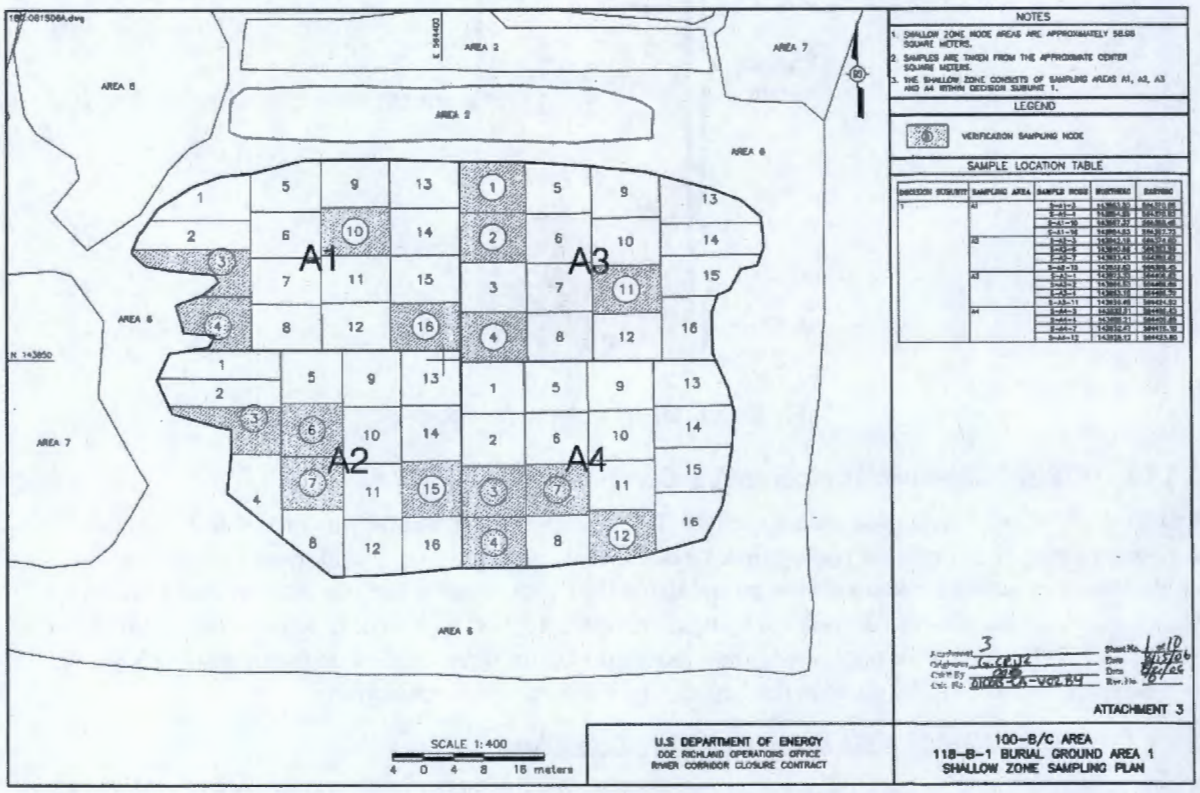

Figure 5-7. Burial Ground Area 1 Shallow Zone Sampling Plan (CVP-2007-000006)

Table 5-4. Area 1 Node Sampling Results

Sample Area	Tritium Soil Concentration (pCi/g)
A1	1.74
A2	239
A3	0.303
A4	0.574

Source: CVP-2007-00006

Table 5-5. Area 1, A2 Sample Area Tritium Soil Concentrations

Sample Node	Tritium Soil Concentration (pCi/g)
A2-3	494
A2-6	106
A2-7	-0.420 U
A2-15	0.170 U

U = undetected

Source: CVP-2007-00006

5.3.1.5 118-B-1 Site-Specific Model Results

As with the general unit-length SSL and PRG calculation, the result of interest from the site-specific model is contaminant concentration in groundwater leaving the model. However, the site-specific model is designed to allow future outcomes to be assessed if current conditions remain in place (as opposed to establishing a protective threshold level for contamination). Forecast values for both irrigation and native vegetation recharge scenarios are shown in Figure 5-8. For the irrigation recharge scenario, tritium concentration peaks at 106,400 pCi/L in 2029 and falls below the Water Quality Standard of 20,000 pCi/L in 2051. For the native vegetation recharge scenario, tritium concentration peaks at 18,640 pCi/L in 2026 and never exceeds the Water Quality Standard.

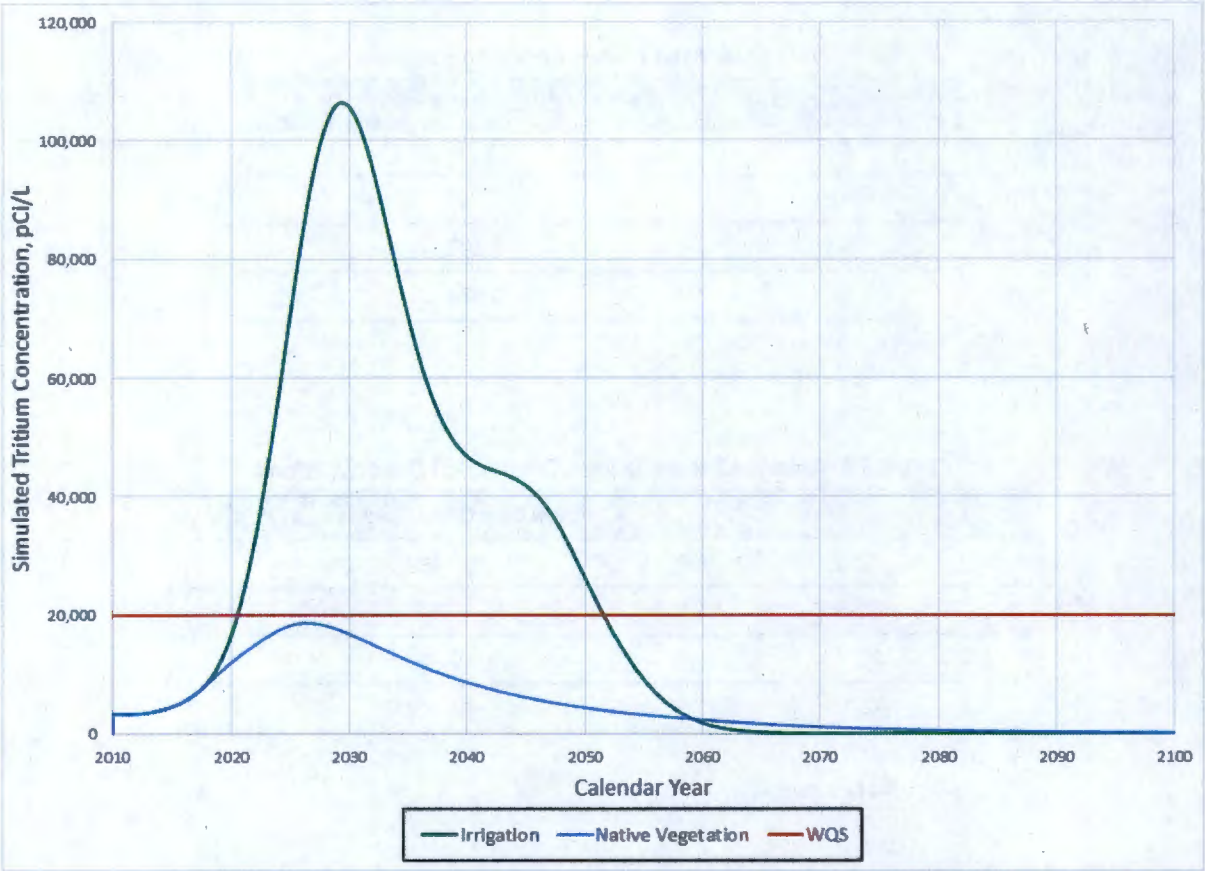

Figure 5-8. 118-B-1 Site-Specific Modeled Groundwater Tritium Concentration

6 Results/Conclusions

The results of this calculation include tabulated unit-length SSL and PRG values (described in Section 6.1) and sensitivity studies on model results (described in Section 6.2).

6.1 Unit-Length Soil Screening Value and Preliminary Remediation Goal Results

As described in Section 5.1, the maximum of the peak groundwater concentrations calculated with STOMP for the range or stratigraphic columns for the 100-BC Area using the irrigation recharge scenario was used in Equation (1a) to compute the unit-length SSL value for each COPC. The resulting unit-length SSL values protective of surface water and of groundwater are reported for each COPC in Attachment A to this ECF.

Similarly, the maximum of the peak groundwater concentrations from the range of stratigraphic columns simulated for the 100-BC Area using the native vegetation recharge scenario was used in Equation (1b) to compute the unit-length PRG value for each COPC. The resulting unit-length PRG values protective of surface water and groundwater are reported for each COPC in Attachment B to this ECF.

The following provisions apply with regard to unit-length SSLs and PRGs reported in Attachments A and B to this ECF, respectively:

- For evaluation of EPC values, the unit-length SSL and PRG values are to be scaled by the representative waste site dimension in the general direction of groundwater flow. This is accomplished by dividing the unit-length value by the representative dimension, checking that the scaled value is not less than the background level or the EQL or 90th percentile background level (where applicable) of the COPC, and then comparing to the EPC value.

- For COPCs for which an applicable water quality standard is not available, the "NA" symbol was applied to the unit-length SSL and PRG values (Section 2.6).

- Breakthrough was assumed not to occur if the simulated peak concentrations in groundwater within the 1000-year limit did not exceed 0.0001 μg/L for non-radionuclide COPCs or 0.0001 pCi/m^3 for radionuclide COPCs, in at least one of the representative stratigraphic columns simulated (Section 2.6.1). **In these instances, the "NR" symbol was applied for these COPCs** to designate a non-representative result, signifying that the results were below a level of numerical significance.

- If the calculated value for any unit-length SSL or PRG was less than the estimated quantitation limit (EQL) for soil concentration for a given COPC, then the unit-length SSL or PRG value was set equal to the EQL for that COPC (Section 2.6.2).

- If the calculated unit-length SSL or PRG value for any COPC exceeded the physical upper bound (389,000 mg/kg), then that unit-length SSL or PRG value was truncated at 389,000 mg/kg (Section 2.6.3).

- The cleanup level for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in HANFORD-11-0165; this value is not dependent on waste site size.

The unit-length SSL and PRG values reported in this calculation are applicable only to sites and COPCs where the conditions and assumptions underpinning this calculation are representative. Some waste sites may require a more rigorous investigation of site-specific conditions than those underlying the unit-length SSL and PRG values listed in Attachments A and B to this ECF.

6.2 Sensitivity Analyses

The depth of backfill and an alternative conceptual model of hexavalent chromium were identified in a separate analysis for the 100-D/H source OUs as potential sensitivities requiring consideration for impact on final unit-length PRG and SSL values. On the basis of the similarities in the models used for 100-D/H and 100-BC Areas, the sensitivity analysis performed in Chapter 6, Section 2 of ECF-HANFORD-11-0063, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units* is taken to be applicable for this calculation. Those analyses showed no appreciable sensitivity to either backfill depth or alternative initial conditions for hexavalent chromium.

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Attachment A

Unit-Length Soil Screening Levels Protective of Groundwater and Unit-Length Soil Screening Levels Protective of Surface Water for the 100-BC Source Operable Units

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Note

Tabulated unit-length soil screening level (SSL) values are presented in Tables A-1, A-3, and A-5 in ascending K_d order. This sorting order reveals the correlation between analyte K_d values and resulting unit-length SSL values. Below this threshold, "NR" (nonrepresentative result) values are reported (though shorter-lived radionuclides may result in "NR" values above the indicated threshold due to radiological decay). The "NR" code reflects that the model simulations did not predict breakthrough within 1000 years, defined here as a peak groundwater concentration exceeding 0.0001 μg/L for non-radionuclide analytes, or 0.0001 pCi/m^3 for radionuclide analytes), a value set as the lower limit of numerical significance for model groundwater concentration results.

The same unit-length SSL values are presented again in Tables A-2, A-4, and A-6, but in ascending contaminant name order to enable lookup by the reader by contaminant name.

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Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
16887-00-6	Chloride	chloride	0.00E+00	2.50E+05	2.00E+00	5.99E+02
14797-55-8	Nitrate	Nitrate	0.00E+00	4.50E+04	2.50E+00	1.08E+02
14797-65-0	Nitrite	Nitrite	0.00E+00	3.30E+03	2.50E+00	7.90E+00
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0.00E+00	1.00E+04	7.50E-01	2.39E+01
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0.00E+00	1.00E+03	7.50E-01	2.39E+00
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0.00E+00	1.00E+04	---	2.39E+01
14808-79-8	Sulfate	sulfate	0.00E+00	2.50E+05	5.00E+00	5.99E+02
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	1.00E-05	3.20E+01	8.25E-01	7.66E-02
67-64-1	Acetone	Acetone	6.00E-04	7.20E+03	2.00E-02	1.74E+01
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	2.80E-03	8.00E+02	---	1.98E+00
75-99-0	Dalapon	Dalapon	3.20E-03	2.00E+02	—	4.99E-01
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	4.50E-03	4.80E+03	1.00E-02	1.22E+01
74-87-3	Chloromethane	chloromethane	6.00E-03	No Value	1.00E-02	NA
74-83-9	Bromomethane	bromomethane	9.00E-03	1.12E+01	1.00E-02	2.99E-02
75-09-2	Methylene chloride	methylene chloride	1.00E-02	5.00E+00	5.00E-03	1.35E-02
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	1.26E-02	6.40E+02	1.00E-02	1.78E+00
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	1.44E-02	4.80E+01	3.30E-01	1.36E-01

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	1.50E-02	4.00E+01	2.00E-02	1.14E-01
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	1.86E-02	6.08E-02	5.00E-03	1.81E-04
75-00-3	Chloroethane	ethyl chloride	2.17E-02	No Value	1.00E-02	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	2.40E-02	1.25E-02	3.30E-01	3.93E-05
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	2.70E-02	4.38E-01	5.00E-03	1.42E-03
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	2.70E-02	4.38E-01	5.00E-03	1.42E-03
1918-00-9	Dicamba	Dicamba	2.88E-02	4.80E+02	---	1.58E+00
108-95-2	Phenol	Phenol	2.88E-02	2.40E+03	3.30E-01	7.91E+00
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	2.90E-02	7.00E+01	---	2.31E-01
131-11-3	Dimethyl phthalate	dimethyl phthalate	3.16E-02	No Value	3.30E-01	NA
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	3.55E-02	1.60E+01	5.00E-03	5.61E-02
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	3.80E-02	4.81E-01	5.00E-03	1.72E-03
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	3.80E-02	1.00E+02	5.00E-03	3.59E-01
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	3.88E-02	5.00E+02	---	1.81E+00
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	3.96E-02	7.20E+01	5.00E-03	2.62E-01
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	4.39E-02	2.40E+03	---	9.06E+00
75-15-0	Carbon disulfide	carbon disulfide	4.57E-02	8.00E+02	5.00E-03	3.06E+00

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
78-59-1	Isophorone	isophorone	4.68E-02	4.61E+01	3.30E-01	1.78E-01
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	4.70E-02	1.22E+00	5.00E-03	4.71E-03
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	4.85E-02	1.60E+01	2.10E+00	6.27E-02
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	4.90E-02	1.60E+02	---	6.30E-01
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	5.30E-02	7.68E+00	1.00E-02	3.12E-02
67-66-3	Chloroform	chloroform	5.30E-02	1.41E+00	5.00E-03	5.73E-03
75-27-4	Bromodichloromethane	bromodichloromethane	5.50E-02	7.06E-01	5.00E-03	2.91E-03
71-43-2	Benzene	Benzene	6.20E-02	7.95E-01	5.00E-03	3.46E-03
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	6.31E-02	5.21E-01	5.00E-03	2.28E-03
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	6.50E-02	7.00E+00	1.00E-02	3.11E-02
106-47-8	4-Chloroaniline	chloroaniline;p-	6.61E-02	2.19E-01	3.30E-01	9.80E-04
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	6.92E-02	1.60E+01	3.30E-01	7.32E-02
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	7.50E-02	7.68E-01	5.00E-03	3.66E-03
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	7.60E-02	3.98E-02	3.30E-01	1.91E-04
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	7.90E-02	2.19E-01	5.00E-03	1.07E-03
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	8.00E-02	5.00E+01	---	2.46E-01

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
84-66-2	Diethylphthalate	diethyl phthalate	8.20E-02	1.28E+04	3.30E-01	6.38E+01
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	8.29E-02	6.25E-01	3.30E-01	3.13E-03
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	9.12E-02	4.00E+02	3.30E-01	2.11E+00
79-01-6	Trichloroethene	trichloroethylene (TCE)	9.40E-02	5.40E-01	5.00E-03	2.90E-03
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	9.55E-02	2.82E-01	3.30E-01	1.53E-03
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	9.84E-02	1.28E+02	1.30E-02	7.05E-01
99-09-2	3-Nitroaniline	nitroaniline, 3-	1.09E-01	4.17E+00	3.30E-01	2.44E-02
100-01-6	4-Nitroaniline	nitroaniline, 4-	1.09E-01	4.38E+00	3.30E-01	2.56E-02
88-74-4	2-Nitroaniline	nitroaniline, 2-	1.11E-01	1.60E+02	3.30E-01	9.48E-01
98-95-3	Nitrobenzene	Nitrobenzene	1.19E-01	1.60E+01	3.30E-01	9.89E-02
75-25-2	Bromoform	bromoform	1.26E-01	5.54E+00	5.00E-03	3.56E-02
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	1.35E-01	2.00E+02	5.00E-03	1.35E+00
108-88-3	Toluene	Toluene	1.40E-01	6.40E+02	5.00E-03	4.44E+00
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	1.47E-01	2.40E+01	3.30E-01	1.73E-01
56-23-5	Carbon tetrachloride	carbon tetrachloride	1.52E-01	6.25E-01	5.00E-03	4.61E-03
108-38-3	m-Xylene	Xylene, m-	1.96E-01	1.60E+03	—	1.43E+01
100-41-4	Ethylbenzene	ethylbenzene	2.04E-01	3.98E+00	5.00E-03	3.66E-02
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	2.09E-01	1.60E+02	3.30E-01	1.50E+00
108-90-7	Chlorobenzene	chlorobenzene	2.24E-01	1.00E+02	5.00E-03	9.89E-01

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
1330-20-7	Xylenes (total)	Xylenes (total)	2.33E-01	1.60E+03	1.00E-02	1.63E+01
95-47-6	o-Xylene	xylene,o-	2.41E-01	1.60E+03	---	1.68E+01
127-18-4	Tetrachloroethene	tetrachloroethylene	2.65E-01	5.00E+00	5.00E-03	5.64E-02
100-02-7	4-Nitrophenol	nitrophenol;4-	2.91E-01	No Value	6.60E-01	NA
88-75-5	2-Nitrophenol	nitrophenol;2-	3.00E-01	No Value	6.60E-01	NA
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	3.00E-01	8.00E+02	---	9.98E+00
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	3.80E-01	No Value	3.30E-01	NA
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	3.80E-01	6.00E+02	3.30E-01	9.11E+00
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	3.80E-01	3.98E+00	3.30E-01	6.04E-02
95-57-8	2-Chlorophenol	Chlorophenol;2-	3.90E-01	4.00E+01	3.30E-01	6.21E-01
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	4.90E-01	1.60E+03	3.30E-01	3.02E+01
87-86-5	Pentachlorophenol	pentachlorophenol	5.90E-01	2.19E-01	3.30E-01	4.87E-03
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	6.20E-01	8.10E+00	5.00E-03	1.89E-01
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	7.20E-01	1.94E-01	3.30E-01	5.18E-03
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	7.50E-01	1.28E+00	3.30E-01	3.54E-02
18540-29-9	Hexavalent Chromium	chromium(VI)	8.00E-01	4.80E+01	---	6[e]
100-42-5	Styrene	styrene	9.10E-01	1.00E+02	5.00E-03	3.31E+00
91-20-3	Naphthalene	naphthalene	1.19E+00	1.60E+02	1.00E-01	6.80E+00
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29E+00	1.79E+01	3.30E-01	8.19E-01

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35E+00	7.95E-02	1.65E-03	3.81E-03
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57E+00	1.60E+03	3.30E-01	8.85E+01
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.60E+00	8.00E+02	3.30E-01	4.50E+01
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66E+00	1.51E+00	3.30E-01	8.80E-02
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76E+00	1.39E-02	1.65E-03	8.57E-04
67-72-1	Hexachloroethane	hexachloroethane	1.78E+00	1.09E+00	3.30E-01	6.82E-02
959-98-8	Endosulfan I	Endosulfan I	2.04E+00	9.60E+01	1.65E-03	7.19E+00
33213-65-9	Endosulfan II	Endosulfan II	2.04E+00	9.60E+01	3.30E-03	7.19E+00
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14E+00	4.86E-02	1.65E-03	3.81E-03
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35E+00	9.72E+00	---	8.35E-01
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48E+00	6.40E+02	3.30E-01	5.79E+01
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48E+00	3.20E+01	3.30E-01	2.90E+00
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81E+00	No Value	1.65E-03	NA
7440-42-8	Boron	Boron	3.00E+00	3.20E+03	2.00E+00	3.48E+02
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08E+00	No Value	3.30E-01	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08E+00	No Value	3.30E-01	NA
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27E+00	No Value	3.30E-03	NA

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
86-74-8	Carbazole	carbazole	3.39E+00	4.38E+00	3.30E-01	5.37E-01
7723-14-0	Phosphorus	phosphorus	3.50E+00	No Value	5.00E+01	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.50E+00	No Value	---	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4.00E+00	5.00E+02	---	7.22E+01
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4.00E+00	5.00E+02	---	7.22E+01
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29E+00	7.00E+00	1.50E-03	1.08E+00
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.50E+00	No Value	7.50E+01	NA
83-32-9	Acenaphthene	acenaphthene	4.90E+00	4.80E+02	1.00E-01	8.47E+01
7782-49-2	Selenium	selenium and compounds	5.00E+00	5.00E+01	1.00E+00	9.01E+00
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03E+00	No Value	1.00E-01	NA
7440-09-7	Potassium	Potassium	5.50E+00	No Value	4.00E+02	NA
7440-43-9	Cadmium	cadmium	6.70E+00	5.00E+00	2.00E-01	1.26E+00
86-73-7	Fluorene	fluorene	7.70E+00	3.20E+02	3.00E-02	9.72E+01
7440-22-4	Silver	silver	8.30E+00	8.00E+01	2.00E-01	2.75E+01
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.40E+00	2.19E-02	1.65E-02	7.69E-03
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.40E+00	2.19E-02	1.65E-02	7.69E-03

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
132-64-9	Dibenzofuran	dibenzofuran	9.20E+00	8.00E+00	3.30E-01	3.35E+00
76-44-8	Heptachlor	heptachlor	9.50E+00	1.94E-02	1.65E-03	8.72E-03
53494-70-5	Endrin ketone	Endrin ketone	9.70E+00	No Value	3.30E-03	NA
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.90E+00	No Value	3.30E-03	NA
57-12-5	Cyanide	cyanide	9.90E+00	4.80E+00	—	2.36E+00
72-20-8	Endrin	endrin	1.08E+01	2.00E+00	3.30E-03	1.22E+00
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	1.38E+01	4.61E+01	3.30E-01	6.04E+01
85-01-8	Phenanthrene	Phenanthrene	1.67E+01	No Value	5.00E-02	NA
7439-98-7	Molybdenum	molybdenum	2.00E+01	8.00E+01	2.00E+00	5.64E+02
7440-50-8	Copper	copper	2.20E+01	6.40E+02	1.00E+00	7.69E+03
120-12-7	Anthracene	anthracene	2.35E+01	2.40E+03	5.00E-02	4.27E+04
7439-89-6	Iron	Iron	2.50E+01	1.12E+04	5.00E+00	2.92E+05
60-57-1	Dieldrin	dieldrin	2.56E+01	5.47E-03	3.30E-03	1.66E-01
7440-38-2	Arsenic	arsenic, inorganic	2.90E+01	5.83E-02	1.00E+00	4.07E+00
7440-24-6	Strontium	strontium	3.50E+01	9.60E+03	1.00E+00	3.89E+05
7440-39-3	Barium	Barium	4.10E+01	2.00E+03	5.00E-01	3.89E+05
7440-36-0	Antimony	antimony	4.50E+01	6.00E+00	6.00E-01	1.19E+04
7440-48-4	cobalt	Cobalt	4.50E+01	4.80E+00	2.00E+00	9.52E+03
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	4.58E+01	3.65E-01	3.30E-03	8.37E+02
309-00-2	Aldrin	aldrin	4.87E+01	2.57E-03	1.65E-03	9.88E+00

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
206-44-0	Fluoranthene	fluoranthene	4.90E+01	6.40E+02	5.00E-02	3.89E+05
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	5.10E+01	2.50E-01	1.65E-02	1.42E+03
57-74-9	Chlordane	chlordane	5.10E+01	2.50E-01	1.65E-02	1.42E+03
7439-97-6	Mercury	mercury (using mercruric chloride)	5.20E+01	2.00E+00	---	1.34E+04
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	5.40E+01	5.61E-01	3.30E-01	5.22E+03
7440-66-6	Zinc	zinc	6.20E+01	4.80E+03	1.00E+00	3.89E+05
7439-96-5	Manganese	manganese	6.50E+01	3.84E+02	5.00E+00	3.89E+05
7440-02-0	Nickel	nickel soluble salts	6.50E+01	1.00E+02	4.00E+00	3.89E+05
129-00-0	Pyrene	pyrene	6.80E+01	2.40E+02	5.00E-02	3.89E+05
7440-28-0	Thallium	Thallium, soluble salts	7.10E+01	1.60E-01	5.00E-01	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	7.70E+01	4.38E-02	1.65E-02	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	7.80E+01	4.38E-02	1.65E-02	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	8.00E+01	5.47E-02	3.30E-01	NR
72-43-5	Methoxychlor	methoxychlor	8.00E+01	4.00E+01	1.65E-02	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	8.30E+01	4.81E-03	1.65E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	8.60E+01	2.57E-01	3.30E-03	NR
8001-35-2	Toxaphene	toxaphene	9.60E+01	7.95E-02	1.65E-01	NR
7440-23-5	Sodium	Sodium	1.00E+02	No Value	5.00E+01	NA
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	1.07E+02	5.00E-01	1.65E-02	NR

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	1.11E+02	6.00E+00	3.30E-01	NR
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	1.31E+02	4.38E-02	1.65E-02	NR
16984-48-8	Fluoride	fluoride (using fluorine)	1.50E+02	9.60E+02	5.00E+00	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	2.00E+02	4.80E+01	3.30E-01	NR
7440-31-5	Tin	tin	2.50E+02	9.60E+03	1.00E+01	NR
7439-93-2	Lithium	Lithium	3.00E+02	3.20E+01	2.50E+00	NR
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	3.58E+02	1.20E-01	1.50E-02	NR
218-01-9	chrysene	Chrysene	3.98E+02	1.20E+00	1.00E-01	NR
7440-61-1	Uranium	Uranium	NVR [f]	3.00E+01	---	NVR [f]
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	6.78E+02	2.57E-01	3.30E-03	NR
7440-41-7	Beryllium	beryllium	7.90E+02	4.00E+00	2.00E-01	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	8.22E+02	4.38E-02	1.65E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	9.69E+02	1.20E-02	1.50E-02	NR
7440-47-3	Chromium	chromium (total)	1.00E+03	1.00E+02	2.00E-01	NR
7440-62-2	Vanadium	vanadium	1.00E+03	8.00E+01	2.50E+00	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1.23E+03	1.20E-01	1.50E-02	NR
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1.23E+03	1.20E-01	1.50E-02	NR
7429-90-5	Aluminum	Aluminum (soluble)	1.50E+03	1.60E+04	5.00E+00	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1.79E+03	1.20E-01	3.00E-02	NR

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1.95E+03	No Value	3.00E-02	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3.47E+03	1.20E-01	3.00E-02	NR
7439-92-1	Lead	lead	1.00E+04	1.50E+01	5.00E-01	NR
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	8.32E+04	1.92E+02	3.30E-01	NR
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	No Value	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	--	No Value	1.00E+01	NA
24959-67-9	Bromide	Bromide	--	No Value	2.50E+00	NA
7440-70-2	Calcium	Calcium	--	No Value	1.00E+02	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	No Value	---	NA
14265-44-2	Phosphate	Phosphate	--	No Value	5.00E+00	NA
7440-21-3	Silicon	Silicon	--	No Value	2.00E+00	NA

a.ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to soil screening levels:

· "NA" was assigned where no applicable water quality standard was available.

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).

Table A-1. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

· Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Soil screening levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil screening levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the soil screening level for evaluation use.

e. The soil screening level for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	2.00E+02	5.00E-03	1.35E+00
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	2.00E-01	5.00E-03	1.07E-03
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	1.00E+00	5.00E-03	3.66E-03
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	7.68E+00	1.00E-02	3.12E-02
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	7.00E+00	1.00E-02	3.11E-02
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	1.50E+00	3.30E-01	8.80E-02
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	0,600	3.30E-01	9.11E+00
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	5.00E-01	5.00E-03	1.72E-03
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	7.20E+01	5.00E-03	2.62E-01
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	1.00E+00	5.00E-03	4.71E-03
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	–	3.30E-01	NA
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	8.00E+00	5.00E-03	1.89E-01
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	1.60E+01	2.10E+00	6.27E-02
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	7.00E+01	---	2.31E-01
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	1.60E+02	---	6.30E-01

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	5.00E+01	---	2.46E-01
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	8.00E+02	3.30E-01	4.50E+01
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	4.00E+00	3.30E-01	6.04E-02
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	1.28E+02	1.30E-02	7.05E-01
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	2.40E+01	3.30E-01	1.73E-01
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	1.60E+02	3.30E-01	1.50E+00
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	0,032	8.25E-01	7.66E-02
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	0,000	3.30E-01	1.53E-03
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	1.60E+01	3.30E-01	7.32E-02
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	4.80E+03	1.00E-02	1.22E+01
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	8.00E+02	---	1.98E+00
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	6.40E+02	3.30E-01	5.79E+01
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	4.00E+01	3.30E-01	6.21E-01
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	0,040	2.00E-02	1.14E-01
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	3.20E+01	3.30E-01	2.90E+00
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	4.00E+02	3.30E-01	2.11E+00
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	0,160	3.30E-01	9.48E-01

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	--	6.60E-01	NA
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	1.94E-01	3.30E-01	5.18E-03
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	3.30E-01	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	4.00E+00	3.30E-01	2.44E-02
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	3.60E-01	3.30E-03	8.37E+02
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	0.00E+00	3.30E-03	NR
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	2.57E-01	3.30E-03	NR
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	1.30E+00	3.30E-01	3.54E-02
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	5.00E+02	---	1.81E+00
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	1.60E+03	3.30E-01	3.02E+01
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	2.00E-01	3.30E-01	9.80E-04
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	6.40E+02	1.00E-02	1.78E+00
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	8.00E+02	---	9.98E+00

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	0,004	3.30E-01	2.56E-02
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	--	6.60E-01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	4.80E+02	1.00E-01	8.47E+01
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	--	1.00E-01	NA
67-64-1	Acetone	Acetone	0.0006	7.20E+03	2.00E-02	1.74E+01
309-00-2	Aldrin	aldrin	48.7	3.00E-03	1.65E-03	9.88E+00
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	1.39E-02	1.65E-03	8.57E-04
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	2.50E-01	1.65E-02	1.42E+03
7429-90-5	Aluminum	Aluminum (soluble)	1500	1.60E+04	5.00E+00	NR
120-12-7	Anthracene	anthracene	23.5	2.40E+03	5.00E-02	4.27E+04
7440-36-0	Antimony	antimony	45	6.00E+00	6.00E-01	1.19E+04
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	5.00E-01	1.65E-02	NR
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	0,000	1.65E-02	7.69E-03
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	0.00E+00	1.65E-02	7.69E-03
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	4.00E-02	1.65E-02	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	0.00E+00	1.65E-02	NR
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	4.00E-02	1.65E-02	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	4.38E-02	1.65E-02	NR
7440-38-2	Arsenic	arsenic, inorganic	29	5.80E-02	1.00E+00	4.07E+00

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
7440-39-3	Barium	Barium	41	2.00E+03	5.00E-01	3.89E+05
71-43-2	Benzene	Benzene	0.062	1.00E+00	5.00E-03	3.46E-03
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	1.20E-01	1.50E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	1.20E-02	1.50E-02	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	1.20E-01	1.50E-02	NR
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	1.20E-01	1.50E-02	NR
7440-41-7	Beryllium	beryllium	790	4.00E+00	2.00E-01	NR
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	4.86E-02	1.65E-03	3.81E-03
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	1.00E+00	3.30E-01	3.13E-03
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	4.80E+01	3.30E-01	1.36E-01
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	0.00E+00	3.30E-01	1.91E-04
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	0,006	3.30E-01	NR
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
7440-42-8	Boron	Boron	3	3.20E+03	2.00E+00	3.48E+02
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	7.10E-01	5.00E-03	2.91E-03
75-25-2	Bromoform	bromoform	0.126	5.54E+00	5.00E-03	3.56E-02

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
74-83-9	Bromomethane	bromomethane	0.009	1.12E+01	1.00E-02	2.99E-02
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	4.61E+01	3.30E-01	6.04E+01
7440-43-9	Cadmium	cadmium	6.7	5.00E+00	2.00E-01	1.26E+00
7440-70-2	Calcium	Calcium	--	--	1.00E+02	NA
86-74-8	Carbazole	carbazole	3.39	4.38E+00	3.30E-01	5.37E-01
75-15-0	Carbon disulfide	carbon disulfide	0.0457	8.00E+02	5.00E-03	3.06E+00
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	1.00E+00	5.00E-03	4.61E-03
57-74-9	Chlordane	chlordane	51	3.00E-01	1.65E-02	1.42E+03
16887-00-6	Chloride	chloride	0	2.50E+05	2.00E+00	5.99E+02
108-90-7	Chlorobenzene	chlorobenzene	0.224	1.00E+02	5.00E-03	9.89E-01
75-00-3	Chloroethane	ethyl chloride	0.0217	--	1.00E-02	NA
67-66-3	Chloroform	chloroform	0.053	0,001	5.00E-03	5.73E-03
74-87-3	Chloromethane	chloromethane	0.006	--	1.00E-02	NA
7440-47-3	Chromium	chromium (total)	1000	1.00E+02	2.00E-01	NR
218-01-9	chrysene	Chrysene	398	1.20E+00	1.00E-01	NR
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	1.60E+01	5.00E-03	5.61E-02
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	0.00E+00	5.00E-03	1.42E-03
7440-48-4	cobalt	Cobalt	45	4.80E+00	2.00E+00	9.52E+03
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	--	--	NA
7440-50-8	Copper	copper	22	6.40E+02	1.00E+00	7.69E+03

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
57-12-5	Cyanide	cyanide	9.9	4.80E+00	---	2.36E+00
75-99-0	Dalapon	Dalapon	0.0032	2.00E+02	---	4.99E-01
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	--	1.65E-03	NA
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	1.20E-01	3.00E-02	NR
132-64-9	Dibenzofuran	dibenzofuran	9.2	8.00E+00	3.30E-01	3.35E+00
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	5.20E-01	5.00E-03	2.28E-03
1918-00-9	Dicamba	Dicamba	0.0288	4.80E+02	---	1.58E+00
60-57-1	Dieldrin	dieldrin	25.6	1.00E-02	3.30E-03	1.66E-01
84-66-2	Diethylphthalate	diethyl phthalate	0.082	1.28E+04	3.30E-01	6.38E+01
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	--	3.30E-01	NA
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	1.60E+03	3.30E-01	8.85E+01
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	1.92E+02	3.30E-01	NR
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	7.00E+00	1.50E-03	1.08E+00
959-98-8	Endosulfan I	Endosulfan I	2.04	9.60E+01	1.65E-03	7.19E+00
33213-65-9	Endosulfan II	Endosulfan II	2.04	9.60E+01	3.30E-03	7.19E+00
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	--	3.30E-03	NA
72-20-8	Endrin	endrin	10.8	2.00E+00	3.30E-03	1.22E+00
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	--	3.30E-03	NA
53494-70-5	Endrin ketone	Endrin ketone	9.7	--	3.30E-03	NA
100-41-4	Ethylbenzene	ethylbenzene	0.204	0,004	5.00E-03	3.66E-02

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
206-44-0	Fluoranthene	fluoranthene	49	6.40E+02	5.00E-02	3.89E+05
86-73-7	Fluorene	fluorene	7.7	3.20E+02	3.00E-02	9.72E+01
16984-48-8	Fluoride	fluoride (using fluorine)	150	9.60E+02	5.00E+00	NR
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	7.95E-02	1.65E-03	3.81E-03
76-44-8	Heptachlor	heptachlor	9.5	2.00E-02	1.65E-03	8.72E-03
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	5.00E-03	1.65E-03	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	1.00E-01	3.30E-01	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	1.00E+00	3.30E-01	5.22E+03
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	4.80E+01	3.30E-01	NR
67-72-1	Hexachloroethane	hexachloroethane	1.78	1.09E+00	3.30E-01	6.82E-02
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	4.80E+01	—	6[e]
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	1.20E-01	3.00E-02	NR
7439-89-6	Iron	Iron	25	1.12E+04	5.00E+00	2.92E+05
78-59-1	Isophorone	isophorone	0.0468	4.61E+01	3.30E-01	1.78E-01
7439-92-1	Lead	lead	10000	1.50E+01	5.00E-01	NR
7439-93-2	Lithium	Lithium	300	3.20E+01	2.50E+00	NR
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA
7439-96-5	Manganese	manganese	65	0,384	5.00E+00	3.89E+05
7439-97-6	Mercury	mercury (using mercruric chloride)	52	2.00E+00	—	1.34E+04

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
72-43-5	Methoxychlor	methoxychlor	80	4.00E+01	1.65E-02	NR
75-09-2	Methylene chloride	methylene chloride	0.01	5.00E+00	5.00E-03	1.35E-02
7439-98-7	Molybdenum	molybdenum	20	0,080	2.00E+00	5.64E+02
108-38-3	m-Xylene	Xylene, m-	0.196	1.60E+03	---	1.43E+01
91-20-3	Naphthalene	naphthalene	1.19	1.60E+02	1.00E-01	6.80E+00
7440-02-0	Nickel	nickel soluble salts	65	1.00E+02	4.00E+00	3.89E+05
14797-55-8	Nitrate	Nitrate	0	4.50E+04	2.50E+00	1.08E+02
14797-65-0	Nitrite	Nitrite	0	3.30E+03	2.50E+00	7.90E+00
98-95-3	Nitrobenzene	Nitrobenzene	0.119	1.60E+01	3.30E-01	9.89E-02
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	1.00E+04	7.50E-01	2.39E+01
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	1.00E+03	7.50E-01	2.39E+00
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	1.00E+04	---	2.39E+01
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	1.00E-02	3.30E-01	3.93E-05
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	0,018	3.30E-01	8.19E-01
95-47-6	o-Xylene	xylene,o-	0.241	1.60E+03	---	1.68E+01
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	2.00E-01	3.30E-01	4.87E-03
85-01-8	Phenanthrene	Phenanthrene	16.7	--	5.00E-02	NA
108-95-2	Phenol	Phenol	0.0288	2.40E+03	3.30E-01	7.91E+00
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	--	--	NA
7440-09-7	Potassium	Potassium	5.5	--	4.00E+02	NA
129-00-0	Pyrene	pyrene	68	2.40E+02	5.00E-02	3.89E+05
7782-49-2	Selenium	selenium and compounds	5	5.00E+01	1.00E+00	9.01E+00
7440-21-3	Silicon	Silicon	--	--	2.00E+00	NA
7440-22-4	Silver	silver	8.3	0,080	2.00E-01	2.75E+01
7440-23-5	Sodium	Sodium	100	--	5.00E+01	NA
7440-24-6	Strontium	strontium	35	9.60E+03	1.00E+00	3.89E+05
100-42-5	Styrene	styrene	0.91	1.00E+02	5.00E-03	3.31E+00
14808-79-8	Sulfate	sulfate	0	2.50E+05	5.00E+00	5.99E+02
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	5.00E+00	5.00E-03	5.64E-02
7440-28-0	Thallium	Thallium, soluble salts	71	2.00E-01	5.00E-01	NR
7440-31-5	Tin	tin	250	9.60E+03	1.00E+01	NR
108-88-3	Toluene	Toluene	0.14	6.40E+02	5.00E-03	4.44E+00
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	5.00E+02	—	7.22E+01
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	5.00E+02	—	7.22E+01
8001-35-2	Toxaphene	toxaphene	96	0.00E+00	1.65E-01	NR
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	1.00E+02	5.00E-03	3.59E-01

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	0.00E+00	5.00E-03	1.42E-03
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	1.00E+01	---	8.35E-01
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	5.40E-01	5.00E-03	2.90E-03
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	2.40E+03	---	9.06E+00
7440-61-1	Uranium	Uranium	NVR [f]	3.00E+01	---	NVR [f]
7440-62-2	Vanadium	vanadium	1000	8.00E+01	2.50E+00	NR
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	6.08E-02	5.00E-03	1.81E-04
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	1.60E+03	1.00E-02	1.63E+01
7440-66-6	Zinc	zinc	62	4.80E+03	1.00E+00	3.89E+05

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to soil screening levels:

· "NA" was assigned where no applicable water quality standard was available.

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

Table A-2. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [c,d] $\left(\frac{mg}{kg}\cdot m\right)$

· Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Soil screening levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil screening levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the soil screening level for evaluation use.

e. The soil screening level for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
16887-00-6	Chloride	chloride	0	2.30E+05	2.00E+00	5.51E+02
14797-55-8	Nitrate	Nitrate	0	--	2.50E+00	NA
14797-65-0	Nitrite	Nitrite	0	--	2.50E+00	NA
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	--	7.50E-01	NA
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	--	7.50E-01	NA
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	--	---	NA
14808-79-8	Sulfate	sulfate	0	--	5.00E+00	NA
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	--	8.25E-01	NA
67-64-1	Acetone	Acetone	0.0006	--	2.00E-02	NA
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	--	---	NA
75-99-0	Dalapon	Dalapon	0.0032	--	---	NA
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	--	1.00E-02	NA
74-87-3	Chloromethane	chloromethane	0.006	--	1.00E-02	NA
74-83-9	Bromomethane	bromomethane	0.009	--	1.00E-02	NA
75-09-2	Methylene chloride	methylene chloride	0.01	--	5.00E-03	NA
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	--	1.00E-02	NA
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	--	3.30E-01	NA
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	--	2.00E-02	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	--	5.00E-03	NA
75-00-3	Chloroethane	ethyl chloride	0.0217	--	1.00E-02	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	--	3.30E-01	NA
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	--	5.00E-03	NA
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	--	5.00E-03	NA
1918-00-9	Dicamba	Dicamba	0.0288	--	---	NA
108-95-2	Phenol	Phenol	0.0288	--	3.30E-01	NA
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	--	---	NA
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	--	3.30E-01	NA
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	--	5.00E-03	NA
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	--	5.00E-03	NA
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	--	5.00E-03	NA
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	--	---	NA
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	--	5.00E-03	NA
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	--	---	NA
75-15-0	Carbon disulfide	carbon disulfide	0.0457	--	5.00E-03	NA
78-59-1	Isophorone	isophorone	0.0468	--	3.30E-01	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	--	5.00E-03	NA
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	--	2.10E+00	NA
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	--	---	NA
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	--	1.00E-02	NA
67-66-3	Chloroform	chloroform	0.053	--	5.00E-03	NA
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	--	5.00E-03	NA
71-43-2	Benzene	Benzene	0.062	--	5.00E-03	NA
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	--	5.00E-03	NA
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	--	1.00E-02	NA
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	--	3.30E-01	NA
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	--	3.30E-01	NA
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	--	5.00E-03	NA
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	--	3.30E-01	NA
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	--	5.00E-03	NA
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	--	---	NA
84-66-2	Diethylphthalate	diethyl phthalate	0.082	--	3.30E-01	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	--	3.30E-01	NA
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	--	3.30E-01	NA
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	--	5.00E-03	NA
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	--	3.30E-01	NA
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	--	1.30E-02	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	--	3.30E-01	NA
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	--	3.30E-01	NA
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	--	3.30E-01	NA
98-95-3	Nitrobenzene	Nitrobenzene	0.119	--	3.30E-01	NA
75-25-2	Bromoform	bromoform	0.126	--	5.00E-03	NA
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	--	5.00E-03	NA
108-88-3	Toluene	Toluene	0.14	--	5.00E-03	NA
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	--	3.30E-01	NA
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	--	5.00E-03	NA
108-38-3	m-Xylene	Xylene, m-	0.196	--	--	NA
100-41-4	Ethylbenzene	ethylbenzene	0.204	--	5.00E-03	NA
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	--	3.30E-01	NA
108-90-7	Chlorobenzene	chlorobenzene	0.224	--	5.00E-03	NA
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	--	1.00E-02	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
95-47-6	o-Xylene	xylene,o-	0.241	--	---	NA
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	--	5.00E-03	NA
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	--	6.60E-01	NA
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	--	6.60E-01	NA
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	--	---	NA
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	--	3.30E-01	NA
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	--	3.30E-01	NA
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	--	3.30E-01	NA
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	--	3.30E-01	NA
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	--	3.30E-01	NA
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	1.30E+01	3.30E-01	2.89E-01
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	--	5.00E-03	NA
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	--	3.30E-01	NA
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	--	3.30E-01	NA
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	1.00E+01	---	6[e]
100-42-5	Styrene	styrene	0.91	--	5.00E-03	NA
91-20-3	Naphthalene	naphthalene	1.19	--	1.00E-01	NA
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	--	3.30E-01	NA
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	8.00E-02	1.65E-03	3.83E-03

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	--	3.30E-01	NA
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	--	3.30E-01	NA
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	--	3.30E-01	NA
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	--	1.65E-03	NA
67-72-1	Hexachloroethane	hexachloroethane	1.78	--	3.30E-01	NA
959-98-8	Endosulfan I	Endosulfan I	2.04	5.60E-02	1.65E-03	4.20E-03
33213-65-9	Endosulfan II	Endosulfan II	2.04	5.60E-02	3.30E-03	4.20E-03
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	--	1.65E-03	NA
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	--	—	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	--	3.30E-01	NA
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	--	3.30E-01	NA
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	--	1.65E-03	NA
7440-42-8	Boron	Boron	3	--	2.00E+00	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	--	3.30E-03	NA
86-74-8	Carbazole	carbazole	3.39	--	3.30E-01	NA
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	--	—	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	--	—	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	--	—	NA
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	--	1.50E-03	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	--	1.00E-01	NA
7782-49-2	Selenium	selenium and compounds	5	5.00E+00	1.00E+00	9.01E-01
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	--	1.00E-01	NA
7440-09-7	Potassium	Potassium	5.5	--	4.00E+02	NA
7440-43-9	Cadmium	cadmium	6.7	2.50E-01	2.00E-01	6.28E-02
86-73-7	Fluorene	fluorene	7.7	--	3.00E-02	NA
7440-22-4	Silver	silver	8.3	2.40E+00	2.00E-01	8.26E-01
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	1.40E-02	1.65E-02	4.92E-03
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	1.40E-02	1.65E-02	4.92E-03
132-64-9	Dibenzofuran	dibenzofuran	9.2	--	3.30E-01	NA
76-44-8	Heptachlor	heptachlor	9.5	3.80E-03	1.65E-03	1.70E-03

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
53494-70-5	Endrin ketone	Endrin ketone	9.7	--	3.30E-03	NA
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	--	3.30E-03	NA
57-12-5	Cyanide	cyanide	9.9	5.20E+00	---	2.56E+00
72-20-8	Endrin	endrin	10.8	2.30E-03	3.30E-03	1.40E-03
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	--	3.30E-01	NA
85-01-8	Phenanthrene	Phenanthrene	16.7	--	5.00E-02	NA
7439-98-7	Molybdenum	molybdenum	20	--	2.00E+00	NA
7440-50-8	Copper	copper	22	9.00E+00	1.00E+00	1.08E+02
120-12-7	Anthracene	anthracene	23.5	--	5.00E-02	NA
7439-89-6	Iron	Iron	25	1.00E+03	5.00E+00	2.61E+04
60-57-1	Dieldrin	dieldrin	25.6	1.90E-03	3.30E-03	5.77E-02
7440-38-2	Arsenic	arsenic, inorganic	29	1.50E+02	1.00E+00	1.05E+04
7440-24-6	Strontium	strontium	35	--	1.00E+00	NA
7440-39-3	Barium	Barium	41	--	5.00E-01	NA
7440-36-0	Antimony	antimony	45	--	6.00E-01	NA
7440-48-4	cobalt	Cobalt	45	--	2.00E+00	NA
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	--	3.30E-03	NA
309-00-2	Aldrin	aldrin	48.7	1.90E-03	1.65E-03	7.29E+00
206-44-0	Fluoranthene	fluoranthene	49	--	5.00E-02	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	4.30E-03	1.65E-02	2.44E+01
57-74-9	Chlordane	chlordane	51	4.30E-03	1.65E-02	2.44E+01
7439-97-6	Mercury	mercury (using mercruric chloride)	52	1.20E-02	--	8.06E+01
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	--	3.30E-01	NA
7440-66-6	Zinc	zinc	62	9.10E+01	1.00E+00	3.89E+05
7439-96-5	Manganese	manganese	65	--	5.00E+00	NA
7440-02-0	Nickel	nickel soluble salts	65	4.50E+01	4.00E+00	3.89E+05
129-00-0	Pyrene	pyrene	68	--	5.00E-02	NA
7440-28-0	Thallium	Thallium, soluble salts	71	--	5.00E-01	NA
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	1.40E-02	1.65E-02	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	1.40E-02	1.65E-02	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	--	3.30E-01	NA
72-43-5	Methoxychlor	methoxychlor	80	3.00E-02	1.65E-02	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	3.80E-03	1.65E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	--	3.30E-03	NA
8001-35-2	Toxaphene	toxaphene	96	2.00E-04	1.65E-01	NR
7440-23-5	Sodium	Sodium	100	--	5.00E+01	NA
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	1.40E-02	1.65E-02	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	--	3.30E-01	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	1.40E-02	1.65E-02	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	--	5.00E+00	NA
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	--	3.30E-01	NA
7440-31-5	Tin	tin	250	--	1.00E+01	NA
7439-93-2	Lithium	Lithium	300	--	2.50E+00	NA
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	--	1.50E-02	NA
218-01-9	chrysene	Chrysene	398	--	1.00E-01	NA
7440-61-1	Uranium	Uranium	NVR [f]	--	---	NVR [f]
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	1.00E-03	3.30E-03	NR
7440-41-7	Beryllium	beryllium	790	--	2.00E-01	NA
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	1.40E-02	1.65E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	--	1.50E-02	NA
7440-47-3	Chromium	chromium (total)	1000	6.50E+01	2.00E-01	NR
7440-62-2	Vanadium	vanadium	1000	--	2.50E+00	NA
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	--	1.50E-02	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	--	1.50E-02	NA
7429-90-5	Aluminum	Aluminum (soluble)	1500	8.70E+01	5.00E+00	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	--	3.00E-02	NA

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	--	3.00E-02	NA
7439-92-1	Lead	lead	10000	2.10E+00	5.00E-01	NR
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	--	3.30E-01	NA
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
7440-70-2	Calcium	Calcium	--	--	1.00E+02	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	--	--	NA
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7440-21-3	Silicon	Silicon	--	--	2.00E+00	NA

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to soil screening levels:

- "NA" was assigned where no applicable water quality standard was available.

Table A-3. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$

- "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).
- Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.
- Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Soil screening levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil screening levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the soil screening level for evaluation use.

e. The soil screening level for hexavalent chromium was limited to a maximum value of 6.0 mg/kg because the Kd value used in the model for residual hexavalent chromium was derived from experiments with soil concentrations below than that value. This value is not scaled by representative length.

f. No Value Required.

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	–	5.00E-03	NA
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	–	5.00E-03	NA
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	–	5.00E-03	NA
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	–	1.00E-02	NA
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	–	1.00E-02	NA
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	–	0.33	NA
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	–	3.30E-01	NA
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	–	5.00E-03	NA
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	–	5.00E-03	NA
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	–	0.005	NA
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	–	0.33	NA
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	–	5.00E-03	NA
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	–	2.10E+00	NA
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	–	—	NA
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	–	—	NA

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	--	—	NA
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	--	3.30E-01	NA
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	--	3.30E-01	NA
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	--	1.30E-02	NA
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	--	3.30E-01	NA
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	--	3.30E-01	NA
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	--	8.25E-01	NA
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	--	3.30E-01	NA
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	--	3.30E-01	NA
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	--	1.00E-02	NA
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	--	—	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	--	0.33	NA
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	--	3.30E-01	NA
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	--	2.00E-02	NA
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	--	3.30E-01	NA
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	--	3.30E-01	NA
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	--	3.30E-01	NA

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	--	0.66	NA
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	--	3.30E-01	NA
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	0.33	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	--	3.30E-01	NA
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	--	3.30E-03	NA
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	--	3.30E-03	NA
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	1.00E-03	3.30E-03	NR
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	--	3.30E-01	NA
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	--	---	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	--	3.30E-01	NA
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	--	3.30E-01	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	--	1.00E-02	NA
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	--	---	NA

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	--	3.30E-01	NA
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	--	6.60E-01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	--	1.00E-01	NA
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	--	1.00E-01	NA
67-64-1	Acetone	Acetone	0.0006	--	2.00E-02	NA
309-00-2	Aldrin	aldrin	48.7	1.90E-03	1.65E-03	7.29E+00
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	--	1.65E-03	NA
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	4.30E-03	1.65E-02	2.44E+01
7429-90-5	Aluminum	Aluminum (soluble)	1500	8.70E+01	5.00E+00	NR
120-12-7	Anthracene	anthracene	23.5	--	5.00E-02	NA
7440-36-0	Antimony	antimony	45	--	6.00E-01	NA
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	1.40E-02	1.65E-02	NR
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	1.40E-02	1.65E-02	4.92E-03
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	1.40E-02	1.65E-02	4.92E-03
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	1.40E-02	1.65E-02	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	1.40E-02	1.65E-02	NR
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	1.40E-02	1.65E-02	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	1.40E-02	1.65E-02	NR
7440-38-2	Arsenic	arsenic, inorganic	29	1.50E+02	1	1.05E+04

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
7440-39-3	Barium	Barium	41	--	5.00E-01	NA
71-43-2	Benzene	Benzene	0.062	--	5.00E-03	NA
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	--	1.50E-02	NA
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	--	1.50E-02	NA
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	--	0.015	NA
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	--	1.50E-02	NA
7440-41-7	Beryllium	beryllium	790	--	2.00E-01	NA
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	--	0.00165	NA
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	--	3.30E-01	NA
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	--	3.30E-01	NA
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	--	3.30E-01	NA
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	--	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
7440-42-8	Boron	Boron	3	--	2.00E+00	NA
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	--	5.00E-03	NA
75-25-2	Bromoform	bromoform	0.126	--	5.00E-03	NA

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
74-83-9	Bromomethane	bromomethane	0.009	--	0.01	NA
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	--	3.30E-01	NA
7440-43-9	Cadmium	cadmium	6.7	2.50E-01	2.00E-01	6.28E-02
7440-70-2	Calcium	Calcium	--	--	1.00E+02	NA
86-74-8	Carbazole	carbazole	3.39	--	3.30E-01	NA
75-15-0	Carbon disulfide	carbon disulfide	0.0457	--	5.00E-03	NA
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	--	5.00E-03	NA
57-74-9	Chlordane	chlordane	51	4.30E-03	1.65E-02	2.44E+01
16887-00-6	Chloride	chloride	0	2.30E+05	2.00E+00	5.51E+02
108-90-7	Chlorobenzene	chlorobenzene	0.224	--	5.00E-03	NA
75-00-3	Chloroethane	ethyl chloride	0.0217	--	1.00E-02	NA
67-66-3	Chloroform	chloroform	0.053	--	5.00E-03	NA
74-87-3	Chloromethane	chloromethane	0.006	--	1.00E-02	NA
7440-47-3	Chromium	chromium (total)	1000	6.50E+01	0.2	NR
218-01-9	chrysene	Chrysene	398	--	1.00E-01	NA
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	--	5.00E-03	NA
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	--	5.00E-03	NA
7440-48-4	cobalt	Cobalt	45	--	2.00E+00	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	--	---	NA
7440-50-8	Copper	copper	22	9.00E+00	1.00E+00	1.08E+02

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
57-12-5	Cyanide	cyanide	9.9	5.20E+00	—	2.56E+00
75-99-0	Dalapon	Dalapon	0.0032	–	—	NA
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	–	1.65E-03	NA
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	–	0.03	NA
132-64-9	Dibenzofuran	dibenzofuran	9.2	–	0.33	NA
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	–	0.005	NA
1918-00-9	Dicamba	Dicamba	0.0288	–	—	NA
60-57-1	Dieldrin	dieldrin	25.6	1.90E-03	3.30E-03	5.77E-02
84-66-2	Diethylphthalate	diethyl phthalate	0.082	–	3.30E-01	NA
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	–	3.30E-01	NA
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	–	3.30E-01	NA
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	–	3.30E-01	NA
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	–	1.50E-03	NA
959-98-8	Endosulfan I	Endosulfan I	2.04	5.60E-02	1.65E-03	4.20E-03
33213-65-9	Endosulfan II	Endosulfan II	2.04	5.60E-02	3.30E-03	4.20E-03
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	–	3.30E-03	NA
72-20-8	Endrin	endrin	10.8	2.30E-03	3.30E-03	1.40E-03
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	–	3.30E-03	NA
53494-70-5	Endrin ketone	Endrin ketone	9.7	–	3.30E-03	NA
100-41-4	Ethylbenzene	ethylbenzene	0.204	–	5.00E-03	NA

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
206-44-0	Fluoranthene	fluoranthene	49	--	5.00E-02	NA
86-73-7	Fluorene	fluorene	7.7	--	0.03	NA
16984-48-8	Fluoride	fluoride (using fluorine)	150	--	5.00E+00	NA
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	8.00E-02	1.65E-03	3.83E-03
76-44-8	Heptachlor	heptachlor	9.5	3.80E-03	1.65E-03	1.70E-03
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	3.80E-03	1.65E-03	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	--	3.30E-01	NA
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	--	3.30E-01	NA
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	--	3.30E-01	NA
67-72-1	Hexachloroethane	hexachloroethane	1.78	--	3.30E-01	NA
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	1.00E+01	—	6[e]
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	--	3.00E-02	NA
7439-89-6	Iron	Iron	25	1.00E+03	5.00E+00	2.61E+04
78-59-1	Isophorone	isophorone	0.0468	--	3.30E-01	NA
7439-92-1	Lead	lead	10000	2.10E+00	5.00E-01	NR
7439-93-2	Lithium	Lithium	300	--	2.50E+00	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA
7439-96-5	Manganese	manganese	65	--	5.00E+00	NA
7439-97-6	Mercury	mercury (using mercruric chloride)	52	1.20E-02	—	8.06E+01

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72-43-5	Methoxychlor	methoxychlor	80	3.00E-02	1.65E-02	NR
75-09-2	Methylene chloride	methylene chloride	0.01	--	0.005	NA
7439-98-7	Molybdenum	molybdenum	20	--	2.00E+00	NA
108-38-3	m-Xylene	Xylene, m-	0.196	--	---	NA
91-20-3	Naphthalene	naphthalene	1.19	--	1.00E-01	NA
7440-02-0	Nickel	nickel soluble salts	65	4.50E+01	4.00E+00	3.89E+05
14797-55-8	Nitrate	Nitrate	0	--	2.50E+00	NA
14797-65-0	Nitrite	Nitrite	0	--	2.50E+00	NA
98-95-3	Nitrobenzene	Nitrobenzene	0.119	--	3.30E-01	NA
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	--	7.50E-01	NA
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	--	7.50E-01	NA
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	--	---	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	--	3.30E-01	NA
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	--	3.30E-01	NA
95-47-6	o-Xylene	xylene,o-	0.241	--	---	NA
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	1.30E+01	3.30E-01	2.89E-01
85-01-8	Phenanthrene	Phenanthrene	16.7	--	5.00E-02	NA
108-95-2	Phenol	Phenol	0.0288	--	3.30E-01	NA
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

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PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	–	—	NA
7440-09-7	Potassium	Potassium	5.5	–	4.00E+02	NA
129-00-0	Pyrene	pyrene	68	–	5.00E-02	NA
7782-49-2	Selenium	selenium and compounds	5	5.00E+00	1.00E+00	9.01E-01
7440-21-3	Silicon	Silicon	–	–	2.00E+00	NA
7440-22-4	Silver	silver	8.3	2.40E+00	0.2	8.26E-01
7440-23-5	Sodium	Sodium	100	–	5.00E+01	NA
7440-24-6	Strontium	strontium	35	–	1.00E+00	NA
100-42-5	Styrene	styrene	0.91	–	5.00E-03	NA
14808-79-8	Sulfate	sulfate	0	–	5.00E+00	NA
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	–	5.00E-03	NA
7440-28-0	Thallium	Thallium, soluble salts	71	–	5.00E-01	NA
7440-31-5	Tin	tin	250	–	1.00E+01	NA
108-88-3	Toluene	Toluene	0.14	–	5.00E-03	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	–	—	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	–	—	NA
8001-35-2	Toxaphene	toxaphene	96	2.00E-04	1.65E-01	NR
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	–	5.00E-03	NA

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CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg}\cdot m\right)$
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	--	5.00E-03	NA
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	--	---	NA
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	--	5.00E-03	NA
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	--	---	NA
7440-61-1	Uranium	Uranium	NVR [f]	--	---	NVR [f]
7440-62-2	Vanadium	vanadium	1000	--	2.50E+00	NA
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	--	0.005	NA
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	--	1.00E-02	NA
7440-66-6	Zinc	zinc	62	9.10E+01	1.00E+00	3.89E+05

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to soil screening levels:

- "NA" was assigned where no applicable water quality standard was available.
- "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).
- Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.
- Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

Table A-4. Unit-Length Soil Screening Levels for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Soil Screening Level Protective of Surface Water [c,d] $\left(\frac{mg}{kg} \cdot m\right)$

d. Soil screening levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil screening levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the soil screening level for evaluation use.

e. The soil screening level for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table A-5. Unit-Length Soil Screening Level for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (K_d order)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Carbon-14 [f]	0	2000	5730	—	4.93E+00
Technetium-99	0	900	213000	—	2.21E+00
Tritium	0	20000	12.35	—	5.96E+01
Iodine-129	1	1	15700000	—	7.37E-02
Neptunium-237	15	15	2140000	—	NR
Nickel-63	30	50	96	—	NR
Strontium-90 [g]	25	8	29.12	—	2.12E+03
Cesium-137	50	200	30	0	NR
Cobalt-60	50	100	5.721	0	NR
Americium-241	200	15	432	1	NR
Carbon-14 [h]	200	2000	5730	—	NR
Curium-243	200	15	28.5	—	NR
Europium-152	200	200	13.3	0.1	NR
Europium-154	200	60	8.8	0.1	NR
Europium-155	200	600	4.96	0.1	NR
Niobium-94	200	--	20300	—	NR
Plutonium-238	200	15	87.7	1	NR
Plutonium-239	200	15	24100	1	NR
Plutonium-240	200	15	6540	1	NR
Plutonium-241	200	300	14	—	NR
Radium-226	200	5	1600	—	NR

Table A-5. Unit-Length Soil Screening Level for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (K_d order)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Radium-228	200	5	5.75	0.2	NR
Thorium-228	200	15	1.91	---	NR
Thorium-230	200	15	77000	---	NR
Thorum-232	200	15	1.41E+10	---	NR

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. Radiochemistry Society website, Available at: http://www.radiochemistry.org/.

c. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

d. The following restrictions were applied to soil screening levels:

· "NA" was assigned where no applicable water quality standard was available.

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 pCi/m^3 (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

e. Soil screening levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil screening levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the soil screening level for evaluation use.

Table A-5. Unit-Length Soil Screening Level for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (K_d order)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$

f. Carbon-14 in liquid form (typically associated with reactor gas condensate).

g. The soil screening level for strontium-90 is calculated based on a 100:0 initial source distribution, an **exception to the convention that analytes with Kd ≥ 2 were calculated based on a 70:30 initial source** distribution, because of data that indicated strontium-90 distributed throughout the vadose zone at some locations in these OUs.

h. Carbon-14 in solid form (typically associated with graphite).

Table A-6. Unit-Length Soil Screening Level for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (Alphabetical Order by Contaminant)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Americium-241	200	15	432	1	NR
Carbon-14 [f]	0	2000	5730	—	4.93E+00
Carbon-14 [h]	200	2000	5730	—	NR
Cesium-137	50	200	30	0	NR
Cobalt-60	50	100	5.721	0	NR
Curium-243	200	15	28.5	—	NR
Europium-152	200	200	13.3	0.1	NR
Europium-154	200	60	8.8	0.1	NR
Europium-155	200	600	4.96	0.1	NR
Iodine-129	1	1	15700000	—	7.37E-02
Neptunium-237	15	15	2140000	—	NR
Nickel-63	30	50	96	—	NR
Niobium-94	200	—	20300	—	NR
Plutonium-238	200	15	87.7	1	NR
Plutonium-239	200	15	24100	1	NR
Plutonium-240	200	15	6540	1	NR
Plutonium-241	200	300	14	—	NR
Radium-226	200	5	1600	—	NR
Radium-228	200	5	5.75	0.2	NR
Strontium-90 [g]	25	8	29.12	—	2.12E+03
Technetium-99	0	900	213000	—	2.21E+00

Table A-6. Unit-Length Soil Screening Level for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (Alphabetical Order by Contaminant)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Thorium-228	200	15	1.91	—	NR
Thorium-230	200	15	77000	—	NR
Thorum-232	200	15	1.41E+10	—	NR
Tritium	0	20000	12.35	—	5.96E+01

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. Radiochemistry Society website, Available at: http://www.radiochemistry.org/.

c. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

d. The following restrictions were applied to soil screening levels:

· "NA" was assigned where no applicable water quality standard was available.

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 pCi/m^3 (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

e. Soil screening levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil screening levels, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the soil screening level for evaluation use.

Table A-6. Unit-Length Soil Screening Level for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (Alphabetical Order by Contaminant)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Soil Screening Level Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$

f. Carbon-14 in liquid form (typically associated with reactor gas condensate).

g. The soil screening level for strontium-90 is calculated based on a 100:0 initial source distribution, an **exception to the convention that analytes with Kd ≥ 2 were calculated based on a 70:30 initial source** distribution, because of data that indicated strontium-90 distributed throughout the vadose zone at some locations in these OUs.

h. Carbon-14 in solid form (typically associated with graphite).

Attachment B

Unit-Length Preliminary Remediation Goals Protective of Groundwater and Unit-Length Preliminary Remediation Goals Protective of Surface Water for the 100-BC Source Operable Units

Note

Tabulated unit-length preliminary remediation goal (PRG) values are presented in Tables B-1, B-3, and B-5 in ascending K_d order. This sorting order reveals the correlation between analyte K_d values and resulting PRG values. Below this threshold, "NR" (nonrepresentative result) values are reported (though shorter-lived radionuclides may result in "NR" values above the indicated threshold due to radiological decay). The "NR" code reflects that the model simulations did not predict breakthrough within 1000 years, defined here as a peak groundwater concentration exceeding 0.0001 µg/L for non-radionuclide analytes, or 0.0001 pCi/m3 for radionuclide analytes), a value set as the lower limit of numerical significance for model groundwater concentration results.

The same unit-length PRG values are presented again in Tables B-2, B-4, and B-6, but in ascending contaminant name order to enable lookup by the reader by contaminant name.

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
16887-00-6	Chloride	chloride	0	250,000	2.00E+00	1.01E+03
14797-55-8	Nitrate	Nitrate	0	45,000	2.50E+00	1.82E+02
14797-65-0	Nitrite	Nitrite	0	3,300	2.50E+00	1.34E+01
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	10,000	7.50E-01	4.05E+01
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	1,000	7.50E-01	4.05E+00
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	10,000	—	4.05E+01
14808-79-8	Sulfate	sulfate	0	250,000	5.00E+00	1.01E+03
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	0,032	8.25E-01	1.30E-01
67-64-1	Acetone	Acetone	0.0006	7200	2.00E-02	2.95E+01
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	800	—	3.42E+00
75-99-0	Dalapon	Dalapon	0.0032	200	—	8.61E-01
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	4800	1.00E-02	2.12E+01
74-87-3	Chloromethane	chloromethane	0.006	—	1.00E-02	NA
74-83-9	Bromomethane	bromomethane	0.009	11.2	1.00E-02	5.35E-02
75-09-2	Methylene chloride	methylene chloride	0.01	5	5.00E-03	2.43E-02
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	640	1.00E-02	3.25E+00
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	48	3.30E-01	2.51E-01
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	0,040	2.00E-02	2.11E-01

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	0.060763889	5.00E-03	3.40E-04
75-00-3	Chloroethane	ethyl chloride	0.0217	--	1.00E-02	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	0.01	3.30E-01	7.58E-05
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	0	5.00E-03	2.77E-03
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	0	5.00E-03	2.77E-03
1918-00-9	Dicamba	Dicamba	0.0288	480	---	3.12E+00
108-95-2	Phenol	Phenol	0.0288	2,400	3.30E-01	1.56E+01
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	70	---	4.56E-01
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	--	3.30E-01	NA
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	16	5.00E-03	1.14E-01
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	0.5	5.00E-03	3.53E-03
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	100	5.00E-03	7.35E-01
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	500	---	3.71E+00
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	72	5.00E-03	5.40E-01
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	2400	---	1.90E+01
75-15-0	Carbon disulfide	carbon disulfide	0.0457	800	5.00E-03	6.47E+00
78-59-1	Isophorone	isophorone	0.0468	46.05	3.30E-01	3.78E-01

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	1	5.00E-03	9.99E-03
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	16	2.10E+00	1.34E-01
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	160	—	1.35E+00
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	7.68	1.00E-02	6.77E-02
67-66-3	Chloroform	chloroform	0.053	0,001	5.00E-03	1.25E-02
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	0.71	5.00E-03	6.37E-03
71-43-2	Benzene	Benzene	0.062	1	5.00E-03	7.77E-03
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	0.52	5.00E-03	5.15E-03
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	7	1.00E-02	7.06E-02
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	0.2	3.30E-01	2.23E-03
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	16	3.30E-01	1.69E-01
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	1	5.00E-03	8.61E-03
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	0	3.30E-01	4.51E-04
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	0.2	5.00E-03	2.56E-03
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	50	—	5.90E-01
84-66-2	Diethylphthalate	diethyl phthalate	0.082	12800	3.30E-01	1.54E+02

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	1	3.30E-01	7.59E-03
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	400	3.30E-01	5.27E+00
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	0.54	5.00E-03	7.30E-03
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	0,000	3.30E-01	3.87E-03
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	128	1.30E-02	1.80E+00
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	4	3.30E-01	6.46E-02
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	0,004	3.30E-01	6.79E-02
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	0,160	3.30E-01	2.53E+00
98-95-3	Nitrobenzene	Nitrobenzene	0.119	16	3.30E-01	2.71E-01
75-25-2	Bromoform	bromoform	0.126	5.537974684	5.00E-03	9.95E-02
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	200	5.00E-03	3.87E+00
108-88-3	Toluene	Toluene	0.14	640	5.00E-03	1.29E+01
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	24	3.30E-01	5.12E-01
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	1	5.00E-03	1.39E-02
108-38-3	m-Xylene	Xylene, m-	0.196	1600	---	4.89E+01
100-41-4	Ethylbenzene	ethylbenzene	0.204	0,004	5.00E-03	1.29E-01
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	160	3.30E-01	5.35E+00
108-90-7	Chlorobenzene	chlorobenzene	0.224	100	5.00E-03	3.69E+00
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	1600	1.00E-02	6.26E+01

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
95-47-6	o-Xylene	xylene,o-	0.241	1600	—	6.58E+01
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	5	5.00E-03	2.38E-01
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	–	6.60E-01	NA
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	–	6.60E-01	NA
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	800	—	4.66E+01
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	–	3.30E-01	NA
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	0,600	3.30E-01	5.31E+01
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	4	3.30E-01	3.52E-01
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	40	3.30E-01	3.72E+00
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	1600	3.30E-01	2.29E+02
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	0.2	3.30E-01	4.54E-02
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	8	5.00E-03	1.86E+00
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	0.194	3.30E-01	5.94E-02
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	1.3	3.30E-01	4.24E-01
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	48	—	6[e]
100-42-5	Styrene	styrene	0.91	100	5.00E-03	4.97E+01
91-20-3	Naphthalene	naphthalene	1.19	160	1.00E-01	1.04E+02
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	0,018	3.30E-01	1.26E+01
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	0.079545455	1.65E-03	5.89E-02

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	1600	3.30E-01	1.39E+03
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	800	3.30E-01	7.07E+02
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	1.5	3.30E-01	1.39E+00
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	0.013888889	1.65E-03	1.36E-02
67-72-1	Hexachloroethane	hexachloroethane	1.78	1.09375	3.30E-01	1.09E+00
959-98-8	Endosulfan I	Endosulfan I	2.04	96	1.65E-03	2.72E+03
33213-65-9	Endosulfan II	Endosulfan II	2.04	96	3.30E-03	2.72E+03
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	0.048611111	1.65E-03	1.86E+00
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	10	—	6.86E+02
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	640	3.30E-01	6.51E+04
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	32	3.30E-01	3.26E+03
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	--	1.65E-03	NA
7440-42-8	Boron	Boron	3	3200	2.00E+00	3.89E+05
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	--	3.30E-03	NA
86-74-8	Carbazole	carbazole	3.39	4.375	3.30E-01	4.49E+03
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	--	---	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	500	---	3.89E+05
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	500	---	3.89E+05
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	7	1.50E-03	4.92E+04
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	480	1.00E-01	3.89E+05
7782-49-2	Selenium	selenium and compounds	5	50	1.00E+00	3.89E+05
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	--	1.00E-01	NA
7440-09-7	Potassium	Potassium	5.5	--	4.00E+02	NA
7440-43-9	Cadmium	cadmium	6.7	5	2.00E-01	NR
86-73-7	Fluorene	fluorene	7.7	320	3.00E-02	NR
7440-22-4	Silver	silver	8.3	0,080	2.00E-01	NR
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	0,000	1.65E-02	NR
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	0	1.65E-02	NR
132-64-9	Dibenzofuran	dibenzofuran	9.2	8	3.30E-01	NR
76-44-8	Heptachlor	heptachlor	9.5	0.02	1.65E-03	NR

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
53494-70-5	Endrin ketone	Endrin ketone	9.7	–	3.30E-03	NA
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	–	3.30E-03	NA
57-12-5	Cyanide	cyanide	9.9	4.8	—	NR
72-20-8	Endrin	endrin	10.8	2	3.30E-03	NR
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	46.1	3.30E-01	NR
85-01-8	Phenanthrene	Phenanthrene	16.7	–	5.00E-02	NA
7439-98-7	Molybdenum	molybdenum	20	0,080	2.00E+00	NR
7440-50-8	Copper	copper	22	640	1.00E+00	NR
120-12-7	Anthracene	anthracene	23.5	2400	5.00E-02	NR
7439-89-6	Iron	Iron	25	11200	5.00E+00	NR
60-57-1	Dieldrin	dieldrin	25.6	0.01	3.30E-03	NR
7440-38-2	Arsenic	arsenic, inorganic	29	0.058	1.00E+00	NR
7440-24-6	Strontium	strontium	35	9600	1.00E+00	NR
7440-39-3	Barium	Barium	41	2000	5.00E-01	NR
7440-36-0	Antimony	antimony	45	6	6.00E-01	NR
7440-48-4	cobalt	Cobalt	45	4.8	2.00E+00	NR
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	0.36	3.30E-03	NR
309-00-2	Aldrin	aldrin	48.7	0.003	1.65E-03	NR
206-44-0	Fluoranthene	fluoranthene	49	640	5.00E-02	NR

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	0.25	1.65E-02	NR
57-74-9	Chlordane	chlordane	51	0.3	1.65E-02	NR
7439-97-6	Mercury	mercury (using mercruric chloride)	52	2	—	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	1	3.30E-01	NR
7440-66-6	Zinc	zinc	62	4800	1.00E+00	NR
7439-96-5	Manganese	manganese	65	0,384	5.00E+00	NR
7440-02-0	Nickel	nickel soluble salts	65	100	4.00E+00	NR
129-00-0	Pyrene	pyrene	68	240	5.00E-02	NR
7440-28-0	Thallium	Thallium, soluble salts	71	0.2	5.00E-01	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	0	1.65E-02	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	0.04	1.65E-02	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	0.1	3.30E-01	NR
72-43-5	Methoxychlor	methoxychlor	80	40	1.65E-02	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	0.005	1.65E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	0	3.30E-03	NR
8001-35-2	Toxaphene	toxaphene	96	0	1.65E-01	NR
7440-23-5	Sodium	Sodium	100	–	5.00E+01	NA
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	0.5	1.65E-02	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	0,006	3.30E-01	NR

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	0.04	1.65E-02	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	960	5.00E+00	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	48	3.30E-01	NR
7440-31-5	Tin	tin	250	9600	1.00E+01	NR
7439-93-2	Lithium	Lithium	300	32	2.50E+00	NR
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	0.119863014	1.50E-02	NR
218-01-9	chrysene	Chrysene	398	1.198630137	1.00E-01	NR
7440-61-1	Uranium	Uranium	NVR [f]	30	—	NVR [f]
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	0.257352941	3.30E-03	NR
7440-41-7	Beryllium	beryllium	790	4	2.00E-01	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	0.04375	1.65E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	0.011986301	1.50E-02	NR
7440-47-3	Chromium	chromium (total)	1000	100	2.00E-01	NR
7440-62-2	Vanadium	vanadium	1000	80	2.50E+00	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	0.119863014	1.50E-02	NR
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	0.119863014	1.50E-02	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	16000	5.00E+00	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	0.119863014	3.00E-02	NR

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	0.119863014	3.00E-02	NR
7439-92-1	Lead	lead	10000	15	5.00E-01	NR
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	192	3.30E-01	NR
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
7440-70-2	Calcium	Calcium	--	--	1.00E+02	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	--	--	NA
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7440-21-3	Silicon	Silicon	--	--	2.00E+00	NA

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to preliminary remediation goals:

· "NA" was assigned where no applicable water quality standard was available.

Table B-1. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

· Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Preliminary remediation goals protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these preliminary remediation goals, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the preliminary remediation goal for evaluation use.

e. The preliminary remediation goal for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	200	5.00E-03	3.87E+00
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	0.2	5.00E-03	2.56E-03
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	1	5.00E-03	8.61E-03
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	7.68	1.00E-02	6.77E-02
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	7	1.00E-02	7.06E-02
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	1.5	3.30E-01	1.39E+00
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	0,600	3.30E-01	5.31E+01
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	0.5	5.00E-03	3.53E-03
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	72	5.00E-03	5.40E-01
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	1	5.00E-03	9.99E-03
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	--	3.30E-01	NA
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	8	5.00E-03	1.86E+00
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	16	2.10E+00	1.34E-01
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	70	—	4.56E-01
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	160	—	1.35E+00

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	50	—	5.90E-01
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	800	3.30E-01	7.07E+02
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	4	3.30E-01	3.52E-01
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	128	1.30E-02	1.80E+00
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	24	3.30E-01	5.12E-01
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	160	3.30E-01	5.35E+00
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	0,032	8.25E-01	1.30E-01
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	0,000	3.30E-01	3.87E-03
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	16	3.30E-01	1.69E-01
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	4800	1.00E-02	2.12E+01
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	800	—	3.42E+00
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	640	3.30E-01	6.51E+04
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	40	3.30E-01	3.72E+00
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	0,040	2.00E-02	2.11E-01
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	32	3.30E-01	3.26E+03
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	400	3.30E-01	5.27E+00

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	0,160	3.30E-01	2.53E+00
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	--	6.60E-01	NA
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	0.194	3.30E-01	5.94E-02
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	3.30E-01	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	4	3.30E-01	6.46E-02
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	0.36	3.30E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	0	3.30E-03	NR
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	0.257352941	3.30E-03	NR
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	1.3	3.30E-01	4.24E-01
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	500	—	3.71E+00
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	1600	3.30E-01	2.29E+02
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	0.2	3.30E-01	2.23E-03
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	640	1.00E-02	3.25E+00

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	800	—	4.66E+01
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	0,004	3.30E-01	6.79E-02
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	–	6.60E-01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	480	1.00E-01	3.89E+05
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	–	1.00E-01	NA
67-64-1	Acetone	Acetone	0.0006	7200	2.00E-02	2.95E+01
309-00-2	Aldrin	aldrin	48.7	0.003	1.65E-03	NR
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	0.013888889	1.65E-03	1.36E-02
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	0.25	1.65E-02	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	16000	5.00E+00	NR
120-12-7	Anthracene	anthracene	23.5	2400	5.00E-02	NR
7440-36-0	Antimony	antimony	45	6	6.00E-01	NR
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	0.5	1.65E-02	NR
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	0,000	1.65E-02	NR
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	0	1.65E-02	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	0.04	1.65E-02	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	0	1.65E-02	NR
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	0.04	1.65E-02	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	0.04375	1.65E-02	NR

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
7440-38-2	Arsenic	arsenic, inorganic	29	0.058	1.00E+00	NR
7440-39-3	Barium	Barium	41	2000	5.00E-01	NR
71-43-2	Benzene	Benzene	0.062	1	5.00E-03	7.77E-03
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	0.119863014	1.50E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	0.011986301	1.50E-02	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	0.119863014	1.50E-02	NR
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	0.119863014	1.50E-02	NR
7440-41-7	Beryllium	beryllium	790	4	2.00E-01	NR
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	0.048611111	1.65E-03	1.86E+00
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	1	3.30E-01	7.59E-03
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	48	3.30E-01	2.51E-01
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	0	3.30E-01	4.51E-04
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	0,006	3.30E-01	NR
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
7440-42-8	Boron	Boron	3	3200	2.00E+00	3.89E+05
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	0.71	5.00E-03	6.37E-03

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
75-25-2	Bromoform	bromoform	0.126	5.537974684	5.00E-03	9.95E-02
74-83-9	Bromomethane	bromomethane	0.009	11.2	1.00E-02	5.35E-02
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	46.1	3.30E-01	NR
7440-43-9	Cadmium	cadmium	6.7	5	2.00E-01	NR
7440-70-2	Calcium	Calcium	–	–	1.00E+02	NA
86-74-8	Carbazole	carbazole	3.39	4.375	3.30E-01	4.49E+03
75-15-0	Carbon disulfide	carbon disulfide	0.0457	800	5.00E-03	6.47E+00
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	1	5.00E-03	1.39E-02
57-74-9	Chlordane	chlordane	51	0.3	1.65E-02	NR
16887-00-6	Chloride	chloride	0	250,000	2.00E+00	1.01E+03
108-90-7	Chlorobenzene	chlorobenzene	0.224	100	5.00E-03	3.69E+00
75-00-3	Chloroethane	ethyl chloride	0.0217	–	1.00E-02	NA
67-66-3	Chloroform	chloroform	0.053	0,001	5.00E-03	1.25E-02
74-87-3	Chloromethane	chloromethane	0.006	–	1.00E-02	NA
7440-47-3	Chromium	chromium (total)	1000	100	2.00E-01	NR
218-01-9	chrysene	Chrysene	398	1.198630137	1.00E-01	NR
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	16	5.00E-03	1.14E-01
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	0	5.00E-03	2.77E-03
7440-48-4	cobalt	Cobalt	45	4.8	2.00E+00	NR
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	–	–	—	NA

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
7440-50-8	Copper	copper	22	640	1.00E+00	NR
57-12-5	Cyanide	cyanide	9.9	4.8	—	NR
75-99-0	Dalapon	Dalapon	0.0032	200	—	8.61E-01
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	–	1.65E-03	NA
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	0.119863014	3.00E-02	NR
132-64-9	Dibenzofuran	dibenzofuran	9.2	8	3.30E-01	NR
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	0.52	5.00E-03	5.15E-03
1918-00-9	Dicamba	Dicamba	0.0288	480	—	3.12E+00
60-57-1	Dieldrin	dieldrin	25.6	0.01	3.30E-03	NR
84-66-2	Diethylphthalate	diethyl phthalate	0.082	12800	3.30E-01	1.54E+02
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	–	3.30E-01	NA
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	1600	3.30E-01	1.39E+03
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	192	3.30E-01	NR
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	7	1.50E-03	4.92E+04
959-98-8	Endosulfan I	Endosulfan I	2.04	96	1.65E-03	2.72E+03
33213-65-9	Endosulfan II	Endosulfan II	2.04	96	3.30E-03	2.72E+03
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	–	3.30E-03	NA
72-20-8	Endrin	endrin	10.8	2	3.30E-03	NR
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	–	3.30E-03	NA

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
53494-70-5	Endrin ketone	Endrin ketone	9.7	--	3.30E-03	NA
100-41-4	Ethylbenzene	ethylbenzene	0.204	0,004	5.00E-03	1.29E-01
206-44-0	Fluoranthene	fluoranthene	49	640	5.00E-02	NR
86-73-7	Fluorene	fluorene	7.7	320	3.00E-02	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	960	5.00E+00	NR
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	0.079545455	1.65E-03	5.89E-02
76-44-8	Heptachlor	heptachlor	9.5	0.02	1.65E-03	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	0.005	1.65E-03	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	0.1	3.30E-01	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	1	3.30E-01	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	48	3.30E-01	NR
67-72-1	Hexachloroethane	hexachloroethane	1.78	1.09375	3.30E-01	1.09E+00
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	48	—	6[e]
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	0.119863014	3.00E-02	NR
7439-89-6	Iron	Iron	25	11200	5.00E+00	NR
78-59-1	Isophorone	isophorone	0.0468	46.05	3.30E-01	3.78E-01
7439-92-1	Lead	lead	10000	15	5.00E-01	NR
7439-93-2	Lithium	Lithium	300	32	2.50E+00	NR
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
7439-96-5	Manganese	manganese	65	0,384	5.00E+00	NR
7439-97-6	Mercury	mercury (using mercruric chloride)	52	2	---	NR
72-43-5	Methoxychlor	methoxychlor	80	40	1.65E-02	NR
75-09-2	Methylene chloride	methylene chloride	0.01	5	5.00E-03	2.43E-02
7439-98-7	Molybdenum	molybdenum	20	0,080	2.00E+00	NR
108-38-3	m-Xylene	Xylene, m-	0.196	1600	---	4.89E+01
91-20-3	Naphthalene	naphthalene	1.19	160	1.00E-01	1.04E+02
7440-02-0	Nickel	nickel soluble salts	65	100	4.00E+00	NR
14797-55-8	Nitrate	Nitrate	0	45,000	2.50E+00	1.82E+02
14797-65-0	Nitrite	Nitrite	0	3,300	2.50E+00	1.34E+01
98-95-3	Nitrobenzene	Nitrobenzene	0.119	16	3.30E-01	2.71E-01
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	10,000	7.50E-01	4.05E+01
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	1,000	7.50E-01	4.05E+00
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	10,000	---	4.05E+01
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	0.01	3.30E-01	7.58E-05
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	0,018	3.30E-01	1.26E+01
95-47-6	o-Xylene	xylene,o-	0.241	1600	---	6.58E+01
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	0.2	3.30E-01	4.54E-02
85-01-8	Phenanthrene	Phenanthrene	16.7	--	5.00E-02	NA

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
108-95-2	Phenol	Phenol	0.0288	2,400	3.30E-01	1.56E+01
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	--	---	NA
7440-09-7	Potassium	Potassium	5.5	--	4.00E+02	NA
129-00-0	Pyrene	pyrene	68	240	5.00E-02	NR
7782-49-2	Selenium	selenium and compounds	5	50	1.00E+00	3.89E+05
7440-21-3	Silicon	Silicon	--	--	2.00E+00	NA
7440-22-4	Silver	silver	8.3	0,080	2.00E-01	NR
7440-23-5	Sodium	Sodium	100	--	5.00E+01	NA
7440-24-6	Strontium	strontium	35	9600	1.00E+00	NR
100-42-5	Styrene	styrene	0.91	100	5.00E-03	4.97E+01
14808-79-8	Sulfate	sulfate	0	250,000	5.00E+00	1.01E+03
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	5	5.00E-03	2.38E-01
7440-28-0	Thallium	Thallium, soluble salts	71	0.2	5.00E-01	NR
7440-31-5	Tin	tin	250	9600	1.00E+01	NR
108-88-3	Toluene	Toluene	0.14	640	5.00E-03	1.29E+01
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	500	---	3.89E+05

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	500	---	3.89E+05
8001-35-2	Toxaphene	toxaphene	96	0	1.65E-01	NR
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	100	5.00E-03	7.35E-01
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	0	5.00E-03	2.77E-03
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	10	---	6.86E+02
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	0.54	5.00E-03	7.30E-03
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	2400	---	1.90E+01
7440-61-1	Uranium	Uranium	NVR [f]	30	---	NVR [f]
7440-62-2	Vanadium	vanadium	1000	80	2.50E+00	NR
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	0.060763889	5.00E-03	3.40E-04
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	1600	1.00E-02	6.26E+01
7440-66-6	Zinc	zinc	62	4800	1.00E+00	NR

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to preliminary remediation goals:

· "NA" was assigned where no applicable water quality standard was available.

Table B-2. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Groundwater in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Groundwater Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [c, d] $\left(\frac{mg}{kg}\cdot m\right)$

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

· Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Preliminary remediation goals protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these preliminary remediation goals, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the preliminary remediation goal for evaluation use.

e. The preliminary remediation goal for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
16887-00-6	Chloride	chloride	0	230,000	2.00E+00	9.33E+02
14797-55-8	Nitrate	Nitrate	0	--	2.50E+00	NA
14797-65-0	Nitrite	Nitrite	0	--	2.50E+00	NA
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	--	7.50E-01	NA
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	--	7.50E-01	NA
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	--	---	NA
14808-79-8	Sulfate	sulfate	0	--	5.00E+00	NA
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	--	8.25E-01	NA
67-64-1	Acetone	Acetone	0.0006	--	2.00E-02	NA
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	--	---	NA
75-99-0	Dalapon	Dalapon	0.0032	--	---	NA
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	--	1.00E-02	NA
74-87-3	Chloromethane	chloromethane	0.006	--	1.00E-02	NA
74-83-9	Bromomethane	bromomethane	0.009	--	1.00E-02	NA
75-09-2	Methylene chloride	methylene chloride	0.01	--	5.00E-03	NA
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	--	1.00E-02	NA
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	--	3.30E-01	NA
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	--	2.00E-02	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	--	5.00E-03	NA
75-00-3	Chloroethane	ethyl chloride	0.0217	--	1.00E-02	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	--	3.30E-01	NA
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	--	5.00E-03	NA
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	--	5.00E-03	NA
1918-00-9	Dicamba	Dicamba	0.0288	--	---	NA
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	--	---	NA
108-95-2	Phenol	Phenol	0.0288	--	3.30E-01	NA
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	--	3.30E-01	NA
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	--	5.00E-03	NA
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	--	5.00E-03	NA
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	--	5.00E-03	NA
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	--	---	NA
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	--	5.00E-03	NA
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	--	---	NA
75-15-0	Carbon disulfide	carbon disulfide	0.0457	--	5.00E-03	NA
78-59-1	Isophorone	isophorone	0.0468	--	3.30E-01	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	--	5.00E-03	NA
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	--	2.10E+00	NA
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	--	---	NA
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	--	1.00E-02	NA
67-66-3	Chloroform	chloroform	0.053	--	5.00E-03	NA
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	--	5.00E-03	NA
71-43-2	Benzene	Benzene	0.062	--	5.00E-03	NA
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	--	5.00E-03	NA
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	--	1.00E-02	NA
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	--	3.30E-01	NA
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	--	3.30E-01	NA
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	--	5.00E-03	NA
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	--	3.30E-01	NA
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	--	5.00E-03	NA
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	--	---	NA
84-66-2	Diethylphthalate	diethyl phthalate	0.082	--	3.30E-01	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	--	3.30E-01	NA
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	--	3.30E-01	NA
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	--	5.00E-03	NA
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	--	3.30E-01	NA
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	--	1.30E-02	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	--	3.30E-01	NA
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	--	3.30E-01	NA
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	--	3.30E-01	NA
98-95-3	Nitrobenzene	Nitrobenzene	0.119	--	3.30E-01	NA
75-25-2	Bromoform	bromoform	0.126	--	5.00E-03	NA
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	--	5.00E-03	NA
108-88-3	Toluene	Toluene	0.14	--	5.00E-03	NA
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	--	3.30E-01	NA
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	--	5.00E-03	NA
108-38-3	m-Xylene	Xylene, m-	0.196	--	--	NA
100-41-4	Ethylbenzene	ethylbenzene	0.204	--	5.00E-03	NA
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	--	3.30E-01	NA
108-90-7	Chlorobenzene	chlorobenzene	0.224	--	5.00E-03	NA
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	--	1.00E-02	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
95-47-6	o-Xylene	xylene,o-	0.241	--	---	NA
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	--	5.00E-03	NA
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	--	6.60E-01	NA
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	--	6.60E-01	NA
106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	--	---	NA
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	--	3.30E-01	NA
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	--	3.30E-01	NA
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	--	3.30E-01	NA
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	--	3.30E-01	NA
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	--	3.30E-01	NA
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	13	3.30E-01	2.70E+00
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	--	5.00E-03	NA
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	--	3.30E-01	NA
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	--	3.30E-01	NA
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	10	---	6[e]
100-42-5	Styrene	styrene	0.91	--	5.00E-03	NA
91-20-3	Naphthalene	naphthalene	1.19	--	1.00E-01	NA
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	--	3.30E-01	NA
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	0.08	1.65E-03	5.92E-02

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	--	3.30E-01	NA
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	--	3.30E-01	NA
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	--	3.30E-01	NA
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	--	1.65E-03	NA
67-72-1	Hexachloroethane	hexachloroethane	1.78	--	3.30E-01	NA
959-98-8	Endosulfan I	Endosulfan I	2.04	0.056	1.65E-03	1.59E+00
33213-65-9	Endosulfan II	Endosulfan II	2.04	0.056	3.30E-03	1.59E+00
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	--	1.65E-03	NA
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	--	---	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	--	3.30E-01	NA
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	--	3.30E-01	NA
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	--	1.65E-03	NA
7440-42-8	Boron	Boron	3	--	2.00E+00	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	--	3.30E-03	NA
86-74-8	Carbazole	carbazole	3.39	--	3.30E-01	NA
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	--	---	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	--	---	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	--	---	NA
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	--	1.50E-03	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	--	1.00E-01	NA
7782-49-2	Selenium	selenium and compounds	5	5	1.00E+00	1.32E+05
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	--	1.00E-01	NA
7440-09-7	Potassium	Potassium	5.5	--	4.00E+02	NA
7440-43-9	Cadmium	cadmium	6.7	0.25	2.00E-01	NR
86-73-7	Fluorene	fluorene	7.7	--	3.00E-02	NA
7440-22-4	Silver	silver	8.3	2.4	2.00E-01	NR
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	0.014	1.65E-02	NR
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	0.014	1.65E-02	NR
132-64-9	Dibenzofuran	dibenzofuran	9.2	--	3.30E-01	NA
76-44-8	Heptachlor	heptachlor	9.5	0.0038	1.65E-03	NR

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
53494-70-5	Endrin ketone	Endrin ketone	9.7	--	3.30E-03	NA
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	--	3.30E-03	NA
57-12-5	Cyanide	cyanide	9.9	5.2	---	NR
72-20-8	Endrin	endrin	10.8	0.0023	3.30E-03	NR
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	--	3.30E-01	NA
85-01-8	Phenanthrene	Phenanthrene	16.7	--	5.00E-02	NA
7439-98-7	Molybdenum	molybdenum	20	--	2.00E+00	NA
7440-50-8	Copper	copper	22	9	1.00E+00	NR
120-12-7	Anthracene	anthracene	23.5	--	5.00E-02	NA
7439-89-6	Iron	Iron	25	1000	5.00E+00	NR
60-57-1	Dieldrin	dieldrin	25.6	0.0019	3.30E-03	NR
7440-38-2	Arsenic	arsenic, inorganic	29	150	1.00E+00	NR
7440-24-6	Strontium	strontium	35	--	1.00E+00	NA
7440-39-3	Barium	Barium	41	--	5.00E-01	NA
7440-36-0	Antimony	antimony	45	--	6.00E-01	NA
7440-48-4	cobalt	Cobalt	45	--	2.00E+00	NA
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	--	3.30E-03	NA
309-00-2	Aldrin	aldrin	48.7	0.0019	1.65E-03	NR
206-44-0	Fluoranthene	fluoranthene	49	--	5.00E-02	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	0.0043	1.65E-02	NR
57-74-9	Chlordane	chlordane	51	0.0043	1.65E-02	NR
7439-97-6	Mercury	mercury (using mercruric chloride)	52	0.012	—	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	--	3.30E-01	NA
7440-66-6	Zinc	zinc	62	91	1.00E+00	NR
7439-96-5	Manganese	manganese	65	--	5.00E+00	NA
7440-02-0	Nickel	nickel soluble salts	65	45	4.00E+00	NR
129-00-0	Pyrene	pyrene	68	--	5.00E-02	NA
7440-28-0	Thallium	Thallium, soluble salts	71	--	5.00E-01	NA
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	0.014	1.65E-02	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	0.014	1.65E-02	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	--	3.30E-01	NA
72-43-5	Methoxychlor	methoxychlor	80	0.03	1.65E-02	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	0.0038	1.65E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	--	3.30E-03	NA
8001-35-2	Toxaphene	toxaphene	96	0.0002	1.65E-01	NR
7440-23-5	Sodium	Sodium	100	--	5.00E+01	NA
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	0.014	1.65E-02	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	--	3.30E-01	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	0.014	1.65E-02	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	--	5.00E+00	NA
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	--	3.30E-01	NA
7440-31-5	Tin	tin	250	--	1.00E+01	NA
7439-93-2	Lithium	Lithium	300	--	2.50E+00	NA
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	--	1.50E-02	NA
218-01-9	chrysene	Chrysene	398	--	1.00E-01	NA
7440-61-1	Uranium	Uranium	NVR [f]	--	--	NVR [f]
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	0.001	3.30E-03	NR
7440-41-7	Beryllium	beryllium	790	--	2.00E-01	NA
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	0.014	1.65E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	--	1.50E-02	NA
7440-47-3	Chromium	chromium (total)	1000	65	2.00E-01	NR
7440-62-2	Vanadium	vanadium	1000	--	2.50E+00	NA
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	--	1.50E-02	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	--	1.50E-02	NA
7429-90-5	Aluminum	Aluminum (soluble)	1500	87	5.00E+00	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	--	3.00E-02	NA

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	--	3.00E-02	NA
7439-92-1	Lead	lead	10000	2.1	5.00E-01	NR
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	--	3.30E-01	NA
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
7440-70-2	Calcium	Calcium	--	--	1.00E+02	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	--	--	NA
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7440-21-3	Silicon	Silicon	--	--	2.00E+00	NA

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to preliminary remediation goals:

· "NA" was assigned where no applicable water quality standard was available.

Table B-3. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (K_d order)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

· Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Preliminary remediation goals protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these preliminary remediation goals, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the preliminary remediation goal for evaluation use.

e. The preliminary remediation goal for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.135	--	5.00E-03	NA
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	--	5.00E-03	NA
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	--	5.00E-03	NA
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	--	1.00E-02	NA
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	--	1.00E-02	NA
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	--	0.33	NA
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.38	--	3.30E-01	NA
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	--	5.00E-03	NA
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	--	5.00E-03	NA
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	--	0.005	NA
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.38	--	0.33	NA
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.62	--	5.00E-03	NA
93-65-2	2-(2-methyl-4-chlorophenoxy) propionic acid	Mecoprop (MCPP)	0.0485	--	2.10E+00	NA
94-75-7	2,4-D(2,4-Dichlorophenoxyacetic acid)	2,4-D(2,4-Dichlorophenoxyacetic acid)	0.029	--	--	NA
93-76-5	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	0.049	--	--	NA

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
93-72-1	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	--	---	NA
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	--	3.30E-01	NA
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.38	--	3.30E-01	NA
94-82-6	2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	Dichlorophenoxy)butyric Acid, 4-(2,4-	0.0984	--	1.30E-02	NA
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	--	3.30E-01	NA
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	--	3.30E-01	NA
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	--	8.25E-01	NA
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	--	3.30E-01	NA
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	--	3.30E-01	NA
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.0045	--	1.00E-02	NA
111-76-2	2-Butoxyethanol	ethylene glycol monobutyl ether (EGBE)	0.0028	--	---	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.48	--	0.33	NA
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.39	--	3.30E-01	NA
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.015	--	2.00E-02	NA
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.48	--	3.30E-01	NA
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.0912	--	3.30E-01	NA

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88-74-4	2-Nitroaniline	nitroaniline, 2-	0.1113	--	3.30E-01	NA
88-75-5	2-Nitrophenol	nitrophenol;2-	0.3	--	0.66	NA
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.72	--	3.30E-01	NA
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	--	--	0.33	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.109	--	3.30E-01	NA
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	--	3.30E-03	NA
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86	--	3.30E-03	NA
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	0.001	3.30E-03	NR
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.75	--	3.30E-01	NA
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	picloram	0.0388	--	--	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	3.08	--	3.30E-01	NA
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.49	--	3.30E-01	NA
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0661	--	3.30E-01	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	--	3.30E-01	NA
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	--	1.00E-02	NA

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

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106-44-5	4-Methylphenol (cresol, p-)	cresol;p-	0.3	--	—	NA
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.1091	--	3.30E-01	NA
100-02-7	4-Nitrophenol	nitrophenol;4-	0.291	--	6.60E-01	NA
83-32-9	Acenaphthene	acenaphthene	4.9	--	1.00E-01	NA
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	--	1.00E-01	NA
67-64-1	Acetone	Acetone	0.0006	--	2.00E-02	NA
309-00-2	Aldrin	aldrin	48.7	0.0019	1.65E-03	NR
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	--	1.65E-03	NA
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	0.0043	1.65E-02	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	87	5.00E+00	NR
120-12-7	Anthracene	anthracene	23.5	--	5.00E-02	NA
7440-36-0	Antimony	antimony	45	--	6.00E-01	NA
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	0.014	1.65E-02	NR
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	8.4	0.014	1.65E-02	NR
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	8.4	0.014	1.65E-02	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	78	0.014	1.65E-02	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	77	0.014	1.65E-02	NR
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	131	0.014	1.65E-02	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	0.014	1.65E-02	NR

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$
7440-38-2	Arsenic	arsenic, inorganic	29	150	1	NR
7440-39-3	Barium	Barium	41	--	5.00E-01	NA
71-43-2	Benzene	Benzene	0.062	--	5.00E-03	NA
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	358	--	1.50E-02	NA
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	969	--	1.50E-02	NA
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	1230	--	0.015	NA
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	--	3.00E-02	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	--	1.50E-02	NA
7440-41-7	Beryllium	beryllium	790	--	2.00E-01	NA
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	--	0.00165	NA
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0829	--	3.30E-01	NA
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.0144	--	3.30E-01	NA
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	--	3.30E-01	NA
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	111	--	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	--	--	1.00E+01	NA
7440-42-8	Boron	Boron	3	--	2.00E+00	NA
24959-67-9	Bromide	Bromide	--	--	2.50E+00	NA
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	--	5.00E-03	NA

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

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75-25-2	Bromoform	bromoform	0.126	--	5.00E-03	NA
74-83-9	Bromomethane	bromomethane	0.009	--	0.01	NA
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	--	3.30E-01	NA
7440-43-9	Cadmium	cadmium	6.7	0.25	2.00E-01	NR
7440-70-2	Calcium	Calcium	--	--	1.00E+02	NA
86-74-8	Carbazole	carbazole	3.39	--	3.30E-01	NA
75-15-0	Carbon disulfide	carbon disulfide	0.0457	--	5.00E-03	NA
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	--	5.00E-03	NA
57-74-9	Chlordane	chlordane	51	0.0043	1.65E-02	NR
16887-00-6	Chloride	chloride	0	230000	2.00E+00	9.33E+02
108-90-7	Chlorobenzene	chlorobenzene	0.224	--	5.00E-03	NA
75-00-3	Chloroethane	ethyl chloride	0.0217	--	1.00E-02	NA
67-66-3	Chloroform	chloroform	0.053	--	5.00E-03	NA
74-87-3	Chloromethane	chloromethane	0.006	--	1.00E-02	NA
7440-47-3	Chromium	chromium (total)	1000	65	0.2	NR
218-01-9	chrysene	Chrysene	398	--	1.00E-01	NA
156-59-2	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	0.0355	--	5.00E-03	NA
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	--	5.00E-03	NA
7440-48-4	cobalt	Cobalt	45	--	2.00E+00	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	--	--	--	NA

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

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7440-50-8	Copper	copper	22	9	1.00E+00	NR
57-12-5	Cyanide	cyanide	9.9	5.2	—	NR
75-99-0	Dalapon	Dalapon	0.0032	–	—	NA
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	–	1.65E-03	NA
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1789	–	0.03	NA
132-64-9	Dibenzofuran	dibenzofuran	9.2	–	0.33	NA
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.0631	–	0.005	NA
1918-00-9	Dicamba	Dicamba	0.0288	–	—	NA
60-57-1	Dieldrin	dieldrin	25.6	0.0019	3.30E-03	NR
84-66-2	Diethylphthalate	diethyl phthalate	0.082	–	3.30E-01	NA
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	–	3.30E-01	NA
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	–	3.30E-01	NA
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83200	–	3.30E-01	NA
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	Dinoseb	4.29	–	1.50E-03	NA
959-98-8	Endosulfan I	Endosulfan I	2.04	0.056	1.65E-03	1.59E+00
33213-65-9	Endosulfan II	Endosulfan II	2.04	0.056	3.30E-03	1.59E+00
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	9.9	–	3.30E-03	NA
72-20-8	Endrin	endrin	10.8	0.0023	3.30E-03	NR
7421-93-4	Endrin aldehyde	Endrin aldehyde	3.27	–	3.30E-03	NA

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53494-70-5	Endrin ketone	Endrin ketone	9.7	--	3.30E-03	NA
100-41-4	Ethylbenzene	ethylbenzene	0.204	--	5.00E-03	NA
206-44-0	Fluoranthene	fluoranthene	49	--	5.00E-02	NA
86-73-7	Fluorene	fluorene	7.7	--	0.03	NA
16984-48-8	Fluoride	fluoride (using fluorine)	150	--	5.00E+00	NA
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	0.08	1.65E-03	5.92E-02
76-44-8	Heptachlor	heptachlor	9.5	0.0038	1.65E-03	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83	0.0038	1.65E-03	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	--	3.30E-01	NA
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	54	--	3.30E-01	NA
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	--	3.30E-01	NA
67-72-1	Hexachloroethane	hexachloroethane	1.78	--	3.30E-01	NA
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	10	--	6[e]
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	--	3.00E-02	NA
7439-89-6	Iron	Iron	25	1000	5.00E+00	NR
78-59-1	Isophorone	isophorone	0.0468	--	3.30E-01	NA
7439-92-1	Lead	lead	10000	2.1	5.00E-01	NR
7439-93-2	Lithium	Lithium	300	--	2.50E+00	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	4.5	--	7.50E+01	NA

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7439-96-5	Manganese	manganese	65	--	5.00E+00	NA
7439-97-6	Mercury	mercury (using mercruric chloride)	52	0.012	---	NR
72-43-5	Methoxychlor	methoxychlor	80	0.03	1.65E-02	NR
75-09-2	Methylene chloride	methylene chloride	0.01	--	0.005	NA
7439-98-7	Molybdenum	molybdenum	20	--	2.00E+00	NA
108-38-3	m-Xylene	Xylene, m-	0.196	--	---	NA
91-20-3	Naphthalene	naphthalene	1.19	--	1.00E-01	NA
7440-02-0	Nickel	nickel soluble salts	65	45	4.00E+00	NR
14797-55-8	Nitrate	Nitrate	0	--	2.50E+00	NA
14797-65-0	Nitrite	Nitrite	0	--	2.50E+00	NA
98-95-3	Nitrobenzene	Nitrobenzene	0.119	--	3.30E-01	NA
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	--	7.50E-01	NA
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	--	7.50E-01	NA
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	--	---	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	--	3.30E-01	NA
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	--	3.30E-01	NA
95-47-6	o-Xylene	xylene,o-	0.241	--	---	NA
87-86-5	Pentachlorophenol	pentachlorophenol	0.59	13	3.30E-01	2.70E+00
85-01-8	Phenanthrene	Phenanthrene	16.7	--	5.00E-02	NA

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108-95-2	Phenol	Phenol	0.0288	--	3.30E-01	NA
14265-44-2	Phosphate	Phosphate	--	--	5.00E+00	NA
7723-14-0	Phosphorus	phosphorus	3.5	--	5.00E+01	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	3.5	--	--	NA
7440-09-7	Potassium	Potassium	5.5	--	4.00E+02	NA
129-00-0	Pyrene	pyrene	68	--	5.00E-02	NA
7782-49-2	Selenium	selenium and compounds	5	5	1.00E+00	1.32E+05
7440-21-3	Silicon	Silicon	--	--	2.00E+00	NA
7440-22-4	Silver	silver	8.3	2.4	0.2	NR
7440-23-5	Sodium	Sodium	100	--	5.00E+01	NA
7440-24-6	Strontium	strontium	35	--	1.00E+00	NA
100-42-5	Styrene	styrene	0.91	--	5.00E-03	NA
14808-79-8	Sulfate	sulfate	0	--	5.00E+00	NA
127-18-4	Tetrachloroethene	tetrachloroethylene	0.265	--	5.00E-03	NA
7440-28-0	Thallium	Thallium, soluble salts	71	--	5.00E-01	NA
7440-31-5	Tin	tin	250	--	1.00E+01	NA
108-88-3	Toluene	Toluene	0.14	--	5.00E-03	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	4	--	--	NA

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TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	4	--	---	NA
8001-35-2	Toxaphene	toxaphene	96	0.0002	1.65E-01	NR
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	--	5.00E-03	NA
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	--	5.00E-03	NA
126-73-8	Tributyl phosphate	Tributyl phosphate	2.35	--	—	NA
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	--	5.00E-03	NA
75-69-4	Trichloromonofluoromethane	trichlorofluoromethane	0.0439	--	—	NA
7440-61-1	Uranium	Uranium	NVR [f]	--	—	NA
7440-62-2	Vanadium	vanadium	1000	--	2.50E+00	NA
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.0186	--	0.005	NA
1330-20-7	Xylenes (total)	Xylenes (total)	0.233	--	1.00E-02	NA
7440-66-6	Zinc	zinc	62	91	1.00E+00	NR

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

c. The following restrictions were applied to preliminary remediation goals:

· "NA" was assigned where no applicable water quality standard was available.

Table B-4. Unit-Length Preliminary Remediation Goals for Non-radionuclides Protective of Surface Water in the 100-BC Source Operable Unit (Alphabetical Order by Contaminant)

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	K_d [a] (mL/g)	Surface Water Standard [a] (µg/L)	Estimated Quantitation Limit [b] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Surface Water [c, d] $\left(\frac{mg}{kg}\cdot m\right)$

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 µg/L (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

· Value was limited to a physical upper bound of 389,000 mg/kg, based on the maximum pore space contaminant mass capacity.

d. Preliminary remediation goals protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these preliminary remediation goals, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the preliminary remediation goal for evaluation use.

e. The preliminary remediation goal for hexavalent chromium is set to 6.0 mg/kg based on the evaluation in ECF-HANFORD-11-0165; this value is not dependent on waste site size.

f. No Value Required.

Table B-5. Unit-Length Preliminary Remediation Goal for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (K_d order)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Carbon-14 [f]	0	2000	5730	—	8.12E+00
Technetium-99	0	900	213000	—	3.65E+00
Tritium	0	20000	12.35	—	1.04E+02
Iodine-129	1	1	15700000	—	5.52E-01
Neptunium-237	15	15	2140000	—	NR
Nickel-63	30	50	96	—	NR
Strontium-90 [g]	25	8	29.12	—	5.30E+03
Cesium-137	50	200	30	0	NR
Cobalt-60	50	100	5.721	0	NR
Americium-241	200	15	432	1	NR
Carbon-14 [h]	200	2000	5730	—	NR
Curium-243	200	15	28.5	—	NR
Europium-152	200	200	13.3	0.1	NR
Europium-154	200	60	8.8	0.1	NR
Europium-155	200	600	4.96	0.1	NR
Niobium-94	200	–	20300	—	NR
Plutonium-238	200	15	87.7	1	NR
Plutonium-239	200	15	24100	1	NR
Plutonium-240	200	15	6540	1	NR
Plutonium-241	200	300	14	—	NR

Table B-5. Unit-Length Preliminary Remediation Goal for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (K_d order)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Radium-226	200	5	1600	—	NR
Radium-228	200	5	5.75	0.2	NR
Thorium-228	200	15	1.91	—	NR
Thorium-230	200	15	77000	—	NR
Thorum-232	200	15	1.41E+10	—	NR

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. Radiochemistry Society website, Available at: http://www.radiochemistry.org/.

c. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

d. The following restrictions were applied to preliminary remediation goals:

· "NA" was assigned where no applicable water quality standard was available.

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 pCi/m^3 (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

e. Preliminary remediation goals protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these preliminary remediation goals, divide the listed value by a representative

Table B-5. Unit-Length Preliminary Remediation Goal for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (K_d order)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$

length across the waste site decision unit in the general direction of groundwater flow to obtain the preliminary remediation goal for evaluation use.

f. Carbon-14 in liquid form (typically associated with reactor gas condensate).

g. The preliminary remediation goal for strontium-90 is calculated based on a 100:0 initial source distribution, **an exception to the convention that analytes with Kd ≥ 2 were calculated based on a 70:30 initial source** distribution, because of data that indicated strontium-90 distributed throughout the vadose zone at some locations in these OUs.

h. Carbon-14 in solid form (typically associated with graphite).

Table B-6. Preliminary Remediation Goal for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (Alphabetical Order by Contaminant)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Americium-241	200	15	432	1	NR
Carbon-14 [f]	0	2000	5730	—	8.12E+00
Carbon-14 [h]	200	2000	5730	—	NR
Cesium-137	50	200	30	0	NR
Cobalt-60	50	100	5.721	0	NR
Curium-243	200	15	28.5	—	NR
Europium-152	200	200	13.3	0.1	NR
Europium-154	200	60	8.8	0.1	NR
Europium-155	200	600	4.96	0.1	NR
Iodine-129	1	1	15700000	—	5.52E-01
Neptunium-237	15	15	2140000	—	NR
Nickel-63	30	50	96	—	NR
Niobium-94	200	—	20300	—	NR
Plutonium-238	200	15	87.7	1	NR
Plutonium-239	200	15	24100	1	NR
Plutonium-240	200	15	6540	1	NR
Plutonium-241	200	300	14	—	NR
Radium-226	200	5	1600	—	NR
Radium-228	200	5	5.75	0.2	NR
Strontium-90 [g]	25	8	29.12	—	5.30E+03
Technetium-99	0	900	213000	—	3.65E+00

Table B-6. Preliminary Remediation Goal for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (Alphabetical Order by Contaminant)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [d,e] $\left(\frac{pCi}{g}\cdot m\right)$
Thorium-228	200	15	1.91	—	NR
Thorium-230	200	15	77000	—	NR
Thorum-232	200	15	1.41E+10	—	NR
Tritium	0	20000	12.35	—	1.04E+02

a. ECF-HANFORD-12-0023, 2014, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area, CH2M-HILL Plateau Remediation Company, Richland, Washington.

b. Radiochemistry Society website, Available at: http://www.radiochemistry.org/.

c. DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100DR-2, 100-HR-1, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*, CH2M-HILL Plateau Remediation Company, Richland, Washington (Appendix A).

d. The following restrictions were applied to preliminary remediation goals:

· "NA" was assigned where no applicable water quality standard was available.

· "NR" was assigned where a non-representative result was obtained in cases where breakthrough was not simulated to occur in more than one representative stratigraphic column within 1000 years, where breakthrough is defined as groundwater concentration exceeding 0.0001 pCi/m^3 (a value set as the lower limit of numerical significance).

· Value defaults to the estimated quantitation limit for any analyte where the calculated value is less than the estimated quantitation limit.

e. Preliminary remediation goals protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these preliminary remediation goals, divide the listed value by a representative length across the waste site decision unit in the general direction of groundwater flow to obtain the preliminary remediation goal for evaluation use.

Table B-6. Preliminary Remediation Goal for Radionuclides Protective of Groundwater for the 100-BC Source Operable Units (Alphabetical Order by Contaminant)

Radionuclide	K_d [a] (mL/g)	Maximum Contaminant Level [a] (pCi/L)	Half-life [b] (yr)	Estimated Quantitation Limit [c] (mg/kg)	Unit-Length Preliminary Remediation Goal Protective of Groundwater [d,e] $\left(\frac{pCi}{g} \cdot m\right)$

f. Carbon-14 in liquid form (typically associated with reactor gas condensate).

g. The preliminary remediation goal for strontium-90 is calculated based on a 100:0 initial source distribution, **an exception to the convention that analytes with Kd ≥ 2 were calculated based on a 70:30 initial source** distribution, because of data that indicated strontium-90 distributed throughout the vadose zone at some locations in these OUs.

h. Carbon-14 in solid form (typically associated with graphite).

Attachment C

Software Installation and Checkout Form for STOMP

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:

Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:

Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No.: Bld 4

EXECUTABLE INFORMATION:

2. Executable Name (include path):

All executable files installed in directory [redacted]/bin

MD5 File Signature	Executable File Name
6536b8e12d8c5b83dca76f2c947b6153	stomp-wae-bcg-chprc04i.x
e0cdf04bc1a2f6c55c5a1b499939f663	stomp-wae-bcg-chprc04l.x
6e72340bb39f6056e232fe5ff241c4d4	stomp-wae-bd-chprc04i.x
3f837a0fb8d9f47dbcada686f542d7fc	stomp-wae-bd-chprc04l.x
7e5b4cc36a8991b3d5a8ea2ed155ce47	stomp-wae-cgsq-chprc04i.x
00a898c0c3ec06817485781ad1c9ec46	stomp-wae-cgsq-chprc04l.x
f18ff5ab5667065d8ab12657344fb6a0	stomp-wae-cgst-chprc04i.x
061af86cf21ad8435b046d0efabe971b	stomp-wae-cgst-chprc04l.x
3c8111a9855dc0e430bf3c8a7abcf37e	stomp-w-bcg-chprc04i.x
20436d615a94955a2ce8eecdb8cba546	stomp-w-bcg-chprc04l.x
8b3df29df21d040189c3e2a50ef823bb	stomp-w-bd-chprc04i.x
066a289a75aedb933eb2536da5d7d1ff	stomp-w-bd-chprc04l.x
c8e62ad7a0d9b6fca39d8a8952ef5d8e	stomp-w-cgsq-chprc04i.x
28ad16806e1307aca51fd7bf89793e75	stomp-w-cgsq-chprc04l.x
6c25051016db2fe1f883a7caaaab1e97	stomp-w-cgst-chprc04i.x
ff9ff6f29b3469419ffaece87d7e772b	stomp-w-cgst-chprc04l.x
0c3e3fba40f5b93e71bcf9586432fd27	stomp-w-r-bcg-chprc04i.x
78492aee80a8c2d0a4e82aabf4a9c213	stomp-w-r-bcg-chprc04l.x
84b129786aba9c4be884e15e45a67389	stomp-w-r-bd-chprc04i.x
e990f1566c8099a8d54508de3da9cd88	stomp-w-r-bd-chprc04l.x
18a589a2b55aab2db290efea19b39351	stomp-w-r-cgsq-chprc04i.x
6569959476772a137df35ce874821889	stomp-w-r-cgsq-chprc04l.x

3. Executable Size (bytes): MD5 signatures above uniquely identify each executable file

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):

Tellus Subsurface Modeling Platform

5. Operating System (include version number):

Linux tellusmgmt.rl.gov 2.6.18-308.4.1.el5 #1 SMP Tue Apr 17 17:08:00 EDT 2012 x86_64 x86 64 x86 64 GNU/Linux

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):

Green Linux Cluster

7. Operating System (include version number):

Linux green 3.2.0-35-generic #55-Ubuntu SMP Wed Dec 5 17:42:16 UTC 2012 x86_64 x86_64 x86 64 GNU/Linux

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No.: Bld 4

8. Open Problem Report? (●) No ( ) Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

[redacted]/itc

10. Procedure(s):

CHPRC-00211 Rev 1, STOMP Software Test Plan

11. Libraries:

N/A (static linking)

12. Input Files:

Input files for ITC-STOMP-1, ITC-STOMP-2, and ITC-STOMP-2
(Baseline for comparison are results files from ATC-STOMP-1, ATC-STOMP-2, and ATC-STOMP-3 prepared on Tellus during acceptance testing)

13. Output Files:

plot.* files produced by STOMP in testing

14. Test Cases:

ITC-STOMP-1, ITC-STOMP-2, and ITC-STOMP-3

15. Test Case Results:

Pass for all executable files listed above.

16. Test Performed By: WE Nichols

17. Test Results: (●) Satisfactory, Accepted for Use ( ) Unsatisfactory

18. Disposition (include HISI update):

Accepted; Installation noted in HISI for users TJ Budge, N Hasan, A Mayenna, WJ McMahon, WE Nichols, S Mehta, H Rashid.

Prepared By:

19. Software Owner (Signature)	WE Nichols (Print)	25 APRIL 2013 (Date)

20. Test Personnel:

Sign	WE Nichols (Print)	25 APRIL 2013 (Date)
Sign	Print	Date
Sign	Print	Date

Approved By:

21. Software SME (Signature)	N/R (per CHPRC-00211 Rev 1) (Print)	Date

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