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Revision 4

STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for 300 Area Source Areas

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

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INTERA, Inc.

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2	Updated calculation to use variable initial source dist (100:0 for Kd < 2, 70:30 for Kd ≥ 2) & include industrial rechar	05/18/2012	All ☒
3	Revised calculation to use updated EPA IRIS (Integrated Risk Information System) basis	03/18/2013	Attachments A-1, A-2 (Tables A-1, A-2, B-1, and B-2) ☒
4	Add text, revise SSL/PRG units, footnotes to clarify dimensional aspect of SSL/PRG values; NO calculation changes.	02/23/2016	Section 2.5, Attachments A-1, A-2 (table headers and footnotes) ☒

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Terms

ARARs	applicable regulations and requirements
AWQL	applicable water quality standards
CHPRC	CH2M HILL Plateau Remediation Company
cm/s	centimeters per second (units)
cm^3/g	cubic centimeters per gram (units)
COPC	contaminant of potential concern
CPK	peak groundwater concentration
ECF	environmental calculation file
EQL	estimated quantitation limit
FEPs	features, events, and processes
HEIS	Hanford Environmental Information System (environmental database)
HISI	Hanford Information System Inventory (software database)
LIDAR	Light Detection and Ranging
m	meter(s)
µg/L	micrograms per liter
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mL/g	milliliters per gram
PNNL	Pacific Northwest National Laboratory
POCal	point of calculation
PRG	preliminary remediation goal
OU	Operable Unit
RAG	remedial action goal
RESRAD	RESidual RADiation (modeling software)
STOMP	Subsurface Transport Over Multiple Phases (modeling software)

SZ	saturated zone
VZ	vadose zone
WQS	water quality standard

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1. Purpose

The objective of this environmental calculation file (ECF) is to provide screening values and preliminary remediation goals (PRGs) for protection of surface water and groundwater in the 300-FF-5 Groundwater Operable Unit (OU) using the STOMP (Subsurface Transport Over Multiple Phases) fate and transport simulation software. For the purposes of this ECF, the 300-FF-5 Groundwater Operable Unit OU is hereafter referred to generically as the 300 Area.

PRGs represent the soil concentration or radioisotope activity that can remain in the vadose zone at each area without causing an exceedance of groundwater or surface water regulatory standards. Based on numerical flow and solute transport simulations using a number of conservative assumptions, two types of PRGs protective of groundwater and protective of surface water are calculated for applicability to two recharge scenarios (native vegetation and industrial) for 191 non-radionuclides and 28 radionuclides in groundwater and 191 non-radionuclides in surface water (the Columbia River). Screening levels protective of groundwater and protective of surface water were calculated based on an irrigation recharge scenario for the same list of contaminants.

Conceptual and numerical models of flow and solute transport under variably saturated conditions were developed for conditions that are representative of the lithology and hydrology observed at observed at various waste sites within 300 OU. Conditions specific to the 300 Area or source areas include time-varying recharge rates specific to the 300 Area, OU-specific vadose zone thickness and lithology, area-specific hydraulic properties, and OU-specific aquifer fluxes. The numerical model implementing the conceptual model is developed assuming that aqueous-phase flow under variably saturated conditions follows the Richards equation and that transport of dilute solutes follows the advection-dispersion equation with radioactive decay and linear sorption and no volatilization or hydrodynamic dispersion.

Contaminant migration from waste sites in the 300 Area 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 end result of competition between precipitation, evaporation, transpiration, infiltration, run-off, and run-on; and man-made discharges, such as those from septic tank leach fields, ponds, lagoons, pipe and tank leaks, and 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 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 STOMP numerical simulations 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 300 Area. The peak concentration within 1000 years was used in screening and PRG value calculation. The 1000 year time period was based on regulatory decision.

The screening and PRG values resulting from the simulations and calculations are only intended to apply to sites that share the same set of conditions and assumptions that form the basis of this calculation.

STOMP - 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.

2. Methodology

Calculation of PRG values for the 300 Area included the use of one-dimensional numerical fate and transport simulations. 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 PRGs in the 300-Area 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. This section of this ECF summarizes the methodology employed to produce screening values and two types of PRG values for the 300 Area using the STOMP code.

2.1 Screening Levels and Preliminary Remediation Goals

Screening levels and 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. Screening levels and 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. There are two types of PRG calculation calculated in this document: one for a native vegetation recharge scenario and one for an industrial recharge scenario, while the screening value calculation is based on a much higher (bounding) irrigation recharge scenario (Section 3.2.1). Both the screening level and PRG values for a particular COPC depend on a number of key factors. These key factors are:

- 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

Model simulations were carried out for the non-radionuclide 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 radionuclides identified in ECF-Hanford-10-0429 Rev. 0, *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.* Groundwater PRG values were calculated for each of these COPCs and surface water PRGs were calculated for all non-radionuclide COPCs.

2.2 Identifying Representative Stratigraphic Columns

Using 300 Area borehole lithological data, a suite of stratigraphic columns were identified that would be representative of the subsurface beneath for 300 Area waste sites. The gravel-dominated Hanford formation is the only lithologic unit present within the 300 Area vadose zone. Thus the representative stratigraphic columns were selected based on the range of vadose-zone thicknesses observed in the 300 Area. A total five stratigraphic columns were selected for use in the STOMP simulations (see Section 3.1).

2.3 STOMP Flow and Transport Simulations

Peak groundwater concentrations in the aquifer beneath a typical 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. Peak concentrations of selected contaminants listed in Section 3.3, were calculated for two different contaminant source distributions, as described in Section 3.2.3, with three recharge scenarios (native vegetation, industrial, and irrigation) having three different soil types controlling infiltration plus an industrial recharge scenario for disturbed soil (Section 3.2.1) for each representative stratigraphic column (Section 3.1).

2.4 Estimation of 1000 year Peak Groundwater Concentrations

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 five meters of the aquifer. The average concentration for the topmost 5 m was assumed to be an estimate of the groundwater concentration that would be measured within a 20-ft-long monitoring well screen that straddled the water table. Using the upper 5 meters of the aquifer is consistent with the requirements for aquifer mixing zone thickness in WAC 173-340-747[5][f][i] , which specifies that the aquifer mixing zone thickness shall not exceed 5 meters in depth. 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 ground water and its year of occurrence. For contaminants not simulated in STOMP, peak groundwater concentrations were calculated by a regression equation or linear interpolation method (Section 5.3).

2.5 Calculating Screening Level and Preliminary Remediation Goal (PRG) Values

A simple calculation was employed to compute screening values 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, PRGs are expressed as contaminant mass per unit mass of soil for non-radionuclides or as contaminant activity per unit mass of soil for radionuclides.

For the irrigation recharge scenario, the soil screening level (SSL) for each contaminant is computed as:

$$SSL = aC_I \frac{WQS}{CPK} \qquad \text{Eqn. 1a}$$

while for both recharge applicable scenarios (native vegetation and industrial) the PRG for each contaminant is computed as:

$$PRG = aC_I \frac{WQS}{CPK} \qquad \text{Eqn. 1b}$$

where SSL = soil screening level and PRG = Preliminary Remediation Goal (contaminant mass or activity / kg of soil]), a is a constant selected to balance units, C_I is the initial soil concentration (typically contaminant mass or activity / mass of soil), WQS = water quality standard (contaminant mass or activity / liter of water), and CPK = peak groundwater concentration (typically contaminant mass or activity / liter of water) resulting from the initial soil concentration C_I simulated within 1000 years under the applicable recharge scenario. The surface water quality standards are input as WQS to compute SSLs or PRGs protective of surface water, whereas the groundwater quality standards are input as WQS to compute SSLs or PRGs protective of groundwater.

The SSL and PRG values 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. To determine waste-site values for evaluation of exposure point concentrations (EPCs), the unit-length values are divided by the representative length of the waste site in the general direction of groundwater flow. To illustrate this concept, assume that the calculated PRG for some COPC is $10\,\frac{mg}{kg}\cdot m$ (Figure 1a). That means that a concentration of 10 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 1b). In this case, the contamination from each individual column contributes to the outflow concentration in groundwater, so the PRG for evaluation of this specific waste site would be

$$PRG_{evalaution} = \frac{PRG_{unit-length}}{L} = \frac{10\,\frac{\mathrm{mg}}{\mathrm{kg}}\cdot m}{5\ \mathrm{m}} = 2\frac{\mathrm{mg}}{\mathrm{kg}}$$

Where PRG is distinguished by the value derived for a unit-length basis ($PRG_{unit\text{-}length}$) and the scaled value appropriate for evaluation of EPCs ($PRG_{evaluation}$), and L is the representative lineal dimension of the waste site decision unit in the general direction of groundwater flow.

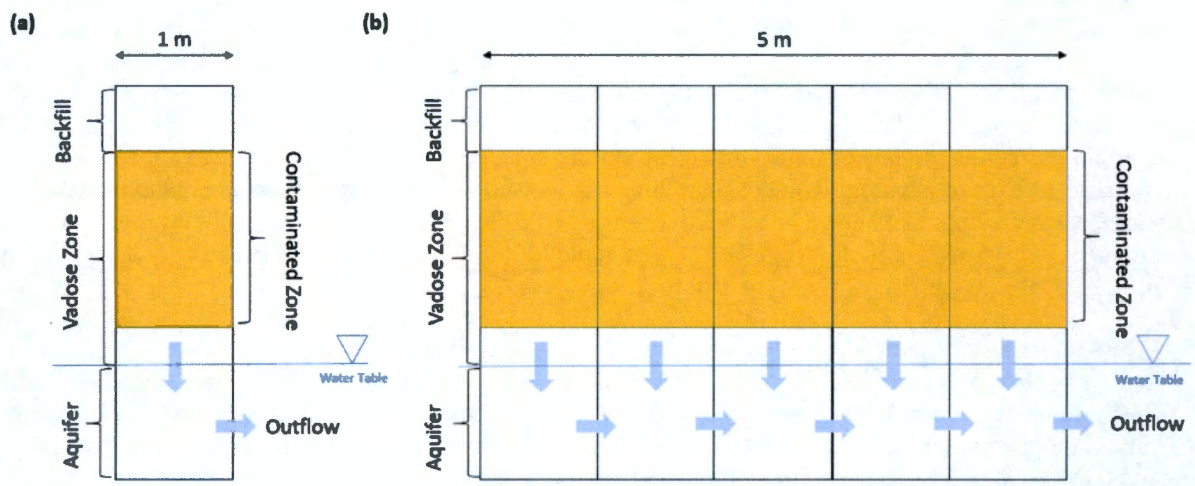


Figure 1. Example of Application of Unit-Length SSL or PRG to a Waste Site Decision Unit

3. Assumptions and Inputs

Two sequential STOMP simulations were used to determine peak groundwater concentrations. The first stage, called the pre-2010 model, simulated flow through the representative columns for a 2,010-year period ending in the year 2010 AD; the only 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 revealed that they had reached equilibrium prior to the end of the simulation. Results from the pre-2010 simulations provided initial aqueous pressure conditions for the 1,000-year-long second stage simulation, the post-2010 model,

which solved for both flow and solute transport. The post-2010 solute transport simulations tracked the fate of contaminants with different distribution coefficients and decay constants through the vadose zone and into the aquifer. These results were used to identify the peak groundwater concentrations and year of peak concentration.

STOMP estimates of contaminant concentration depend on the model inputs and assumptions. Inputs to the models and their underlying assumptions can be divided into the following categories:

- Model domain
- Boundary and initial conditions
- Hydraulic and transport parameters
- Initial contaminant source distribution

Each of these is discussed in the sub-sections below.

3.1 Model Domain

Conceptually, the model represents a column of sediments comprised of a vadose zone underlain by an aquifer. Water flow moves vertically downward through the vadose zone as a result of gravitational and capillary forces, where it encounters the underlying unconfined aquifer where a pressure gradient results in horizontal flow under saturated conditions. Diluted, mobilized contaminants are transported with the water in this system, with additional transport processes including advection, diffusion, adsorption and desorption affecting the rate of transport. At the start of each post-2010 simulation, the vadose zone comprises a cover of clean fill with constant thickness as well as contaminated and uncontaminated sediments of varying thickness. The aquifer constitutes the base of the column with a minimum thickness of 5 m so that a 5-m-long monitoring well screen could be simulated. In the 300 Area the vadose zone and saturated zone is comprised only of the Hanford formation.

The model represents the vadose zone as a vertical, one-dimensional column of evenly-spaced grid blocks, each containing a node at the centroid. In STOMP, boundary conditions are specified at the faces of the grid blocks, so each grid block is assigned an arbitrary but constant length to avoid large grid Courant numbers in the aquifer grid blocks during transport simulations. Each grid block is 0.25 m in height and 10 m in length. A length of 10 m was chosen to reduce the Courant number below 1.0 to reduce numerical errors. The Courant number represents a simple guideline for selecting grid element and time step size to limit numerical dispersion in advection dominated problems (Huyakorn and Pinder, 1983). In practice, the time step is easier to control in a simulation because the grid is fixed in advance. STOMP includes an automatic Courant limitation scheme that automatically subdivides transport time steps within flow solution time steps to ensure the Courant limit is maintained throughout the computational mesh; this feature of STOMP was used in this calculation. Following the simulation, the contaminant aqueous concentration output was scaled back to 1 m length by taking the aqueous concentrations and dividing by 10. The accuracy of this methodology was verified through simulation with varying grid dimensions (not presented here).

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

The thickness of the vadose zone varies according to the geology of each waste site in the 300 Area. The range in vadose zone thicknesses across the 300 Area was calculated by taking the difference between the ground surface and a single selected water table surface. The ground surface data was obtained from Hanford Site-wide LIDAR (Light Detection and Ranging) data. This data was then converted into raster format in ArcGIS®[1]. The March 2009 water table elevation map that was presented in the 2009 Groundwater Annual Report (DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009 Volumes 1 and 2*) was selected because the surface covered a large areal extent and encompassed all of the 300 Area waste sites. The water table contour was converted to a raster file in ArcGIS® environment and then subtracted from the ground surface map to calculate the vadose zone thickness across the 300 Area. Then the vadose zone thickness at each waste site location was determined. The determined vadose zone thickness for the 300 Area waste sites ranges between 6.8 m and 16.7 m, as noted in Table 1.

Because of natural variability in the thickness of various hydrostratigraphic units it is not practical to calculate PRG values for all possible variations in thicknesses observed in the various boreholes. Instead, representative stratigraphic columns were identified. Representative columns were identified by collecting and reviewing geologic data from 103 boreholes nearest to the waste sites in each geographic area. All borehole data were taken from the Hanford Environmental Information System (HEIS) borehole database. The columns include the vadose zone and the unconfined aquifer. Using water table elevations to represent the annually occurring highest water table, a conservative (smaller) thickness of the VZ was computed for each borehole. The borehole data also provided estimates of 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. This process yielded five representative vadose zone thicknesses of 6.5, 9.5, 12.5, 14.5 and 16.5 m (Figure 2). In addition to the 5-m thick saturated zone and the selected vadose-zone thickness, each model column was assumed to contain clean backfill to represent conditions resulting from interim remediation activities. The backfill was assumed to replace the uppermost 4.5 m of each column (Figure 2).

3.2 Boundary Conditions and Initial Conditions

Solving the governing equations for variably-saturated flow and transport requires stipulation of boundary conditions and initial conditions. A complete set of boundary and initial conditions must be stipulated for each governing equation.

For water flow, a specified-flux boundary condition was applied at the surface to represent recharge, no-flow boundary conditions were assigned to the edges of the vadose zone and the bottom of the saturated aquifer, and prescribed pressure boundaries were assigned to the edges of the saturated aquifer (Figure 3a). The prescribed pressures were selected to create the water table at the desired elevation and with the desired hydraulic gradient.

For solute transport, specified zero flux boundaries were applied at the top of the model domain, along both edges of the vadose zone, along the up-gradient edges of the aquifer grid blocks, and the bottom of the aquifer (Figure 3b). The downgradient edges of the aquifer grid blocks were assigned STOMP's outflow solute boundary condition (see page 6.21 of PNNL-12030, *STOMP Subsurface Transport Over Multiple Phases: Theory Guide*, and page 4.4 of PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases: User's Guide Version 4.0*), 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 3b).

[1] ArcGIS is a registered trademark of ESRI, Inc.

3.2.1 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, potential evaporation, transpiration, run-off and run-on. In an arid climate, downward fluxes resulting from this competition are episodic and usually infrequent, but this effect is typically damped towards a nearly constant rate with depth 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, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*). Because some waste sites will be in industrial use areas while others in unrestricted use areas, two recharge scenarios are used to develop PRG values so the appropriate value may be selected by waste site. In contrast, soil screening level values are developed for all sites under an irrigation scenario (most conservative with greatest recharge).

3.2.1.1 Native Vegetation Recharge Scenario

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 in Pacific Northwest National Laboratory (PNNL-14702 Rev. 1, *Vadose Zone Hydrology Data Package for Hanford Assessments for the 100 Areas)* and reported as well in DOE/RL-2011-50. The 300 Area-specific recharge rates in PNNL-14702 Rev. 1 varied with surface soil type and so provide an estimate of the range of possible recharge rates for various land uses. The three surface soil types were the Ephrata sandy loam, Burbank sandy loam and Rupert sand. Each vadose zone representative stratigraphic column is simulated with each of these three soil types as the surface soil; this is implicit to the model. That is, the soil cover and evapotranspiration processes are not directly simulated; rather, the effective recharge rate applicable to each soil cover and vegetation cover are applied as a flux rate to the upper boundary of each representative vadose zone column.

For the pre-2010 simulations, land use and recharge rates were assumed to change from shrub-steppe (during the Hanford pre-operational period) to bare soil (Hanford operational period) for each soil type. Base recharge rates for each type of land cover for each soil type were applied to the top boundary from the year 0 to 1944 for the pre-operational period (an arbitrarily long period to allow the full soil profile to stabilize at equilibrium) and from 1944 to 2010 for the operational period (Table 2).

For the post-2010 simulations, two different land use/cover scenarios were evaluated (Table 3). The first, termed the native vegetation recharge scenario, evaluated the transition of surface cover from bare soil to mixed grass and shrub cover to mature shrub steppe cover. The second scenario, termed the irrigation recharge scenario, evaluated an increase in recharge due to irrigation farming practices following the period of bare soil cover. The third scenario, termed the industrial recharge scenario, evaluated the transition of surface cover from bare soil to a permanently disturbed, cheatgrass dominated cover. The recharge rates were assumed to change over time in step function-fashion for these recharge scenarios (except for a linear transition in the industrial scenario from bare soil to cheatgrass).

To account for the change in the land use/cover over time in the post-2010 simulations, three recharge time periods were specified to represent the changes in recharge rates (Table 3 and Figure 4). The first recharge period (Period 1), spans from 2010 to 2015 and represents the period of bare soil cover. Recharge Period 2 represents different land use/covers for each of the two PRG recharge scenarios. For the native vegetation recharge scenario, the second recharge period lasts 30 years and represents grasses and shrubs covering bare soil. This is followed by establishment of a mature shrub steppe for Period 3 which lasts for the remainder of the simulation period. The recharge rates decreased with time for the native vegetation recharge scenario (Table 3 and Figure 4).

3.2.1.2 Irrigation Recharge Scenario

Recharge rates for the irrigation scenario were estimated using the same approach employed to assess interim remediation at 100 Area waste sites (DOE/RL-96-17 Rev. 6, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*). These previous site assessments used Remedial Action Goals (RAGs) calculated from RESRAD (RESidual RADiation) simulations that assumed total recharge was a combination of irrigation and non-irrigation (native vegetation) recharge rates. As the native vegetation recharge rates used in the RESRAD simulations were different than those adopted from PNNL-14702 Rev. 1, the RESRAD equation for total recharge was solved to determine the rate attributable to irrigation alone. According to the RESRAD manual, total recharge is a function of precipitation, evapotranspiration, run-off, and applied irrigation and is defined as

$$I = (1 - C_e)[(1 - C_r)P_r + I_{rr}] \qquad \text{Eqn. 2}$$

in which 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}). Solving Equation 2 with I_{rr} = 0 yielded the non-irrigation total recharge rate of 11.6 mm/yr and therefore the recharge attributable to irrigation alone was 68.4 mm/yr, which was then added to the native vegetation recharge scenario rates (Table 3) to determine a recharge rate for the irrigation scenario for each soil type. For example, the irrigation scenario for the Ephrata soils set the recharge rate to 17 mm/yr from 2010 to 2015, 71.4 mm/yr from 2015 to 2045, and 69.9 mm/yr from 2045 to 5010 (Table 3 and Figure 4).

3.2.1.3 Industrial Recharge Scenario

An industrial scenario is developed with regulator agreement to evaluate representative conditions for land surface that remains in a permanently disturbed condition as a consequence of industrial land use. In this scenario, recharge begins with a steady state of 50 mm/yr and continues at this rate for five years. This rate is similar to that measured rate of 51 mm/yr for an area covered with gravelly sand at the Hanford Solid Waste Landfill from data collected over a 22-year period with less than 5 percent vegetation cover (DOE/RL-2011-50, Table 4-7). Next, the rate transitions linearly from 50 mm/yr to 25 mm/yr over a period of 5 years, representing the establishment of a cheatgrass community. Thereafter, the surface is assumed to remain in a permanently disturbed state with the cheat grass community unchanged. The 25 mm/yr rate for cheatgrass is similar to the measured rate of 25.4 mm/yr at the "Grass Site" in the 300 Area covered with coarse-grained soil and cheat grass (DOE/RL-2011-50, Table 4-7). These values also are shown in Table 3.

Table 1. Vadose Zone Thickness of 300 Area Waste Sites

Waste Site	Thickness of Vadose Zone (m)
300-10	12.4
300-18	13.4
300-259	16.4
300-275	9.5
300-44	13.3
300-45	12.9
300-49	6.8
300-50	10.0
300-8	14.9
300 ASH PITS	15.1
300 VTS	16.3
316-1	14.4
316-2	11.1
316-5	13.8
331 LSLDF	11.0
600-243	14.6
600-259	16.7
600-47	12.7
618-1	16.4
618-12	12.0
618-13	15.3
618-3	15.6
618-4	12.9
618-5	16.1
618-7	16.2
618-8	15.2
618-9	13.7
628-4	12.3
618-2	9.7

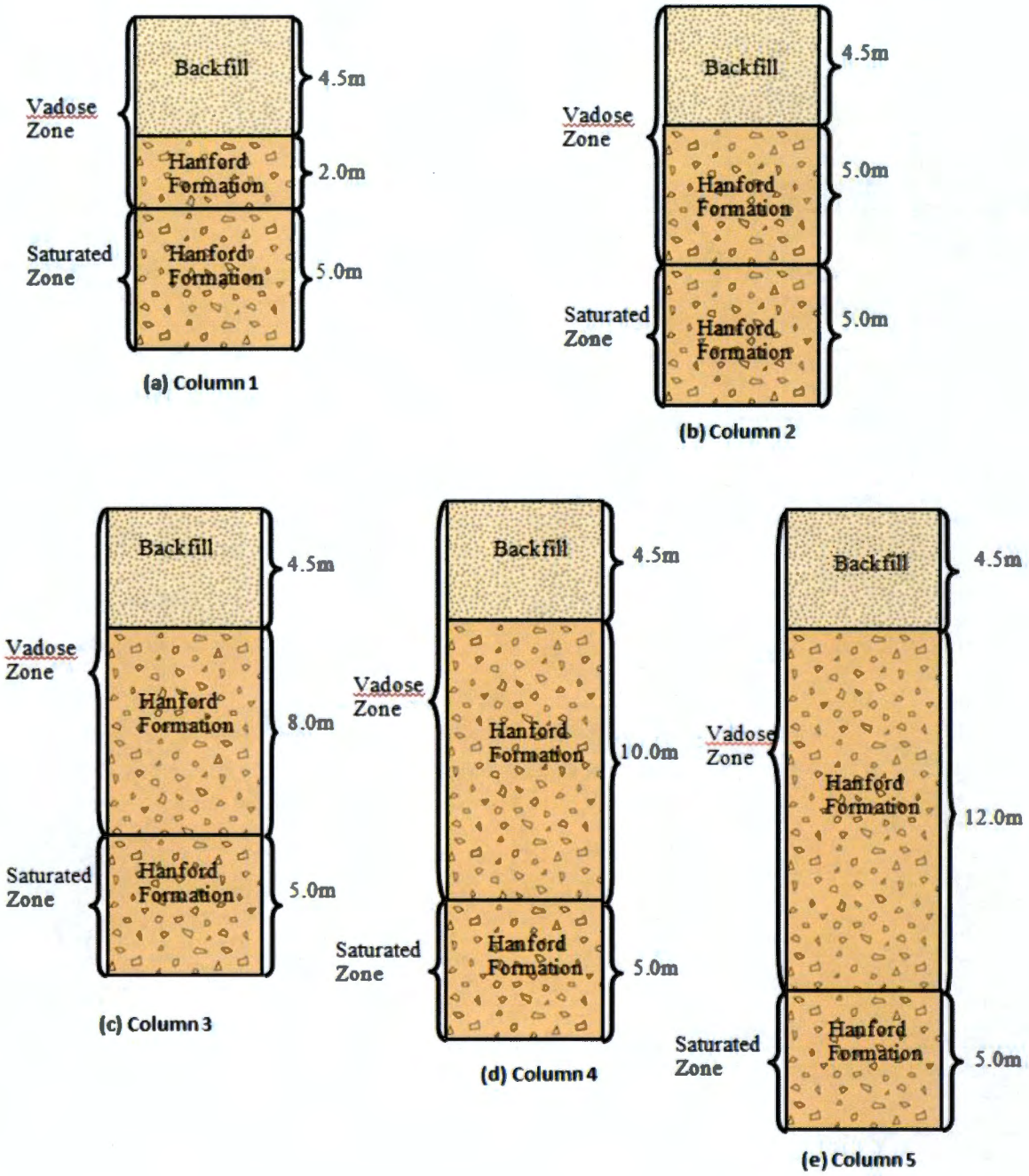


Figure 2. Representative Stratigraphic Columns for 300 Area

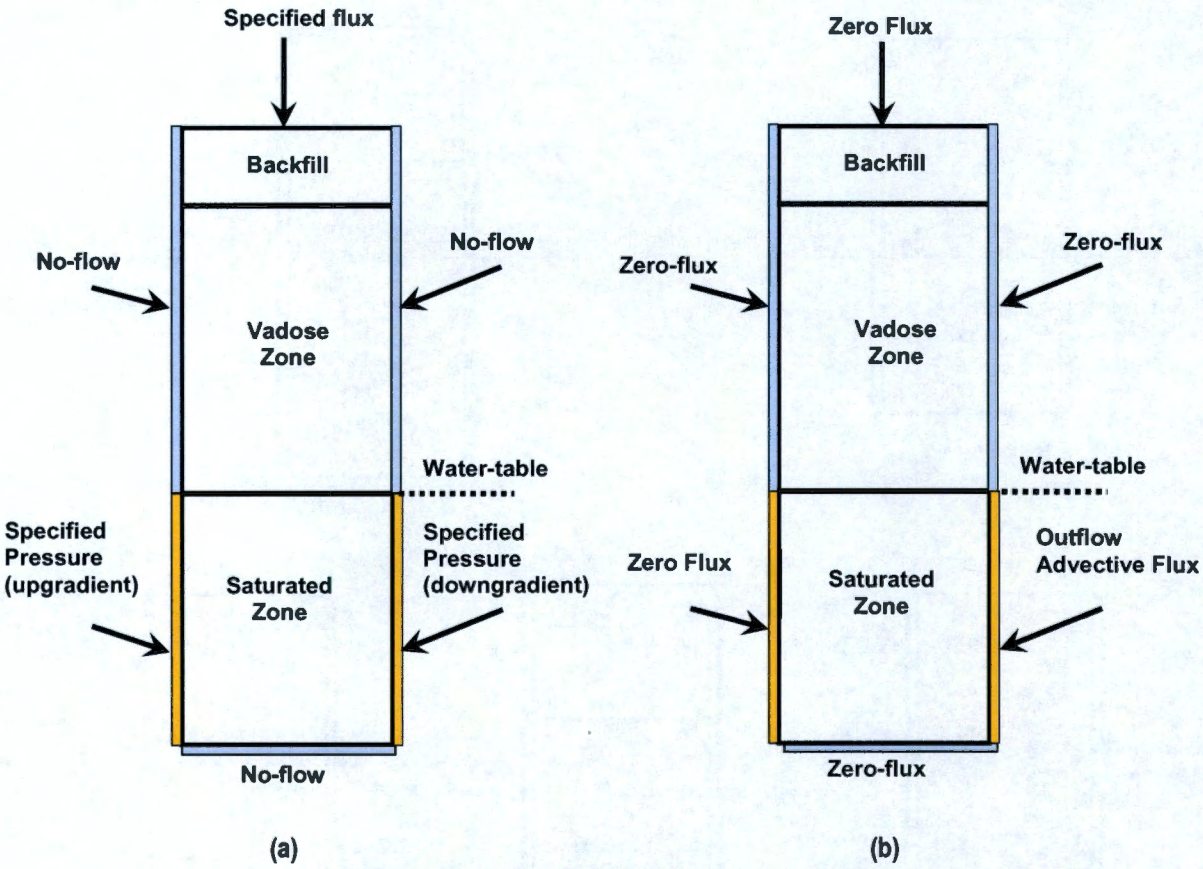


Figure 3. Boundary Conditions for (a) Flow and (b) Solute Transport

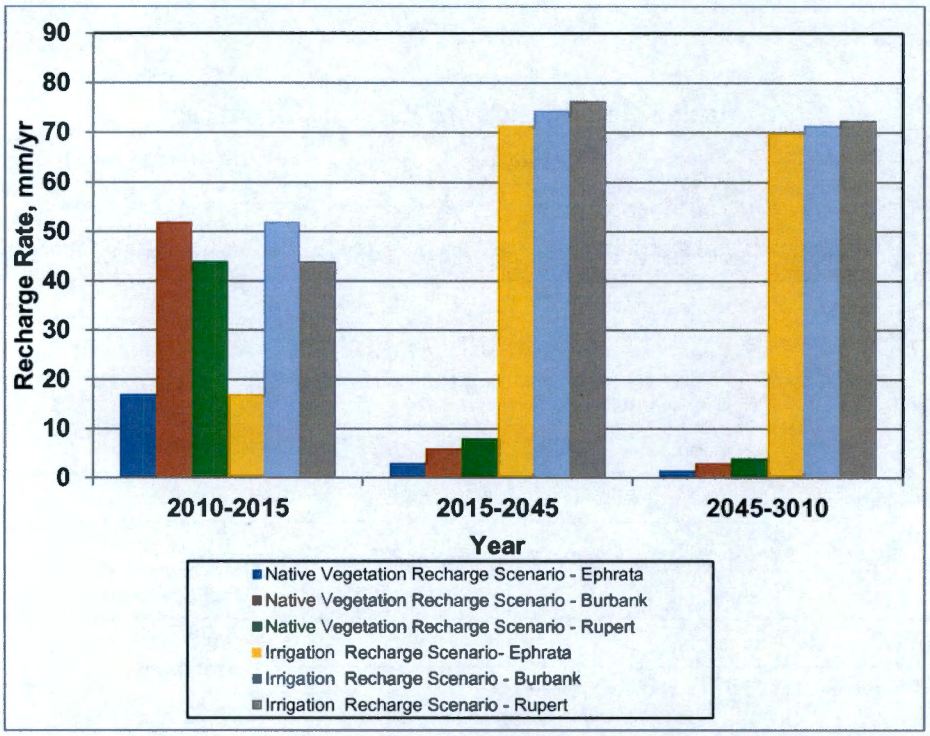
Table 2. Recharge Rates for Pre-2010 Simulations

Soil Type	Recharge Scenario	Recharge Rate for Different Period (mm/yr)	
		Establish Initial Steady-State	Operational Era
Native Vegetation and Irrigation		(0-1944)	(1944-2010)
Ephrata Sandy Loam and Stony Loam	Native Vegetation	1.5	17.0
	Irrigation		
Burbank Sandy Loam	Native Vegetation	3.0	52.0
	Irrigation		
Rupert Sand	Native Vegetation	4.0	44.0
	Irrigation		
Industrial		(0-1944)	(1944-2010)
Disturbed Soil	Industrial	25.0	50.0

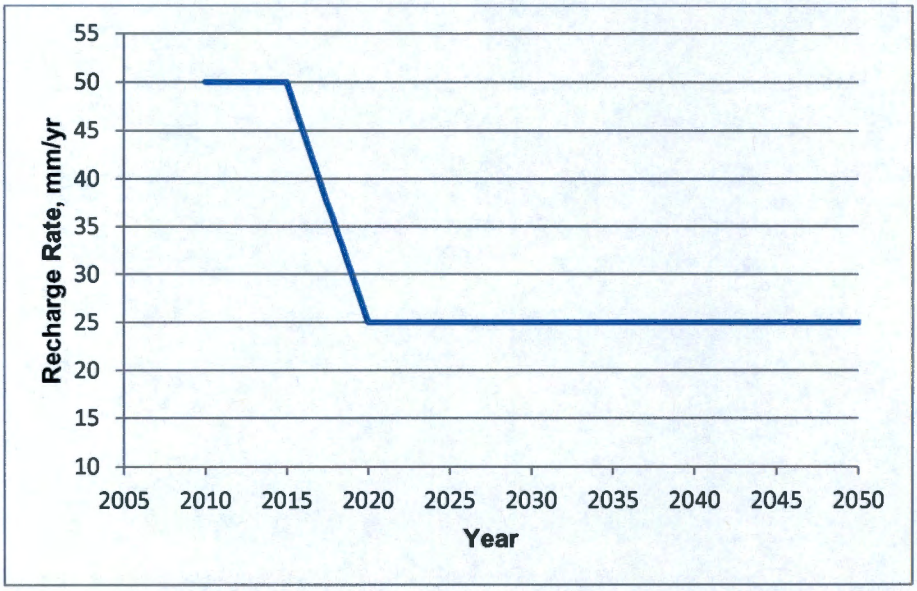
Table 3. Recharge Rates for Post-2010 Simulations

Soil Type	Recharge Scenario	Recharge Rate (mm/yr)		
		Period 1	Period 2	Period 3
Native Vegetation and Irrigation		(2010-2015)	(2015-2045)	(after 2045)
Ephrata Sandy Loam and Stony Loam	Native Vegetation	17.0	3.0	1.5
	Irrigation	17.0	71.4	69.9
Burbank Sandy Loam	Native Vegetation	52.0	6.0	3.0
	Irrigation	52.0	74.4	71.4
Rupert Sand	Native Vegetation	44.0	8.0	4.0
	Irrigation	44.0	76.4	72.4
Industrial		(2010-2015)	(2015-2020)	(after 2020)
Disturbed Soil	Industrial	50.0	50.0 to 25.0[a]	25.0

[a] linear transition from 50.0 to 25.0 mm/yr during period



(a) Native Vegetation and Irrigation Recharge Scenarios



(b) Industrial Recharge Scenario

Figure 4. Recharge Rates used in Post-2010 STOMP Simulations

3.2.2 Aquifer Gradient

The specified pressure values assigned to the edges of the saturated aquifer grid blocks were selected to create a hydraulic gradient across the model domain. The gradient was calculated by the following steps:

1. First water table contours within the Hanford formation were developed for the months of January, March, June, and December in 2009. These months were selected because there was a sufficient completeness of data available to develop a comprehensive surface. The June water table represents the highest stages of the annual cycle of river flows; the December water table represents the lowest stages. The contoured surfaces were developed using ArcGIS®.

2. After the contours were drawn for each month the flow lines were hand drawn.

3. Then the gradient was calculated for each segment in the flow line in between the contour lines.

4. For each waste site, a gradient was calculated for each of the four different months.

5. The average of the four gradients at each waste site was calculated.

6. The median value was determined for all the four-month averaged gradients to develop an overall average gradient of 0.00033 m/m.

3.2.3 Initial Conditions

An arbitrary value was assigned as the initial pressure for the pre-2010 flow simulations. A value of 86,656.7 Pascal, 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 pre-2010 simulations were used as the initial pressures for the post-2010 flow and transport simulations.

For contaminants with K_d < 2 mL/g, peak concentration occur within 1000 years while for K_d > 2 mL/g the peak concentration occurs after 1000 years. Observations of this behavior and implications are discussed in Section 3.5. Based on this consideration, contaminants are evaluated in two categories, one with low distribution coefficients < 2 mL/g and another one with the high distribution coefficients ≥ 2 mL/g for both screening value and PRG calculations. A different initial concentration condition is applied to these categories. A uniform concentration of 1 mg/kg was applied in the entire vadose zone below the clean backfill up to 0.5 m (two grid blocks) above the water table for the low K_d contaminants and mentioned here as effective 100:0 distribution. Initial concentration in the 0.5 m zone above the water table was not applied due to physical 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 results in unrepresentative large peak releases in the simulation start as a result of the extreme concentration gradient that created by application of this initial condition. For the high K_d contaminants 70% of the vadose zone below the clean backfill was assumed to be contaminated with remaining 30% as uncontaminated (referred as 70:30 source distribution). This 70:30 source distribution assumption is considered to be conservative for the high K_d contaminants based on observed limited vertical extent (with the notable exception of uranium, which is addressed separately in ECF-300FF5-11-0151, *Groundwater Flow and Transport Modeling in Support of the 300 Area FF-5 RI/FS Document*).

The unit initial concentration is arbitrary but was chosen only for convenience in calculating PRG values and has no effect on the PRG values since the initial concentration C_I is accounted for in Equation 1.

3.3 Hydraulic and Transport Parameters

The hydraulic properties of the Hanford formation were assumed to follow the van Genuchten (1980) moisture retention constitutive relation and the Mualem –van Genuchten relative permeability constitutive relation (Mualem, 1976). Thus the following parameter values were required for each lithologic unit:

- K_s, saturated hydraulic conductivity, (LT^{-1})
- n_T, total porosity (L^3L^{-3}); assumed equivalent to diffusive porosity (n_D) in this calculation
- θ_s, saturated volumetric water content (L^3L^{-3})
- s_r, residual saturation (dimensionless); equal to the residual volumetric water content divided by the saturated volumetric water content
- α, van Genuchten inverse air entry head (L^{-1})
- n, the dimensionless van Genuchten exponential fitting parameter (dimensionless)

The van Genuchten m 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*). These Mualem-van Genuchten hydraulic parameters were obtained for the Hanford formation from PNNL-15125. A summary of the hydraulic parameters are listed in Table 4.

Hydraulic parameters were also required for the backfill portion of the model domain. The simulated peak groundwater concentrations will be insensitive to the backfill hydraulic parameters because contaminated vadose zone sediments are located beneath clean backfill in all source distribution models for all simulations. The backfill parameter values used for the 300 Area simulations (Table 4) were identical to those used in the 200 Area PRG calculation simulations (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*).

For transport simulations, STOMP requires the particle density (ρ_p) values of the backfill and Hanford formation. The particle density of each unit can be calculated using the bulk density (ρ_B) and porosity. Bulk density is necessary for retardation scaling factor calculations. Estimates of bulk density for Hanford formation were obtained from PNNL-14702 Rev. 1, which gave 1.93 g/cm^3 for the Hanford formation. The bulk density estimate of 1.94 g/cm^3 for backfill was obtained from PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses*. Dispersion was conservatively assumed to be negligible, so dispersivity values were set to zero. Barring numerical dispersion introduced by the numerical solution technique, setting dispersivity values to zero yields higher peak concentrations than setting non-zero values and therefore yields conservative PRG values. One artifact of this approach is that the grid Peclet number (a dimensionless number that measures the degree of advection domination compared to hydrodynamic dispersion) becomes infinite. This can cause smearing of the sharp concentration front (by numerical dispersion) and could also lead to artificial oscillations at the concentration front. However, no appreciable numerical errors were noticed in the simulations and did not result in smearing the peak concentrations.

Distribution coefficient, K_d, for the chemicals were taken from ECF-Hanford-10-0442 Rev. 1 and for the radionuclides K_d and half-life values were taken from ECF-Hanford-10-0429 Rev. 0, and are listed in

Attachments A-1 and A-2 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, Rev. 1, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area*. Simulations were run for 1000 years to produce peak groundwater concentrations for a subset of the entire range of distribution coefficients required for all contaminants. Typically, the subset comprised 26 distribution coefficients (Table 5) between 0 and 16 mL/g. Peak concentrations were estimated for the remaining distribution coefficients using either the scaling methods described in Section 5.3.

Table 4. Hydraulic Parameters used for 300 Area Simulations

Model Zone	Total Porosity n_D	Diffusive Porosity n_D	van Genuchten α (1/cm)	van Genuchten n	Residual Saturation s_r	Horizontal Saturated Hydraulic Conductivity $K_{s,h}$ (cm/s)	Vertical Saturated Hydraulic Conductivity $K_{s,v}$ (cm/s)
Backfill	0.276	0.262	0.0190	1.4	0.1620	5.98E-04	5.98E-04
Vadose	0.280	0.250	0.0824	2.0932	0.1516	1.7361	0.1736
Saturated	0.280	0.250	0.0824	2.0932	0.1516	1.7361	0.1736

Table 5. Distribution Coefficients Used in STOMP Simulations

K_d Values (mL/g)	
0.00000	0.6
0.00001	0.7
0.0001	0.8
0.001	0.9
0.01	1.0
0.02	2.0
0.04	4.0
0.06	6.0
0.08	8.0
0.1	10.0
0.2	12.0
0.3	14.0
0.4	16.0
0.5	

3.4 Point of Calculation and Protectiveness Metric

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, 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]*) and to "Point of Compliance" in federal and state regulations and guidelines (DOE/RL-2011-50). For this calculation, the POCal is the outflow (downgradient) edge of the 1-D column for the grid blocks that are located in the topmost five meters of the aquifer representing the screened portion of a monitoring well. The peak value of concentration within the topmost five meters of the aquifer was used to compare to the regulatory compliance criteria (Section 2.4).

The protectiveness metric is the set of 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 AWQL for each contaminant for protectiveness of groundwater and surface water in the 100-N Area are included in the Attachments A-1 and A-2.

3.5 Screening Levels and Preliminary Remediation Goals (PRGs)

The screening values and two types of PRG values were calculated assuming the most conservative set of input values. For the screening value calculation the maximum recharge (irrigation recharge scenario) was applied and one PRG value was calculated for the native vegetation recharge scenario and another PRG value was calculated for the industrial recharge scenario. PRGs for each recharge scenario are provided so that a waste site can be evaluated based on its zoned land use.

The peak concentration within the 1000 year simulation was used to calculate the screening value and two PRG values (native vegetation and industrial recharge scenarios). Note that, particularly for contaminants with greater sorption, peaks may occur beyond 1000 years but these are not calculated or reported because a 1000-year limit was established for purposes of PRG calculation by agreement with regulatory agencies. One set of test case simulations were run for selecting the low K_d and high K_d contaminants, for Column 1 as an example, the native recharge scenario for Burbank sandy loam soil and the same column for the industrial recharge scenario. The effective 100:0 distribution was used. The breakthrough curves for different distribution coefficients for the native vegetation recharge scenarios are shown in Figure 5. The simulations were run for 1000 years (calendar years 2010 to 3010); the end of the simulations is denoted by the vertical dashed line at year 3010 in these figures. Observation of the breakthrough curves in Figure 5 reveals that for $K_d < 2$ mL/g the peak concentration occurs within 1000 years and for $K_d > 2$ mL/g the peak concentration occurs after 1000 years. As a result, the contaminants were grouped into two groups, one with low distribution coefficients < 2 mL/g and another one with the high distribution coefficients ≥ 2 mL/g for both screening value and PRG calculations. For the low K_d contaminants effective 100:0 source distribution was used and for the high K_d contaminants 70:30 source distribution was used. The final screening value and two PRG values (native vegetation and industrial) for each recharge scenario is chosen by selecting the minimum value (lowest PRG value calculated from amongst all of the representative columns). If the minimum value thus obtained is below the estimated quantitation limit (EQL) for soil then EQL is substituted for screening and PRG value (as a lower threshold). The EQL values represent the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. EQLs normally are arbitrarily set rather than explicitly determined, and for purposes of this calculation are specified in DOE/RL-2009-45, 2009, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*.

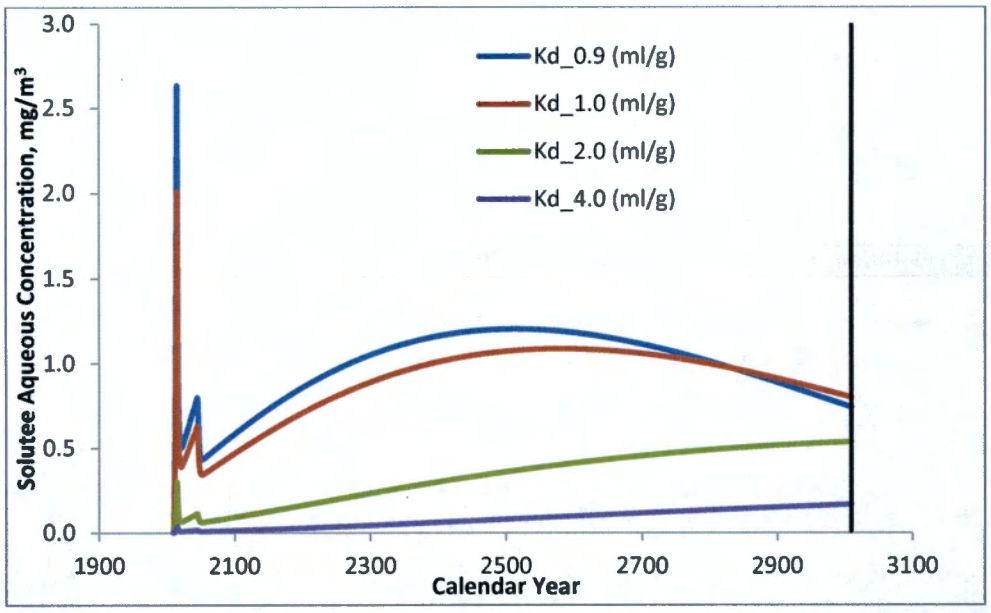


Figure 5. Breakthrough Curves for Select Distribution Coefficients with Native Vegetation Recharge Scenario

3.1 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).

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 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 time 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 one-dimensional simulations force 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.

- Dilution upon mixing of groundwater with Columbia River water is assumed to be negligible.
- Dispersion is assumed to be 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.

Assumptions that may or may not be conservative include:

- The median hydraulic gradient value 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.
- The assumption of a five-meter-thick aquifer may or may not be conservative for those 300 Area locations with aquifer thicknesses less than five meters.

4. Software Applications

Microsoft Excel®[2] spreadsheets were used to calculate contaminant inventory values and approximate contaminant solute concentrations, back calculate PRG values, and evaluate the results produced by STOMP. These calculations were performed on a desktop with ID INTERA-00295. The hardware is a Dell Precision E7200 with a 2.53-GHz Intel® Core™ 2 Duo CPU processor and 3.25 GB of RAM loaded with the Windows® XP Professional 64-bit operating system.

4.1 Approved Software

The vadose zone fate and transport calculations are performed using CH2M HILL Plateau Remediation Company (CHPRC) Build 2 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 Rev. 1, *STOMP Functional Requirements Document*; CHPRC-00176 Rev. 2, *STOMP Software Management Plan*; CHPRC-00211 Rev. 1, *STOMP Software Test Plan*; CHPRC-00515 Rev. 1, *STOMP Acceptance Test Report*; and CHPRC-00269 Rev. 1, *STOMP Requirements Traceability Matrix*.

4.2 Description

The STOMP software package was used in the calculation; required information on this software is provided here:

- Software Title: STOMP
- Software Version: CHPRC Build 2

[2] Excel and Windows are registered trademarks of Microsoft Corporation in the United States and other countries.

- HISI Identification Number: 2471
- Workstation type and property number (from which software is run): STOMP was executed on the INTERA Richland GREEN Linux®[3] Cluster that is owned and managed by INTERA, Inc., a pre-selected subcontractor to CHPRC. The computer property tag identifier for the front end node is #469 at INTERA's Richland, Washington office. This node is a Dell PowerEdge R510 with two six-core Intel Xeon X5660 processors @ 2.80GHz and 48 GB of RAM. As given by the command "uname –a", the operating system details are:

```
Linux green 2.6.32-32-server #62-Ubuntu SMP Wed Apr 20 22:07:43
UTC 2011 x86_64 GNU/Linux (gcc version Ubuntu 4.4.3-4ubuntu5
4.4.3)
```

4.2.1 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 B of this ECF.

4.2.2 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 software acceptance testing (CHPRC-00515 Rev. 1) demonstrated that the STOMP software is acceptable for its intended use by the CHPRC. Installations of the software are operating correctly, as demonstrated by the INTERA Linux® cluster system producing the same results as those presented for selected problems from the STOMP application guide (PNNL-11216, *STOMP Subsurface Transport Over Multiple Phases: Application Guide*) in accordance with the *STOMP Software Test Plan* (CHPRC 00211 Rev. 1).

5. Calculation

STOMP simulations were created and run using the representative stratigraphic columns, boundary conditions, initial conditions, and parameter values described in Section 3. The details of screening value and PRG value calculation are described in the following sub-sections.

5.1 Time Steps and Solution Method

STOMP simulations were all run with a maximum time step of 0.01 years and grid dimension of 10 m (in the horizontal direction) and 0.25 m (in the vertical direction). Numerical error was controlled by use of

[3] Linux is a registered trademark of Linux Torvalds in the United States and other countries.

STOMP's automatic Courant limitation scheme to limit numerical dispersion. The flow simulations were run with the Newton-Raphson iteration method and transport simulations were solved using the Patankar solute transport method. The STOMP-W executable with banded matric solver was used for all simulations. The aqueous concentration output was scaled back to 1.0 m horizontal grid length by taking the aqueous concentrations and dividing by 10. The accuracy of this methodology was verified through simulation with varying grid dimensions (details not presented here).

5.2 Groundwater Concentration Calculation

Peak groundwater concentrations were calculated for each model time step along a portion of the domain's downgradient boundary corresponding to the top five meters of the aquifer. 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 conservatively 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.

5.3 Dilution Factors

Dilution factors are calculated following the Washington Administrative Code (WAC 173-340-747), wherein the dilution factor is the ratio of the combined aquifer and vadose zone water fluxes to the vadose zone water flux:

$$Df = \frac{Q_{VZ}+Q_A}{Q_{VZ}} \qquad \text{Eqn. 3}$$

where Df is the dimensionless dilution factor, Q_{VZ} is the volumetric flux from the vadose zone into the aquifer (L^3T^{-1}), and Q_A is the volumetric flux through the topmost five meters of the aquifer (L^3T^{-1}). The dilution factors for the representative stratigraphic columns for the 300 Area under each recharge scenario are listed in Table 6.

Table 6. Calculated Dilution Factors

Recharge Scenario	Dilution Factor[a]		
Surface Soil	Ephrata sandy loam	Burbank sandy loam	Rupert sand
Native Vegetation	6.02E+05	3.01E+05	2.26E+05
Irrigation	1.29E+04	1.27E+04	1.21E+04
Surface Soil		Disturbed soil	
Industrial		3.61E+04	

(a) Calculated per Washington Administrative Code (WAC 173-340-747).

5.4 Scaling of Peak Concentration

The results of peak concentration scaling are presented in Section 5.4.1 for the screening values (based on irrigation recharge scenario) and in Section 5.4.2 for PRG values (based on both the native vegetation and industrial recharge scenarios).

5.4.1 Estimation of Peak Concentration for Screening Level Values

Peak concentrations were calculated by running multiple simulations using STOMP for set of K_d values. Typically, the subset comprised of 27 K_d values ranging from 0 to 16 mL/g. For the contaminants with lower K_d values, the peak concentrations were estimated using the 'FORCAST' function of Excel®. The peak concentrations beyond the simulated K_d values were estimated using regression equation mentioned. An example is shown in Figure 6 using Column 1 with irrigation recharge for Ephrata sandy loam soil.

No breakthrough was assumed if the estimated peak concentration within 1000 years was found to be less than 1×10^{-4} µg/L for nonradioactive COPCs or 1×10^{-4} pCi/L for radionuclide COPCs. The "NR" symbol was used to denote those analytes with non-representative results. The "NR" symbol (denoting a non-representative result) was assigned for those COPCs for which no breakthrough occurred (under the 1000-year threshold limit just mentioned) in in at least four of the five representative columns, or when the calculated PRG value for any COPC was greater than 384,000 µg/kg. This condition was observed for analytes with K_d values greater than 50 mL/g and therefore the screening levels for all analytes with K_d greater than 50 mL/g are set assigned value "NR."

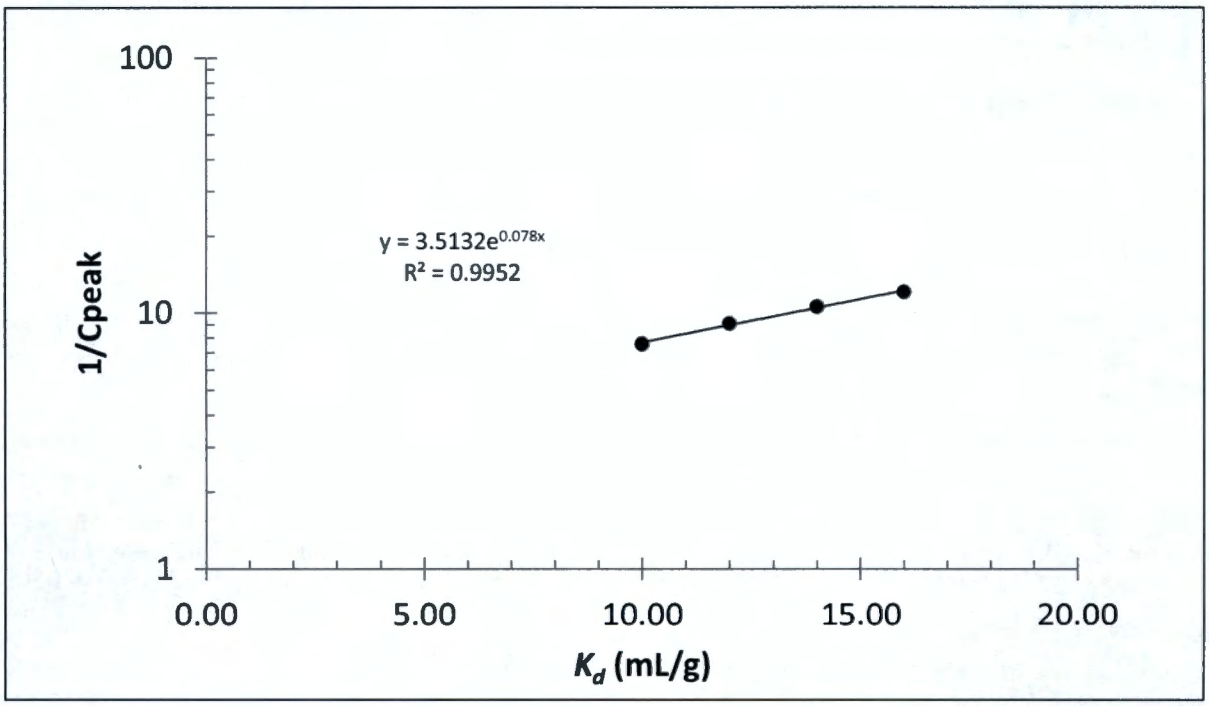


Figure 6. Non-linear Regression Equation for High K_d Contaminants

5.4.2 Estimation of Peak Concentration for Preliminary Remediation Goal (PRG) Values

Peak concentrations were calculated by using STOMP to simulate the set of K_d values listed in Table 5 (ranging from 0 to 16 mL/g) for each of the three recharge scenarios (native vegetation, industrial, and irrigation). The peak concentrations beyond the range of K_d values for which peak concentrations were calculated were estimated based on regression analysis (Section 5.4.1). It was assumed that no breakthrough occurred if the calculated peak concentration within 1000 years was less than 1×10^{-4} µg/L for non-radionuclide COPCs or 1×10^{-4} pCi/L for radionuclide COPCs. The "NR" symbol (denoting a non-representative result) was assigned for those COPCs for which no breakthrough occurred (under the 1000-year threshold limit just mentioned) in in at least four of the five representative columns, or when

the calculated PRG value for any COPC was greater than 384,000 µg/kg. This final condition (PRG values greater than 384,000 µg/kg) was found to occur for COPCs with a K_d value greater than 1 mL/g for the native vegetation recharge scenario and a K_d value greater than 20 mL/g for the industrial recharge scenario. Therefore, when K_d value was greater than 1 mL/g the PRG of the native vegetation is set to "NR" and for industrial recharge scenarios for K_d greater than 20 mL/g is set to "NR."

The soil screening levels obtained in this calculation are listed in Attachment A-1.

5.5 Calculation of Screening and Preliminary Remediation Goal (PRG) Values

Screening values and two types of PRG values were calculated from the peak groundwater concentrations using Equation 1 and the applicable surface water and groundwater regulatory standards. If simulated peak concentrations are very small, application of Equation 1 can lead to physically unrealistic soil concentrations, e.g., 10 kg of aluminum per kg of soil. Although not strictly necessary, the maximum PRG value was capped at an estimate of the total COPC mass that could occupy the void volume within a kilogram of soil. PRG values pertain to soil with pore water present, so in the $K_d = 0$ case (unsorbed COPC) where no contaminant is in the soil, the concentration accounts the pore water portion.

The bulk density (ρ_B) of the soil in the 300 Area is 1930 kg/m^3. For 1 kg of soil, the total volume (V_T) of the soil is:

$$\frac{1\ \text{kg}}{1930\,\frac{\text{kg}}{\text{m}^3}} = 5.18 \times 10^{-4}\ \text{m}^3$$

The COPC is assumed to fully occupy the diffusive or total porosity (in this calculation, the diffusive and the total porosity as formulated in STOMP were assumed equivalent). Thus, the maximum mass of COPC in the soil is:

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

where n_T is the total porosity and ρ_p is the particle density of the COPC. In the 300 Area, the total porosity of the Hanford formation is 0.28, and the particle density of the COPC is assumed to equal the particle density of the soil, 2650 kg/m^3 (PNNL-18564). The maximum mass of COPC in 1 kg soil is given by

$$\begin{aligned} m_{max,p} &= (0.28) \times \left(5.18 \times 10^{-4}\ \text{m}^3\right) \times \left(2650\ \frac{\text{kg}}{\text{m}^3}\right) \\ &= 0.384\ \text{kg} \times \left(\frac{1{,}000{,}000\ \text{mg}}{1\ \text{kg}}\right) = 3.84 \times 10^5 \text{mg} \end{aligned}$$

Thus the maximum screening or PRG value for non-radionuclides is 384,000 mg per kg of soil. Any larger non-radionuclide PRG value was replaced with the 384,000 mg per kg of soil value.

The PRG values obtained in this calculation are listed in Attachment A-2.

6. Results/Conclusions

STOMP simulations and scaling calculations were used to estimate the two types of PRG values for 300 Area over a representative range of vadose zone thicknesses, soil types, and recharge scenarios.

Attachment A-1 contains the surface water and groundwater screening values for each soil type and representative column for the 300 Area. Attachment A-2 contains the PRG values for native vegetation recharge and industrial recharge scenarios for each soil type and representative column for the 300 Area. Note the following with regard to screening values and PRGs reported in Attachments A-1 and A-2:

- If the screening value or the PRG value for any analyte was calculated to be less than its EQL for soil concentration then the screening value or the PRG value was set to EQL for that analyte.
- The PRG values for Cr(VI) were limited to a maximum value of 6 mg/kg because the K_d value used in the model was derived from experiments with soil concentration less than 6 mg/kg, as there is no basis to infer greater PRGs for Cr(VI) based on these data so this conservative limit is applied (ECF-Hanford-11-0165 Rev. 1).
- No breakthrough was assumed if the estimated peak concentration within 1000 years was found to be less than 1×10^{-4} µg/L for non-radionuclide COPCs or 1×10^{-4} pCi/L for radionuclide COPCs. The "NR" symbol was used for these analytes to designate non-representative result (below a level of numerical significance). The "NR" symbol was also assigned when no breakthrough was observed one or fewer representative stratigraphic columns, or when the PRG value for any COPC exceeded than 384,000 µg/kg. This condition was observed for analytes with K_d greater than 1 mL/g for the native recharge case scenario and K_d greater than 20 mL/g for industrial recharge case scenario. For the screening value calculation the K_d value is greater than 50 mL/g.
- For some contaminants the applicable water quality standard was not available. For those contaminants "NA" symbol was used in screening and PRG values.

The PRG values resulting from the simulations and estimation are only intended to be applied to sites that share the same set of conditions and assumptions underpinning these calculations. Some waste sites may require a more rigorous investigation of site specific conditions than those underlying the screening and PRG values found in Attachments A-1 and A-2.

6.1 Evaluation of K_d Influence on Breakthrough

The column 1 was run with irrigation recharge scenario for Ephrata sandy soil with effective 100:0 source distribution. Figure 7 shows the breakthrough curves for different K_d values ranging from 0.9 – 8.0 mL/g. Observation of the break through curves from Figure 7 reveals that all the peak concentrations occur within 1000 year simulation time. As the irrigation recharge is really high it flushes the contaminants very fast through the vadose zone even with higher K_d values. The irrigation recharge scenario does not represent the actual site conditions; it is used as a limiting conservative condition for the purpose of calculation screening values only; those waste sites that do not pass the screening levels will be further evaluated using the appropriate PRG values for determination of site remediation actions.

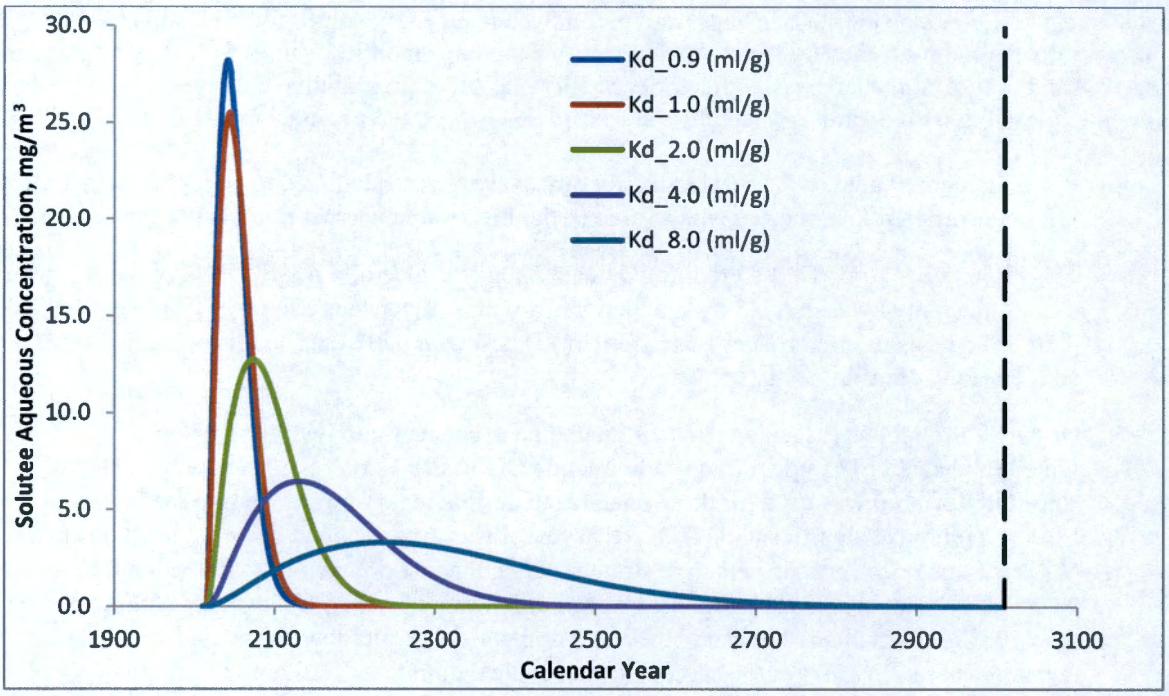


Figure 7. Breakthrough Curves for Select Distribution Coefficients with Irrigation Recharge Scenario

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Attachment A-1

Screening Values for 300 Area

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Table A1-1. Groundwater Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Ground Water Standard (µg/L)	EQL (mg/kg)	Groundwater Screening Values $\left(\frac{mg}{kg}\text{-}dry\right)$ [1,2,3,4,5] Irrigation Recharge Scenario
16887-00-6	Chloride	chloride	0	2.5E+05	2.00E+00	7.56E+04
14797-55-8	Nitrate	Nitrate	0	4.5E+04	2.50E+00	1.36E+04
14797-65-0	Nitrite	Nitrite	0	3.3E+03	2.50E+00	9.99E+02
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	1.0E+04	7.50E-01	3.03E+03
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	1.0E+03	7.50E-01	3.03E+02
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	1.0E+04	—	3.03E+03
14808-79-8	Sulfate	sulfate	0	2.5E+05	5.00E+00	7.56E+04
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	3.2E+01	8.25E-01	9.69E+00
67-64-1	Acetone	Acetone	0.0006	7.2E+03	2.00E-02	2.23E+03
107-21-1	Ethylene Glychol	Ethylene Glychol	0.001	16,000	—	5.03E+03
111-76-2	2-Butoxyethanol	Ethylene Glychol Mono Butyl Ether	0.001	800	—	2.51E+02
75-99-0	Dalapon	Dalapon	0.0027	200	—	6.60E+01
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.00277	4.8E+01	3.30E-01	1.59E+01
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.00451	4.8E+03	1.00E-02	1.67E+03
74-87-3	Chloromethane	chloromethane	0.006	No Value	1.00E-02	NA
74-83-9	Bromomethane	bromomethane	0.009	1.1E+01	1.00E-02	4.53E+00
60-29-7	Diethylether	Diethylether	0.009699	1600	—	6.64E+02
75-09-2	Methylene chloride	methylene chloride	0.01	5.0E+00	5.00E-03	2.10E+00
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	6.4E+02	1.00E-02	2.85E+02
591-78-6	2-Hexanone	HEXANONE;2-[MBK, methyl butyl ketone]	0.01498	4.0E+01	2.00E-02	1.89E+01
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.019	6.1E-02	5.00E-03	3.18E-02
75-00-3	Chloroethane	ethyl chloride	0.0217	No Value	1.00E-02	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	1.3E-02	3.30E-01	3.30E-01
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	4.4E-01	5.00E-03	2.63E-01
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	4.4E-01	5.00E-03	2.63E-01
108-95-2	Phenol	Phenol	0.0288	2.4E+03	3.30E-01	1.49E+03
94-75-7	2,4-D	2,4-Dichlorophenoxyacetic acid	0.029	70	—	4.37E+01
1918-00-9	Dicamba	Dicamba	0.029	480	—	2.99E+02
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	No Value	3.30E-01	NA
[redacted]	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	[redacted]	[redacted]	[redacted]	[redacted]
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	4.8E-01	5.00E-03	3.57E-01
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	1.0E+02	5.00E-03	7.42E+01
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	4-Amino-3,5,8-trichloropicolinic acid	0.039	500	—	3.79E+02
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0392	6.3E-01	3.30E-01	4.76E-01
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	7.2E+01	5.00E-03	5.53E+01
75-69-4	Trichloromonofluoromethane	Trichloromonofluoromethane	0.04389	2400	—	1.95E+03
75-15-0	Carbon disulfide	carbon disulfide	0.046	8.0E+02	5.00E-03	6.66E+02
78-59-1	Isophorone	isophorone	0.0468	4.6E+01	3.30E-01	3.87E+01
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	1.2E+00	5.00E-03	1.03E+00
93-76-5	2,4,5-T	2,4,5-Trichlorophenoxyacetic acid	0.049	160	—	1.39E+02

Table A1-1. Groundwater Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Ground Water Standard (µg/L)	EQL (mg/kg)	Groundwater Screening Values $\left(\frac{mg}{kg}\cdot m\right)$ [1,2,3,4,5] Irrigation Recharge Scenario
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.0516	4.2E+00	3.30E-01	3.73E+00
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.0516	4.4E+00	3.30E-01	3.92E+00
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.0527	1.6E+02	3.30E-01	1.46E+02
[redacted]	1,1-Dichloroethane	dichloroethane;1,1-	[redacted]	[redacted]	1.00E-02	[redacted]
67-66-3	Chloroform	chloroform	0.053	1.4E+00	5.00E-03	1.29E+00
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	7.1E-01	5.00E-03	6.63E-01
71-43-2	Benzene	Benzene	0.062	8.0E-01	5.00E-03	8.20E-01
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.063	5.2E-01	5.00E-03	5.42E-01
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	7.0E+00	1.00E-02	7.43E+00
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	1.6E+01	3.30E-01	1.77E+01
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0725	2.2E-01	3.30E-01	3.30E-01
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	7.7E-01	5.00E-03	9.05E-01
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	4.0E-02	3.30E-01	3.30E-01
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	2.2E-01	5.00E-03	2.70E-01
93-72-1	2,4,5-TP	(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	50	—	6.24E+01
84-66-2	Diethylphthalate	diethyl phthalate	0.082	1.3E+04	3.30E-01	1.62E+04
[redacted]	Trichloroethene	trichloroethylene (TCE)	[redacted]	[redacted]	[redacted]	[redacted]
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	2.8E-01	3.30E-01	4.02E-01
94-82-6	2,4-DB	(4-(2,4-Dichlorophenoxy)butanoic acid)	0.1	128	—	1.90E+02
98-95-3	Nitrobenzene	Nitrobenzene	0.119	1.6E+01	3.30E-01	2.59E+01
75-25-2	Bromoform	bromoform	0.13	5.5E+00	5.00E-03	9.48E+00
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.14	2.0E+02	5.00E-03	3.61E+02
108-88-3	Toluene	Toluene	0.14	6.4E+02	5.00E-03	1.15E+03
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	2.4E+01	3.30E-01	4.50E+01
[redacted]	Carbon tetrachloride	carbon tetrachloride	[redacted]	[redacted]	[redacted]	[redacted]
100-41-4	Ethylbenzene	ethylbenzene	0.2	4.0E+00	5.00E-03	1.06E+01
108-38-3	m-Xylene	Xylene, m-	0.2	1.6E+03	—	4.27E+03
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	1.6E+02	3.30E-01	4.39E+02
108-90-7	Chlorobenzene	chlorobenzene	0.22	1.0E+02	5.00E-03	2.84E+02
1330-20-7	Xylenes (total)	Xylenes (total)	0.23	1.6E+03	1.00E-02	4.70E+03
95-47-6	o-Xylene	xylene,o-	0.24	1.6E+03	—	4.87E+03
127-18-4	Tetrachloroethene	tetrachloroethylene	[redacted]	[redacted]	[redacted]	[redacted]
88-75-5	2-Nitrophenol	nitrophenol;2-	0.297	No Value	6.60E-01	NA
[redacted]	4-Nitrophenol	nitrophenol;4-	[redacted]	[redacted]	[redacted]	[redacted]
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2- (ortho-Dichlorobenzene)	0.379	6.0E+02	3.30E-01	2.84E+03
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.381	4.0E+00	3.30E-01	1.89E+01
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.388	4.0E+01	3.30E-01	1.94E+02
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.434	No Value	3.30E-01	NA
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.434	4.0E+02	3.30E-01	2.16E+03
[redacted]	4-Methylphenol (cresol, p-)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.4918	1.6E+03	3.30E-01	9.78E+03

Table A1-1. Groundwater Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Ground Water Standard (µg/L)	EQL (mg/kg)	Groundwater Screening Values ([redacted]) [1,2,3,4,5] Irrigation Recharge Scenario
[redacted]	Pentachlorophenol	pentachlorophenol	[redacted]	[redacted]	[redacted]	[redacted]
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.6015	1.3E+00	3.30E-01	9.55E+00
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4 - (para-Dichlorobenzene)	0.616	8.1E+00	5.00E-03	6.17E+01
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3, 3'-	0.724	1.9E-01	3.30E-01	1.74E+00
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	4.8E+01	—	6*
100-42-5	Styrene	styrene	0.91	1.0E+02	5.00E-03	1.15E+03
91-20-3	Naphthalene	naphthalene	1.19	1.6E+02	1.00E-01	2.26E+03
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	1.8E+01	3.30E-01	2.67E+02
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	8.0E-02	1.65E-03	1.23E+00
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	1.6E+03	3.30E-01	2.85E+04
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4, 5-	1.6	8.0E+02	3.30E-01	1.46E+04
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2 ,4-	1.66	1.5E+00	3.30E-01	2.87E+01
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	1.4E-02	1.65E-03	2.85E-01
[redacted]	Hexachloroethane	hexachloroethane	[redacted]	[redacted]	[redacted]	[redacted]
126-73-8	Tributyl phosphate	Tributyl phosphate	1.89	9.51	—	2.17E+02
959-98-8	Endosulfan I	Endosulfan I	2.04	9.6E+01	1.65E-03	2.46E+03
33213-65-9	Endosulfan II	Endosulfan II	2.04	9.6E+01	3.30E-03	2.46E+03
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	2.04	No Value	3.30E-03	NA
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	4.9E-02	1.65E-03	1.28E+00
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	No Value	1.65E-03	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.98	6.4E+02	3.30E-01	2.14E+04
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.98	3.2E+01	3.30E-01	1.07E+03
7440-42-8	Boron	Boron	3	3.2E+03	2.00E+00	1.08E+05
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	No Value	3.30E-01	NA
86-74-8	Carbazole	carbazole	3.39	4.4E+00	3.30E-01	1.69E+02
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
88-85-7	Dinoseb	2-secButyl-4,6-dinitrophenol	3.5	7	—	2.83E+02
7440-36-0	Antimony	antimony	3.76	6.0E+00	6.00E-01	2.70E+02
7782-49-2	Selenium	selenium and compounds	5	5.0E+01	1.00E+00	3.02E+03
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	No Value	1.00E-01	NA
[redacted]	Acenaphthene	acenaphthene	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	3.08E+04
76-44-8	Heptachlor	heptachlor	9.53	1.9E-02	1.65E-03	2.39E+00
53494-70-5	Endrin ketone	Endrin ketone	9.72	No Value	3.30E-03	NA
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	Aroclor-1221	aroclor 1221 [PCB]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	Aroclor-1232	aroclor 1232 [PCB]	[redacted]	[redacted]	[redacted]	[redacted]

Table A1-1. Groundwater Screening Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Ground Water Standard (µg/L)	EQL (mg/kg)	Groundwater Screening Values $\left(\frac{mg}{kg}\cdot m\right)$ [1,2,3,4,5] Irrigation Recharge Scenario
72-20-8	Endrin	endrin	10.8	2.0E+00	3.30E-03	2.76E+02
7421-93-4	Endrin aldehyde	Endrin aldehyde	10.8	No Value	3.30E-03	NA
[redacted]	Dibenzofuran	dibenzofuran	[redacted]	[redacted]	[redacted]	[redacted]
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	4.6E+01	3.30E-01	8.41E+03
85-01-8	Phenanthrene	Phenanthrene	16.7	No Value	5.00E-02	NA
7439-98-7	Molybdenum	molybdenum	20	8.0E+01	2.00E+00	2.58E+04
7440-50-8	Copper	copper	22	6.4E+02	1.00E+00	2.41E+05
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7440-39-3	Barium	Barium	25	2.0E+03	5.00E-01	NR
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7440-24-6	Strontium	strontium	25	9.6E+03	1.00E+00	NR
60-57-1	Dieldrin	dieldrin	25.6	5.5E-03	3.30E-03	2.73E+00
7440-38-2	Arsenic	arsenic, inorganic	29	5.8E-02	1.00E+00	3.80E+01
7440-43-9	Cadmium	cadmium	30	5.0E+00	2.00E-01	3.52E+03
7439-92-1	Lead	lead	30	1.5E+01	5.00E-01	1.06E+04
7439-97-6	Mercury	mercury	30	2.0E+00	—	1.41E+03
7440-66-6	Zinc	zinc	30	4.8E+03	1.00E+00	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	43.9	4.4E-02	1.65E-02	9.11E+01
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	44.8	4.4E-02	1.65E-02	9.77E+01
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	3.6E-01	3.30E-03	8.81E+02
309-00-2	Aldrin	aldrin	48.7	2.6E-03	1.65E-03	7.79E+00
206-44-0	Fluoranthene	fluoranthene	49.1	6.4E+02	5.00E-02	NR
7440-48-4	Cobalt	Cobalt	50	4.8E+00	2.00E+00	NR
7439-93-2	Lithium	Lithium	50	3.2E+01	2.50E+00	NR
7439-96-5	Manganese	manganese	50	3.8E+02	5.00E+00	NR
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	2.5E-01	1.65E-02	NR
57-74-9	Chlordane	chlordane	51	2.5E-01	1.65E-02	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	53.7	5.6E-01	3.30E-01	NR
7440-02-0	Nickel	nickel soluble salts	65	1.0E+02	4.00E+00	NR
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	5.00E-02	[redacted]
[redacted]	[redacted]	Thallium, soluable salts	[redacted]	[redacted]	[redacted]	[redacted]
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	75.6	4.4E-02	1.65E-02	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	5.5E-02	3.30E-01	NR
72-43-5	Methoxychlor	methoxychlor	80	4.0E+01	1.65E-02	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83.2	4.8E-03	1.65E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86.4	2.6E-01	3.30E-03	NR
7440-22-4	Silver	silver	90	8.0E+01	2.00E-01	NR
8001-35-2	Toxaphene	toxaphene	95.8	8.0E-02	1.65E-01	NR
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	5.0E-01	1.65E-02	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	110	6.0E+00	3.30E-01	NR
7440-31-5	Tin	tin	130	9.6E+03	1.00E+01	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	9.6E+02	5.00E+00	NR
7440-47-3	Chromium	chromium (total)	200	1.0E+02	2.00E-01	NR
218-01-9	Chrysene	Chrysene	200	1.2E+00	1.00E-01	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	4.8E+01	3.30E-01	NR
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	360	1.2E-01	1.50E-02	NR

Table A1-1. Groundwater Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Ground Water Standard (µg/L)	EQL (mg/kg)	Groundwater Screening Values (mg/kg) [1,2,3,4,5] Irrigation Recharge Scenario
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	2.6E-01	3.30E-03	NR
7440-41-7	Beryllium	beryllium	790	4.0E+00	2.00E-01	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	803	1.2E-01	1.50E-02	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	4.4E-02	1.65E-02	NR
7440-62-2	Vanadium	vanadium	1000	8.0E+01	2.50E+00	NR
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	1.2E-01	1.50E-02	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	5.0E+01	5.00E+00	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1790	1.2E-01	3.00E-02	NR
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	No Value	3.00E-02	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	1.2E-01	3.00E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	5500	1.2E-02	1.50E-02	NR
	Di-n-octylphthalate	di-n-octyl phthalate				
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	No Value	No Value	3.30E-01	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	No Value	No Value	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	No Value	No Value	1.00E+01	NA
24959-67-9	Bromide	Bromide	No Value	No Value	2.50E+00	NA
7440-70-2	Calcium	Calcium	No Value	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	No Value	—	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	No Value	No Value	7.50E+01	NA
14265-44-2	Phosphate	Phosphate	No Value	No Value	5.00E+00	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	No Value	No Value	—	NA
7440-09-7	Potassium	Potassium	No Value	No Value	4.00E+02	NA
7440-21-3	Silicon	Silicon	No Value	No Value	2.00E+00	NA
7440-23-5	Sodium	Sodium	No Value	No Value	5.00E+01	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	No Value	5.0E+02	—	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	No Value	5.0E+02	—	NA

1. All COPC screening values default to the estimated quantitation limit (EQL) when the calculated value is less than the EQL.
2. * indicates that Cr(VI) value set to a maximum value of 6.0 mg/kg because the K_d value used in the model was derived from experiments with soil concentrations less than 6.0 mg/kg. Scaling by representative length across the waste site decision unit in the general direction of groundwater flow is not applicable to this COPC because of this limit.
3. "NR" indicates non-representative results when there is no breakthrough simulated within 1000 years for four or more of the five soil representative columns (where breakthrough is defined as concentrations exceeding 1.0E-04 µg/L).
4. "NA" indicates an applicable water quality standard is not available to calculate the SSL or PRG values.
5. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup 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 cleanup value for evaluation use.

CAS = Chemical Abstract Service

Cyan highlight denotes calculated values that changed as a result of incorporating updated **IRIS (EPA's Integrated Risk Information System)** groundwater standard values.

Table A1-2. Surface Water Screening Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water Screening Values ($\frac{mg}{kg}$)[1,2,3,4,5] Irrigation Recharge Scenario
16887-00-6	Chloride	chloride	0	2.3E+05	2.00E+00	6.96E+04
14797-55-8	Nitrate	Nitrate	0	4.5E+04	2.50E+00	1.36E+04
14797-65-0	Nitrite	Nitrite	0	No Value	2.50E+00	NA
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	1.0E+04	7.50E-01	3.03E+03
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	No Value	7.50E-01	NA
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	1.0E+04	—	3.03E+03
14808-79-8	Sulfate	sulfate	0	No Value	5.00E+00	NA
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	6.9E+01	8.25E-01	2.09E+01
67-64-1	Acetone	Acetone	0.0006	7.4E+05	2.00E-02	2.28E+05
107-21-1	Ethylene Glychol	Ethylene Glychol	0.001	1,640,000	—	NR
111-76-2	2-Butoxyethanol	Ethylene Glychol Mono Butyl Ether	0.001	82044	—	2.58E+04
75-99-0	Dalapon	Dalapon	0.0027	10773	—	3.55E+03
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.00277	2.3E+03	3.30E-01	7.74E+02
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.00451	4.9E+05	1.00E-02	1.71E+05
74-87-3	Chloromethane	chloromethane	0.006	No Value	1.00E-02	NA
74-83-9	Bromomethane	bromomethane	0.009	4.7E+01	1.00E-02	1.90E+01
60-29-7	Diethylether	Diethylether	0.009699	96000	—	3.98E+04
75-09-2	Methylene chloride	methylene chloride	0.01	4.6E+00	5.00E-03	1.93E+00
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	6.1E+04	1.00E-02	2.72E+04
591-78-6	2-Hexanone	HEXANONE;2-[MBK, methyl butyl ketone]	0.01498	3.4E+03	2.00E-02	1.62E+03
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.019	2.5E-02	5.00E-03	1.31E-02
75-00-3	Chloroethane	ethyl chloride	0.0217	No Value	1.00E-02	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	5.0E-03	3.30E-01	3.30E-01
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	3.4E-01	5.00E-03	2.05E-01
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	3.4E-01	5.00E-03	2.05E-01
108-95-2	Phenol	Phenol	0.0288	1.0E+04	3.30E-01	6.21E+03
94-75-7	2,4-D	2,4-Dichlorophenoxyacetic acid	0.029	1.0E+02	—	6.24E+01
1918-00-9	Dicamba	Dicamba	0.029	2.46E+04	—	1.53E+04
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	2.7E+05	3.30E-01	1.76E+05
[redacted]	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	[redacted]	[redacted]	[redacted]	[redacted]
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	3.8E-01	5.00E-03	2.82E-01
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	1.4E+02	5.00E-03	1.04E+02
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	4-Amino-3,5,6-trichloropicolinic acid	0.039	57431	—	4.35E+04
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0392	3.7E+01	3.30E-01	2.85E+01
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	2.1E+03	5.00E-03	1.61E+03
75-69-4	Trichloromonofluoromethane	Trichloromonofluoromethane	0.04389	35800	—	2.90E+04
75-15-0	Carbon disulfide	carbon disulfide	0.046	1.3E+04	5.00E-03	1.11E+04
78-59-1	Isophorone	isophorone	0.0468	8.4E+00	3.30E-01	7.07E+00
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	5.0E-01	5.00E-03	4.22E-01

Table A1-2. Surface Water Screening Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water Screening Values ($\frac{mg}{kg}$) [1,2,3,4,5] Irrigation Recharge Scenario
93-76-5	2,4,5-T	2,4,5-Trichlorophenoxyacetic acid	0.049	No Value	—	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.0516	1.0E+02	3.30E-01	9.22E+01
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.0516	8.1E+01	3.30E-01	7.26E+01
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.0527	2.6E+03	3.30E-01	2.36E+03
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	7.4E+04	1.00E-02	6.72E+04
67-66-3	Chloroform	chloroform	0.053	5.7E+00	5.00E-03	5.21E+00
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	2.7E-01	5.00E-03	2.54E-01
71-43-2	Benzene	Benzene	0.062	1.2E+00	5.00E-03	1.24E+00
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.063	4.0E-01	5.00E-03	4.16E-01
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	5.7E-02	1.00E-02	6.05E-02
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	1.2E+02	3.30E-01	1.31E+02
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0725	4.6E+00	3.30E-01	5.33E+00
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	5.9E-01	5.00E-03	6.95E-01
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	3.0E-02	3.30E-01	3.30E-01
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	1.7E-01	5.00E-03	2.10E-01
93-72-1	2,4,5-TP	(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	10	—	1.25E+01
84-66-2	Diethylphthalate	diethyl phthalate	0.082	1.7E+04	3.30E-01	2.16E+04
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	2.5E+00	5.00E-03	3.51E+00
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	1.1E-01	3.30E-01	3.30E-01
94-82-6	2,4-DB	(4-(2,4-Dichlorophenoxy)butanoic acid)	0.1	6564	—	9.74E+03
96-95-3	Nitrobenzene	Nitrobenzene	0.119	1.7E+01	3.30E-01	2.76E+01
75-25-2	Bromoform	bromoform	0.13	4.3E+00	5.00E-03	7.36E+00
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.14	9.3E+05	5.00E-03	NR
108-88-3	Toluene	Toluene	0.14	1.3E+03	5.00E-03	2.35E+03
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	7.7E+01	3.30E-01	1.44E+02
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	2.3E-01	5.00E-03	4.44E-01
100-41-4	Ethylbenzene	ethylbenzene	0.2	1.6E+01	5.00E-03	4.19E+01
108-38-3	m-Xylene	Xylene, m-	0.2	No Value	—	NA
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	3.8E+02	3.30E-01	1.04E+03
108-90-7	Chlorobenzene	chlorobenzene	0.22	1.3E+02	5.00E-03	3.70E+02
1330-20-7	Xylenes (total)	Xylenes (total)	0.23	No Value	1.00E-02	NA
95-47-6	o-Xylene	xylene,o-	0.24	No Value	—	NA
[redacted]	Tetrachloroethene	tetrachloroethylene	[redacted]	[redacted]	[redacted]	[redacted]
88-75-5	2-Nitrophenol	nitrophenol;2-	0.297	No Value	6.60E-01	NA
[redacted]	4-Nitrophenol	nitrophenol;4-	[redacted]	[redacted]	[redacted]	[redacted]
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2-(ortho-Dichlorobenzene)	0.379	4.2E+02	3.30E-01	1.99E+03
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.381	1.4E+00	3.30E-01	6.66E+00
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.388	8.1E+01	3.30E-01	3.94E+02
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.434	3.2E+02	3.30E-01	1.72E+03
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.434	1.2E+04	3.30E-01	6.53E+04

Table A1-2. Surface Water Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water Screening Values $\left(\frac{mg}{kg}\cdot m\right)$ [1,2,3,4,5] Irrigation Recharge Scenario
[redacted]	4-Methylphenol (cresol, p-)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.4918	3.1E+04	3.30E-01	1.87E+05
87-86-5	Pentachlorophenol	pentachlorophenol	0.592	2.7E-01	3.30E-01	1.98E+00
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.6015	1.3E+01	3.30E-01	9.70E+01
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4 - (para-Dichlorobenzene)	0.616	2.2E+01	5.00E-03	1.65E+02
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.724	2.1E-02	3.30E-01	3.30E-01
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	1.0E+01	—	6*
100-42-5	Styrene	styrene	0.91	3.8E+04	5.00E-03	NR
91-20-3	Naphthalene	naphthalene	1.19	4.9E+03	1.00E-01	6.97E+04
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	3.3E+00	3.30E-01	4.93E+01
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	1.9E-02	1.65E-03	2.94E-01
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	2.0E+03	3.30E-01	3.56E+04
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	4.9E+02	3.30E-01	8.85E+03
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	2.0E+00	3.30E-01	3.72E+01
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	2.6E-03	1.65E-03	5.33E-02
67-72-1	Hexachloroethane	hexachloroethane	1.78	1.4E+00	3.30E-01	2.92E+01
126-73-8	Tributyl phosphate	Tributyl phosphate	1.89	24.3	—	5.56E+02
959-98-8	Endosulfan I	Endosulfan I	2.04	5.6E-02	1.65E-03	1.43E+00
33213-65-9	Endosulfan II	Endosulfan II	2.04	5.6E-02	3.30E-03	1.43E+00
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	2.04	9.3E-01	3.30E-03	2.38E+01
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	9.1E-03	1.65E-03	2.39E-01
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	No Value	1.65E-03	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.98	1.0E+03	3.30E-01	3.35E+04
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.98	1.4E+02	3.30E-01	4.65E+03
7440-42-8	Boron	Boron	3	No Value	2.00E+00	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	No Value	3.30E-01	NA
86-74-8	Carbazole	carbazole	3.39	No Value	3.30E-01	NA
7723-14-0	Phosphorus	phosphorus	3.5	No Value	5.00E+01	NA
88-85-7	Dinoseb	2-secButyl-4,6-dinitrophenol	3.5	No Value	—	NA
7440-36-0	Antimony	antimony	3.76	5.6E+00	6.00E-01	2.52E+02
7782-49-2	Selenium	selenium and compounds	5	5.0E+00	1.00E+00	3.02E+02
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	No Value	1.00E-01	NA
83-32-9	Acenaphthene	acenaphthene	6.12	6.4E+02	1.00E-01	4.94E+04
86-73-7	Fluorene	fluorene	7.71	1.1E+03	3.00E-02	1.06E+05
76-44-8	Heptachlor	heptachlor	9.53	7.9E-05	1.65E-03	9.71E-03

Table A1-2. Surface Water Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water Screening Values $\left(\frac{mg}{kg}\text{-}m\right)$ [1,2,3,4,5]
						Irrigation Recharge Scenario
53494-70-5	Endrin ketone	Endrin ketone	9.72	No Value	3.30E-03	NA
57-12-5	Cyanide	cyanide	9.9	5.2E+00	—	6.61E+02
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	10.3	6.4E-05	1.65E-02	1.65E-02
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	10.3	6.4E-05	1.65E-02	1.65E-02
72-20-8	Endrin	endrin	10.8	2.3E-03	3.30E-03	3.18E-01
7421-93-4	Endrin aldehyde	Endrin aldehyde	10.8	2.9E-01	3.30E-03	4.01E+01
132-64-9	Dibenzofuran	dibenzofuran	11.3	1.7E+00	3.30E-01	2.47E+02
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	8.2E+00	3.30E-01	1.50E+03
85-01-8	Phenanthrene	Phenanthrene	16.7	No Value	5.00E-02	NA
7439-98-7	Molybdenum	molybdenum	20	1.3E+03	2.00E+00	NR
7440-50-8	Copper	copper	22	9.0E+00	1.00E+00	3.40E+03
120-12-7	Anthracene	anthracene	23.5	8.3E+03	5.00E-02	NR
7440-39-3	Barium	Barium	25	1.0E+03	5.00E-01	NR
7439-89-6	Iron	Iron	25	3.0E+02	5.00E+00	1.43E+05
7440-24-6	Strontium	strontium	25	2.6E+04	1.00E+00	NR
60-57-1	Dieldrin	dieldrin	25.6	5.2E-05	3.30E-03	2.60E-02
7440-38-2	Arsenic	arsenic, inorganic	29	1.8E-02	1.00E+00	1.17E+01
7440-43-9	Cadmium	cadmium	30	2.5E-01	2.00E-01	1.76E+02
7439-92-1	Lead	lead	30	2.1E+00	5.00E-01	1.48E+03
7439-97-6	Mercury	mercury	30	1.2E-02	—	8.45E+00
7440-66-6	Zinc	zinc	30	9.1E+01	1.00E+00	6.41E+04
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	43.9	6.4E-05	1.65E-02	1.33E-01
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	44.8	6.4E-05	1.65E-02	1.43E-01
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	3.1E-04	3.30E-03	7.49E-01
309-00-2	Aldrin	aldrin	48.7	4.9E-05	1.65E-03	1.48E-01
206-44-0	Fluoranthene	fluoranthene	49.1	9.0E+01	5.00E-02	2.82E+05
7440-48-4	Cobalt	Cobalt	50	2.6E+00	2.00E+00	NR
7439-93-2	Lithium	Lithium	50	No Value	2.50E+00	NA
7439-96-5	Manganese	manganese	50	5.0E+01	5.00E+00	NR
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	5.7E-04	1.65E-02	NR
57-74-9	Chlordane	chlordane	51	5.7E-04	1.65E-02	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	53.7	4.4E-01	3.30E-01	NR
7440-02-0	Nickel	nickel soluble salts	65	5.2E+01	4.00E+00	NR
129-00-0	Pyrene	pyrene	68	8.3E+02	5.00E-02	NR
[redacted]	[redacted]	Thallium, soluable salts	[redacted]	[redacted]	[redacted]	[redacted]
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	75.6	6.4E-05	1.65E-02	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	2.8E-04	3.30E-01	NR
72-43-5	Methoxychlor	methoxychlor	80	3.0E-02	1.65E-02	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83.2	3.9E-05	1.65E-03	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86.4	2.2E-04	3.30E-03	NR
7440-22-4	Silver	silver	90	2.6E+00	2.00E-01	NR
8001-35-2	Toxaphene	toxaphene	95.8	2.0E-04	1.65E-01	NR
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	6.4E-05	1.65E-02	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	110	1.2E+00	3.30E-01	NR
7440-31-5	Tin	tin	130	5.2E+02	1.00E+01	NR

Table A1-2. Surface Water Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water Screening Values $\left(\frac{mg}{kg}\text{-}m\right)$ [1,2,3,4,5] Irrigation Recharge Scenario
16984-48-8	Fluoride	fluoride (using fluorine)	150	1.6E+04	5.00E+00	NR
7440-47-3	Chromium	chromium (total)	200	6.5E+01	2.00E-01	NR
218-01-9	Chrysene	Chrysene	200	2.8E-03	1.00E-01	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	4.0E+01	3.30E-01	NR
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	360	2.8E-03	1.50E-02	NR
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	2.2E-04	3.30E-03	NR
7440-41-7	Beryllium	beryllium	790	2.7E+02	2.00E-01	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	803	2.8E-03	1.50E-02	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	6.4E-05	1.65E-02	NR
7440-62-2	Vanadium	vanadium	1000	No Value	2.50E+00	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	2.8E-03	1.50E-02	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	8.7E+01	5.00E+00	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1790	2.8E-03	3.00E-02	NR
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	No Value	3.00E-02	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	2.8E-03	3.00E-02	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	5500	2.8E-03	1.50E-02	NR
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83000	No Value	3.30E-01	NA
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	No Value	No Value	3.30E-01	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	No Value	No Value	3.30E-01	NA
7440-69-9	Bismuth	Bismuth	No Value	No Value	1.00E+01	NA
24959-67-9	Bromide	Bromide	No Value	No Value	2.50E+00	NA
7440-70-2	Calcium	Calcium	No Value	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	No Value	—	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	No Value	No Value	7.50E+01	NA
14265-44-2	Phosphate	Phosphate	No Value	No Value	5.00E+00	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	No Value	No Value	—	NA
7440-09-7	Potassium	Potassium	No Value	No Value	4.00E+02	NA
7440-21-3	Silicon	Silicon	No Value	No Value	2.00E+00	NA
7440-23-5	Sodium	Sodium	No Value	No Value	5.00E+01	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	No Value	No Value	—	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	No Value	No Value	—	NA

Table A1-2. Surface Water Screening Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water Screening Values $\left(\frac{mg}{kg}\right)$ [1,2,3,4,5]
						Irrigation Recharge Scenario

1. All COPC screening values default to the estimated quantitation limit (EQL) when the calculated value is less than the EQL.
2. * indicates that Cr(VI) value set to a maximum value of 6.0 mg/kg because the K_d value used in the model was derived from experiments with soil concentrations less than 6.0 mg/kg. Scaling by representative length across the waste site decision unit in the general direction of groundwater flow is not applicable to this COPC because of this limit.
3. "NR" indicates non-representative results when there is no breakthrough simulated within 1000 years for four or more of the five soil representative columns (where breakthrough is defined as concentrations exceeding 1.0E-04 µg/L).
4. "NA" indicates an applicable water quality standard is not available to calculate the SSL or PRG values.
5. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup 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 cleanup value for evaluation use.

CAS = Chemical Abstract Service

Cyan highlight denotes calculated values that changed as a result of incorporating updated IRIS (EPA's Integrated Risk Information System) groundwater standard values.

Table A1-3. Groundwater Screening Values for Radionuclides

Radionuclide Contaminant of Potential Concern	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Maximum Contaminant Level (pCi/L)	Half-life (yr)	EQL (mg/kg)	Groundwater Screening Values $\left(\frac{pCi}{g}\cdot m\right)$ [1,2,3,4]
					Irrigation Recharge Scenario
Carbon-14[5]	0	2000	5.7300E+03	—	6.06E+02
Technetium-99	0	900	2.1300E+05	—	2.72E+02
Tritium	0	20000	1.2350E+01	—	9.18E+03
Iodine-129	1	1	1.5700E+07	—	1.28E+01
Neptunium-237	15	15	2.1400E+06	—	3.04E+03
Strontium-90	25	8	2.9120E+01	—	2.27E+05
Nickel-63	30	50	9.6000E+01	—	3.17E+05
Cesium-137	50	200	3.0000E+01	1.0000E-01	NR
Cobalt-60	50	100	5.7210E+00	5.0000E-02	NR
Americium-241	200	15	4.32E+02	1.00E+00	NR
Carbon-14[6]	200	2,000	5.73E+03	—	NR
Cm-243	200	15	2.85E+01	—	NR
Europium-152	200	200	1.33E+01	1.00E-01	NR
Europium-154	200	60	8.80E+00	1.00E-01	NR
Europium-155	200	600	4.96E+00	1.00E-01	NR
Niobium-94	200	No Value	2.03E+04	—	NA
Plutonium-238	200	15	8.77E+01	1.00E+00	NR
Plutonium-239	200	15	2.41E+04	1.00E+00	NR
Plutonium-240	200	15	6.54E+03	1.00E+00	NR
Plutonium-241	200	300	1.40E+01	—	NR
Radium-226	200	5	1.60E+03	—	NR
Radium-228	200	5	5.75E+00	2.00E-01	NR
Thorium-228	200	15	1.91E+00	—	NR
Thorium-230	200	15	7.70E+04	—	NR
Thorium-232	200	15	1.41E+10	—	NR

1. All COPC screening values default to the estimated quantitation limit (EQL) when the calculated value is less than the EQL.
2. "NR" indicates non-representative results where there is no breakthrough simulated within 1000 years for at least four of the five soil columns (where breakthrough is defined as concentrations above 1.0E-04 pCi/L).
3. "NA" indicates an applicable water quality standard is not available to calculate the SSL or PRG values.
4. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup 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 cleanup value for evaluation use.
5. Carbon-14 in liquid form, typically associated with reactor gas condensate.
6. Carbon-14 in solid form, typically associated with graphite.

Attachment A-2

Preliminary Remediation Goal (PRG) Values for 300 Area for Native Vegetation and Industrial Recharge Scenarios

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Table A2-1. Groundwater Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Groundwater Standard (µg/L)	EQL (mg/kg)	Groundwater PRG Values $\left(\frac{mg}{kg}\cdot m\right)$ [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
16887-00-6	Chloride	chloride	0	2.5E+05	2.00E+00	1.13E+05	1.17E+05
14797-55-8	Nitrate	Nitrate	0	4.5E+04	2.50E+00	2.03E+04	2.10E+04
14797-65-0	Nitrite	Nitrite	0	3.3E+03	2.50E+00	1.49E+03	1.54E+03
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	1.0E+04	7.50E-01	4.51E+03	4.67E+03
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	1.0E+03	7.50E-01	4.51E+02	4.67E+02
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	1.0E+04	—	4.51E+03	4.67E+03
14808-79-8	Sulfate	sulfate	0	2.5E+05	5.00E+00	1.13E+05	1.17E+05
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	3.2E+01	8.25E-01	1.44E+01	1.50E+01
67-64-1	Acetone	Acetone	0.0006	7.2E+03	2.00E-02	3.32E+03	3.44E+03
107-21-1	Ethylene Glychol	Ethylene Glychol	0.001	16,000	—	7.50E+03	7.77E+03
111-76-2	2-Butoxyethanol	Ethylene Glychol Mono Butyl Ether	0.001	800	—	3.75E+02	3.88E+02
75-99-0	Dalapon	Dalapon	0.0027	200	—	9.85E+01	1.02E+02
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.00277	4.8E+01	3.30E-01	2.37E+01	2.46E+01
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.00451	4.8E+03	1.00E-02	2.50E+03	2.59E+03
74-87-3	Chloromethane	chloromethane	0.006	No Value	1.00E-02	NA	NA
74-83-9	Bromomethane	bromomethane	0.009	1.1E+01	1.00E-02	6.82E+00	7.06E+00
60-29-7	Diethylether	Diethylether	0.009699	1600	—	1.00E+03	1.04E+03
75-09-2	Methylene chloride	methylene chloride	0.01	5.0E+00	5.00E-03	3.16E+00	3.27E+00
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	6.4E+02	1.00E-02	4.30E+02	4.45E+02
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.01498	4.0E+01	2.00E-02	2.85E+01	2.95E+01
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.019	6.1E-02	5.00E-03	4.84E-02	5.00E-02
75-00-3	Chloroethane	ethyl chloride	0.0217	No Value	1.00E-02	NA	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	1.3E-02	3.30E-01	3.30E-01	3.30E-01
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	4.4E-01	5.00E-03	4.05E-01	4.18E-01
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	4.4E-01	5.00E-03	4.05E-01	4.18E-01
108-95-2	Phenol	Phenol	0.0288	2.4E+03	3.30E-01	2.30E+03	2.37E+03
94-75-7	2,4-D	2,4-Dichlorophenoxyacetic acid	0.029	70	—	6.72E+01	6.94E+01
1918-00-9	Dicamba	Dicamba	0.029	480	—	4.61E+02	4.76E+02
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	No Value	3.30E-01	NA	NA
[redacted]	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	4.8E-01	5.00E-03	5.58E-01	5.75E-01
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	1.0E+02	5.00E-03	1.16E+02	1.20E+02
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	4-Amino-3,5,6-trichloropicolinic acid	0.039	500	—	5.94E+02	6.12E+02
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0392	6.3E-01	3.30E-01	7.46E-01	7.68E-01
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	7.2E+01	5.00E-03	8.67E+01	8.93E+01
75-69-4	Trichloromonofluoromethane	Trichloromonofluoromethane	0.04389	2400	—	3.07E+03	3.16E+03
75-15-0	Carbon disulfide	carbon disulfide	0.046	8.0E+02	5.00E-03	1.06E+03	1.09E+03
78-59-1	Isophorone	isophorone	0.0468	4.6E+01	3.30E-01	6.15E+01	6.32E+01
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	1.2E+00	5.00E-03	1.63E+00	1.67E+00

Table A2-1. Groundwater Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Groundwater Standard (µg/L)	EQL (mg/kg)	Groundwater PRG Values [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
93-76-5	2,4,5-T	2,4,5-Trichlorophenoxyacetic acid	0.049	160	---	2.21E+02	2.27E+02
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.0516	4.2E+00	3.30E-01	5.97E+00	6.13E+00
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.0516	4.4E+00	3.30E-01	6.27E+00	6.44E+00
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.0527	1.6E+02	3.30E-01	2.33E+02	2.39E+02
[redacted]	1,1-Dichloroethane	dichloroethane;1,1-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
67-66-3	Chloroform	chloroform	0.053	1.4E+00	5.00E-03	2.07E+00	2.12E+00
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	7.1E-01	5.00E-03	1.07E+00	1.09E+00
71-43-2	Benzene	Benzene	0.062	8.0E-01	5.00E-03	1.34E+00	1.37E+00
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.063	5.2E-01	5.00E-03	8.88E-01	9.08E-01
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	7.0E+00	1.00E-02	1.22E+01	1.25E+01
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	1.6E+01	3.30E-01	2.94E+01	3.00E+01
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0725	2.2E-01	3.30E-01	4.19E-01	4.27E-01
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	7.7E-01	5.00E-03	1.52E+00	1.55E+00
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	4.0E-02	3.30E-01	3.30E-01	3.30E-01
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	2.2E-01	5.00E-03	4.58E-01	4.65E-01
93-72-1	2,4,5-TP	(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	50	---	1.06E+02	1.08E+02
84-66-2	Diethylphthalate	diethyl phthalate	0.082	1.3E+04	3.30E-01	2.77E+04	2.81E+04
[redacted]	Trichloroethene	trichloroethylene (TCE)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	2.8E-01	3.30E-01	7.08E-01	7.15E-01
94-82-6	2,4-DB	(4-(2,4-Dichlorophenoxy)butanoic acid)	0.1	128	---	3.39E+02	3.41E+02
98-95-3	Nitrobenzene	Nitrobenzene	0.119	1.6E+01	3.30E-01	4.76E+01	4.77E+01
75-25-2	Bromoform	bromoform	0.13	5.5E+00	5.00E-03	1.78E+01	1.77E+01
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.14	2.0E+02	5.00E-03	6.90E+02	6.86E+02
108-88-3	Toluene	Toluene	0.14	6.4E+02	5.00E-03	2.21E+03	2.19E+03
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	2.4E+01	3.30E-01	8.75E+01	8.66E+01
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	5.3E-01	5.00E-03	2.89E+00	2.36E+00
100-41-4	Ethylbenzene	ethylbenzene	0.2	4.0E+00	5.00E-03	2.51E+01	2.39E+01
108-38-3	m-Xylene	Xylene, m-	0.2	1.6E+03	---	1.01E+04	9.60E+03
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	1.6E+02	3.30E-01	1.06E+03	1.00E+03
108-90-7	Chlorobenzene	chlorobenzene	0.22	1.0E+02	5.00E-03	6.99E+02	6.59E+02
1330-20-7	Xylenes (total)	Xylenes (total)	0.23	1.6E+03	1.00E-02	1.18E+04	1.11E+04
95-47-6	o-Xylene	xylene,o-	0.24	1.6E+03	---	1.25E+04	1.17E+04
[redacted]	Tetrachloroethene	tetrachloroethylene	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
88-75-5	2-Nitrophenol	nitrophenol;2-	0.297	No Value	6.60E-01	NA	NA
[redacted]	4-Nitrophenol	nitrophenol;4-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2-(ortho-Dichlorobenzene)	0.379	6.0E+02	3.30E-01	1.10E+04	8.50E+03
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.381	4.0E+00	3.30E-01	7.35E+01	5.67E+01
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.388	4.0E+01	3.30E-01	7.73E+02	5.86E+02
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.434	No Value	3.30E-01	NA	NA
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.434	4.0E+02	3.30E-01	9.60E+03	6.58E+03

Table A2-1. Groundwater Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Groundwater Standard (µg/L)	EQL (mg/kg)	Groundwater PRG Values ($\frac{mg}{L}$) [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
	4-Methylphenol (cresol, p-)						
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.4918	1.6E+03	3.30E-01	5.08E+04	2.98E+04
	Pentachlorophenol	pentachlorophenol					
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.6015	1.3E+00	3.30E-01	6.38E+01	2.90E+01
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.616	8.1E+00	5.00E-03	4.22E+02	1.87E+02
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.724	1.9E-01	3.30E-01	1.47E+01	5.25E+00
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	4.8E+01	—	6*	6*
100-42-5	Styrene	styrene	0.91	1.0E+02	5.00E-03	1.33E+04	3.38E+03
91-20-3	Naphthalene	naphthalene	1.19	1.6E+02	1.00E-01	NR	7.03E+03
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	1.8E+01	3.30E-01	NR	8.49E+02
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	8.0E-02	1.65E-03	NR	3.95E+00
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	1.6E+03	3.30E-01	NR	9.23E+04
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	8.0E+02	3.30E-01	NR	4.70E+04
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	1.5E+00	3.30E-01	NR	9.19E+01
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	1.4E-02	1.65E-03	NR	8.96E-01
	Hexachloroethane	hexachloroethane					
126-73-8	Tributyl phosphate	Tributyl phosphate	1.89	9.51	—	NR	6.58E+02
959-98-8	Endosulfan I	Endosulfan I	2.04	9.6E+01	1.65E-03	NR	7.16E+03
33213-65-9	Endosulfan II	Endosulfan II	2.04	9.6E+01	3.30E-03	NR	7.16E+03
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	2.04	No Value	3.30E-03	NA	NA
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	4.9E-02	1.65E-03	NR	3.73E+00
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	No Value	1.65E-03	NA	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.98	6.4E+02	3.30E-01	NR	6.44E+04
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.98	3.2E+01	3.30E-01	NR	3.22E+03
7440-42-8	Boron	Boron	3	3.2E+03	2.00E+00	NR	3.25E+05
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	No Value	3.30E-01	NA	NA
86-74-8	Carbazole	carbazole	3.39	4.4E+00	3.30E-01	NR	5.11E+02
88-85-7	Dinoseb	2-secButyl-4,6-dinitrophenol	3.5	7	—	NR	8.53E+02
7440-36-0	Antimony	antimony	3.76	6.0E+00	6.00E-01	NR	8.15E+02
7782-49-2	Selenium	selenium and compounds	5	5.0E+01	1.00E+00	NR	9.12E+03
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	No Value	1.00E-01	NA	NA
	Acenaphthene	acenaphthene					
76-44-8	Heptachlor	heptachlor	9.53	1.9E-02	1.65E-03	NR	7.40E+00
53494-70-5	Endrin ketone	Endrin ketone	9.72	No Value	3.30E-03	NA	NA

Table A2-1. Groundwater Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Groundwater Standard (µg/L)	EQL (mg/kg)	Groundwater PRG Values (µg/L) [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
[redacted]	Aroclor-1221	aroclor 1221 [PCB]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	Aroclor-1232	aroclor 1232 [PCB]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
72-20-8	Endrin	endrin	10.8	2.0E+00	3.30E-03	NR	8.49E+02
7421-93-4	Endrin aldehyde	Endrin aldehyde	10.8	No Value	3.30E-03	NA	NA
[redacted]	Dibenzofuran	dibenzofuran	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	4.6E+01	3.30E-01	NR	2.68E+04
85-01-8	Phenanthrene	Phenanthrene	16.7	No Value	5.00E-02	NA	NA
7439-98-7	Molybdenum	molybdenum	20	8.0E+01	2.00E+00	NR	NR
7440-50-8	Copper	copper	22	6.4E+02	1.00E+00	NR	NR
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7440-39-3	Barium	Barium	25	2.0E+03	5.00E-01	NR	NR
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7440-24-6	Strontium	strontium	25	9.6E+03	1.00E+00	NR	NR
60-57-1	Dieldrin	dieldrin	25.6	5.5E-03	3.30E-03	NR	NR
7440-38-2	Arsenic	arsenic, inorganic	29	5.8E-02	1.00E+00	NR	NR
7440-43-9	Cadmium	cadmium	30	5.0E+00	2.00E-01	NR	NR
7439-92-1	Lead	lead	30	1.5E+01	5.00E-01	NR	NR
7439-97-6	Mercury	mercury	30	2.0E+00	—	NR	NR
7440-66-6	Zinc	zinc	30	4.8E+03	1.00E+00	NR	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	43.9	4.4E-02	1.65E-02	NR	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	44.8	4.4E-02	1.65E-02	NR	NR
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	3.6E-01	3.30E-03	NR	NR
309-00-2	Aldrin	aldrin	48.7	2.6E-03	1.65E-03	NR	NR
206-44-0	Fluoranthene	fluoranthene	49.1	6.4E+02	5.00E-02	NR	NR
7440-48-4	Cobalt	Cobalt	50	4.8E+00	2.00E+00	NR	NR
7439-93-2	Lithium	Lithium	50	3.2E+01	2.50E+00	NR	NR
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	2.5E-01	1.65E-02	NR	NR
57-74-9	Chlordane	chlordane	51	2.5E-01	1.65E-02	NR	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	53.7	5.6E-01	3.30E-01	NR	NR
7440-02-0	Nickel	nickel soluble salts	65	1.0E+02	4.00E+00	NR	NR
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	Thallium, soluable salts	[redacted]	1.6E-01	[redacted]	[redacted]	[redacted]
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	75.6	4.4E-02	1.65E-02	NR	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	5.5E-02	3.30E-01	NR	NR
72-43-5	Methoxychlor	methoxychlor	80	4.0E+01	1.65E-02	NR	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83.2	4.8E-03	1.65E-03	NR	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86.4	2.6E-01	3.30E-03	NR	NR
7440-22-4	Silver	silver	90	8.0E+01	2.00E-01	NR	NR
8001-35-2	Toxaphene	toxaphene	95.8	8.0E-02	1.65E-01	NR	NR
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	5.0E-01	1.65E-02	NR	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	110	6.0E+00	3.30E-01	NR	NR
7440-31-5	Tin	tin	130	9.6E+03	1.00E+01	NR	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	9.6E+02	5.00E+00	NR	NR
7440-47-3	Chromium	chromium (total)	200	1.0E+02	2.00E-01	NR	NR

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						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
218-01-9	Chrysene	Chrysene	200	1.2E+00	1.00E-01	NR	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	4.8E+01	3.30E-01	NR	NR
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	360	1.2E-01	1.50E-02	NR	NR
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	2.6E-01	3.30E-03	NR	NR
7440-41-7	Beryllium	beryllium	790	4.0E+00	2.00E-01	NR	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	803	1.2E-01	1.50E-02	NR	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	4.4E-02	1.65E-02	NR	NR
7440-62-2	Vanadium	vanadium	1000	8.0E+01	2.50E+00	NR	NR
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	1.2E-01	1.50E-02	NR	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	5.0E+01	5.00E+00	NR	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1790	1.2E-01	3.00E-02	NR	NR
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	No Value	3.00E-02	NA	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	1.2E-01	3.00E-02	NR	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	5500	1.2E-02	1.50E-02	NR	NR
	Di-n-octylphthalate	di-n-octyl phthalate					
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	No Value	No Value	3.30E-01	NA	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	No Value	No Value	3.30E-01	NA	NA
7440-69-9	Bismuth	Bismuth	No Value	No Value	1.00E+01	NA	NA
24959-67-9	Bromide	Bromide	No Value	No Value	2.50E+00	NA	NA
7440-70-2	Calcium	Calcium	No Value	No Value	1.00E+02	NA	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	No Value	No Value	—	NA	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	No Value	No Value	7.50E+01	NA	NA
14265-44-2	Phosphate	Phosphate	No Value	No Value	5.00E+00	NA	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	No Value	No Value	—	NA	NA
7440-09-7	Potassium	Potassium	No Value	No Value	4.00E+02	NA	NA
7440-21-3	Silicon	Silicon	No Value	No Value	2.00E+00	NA	NA
7440-23-5	Sodium	Sodium	No Value	No Value	5.00E+01	NA	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	No Value	5.0E+02	—	NA	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	No Value	5.0E+02	—	NA	NA

1. All COPC screening values default to the estimated quantitation limit (EQL) when the calculated value is less than the EQL.
2. * indicates that Cr(VI) value set to a maximum value of 6.0 mg/kg because the K_d value used in the model was derived from experiments with soil concentrations less than 6.0 mg/kg. Scaling by representative length across the waste site decision unit in the general direction of groundwater flow is not applicable to this COPC because of this limit.
3. "NR" indicates non-representative results when there is no breakthrough simulated within 1000 years for four or more of the five soil representative columns (where breakthrough is defined as concentrations exceeding 1.0E-04 µg/L).
4. "NA" indicates an applicable water quality standard is not available to calculate the SSL or PRG values.
5. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup 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 cleanup value for evaluation use.

CAS = Chemical Abstract Service

Cyan highlight denotes calculated values that **changed as a result of incorporating updated IRIS (EPA's Integrated Risk Information System)** groundwater standard values.

Table A2-2. Surface Water Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water PRG Values [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
16887-00-6	Chloride	chloride	0	2.3E+05	2.00E+00	1.04E+05	1.07E+05
14797-55-8	Nitrate	Nitrate	0	4.5E+04	2.50E+00	2.03E+04	2.10E+04
14797-65-0	Nitrite	Nitrite	0	No Value	2.50E+00	NA	NA
NO3-N	Nitrogen in Nitrate	Nitrogen in Nitrate	0	1.0E+04	7.50E-01	4.51E+03	4.67E+03
NO2-N	Nitrogen in Nitrite	Nitrogen in Nitrite	0	No Value	7.50E-01	NA	NA
NO2+NO3-N	Nitrogen in Nitrite and Nitrate	Nitrogen in Nitrite and Nitrate	0	1.0E+04	—	4.51E+03	4.67E+03
14808-79-8	Sulfate	sulfate	0	No Value	5.00E+00	NA	NA
51-28-5	2,4-Dinitrophenol	dinitrophenol;2,4-	0.00001	6.9E+01	8.25E-01	3.11E+01	3.22E+01
67-64-1	Acetone	Acetone	0.0006	7.4E+05	2.00E-02	3.41E+05	3.53E+05
107-21-1	Ethylene Glychol	Ethylene Glychol	0.001	1,640,000	—	NR	NR
111-76-2	2-Butoxyethanol	Ethylene Glychol Mono Butyl Ether	0.001	82044	—	3.84E+04	3.98E+04
75-99-0	Dalapon	Dalapon	0.0027	10773	—	5.31E+03	5.50E+03
111-91-1	Bis(2-Chloroethoxy)methane	bis(2-chloroethoxyl)methane	0.00277	2.3E+03	3.30E-01	1.16E+03	1.20E+03
78-93-3	2-Butanone	methyl ethyl ketone (MEK; 2-butanone)	0.00451	4.9E+05	1.00E-02	2.57E+05	2.66E+05
74-87-3	Chloromethane	chloromethane	0.006	No Value	1.00E-02	NA	NA
74-83-9	Bromomethane	bromomethane	0.009	4.7E+01	1.00E-02	2.86E+01	2.96E+01
60-29-7	Diethylether	Diethylether	0.009699	96000	—	6.00E+04	6.21E+04
75-09-2	Methylene chloride	methylene chloride	0.01	4.6E+00	5.00E-03	2.91E+00	3.01E+00
108-10-1	4-Methyl-2-pentanone	methyl isobutyl ketone	0.0126	6.1E+04	1.00E-02	4.10E+04	4.25E+04
591-78-6	2-Hexanone	HEXANONE;2- [MBK, methyl butyl ketone]	0.01498	3.4E+03	2.00E-02	2.45E+03	2.53E+03
75-01-4	Vinyl chloride	vinyl chloride [chloroethene; 1-]	0.019	2.5E-02	5.00E-03	1.99E-02	2.06E-02
75-00-3	Chloroethane	ethyl chloride	0.0217	No Value	1.00E-02	NA	NA
621-64-7	n-Nitrosodi-n-dipropylamine	nitroso-di-n-propylamine;N-	0.024	5.0E-03	3.30E-01	3.30E-01	3.30E-01
10061-01-5	cis-1,3-Dichloropropene	dichloropropene;1,2-,cis	0.027	3.4E-01	5.00E-03	3.15E-01	3.25E-01
10061-02-6	trans-1,3-Dichloropropene	dichloropropene;1,3-,trans	0.027	3.4E-01	5.00E-03	3.15E-01	3.25E-01
108-95-2	Phenol	Phenol	0.0288	1.0E+04	3.30E-01	9.57E+03	9.88E+03
94-75-7	2,4-D	2,4-Dichlorophenoxyacetic acid	0.029	100	—	9.61E+01	9.92E+01
1918-00-9	Dicamba	Dicamba	0.029	24613	—	2.36E+04	2.44E+04
131-11-3	Dimethyl phthalate	dimethyl phthalate	0.0316	2.7E+05	3.30E-01	2.73E+05	2.82E+05
	cis-1,2-Dichloroethylene	dichloroethylene;1,2-,cis					
107-06-2	1,2-Dichloroethane	dichloroethane;1,2-	0.038	3.8E-01	5.00E-03	4.41E-01	4.54E-01
156-60-5	trans-1,2-Dichloroethylene	dichloroethylene;1,2-,trans	0.038	1.4E+02	5.00E-03	1.62E+02	1.67E+02
1918-02-1	4-Amino-3,5,6-trichloropicolinic acid	4-Amino-3,5,6-trichloropicolinic acid	0.039	57431	—	6.82E+04	7.02E+04
108-60-1	Bis(2-chloro-1-methylethyl)ether	bis(2-chloro-1-methyl-ethyl)ether	0.0392	3.7E+01	3.30E-01	4.47E+01	4.61E+01
540-59-0	1,2-Dichloroethene (Total)	dichloroethylene,1,2- (mixed isomers)	0.0396	2.1E+03	5.00E-03	2.53E+03	2.61E+03
75-69-4	Trichloromonofluoromethane	Trichloromonofluoromethane	0.04389	35800	—	4.59E+04	4.72E+04
75-15-0	Carbon disulfide	carbon disulfide	0.046	1.3E+04	5.00E-03	1.75E+04	1.80E+04
78-59-1	Isophorone	Isophorone	0.0468	8.4E+00	3.30E-01	1.12E+01	1.15E+01
78-87-5	1,2-Dichloropropane	dichloropropane;1,2-	0.047	5.0E-01	5.00E-03	6.69E-01	6.88E-01

Table A2-2. Surface Water Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water PRG Values (µg/L) [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
93-76-5	2,4,5-T	2,4,5-Trichlorophenoxyacetic acid	0.049	No Value	—	NA	NA
99-09-2	3-Nitroaniline	nitroaniline, 3-	0.0516	1.0E+02	3.30E-01	1.47E+02	1.51E+02
100-01-6	4-Nitroaniline	nitroaniline, 4-	0.0516	8.1E+01	3.30E-01	1.16E+02	1.19E+02
88-74-4	2-Nitroaniline	nitroaniline, 2-	0.0527	2.6E+03	3.30E-01	3.78E+03	3.88E+03
75-34-3	1,1-Dichloroethane	dichloroethane;1,1-	0.053	7.4E+04	1.00E-02	1.08E+05	1.11E+05
67-66-3	Chloroform	chloroform	0.053	5.7E+00	5.00E-03	8.35E+00	8.57E+00
75-27-4	Bromodichloromethane	bromodichloromethane	0.055	2.7E-01	5.00E-03	4.09E-01	4.19E-01
71-43-2	Benzene	Benzene	0.062	1.2E+00	5.00E-03	2.02E+00	2.07E+00
124-48-1	Dibromochloromethane	chlorodibromomethane [dibromochloromethane]	0.063	4.0E-01	5.00E-03	6.82E-01	6.97E-01
75-35-4	1,1-Dichloroethene	Dichloroethene;1,1-	0.065	5.7E-02	1.00E-02	9.95E-02	1.02E-01
606-20-2	2,6-Dinitrotoluene	dinitrotoluene;2,6-	0.0692	1.2E+02	3.30E-01	2.16E+02	2.21E+02
106-47-8	4-Chloroaniline	chloroaniline;p-	0.0725	4.6E+00	3.30E-01	8.89E+00	9.06E+00
79-00-5	1,1,2-Trichloroethane	trichloroethane;1,1,2-	0.075	5.9E-01	5.00E-03	1.17E+00	1.19E+00
111-44-4	Bis(2-chloroethyl) ether	bis(2-chloroethyl)ether	0.076	3.0E-02	3.30E-01	3.30E-01	3.30E-01
79-34-5	1,1,2,2-Tetrachloroethane	tetrachloroethane;1,1,2,2-	0.079	1.7E-01	5.00E-03	3.56E-01	3.61E-01
93-72-1	2,4,5-TP	(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	0.08	10	—	2.12E+01	2.16E+01
84-66-2	Diethylphthalate	diethyl phthalate	0.082	1.7E+04	3.30E-01	3.68E+04	3.74E+04
79-01-6	Trichloroethene	trichloroethylene (TCE)	0.094	2.5E+00	5.00E-03	6.16E+00	6.22E+00
121-14-2	2,4-Dinitrotoluene	dinitrotoluene;2,4-	0.0955	1.1E-01	3.30E-01	3.30E-01	3.30E-01
94-82-6	2,4-DB	(4-(2,4-Dichlorophenoxy)butanoic acid)	0.1	6564	—	1.74E+04	1.75E+04
98-95-3	Nitrobenzene	Nitrobenzene	0.119	1.7E+01	3.30E-01	5.06E+01	5.07E+01
75-25-2	Bromoform	bromoform	0.13	4.3E+00	5.00E-03	1.38E+01	1.38E+01
71-55-6	1,1,1-Trichloroethane	Trichloroethane;1,1,1-	0.14	9.3E+05	5.00E-03	NR	NR
108-88-3	Toluene	Toluene	0.14	1.3E+03	5.00E-03	4.49E+03	4.46E+03
120-83-2	2,4-Dichlorophenol	dichlorophenol;2,4-	0.147	7.7E+01	3.30E-01	2.81E+02	2.78E+02
56-23-5	Carbon tetrachloride	carbon tetrachloride	0.152	2.3E-01	5.00E-03	8.73E-01	8.62E-01
100-41-4	Ethylbenzene	ethylbenzene	0.2	1.6E+01	5.00E-03	9.93E+01	9.42E+01
108-38-3	m-Xylene	Xylene, m-	0.2	No Value	—	NA	NA
105-67-9	2,4-Dimethylphenol	dimethylphenol;2,4-	0.209	3.8E+02	3.30E-01	2.51E+03	2.37E+03
108-90-7	Chlorobenzene	chlorobenzene	0.22	1.3E+02	5.00E-03	9.09E+02	8.57E+02
1330-20-7	Xylenes (total)	Xylenes (total)	0.23	No Value	1.00E-02	NA	NA
95-47-6	o-Xylene	xylene,o-	0.24	No Value	—	NA	NA
[redacted]	Tetrachloroethene	tetrachloroethylene	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
88-75-5	2-Nitrophenol	nitrophenol;2-	0.297	No Value	6.60E-01	NA	NA
[redacted]	4-Nitrophenol	nitrophenol;4-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
95-50-1	1,2-Dichlorobenzene	dichlorobenzene;1,2-(ortho-Dichlorobenzene)	0.379	4.2E+02	3.30E-01	7.67E+03	5.95E+03
88-06-2	2,4,6-Trichlorophenol	Trichlorophenol2,4,6-	0.381	1.4E+00	3.30E-01	2.59E+01	2.00E+01
95-57-8	2-Chlorophenol	Chlorophenol;2-	0.388	8.1E+01	3.30E-01	1.57E+03	1.19E+03
541-73-1	1,3-Dichlorobenzene	dichlorobenzene;1,3	0.434	3.2E+02	3.30E-01	7.68E+03	5.26E+03
95-48-7	2-Methylphenol (cresol, o-)	cresol;o-	0.434	1.2E+04	3.30E-01	2.91E+05	1.99E+05

Table A2-2. Surface Water Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water PRG Values ($\frac{mg}{kg}$-$\frac{m^3}{m^3}$) [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
	4-Methylphenol (cresol, p-)					NR	
59-50-7	4-Chloro-3-methylphenol	chloro-3-methylphenol;4-	0.4918	3.1E+04	3.30E-01	NR	NR
87-86-5	Pentachlorophenol	pentachlorophenol	0.592	2.7E-01	3.30E-01	1.29E+01	6.01E+00
534-52-1	4,6-Dinitro-2-methylphenol	dinitro-2-methylphenol;4,6-	0.6015	1.3E+01	3.30E-01	6.48E+02	2.95E+02
106-46-7	1,4-Dichlorobenzene	dichlorobenzene;1,4- (para-Dichlorobenzene)	0.616	2.2E+01	5.00E-03	1.12E+03	4.99E+02
91-94-1	3,3'-Dichlorobenzidine	dichlorobenzidine;3,3'-	0.724	2.1E-02	3.30E-01	1.59E+00	5.67E-01
18540-29-9	Hexavalent Chromium	chromium(VI)	0.8	1.0E+01	—	6*	6*
100-42-5	Styrene	styrene	0.91	3.8E+04	5.00E-03	NR	NR
91-20-3	Naphthalene	naphthalene	1.19	4.9E+03	1.00E-01	NR	2.17E+05
86-30-6	n-Nitrosodiphenylamine	nitrosodiphenylamine;N-	1.29	3.3E+00	3.30E-01	NR	1.57E+02
58-89-9	Gamma-BHC (Lindane)	lindane [gamma-BHC] (see hexachlorocyclohexane)	1.35	1.9E-02	1.65E-03	NR	9.45E-01
84-74-2	Di-n-butylphthalate	di-butyl phthalate	1.57	2.0E+03	3.30E-01	NR	1.15E+05
95-95-4	2,4,5-Trichlorophenol	Trichlorophenol;2,4,5-	1.6	4.9E+02	3.30E-01	NR	2.86E+04
120-82-1	1,2,4-Trichlorobenzene	trichlorobenzene;1,2,4-	1.66	2.0E+00	3.30E-01	NR	1.19E+02
319-84-6	Alpha-BHC	hexachlorocyclohexane;alpha (alpha-BHC, HCH)	1.76	2.6E-03	1.65E-03	NR	1.68E-01
67-72-1	Hexachloroethane	hexachloroethane	1.78	1.4E+00	3.30E-01	NR	9.14E+01
126-73-8	Tributyl phosphate	Tributyl phosphate	1.89	24.3	—	NR	1.68E+03
959-98-8	Endosulfan I	Endosulfan I	2.04	5.6E-02	1.65E-03	NR	4.17E+00
33213-65-9	Endosulfan II	Endosulfan II	2.04	5.6E-02	3.30E-03	NR	4.17E+00
1031-07-8	Endosulfan sulfate	Endosulfan sulfate	2.04	9.3E-01	3.30E-03	NR	6.93E+01
319-85-7	beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	hexachlorocyclohexane;beta-	2.14	9.1E-03	1.65E-03	NR	6.98E-01
319-86-8	Delta-BHC	hexachlorocyclohexane;delta-	2.81	No Value	1.65E-03	NA	NA
91-58-7	2-Chloronaphthalene	beta-chloronaphthalene	2.98	1.0E+03	3.30E-01	NR	1.01E+05
91-57-6	2-Methylnaphthalene	methylnapthalene;2-	2.98	1.4E+02	3.30E-01	NR	1.40E+04
7440-42-8	Boron	Boron	3	No Value	2.00E+00	NA	NA
7005-72-3	4-Chlorophenylphenyl ether	chlorodiphenyl ether;4-	3.08	No Value	3.30E-01	NA	NA
86-74-8	Carbazole	carbazole	3.39	No Value	3.30E-01	NA	NA
7723-14-0	Phosphorus	phosphorus	3.5	No Value	5.00E+01	NA	NA
88-85-7	Dinoseb	2-secButyl-4,6-dinitrophenol	3.5	No Value	—	NA	NA
7440-36-0	Antimony	antimony	3.76	5.6E+00	6.00E-01	NR	7.60E+02
7782-49-2	Selenium	selenium and compounds	5	5.0E+00	1.00E+00	NR	9.12E+02
208-96-8	Acenaphthylene	acenaphthylene (Not in CLARC database tables; use acenaphthene as surrogate)	5.03	No Value	1.00E-01	NA	NA
83-32-9	Acenaphthene	acenaphthene	6.12	6.4E+02	1.00E-01	NR	1.49E+05
86-73-7	Fluorene	fluorene	7.71	1.1E+03	3.00E-02	NR	3.48E+05
76-44-8	Heptachlor	heptachlor	9.53	7.9E-05	1.65E-03	NR	3.01E-02
53494-70-5	Endrin ketone	Endrin ketone	9.72	No Value	3.30E-03	NA	NA
57-12-5	Cyanide	cyanide	9.9	5.2E+00	—	NR	2.04E+03

Table A2-2. Surface Water Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced In EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water PRG Values $\left(\frac{mg}{kg}\text{-}m\right)$ [1,2,3,4,6]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
11104-28-2	Aroclor-1221	aroclor 1221 [PCB]	10.3	6.4E-05	1.65E-02	NR	2.60E-02
11141-16-5	Aroclor-1232	aroclor 1232 [PCB]	10.3	6.4E-05	1.65E-02	NR	2.60E-02
72-20-8	Endrin	endrin	10.8	2.3E-03	3.30E-03	NR	9.76E-01
7421-93-4	Endrin aldehyde	Endrin aldehyde	10.8	2.9E-01	3.30E-03	NR	1.23E+02
132-64-9	Dibenzofuran	dibenzofuran	11.3	1.7E+00	3.30E-01	NR	7.58E+02
85-68-7	Butylbenzylphthalate	butyl benzyl phthalate	13.8	8.2E+00	3.30E-01	NR	4.80E+03
85-01-8	Phenanthrene	Phenanthrene	16.7	No Value	5.00E-02	NA	NA
7439-98-7	Molybdenum	molybdenum	20	1.3E+03	2.00E+00	NR	NR
7440-50-8	Copper	copper	22	9.0E+00	1.00E+00	NR	NR
120-12-7	Anthracene	anthracene	23.5	8.3E+03	5.00E-02	NR	NR
7440-39-3	Barium	Barium	25	1.0E+03	5.00E-01	NR	NR
7439-89-6	Iron	Iron	25	3.0E+02	5.00E+00	NR	NR
7440-24-6	Strontium	strontium	25	2.6E+04	1.00E+00	NR	NR
60-57-1	Dieldrin	dieldrin	25.6	5.2E-05	3.30E-03	NR	NR
7440-38-2	Arsenic	arsenic, inorganic	29	1.8E-02	1.00E+00	NR	NR
7440-43-9	Cadmium	cadmium	30	2.5E-01	2.00E-01	NR	NR
7439-92-1	Lead	lead	30	2.1E+00	5.00E-01	NR	NR
7439-97-6	Mercury	mercury	30	1.2E-02	—	NR	NR
7440-66-6	Zinc	zinc	30	9.1E+01	1.00E+00	NR	NR
12672-29-6	Aroclor-1248	aroclor 1248 [PCB]	43.9	6.4E-05	1.65E-02	NR	NR
53469-21-9	Aroclor-1242	aroclor 1242 [PCB]	44.8	6.4E-05	1.65E-02	NR	NR
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	ddd	45.8	3.1E-04	3.30E-03	NR	NR
309-00-2	Aldrin	aldrin	48.7	4.9E-05	1.65E-03	NR	NR
206-44-0	Fluoranthene	fluoranthene	49.1	9.0E+01	5.00E-02	NR	NR
7440-48-4	Cobalt	Cobalt	50	2.6E+00	2.00E+00	NR	NR
7439-93-2	Lithium	Lithium	50	No Value	2.50E+00	NA	NA
7439-96-5	Manganese	manganese	50	5.0E+01	5.00E+00	NR	NR
5103-71-9	Alpha-Chlordane	Alpha-Chlordane	51	5.7E-04	1.65E-02	NR	NR
57-74-9	Chlordane	chlordane	51	5.7E-04	1.65E-02	NR	NR
87-68-3	Hexachlorobutadiene	hexachlorobutadiene	53.7	4.4E-01	3.30E-01	NR	NR
7440-02-0	Nickel	nickel soluble salts	65	5.2E+01	4.00E+00	NR	NR
129-00-0	Pyrene	pyrene	68	8.3E+02	5.00E-02	NR	NR
7440-28-0	Thallium	Thallium, soluable salts	71	2.2E-01	5.00E-01	NR	NR
11097-69-1	Aroclor-1254	aroclor 1254 (PCB)	75.6	6.4E-05	1.65E-02	NR	NR
118-74-1	Hexachlorobenzene	hexachlorobenzene	80	2.8E-04	3.30E-01	NR	NR
72-43-5	Methoxychlor	methoxychlor	80	3.0E-02	1.65E-02	NR	NR
1024-57-3	Heptachlor epoxide	Heptachlor epoxide	83.2	3.9E-05	1.65E-03	NR	NR
72-55-9	4,4'-DDE (Dichlorodiphenyldichloroethylene)	dde	86.4	2.2E-04	3.30E-03	NR	NR
7440-22-4	Silver	silver	90	2.6E+00	2.00E-01	NR	NR
8001-35-2	Toxaphene	toxaphene	95.8	2.0E-04	1.65E-01	NR	NR
12674-11-2	Aroclor-1016	aroclor 1016 (PCB)	107	6.4E-05	1.65E-02	NR	NR
117-81-7	Bis(2-ethylhexyl) phthalate	bis(2-ethylhexyl) phthalate	110	1.2E+00	3.30E-01	NR	NR
7440-31-5	Tin	tin	130	5.2E+02	1.00E+01	NR	NR
16984-48-8	Fluoride	fluoride (using fluorine)	150	1.6E+04	5.00E+00	NR	NR
7440-47-3	Chromium	chromium (total)	200	6.5E+01	2.00E-01	NR	NR

Table A2-2. Surface Water Preliminary Remediation Goal (PRG) Values

CAS No.	Analyte	Alternate Name Referenced in EPA Regional Screening Table	300 Area K_d Value used to Calculate Surface Water Protection (ml/g)	Surface Water Standard (µg/L)	EQL (mg/kg)	Surface Water PRG Values $\left(\frac{mg}{kg}\cdot m\right)$ [1,2,3,4,5]	
						Native Vegetation Recharge Scenario	Industrial Recharge Scenario
218-01-9	Chrysene	Chrysene	200	2.8E-03	1.00E-01	NR	NR
77-47-4	Hexachlorocyclopentadiene	hexachlorocyclopentadiene	200	4.0E+01	3.30E-01	NR	NR
56-55-3	Benzo(a)anthracene	Benzo(a)anthracene	360	2.8E-03	1.50E-02	NR	NR
50-29-3	4,4'-DDT (Dichlorodiphenyltrichloroethane)	ddt	678	2.2E-04	3.30E-03	NR	NR
7440-41-7	Beryllium	beryllium	790	2.7E+02	2.00E-01	NR	NR
205-99-2	Benzo(b)fluoranthene	Benzo(b)fluoranthene	803	2.8E-03	1.50E-02	NR	NR
11096-82-5	Aroclor-1260	aroclor 1260 (PCB)	822	6.4E-05	1.65E-02	NR	NR
7440-62-2	Vanadium	vanadium	1000	No Value	2.50E+00	NA	NA
207-08-9	Benzo(k)fluoranthene	Benzo(k)fluoranthene	1230	2.8E-03	1.50E-02	NR	NR
7429-90-5	Aluminum	Aluminum (soluble)	1500	8.7E+01	5.00E+00	NR	NR
53-70-3	Dibenz[a,h]anthracene	Dibenz[a,h]anthracene	1790	2.8E-03	3.00E-02	NR	NR
191-24-2	Benzo(ghi)perylene	BENZO(g,h,i)PERYLENE (using pyrene as a surrogate)	1950	No Value	3.00E-02	NA	NA
193-39-5	Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	3470	2.8E-03	3.00E-02	NR	NR
50-32-8	Benzo(a)pyrene	Benzo(a)pyrene	5500	2.8E-03	1.50E-02	NR	NR
117-84-0	Di-n-octylphthalate	di-n-octyl phthalate	83000	No Value	3.30E-01	NA	NA
65794-96-9	3+4 Methylphenol (cresol, m+p)	methylphenol,3+4 (cresol, m+p)	No Value	No Value	3.30E-01	NA	NA
101-55-3	4-Bromophenylphenyl ether	bromodiphenyl ether;4-	No Value	No Value	3.30E-01	NA	NA
7440-69-9	Bismuth	Bismuth	No Value	No Value	1.00E+01	NA	NA
24959-67-9	Bromide	Bromide	No Value	No Value	2.50E+00	NA	NA
7440-70-2	Calcium	Calcium	No Value	No Value	1.00E+02	NA	NA
PCB1242/1016	Co-elution of Aroclor 1242 and Aroclor 1016	Co-elution of Aroclor 1242 and Aroclor 1017	No Value	No Value	—	NA	NA
7439-95-4	Magnesium	Magnesium (Not in CLARC database Tables)	No Value	No Value	7.50E+01	NA	NA
14265-44-2	Phosphate	Phosphate	No Value	No Value	5.00E+00	NA	NA
PO4-P	Phosphorus in phosphate	Phosphorus in phosphate	No Value	No Value	—	NA	NA
7440-09-7	Potassium	Potassium	No Value	No Value	4.00E+02	NA	NA
7440-21-3	Silicon	Silicon	No Value	No Value	2.00E+00	NA	NA
7440-23-5	Sodium	Sodium	No Value	No Value	5.00E+01	NA	NA
TPHDIESEL	Total petroleum hydrocarbons - diesel range	Total petroleum hydrocarbons - diesel range	No Value	No Value	—	NA	NA
TPH/OILH	Total petroleum hydrocarbons - motor oil (high boiling)	Total petroleum hydrocarbons - motor oil (high boiling)	No Value	No Value	—	NA	NA

1. All COPC screening values default to the estimated quantitation limit (EQL) when the calculated value is less than the EQL.
2. * indicates that Cr(VI) value set to a maximum value of 6.0 mg/kg because the K_d value used in the model was derived from experiments with soil concentrations less than 6.0 mg/kg. Scaling by representative length across the waste site decision unit in the general direction of groundwater flow is not applicable to this COPC because of this limit.
3. "NR" indicates non-representative results when there is no breakthrough simulated within 1000 years for four or more of the five soil representative columns (where breakthrough is defined as concentrations exceeding 1.0E-04 µg/L).
4. "NA" indicates an applicable water quality standard is not available to calculate the SSL or PRG values.
5. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup 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 cleanup value for evaluation use.

CAS = Chemical Abstract Service

Cyan highlight denotes calculated values that **changed as a result of incorporating updated IRIS (EPA's Integrated Risk Information System)** groundwater standard values.

Table A2-3. Groundwater Preliminary Remediation Goal (PRG) Values for Radionuclides

Radionuclide Contaminant of Potential Concern	300 Area K_d Value used to Calculate Groundwater Protection (ml/g)	Maximum Contaminant Level (pCi/L)	Half-life (yr)	EQL (mg/kg)	Groundwater Screening Values $\left(\frac{pCi}{g \cdot m}\right)$ [1,2,3,4]	
					Native Vegetation Recharge Scenario	Industrial Recharge Scenario
Carbon-14[5]	0	2000	5.7300E+03	---	9.02E+02	9.35E+02
Technetium-99	0	900	2.1300E+05	---	4.05E+02	4.20E+02
Tritium	0	20000	1.2350E+01	---	1.17E+04	1.22E+04
Iodine-129	1	1	1.5700E+07	---	NR	3.71E+01
Uranium-235	2	No Value	7.0380E+08	5.0000E-01	NA	NA
Uranium-238	2	No Value	4.4680E+09	1.0000E+00	NA	NA
Neptunium-237	15	15	2.1400E+06	---	NR	9.77E+03
Strontium-90	25	8	2.9120E+01	---	NR	NR
Nickel-63	30	50	9.6000E+01	---	NR	NR
Cesium-137	50	200	3.0000E+01	1.0000E-01	NR	NR
Cobalt-60	50	100	5.7210E+00	5.0000E-02	NR	NR
Americium-241	200	15	4.32E+02	1.00E+00	NR	NR
Carbon-14[6]	200	2,000	5.73E+03	---	NR	NR
Curium-243	200	15	2.85E+01	---	NR	NR
Europium-152	200	200	1.33E+01	1.00E-01	NR	NR
Europium-154	200	60	8.80E+00	1.00E-01	NR	NR
Europium-155	200	600	4.96E+00	1.00E-01	NR	NR
Niobium-94	200	No Value	2.03E+04	---	NA	NA
Plutonium-238	200	15	8.77E+01	1.00E+00	NR	NR
Plutonium-239	200	15	2.41E+04	1.00E+00	NR	NR
Plutonium-240	200	15	6.54E+03	1.00E+00	NR	NR
Plutonium-241	200	300	1.40E+01	---	NR	NR
Radium-226	200	5	1.60E+03	---	NR	NR
Radium-228	200	5	5.75E+00	2.00E-01	NR	NR
Thorium-228	200	15	1.91E+00	---	NR	NR
Thorium-230	200	15	7.70E+04	---	NR	NR
Thorium-232	200	15	1.41E+10	---	NR	NR

1. All COPC screening values default to the estimated quantitation limit (EQL) when the calculated value is less than the EQL.
2. "NR" indicates non-representative results where there is no breakthrough simulated within 1000 years for at least four of the five soil columns (where breakthrough is defined as concentrations above 1.0E-04 pCi/L).
3. "NA" indicates an applicable water quality standard is not available to calculate the SSL or PRG values.
4. Soil cleanup levels protective of groundwater and protective of surface water are provided on a unit-length basis. To apply these soil cleanup 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 cleanup value for evaluation use.
5. Carbon-14 in liquid form, typically associated with reactor gas condensate.
6. Carbon-14 in solid form, typically associated with graphite.

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Attachment B

Software Installation and Checkout Form for STOMP Build 2 on GREEN

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.: Build2

EXECUTABLE INFORMATION:

2. Executable Name (include path):

```
a51dc453e98a084b391c08ac2ac3a976  stomp-wae-bd-chprc02i.x
70fd1a594885ff9118d5802be8aaaa47  stomp-wae-cg-chprc02i.x
c2ddd7624276023bd4d3d0ef1817a40e  stomp-wae-cgs-chprc02i.x
21713e06e4676a0204d8292680911bdd  stomp-w-bd-chprc02i.x
7d712b548eea0326a6b3e5fd956ee61b  stomp-w-cg-chprc02i.x
32c15e8d89b508e78814ff091d2a49d0  stomp-w-cgs-chprc02i.x
6988abf48a371ec20ff652920f72d6c6  stomp-w-r-bd-chprc02i.x
```

3. Executable Size (bytes): MD5 signatures shown above uniquely identify executables

COMPILATION INFORMATION:

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

RANSAC Linux Cluster (WD56054)

5. Operating System (include version number):

Redhat Enterprise Linux WS3 (Taroon Update)

INSTALLATION AND CHECKOUT INFORMATION:

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

INTERA GREEN Linux File Server (INTERA-00469)

7. Operating System (include version number):

Linux green 2.6.32-30-server #59-Ubuntu SMP Tue Mar 1 22:46:09 UTC 2011 x86 64 GNU/Linux

8. Open Problem Report? ◉ No ○ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

[redacted]/build-02

10. Procedure(s):

CHPRC-00211 Rev. 1, STOMP Software Test Plan

11. Libraries:

N/A (static linking)

12. Input Files:

Input files for ATC-STOMP-1, ATC-STOMP-2, and ATC-STOMP-2

13. Output Files:

plot.* files produced by STOMP executables

14. Test Cases:

ATC-STOMP-1, ATC-STOMP-2, and ATC-STOMP-3

15. Test Case Results:

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No.: Build2

PASS (diff all plot files showed no numerical differences)

16. Test Performed By: WE Nichols

17. Test Results: ◉ Satisfactory, Accepted for Use ○ Unsatisfactory

18. Disposition (include HISI update):

Installation added to STOMP HISI Entry. This is a multiuser server; approved software users include T Clemo, J Ludwig, T Budge, N Hasan, A Mayenna, H Rashid, C Courbet, W Nichols, T Dale, S Mehta.

Prepared By: William E. Nichols Digitally signed by William E. Nichols DN: cn=William E. Nichols, o=CHPRC, ou=EPSP, email=william_e_nichols@rl.gov, c=US Date: 2011.03.31 16:06:34 -07'00'

19.		
Software Owner (Signature)	Print	Date
William E. Nichols	WE Nichols	

20. Test Personnel:

Sign	Print	Date
William E. Nichols (Digitally signed by William E. Nichols)	WE Nichols	
Sign	Print	Date
Sign	Print	Date

Approved By:

21.		
Software SME (Signature)	Print	Date
	N/R	