# Appendix O

# Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation/Feasibility Study

This page intentionally left blank.

This crosswalk demonstrates how the WAC 173-340-747(8) requirements for use of alternative fate and transport modeling are met in the use of STOMP modeling to derive soil screening level (SSL) and preliminary remediation goal (PRG) values for 100-D/H. Each requirement is listed in tabular form with a simple response, followed by an explanation, justification, and cross reference to where the information is found elsewhere in this RI/FS. Focus is on the parameterization of the alternative fate and transport model. Demonstration of the suitability of the STOMP code itself for use in alternative fate and transport modeling to meet WAC requirements is provided in DOE/RL-2011-50 Rev. 1.

This page intentionally left blank.

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | Response |
|---|---|---|
| 8(b) | **Assumptions.** When using alternative models, chemical partitioning and advective flow may be coupled with other processes to predict contaminant fate and transport, provided the following conditions are met: | |
| 8(b)(i) | Sorption. Was approach (4)(c) or (5)(b) used? Go to correct entry and meet all requirements. | **Both** |

Explanation:

- Both Approach (4)(c) and 5(b) were used, depending on the COPC evaluated, for the 201 non-radionuclide, and 32 radionuclide, COPCs evaluated using the alternative fate and transport model of the vadose zone.

Justification:

- For radionuclides, $K_d$ values are selected from Appendix E of DOE/RL-96-17 Rev. 6, which provided a compilation of Hanford-Site-specific values derived from scientific literature, with the exception of one radionuclide, Silver-108m, which is a generic value from scientific literature.
- For organic analytes, $K_d$ values are calculated using Equation 747-2. The $K_d$ calculations assume a value of 0.001 g/g for the soil fraction of organic carbon ($f_{oc}$), as specified in Equation 747-2. Analyte-specific soil organic carbon-water partitioning coefficient ($K_{oc}$) values used in the $K_d$ calculations are obtained from the following sources, in order of preference (i.e., if values available in higher preference source, those are used):
    1. Washington State Department of Ecology's "Cleanup Levels and Risk Calculations (CLARC)" online database application (Ecology, 2014) (https://fortress.wa.gov/ecy/clarc/CLARCOverview.aspx)
    2. EPA's "Regional Screening Levels for Chemical Contaminants at Superfund Sites" web site (EPA, 2012) (http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/)
    3. Oak Ridge National Laboratory's (ORNL) Risk Assessment Information System (RAIS) (ORNL, 2014) (http://rais.ornl.gov/cgi-bin/tools/TOX_search?select=chem_spef)
- For inorganic analytes, $K_d$ values are obtained directly from tabulated sources in the same order of precedence shown above for organic analytes.
- Exception: for hexavalent chromium, the $K_d$ value selected for use in modeling the residual fraction remaining in the vadose zone following remediation is 0.8 mL/g. This value is obtained from ECF-HANFORD-11-0165.

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | • Exception: for total petroleum hydrocarbons (TPH), the $K_d$ value selected for use in modeling the residual fraction of TPH remaining in the vadose zone following remediation is 4 mL/g. This value is obtained from ECF-100NR2-12-0053.<br><br>Documented:<br><br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety)<br>• DOE/RL-96-17, 2009, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 6 (in its entirety). Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095436<br>• Appendix F, ECF-HANFORD-11-0165, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area* (in its entirety)<br>• ECF-100NR2-12-0053, 2012, *Saturated Zone Flow and Transport Modeling in Support of 100-N RI/FS Document*, Rev. 6, Section 4.6.2.3 "$K_d$ for TPH"; note this document is part of the 100-N RI/FS, and hence is not included the 100-D/H RI/FS. | | | |
| 8(b)(i) | 4(c) | **4(c) Distribution coefficient ($K_d$).** The default $K_d$ values for organics and metals used in Equation 747-1. | | |
| 8(b)(i) | (4c) | (i) | **(i) Organics.** For organic hazardous substances, was the $K_d$ value derived using Equation 747-2? (required) | **Yes** |
| | | | Explanation:<br><br>• $K_d$ values were derived under Method (4)(c)(i), using Equation 747-2 from WAC 173-340-747 for the following organics using analyte-specific soil organic carbon-water partitioning coefficient ($K_{oc}$) values from the sources indicated:<br><br>○ $K_d$ values derived using $K_{oc}$ values from CLARC tables (Ecology 2014):<br><br>1,1,1-Trichloroethane, 1,1,2,2-Tetrachloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene, 1,2-Dichloroethane, 1,2-Dichloropropane, 1,4-Dichlorobenzene, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 2-Chlorophenol, 2-Methylphenol (cresol, o-), 3,3'-Dichlorobenzidine, 4,4'-DDD (Dichlorodiphenyldichloroethane), 4,4'-DDE (Dichlorodiphenyldichloroethylene), 4,4'-DDT (Dichlorodiphenyltrichloroethane), 4-Chloroaniline, Acenaphthene, Acetone, Aldrin, Alpha-BHC, | |

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | Alpha-Chlordane, Anthracene, Aroclor-1016, Aroclor-1260, Benzene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC), Bis(2-chloroethyl) ether, Bis(2-ethylhexyl) phthalate, Bromodichloromethane, Bromoform, Bromomethane, Butylbenzylphthalate, Carbazole, Carbon disulfide, Carbon tetrachloride, Chlordane, Chlorobenzene, Chloroform, Chloromethane, chrysene, cis-1,2-Dichloroethylene, cis-1,3-Dichloropropene, Dibenz[a,h]anthracene, Dibromochloromethane, Dieldrin, Diethylphthalate, Di-n-butylphthalate, Di-n-octylphthalate, Endosulfan I, Endosulfan II, Endrin, Ethylbenzene, Fluoranthene, Fluorene, Gamma-BHC (Lindane), Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Hexachlorobutadiene, Hexachlorocyclopentadiene, Hexachloroethane, Indeno(1,2,3-cd)pyrene, Isophorone, Methoxychlor, Methylene chloride, m-Xylene, Naphthalene, Nitrobenzene, n-Nitrosodi-n-dipropylamine, n-Nitrosodiphenylamine, o-Xylene, Pentachlorophenol, Phenol, Pyrene, Styrene, Tetrachloroethene, Toluene, Toxaphene, trans-1,2-Dichloroethylene, trans-1,3-Dichloropropene, Trichloroethene, Vinyl chloride, Xylenes (total).<br>○ $K_d$ values derived using $K_{oc}$ values from EPA (2012):<br>1,2-Dichloroethene (Total), 2-(2-methyl-4-chlorophenoxy) propionic acid, 2,4,5-T(2,4,5-Trichlorophenoxyacetic acid), 2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex, 2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid), 2,4-Dichlorophenoxyacetic acid, 2-Butanone, 2-Butoxyethanol, 2-Chloronaphthalene, 2-Hexanone, 2-Methylnaphthalene, 2-Nitroaniline, 4,6-Dinitro-2-methylphenol, 4-Amino-3,5,6-trichloropicolinic acid, 4-Chloro-3-methylphenol, 4-Methyl-2-pentanone, 4-Methylphenol (cresol, p-), 4-Nitroaniline, Acrylamide, Acrylonitrile, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Bis(2-chloro-1-methylethyl)ether, Bis(2-Chloroethoxy)methane, Chloride, Chloroethane, Co-elution of Aroclor 1242 and Aroclor 1016, Cyanide, Dalapon, Dibenzofuran, Dicamba, Diethyl ether, Dinoseb(2-secButyl-4,6-dinitrophenol), Ethyl acetate, Ethylene glycol, Isopropylbenzene, Methanol, Nitrate, Nitrite, Nitrogen in Nitrate, Nitrogen in Nitrite, Nitrogen in Nitrite and Nitrate, Tributyl phosphate, Trichloromonofluoromethane.<br>○ $K_d$ value derived using $K_{oc}$ values from ORNL (2014):<br>1,3-Dichlorobenzene, 2-Nitrophenol, 3-Nitroaniline, 4-Bromophenylphenyl ether, 4-Chlorophenylphenyl ether, 4-Nitrophenol, Acenaphthylene, Benzo(ghi)perylene, Delta-BHC, Dichloroprop, Dimethyl phthalate, Endosulfan sulfate, Endrin aldehyde, Endrin ketone, Phenanthrene.<br>○ $K_d$ value derived from consideration of total petroleum hydrocarbon ranges (ECF- 100NR2-12-0053):<br>Total petroleum hydrocarbons - diesel range, Total petroleum hydrocarbons - motor oil (high boiling) | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | | Response |
|---|---|---|---|---|---|
| | | | Justification:<br>• Refer to responses by entry, below.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety)<br>• ECF-100NR2-12-0053, Rev. 2, *Saturated Zone Flow and Transport Modeling in Support of 100-N RI/FS Document*, Section 4.6.2.3 "$K_d$ for TPH"; note this document is part of the 100-N RI/FS, and hence is not included the 100-D/H RI/FS. | | |
| 8(b)(i) | (4c) | (i) | The $K_{oc}$ (soil organic carbon-water partition coefficient) parameter specified in Equation 747-2 shall be derived as follows: | | |
| 8(b)(i) | (4c) | (i) | (A) | (A) **Nonionic organics.** Are there individual nonionic hydrophobic organic hazardous substances (e.g., benzene and naphthalene)? | **Yes** |
| | | | | Explanation:<br>• The COPC list includes nonionic organics, including naphthalene.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | (4c) | (i) | (A) | • If so, were $K_{oc}$ values from Table 747-1 used? OR | **Yes** |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | | | | Requirement | Response |
|---|---|---|---|---|---|
| | | | | Explanation:<br>• Yes, $K_{oc}$ values from Table 747-1 were used.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | (4c) | (i) | (A) | • For hazardous substances not listed in Table 747-1, were $K_d$ values used from (5) (variable three-phase partitioning model)? | **N/A** |
| | | | | Explanation:<br>• No COPCs analyzed met this condition.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | (4c) | (i) | (B) | (B) **Ionizing organics.** For ionizing organic hazardous substances (e.g., pentachlorophenol and benzoic acid), were $K_{oc}$ values used from Table 747-2? (required) | **Yes** |
| | | | | Explanation: | |

| WAC | | | | Requirement | Response |
|---|---|---|---|---|---|
| | | | | • The following ionizing organic hazardous substances are COPCs: 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2-Chlorophenol, Pentachlorophenol. $K_d$ values for these were derived under Method (4)(c)(i), using Equation 747-2 from WAC 173-340-747 for the following organics using analyte-specific soil organic carbon-water partitioning coefficient ($K_{oc}$) values from CLARC tables (Ecology 2009).<br>Justification:<br>• Compliant; no further justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | (4c) | (i) | (B) | Was the soil pH measured? (required) and the $K_{oc}$ value for the corresponding soil pH used? | **Yes** |
| | | | | Explanation:<br>• Soil pH was measured and the $K_{oc}$ value for the corresponding soil pH was used.<br>Justification:<br>• Compliant; no further justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | (4c) | (i) | (B) | If the soil pH fell between the pH values provided, were the values correctly interpolated? | **N/A** |
| | | | | Explanation: | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | | • None detected, and hence not applicable.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) |
| 8(b)(i) | (4c) | (ii) | **(ii) Metals.** | |
| 8(b)(i) | (4c) | (ii) | Were the $K_d$ values from Table 747-3 used? | **Yes**<br>**Except Cr(VI)** |
| | | | Explanation:<br>• Yes: $K_d$ values from Table 747-3 were used for the following metals: Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc.<br>• No: $K_d$ values were not available from Table 747-4 and were obtained from EPA (2012) for the following metals: Aluminum, Boron, Calcium, cobalt, Fluoride, Iron, Lithium, Magnesium, Manganese, Molybdenum, Potassium, Sodium, Strontium, Tin<br>• No: a site-specific $K_d$ value based on leach test results was used for Hexavalent Chromium.<br>Justification:<br>• No justification is required for the use of $K_d$ values from Table 747-3.<br>• Justification for using a site-specific $K_d$ value derived from leach test results is provided below, in the response to 5(b)(iii).<br>Documented: | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | • Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | (4c) | (ii) | If metals were not listed in Table 747-3, was the subsection (5) (variable three-phase partitioning model) used? | **No** |
| | | | Explanation:<br>• The variable three-phase partitioning model was not used.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | 5(b) | | **5(b) Methods for deriving a distribution coefficient ($K_d$).** To derive a site-specific distribution coefficient, which one of the following methods was used? Go to (i), (ii), (iii), or (iv). | **(iii) and (iv)** |
| | | | Explanation:<br>• A site-specific $K_d$ value for hexavalent chromium for the 100 Area was derived from batch leach test results under Method (iii).<br>• Scientific literature was used to derive site-specific values for $K_d$ for several constituents under Method (iv).<br>Justification:<br>• Justification is provided with explanation in responses to Methods (iii) and (iv), below.<br>Documented: | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | • Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | | |
| 8(b)(i) | 5(b) | (i) | **(i) Deriving $K_d$ from soil fraction of organic carbon (foc) measurements.** | |
| | | | • Was Equation 747-2 used to derive distribution coefficients for nonionic hydrophobic organics for site-specific measurements of soil organic carbon? | **Yes** |
| | | | Explanation:<br>• The COPC list includes nonionic organics, including naphthalene, and Equation 747-2 was used to derive distribution coefficients.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | 5(b) | (i) | • Were soil organic carbon measurements based on uncontaminated soil below the root zone (i.e., soil greater than one meter in depth) that is representative of site conditions or in areas through which contaminants are likely to migrate? | **N/A** |
| 8(b)(i) | 5(b) | (i) | • Were laboratory protocols in the Puget Sound Estuary Program (March, 1986) used? | **N/A** |
| 8(b)(i) | 5(b) | (i) | • Were other methods used and approved by the department? | **N/A** |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| 8(b)(i) | 5(b) | (i) | • Were all laboratory measurements of soil organic carbon based on methods that do not include inorganic carbon in the measurements? | **N/A** |
| 8(b)(i) | 5(b) | (ii) | **(ii) Deriving $K_d$ from site data.** | |
| 8(b)(i) | 5(b) | (ii) | • Were site-specific measurements of hazardous concentrations in soil and soil pore water or ground water used to derive a $K_d$ and was department approval obtained? | **No** |
| | | | Explanation:<br>• This method was not used to derive a $K_d$ value for any COPC evaluated.<br>Justification:<br>• No justification is required for this response.<br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area* (in its entirety) | |
| 8(b)(i) | 5(b) | (ii) | • Were $K_d$s derived from site data based on measurements of soil and ground water hazardous substance concentrations from the same depth and location? | **N/A** |
| 8(b)(i) | 5(b) | (ii) | • Were soil and ground water samples containing hazardous substances present as a nonaqueous phase liquid (NAPL) used to derive a $K_d$? (not allowed) and were measures taken to minimize biodegradation and volatilization during sampling, transport and analysis? | **N/A** |
| 8(b)(i) | 5(b) | (iii) | (iii) **Deriving $K_d$ from batch tests.** | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | | | Requirement | Response |
|---|---|---|---|---|
| 8(b)(i) | 5(b) | (iii) | • Was a site-specific $K_d$ derived by using batch equilibrium tests to measure hazardous substance adsorption and desorption and was department approval obtained? | **Yes** |
| | | | Explanation:<br>• A site-specific value (specific to the 100 Area of the Hanford Site) of $K_d$ for hexavalent chromium was derived using batch equilibrium tests.<br>Justification:<br>• Ecology approved the batch leach testing with the approval of the D/H SAP DOE/RL-2009-40 Rev 0. Page 2-127 describes the procedure. It was also modified by TPA-CN-368 signed by Ecology on 8/26/2010 to allow for removing the requirement for pH adjustment of demineralized water.<br>Documented:<br>• Chapter 5, Section 5.5.2 "Development of a Hexavalent Chromium Distribution Coefficient for Vadose Zone Simulations from Batch Leach Testing Results"<br>• Appendix F, ECF-HANFORD-11-0165 Rev. 1, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area* (in its entirety) | |
| 8(b)(i) | 5(b) | (iii) | • Were samples with hazardous substances present as a nonaqueous phase liquid (NAPL) used to derive a distribution coefficient (not allowed) and were measures shall be taken to minimize biodegradation and volatilization during testing? | **No** |
| | | | Explanation:<br>• No samples with NAPLs present were used in the determination of $K_d$ values.<br>Justification:<br>• No justification is required for this response. | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

<table>
<tr><th>WAC</th><th colspan="3">Requirement</th><th>Response</th></tr>
<tr><td></td><td></td><td></td><td colspan="2">Documented:<ul><li>Appendix F, ECF-HANFORD-12-0023, Rev. 3, Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area (in its entirety)</li></ul></td></tr>
<tr><td rowspan="2">8(b)(i)</td><td rowspan="2">5(b)</td><td rowspan="2">(iv)</td><td>(iv) Deriving $K_d$ from the scientific literature.<br>Was scientific literature used to derive a site-specific distribution coefficient ($K_d$)?<br>If so, were the requirements in WAC 173-340-702 (14), (15) and (16) met? (see end of list under 8(c))</td><td>Yes</td></tr>
<tr><td colspan="2">Explanation:<ul><li>Scientific literature values were applied to select COPCs as follows:<br>General $K_d$ values were derived from scientific literature for these COPCs:<ul><li>Silver-108m – from ANL (1993)</li></ul>Hanford site-specific $K_d$ values were derived from scientific literature for these COPCs:<ul><li>Thorium-228, Thorium-230, Thorium-232 - Ames and Rai (1978)</li><li>Americium-241, Cesium-137, Cobalt-60, Europium-152, Europium-154, Europium-155, Nickel-63, Strontium-90 - Ames and Serne (1991)</li><li>Carbon-14 – from BHI (2002a)</li><li>Curium-243, Curium-244, Iodine-129, Neptunium-237, Niobium-94, Potassium-40, Sodium-22 – from Kincaid et al. (1998)</li><li>Plutonium-238, Plutonium-239/240, Plutonium-239, Plutonium-240, Plutonium-241, Radium-226, Radium-228, Technetium-99, Tritium (H-3), Uranium-233/234, Uranium-235, Uranium-238 – from Serne and Wood (1990), except all uranium values are replaced with “NVR” (no value required) for 100-D/H modeling purposes because uranium does not require modeling.</li></ul>No $K_d$ values were available for these COPCs:</li></ul></td></tr>
</table>

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | Response |
|---|---|---|
| | ○ No value available: 3+4 Methylphenol (cresol, m+p), Bismuth, Bromide, Calcium, Co-elution of Aroclor 1242 and Aroclor 1016, Phosphate, Silicon.<br><br>Justification:<br>• Best-available scientific information applied in absence of higher-precedence values (CLARC 2014, EPA 2012, or ORNL 2014).<br><br>Documented:<br>• Appendix F, ECF-HANFORD-12-0023, Rev. 3, *Groundwater and Surface Water Cleanup Levels and Distribution Coefficients for Nonradiological and Radiological Analytes in the 100 Areas and 300 Area,* Table 3-5 "Final Nonradiological Analyte Distribution Coefficient ($K_d$) Selection" and Table 3-6 "Radiological Analyte Distribution Coefficients ($K_d$)"<br>• DOE/RL-96-17, 2009, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 6 (in its entirety). Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095436 | |
| 8(b)(ii) | **Vapor phase partitioning.** If Henry's law constant is used to establish vapor phase partitioning, then the constant shall be derived in accordance with subsection (4)(d) of this section. | **N/A** |
| | Explanation:<br>• Volatilization was conservatively neglected in the calculation of SSL and PRG values.<br><br>Justification:<br>• This assumption is conservative, with respect to SSL and PRG values only, because modeling volatilization would reduce the mass transport to the groundwater pathway, with result of lower peak groundwater concentrations and hence higher SSL and PRG values.<br>• This calculation is not the basis for direct exposure evaluations (presented in Chapter 6 of the RI/FS). Hence, this assumption does not apply to the inhalation pathway for direct exposure.<br><br>Documented:<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 6.1 "Modeling Conservatisms" notes that volatile organic compounds were assumed to have negligible volatilization so that the resulting peak concentrations are larger than if volatilization had been included.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary* | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | *Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.4 "Contaminant Transport Parameters" documents neglecting volatilization. | | | |
| 8(b)(ii) | (4)(d) | **(4)(d) Henry's law constant.** | | |
| 8(b)(ii) | (4)(d) | | For petroleum fractions, were the values for Henry's law constant in Table 747-4 used in Equation 747-1? (required) | **N/A** |
| 8(b)(ii) | (4)(d) | | For individual organic hazardous substances, was the value based on values in the scientific literature? (required) | **N/A** |
| 8(b)(ii) | (4)(d) | | For all metals present as inorganic compounds except mercury, was zero used? (required)<br>For mercury, was either 0.47 or a value derived from the scientific literature used? (required) | **N/A** |
| 8(b)(ii) | (4)(d) | | Did the derivation of Henry's law constant from the scientific literature comply with WAC 173-340-702 (14), (15) and (16)? (required) (*see end of list under 8(c)*) | **N/A** |
| 8(b)(iii) | **Natural biodegradation.** Were the rates of natural biodegradation derived from site-specific measurements? (required) | | | **No** |
| | Explanation:<br>• Biodegradation is not incorporated into the calculation.<br>Justification:<br>• All COPCs are assumed not to be subject to natural biodegradation for purposes of calculating SSLs and PRG values. This is generally a conservative assumption (because of overstating COPC persistence by neglecting biodegradation).<br>• This assumption may be non-conservative in some circumstances, e.g., COPCs such as chloroform can degrade to methylene chloride and chloromethane, which have higher cancer slope factors. Dichloroethylene can eventually degrade to vinyl chloride, which has a higher cancer slope factor than dichloroethylene. Groundwater protection levels are calculated based on meeting all applicable standards immediately under the waste site; including meeting ambient water quality standards with no credit for attenuation of organics as they | | | |

| WAC | Requirement | Response |
|---|---|---|
| | travel from the waste site and interface with oxic water conditions. This additional conservatism covers the potential for biodegradation products to be generated while keeping the calculations as simple and transparent as possible. This is further supported by groundwater data collected from the OU which indicate that biodegradation products, such as 1,1-DCE and vinyl chloride, have not been detected in groundwater.<br><br>Documented:<br><br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.4 "Contaminant Transport Parameters" documents that biodegradation is not incorporated into the calculation. | |
| 8(b)(iv) | **Dispersion.** Were estimates of dispersion derived from either site-specific measurements or literature values? (required) | **N/A** |
| | Explanation:<br><br>• Dispersion was conservatively minimized in the calculation by setting coefficients for hydrodynamic dispersion to zero. Additional considerations of the 1-D model construct follow:<br><br>  • The 1-D model construct does not address lateral transport, effectively assuming that contaminants in the vadose zone are continuously moving in one direction (downward) with no accounting for potential lateral migration. While lateral migration is highly likely under field conditions, this effect reduces and delays the peak groundwater concentration resulting from a given waste site. Hence, this 1-D modeling construct is conservative because it overstates the potential for groundwater impacts compared to a higher-dimensionality model construct that accounts for lateral migration.<br><br>  • The PRZ is not explicitly modeled (rise and fall of the water table is not assumed) to provide a bounding calculation. A fluctuating water table will provide additional attenuation distance between the source area and groundwater for six months every year.<br><br>  • Conditions from summer months (the period of highest river stage and groundwater heads in this locale) are used in the 1D STOMP models. This parameterization provides the simplest and most conservative evaluation of conditions under a waste site by providing the shortest travel distance from the contaminated source to groundwater, and by assuming that this short travel distance persists indefinitely. This, in turn, maximizes the predicted impact on groundwater by yielding a higher peak concentration is calculated than if water table is simulated as fluctuating. The effects of the PRZ are handled internally within STOMP. A three-dimensional treatment cannot result in greater impact on groundwater than the one-dimensional assumption because the one-dimensional treatment allows no lateral diffusion of contaminants; the only possible direction for contaminant movement is downward.<br><br>Justification: | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

<table>
<tr><th>WAC</th><th>Requirement</th><th>Response</th></tr>
<tr><td></td><td colspan="2">
<ul><li>Simulating with no hydrodynamic dispersion is conservative, with respect to SSL and PRG values, because inclusion of greater hydrodynamic dispersion would result in lower peak groundwater concentrations, and therefore higher SSL and PRG values.</li></ul>
<u>Documented:</u>
<ul>
<li>Chapter 5, Table 5-5, “Summary of Selected Primary Fate and Transport Simulation Input Parameters Used with 1-D Model Implemented in STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units”</li>
<li>Appendix F, SGW-50776 Rev. 2, Model Package Report: Vadose Zone Model for the River Corridor, Section 4.5.1 “Parameters and Ranges” notes that dispersion was conservatively assumed negligible, so dispersivity values were all set to zero.</li>
<li>Appendix F, ECF-HANFORD-11-0063 Rev. 6, STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units, Section 3.4 “Contaminant Transport Parameters” documents that hydrodynamic dispersion is set to zero in the calculation.</li>
</ul>
</td></tr>
<tr><td>8(b)(v)</td><td>Decaying source. Were fate and transport algorithms used that account for decay over time? Regulation states that Fate and Transport algorithms may be used that account for decay over time.</td><td>Yes</td></tr>
<tr><td></td><td colspan="2">
<u>Explanation</u>:
<ul><li>Radioactive decay is accounted for in the STOMP code for radionuclides only. The STOMP simulator solves the Arrhenius-type kinetic reaction (PNNL-12030) according to the equation
$$\frac{\partial c}{\partial t} = -\lambda^C c$$
where $c$ is concentration of the COPC $C$ in solute, $t$ is time, and $\lambda^C$ is the decay rate constant for COPC $C$. The decay rate is related to the radionuclide half-life according to the equation
$$\lambda^C = \frac{\ln(2)}{t_{\frac{1}{2}}^C}$$
where $t_{1/2}^C$ is the half-life of COPC $C$. STOMP is capable of solving for chain decay, but this feature was not required or used for the SSL and PRG calculations. The only input parameter required is the half-lives $t_{1/2}^C$ for each radionuclide. All half-lives for this RI/FS were obtained from the Radiochemistry website in September 2011 (Radiochemistry Society, 2011).</li></ul>
<u>Justification</u>:
</td></tr>
</table>

| WAC | Requirement | Response |
|---|---|---|
| | • Radioactive decay is an established physical process for radionuclides evaluated in this RI/FS and follow well established rate laws that are solved using analytical equations in the STOMP code. DOE/RL-96-17 Rev. 6 notes, with regard to radioactive daughter products, "The development of cleanup standards for the 100 Area will not be affected because the principal radionuclides of concern in the 100 Area (e.g., cobalt-60, cesium-137, europium-152, and europium-154) do not decay to daughter products that are more radioactive."<br>• No radionuclide is simulated that has significant daughter products (no significant daughter/decay products associated with the alpha, beta, and gamma emitters that are present at 100-D/H. The gamma emitters do not have decay products).<br>• It is true that some volatiles are simulated with no biodegradation, which can have more toxic daughter products. While this could generate lower PRGs and SSLs for these volatiles, other conservatisms allow the calculated values to remain protective. The most notable conservatism for these volatiles is that their cleanup levels are based on the lowest applicable water quality standard. The groundwater protection levels are calculated based on meeting all applicable standards immediately under the waste site; including meeting ambient water quality standards with no credit for attenuation of organics as they travel from the waste site and interface with oxic water conditions. This additional conservatism covers the potential for biodegradation products to be generated while keeping the calculations as simple and transparent as possible. This is further supported by groundwater data collected from the OU which indicate that biodegradation products, such as 1,1-DCE and vinyl chloride, have not been detected in groundwater.<br><u>Documented:</u><br>• Chapter 5, Section 5.3.2, "Persistence of Radiological Constituents" describes the applicable radioactive decay processes.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.4 "Contaminant Transport Parameters" documents that STOMP is used to account for first-order decay in the solute mass conservation equation. The half-lives used for input to STOMP by radionuclide COPC are listed in Attachment B, Table B-3 and in Attachment C, Table C-3 list. Section 3.4 "Contaminant Transport Parameters" references PNNL-12030, *STOMP Subsurface Transport Over Multiple Phases Version 2.0 Theory Guide*, which describes the calculation of radioactive decay in the STOMP code. Section 3.4 "Contaminant Transport Parameters" also notes chain decay is not accounted for in this calculation.<br>• DOE/RL-96-17 Rev. 6, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Section 2.1.2.2 "Remedial Action Goals for Radionuclide Contaminants in Soil" dismisses the need to consider chain decay based on lack of daughter products for principal radionuclides of concern in the 100 Area. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0095436. | |
| 8(b)(vi) | **Dilution.** Was dilution based on site-specific measurements or estimated using a model incorporating site-specific characteristics? (required) | **Estimated using a model incorporating site-specific** |

| WAC | Requirement | Response |
|---|---|---|
| | | characteristics |
| | Explanation:<br>• Dilution is directly simulated in the STOMP model for SSL and PRG calculation through inclusion of the upper portion of the aquifer in the model, and using the mean hydraulic gradient for the OU to simulate for dilution directly. The dilution factor can be derived from the equation<br>$$Df = \frac{Q_{VZ} + Q_A}{Q_{VZ}}$$<br>where $D_f$ is the dimensionless dilution factor, $Q_{VZ}$ is the volumetric flux from the vadose zone into the aquifer, and $Q_A$ is the volumetric flux through the upper 5 m of the aquifer. The value of $Q_A$ is dependent upon the hydraulic gradient and hydraulic conductivity of the aquifer portion of the model. These input parameter values are input to the STOMP model constructed for SSL and PRG development. The dilution factor is noted to vary significantly depending on whether the aquifer is composed of the Ringold Formation or the Hanford formation (e.g., for 100-D the Ringold dilution factor was two times less than the Hanford dilution factor). The recharge rate varies over time in the calculation according to the recharge scenario simulated; hence, the effective dilution factor also varies in time because the $Q_{VZ}$ term in the dilution factor calculation represents the flux attributable to the recharge rate. The effective dilution factors were calculated and presented for all combinations of recharge scenarios, recharge phases, and hydraulic gradients used in the alternative fate and transport modeling. These dilution rates ranged from a low of 76 for the irrigation recharge rate at 100-D waste sites that have the saturated zone in the Ringold Formation, to a high of 15,600 for the mature shrub-steppe recharge rate at 100-H waste sites that have the saturated zone in the Hanford formation. For context, if the default fixed parameter three-phase partition model (WAC 173-340-747(3)(a)) were used to establish soil concentrations for groundwater protection, the default groundwater dilution factor is 20 for unsaturated zone soil.<br>• Using the upper 5 m of the aquifer, although allowed by the regulations, does not match site-specific conditions for some waste site locations where the aquifer thickness is less than 5 m. In these locations, the thinner aquifer would result in a higher concentration in the model prediction if all other factors in this calculation were unchanged. However, use of the median area hydraulic gradient in the model for each area, rather than site-specific hydraulic gradient, would also affect the dilution if considered (this gradient would typically be higher at locations with a thinner aquifer to maintain the same aquifer flow rate).<br>Justification:<br>• Where using an alternative fate and transport model (WAC 173-340-747(8)), it is required that dilution "be based on site-specific measurements or estimated using a model incorporating site-specific characteristics." The hydraulic gradient incorporates site-specific characteristics of the aquifer. The depth of the aquifer used for the dilution calculation follows WAC 173-340-747.<br>Documented: | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | Response |
|---|---|---|
| | • Chapter 5, Section 5.6 "Vadose Zone Modeling Methods and Results" describes the methodology for inclusion of the aquifer in the model domain and direct simulation of dilution as a function of aquifer depth, hydraulic gradient, domain size, and vadose zone leaching.<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 5.4 "Calculating Dilution Factors" presents and discusses dilution factor calculation in the STOMP modeling.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 5.1.3 "Dilution Factor" | |
| 8(b)(vi) | If detectable concentrations of hazardous substances are present in upgradient ground water, then the dilution factor may need to be adjusted downward in proportion to the background (upgradient) concentration. Was an adjustment made? | **No** |
| | Explanation:<br>• Adjustments were not made based on upgradient groundwater concentrations of hazardous substances.<br>Justification:<br>• In 100-D/H, there are no upgradient contamination issues for groundwater COCs other than Cr(VI). For Cr(VI), the current plume is not background contamination (all sources are anthropogenic in origin), and the existing Cr(VI) is being addressed through the pump-and-treat remedy that will effectively eliminate the upgradient contamination in a relatively short period of time. This remedy will address any leaching of Cr(VI) during the remedy application period.<br>• Ecology has determined that no dilution factor adjustments are needed in the alternative fate and transport modeling for the following reasons:<br>o WAC language allows for dilution factor adjustment, but does not require it.<br>o The soil PRGs for protection of groundwater/surface water for hexavalent chromium is not based on the results of alternative fate and transport modeling, but on the values from the interim cleanup actions (originally based on the "100 times rule").<br>o The fate and transport modeling results show no migration of vadose zone contaminants to groundwater within 1000 years. With no migration to groundwater, the value of the dilution factor is irrelevant.<br>Note that the "100 times rule" used as the basis for the interim cleanup actions produced a more conservative limit for hexavalent chromium than did the alternative fate and transport modeling.<br>Documented:<br>• Appendix F, ECF-HANFORD-11-0063 Rev 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary* | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

<table>
<tr><th>WAC</th><th colspan="2">Requirement</th><th>Response</th></tr>
<tr><td></td><td colspan="3">Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units, Section 5.1.3 “Dilution Factor”</td></tr>
<tr><td rowspan="2">8(b)(vii)</td><td colspan="2">Infiltration. Was infiltration derived in accordance with subsection (5)(f)(ii)(A) or (B) of this section? (required)</td><td>Yes; (B)</td></tr>
<tr><td colspan="3">Explanation:<ul><li>(5)(f)(ii)(B); Infiltration was derived from site-specific measurements.</li></ul>Justification:<ul><li>Use of site-specific values is permitted under (5)(f)(ii)(B).</li></ul>Documented:<ul><li>Chapter 5, Section 5.4.1 “Surface Cover, Infiltration, and Recharge”</li><li>Chapter 5, Table 5-5, “Summary of Selected Fate and Transport Simulation Input Parameters Used with 1 D Model Implemented in the STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units”</li><li>Appendix F, SGW-50776 Rev. 2, Model Package Report: Vadose Zone Model for the River Corridor, Section 4.4.1 “Flow and Transport Boundary Conditions” presents the range of applicable site-specific recharge rates from<ul><li>PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.</li></ul></li><li>Appendix F, ECF-HANFORD-11-0063 Rev. 6, STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units, Section 3.2.1 “Upper Boundary Conditions” identifies the use of 100-Area-specific recharge rates for disturbed soils in the model (Tables 3 and 4 and Figures 3 and 4) obtained from<ul><li>PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.</li></ul></li></ul></td></tr>
<tr><td rowspan="2">8(b)(vii)</td><td rowspan="2">(5)(f)(ii)</td><td><u>(5)(f)(ii)</u> Calculating or estimating infiltration. Was equation 747-5 used to calculate the volume of water infiltrating ($Q_p$)?</td><td>No</td></tr>
<tr><td colspan="2">Explanation:<ul><li>Equation 747-5 was not used. Site-specific measurements of infiltration were applied.</li></ul></td></tr>
</table>

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | Justification:<br>• Use of site-specific values is permitted under (5)(f)(ii)(B).<br>Documented:<br>• Chapter 5, Section 5.4.1 "Surface Cover, Infiltration, and Recharge"<br>• Chapter 5, Table 5-5, "Summary of Selected Fate and Transport Simulation Input Parameters Used with 1 D Model Implemented in the STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units"<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 4.4.1 "Flow and Transport Boundary Conditions" presents the range of applicable site-specific recharge rates from<br>o PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" notes the use of 100-Area-specific recharge rates for disturbed soils from<br>o PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf. | |
| 8(b)(vii) | (5)(f)(ii) | (A) | (A) If a default annual infiltration value (Inf) was used, the value shall meet the following: (required)<br>• For sites west of the Cascade Mountains, was the default annual infiltration value = 70% of the average annual precipitation amount used?<br>• For sites east of the Cascade Mountains, was the default annual infiltration value = 25% of the average annual precipitation amount used? | **N/A** |
| | | | Explanation:<br>• Default infiltration values under (5)(f)(ii)(A) were not used.<br>Justification:<br>• Use of site-specific values is permitted under (5)(f)(ii)(B). | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | | | Requirement | Response |
|---|---|---|---|---|
| | | | Documented:<br>• Chapter 5, Section 5.4.1 "Surface Cover, Infiltration, and Recharge"<br>• Chapter 5, Table 5-5 "Summary of Selected Fate and Transport Simulation Input Parameters Used with 1 D Model Implemented in the STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units"<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 4.4.1 "Flow and Transport Boundary Conditions" presents the range of applicable site-specific recharge rates from<br>o PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" notes the use of 100-Area-specific recharge rates for disturbed soils in the model (reference Tables 3 and 4 and Figures 3 and 4 in that section) from<br>o PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf. | |
| 8(b)(vii) | (5)(f)(ii) | (B) | (B) If a site-specific measurement or estimate of infiltration (Inf) was made, was it based on | |
| 8(b)(vii) | (5)(f)(ii) | (B) | • Site conditions without surface caps (e.g., pavement) or other structures that would control or impede infiltration? | **Yes** |
| | | | Explanation:<br>• Site-specific measurements of infiltration for site surface conditions without surface caps that would impede infiltration were used in the STOMP modeling to derive SSL and PRG values.<br>Justification:<br>• Reductions in infiltration due to surface caps are not considered; hence, no justification is necessary for this response. | |

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | Documented:<br>• Chapter 5, Section 5.4.1 "Surface Cover, Infiltration, and Recharge"<br>• Chapter 5, Table 5-5 "Summary of Selected Fate and Transport Simulation Input Parameters Used with 1 D Model Implemented in the STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units"<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 4.4.1 "Flow and Transport Boundary Conditions" presents the range of applicable site-specific recharge rates from<br>o PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" notes the use of 100-Area-specific recharge rates for disturbed soils in the model (Tables 3 and 4 and Figures 3 and 4) from<br>o PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf | |
| 8(b)(vii) | (5)(f)(ii) | (B) | • The presence of a cover or cap may be considered when evaluating the protectiveness of a remedy under WAC 173-340-350 through 173-340-360. | **Not Considered** |
| | | | Explanation:<br>• Site-specific measurements of infiltration for site surface conditions without surface caps that would impede infiltration were used in the STOMP modeling to derive SSL and PRG values.<br>Justification:<br>• Reductions in infiltration due to surface caps are not considered; no justification is necessary for this response.<br>Documented:<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 4.4.1 "Flow and Transport Boundary Conditions" presents the range of applicable site-specific recharge rates | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | from<br>○ PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" notes the use of 100-Area-specific recharge rates for disturbed soils (Figures 3 and 4) from<br>○ PNNL-14702 Rev. 1, Table 4-15, available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf. | |
| 8(b)(vii) | (5)(f)(ii) | (B) | • If a site-specific measurement or estimate of infiltration is made, did it comply with WAC 173-340-702 (14), (15) and (16)? required) (*requirements of 173-340-702 subsections follow*) | **Yes** |
| | | | Explanation:<br>• Infiltration values used were temporally variable, reflecting changing surface conditions under two recharge scenarios. These were the native vegetation recharge scenario, representing the expected future land use (conservation with native shrub steppe vegetation developing over time following closure and revegetation) and the irrigation recharge scenario (representing an irrigated agriculture land use beginning very soon following closure).<br>Justification:<br>• Site-specific measurements of infiltration applicable to three different surface soil types present in the 100 Areas (Ephrata sandy loam and Ephrata stony loam; Burbank sandy loam; and Rupert sand) are used to represent the variability of surface soil types on infiltration rates. Infiltration rates for these surface soil types under mature shrub steppe conditions that prevailed before Hanford operations commenced (that is, prior to 1944), and that would be prevalent again in the future following site closure with revegetation and a transition period to develop mature shrub steppe, are taken from values reported in PNNL-14702 Rev 1, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*. Successful revegetation programs in the 100 Areas are well documented (WCH-288 Rev. 0; WCH-362 Rev. 0; WCH-428 Rev. 0; WCH-512 Rev. 0; WCH-554 Rev. 0), supporting the recharge scenarios that postulate plant succession for the native vegetation recharge scenario. The recharge rate estimates for natural recharge from PNNL-14702 Rev. 1 do not account for overland flow from roadways or roofs, waterline leaks, or any other anthropogenic recharge sources. The estimates were developed for natural | |

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | and disturbed soils, and these are composited into the temporally variable recharge scenarios used to develop SSLs (irrigation scenario) and PRGs (native vegetation recharge scenario).DOE-RL/2011-50 Rev. 1 references PNNL-14702 Rev. 1 as a basis for recharge rates appropriate as initial parameter values for modeling of Central Plateau sites. The surface soil types and vegetation patterns present on the Central Plateau are prevalent in the River Corridor, so Hanford Site-specific recharge rates use the same documented basis that are listed above. The prevalence of the same surface soil types, precipitation patterns, and vegetation patterns that control recharge rates are the justification for use of recharge rate estimates derived from measurements collected at multiple sites across the Hanford Site. A range of surface soil types and temporally varying recharge reflecting changing surface conditions are used in the model to capture a range of expected response, with the most conservative result applied for determination of SSLs and PRGs.<br><br>Documented:<br>• Recharge scenarios and rates are discussed in:<br>o Chapter 5, Section 5.4.1 "Surface Cover, Infiltration, and Recharge"<br>o Chapter 5, Table 5-5, "Summary of Selected Fate and Transport Simulation Input Parameters Used with 1-D Model Implemented in the STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units"<br>o Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 4.4.1 "Flow and Transport Boundary Conditions" presents the range of applicable site-specific recharge rates from PNNL-14702 Rev. 1. See Tables 4-1 and 4-2 in that report.<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" notes the use of 100-Area-specific recharge rates for disturbed soils from PNNL-14702 Rev. 1 in the model. Reference Tables 3 and 4 and Figures 3 and 4 in that section.<br>• Limitations and uncertainty associated with recharge scenarios and rates are discussed in:<br>o Chapter 5, Section 5.9.4 "Uncertainties, Assumptions, and Limitations Specific to Vadose Zone Modeling"<br>o Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 6 "Model Sensitivity and Uncertainty" presents discussion of the modeling conservatism and the results of sensitivity and uncertainty analyses conducted to gain understanding of the important parameters that can affect soil screening level and preliminary remediation goal calculations, including | |

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | recharge rate considerations.<br>○ Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.6 "Uncertainties, Assumptions, and Conservatism"<br>• Revegetation is discussed in:<br>○ Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1.1 "Native Vegetation Recharge Scenario" discusses revegetation of waste sites in accordance with the DOE/RL-96-32, *Hanford Biological Resources Management Plan*. Documentation of successful revegetation conducted in the 100 Areas is provided in:<br>▪ WCH-288 Rev. 0, *2008 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*.<br>▪ WCH-352 Rev. 0, 2009 *River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*.<br>▪ WCH-428 Rev. 0, *2010 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*.<br>▪ WCH-512 Rev. 0, *2011 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*.<br>▪ WCH-554 Rev. 0, *2012 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*. | |
| 340-702 | **Evaluation criteria.** Proposed fate and transport models, input parameters, and assumptions shall comply with WAC 173-340-702 (14), (15) and (16). | | | **Yes** |
| | See responses to (14), (15), and (16) below. | | | |
| 340-702 | 14 | **WAC 173-340-702 (14) Burden of proof.** Any person responsible for undertaking a cleanup action under this chapter who proposes to: | | |
| 340-702 | 14 | (a) | (a) Use a reasonable maximum exposure scenario other than the default provided for each medium; | **No** |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | Response |
|---|---|---|---|---|
| | | | Explanation:<br>• The default reasonable maximum exposure scenario (WAC 173-340-720-4) was used.<br>Justification:<br>• No justification is necessary for using the default maximum exposure scenario.<br>Documented:<br>• Section 6.3.2.2 "Identification of Action Levels" | |
| 340-702 | 14 | (b) | (b) Use assumptions other than the default values provided for in this chapter; | **Yes** |
| | | | Explanation:<br>• The following parameter values used in modeling were not default values:<br>  ○ Infiltration Rate: Assigned site-specific values for recharge rates (net infiltration).<br>  ○ Dilution Factor: The default dilution factor for the three-phase equation (WAC 173-340-747(3)(a)) was not used. Instead, of site-specific hydraulic properties and median site-specific hydraulic gradient were applied in the saturated portion of the model to effectively account for groundwater dilution in the calculation.<br>Justification:<br>• Infiltration Rate: Use of site-specific values is permitted under (5)(f)(ii)(B).<br>• Dilution Factor: If using an alternative fate and transport model (WAC 173-340-747(8)), it is required that dilution "be based on site-specific measurements or estimated using a model incorporating site-specific characteristics."<br>Documented:<br>• Infiltration Rate<br>  ○ Chapter 5, Section 5.4.1 "Surface Cover, Infiltration, and Recharge"<br>  ○ Chapter 5, Table 5-5, "Summary of Selected Fate and Transport Simulation Input Parameters Used with 1-D Model Implemented in the STOMP Code for Screening Level and Preliminary Remediation Goal Calculations in 100-D and 100-H Operable Units"<br>  ○ Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, | |

| WAC | | | Requirement | Response |
|---|---|---|---|---|
| | | | Section 4.4.1 "Flow and Transport Boundary Conditions" presents the range of applicable site-specific recharge rates from PNNL-14702 Rev. 1. See Tables 4-1 and 4-2 in that report.<br>○ Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" notes the use of 100-Area-specific recharge rates for disturbed soils from PNNL-14702 Rev. 1 in the model. Reference Tables 3 and 4 and Figures 3 and 4 in that section.<br>• Dilution Factor<br>○ Chapter 5, Section 5.6 "Vadose Zone Modeling Methods and Results" describes the methodology for inclusion of the aquifer in the model domain and direct simulation of dilution as a function of aquifer depth, hydraulic gradient, domain size, and vadose zone leaching.<br>○ Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 5.4 "Calculating Dilution Factors" presents and discusses dilution factor calculation in the STOMP modeling.<br>○ Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 5.1.3 "Dilution Factor". | |
| 340-702 | 14 | (c) | (c) Establish a cleanup level under Method C; or | **No** |
| | | | Explanation:<br>• A cleanup level was not established under Method C; the cleanup level used was beneficial use (drinking water).<br>Justification:<br>• For groundwater, The NCP at 40 C.F.R. § 300.430(a)(1)(iii)(F) states that EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. The State of Washington defines groundwater as potable in WAC 173 340 720(2), unless the exclusion criteria in WAC 173 340 720(2)(a) through (c) can be demonstrated (insufficient yield, natural constituents that make it unsuitable as a drinking water source). The groundwater beneath the 100 Area does not meet the exclusion criteria; therefore, it is classified by the State as potable. The State of Washington has further determined that the highest beneficial use for potable groundwater, including the potable groundwater at | |

| WAC | | Requirement | | Response |
|---|---|---|---|---|
| | | | the Hanford Site, is as a potential source of domestic drinking water (WAC 173 340 720(1)(a)). For surface water, the point of compliance is defined in the MTCA, "Surface Water Cleanup Standards" (WAC 173-340-730(7)(a)) as the point or points at which hazardous substances are released to surface waters of the state. MTCA, "Surface Water Cleanup Standards" (WAC 173-340-730(7)(b)) indicates that no mixing zone shall be allowed to demonstrate compliance with surface water cleanup levels.<br>Documented:<br>• Chapter 6, Section 6.3.2.2 "Identify Action Levels"<br>• Appendix G, ECF-100NPL-10-0462, *Calculation of Standard Method B Groundwater Cleanup Levels for Potable Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*. | |
| 340-702 | 14 | (d) | d) Use a conditional point of compliance, | **No** |
| | | | Explanation:<br>• The point of compliance is all soil per WAC-173-340-740(6)(b). Note here that the point of calculation referenced in the RI/FS and supporting documentation is the point where groundwater impacts of soil contamination is calculated to derive SSLs and PRGs; it is not the point of compliance itself.<br>Justification:<br>• No justification is necessary for using the prescribed point of compliance.<br>Documented:<br>• Chapter 5, Section 5.7.1 "Identification of Peak Groundwater Concentrations"<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 2.4 "Point of Calculation, Point of Compliance, and Protectiveness Criteria" identifies the point of compliance for SSL and PRG calculation as the WAC required point of compliance: all vadose zone soil. | |
| 340-702 | 14 | shall have the burden of demonstrating to the department that requirements in this chapter have been met to ensure protection of human health and the environment. The department shall only approve of such proposals when it determines that this burden of proof is met. | | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | | Requirement | | Response |
|---|---|---|---|---|
| 340-702 | 15 | **WAC 173-340-702 (15) New scientific information.**<br>Did the proposal to use new scientific information meet the quality of information requirements in (16)? (required)<br>Any proposal to use new scientific information should be introduced as early in the cleanup process as possible.<br>Proposals to use new scientific information may be considered up to the time of issuance of the final cleanup action plan governing the cleanup action for a site unless triggered as part of a periodic review under WAC 173-340-420 or through a reopener under RCW 70.105D.040 (4)(c). | | **Yes** |
| | | Explanation:<br>• New scientific information was introduced in the derivation of a site-specific value (specific to the 100 Area of the Hanford Site) of $K_d$ for hexavalent chromium using batch equilibrium tests.<br>Justification:<br>• Ecology approved the batch leach testing with the approval of the D/H SAP DOE/RL-2009-40 Rev 0. Page 2-127 describes the procedure. It was also modified by TPA-CN-368 signed by Ecology on 8/26/2010 to allow for removing the requirement for pH adjustment of demineralized water.<br>Documented:<br>• Chapter 5, Section 5.5.2 "Development of a Hexavalent Chromium Distribution Coefficient for Vadose Zone Simulations from Batch Leach Testing Results"<br>• Appendix F, ECF-HANFORD-11-0165 Rev. 1, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area.* | | |
| 340-702 | 16 | **WAC 173-340-702 (16) Criteria for quality of information.** | | |
| 340-702 | 16 | (a) | (a) The intent of this subsection is to establish minimum criteria to be considered when evaluating information used by or submitted to the department proposing to modify the default methods or assumptions specified in this chapter or proposing methods or assumptions not specified in this chapter for calculating cleanup levels and remediation levels. This subsection does not establish a burden of | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | | Response |
|---|---|---|---|---|---|
| | | | proof or alter the burden of proof provided for elsewhere in this chapter. | | |
| 340-702 | 16 | (b) | (b) When evaluating the quality of the information the department shall consider the following factors, as appropriate for the type of information submitted: | | |
| 340-702 | 16 | (b) | (i) | (i) Is the information based on a theory or technique that has widespread acceptance within the relevant scientific community? | **Yes** |
| | | | | Explanation:<br>• The general modeling approach for using the STOMP code to calculate SSLs and PRGs under was proposed and accepted in DOE/RL-2011-50 Rev. 1. This document was noted to "provide justification for the uses of the STOMP code itself, but specific models implemented using the STOMP code require justification in application specific documents". Such information is provided in key supporting documents included in Appendix F of this RI/FS report.<br>Justification:<br>• Use of STOMP as a computational code to implement a numerical model for calculation of SSLs and PRGs under a general approach is justified in DOE/RL-2011-50 Rev. 1. (This justification is limited to STOMP as a computational tool, and does not cover the specific models implemented in STOMP, which must be documented and justified for specific applications.)<br>• As noted by Ecology in their acceptance of DOE/RL-2011-50 Rev. 1, specific applications of this approach and use of STOMP require presentation and justification of model implementation (construction and parameterization) in application-specific documents. This RI/FS constitutes such an application-specific document. The specific conceptual model and parameterization to be implemented in STOMP are presented and justified in the RI/FS, specifically in the model package report SGW-50776 Rev. 2 and in the application of the model to calculate SSLs and PRGs in ECF-HANFORD-11-0063 Rev. 6.<br>Documented:<br>• Chapter 5, Section 5.7 "Groundwater/Surface Water Protection Screening Level and Preliminary Remediation Goal Development" presents an overview of the SSL and PRG modeling approach.<br>• DOE/RL-2011-50 Rev. 1, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*, justifies use of STOMP as a computational code for implementation of | |

| WAC | Requirement | | | | Response |
|---|---|---|---|---|---|
| | | | | numerical models to calculate SSLs and PRGs.<br>• PNNL-12030, *STOMP Subsurface Transport Over Multiple Phases Version 2.0 Theory Guide*, comprehensively documents the available governing and constitutive equations available in the STOMP code.<br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor* (in its entirety) presents the basis for the modeling and parameterization of vadose zone models implemented in STOMP for the purpose of calculation of SSL and PRG values. This includes identification of the specific operational mode of STOMP used to implement the model, as well as identification of which STOMP equations are used in this model (in Section 4.1 "Governing Equations").<br>• Appendix F, ECF-Hanford-11-0063 (in its entirety) presents details on the application of STOMP to calculate SSL and PRG values. | |
| 340-702 | 16 | (b) | (ii) | (ii) Is the information derived using standard testing methods or other widely accepted scientific methods? | **Yes** |
| | | | | Explanation:<br>• Batch leach test data used to derive a 100 Area specific $K_d$ value for hexavalent chromium. Site-specific recharge rates were taken from scientific literature.<br>Justification:<br>• Batch leach test data were collected and submitted for leaching using ASTM D3987-06, *Standard Test Method for Shake Extraction of Solid Waste with Water*.<br>Documented:<br>• Soil Leaching Data:<br>o Appendix F, ECF-HANFORD-11-0165 Rev. 1, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area*.<br>• Recharge Rates:<br>o Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 3.2.2 "Recharge and Evapotranspiration", Section 4.4.1 "Flow and Transport Boundary Conditions", and Section 6.2.2 "Sensitivity to Long Term Recharge" | |

| WAC | | | | Requirement | Response |
|---|---|---|---|---|---|
| | | | | ○ Appendix F, ECF-HANFORD-11-0063, *STOMP 1-D Modeling for Determination of Preliminary Remediation Goals for 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" which references these sources of site-specific recharge rates:<br>▪ PNNL-14702 Rev. 1, *Vadose Zone Hydrogeology Data Package for Hanford Assessments* (available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf) cites scientific data noted above in response to WAC requirement 8(b)(vii).<br>▪ PNNL-17841, *Compendium of Data for the Hanford Site (Fiscal Years 2004 to 2008) Applicable to Estimation of Recharge Rates* (available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17841.pdf) provides additional scientific basis for recharge rate measurements. | |
| 340-702 | 16 | (b) | (iii) | (iii) Has a review of relevant available information, both in support of and not in support of the proposed modification, been provided along with the rationale explaining the reasons for the proposed modification? | **Yes** |
| | | | | Explanation:<br>• A conservative basis was selected for deriving a $K_d$ value for hexavalent chromium through use of a 90 percent likelihood that actual values for residual hexavalent chromium contamination would exhibit a greater sorptive value.<br>Justification:<br>• This basis represents a conservative value for sorption of residual hexavalent chromium in the vadose zone. This assumption is not applicable to the mobile fraction of hexavalent chromium that has already migrated to groundwater.<br>Documented:<br>• Appendix F, ECF-HANFORD-11-0165 Rev. 1, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area* (in its entirety) | |
| | | | | Explanation: | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | | | | Requirement | Response |
|---|---|---|---|---|---|
| | | | | • Batch leach test data used to derive a 100 Area specific $K_d$ value for hexavalent chromium. Site-specific recharge rates were taken from scientific literature.<br><br>Justification:<br><br>• Batch leach test data were collected and submitted for leaching using ASTM D3987-06, *Standard Test Method for Shake Extraction of Solid Waste with Water*.<br><br>Documented:<br><br>• Soil Leaching Data:<br><br>o Appendix F, ECF-HANFORD-11-0165 Rev. 1, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area*.<br><br>• Recharge Rates:<br><br>o Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 3.2.2 "Recharge and Evapotranspiration", Section 4.4.1 "Flow and Transport Boundary Conditions", and Section 6.2.2 "Sensitivity to Long Term Recharge"<br><br>o Appendix F, ECF-HANFORD-11-0063, *STOMP 1-D Modeling for Determination of Preliminary Remediation Goals for 100-D and 100-H Source Operable Units*, Section 3.2.1 "Upper Boundary Conditions" which references these sources of site-specific recharge rates:<br><br>▪ PNNL-14702 Rev. 1, *Vadose Zone Hydrogeology Data Package for Hanford Assessments* (available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf) cites scientific data noted above in response to WAC requirement 8(b)(vii).<br><br>▪ PNNL-17841, *Compendium of Data for the Hanford Site (Fiscal Years 2004 to 2008) Applicable to Estimation of Recharge Rates* (available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17841.pdf) provides additional scientific basis for recharge rate measurements. | |
| 340-702 | 16 | (b) | (iv) | (iv) Are the assumptions used in applying the information to the facility valid and would they ensure the proposed modification would err on behalf of human health and the environment? | **Yes** |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | Response |
|---|---|---|
| | Explanation:<br>• The modeling approach applied conservative assumptions, with respect to SSLs and PRGs, to structure and parameterization of the model, where uncertainty existed, to achieve this standard. Conservative assumptions include (not are not limited to):<br>o The point of calculation is assumed to at the waste site boundary on the downstream side of the waste site,<br>o Contaminant source is assumed to span a large portion of the vadose zone (100% of the vadose zone for mobile and somewhat immobile contaminants; upper 70% for less mobile contaminants), and<br>o No credit is taken for natural degradation, air-phase partitioning, or hydrodynamic dispersion.<br>Discussion of the limitations and uncertainty in the model and parameterization are provided. Other examples of conservatism include:<br>o Application of irrigation for the irrigation recharge scenario starting less than five years after remedial action (when presumably institutional controls would delay this by decades; resulting in conservatism because higher recharge mobilizes and transports contaminants sooner and faster with higher peak groundwater concentrations and hence lower PRG values);<br>o Derivation of stratigraphic profiles for the model at maximum water table (conservative because this minimizes transport distance in the vadose zone, resulting in earlier and higher peak concentrations); and<br>o Assumption of uniform contamination in the vadose zone at the peak level (100:0 and 70:30 rules, depending on contaminant mobility) which is conservative because it brackets, and likely overestimates, the amount of contaminant mass present.<br>These examples are not an exhaustive list of the conservatisms present in the alternative fate and transport model used for SSL and PRG development; full discussion is provided in model uncertainty and limitations discussions in Chapter 5 and the supporting environmental calculation file. Conservatism in the initial concentration distribution was validated to determine whether site-specific modeling was required. A more conservative approach was applied to simulate strontium-90 with a 100:0 distribution, despite its lower mobility under present day transport conditions, in recognition of its current distribution in the deep subsurface environment as a result of past discharge conditions for that constituent.<br>• Dilution factors were treated with representative, site-specific parameter values rather than conservative | |

| WAC | Requirement | Response |
|---|---|---|
| | assumptions. For context, if the default fixed parameter three-phase partition model [WAC 173-340-747(3)(a)] were used to establish soil concentrations for groundwater protection, the default groundwater dilution factor is 20 for unsaturated zone soil. However, this default is not applicable to this calculation, because it uses alternative fate and transport models [WAC 173-340-747(8)] and not the default parameter three-phase partition model [WAC 173-340-747(3)]. Where alternative fate and transport models are used, the WAC requires that dilution "be based on site-specific measurements or estimated using a model incorporating site-specific characteristics". This requirement is met in this calculation by using STOMP to model the aquifer with the appropriate aquifer thickness and a median hydraulic gradient based on site-specific measurements.<br>• Using the upper 5 m of the aquifer, although allowed by the regulations, does not match site-specific conditions for some waste site locations where the aquifer thickness is less than 5 m. In these locations, the thinner aquifer would result in a higher concentration in the model prediction if all other factors in this calculation were unchanged. However, use of the median area hydraulic gradient in the model for each area, rather than site-specific hydraulic gradient, would also affect the dilution if considered (this gradient would typically be higher at locations with a thinner aquifer to maintain the same aquifer flow rate).<br><u>Justification</u>:<br>• Uncertainty is consistently addressed through use of conservative assumptions and parameterization.<br><u>Documented</u>:<br>• Point of Calculation:<br>o Chapter 5, Section 5.9.4 "Uncertainties, Assumptions, and Limitations Specific to Vadose Modeling"<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 2.4 "Point of Calculation, Point of Compliance, and Protectiveness Criteria"<br>• Contaminant Initial Source Representation:<br>o Chapter 5, Section 5.6.1 "Initial Contaminant Distribution"<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and* | |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | | | | Requirement | Response |
|---|---|---|---|---|---|
| | | | | *100-H Source Operable Units*, Section 3.2.4 "Initial Conditions"<br>• No credit taken for natural degradation, air-phase partitioning, or dispersion:<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.4 "Contaminant Transport Parameters"<br>• Model Uncertainties:<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.6 "Uncertainties, Assumptions, and Conservatism"<br>• Validation of conservatism in initial distribution conditions for SSL and PRG development and treatment of strontium-90 initial condition:<br>o Chapter 5, Section 5.7.2 "Site-Specific Modeling"<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 5.2.1 "Validation of Conservative Basis for 70:30 Source Distribution for High $K_d$ Contaminants"<br>• Dilution Factor:<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 5.3 "Dilution Factor"<br>• Aquifer Thickness Representation:<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.2.3 "Lateral Boundary Conditions" | |
| 340-702 | 16 | (b) | (v) | (v) Does the information adequately address populations that are more highly exposed than the population as a whole and are reasonably likely to be present at the site? And | **No** |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | | | | Response |
|---|---|---|---|---|---|
| | | | | Explanation:<br>• No cleanup levels are developed for sensitive subpopulations. However, Native American risk assessments are prepared and presented.<br>Justification:<br>• Reasonable maximum exposure assumptions are based on exposure scenarios used to derive regulatory standards, and therefore assumed protective of all populations and adequate to restore the resource to beneficial use.<br>Documented:<br>• Chapter 6, Sections 6.1.4 "Other Residential Land Use Scenarios in RCBRA"<br>• Chapter 6, Section 6.3.8.4.1 "Uncertainties Associated with the Native American Risk Assessments"<br>• Appendix G, ECF-100HR3-10-0477 Rev. 1, *Native American Risk Assessment for the 100-HR-3 Groundwater Operable Unit* (in its entirety) | |
| 340-702 | 16 | (b) | (vi) | (vi)<br>• Has adequate quality assurance and quality control procedures been used?<br>• Are any significant anomalies adequately explained?<br>• Are the limitations of the information identified? and<br>Is the known or potential rate of error is acceptable? | **Yes** |
| | | | | Explanation:<br>• Quality assurance for use of modeling to develop SSL and PRG values was performed following EPA guidance (EPA/240/R-02/007, EPA QA/G-5M, *Guidance for Quality Assurance Project Plans for Modeling*). Requirements addressed modeler training, software and model documentation and configuration control, model application checking, and controlled software use in the preparation of calculations using STOMP to derive SSL and PRG values. No significant anomalies were found during implementation of the STOMP model. The limitations of the alternative fate and transport modeling used to derive SSL and PRG values are identified. The STOMP code solves the numerical equations to a defined level of precision; hence, effectively any error would be associated with model uncertainties, | |

| WAC | Requirement | Response |
|---|---|---|
| | | scenario uncertainties, and parameter uncertainties. Judicious use of conservatism is made in the development of the model, scenarios, and parameterization to ensure that errors are biased in a conservative direction relative to protection of surface water and groundwater. That is, conservatism with regard to these areas where uncertainty in the model exists is used to cause calculated SSL and PRG values to be lower than would be calculated with reduced uncertainty and/or with less conservative bias in model development. Quality assurance for use of software used to implement the model was performed in accordance with the requirements of DOE Order 414.1, *Quality Assurance*, which imposes NQA-1 standards on software use. The STOMP software was tested and qualified before use for modeling under procedures that implement the requirements of DOE Order 414.1 and guidance of NQA-1.<br><br>Justification:<br>• Approved quality assurance plans and procedures written to meet the requirements of DOE and the guidance of the EPA were adhered to throughout the modeling process. All aspects required under this WAC requirement were included in the RI/FS documentation. Limitations of the model are discussed in the primary categories of (1) model uncertainties, (2) scenario uncertainties, and (3) parameter uncertainties.<br><br>Documented:<br>• Demonstration of quality assurance and quality control procedure use:<br>o Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units* (in its entirety) provides demonstration of documentation of model application in compliance with a plan that followed the guidance provided in<br>o EPA/240/R-02/007, EPA QA/G-5M, *Guidance for Quality Assurance Project Plans for Modeling*<br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 4 " Software Applications" demonstrates controlled software use under an approved quality assurance process in compliance with implementing procedures compliant with<br>o DOE O 414.1D, *Quality Assurance*<br>• Signatures of the checker and senior reviewer on cover sheet of Appendix F, Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and* |

**Crosswalk of WAC Requirements (WAC 173-340-747(8), 2007) for Use of Alternative Fate and Transport Modeling to Modeling Basis of Soil Screening Levels and Preliminary Remediation Goals for 100-D/H Remedial Investigation / Feasibility Study**

| WAC | Requirement | Response |
|---|---|---|
| | | *Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*,, validate completion of independent review and checking of model application as required under an approved quality assurance procedure governing preparation of environmental calculations.<br><br>Limitations of the information identified, and known or potential error rate:<br><br>• Chapter 5, Section 5.9 "Uncertainties that Apply to Groundwater and Vadose Zone Modeling"<br><br>• Appendix F, SGW-50776 Rev. 2, *Model Package Report: Vadose Zone Model for the River Corridor*, Section 6.1 "Modeling Conservatisms", Section 6.2 "Sensitivity Analyses", and Section 6.3 "Uncertainty Analyses"<br><br>• Appendix F, ECF-HANFORD-11-0063 Rev. 6, *STOMP 1-D Modeling for Determination of Soil Screening Levels and Preliminary Remediation Goals for Waste Sites in the 100-D and 100-H Source Operable Units*, Section 3.6 "Uncertainties, Assumptions, and Conservatism" | |