Table 6-3. Summary of Residential Scenario Risk Assessment Results for Radionuclides

Waste Site Name*	RI/FS Decision Unit	Radionuclides and Radiological Risk Drivers			
		RCBRA Radiological Risk	RCBRA Radiological Risk Driver	RI/FS Radiological Risk	RI/FS Radiological Risk Driver
300 Ash Pit	Shallow	--	--	1.8×10^{-6}	None
300 VTS	Shallow	1×10^{-6}	None	6.6×10^{-7}	None
300-8	Shallow	3×10^{-6}	None	2.1×10^{-6}	None
300-10	Shallow Focused	1×10^{-5}	None	6.3×10^{-6}	None
300-18	Shallow	2×10^{-6}	None	1.3×10^{-6}	None
300-45	Shallow Focused	6×10^{-6}	None	3.1×10^{-6}	None
300-49	Shallow	1×10^{-5}	None	7.9×10^{-6}	None
300-50	Shallow	5×10^{-5}	None	2.7×10^{-5}	None
316-1	Shallow 1	2×10^{-4}	Cobalt (1×10^{-4})	6.0×10^{-5}	None
	Shallow 3	Not Evaluated	Not Evaluated	1.6×10^{-4}	None
	Shallow 4	Not Evaluated	Not Evaluated	4.9×10^{-5}	None
316-2	Shallow 1	3×10^{-4}	Uranium-238 (2×10^{-4})	2.7×10^{-4}	Uranium-238 (1.3×10^{-4})
	Shallow 2	Not Evaluated	Not Evaluated	3.6×10^{-4}	Uranium-238 (1.8×10^{-4})
	Shallow 3	Not Evaluated	Not Evaluated	5.1×10^{-5}	None
316-5	Shallow 1	5×10^{-4}	Uranium-235 (1×10^{-4}) Uranium-238 (2×10^{-4})	3.3×10^{-4}	Uranium-235 (1.1×10^{-4}) Uranium-238 (1.7×10^{-4})
	Shallow 2	Not Evaluated	Not Evaluated	2.2×10^{-4}	Uranium-238 (1.3×10^{-4})
	Shallow Focused	Not Evaluated	Not Evaluated	1.7×10^{-4}	None
618-4	Shallow	1×10^{-5}	None	8.1×10^{-6}	None
618-5	Shallow	5×10^{-6}	None	2.7×10^{-6}	None
618-12	Shallow	5×10^{-5}	None	2.3×10^{-5}	None
628-4	Shallow	5×10^{-6}	None	3.5×10^{-6}	None

Table 6-3. Summary of Residential Scenario Risk Assessment Results for Radionuclides

Waste Site Name*	RI/FS Decision Unit	Radionuclides and Radiological Risk Drivers			
		RCBRA Radiological Risk	RCBRA Radiological Risk Driver	RI/FS Radiological Risk	RI/FS Radiological Risk Driver
600-47	Shallow	7×10^{-6}	None	4.0×10^{-6}	None
600-259	Shallow	3×10^{-6}	None	1.6×10^{-6}	None
	Shallow Focused	Not Evaluated	Not Evaluated	8.6×10^{-7}	None

Sources:

RCBRA data: DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment*, Volume II, Part 2, Table 2-10

RI/FS data: Appendix G, Table G-22

Notes:

Radionuclide drivers shown have an associated risk greater than 1×10^{-4}.

The risk value for the individual drivers is shown in parentheses after the name of the risk driver chemical.

Risks are based on reasonable maximum exposure point concentrations.

* With the exception of the 300 Vitrification Test Site (VTS), 600-47, and 600-259 waste sites, all waste sites listed on this table were remediated using industrial remedial action goals and objectives. Waste sites 300 VTS, 600-47, and 600-259 are located outside the core industrial zone and were remediated using unrestricted remedial action goals and objectives.

-- = Radionuclide COPCs were not identified.

6.1.2 RI/FS Supplemental Risk Evaluation (Unrestricted Land Use)

As shown in Table 6-1 through Table 6-3, the risk assessment results are similar between the RCBRA and the RI/FS for the residential scenario. Differences in results are attributed generally to the COPC identification process, the method used to calculate EPCs, and the PRG value used for comparison. The risk evaluation provided in this chapter supplements the RCBRA because there are several key differences between the scope and purpose of the RCBRA and the scope and purpose of the RI/FS. The following summarizes the key differences and Table 6-4 provides additional detail about these differences:

- Basis of PRG values for radioisotopes and chemicals
- Inclusion of all decision units[6] associated with a waste site
- Inclusion of analytical data from focused sampling designs
- Analysis time frame
- Calculation of EPCs

[6] The floor and the sidewalls of an excavated waste site are divided into one or more decision units. A sample design is developed for each decision unit. See Section 6.2.2.2 for additional information about the decision unit.

Table 6-4. Comparison of Methods and Assumptions Used for the Residential Scenario

Parameter	Method Used in RCBRA	Method Used in RI/FS	Overall Effect on RI/FS
Basis of PRG Values for Radioisotopes and Chemicals			
Residential PRG value for radioisotopes	Radionuclide cancer risk is evaluated using the interim action ROD rural residential exposure scenario reported in *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17). Radionuclide RAGs were calculated based on a dose threshold of 15 mrem/yr. In the RCBRA, these RAGs were converted to RBSLs based on a risk threshold of 1×10^{-4} (pg 2-41 of the RCBRA). The interim action ROD rural residential exposure scenario is considered a local area exposure scenario (located on a waste site).	Radionuclide cancer risk is evaluated using the residential exposure scenario. This exposure scenario is similar to the interim action ROD rural residential scenario but incorporates updates to reflect recent EPA guidance.	The residential scenario used in the RI/FS reflects updates in methodology (risk-based versus dose-based threshold) and recent recommendations in exposure assumptions. RBSL/PRG values differ slightly between the RCBRA and the RI/FS for key COPCs (gamma emitters and Sr-90).
Updates to EPA guidance for residential PRG	External gamma shielding factor is 0.7. Outdoor time fraction is 0. 2 (5 hours per day over 350 days per year) Target cancer risk value is 1×10^{-4}.	External gamma shielding factor is 0.4 (EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User's Guide*). Outdoor time fraction is 0.12 (3 hours per day over 350 days per year) (EPA 600/P-95/002Fa-c, *Exposure Factors Handbook*). Target cancer risk value is 1×10^{-4}.	The gamma-shielding factor was revised from 0.7 to 0.4. The current assumption accounts for a 60 percent reduction in external exposure due to shielding from structures rather than a 30 percent reduction. The use of the updated assumption would result in slightly less exposure and a less conservative PRG value. The outdoor time fraction was revised from 0.2 to 0.12. The current assumption assumes the resident spends 3 hours per day outside rather than 5 hours per day. Use of the updated assumption would result in a less exposure and a less conservative PRG value. The protective threshold value was updated from a dose-based value to a risk-based value. The overall outcome is

Table 6-4. Comparison of Methods and Assumptions Used for the Residential Scenario

Parameter	Method Used in RCBRA	Method Used in RI/FS	Overall Effect on RI/FS
			that updated PRGs values used in the RI/FS are slightly lower for beta- and gamma-emitting radioisotopes and higher for alpha-emitting radioisotopes.
MTCA Method B soil cleanup levels for unrestricted land use	MTCA Method B levels are based solely on incidental soil ingestion.	Separate MTCA Method B levels were calculated for incidental soil ingestion and inhalation.	Chemicals that only report toxicity values for the inhalation exposure route are not included in the RCBRA evaluation (beryllium, cadmium, cobalt, Cr(VI), and nickel). The RI/FS separately reports cancer risks and noncancer hazard indices for both incidental soil ingestion and inhalation exposure routes.
MTCA Method B inhalation cleanup levels for unrestricted land use	MTCA Method B inhalation cleanup levels were not evaluated in the RCBRA. *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17), reports RAGs for beryllium, cadmium, Cr(VI) based on the inhalation exposure pathway, WAC 173-340-750(3), 1996. A PEF value of 1.0×10^7 m^3/kg was used to convert air concentrations to soil concentrations. The PEF value of 1.0×10^7 m^3/kg is based on the default mass loading factor in RESRAD. This is roughly two orders of magnitude smaller than EPA's default PEF of 1.4×10^9 m^3/kg.	MTCA Method B inhalation cleanup levels were calculated for the inhalation exposure route. A PEF value of 7.3×10^{10} m^3/kg is used to convert air concentrations to soil concentrations. This PEF uses meteorological data from Boise, Idaho and Hanford Site-specific annual wind speed (OSWER 9355.4-24).	Inhalation pathway cleanup levels that use a PEF value based on the default mass loading factor in RESRAD are lower values (more conservative) that those cleanup levels that are based on EPA Methodology.

Table 6-4. Comparison of Methods and Assumptions Used for the Residential Scenario

Parameter	Method Used in RCBRA	Method Used in RI/FS	Overall Effect on RI/FS
Data Analysis			
Waste site decision units and analysis time frame	For local area exposure scenarios (including the interim action ROD rural residential scenario), the RCBRA used only the CVP/RSVP data sets from shallow zone decision units. These data sets are from waste sites that were excavated/remediated through calendar year 2005. The shallow zone decision unit is typically represented by soils from the excavation floor if at or above 4.6 m (15 ft) and any sidewalls from grade level (0 m [0 ft]) to a depth of 4.6 m (15 ft).	The RI/FS used CVP/RSVP data sets from all decision units associated with an excavated/remediated waste site through May 2011. In addition to the shallow zone decision unit, the RI/FS evaluates the risk contribution from soils associated with the overburden, staging pile footprint area, and the deep zone decision units.	The RI/FS risk evaluation is intended to supplement the analysis in Chapter 2 of the RCBRA. The RI/FS risk evaluation results can be used to disposition the closeout document for each remediated waste site from an interim status to final closure status.
Statistical and focused sample designs	When both focused and statistical samples exist for an analyte at a waste site, only the statistical samples were used to calculate the representative concentrations. An uncertainty analysis was performed to evaluate the selection of focused and/or statistical samples has on the risk assessment results, representative concentrations for these waste sites are also calculated using the combined focused and statistical samples. The statistical representative concentrations were compared to the combined focused and statistical samples and shown in Table C3-11 in Appendix C, Section C-3, "Representative Concentrations."	The approach used to evaluate the data set for each sample design is similar to that used for the closeout documentation. The layout and orientation of sampling designs are based on the size, shape, and depth of the site. The data sets from the sample design are used to confirm attainment of remedial action objectives.	Evaluation of only the data from statistical sample designs when focused sample data are also collected has the potential to understate risk. Frequently focused sample results are collected in areas with the highest potential for contamination to be present. The RI/FS risk evaluation results can be used to disposition the closeout document for each remediated waste site from an interim status to final closure status.

Table 6-4. Comparison of Methods and Assumptions Used for the Residential Scenario

Parameter	Method Used in RCBRA	Method Used in RI/FS	Overall Effect on RI/FS
COPC Identification	COPC refinement process includes a number of complementary steps and criteria, including a pre-selected list of contaminants that were excluded and a list that were included, as determined and agreed upon among the Tri-Parties. Additional selection steps include evaluation of all data according to detection status, statistical comparisons of Hanford Site data to background and reference site data, and an analyte-specific evaluation. Each interim action ROD area has a separate list of COPCs.	COPC identification uses the exclusion criteria defined in Section 3.2.2.1 of the RCBRA. The inclusion list and other refinement steps used in the RCBRA were not incorporated into the RI/FS. When a COPC was detected at least once in a waste site decision unit (and it did not meet the exclusion criteria) it was carried into all risk calculations.	COPC refinement in RCBRA often included analytes that were not detected at the waste site. The inclusion of analytes that were not detected at a waste site decision unit results in an overstatement of risk. The method used to identify COPCs in the RI/FS is similar to the method used in the closeout documentation. Although two different COPC identification processes were used, similar risk drivers were identified in the risk characterization step of the analysis.
Exposure point concentrations	Representative concentrations pertain to sampled medium, whereas EPCs also include modeled concentrations in other exposure media. In general, the process used in the RCBRA follows EPA guidance as provided in the *ProUCL Version 4.0 User Guide* (EPA/600/R-07/038). The ProUCL software was not used to calculate representative concentrations.	*Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) is the EPA guidance for UCL calculation and ProUCL 4.00.05 serves as the companion software package for this guidance. ProUCL 4.00.05 contains rigorous parametric and nonparametric (including bootstrap methods) statistical methods that can be used on full data sets without nondetects and on data sets with below detection or nondetect observations. Both ProUCL and *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) were used to recalculate the UCLs for the 300 Area Source OU.	*ProUCL Version 4.0 User Guide* (EPA/600/R-07/038) draws from guidance documented in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10). Methodologies for calculating UCL-95s are similar between the RCBRA and the RI/FS.

Table 6-4. Comparison of Methods and Assumptions Used for the Residential Scenario

Parameter	Method Used in RCBRA	Method Used in RI/FS	Overall Effect on RI/FS
Waste Site-Specific Information			
Exclusion of focused sample design data from waste site 316-5	Focused sample design data sets were not evaluated. Only statistical sample design data sets were evaluated.	Both focused and statistical sample design data sets were evaluated in the RI/FS.	Exclusion of some data sets has the potential to understate risks in the RCBRA.
Hazard Index for 300-49	300 Area did not include cobalt, iron, or vanadium as COPCs	COPC identification process for the RI/FS includes all detected analytes (includes cobalt, iron, and vanadium as COPCs).	Inclusion of additional COPCs in the RI/FS may have the potential to overstate risks.
Hazard Index for 300-50	300 Area did not include cobalt, iron, or vanadium as COPCs	COPC identification process for the RI/FS includes all detected analytes (includes cobalt, iron, and vanadium as COPCs).	Inclusion of additional COPCs in the RI/FS may have the potential to overstate risks.

Sources:

DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*

EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User's Guide*

EPA 600/P-95/002Fa-c, *Exposure Factors Handbook*

EPA/600/R-07/038, *ProUCL Version 4.00.05 User Guide (Draft)*

OSWER 9285.6-10, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*

WAC 173-340-750, "Model Toxics Control Act—Cleanup," "Cleanup Standards to Protect Air Quality"

PEF = particulate emission factor

RESRAD = RESidual RADiation

RAOs are narrative statements that define the extent to which waste sites require cleanup to protect HHE. Further, PRGs (also used as RBSLs) are the numeric values that represent the RAOs presented in Chapter 8. The 300 Area PRGs are developed in the RCBRA and presented in this chapter.

The industrial scenario represents the reasonably anticipated land use for the majority of the 300 Decision Area. In select portions of the 300 Decision Area, land use is designated as conservation (mining). The resident Monument worker and the casual user scenario represent reasonably anticipated future land use in these non-industrial areas. Although the anticipated future land use is industrial or conservation (mining), DOE has elected to clean up a large portion of the 300 Area (outside the 300 Area Industrial Complex and the 618-11 Burial Ground) to a more protective land use standard (unrestricted). Both the unrestricted and industrial land use criteria are used for the preparation of RAOs.

This section describes the results of the supplemental risk evaluation based on the residential scenario. The following section (Section 6.1.3) describes the results of the supplemental risk evaluation for reasonably anticipated future land uses, which includes the industrial scenario.

For the 300 Area Source OU, the results of the supplemental soil risk evaluation presented in this chapter will be used to determine whether additional remedial action is necessary for waste sites where remediation has been completed, and whether the goals and objectives of the interim action RODs have been met, as demonstrated by verification sampling and analysis. The risk-based screening evaluation for the residential scenario and the industrial scenario in this chapter provides information necessary to resolve the following questions and provides information needed to support final remedial decisions that will ensure protection of HHE:

- Are residual conditions for cleanup actions completed under the interim action RODs protective of HHE based on comparison to RBSLs calculated in accordance with current EPA guidance?
- Are there waste sites with a no action, or interim closed reclassification status that should be carried into the FS?
- What uncertainties are associated with the risk results that require a risk management decision?

Waste sites remediated under the 300-FF-1 and 300-FF-5 ROD (EPA/ROD/R10-96/143) are closed and remediation is complete with regard to the protection of human health from direct contact with soil. RAGs (for direct contact) for the 300-FF-1 waste sites were based on the industrial scenario. Although the remedial actions implemented for the 300-FF-1 waste sites are complete, they are included in this chapter to provide a complete picture of the potential vadose zone contamination remaining beneath the waste sites.

Waste site remediated under the 300-FF-2 interim action ROD are Interim Closed using RAGs related to direct contact soil exposure by human receptors. With the exception of eight waste sites located outside the core industrial zone, RAGs (for direct contact) for 300-FF-2 waste sites were based on an industrial scenario. *Explanation of Significant Differences for the 300-FF-2 Operable Unit Record of Decision* (EPA, Ecology, and DOE, 2004) identified eight wastes sites to be remediated using unrestricted RAGs. These eight waste sites include: 618-7 Burial Ground, 300 Vitrification Test Site (VTS), 618-13 Burial Ground, 600-47 Dumping Area, 316-4 Crib, 600-63 Lysimeter Facility, 600-259 Lysimeter Facility, and 618-10 Burial Ground.

Remedial action goals in the 100 Area of the River Corridor (for direct contact) were based on a rural residential exposure scenario. The interim action ROD residential scenario for radionuclides is a Rural Residential scenario that, in addition to direct contact, includes food chain exposure pathways (e.g., ingestion of homegrown produce, beef, and milk). Since the *Remedial Design Report/Remedial Action*

Work Plan for the 100 Area (DOE/RL-96-17) was originally published, EPA has published a change in policy associated with health protectiveness thresholds as well as updates in guidance associated with several exposure assumptions. PRGs presented in this chapter incorporate exposure assumptions that were updated to reflect current EPA guidance. These assumptions include a decrease in the external gamma-shielding factor (decreased shielding) and a decrease in the outdoor time fraction. Health protective levels were also updated from a target annual dose rate of 15 mrem/yr to a target risk of 1×10^{-4} to be consistent with guidance recommended in *Radiation Risk Assessment At CERCLA Sites: Q & A* (EPA/540/R/99/006).

The interim action ROD residential scenario for chemicals is based on the MTCA Method B Soil Cleanup Levels ("Unrestricted Land Use Soil Cleanup Standards" [WAC 173-340-740]). The MTCA Method B levels are based solely on incidental soil ingestion and do not address the food exposure pathways that were included for the radionuclide Rural Residential scenario. The MTCA Method B cleanup levels developed in this chapter are similar to those published in the most recent version of the 100 Area RDR/RAWP (DOE/RL-96-17) with the exception of those chemicals whose RAG is based on the inhalation exposure route. RAGs reported in the 100 Area RDR/RAWP (DOE/RL-96-17) incorporate the use of a particulate emission factor (PEF) that is based on the mass loading rate reported in the RESRAD code. The PEF used to calculate the inhalation RAG is roughly two orders of magnitude greater than the site-specific PEF developed with EPA guidance for the Hanford Site and used in this chapter.

In addition to performing the risk-based screening evaluation, another purpose for updating the PRGs is to determine if the RAGs developed and reported in the 100 Area RDR/RAWP (DOE/RL-96-17) are protective when compared to current guidance. Chapter 8 will provide a summary of the RAGs reported in the 100 Area RDR/RAWP (DOE/RL-96-17) in addition to the PRGs presented in this chapter. To satisfy RAOs for protection of human health, the RAGs reported in the 100 Area RDR/RAWP (DOE/RL-96-17) will be compared to the PRGs presented in this chapter for the residential scenario. The lower of the two values will be selected to satisfy RAO 4 and RAO 5. This approach is used in Chapter 8 to ensure that PRGs for protection of human health from direct contact with soil achieve comparable or greater levels of protectiveness as was achieved by the RAGs presented in the interim action RODs.

Differences between the RCBRA and the RI/FS in the methodologies used for assessing residual risks are described in Table 6-4; these include methods for COPC identification, selection of exposure factors used for the RAGs and PRGs, inclusion of all decision units associated with a waste site, and inclusion of analytical data from focused sampling designs. Because of these differences, the evaluation provided in the RI/FS more directly supports the evaluation of remedial alternatives in the FS.

6.1.3 RI/FS Supplemental Soil Risk Evaluation (Reasonably Anticipated Future Land Use Scenarios)

The RCBRA evaluated risks for a range of exposure scenarios that represent a range of upper bound and reasonably anticipated receptors and activities. When soil cleanup goals were established initially for the River Corridor, the TPA signatories agreed that it was appropriate to protect for a range of potential exposures in the future so that interim cleanup actions did not limit future use of the site. The industrial scenario represents reasonably anticipated land use in the designated industrial area of the 300 Area. The resident Monument worker and the casual user scenario represent reasonably anticipated future land use except in the designated industrial area. PRGs are presented in this section for all three scenarios for use in the risk-based screening evaluation. CVP and RSVP data are compared to these numeric values to determine if further remedy is warranted. When the total risk for a waste site exceeds 1×10^{-4} based on the residential scenario, then the waste site is compared to the PRGs developed for reasonably anticipated future land use. The results of these comparisons are used to determine the need for remedy selection relative to reasonably anticipated land use. The results of these comparisons (presented in Section 6.2.5.2)

show that the total risk calculated for the resident and the resident Monument worker scenarios are essentially identical.

The industrial/commercial exposure scenario for local areas is presented in Chapter 5 of the RCBRA Report (DOE/RL-2007-21), using the methodology described in Chapter 3 of the RCBRA Report (DOE/RL-2007-21). The industrial/commercial scenario in Chapter 5 of the RCBRA Report (DOE/RL-2007-21) is a traditional scenario that has been described in various EPA documents (*Soil Screening Guidance: Technical Background Document* [EPA/540/R-95/128]; "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" [Clay, 1991]; *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* [OSWER 9355.4-24]) and does not use the interim action ROD risk assessment models. In the RCBRA, an adult worker is assumed to work at a building located on a remediated waste site (local area), but resides offsite. The industrial/commercial exposure scenario was used to calculate forward risk estimates in the RCBRA but was not used to develop a PRG.

Remedial action goals in the 300 Area (for direct contact) were based on an industrial worker exposure scenario. The interim action ROD industrial scenario for radionuclides is an industrial worker scenario that includes the direct contact exposure pathway (e.g., external gamma exposure, inhalation of dust, and incidental soil ingestion). The RAGs for radionuclides have not been revised since originally published in 1996. EPA has since published a change in policy associated with health protectiveness thresholds as well as updates in guidance associated with several exposure assumptions. The PRGs presented in this chapter for the industrial scenario incorporate updated exposure assumptions to reflect current EPA guidance. These assumptions include a decrease in the external gamma-shielding factor (decreased shielding), a decrease in the exposure duration, inhalation rate, and incidental soil ingestion rate. Health protective levels were also updated from a target annual dose rate of 15 mrem/yr to a target risk of 1×10^{-4} to be consistent with guidance recommended in *Radiation Risk Assessment at CERCLA Sites: Q & A* (EPA/540/R/99/006). A summary of the differences in exposure assumptions for the industrial worker between the interim action ROD and the RI/FS is listed in Table 6-5.

The interim action ROD industrial scenario for chemicals is based on the MTCA Method C Soil Cleanup Standards for Industrial Land Use ("Soil Cleanup Standards for Industrial Properties" [WAC 173-340-745]). The MTCA Method C levels are based solely on incidental soil ingestion. The MTCA Method C cleanup levels developed in this chapter are similar to those published in the most recent version of the 300-FF-1 RDR/RAWP (DOE/RL-96-70) and the 300 Area RDR/RAWP (DOE/RL-2001-47). RAGs reported in the 300 Area RDR/RAWP (DOE/RL-2001-47) incorporate the use of a PEF that is based on the mass loading rate reported in the RESRAD code. The PEF used to calculate the inhalation RAG is roughly two orders of magnitude greater than the site-specific PEF developed with EPA guidance for the Hanford Site and used in this chapter.

In addition to performing the risk-based screening evaluation, another purpose for updating the industrial PRGs is to determine if the RAGs developed and reported in the 300 Area RDR/RAWP (DOE/RL-2001-47) are protective when compared to current guidance. Chapter 8 will provide a summary of the RAGs reported in the 300 Area RDR/RAWP (DOE/RL-2001-47) in addition to the industrial PRGs presented in this chapter. To satisfy RAOs for protection of human health, the RAGs reported in the 300 Area RDR/RAWP (DOE/RL-2001-47) will be compared to the PRGs presented in this chapter for the industrial scenario. The lower of the two values will be selected to satisfy RAO 4 and RAO 5. This approach is used in Chapter 8 to ensure that PRGs for protection of human health from direct contact with soil achieve comparable or greater levels of protectiveness as was achieved by the RAGs presented in the interim action RODs.

Table 6-5. Summary of Differences in Exposure Assumptions for the Industrial Worker Between the Interim Action ROD and RI/FS Risk Evaluation

Parameter	Interim Action ROD Industrial Worker*	RI/FS Industrial Worker
Soil ingestion rate	The interim action ROD assumed a soil ingestion rate of 25 g/yr.	The RI/FS used a soil ingestion rate of 18.25 g/yr, based on 50 mg/day for 365 days/yr, consistent with current guidance (OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*).
Inhalation rate	The interim action ROD used an inhalation rate of 8,400 m^3/yr.	The RI/FS used an inhalation rate of 7,300 m^3/yr based on a daily inhalation rate of 20 m^3/day (365 days/yr) (OSWER Directive 9285.6-03, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual* Supplemental Guidance *"Standard Default Exposure Factors" Interim Final*).
Mass loading for inhalation	The interim action ROD used a mass loading factor of 0.0002 g/m^3.	The RI/FS used a mass loading factor of 0.0001 g/m^3 based on Washington State Department of Health guidance (WDOH/320-015, *Hanford Guidance for Radiological Cleanup*).
Wind speed	The interim action ROD does not account for dispersion of dust in air from wind.	The RI/FS accounts for dispersion of dust in air using a site-specific wind speed of 3.4 m/s (consistent with the most recent version of the RESRAD code).
Exposure duration	The interim action ROD used an exposure duration of 30 years.	The RI/FS used an exposure duration of 25 years consistent with EPA guidance (OSWER Directive 9285.6-03, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual* Supplemental Guidance *"Standard Default Exposure Factors" Interim Final*).
Indoor time fraction	The interim action ROD assumed an indoor time fraction 0.165, which is based on 1,445 hours/8,760 hours.	The RI/FS assumed an indoor time fraction of 0.17 based on 6 hours/day onsite indoors for 250 days/yr (1,500 hours/8,760 hours).
Outdoor time fraction	The interim action ROD assumed an outdoor time fraction of 0.055, which is based on 482 hours/8,760 hours.	The RI/FS assumed an indoor time fraction of 0.17 based on 6 hours/day onsite indoors for 250 days/yr (1,500 hours/8,760 hours).
Gamma shielding factor	The IAROD use an external gamma-shielding factor of 0.7.	The RI/FS used an external gamma-shielding factor of 0.4 consistent with current guidance (EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User's Guide*).

* DOE/RL-2001-47, *Remedial Design Report/Remedial Action Work Plan for the 300 Area*

The resident National Monument worker scenario was evaluated in the RCBRA as an occupational scenario and was applied on a local and broad area scale. In the RCBRA, the resident Monument worker spent a fraction of the day on the waste site as his residence (local area) and spent a fraction of the same day in a region as large as an individual interim action ROD decision area and potentially as large as the entire River Corridor conducting work activities (broad area). This exposure scenario was used to calculate forward risk estimates and was not developed for calculating a PRG. To incorporate the use of this exposure scenario in the RI/FS process, the scenario was modified to assume that the broad area concentration was equal to the RME broad area upland surface soil concentration reported in RCBRA.

The PRG value represents the concentration of soil the resident Monument worker is exposed to on the waste site (local area).

With the exception of the soil ingestion rate and exposure time, the exposure assumptions used to calculate the resident Monument worker local area PRGs are the same as those that would be used to provide a RME for the residential exposure scenario. With the exception of the soil ingestion rate, the exposure assumptions used to calculate the resident Monument worker broad area risks are the same as those that would be used to provide an RME for the industrial worker exposure scenario defined in *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final* (OSWER Directive 9285.6-03). Some exposure assumptions were updated based on recent EPA guidance or modified to conform to recommended EPA methodology for calculation of PRGs. Exposure assumptions that were updated based on recent guidance include inhalation rates, PEFs, and the external gamma shielding factor. The exposure assumptions that were modified to lend themselves to standard PRGs equations include soil ingestion rates, indoor time fraction, onsite exposure time, and use of decay factors. These updates and modifications allow a numeric value to be developed to confirm that cleanup actions at the waste site are protective. Table 6-6 summarizes the modifications made to the resident Monument worker exposure scenario for use as a PRG.

Table 6-6. Summary of Differences in Exposure Assumptions for the Resident Monument Worker between the RCBRA and RI/FS Risk Evaluation

Parameter	RCBRA Resident Monument Worker	RI/FS Resident Monument Worker
Soil ingestion rate	A soil ingestion rate of 100 mg/day is assumed for this receptor. The soil ingestion rate is apportioned to the local area and the broad area based on the amount of time he spends at each area. The RCBRA allocated 52.2 mg/day to the residential portion (local area) of this scenario and 25 mg/day to the occupational portion (broad area) of this scenario.	A soil ingestion rate of 100 mg/day is assumed for this receptor. The RI/FS allocated 76.2 mg/day to residential portion (local area) of this scenario and 23.8 mg/day to the occupational portion (broad area) of this scenario for a total of 100 mg/day.
Inhalation rate	The RCBRA assumed an inhalation rate of 0.63 m^3/hour based on an inhalation rate of 15 m^3/day.	The RI/FS assumed an inhalation rate of 0.83 m^3/hour based on an inhalation rate of 20 m^3/day (OSWER 9285.6-03, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final*).
Particulate Emission Factor	The RCBRA used a PEF of 1.08×10^8 m^3/kg for the local area and a PEF of 4.3×10^8 m^3/kg for the broad area.	The RI/FS used a of 7.3×10^{10} m^3/kg for the local area and a PEF of 2.6×10^{10} m^3/kg for the broad area, calculated using site-specific parameters and guidance from OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.

Table 6-6. Summary of Differences in Exposure Assumptions for the Resident Monument Worker between the RCBRA and RI/FS Risk Evaluation

Parameter	RCBRA Resident Monument Worker	RI/FS Resident Monument Worker
Time spent on the local area and broad area scale	The RCBRA assumed an exposure time of 13 hours/day spent at the residence (local area), 8 hours spent at onsite at work (broad area), and 3 hours offsite (neither local nor broad area) for a total of 24 hours/day.	The RI/FS assumed that an exposure time of 16 hours/day was spent at the residence (local area) and 8 hours/day onsite at work (broad area) for a total of 24 hours per day.
Indoor and outdoor exposure time	The RCBRA assumed that the resident spent 10 hours/day indoors, 3 hours/day outdoors, 3 hours per day offsite, and the worker spent 8 hours/day outdoors.	The RI/FS assumed that the resident spent 13 hours/day indoors and 3 hours/day outdoors (local area) and the worker spent 8 hours/day outdoors (broad area).
Gamma shielding factor	The RCBRA used an external gamma-shielding factor of 0.7.	The RI/FS used an external gamma shielding factor is 0.4 based on current guidance (EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User's Guide*).
Radiological decay factors	Decay of radioisotopes over the exposure duration was not accounted for.	Decay of radioisotopes over the exposure duration was incorporated.

The casual user scenario was evaluated in the RCBRA as a recreational scenario and was applied on a broad area scale. In the RCBRA, the casual user only spent time in a region as large as an individual interim action ROD OU and potentially as large as the entire River Corridor enjoying recreational activities (broad area). Similar to the resident Monument worker, this exposure scenario was used to calculate forward risk estimates. To incorporate the use of this exposure scenario in the RI/FS process, the scenario was modified to develop a PRG assuming that all of the casual user time was spent on the waste site (local area). This assumption is the only modification made to this exposure scenario; no changes were made to the exposure assumptions used to calculate PRG values. This modification allows a conservative numeric value to be developed to confirm that cleanup actions at the waste site are protective.

Some exposure assumptions for the casual user scenario were updated based on recent EPA guidance or modified to conform to recommended EPA methodology for calculation of PRGs. Exposure assumptions that were updated based on recent guidance include the incidental soil ingestion rate, the inhalation rate, the PEF, the time spent on the local area and broad area scale, the external gamma shielding factor, and radiological decay. The exposure assumptions that were modified to lend themselves to standard PRGs equations include soil ingestion rates and use of decay factors. These updates and modifications allow a numeric value to be developed to confirm that cleanup actions at the waste site are protective. Table 6-7 summarizes the modifications made to the casual user exposure scenario for use as a PRG.

Table 6-7. Summary of Differences in Exposure Assumptions for the Casual User between the RCBRA and RI/FS Risk Evaluation

Parameter	RCBRA Casual User	RI/FS Casual User
Soil ingestion rate	A soil ingestion rate of 100 mg/day for an adult and 200 mg/day for a child were assumed for this receptor. Soil ingestion at the waste site was assumed proportional to the fraction of waking hours spent at the site.	A soil ingestion rate of 100 mg/day for an adult and 200 mg/day for a child were assumed for this receptor. All soil ingestion was assumed to occur at the waste site.
Inhalation rate	The RCBRA assumed an inhalation rate of 1 m^3/hour for an adult and 1 m^3/hour for a child based on EPA recommended short-term exposure values for light activity.	The RI/FS assumed an inhalation rate of 0.83 m^3/hour for an adult, based on an inhalation rate of 20 m^3/day, and 0.417 m^3/hour for a child, based on an inhalation rate of 10 m^3/day (EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals): Interim*).
Particulate Emission Factor	The RCBRA used a PEF of 4.3 × 108 m^3/kg for the broad area.	The RI/FS used the EPA default PEF of 7.3 × 1,010 m^3/kg (OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*).
Time spent on the local area and the broad area scale	The RCBRA assumed an exposure time of 6 hours/day is spent onsite, all in the broad area.	The RI/FS assumed an exposure time of 6 hours/day is spent onsite, all in the local area.
Gamma shielding factor	The RCBRA did not apply a gamma-shielding factor (all exposure is assumed to occur outdoors).	The RI/FS did not apply a gamma-shielding factor (all exposure is assumed to be occurring outdoors).
Radiological decay factors	Decay of radioisotopes over the exposure duration was not accounted for.	Decay of radioisotopes over the exposure duration was incorporated.

6.1.4 Other Land Use Scenarios in RCBRA

The RCBRA also evaluated three residential scenarios that describe exposures related to a rural land-use pattern that involves home-produced foods. The subsistence farmer scenario envisions a substantial quantity of home-produced foods, but not a diet composed solely of such foods. The two Native American resident scenarios, however, envision a complete subsistence lifestyle where all foods are grown at the home or (in the case of fish) caught in the Columbia River. Residential receptors are assumed to spend effectively all of their time in the area around a residence located on a remediated waste site to assign all soil-related exposures protectively to that site.

DOE, through discussions with the Tribes (Brockman, 2007), has agreed to include quantitative analysis of Native American scenarios in risk assessments supporting RI/FS documents. The two scenarios considered are provided by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the Yakama Nation. These tribal scenarios have been evaluated and presented in Hanford Site risk assessments to assist interested parties in providing input on remedial alternatives (*Feasibility Study*

Report for the 200-ZP-1 Groundwater Operable Unit [DOE/RL-2007-28]), and have not been used for development of PRGs as part of alternatives analyses in the FS.

The results of the local area risk assessment for the residential scenarios indicate that present-day RME cancer risk is frequently greater than 1×10^{-4} and that RME chemical HI frequently exceeds the threshold HI of 1. Present-day RME cancer risks greater than 1×10^{-4} for the subsistence farmer exposure scenario are almost entirely related to one of three factors:

- External irradiation from short-lived radionuclides including europium-152, Cs-137, and Co-60
- Exposure to arsenic from ingestion of garden produce
- Exposure to the short-lived radionuclide Sr-90 from ingestion of produce and livestock products

As evaluated and explain in the RCBRA, by the year 2075, subsistence farmer RME cancer risks above 1×10^{-4} are related overwhelmingly to arsenic exposure from produce ingestion. Because the CTUIR resident and Yakama resident scenarios use very high (subsistence level) site-raised food ingestion rates, Sr-90 still plays a significant role in food-related exposures at year 2075 for these scenarios. By year 2150, however, CTUIR resident and Yakama resident cancer risks above 1×10^{-4} are dominated by arsenic exposure from ingestion of garden produce.

The RCBRA subsistence farmer cancer risk and chemical HI results were frequently above threshold criteria. There are two major differences between the risk assessment methods used in the RCBRA and the basis of the interim action ROD residential cleanup levels. These differences largely explain why some waste sites remediated to meet the interim action ROD residential cleanup levels still appear to present high levels of residual risk under the Subsistence Farmer scenario:

- Residential interim action ROD cleanup levels for chemicals are the MTCA Method B Soil Cleanup Levels ("Unrestricted Land Use Soil Cleanup Standards" [WAC 173-340-740]), which is an RME scenario based on incidental soil ingestion and does not address the food exposure pathways historically evaluated for radionuclides.

- The interim action ROD cleanup level for arsenic is 20 mg/kg, which is an "adjusted" value established by the state of Washington to address a range of natural background levels ("Tables" [WAC 173-340-900]).

One of the primary uncertainties for site-specific results relates to modeled exposure concentrations in foods, particularly garden produce. Further discussion of the potential biases in modeled food chain exposures is provided in the RCBRA. As discussed in Section 5.9.4.2 of the RCBRA, in the case of the noncancer HI results for produce ingestion of mercury, uranium, and copper, a large conservative bias is anticipated because a linear plant uptake model was applied to soil concentrations that are far above naturally occurring levels. In the case of arsenic, produce ingestion provides the largest contribution to total cancer risk, even though the range of site soil concentrations is relatively small. Uncertainty in produce concentrations is attributable to intrinsic variability related to soil conditions, plant species and tissue type, harvest time, and other variables. A review of recommended plant-soil ratios from a number of sources, described in Section 5.9.2.4 of the RCBRA, shows that the range of soil to plant transfer ratios for arsenic (from 0.006 to 1.125) is approximately a factor of 200. The value of 0.53 used in the HHRA, from the RESRAD computer code that has been used to perform dose assessment at the Hanford Site and other DOE facilities, is near the upper end of this range. The high-end values for plant-soil concentrations, many of which were used in the RCBRA to assess exposure through food pathways, may result in a scenario that provides exposures to nonradionuclide contaminants higher than an RME. Therefore, these food chain pathways have not been incorporated into the development of PRGs for nonradiological constituents.

6.2 Supplemental Soil Risk Evaluation

The 300 Area Source OU supplemental risk evaluation followed the approach described below:

- Identify all waste sites with a "no action," "closed," or "interim closed" reclassification status.
- Obtain verification sampling and analysis data for all "no action," "closed," and "interim closed" waste sites that have been remediated through May 2011[7].
- Compute EPCs for each detected analyte measured at a waste site using the EPA's ProUCL version 4.00.05 software (*ProUCL Version 4.00.05 User Guide (Draft)* [EPA/600/R-07/038]).
- Compare EPCs to direct contact RBSLs selected to represent baseline conditions and reasonably anticipated future site use.
- Calculate cancer risk and noncancer hazards for each detected analyte.
- Compare cancer risks and noncancer hazards to acceptable state and federal target risk and noncancer thresholds.
- Determine if the "no action," "closed," or "interim closed" waste site should be carried forward into the FS to select remedial alternatives.

This supplemental soil risk evaluation follows the risk assessment guide (*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final* [EPA/540/1-89/002]). The following subsections describe the four-step process. Because this supplemental soil risk evaluation is intended to complement the analysis performed in the RCBRA, where applicable, a brief description is provided to describe the similarities in approach.

6.2.1 Data Analysis

This section describes the sources of data used in the risk assessment (Section 6.2.1.1), describes the data quality assessment (DQA) and data validation process (Section 6.2.1.2), and identifies COPCs in vadose zone material that are accessible for human exposures (Section 6.2.1.3). During the course of this risk assessment, analytes were evaluated to identify COPCs and prioritize those estimated to pose an unacceptable risk and warrant evaluation in the FS.

6.2.1.1 Sources of Analytical Data Used in Risk Assessment

This supplemental soil risk evaluation includes the evaluation of vadose zone material samples for remediated waste sites located in both the 300-FF-1 OU and the 300-FF-2 OU. The 300-FF-1 OU waste sites have been remediated and reclassified as "closed out" under a final action ROD. One waste site, 300-275, is geographically located within the 300-FF-1 OU but was remediated and "interim closed out" under the 300-FF-2 Interim Action ROD. The 300-FF-2 waste sites were remediated under the 300-FF-2 Interim Action ROD and have a reclassification status of "interim closed" or "no action." Waste sites where remediation and verification sampling and analysis were assessed by the end of May 2011 are included in the supplemental soil risk evaluation.

[7]Waste sites for which interim action cleanups had been completed under IARODs and for which the CVPs were completed through May 2011.

All 300-FF-1 OU samples were collected in accordance with the requirements stated in the 300-FF-1 RDR/RAWP (DOE/RL-96-70), which includes the applicable SAP. The 300-FF-1 RDR/RAWP (DOE/RL-96-70), describes the design and the implementation of the remedial action process required by the following:

- *Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington* [EPA/ROD/R10-96/143]
- *Explanation of Significant Differences for the 300-FF-1 Operable Unit Record of Decision, Hanford Site* (EPA, 2000)

All 300-FF-2 OU samples were collected in accordance with the requirements stated in the *300 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-48). Data collected under the *300 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-48) are used to meet the purpose and objectives of the 300 Area RDR/RAWP (DOE/RL-2001-47), which describes the design and the implementation of the remedial action processes required by the following:

- EPA/ROD/R10-01/119, *Declaration of Interim Record of Decision for the 300-FF-2 Operable Unit, Hanford Site, Benton County, Washington*
- EPA et al., 2004, *Explanation of Significant Differences for the 300-FF-2 Operable Unit Record of Decision*

Remediation of waste sites in the 300 Area Source OU began in 1997. Analytical results for each waste site are included in the associated closeout documentation, which are listed in Appendix A, Table A-1 of the 300 Area RI/FS Work Plan (DOE/RL-2009-30). The 300 Area RI/FS Work Plan (DOE/RL-2009-30) and the 300 Area RDR/RAWP (DOE/RL-2001-47) were reviewed and approved by the Tri-Parties.

Ten 300-FF-1 OU waste sites have verification sampling and analysis data and are included in this risk evaluation. Nine of these 10 300-FF-1 OU waste sites were evaluated in RCBRA Volume II (DOE/RL-2007-21). An additional 24 300-FF-1 waste sites, referred to as consolidated waste sites, have been remediated but are included in another waste site's sampling and closeout documentation. Thirty 300-FF-2 OU waste sites have verification sampling and analysis data and are included in this risk evaluation. Eight of these 30 300-FF-2 OU waste sites were evaluated in RCBRA Volume II (DOE/RL-2007-21). Six additional 300-FF-2 waste sites, referred to as consolidated waste sites, have been remediated, but are included in another waste site's sampling and closeout documentation. A summary of the waste sites, associated decision unit(s), and reclassification status for the 300 Area Source OU is provided in Table G-1 (Appendix G). The waste sites listed in Table G-1 are a subset of the waste sites that are listed in Table A-1 of the 300 Area RI/FS Work Plan (DOE/RL-2009-30). A summary of the remediated waste sites and consolidated waste sites for the 300-FF-1 and 300-FF-2 OUs is provided in Table 6-8.

The following sources of analytical data were used in the supplemental soil risk evaluation:

- All verification sampling and analysis data reside in the HEIS database.
- All the closeout verification data used in this risk evaluation are included in Appendix D of this report.

Table 6-8. Summary of Remediated Waste Sites and Consolidated Waste Sites in the 300-FF-1 and 300-FF-2 Operable Units

Waste Site Totals	Remediated Waste Site	Consolidated Waste Sites[a]			
300-FF-1					
	300 Ash Pits	--			
	300-44				
	300-49				
	300-50				
	316-1	300 RFBP UPR-300-32	UPR-300-33 UPR-300-34	UPR-300-35 UPR-300-36	UPR-300-37 UPR-300-FF-1
	316-2	--			
	316-5	UPR-300-15 UPR-300-19 UPR-300-20 UPR-300-21	UPR-300-22 UPR-300-23 UPR-300-24 UPR-300-25	UPR-300-26 UPR-300-27 UPR-300-28 UPR-300-29	UPR-300-30 UPR-300-47 UPR-300-8 UPR-300-9
	618-12	--			
	618-4				
	628-4				
300-FF-1 Totals	**10**	**24**			
300-FF-2					
	See footnote b	300-262			
	300 VTS	--			
	300-10				
	300-109	300-110 303-M SA		303-M UOF 333 ESHWSA	
	300-18	--			
	300-223				
	300-23				
	300-256[c]				
	300-259				
	300-260				
	300-272				
	300-275				
	300-33[c]				
	300-37				

Table 6-8. Summary of Remediated Waste Sites and Consolidated Waste Sites in the 300-FF-1 and 300-FF-2 Operable Units

Waste Site Totals	Remediated Waste Site	Consolidated Waste Sites[a]
	300-41[c]	
	300-45	
	300-8	
	331 LSLDF	
	600-243	
	600-259	
	600-47	
	618-1	300-110
	618-13	600-290:1
	618-2	--
	618-3	
	618-5	
	618-7	
	618-8	
	618-9	
	UPR-300-17	
	UPR-300-46	
300-FF-2 Totals	**30**	**6**
300-FF-1 and 300-FF-2 Totals	**40**	**30**
300 Area Total	**70**	

a. Consolidated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. Consolidated with the 316-1 (300-FF-1) remediated waste.

c. Samples results are consolidated for the 300-33, 300-41, and 300-256 waste sites.

ESHWSA = East Side Hazardous Waste Storage Area
LSLDF = Life Sciences Laboratory Drainfield
SA = Storage Area
UOF = Uranium Oxide Facility

6.2.1.2 Data Quality Evaluation and Data Validation

A DQA is performed and reported in each closeout documentation report. The DQA compares the verification sampling approach and resulting analytical data with the sampling and data quality requirements specified by the project objectives and performance specifications. The DQA determines if the data are of the right type, quality, and quantity to support site cleanup verification decisions within specified error tolerances. The DQA also determines if the analytical data are found acceptable for

decision-making purposes and if the sample design was sufficient for the purpose of cleanup site verification. The cleanup verification sample analytical data and detailed DQA are summarized in the appendices associated with the CVPs. The results of each DQA are incorporated by reference and no further DQA was performed as part of this risk assessment.

All the analytical data are evaluated and a portion validated for compliance with QAPjP requirements as documented in the *300 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-48) and the 300 Area RDR/RAWP (DOE/RL-2001-47). Data evaluation is performed to determine if the laboratory carried out all steps required by the SAP and the laboratory contract governing the conduct of analysis and reporting of the data. This evaluation also examines the available laboratory data to determine if an analyte is present or absent in a sample and the degree of overall uncertainty associated with that determination. Data validation was done in accordance with validation procedures as part of data evaluation.

6.2.1.3 Identification of COPCs

For the purposes of this evaluation, a "COPC" is defined as an analyte suspected of being associated with site-related activities, that represents a potential threat to HHE, and whose data are of sufficient quality for use in a quantitative BRA.

All analytes detected at least once in a waste site decision unit for the waste sites included in the risk evaluation are identified as COPCs. As described in Section 6.2.2.2, the floor and sidewalls of an excavated waste site are divided into one or more decision units (e.g., shallow zone, deep zone, overburden, and staging pile area). Verification sampling and analysis data are collected according to sample design requirements for the type of decision unit. For the purpose of this supplemental soil risk evaluation, an "exposure area" and a "decision unit" are operationally defined as being the same. Verification sampling and analysis data are subsequently grouped to calculate EPCs.

The contribution from naturally occurring metals and anthropogenic radioisotopes are discussed in the risk characterization section, in accordance with *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-R-01-003). The risk characterization will discuss elevated background concentrations and their contribution to site risks as well as naturally occurring elements that are not CERCLA hazardous substances, pollutants, and contaminants, but exceed the RBSLs.

The RCBRA identifies a subset of analytes that are excluded from consideration as COPCs by agreement among the Tri-Parties based on relevant Hanford Site data. The following exclusion lists employed in the RCBRA Report (DOE/RL-2007-21) were also applied to the waste site verification data during the data reduction steps described in Section 6.2.2.2:

- **Radionuclides with a half-life of less than three years:** Radionuclides with half-lives less than 3 years would not be present because of historical Hanford Site operations due to radioactive decay that would have occurred since operations ceased.

- **Essential nutrients:** Essential nutrients that are present at relatively low concentrations and are toxic only at high concentrations need not be considered in a quantitative risk assessment.

- **Water quality or soil physical property measurements:** These analytes were measured to obtain information on water quality or soil properties to understand potential confounding factors for bioassays conducted for soil, sediment, or water or to interpret their influence on the toxicity of COPCs (e.g., grain size for soils, water hardness for metal effects).

- **Background radionuclides (potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232):** These background radionuclides were identified by consensus of Tri-Party managers as not directly related to Hanford Site operations or processes.

The RCBRA includes two additional steps to identify COPCs that the supplemental soil risk evaluation did not apply:

- Analytes that are reported commonly in waste site cleanup verification reports based on frequency of detection. Inclusion list analytes was not reported consistently in the CVP and RSVP data; therefore, this step was not implemented.

- Evaluate remaining analytes as candidate COPCs, based on comparisons to Hanford Site background, reference areas, and an "analyte-specific" evaluation.

Because of not applying the last two steps used in the RCBRA to identify COPCs, more analytes are identified as COPCs in this supplemental soil risk evaluation than were identified in the RCBRA. Identifying all detected analytes (except those on the exclusion list) as COPCs is a more streamlined approach that is consistent with *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-R-01-003).

6.2.2 Exposure Point Concentrations

Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10) states that, "an exposure point concentration (EPC) is a conservative estimate of the average chemical concentration in an exposure medium." *Supplemental Guidance to RAGS: Calculating the Concentration Term* (OSWER Publication 9285.7-081) states that, "because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent UCL of the arithmetic mean should be used for this variable." Use of the UCL-95 of the arithmetic mean yields risk estimates that correspond to a RME. Instances where a value different from a UCL is used as the EPC are clearly stated in this risk assessment. Reasons and/or justifications are also provided.

Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10) further states that, "The EPC is determined for each individual exposure unit within a site. An exposure unit is the area throughout which a receptor moves and encounters an environmental medium for the duration of the exposure. Unless there is site-specific evidence to the contrary, an individual receptor is assumed to be equally exposed to media within all portions of the exposure unit over the time frame of the risk assessment." For this supplemental soil risk evaluation, the "exposure unit" and the "decision unit" are operationally defined as being the same. As previously described, one or more decision units are included within a waste site, including shallow vadose zone material (0 to 4.6 m [0 to 15 ft] bgs), deep vadose zone material (greater than 4.6 m [15 ft] bgs), overburden material, and staging pile area footprint material.

Statistical Guidance for Ecology Site Managers (Ecology Publication 92-54) has been used to calculate EPCs for all closeout documentation to date. Published in 1992, *Statistical Guidance for Ecology Site Managers* (Ecology Publication 92-54) has been superseded by *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10), which was published in 2002. For this supplemental soil risk evaluation, UCLs were recalculated for all waste sites and decision units to incorporate the updated guidance in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10). UCLs that incorporate updated guidance use more rigorous statistical methods to estimate exposure concentrations. In addition, these UCLs eliminate the use of the simple substitution method for nondetects where a proxy value of one-half the detection limit is assigned to all nondetected results.

Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10) notes that because of the complicated formulas used to compute UCLs, there is no general rule about which substitution rule will yield an appropriate UCL. The uncertainty associated with the substitution method increases, and its appropriateness decreases, as the detection limit becomes larger and as the number of nondetects in the data set increases.

The following describes the statistical methodology used for closeout documentation (Section 6.2.2.1) and the statistical methodology used for this supplemental soil risk evaluation (Section 6.2.2.2). While both evaluations used the same dataset, the differences in statistical methodologies may result in differences in the EPC values between the closeout documentation and this risk assessment for the same COPCs in a waste site decision unit. The following provides a basis for these potential differences.

6.2.2.1 Statistical Evaluation Methodology Used for Closeout Documentation

For waste sites closed using a statistical/random sampling design, the primary statistical calculation to support cleanup verification was the UCL-95 on the arithmetic mean of the data. Statistical calculations were performed in compliance with *Statistical Guidance for Ecology Site Managers* (Ecology Publication 92-54). This guidance addresses two kinds of data distributions: normal and lognormal. For normal data, the guidance recommends a UCL on the mean based on the Student's t-statistic. For lognormal data, the guidance recommends the Land method using the H-statistic. This guidance also implements the substitution method where a proxy value of one-half the detection limit is assigned to nondetected results.

Small data sets (n<10) were evaluated in accordance with Section 5.2.1.4 of *Statistical Guidance for Ecology Site Managers* (Ecology Publication 92-54), and a nonparametric distribution was assumed. When a nonradionuclide was detected in fewer than 50 percent of the samples collected and for focused sampling designs, the maximum detected value was used for comparison purposes.

6.2.2.2 Statistical Evaluation Methodology Used for the Supplemental Soil Risk Evaluation

Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10) is the EPA guidance for UCL calculation, and ProUCL 4.00.05 serves as the companion software package for this guidance. ProUCL 4.00.05 contains rigorous parametric and nonparametric (including bootstrap methods) statistical methods that can be used on full data sets without nondetects and on data sets with nondetect observations. Both ProUCL and *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) were used to recalculate the UCLs for the 300 Area Source OU.

To ensure that waste sites and decision units are grouped correctly and UCLs are accurately recalculated, all waste sites, decision unit groupings, and sample numbers were individually verified against the original closeout documentation. *Waste Site Evaluation Process for the 300-FF-2 Source Operable Unit* (ECF-300NPL-11-0036), which is provided in Appendix G, documents the process used to confirm a complete list of waste sites with a reclassification status of "closed," "interim closed," or "no action" through May 2011. Verification of sample numbers associated with each waste site was confirmed along with the decision unit grouping with which the sample is associated. This list of samples is used to verify the sampling results are complete. The analytical data that have undergone this review process become the final data set used to calculate the UCLs and associated summary statistics used in this supplemental soil risk evaluation. A list of the sample numbers associated with each waste site decision unit is provided in Table G-2 (Appendix G); it also lists the date the sample was collected, the type of sample design used, and the Washington State plane coordinates of the sample location.

6.2.2.2.1 Waste Site Decision Units

Verification sampling and analysis data that are associated with the samples listed in Table G-2 (Appendix G) are from several different decision units within a waste site, including shallow vadose zone material, deep vadose zone material, overburden material, and staging pile area footprint material. The following describes the basis of each decision unit and briefly describes the sample designs used.

The floor and sidewalls of an excavated waste site are divided into one or more decision units. A sample design is developed for the decision unit. Sample design requirements for each decision unit are described in the *300 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-48). In practice, the shallow zone decision unit is typically represented by material from the excavation floor if at or above 4.6 m (15 ft) and any sidewall materials from grade level (0 m to a depth of 4.6 m (0 to 15 ft). The deep zone decision unit is represented by material from the excavation floor (if below 4.6 m [15 ft]) and by any sidewall materials below 4.6 m (15 ft). As needed, decision subunits and an associated sample design are also established for suspect clean overburden stockpiles (i.e., to verify suitability for backfill material) and the footprint of the staging pile area. The layout and orientation of the sampling designs are based on the size, shape, and depth of the site. Sampling of a waste site decision unit to confirm attainment of RAOs was performed according to one of three types of sampling designs: focused sampling design, random or statistical sampling, or a combination of both.

The decision unit naming convention is summarized in Table 6-9.

The process used to calculate EPCs for each waste site and decision unit is documented in *Computation of Exposure Point Concentrations for the 300-FF-2 Source Operable Unit* (ECF-300NPL-11-0037), which is provided in Appendix G. The purpose of *Exposure Point Concentrations for the 300-FF-2 Source Operable Unit* (ECF-300NPL-11-0037) is to document the data processing and reduction steps, methodology, decision logic, assumptions, input files, and output files used to determine the EPCs.

Table 6-9. Summary and Definition of Decision Unit Types

Decision Unit Name	Depth	Sampling Design Description
Shallow	0 to 4.6 m (15 ft) bgs	Samples collected using a statistical sampling design
Deep	Greater than 4.6 m (15 ft) bgs	
Overburden	Not applicable	
Staging pile area	Not applicable	
Shallow_Focused	0 to 4.6 m (15 ft) bgs	Samples collected using a focused sampling design
Deep_Focused	Greater than 4.6 m (15 ft) bgs	
Overburden_Focused	Not applicable	
Staging pile area_Focused	Not applicable	

6.2.2.2.2 Data Processing and Reduction

This section describes the data processing and reduction steps that are taken prior to the calculation of UCLs. Figure 6-1 shows each of the data processing and data reduction steps, and the number of records associated with each step for the 300 Area Source OU.

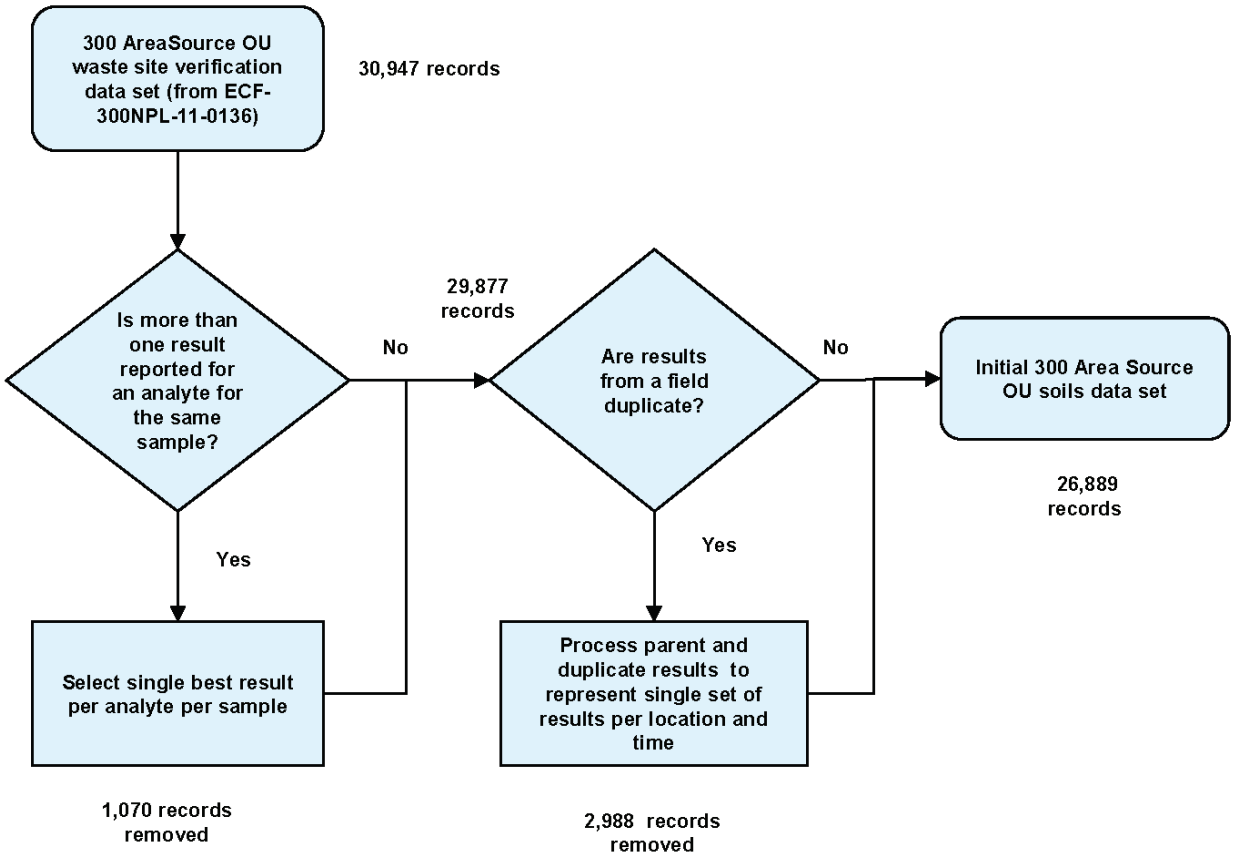

Figure 6-1. Data Processing and Reduction Steps for the 300 Area Source OU Set

6.2.2.2.3 Laboratory and Data Validation Flags

Analytical data are received from the laboratory with data qualification flags; validation qualifiers are assigned during the data validation process. The following rules are applied to determine how the sample results can be used for calculating UCLs.

- All sample results flagged with a "U" qualifier or combination of qualifiers that include a "U," such as a "UJ," are considered nondetected concentrations.
- All sample results without a "U" qualifier are considered detected concentrations, including results without a qualifier or with an "E" or a "J" qualifier.
- Sample results that are rejected and flagged with a validation qualifier of "R" are not used for calculating UCLs.

where:

U = Analyzed for but not detected above limiting criteria.
J = Estimated value.
E = Reported value is estimated because of interference (inorganics).
R = Do not use. Further review indicates the result is not valid.

6.2.2.2.4 Analytes Reported by Multiple Analytical Methods

Often a sample is analyzed for an analyte using more than one analytical method, resulting in multiple results for the analyte from the same location and sample date. When analytes are reported by more than one analytical method for a sample, the results are processed to select the method that provides the most reliable results. Considerations for determining data to be retained include method-associated sample size, detection frequency, and detection limits. The most conservative (i.e., health-protective) use of these types of data is the goal. Larger sample size, higher detection frequencies, and lower detection limits are given higher priority for method selection.

For example, lead may be analyzed using EPA Method 200.8 with an EQL of 0.5 mg/kg or EPA Method 6010 with an EQL of 5.0 mg/kg. For a sample with lead concentrations reported by both methods, the results reported by EPA Method 200.8 are chosen over EPA Method 6010 because of the more sensitive detection limit.

6.2.2.2.5 Field Duplicate Results

Field QC samples (field duplicates) are collected in the field and analyzed by the laboratory as unique samples. The parent sample and field QC samples are collected from the same location (i.e., sample node) and same date, resulting in more than one sample per location and date. Because multiple sets of analytical results cannot be used to quantify risk (i.e., this would result in multiple-counting of a chemical), the results for the same location and date are reduced to a single result for each reported analyte. The most conservative (i.e., health-protective) result is the goal. The following criteria are used to reduce multiple sample results for one location and date to a single result:

- If two or more detections are reported, the maximum concentration is used.
- If one detection and one or more nondetections are reported, the detected concentration is used.
- If two or more nondetections are reported, the lowest detection limit is used.

6.2.2.2.6 Identify Analytes for 95 Percent UCL Calculation

After extracting and processing the data set, it is reduced further to identify a subset of analytes that require computation of a UCL. Analytes that meet any of the exclusion criteria or were not detected in any of the samples analyzed with the 300 Area Source OU are not carried forward into the statistical calculations and EPC selection. The analyte identification steps and the number of records associated with each of the steps are presented in Figure 6-2 for the 300 Area Source OU.

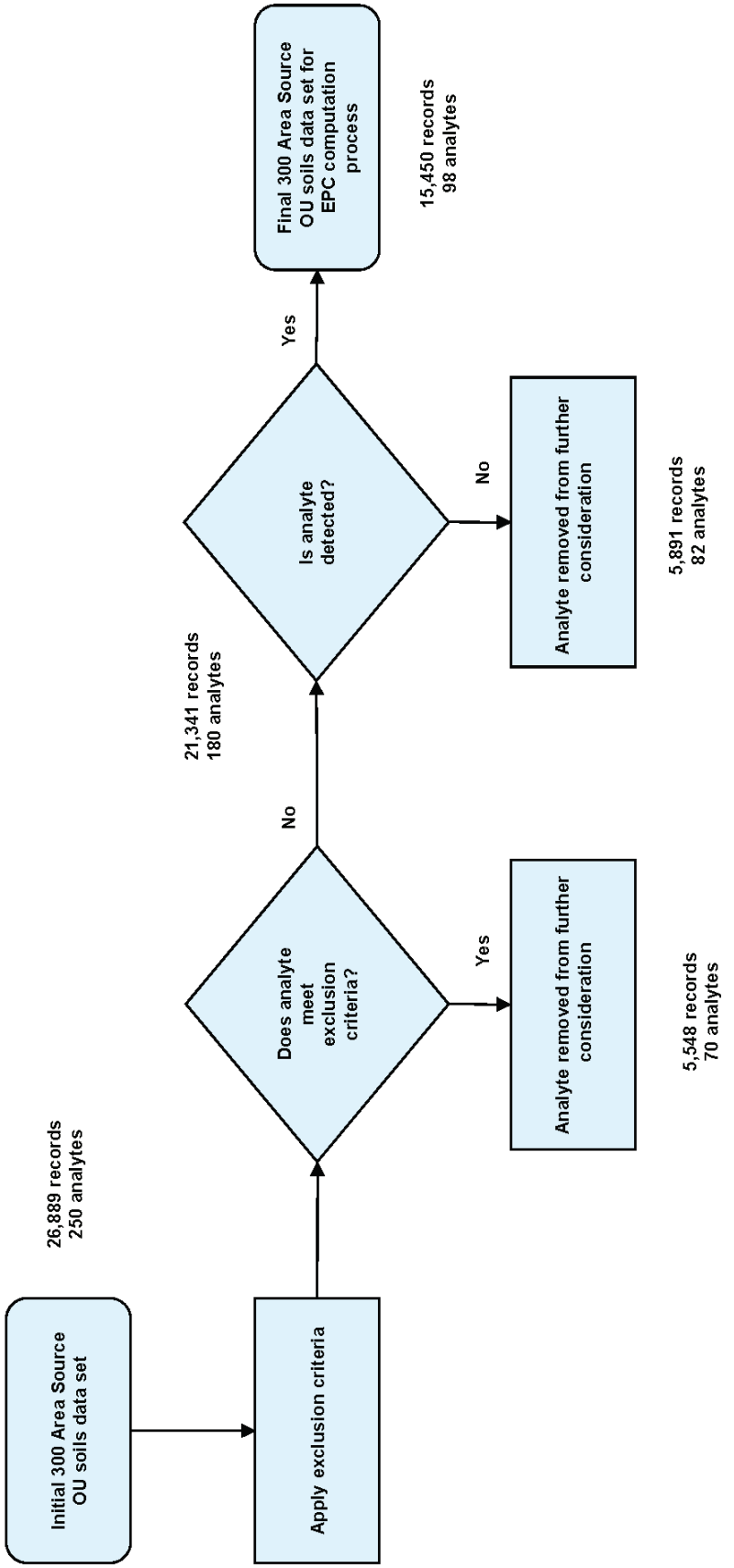

Figure 6-2. Analyte Identification Steps for the 300 Area Source OU Data Set

6.2.2.2.7 Apply Exclusion Criteria

The first step used to identify analytes that require a UCL-95 calculation is to apply exclusion criteria. Analytes that do not meet the exclusion criteria are carried forward into the next step of the process. Analytes that meet exclusion criteria are eliminated from further consideration. The following were excluded:

- Radionuclides that have half-lives of less than 3 years and that are not significant daughter products
- Background radionuclides that are not directly related to Hanford Site operations or processes
- Essential nutrients (minerals)
- Analytes without known toxicity information

Seventy analytes for the 300 Area Source OU meet the exclusion criteria and are listed in Table G-3 (Appendix G). Sampling dates, minimum and maximum detected concentrations, minimum and maximum MDLs, and the basis for their exclusion are provided in this table.

6.2.2.2.8 Identify Nondetected Analytes

The next step used to identify analytes that require a UCL-95 calculation is to identify nondetected analytes. Analytes that are measured at appropriate sampling locations, have adequate detection limits, and that have not been detected in any of the samples are eliminated from further consideration. Any analyte that is detected at least once in the 300 Area Source OU is carried forward to the next step of the process.

Eighty-two analytes were not detected in the 300 Area Source OU samples, as listed in Table G-4 (Appendix G). The table also provides sampling dates, total number of samples, and minimum and maximum MDLs.

6.2.2.2.9 UCL-95 Calculation Methodology

A discussion of waste site decision units was provided earlier in this section. It should be noted that calculated UCLs and EPCs selected for shallow zone and deep zone decision units represent verification data collected from the floor and the sidewall of the excavated waste site. As a result, risks are likely overstated because the UCL and the EPC do not take credit for the existing clean backfill that covers the remediated waste site.

Analytical data for all analytes that have been detected at least once in each waste site decision unit are extracted from the data set and subsequently formatted so they can be directly imported into ProUCL where UCL-95 calculations and summary statistics are performed. The following information is obtained from the UCL calculations and summary statistics generated for each waste site decision unit:

- Waste site decision unit name
- Analyte name and Chemical Abstract Service (CAS) Registry number
- Total number of sample results, total number of detects, and total number of nondetects
- Minimum and maximum detection limits for each detected analyte (when available)[8]
- Minimum and maximum detected concentrations for each analyte
- Coefficient of variation (CV) for each analyte
- The UCL value, the UCL basis, and comments and/or warning statements for each analyte

[8] Minimum and maximum detection limits are summarized in the ProUCL output only when a valid UCL can be calculated

For most data sets, ProUCL recommends a single UCL as the decision statistic. When a single decision statistic is recommended, this UCL is selected. However, ProUCL will recommend more than one decision statistic for some data sets. The most conservative (i.e., health-protective) result is the goal when selecting the UCL to represent the EPC. When more than one decision statistic is given, the following logic is used to select the UCL:

- If more than one UCL is recommended as a decision statistic and the UCLs are less than or equal to the maximum observed concentration, then the highest recommended UCL is selected as the decision statistic.
- If more than one UCL is recommended as a decision statistic and the UCLs are greater than the maximum observed concentration, then the maximum observed concentration is selected as the decision statistic.
- If more than one UCL is recommended as a decision statistic, at least one is less than the maximum observed concentration, and at least one is greater than the maximum observed concentration, then the maximum observed concentration is selected as the decision statistic.

There were 23 analytes where more than one UCL was recommended and at least one of the UCLs was greater than the maximum observed concentration.

6.2.2.3 Selection of EPCs

The following logic was used to select the EPC for each detected analyte in a waste site decision unit:

- For samples collected in accordance with a focused sampling design, the maximum detected concentration is selected as the EPC for every detected analyte.
- For samples collected in accordance with a statistical sampling design, the following logic is applied.
  - If a valid UCL-95 can be calculated, then the highest potential UCL-95 value (if more than one potential UCL value is recommended) is selected.
  - If the recommended UCL-95 is greater than the maximum detected concentration then the maximum detected concentration is selected.
  - If a valid UCL-95 cannot be calculated, then the maximum detected concentration is selected.

Selection of the EPC value using the above decision logic is presented in Figure 6-3.

A summary of the EPCs for each detected analyte in a given waste site decision unit is provided in Table G-5 (Appendix G) for the 300 Area Source OU.

6.2.2.4 Use of Maximum Detected Concentrations to Estimate the EPC

The EPC defaults to the maximum detected concentration when the following conditions are met:

- When samples are collected using a focused sampling design
- When a valid UCL-95 cannot be calculated due to small sample size
- When a valid UCL-95 is greater than the maximum detected concentration

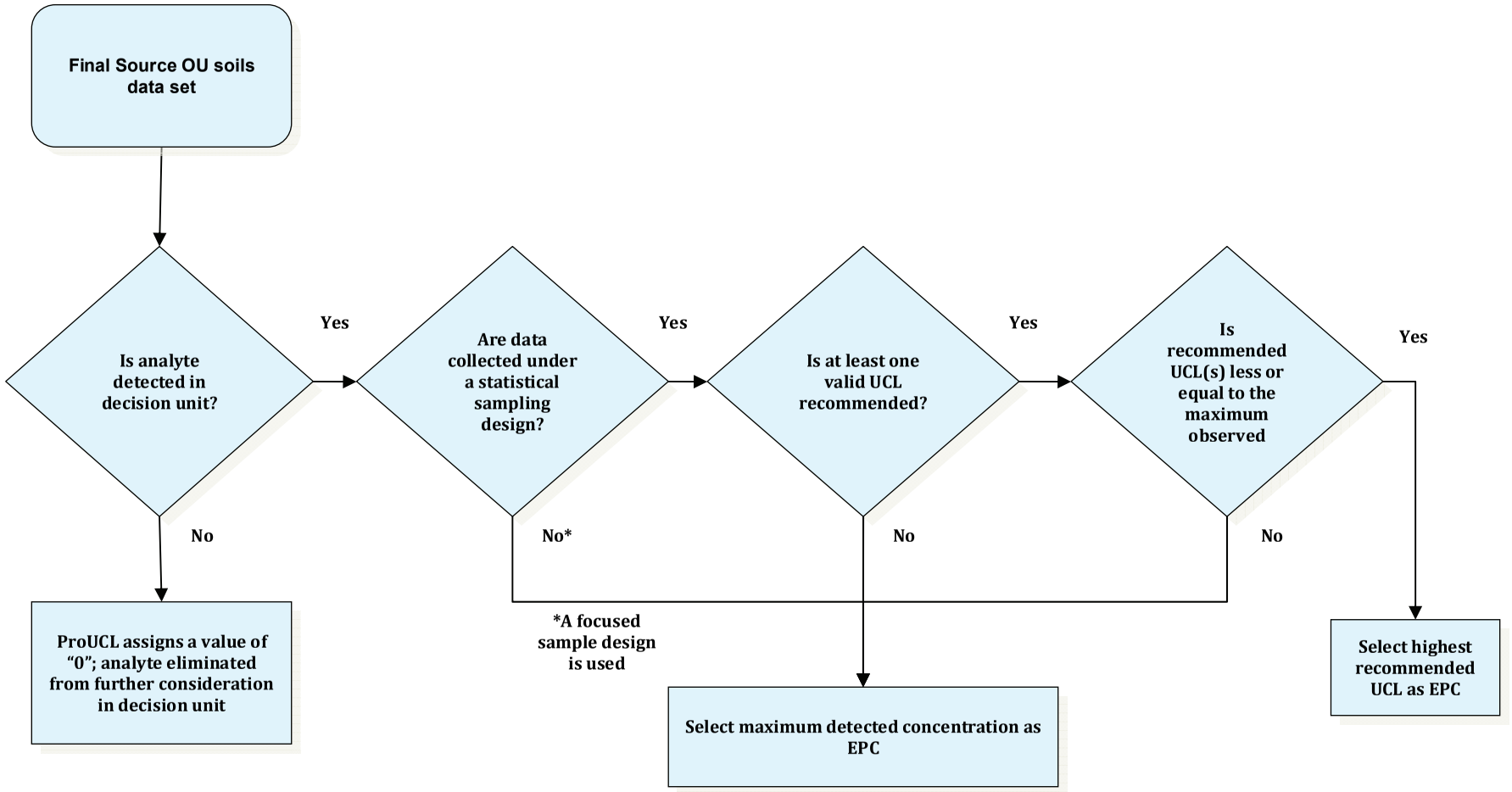

Figure 6-3. Decisions Logic for Computing Exposure Point Concentrations

The sampling plan for a focused decision unit was designed to sample the areas of suspected contamination. The results from this type of sampling design can introduce bias into statistical analyses to estimate means, such as calculations of UCLs. Guidance provided by *Supplemental Guidance to RAGS: Calculating the Concentration Term* (OSWER Publication 9285.7-081) states "a value other than the 95 percent UCL can be used, provided the risk assessor can document that high coverage of the true population mean occurs (i.e., the value equals or exceeds the true population mean with high probability)." Because the sampling design for these decision units focused on areas of suspected contamination, the conclusion that maximum detected concentration exceeds the true population mean in a focused decision unit can be made with certainty. Additionally, the closeout documentation for the focused decision units used the maximum detected concentration to determine if the RAG has been attained. The maximum detected concentration is selected as a conservative estimate of the EPC for the focused decision units because of the potential for statistical bias. In addition, the concentration is selected to maintain consistency with the closeout documentation.

ProUCL has minimum size requirements to compute UCLs. For data sets of at least five results, a UCL is not calculated when there is only one detected result in the data set. ProUCL notes that in cases where the number of available detected samples is small (<5), the estimation of the EPC term is decided upon on a site-specific basis. ProUCL generates warning messages regarding the potential deficiencies associated with a small data set. For small data sets with very few detected values (<5), where a valid UCL cannot be calculated, the EPC defaults to the maximum (single) concentration for the 300 Area Source OU.

Some of the distributional methods employed by ProUCL can produce very high estimates of the UCL (particularly the Land method). *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) acknowledges that the Land method can produce extremely high values for the UCL when data exhibit high variance and the sample size is small. *Supplemental Guidance to RAGS: Calculating the Concentration Term* (OSWER Publication 9285.7-081) recognizes the problem of extremely high UCLs, and recommends the maximum detected concentration become the default when the calculated UCL exceeds this value. When the recommended UCL exceeds the maximum detected concentration, ProUCL, however, advises that an alternative UCL (i.e., Chebyshev inequality) be selected instead of the maximum detected concentration for an EPC. When the recommended UCL is greater than the maximum detected result, the maximum detected value is selected as the EPC for the 300 Area Source OU. ProUCL displays a warning message when the recommended UCL-95 exceeds the observed maximum concentration.

6.2.2.5 Methodology Used to Calculate Total Uranium Concentrations from Isotopic Uranium Concentrations

Uranium analytical data are reported for most of the 300 Area Source OU waste site decision units as isotopic uranium (reported in units of pCi/g) and not as total uranium (reported in units of µg/kg). Because total uranium (µg/kg) is needed to support the 300 Area Source OU FS, an additional step is performed to calculate a mass-based total uranium concentration (µg/kg) from the activity-based isotopic uranium concentrations (pCi/g) reported for each waste site decision unit. This step entails obtaining the uranium isotope analytical data for each sample, converting the data from activity- to mass-based concentrations, and then summing the converted values for detected concentrations to produce a mass-based total uranium value. For sample results where all uranium isotope results are reported as non-detects, the individual values are not summed, but the maximum non-detect value is retained and put in the ProUCL file, flagged as a nondetect. The pCi/g to µg/kg conversions and subsequent summations are performed using specific activities for the uranium isotopes and appropriate conversion factors, as shown in the calculation example provided in Table 6-10. As mentioned previously, only detected concentrations are included in the summations. In the Table 6-10 example, U-235 is a nondetect and thus

not included in the summation. The calculated total uranium values are assigned an analyte name of Total_U_Isotopes in the data sets and then a ProUCL input file (as described in Section 6.2.2.2) containing the Total_U_Isotopes data is produced for each waste site decision unit.

Table 6-10. Example Conversion from Activity- to Mass-Based Concentration (pCi/g to µg/kg) for Uranium Isotopes and Summation to Produce a Mass-Based Total Uranium Concentration (µg/kg)

Uranium Isotope	Measured Activity (pCi isotope/ g soil)[a] (ND or D)	Specific Activity (Bq isotope/ g isotope)[b]	Specific Activity (pCi isotope/ g isotope)[c]	Conversion Factor (µg isotope/ g isotope)	Conversion Factor (g soil/ kg soil)	Calculated Concentration (µg isotope/ kg soil)[d]
U-233/234	0.649 (D)	2.302E+08	6.222E+09	1,000,000	1,000	0.10
U-235	0.031 (ND)	7.995E+04	2.161E+06	1,000,000	1,000	14 (not summed)
U-238	0.338 (D)	1.243E+04	3.359E+05	1,000,000	1,000	1,006
Total Uranium Concentration (Total_U_Isotopes) (µg total uranium/kg soil) =						**1,006**

a. Example analytical data shown for illustration purposes only.

b. *Table of Isotopes* (Firestone and Shirley, 1996), last update April 12, 1998.

c. Formula = specific activity (Bq/g) / 3.7E+10 Bq/Ci × 1.0E+12 pCi/Ci

d. Formula = measured activity (pCi/g) / specific activity (pCi/g) × conversion factor (µg/g) × conversion factor (g/kg)

ND = nondetect

D = detect

6.2.3 Exposure Assessment

This section defines the exposure scenarios used for various land use and receptor activities, describes the potential exposure pathways resulting from site contaminants, and provides the methodology for calculating the RBSLs for direct contact, based on currently available site information. The conceptual exposure model is formulated according to EPA guidance, taking into consideration information on contaminant sources, release mechanisms, routes of migration, potential exposure points, potential routes of exposure, and potential receptor groups associated with the 300 Area Source OU. This results in a set of exposure pathways that reflect an RME.

An exposure pathway can be described as the physical course that a COPC takes from the point of release to a receptor. The route of exposure is the means by which a COPC enters a receptor. For an exposure pathway to be complete, all of the following components must be present:

- A source
- A mechanism of chemical release and transport
- An environmental transport medium
- An exposure point
- An exposure route
- A receptor or exposed population

In the absence of any one of these components, an exposure pathway is considered incomplete; therefore, it creates no risk or hazard.

6.2.3.1 Contaminant Sources

The primary sources of contamination in 300 Area Source OU originated with uranium fuel production operations and various R&D activities focused on improving uranium fuel production methods and improving the plutonium extraction operations carried out in the 200 Area.

During 300 Area operations, there were intentional releases of waste materials to the environment most notably in the form of process liquids discharged to the large, unlined infiltration ponds and trenches. Burial grounds located in the 600 Area are tied to the waste management practices conducted in the 300 Area industrial complex as well. Additionally, there were several UPRs of both solids and liquids to the soil below and around the uranium production laboratories and waste handling facilities. Contaminant sources (i.e., facilities and waste sites) are listed in Sections 4.2.1 and 5.2 of this report.

6.2.3.2 Release Mechanisms and Environmental Transport Media

The primary COPC release mechanisms and transport pathways at the 300 Area Source OU are discussed in Sections 5.3 and 5.4, and include the following:

- Migration of contaminated liquids through the vadose zone column through infiltration, percolation, or leaching
- Direct contact and external radiation from vadose zone material containing COPCs (receptor contact with shallow vadose zone material replaces release and transport)
- Emission of dusts and vapors during former plant operations
- Generation of dust emanating from shallow vadose zone material to ambient air from wind, or during maintenance or excavation activities occurring at the 300 Area Source OU
- Volatilization of COPCs emanating from shallow vadose zone material to ambient air at the 300 Area Source OU

6.2.3.3 Potentially Complete Human Exposure Pathways and Receptors

Based on the current understanding of land use conditions near the 300 Area Source OU, the most plausible exposure pathways for calculating PRGs and characterizing the human health risks have been identified (represented in Figures 6-4 and 6-5). The groundwater supplemental risk evaluation is provided in Section 6.3.

For the purpose of this supplemental soil risk evaluation, shallow vadose zone material is represented by samples collected from 0 to 4.6 m (0 to 15 ft) bgs and deep vadose zone material is represented by samples collected from depths greater than 4.6 m (15 ft) bgs (Section 6.2.2.2, Table 6-9). Groundwater is represented by samples collected from the unconfined aquifer and discussed in Section 6.3.

6.2.3.3.1 Residential Scenario

PRGs (also used as RBSLs) developed for the residential scenario are the numeric values that represent the RAOs presented in Chapter 8. The results of comparing EPCs to the RBSLs in this supplemental soil risk evaluation will be used to help determine whether additional remedial action is necessary for waste sites where remediation has been completed, and whether the goals and objectives of the interim action RODs have been met, as demonstrated by verification sampling and analysis.

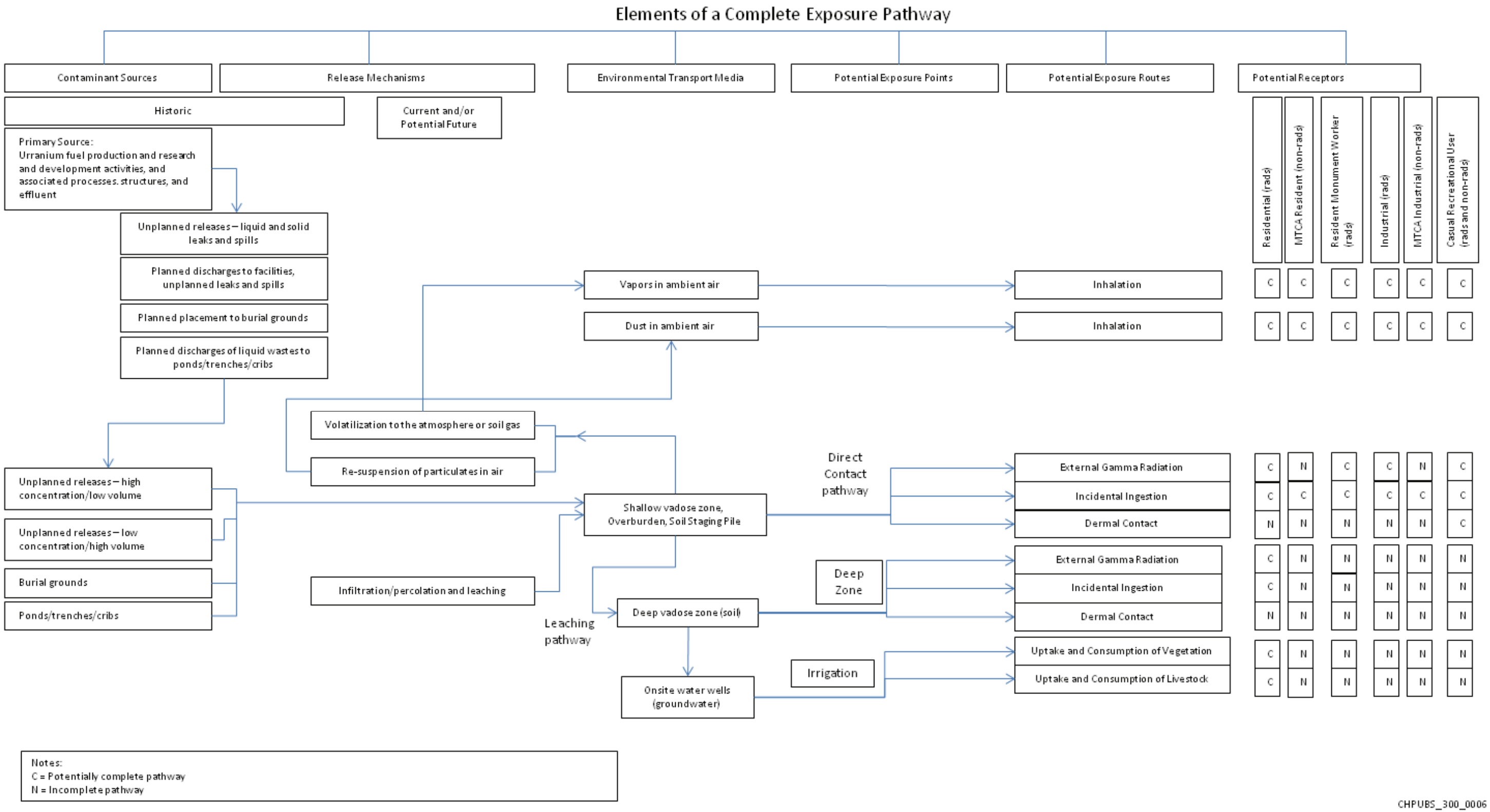

Figure 6-4. 300 Area Source OU Conceptual Site Model

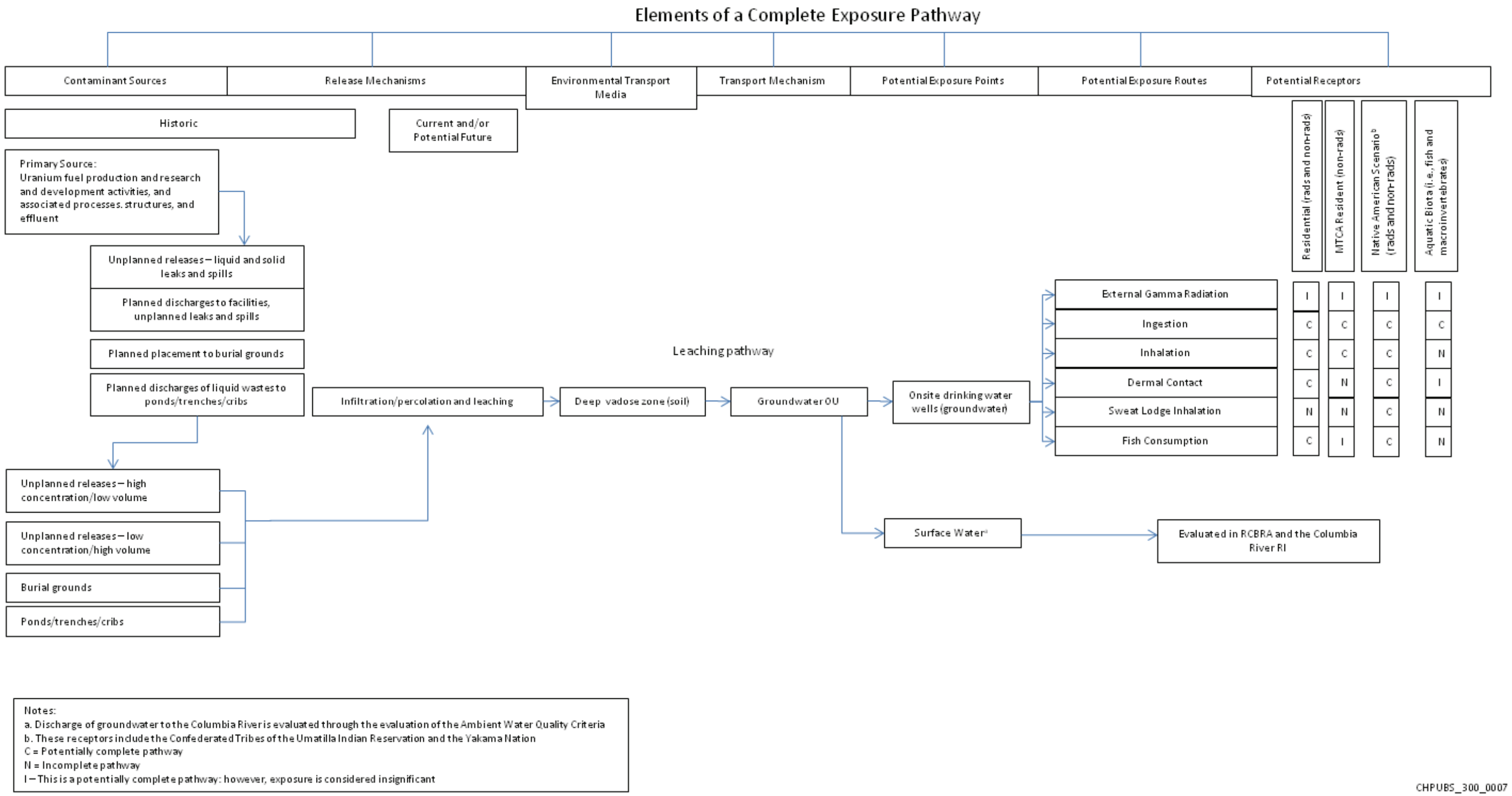

Figure 6-5. 300 –FF-5 Groundwater OU Conceptual Site Model

The residential scenario for radiological and nonradiological analytes is based on two different conceptual exposure models. The exposure pathways for radionuclides include direct contact in addition to dust inhalation, consumption of homegrown foodstuffs (e.g., produce, beef, and milk), and the leaching pathway (includes drinking water ingestion and fish ingestion). The exposure pathways for nonradiological analytes in vadose zone material include direct contact from incidental ingestion and inhalation of vapors and dust in ambient air.

The residential scenarios described below are consistent with the exposure scenario and ARARs used to develop the interim action ROD RAGs for soil presented in the 300 Area RDR/RAWP (DOE/RL-2001-47). This exposure scenario is also evaluated in the RCBRA to determine if cleanup actions completed under the interim action RODs are protective of HHE relative to the range of exposure scenarios evaluated in this risk assessment.

6.2.3.3.2 Radiological

Consistent with the 100 Area RDR/RAWP (DOE/RL-96-17), the RESRAD code is used to evaluate exposure to radiological contaminants in vadose zone material. Revisions to this exposure scenario reflect updates in guidance since the 100 Area RDR/RAWP (DOE/RL-96-17) was originally published in 1996. With the exception of changes resulting from updates in guidance, the residential scenario is the same as that published in the 100 Area RDR/RAWP (DOE/RL-96-17). Exposure assumptions that were updated to reflect current EPA guidance include a decrease in the external gamma-shielding factor (increased shielding) and a decrease in the outdoor time fraction. Health protective levels were also updated from a target annual dose rate of 15 mrem/yr to a target risk of 1×10^{-4} to be consistent with guidance recommended in *Radiation Risk Assessment At CERCLA Sites: Q & A* (EPA/540/R/99/006). A detailed description of this exposure scenario is provided in *Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 Areas and 300 Areas Remedial Investigation/Feasibility Study (RI/FS) Reports* (ECF-HANFORD-10-0429).

Unrestricted future land use conditions are represented by a resident in a subsistence farming setting. This assumes that each interim remediated waste site decision unit has the potential to be developed into a residence with a basement, vegetable and fruit crops are grown in a backyard garden, and a pasture is used to raise livestock sufficient for meat and milk production. A downgradient well is installed where exposure could potentially occur from contaminants leaching from the vadose zone material to groundwater beneath the residence (i.e., the leaching pathway). The resident could potentially come into direct contact with soil from the remediated waste site and potentially inhale dust in ambient air. The resident could potentially consume crops raised in a backyard garden and consume meat (beef, poultry, and fish) and milk raised on the pasture. Based upon the land uses identified in "Amended Record of Decision for the Hanford Comprehensive Land-Use Plan Environmental Impact Statement" (73 FR 55824) and the proclamation of "Establishment of the Hanford Reach National Monument" (65 FR 37253), it is unlikely that land within the 300 Area Source OU will be used for residential purposes.

The residential scenario evaluates residential pathways that include exposure to shallow vadose zone material from residential yards or groundwater from domestic wells. Potential routes of exposure to shallow vadose zone material evaluated in the RESRAD code include direct external exposure, incidental material ingestion, and inhalation of dust generated from wind or from yard maintenance activities. This scenario also evaluates residential exposure to radiological contaminants through food chain pathways (uptake of contamination from vadose zone material to plants and animals). Food chain pathways include the consumption of fruits and vegetables grown in a backyard garden, and consumption of meat and milk from livestock raised on the pasture. From the leaching pathway, this scenario evaluates residential consumption of drinking water from a downgradient well, use the well for irrigation of crops and

watering livestock, and consume fish raised in a pond supplemented with water from the downgradient well.

6.2.3.3.3 Nonradiological

The residential scenario for nonradiological analytes measured in soil is also consistent with the exposure scenario used as interim action ROD RAGs for soil presented in the 100 Area RDR/RAWP (DOE/RL-96-17). The exposure scenario for protection of human health is based on MTCA Standard Method B Soil Cleanup Levels ("Unrestricted Land Use Soil Cleanup Standards" [WAC 173-340-740(3)]) and Standard Method B standards ("Cleanup Standards to Protect Air Quality" [WAC 173-340-750(3)]). The MTCA Standard Method B soil cleanup levels are based on exposure to a child receptor that includes incidental ingestion, and use residential exposure frequency and duration assumptions. The MTCA Standard Method B air cleanup levels are based on exposure to child and adult receptors, includes inhalation of vapors and dust in ambient air, and assumes residential exposure frequency and duration assumptions. For arsenic and lead, the "Tables" (WAC 173-340-900), Table 740-1 Method A, soil cleanup levels for unrestricted land use of 20 and 250 mg/kg were used.

6.2.3.3.4 Groundwater

Groundwater within the 300-FF-5 OU is currently contaminated, and withdrawal is prohibited because of ICs placed on it by DOE. Under current site use conditions, no complete human exposure pathways to groundwater are assumed to exist. In addition, groundwater currently discharges to the Columbia River through upwelling and seeps.Groundwater within this OU is not anticipated to become a future source of drinking water until cleanup criteria are met and groundwater is restored to its highest beneficial use. However, groundwater in this risk analysis is evaluated for drinking water use and undiluted groundwater concentrations are compared to DWS and aquatic criteria to support the determination of the basis for action and to support the development of PRGs for evaluating remedial alternatives in the FS.

The residential scenario for radiological and nonradiological analytes measured in groundwater is also consistent with the RAGs documented in the interim action RODs and in the 100 Area RDR/RAWP (DOE/RL-96-17). Groundwater concentrations are compared to current MCLs for radionuclides, which are set at 4 mrem/yr for the sum of the doses from beta particle and photon emitters, 15 pCi/L for gross alpha emitter activity (including radium-226, but excluding uranium and radon), and 5 pCi/L combined for radium-226 and radium-228. A mass based concentration MCL has been established for uranium as 30 µg/L. The exposure scenario for protection of human health is based on the MTCA Standard Method B "Standard Method B Potable Groundwater Cleanup Levels" ("Groundwater Cleanup Standards" [WAC 173-340-720(4)(b)]). The MTCA Standard Method B groundwater cleanup levels are based on exposure to child and adult receptors, includes drinking water ingestion, and inhalation of vapors, and assumes residential exposure frequency and duration assumptions.

6.2.3.3.5 Industrial Scenario

The industrial exposure scenario is used to represent reasonably anticipated future land use conditions and to evaluate the balancing criteria in the FS. Balancing criteria include the following: long-term effectiveness and permanence, reduction of toxicity mobility, or volume through treatment, short-term effectiveness, implementability, and cost. The industrial worker is selected as the receptor to represent potential exposures from industrial land similar to that experienced in the 300 Area. It is also the exposure scenario from which RAGS are developed and presented in the 300 Area RDR/RAWP (DOE/RL-2001-47).

The industrial scenario for radiological and nonradiological analytes in soil is based on two different conceptual exposure models. The exposure pathways for radionuclides include direct contact and dust inhalation. The exposure pathways for nonradiological analytes in soil include direct contact from incidental soil ingestion and inhalation of vapors and dust in ambient air.

The industrial scenarios described below are consistent with the exposure scenario and ARARs used to develop the cleanup levels for industrial land use for the 300-FF-2 ROD (EPA/ROD/R10-01/119).

6.2.3.3.6 Radiological

Consistent with the 300 Area RDR/RAWP (DOE/RL-2001-47), the RESRAD code is used to evaluate exposure to radiological contaminants in soil. Revisions to this exposure scenario reflect updates in guidance since the 300 Area RDR/RAWP (DOE/RL-2001-47) was originally published. Exposure assumptions that were updated to reflect current EPA guidance include a decrease in the external gamma-shielding factor (increased shielding), a decrease in the inhalation rate, and use of the default RESRAD mass loading parameter used to estimate particulate emissions. Health protective levels were also updated from a target annual dose rate of 15 mrem/yr to a target risk of 1×10^{-4} to be consistent with guidance recommended in *Radiation Risk Assessment At CERCLA Sites: Q & A* (EPA/540/R/99/006). A detailed description of this exposure scenario is provided in *Calculation of Radiological Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports* (ECF-HANFORD-10-0452).

6.2.3.3.7 Nonradiological

The industrial scenario for nonradiological analytes measured in soil is also consistent with the exposure scenario used in the 300 Area RDR/RAWP (DOE/RL-2001-47). The exposure scenario for protection of human health is based on the MTCA "Standard Method C Industrial Soil Cleanup Levels" (WAC 173-340-745(5)(b)) and "Standard Method C Air Cleanup Levels" (WAC 173-340-750(4)(b)). The MTCA Standard Method C soil cleanup levels are based on exposure to an adult receptor includes incidental soil ingestion, and use industrial exposure frequency and duration assumptions. The MTCA Standard Method C air cleanup levels are based on exposure to an adult receptor, includes inhalation of vapors and dust in ambient air, and assumes industrial exposure frequency and duration assumptions. For arsenic and lead, the "Tables" (WAC 173-340-900), Table 745-1, Method A, soil cleanup levels for Industrial Properties of 20 and 1,000 mg/kg were used.

6.2.3.3.8 Residential Monument Worker Scenario

Land use within the River Corridor's 100 and 600 Areas is predominantly conservation/preservation. Reasonably anticipated future land use in the 300 Area is discussed in Section 3.8. In 2000, a Presidential Proclamation was signed, creating the Hanford Reach National Monument to be managed by USFWS and DOE ("Establishment of the Hanford Reach National Monument" [65 FR 37253]). The Monument was established for protecting the biological, historic, and scientific objects contained within. To support continued protection of natural and cultural resources, the proclamation stated that the Monument would not be developed for residential or commercial use in the future ("Establishment of the Hanford Reach National Monument" [65 FR 37253]).

For the purposes of the RI/FS, the resident Monument worker represents reasonably anticipated future land use. However, exposure does not occur to the resident worker in the "industrial area" inside the fence of the 300 Area, the 618-10 Burial Ground, or the 618-11 Burial Ground. PRGs are developed for this scenario for use in the risk-based screening evaluation. Resident worker PRG values are developed for radiological contaminants; PRG values for the resident worker were not developed for chemical contaminants. When the total risk for a waste site exceeds 1×10^{-4} based on the residential scenario, then the waste site is compared to the PRGs developed for the resident worker. The results of these

comparisons are used to determine the need for remedy selection relative to reasonably anticipated land use.

CVP and RSVP data are compared to these numeric values to confirm that cleanup actions are protective of the reasonably foreseeable land uses that DOE and USFWS anticipate for the River Corridor. The resident Monument worker is selected as the receptor to represent potential exposures from occupational use along the River Corridor. This exposure scenario was included in the subset of occupational scenarios presented in the RCBRA. The resident Monument worker scenario is a site-specific scenario that envisions a resident employee of the Hanford Reach National Monument. These receptors are assumed to be exposed primarily in an outdoor environment as they lead tours, conduct ecological education, or perform similar activities. When not working, these receptors are envisioned to live in an onsite residence associated with the Monument. By use of a domestic well at their residence, these receptors may also be exposed to groundwater contaminants through domestic water use. Exposure to groundwater as a domestic source of water by the resident Monument worker is not included in the soil PRG value that is calculated for this exposure scenario. The risks from exposure to 300-FF-5 groundwater from use as a domestic source of water can be separately added to provide a total risk from exposure to soil and groundwater.

The residential Monument worker scenario for radiological and nonradiological analytes in vadose zone material is based on the same conceptual exposure model. The exposure pathways include direct contact and inhalation of vapors and dust in ambient air. Adults could potentially be exposed to site contaminants in shallow vadose zone material at their residence through direct external exposure, incidental ingestion, dermal absorption, and inhalation. During working activities, these adults may also be potentially exposed to contaminants in shallow vadose zone material by direct external exposure, incidental ingestion, dermal absorption, and inhalation. No food chain pathways are included in this exposure scenario.

6.2.3.3.9 Casual Recreational User Scenario

As discussed previously, reasonably anticipated future land use within the River Corridor's 100 and 600 Areas is predominantly conservation/preservation. The casual recreational user scenario is also used in the evaluation of balancing criteria in the FS. The casual recreational user is selected as the receptor to represent potential exposures from recreational use along the River Corridor. This exposure scenario was included in the subset of recreational use scenarios presented in the RCBRA. The casual recreational user scenario is a site-specific scenario representing occasional recreational use that focuses on activities such as walking and picnicking in areas along the Columbia River where paths and benches are likely to exist. These receptors are assumed to be exposed entirely in an outdoor environment. This scenario also assumes that drinking water is obtained from an offsite source.

For the purposes of the RI/FS, the casual user represents reasonably anticipated future land use. However, exposure does not occur to the casual user in the "industrial area" inside the fence of the 300 Area, the 618-10 Burial Ground, or the 618-11 Burial Ground. PRGs are developed for this scenario for use in the risk-based screening evaluation. Casual user PRG values are developed for radiological and nonradiological contaminants. When the total risk for a waste site exceeds 1×10^{-4} based on the residential scenario, then the waste site is compared to the PRGs developed for the casual user. The results of these comparisons are used to determine the need for remedy selection relative to reasonably anticipated land use.

CVP and RSVP data are compared to these numeric values to confirm that cleanup actions are protective of the reasonably foreseeable land uses that DOE and USFWS anticipate for the River Corridor. The casual recreational user scenario for radiological and nonradiological analytes in vadose zone material is based on the same conceptual exposure model. The exposure pathways include direct contact and

inhalation of vapors and dust in ambient air. Adults and children could potentially be exposed to site contaminants in shallow vadose zone material along the river through direct external exposure, incidental ingestion, dermal absorption, and inhalation of vapors and dust in ambient air.

6.2.3.4 Quantification of Potential Exposures

Quantification of potential exposures in this risk assessment is evaluated through the comparison of EPCs to PRGs (which are also used as RBSLs). Risk Assessment Guidance Volume I, Part B (*Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals): Interim* [EPA/540/R-92/003]) provides guidance on using EPA toxicity values and exposure information to calculate PRGs. It is recommended that PRGs should not be used as cleanup levels for a CERCLA site until the remedy selection identified in the relevant portion of the NCP (40 CFR 300) has been evaluated and considered. Once the BRA has been performed, PRGs can be derived using site-specific risks; PRGs developed in the FS will usually be based on site-specific risks and ARARs and not on screening levels. PRGs are obtained from two general sources: concentrations based on ARARs (for example MTCA) and concentrations based on risk assessment. It should be recognized that the ARAR-based PRGs are also considered risk-based. Exposure assumptions published by the state and EPA and toxicity values published by EPA are used to derive risk-based PRGs.

PRGs based on risk assessment include the resident Monument worker and the casual user scenarios. PRGs for these scenarios are calculated using methodologies published in *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals): Interim* (EPA/540/R-92/003) and *Superfund Radionuclide Preliminary Remediation Goal (PRG) Download and Calculation Website* (EPA, 2010). Toxicity values and exposure values published by EPA are used to derive risk-based PRGs.

PRGs for soil ingestion are calculated using the equations provided in "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740(3)). PRGs for the inhalation pathway are calculated using the equations provided in "Cleanup Standards to Protect Air Quality" (WAC 173-340-750(3)), "Method B Air Cleanup Levels." Air cleanup levels are converted to soil concentrations using EPA published volatilization factors for analytes that meet the operational definition of a volatile and a PEF for analytes that are not volatile. MTCA Method A soil cleanup levels for unrestricted land use, obtained from "Tables" (WAC 173-340-900), Table 740-1, are used as PRGs for arsenic and lead.

In addition to the guidance listed previously, radionuclide PRGs for the resident and industrial worker are calculated using the RESRAD code. The RESRAD code was used to calculate PRGs for the residential scenario because of unique exposure pathways. The RESRAD code was used for the residential scenario because this scenario includes the food chain pathway and the leaching to groundwater pathway. According to *User's Manual for RESRAD Version 6* (ANL/EAD-4), the RESRAD model and computer code were developed as a multifunctional tool to assist in developing cleanup criteria and assessing the dose or risk associated with residual radioactive material. The RESRAD code was used to calculate PRGs for the industrial scenario to maintain consistency with the approach used to calculate the PRGs in the 300 Area RDR/RAWP (DOE/RL-2001-47).

Table 6-11 summarizes the PRG values for each exposure scenario.

6.2.3.4.1 Calculation of Residential PRGs using RESRAD

The radionuclide PRGs for the residential scenario are calculated using the RESRAD, Version 6.5 (ANL, 2009) model and code according to the guidance specified in *User's Manual for RESRAD Version 6* (ANL/EAD-4). The RESRAD model was used to calculate single radionuclide concentrations that correspond to a target cancer risk level of 1×10^{-4} for the residential scenario. For the purpose of this

risk evaluation, the single radionuclide concentrations described in this section are used as PRGs for the residential scenario.

The RESRAD model allows for the use of site-specific chemical and physical parameters to estimate single radionuclide concentrations. The potentially complete exposure pathways considered are direct contact, inhalation pathway, the food chain pathway, and leaching of contaminants in the vadose zone through the vadose zone column to the groundwater table. Exposure routes associated with the direct contact and inhalation pathways include external gamma exposure, incidental ingestion, and inhalation of dust. Exposure routes associated with the food chain exposure pathway include consumption of homegrown produce, meat, and milk. Exposure routes associated with the leaching pathway include crop irrigation, aquatic food consumption, and drinking water ingestion. A list of the site-specific RESRAD input parameters is provided in Table G-6 (Appendix G). A detailed description of methodology, inputs, assumptions, and results of the calculations is presented in *Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 Areas and 300 Areas Remedial Investigation/Feasibility Study (RI/FS) Reports* (ECF-HANFORD-10-0429) (Appendix G).

Table 6-11. Summary of Preliminary Remediation Goals for the 300 Area Source Operable Unit

Analyte	90th Percentile Background	Method A Soil Cleanup Level (Unrestricted Land Use)	Method A Soil Cleanup Level (Industrial Land Use)	Residential PRG	Method B Direct Contact PRG (carcinogen)	Method B Direct Contact PRG (noncarcinogen)	Method B Inhalation PRG (carcinogen)	Method B Inhalation PRG (noncarcinogen)	Industrial PRG	Method C Direct Contact PRG (carcinogen)	Method C Direct Contact PRG (noncarcinogen)	Method C Inhalation PRG (carcinogen)	Method C Inhalation PRG (noncarcinogen)	Casual Recreational User PRG (carcinogen)	Casual Recreational User PRG (noncarcinogen)	Resident National Monument Worker PRG (carcinogen)
Radionuclides (pCi/g)																
Americium-241	--	--	--	155.00	--	--	--	--	942	--	--	--	--	2570	--	275
Cesium-137	1.05	--	--	4.4	--	--	--	--	18	--	--	--	--	100	--	6.2
Cobalt-60	0.01	--	--	3.1	--	--	--	--	9.4	--	--	--	--	63	--	3.3
Europium-155	0.05	--	--	327	--	--	--	--	966	--	--	--	--	5869	--	354
Plutonium-238	0.0038	--	--	236	--	--	--	--	3370	--	--	--	--	3818	--	605
Plutonium-239/240	0.02	--	--	203	--	--	--	--	2906	--	--	--	--	3342	--	539
Plutonium-241	--	--	--	5080	--	--	--	--	31100	--	--	--	--	--	--	77180
Total beta radiostrontium	0.18	--	--	2.3	--	--	--	--	1968	--	--	--	--	5064	--	518
Tritium	--	--	--	623	--	--	--	--	49800	--	--	--	--	15376	--	1265436
Uranium-233/234	1.1	--	--	133	--	--	--	--	1757	--	--	--	--	5808	--	931
Uranium-235	0.11	--	--	16.3	--	--	--	--	61	--	--	--	--	295	--	22
Uranium-238	1.06	--	--	54	--	--	--	--	283	--	--	--	--	1093	--	93
Metals (mg/kg)																
Aluminum	11800	--	--	--	--	80000	--	>1,000,000	--	--	>1,000,000	--	>1,000,000	--	912453	--
Antimony	0.13	--	--	--	--	32	--	--	--	--	1400	--	--	--	365	--
Arsenic	6.5	20	20	--	0.67	24	42414	500240	--	87.5	1050	424137	>1,000,000	4.5	253	--
Barium	132	--	--	--	--	16000	--	>1,000,000	--	--	700000	--	>1,000,000	--	182481	--
Beryllium	1.5	--	--	--	--	160	75991	666986.16	--	--	7000	759913	>1,000,000	>1,000,000	1825	--
Boron	3.9	--	--	--	--	16000	--	>1,000,000	--	--	700000	--	>1,000,000	--	182500	--
Cadmium	0.56	--	--	--	--	40	101322	333493.08	--	--	3500	>1,000,000	729516	>1,000,000	821	--
Chromium	18.5	--	--	--	--	120000	--	--	--	--	>1,000,000	--	--	--	>1,000,000	--
Cobalt	15.7	--	--	--	--	24	20264	200095.85	--	--	1050	202643	437710	920451	274	--
Copper	22	--	--	--	--	3200	--	--	--	--	140000	--	--	--	36500	--
Hexavalent Chromium	--	--	--	--	--	240	2171	>1,000,000	--	--	10500	21712	>1,000,000	98620	2737	--
Iron	32600	--	--	--	--	56000	--	--	--	--	>1,000,000	--	--	--	638750	--
Lead	10.2	250	1000	--	--	--	--	--	--	--	--	--	--	--	--	--
Lithium	13.3	--	--	--	--	160	--	--	--	--	7000	--	--	--	1825	--

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Analyte	90th Percentile Background	Method A Soil Cleanup Level (Unrestricted Land Use)	Method A Soil Cleanup Level (Industrial Land Use)	Residential PRG	Method B Direct Contact PRG (carcinogen)	Method B Direct Contact PRG (noncarcinogen)	Method B Inhalation PRG (carcinogen)	Method B Inhalation PRG (noncarcinogen)	Industrial PRG	Method C Direct Contact PRG (carcinogen)	Method C Direct Contact PRG (noncarcinogen)	Method C Inhalation PRG (carcinogen)	Method C Inhalation PRG (noncarcinogen)	Casual Recreational User PRG (carcinogen)	Casual Recreational User PRG (noncarcinogen)	Resident National Monument Worker PRG (carcinogen)
Manganese	512	--	--	--	--	11200	--	>1,000,000	--	--	490000	--	>1,000,000	--	127658	--
Mercury	0.013	--	--	--	--	24	--	>1,000,000	--	--	1050	--	>1,000,000	--	274	--
Molybdenum	0.47	--	--	--	--	400	--	--	--	--	17500	--	--	--	4563	--
Nickel	19.1	--	--	--	--	1600	701458	>1,000,000	--	--	70000	>1,000,000	>1,000,000	>1,000,000	18249	--
Selenium	0.78	--	--	--	--	400	--	>1,000,000	--	--	17500	--	>1,000,000	--	4562	--
Silver	0.17	--	--	--	--	400	--	--	--	--	17500	--	--	--	4563	--
Strontium	--	--	--	--	--	48000	--	--	--	--	>1,000,000	--	--	--	547500	--
Tin	--	--	--	--	--	48000	--	--	--	--	>1,000,000	--	--	--	547500	--
Total Calculated Uranium	3.2	--	--	161	--	--	--	--	842	--	--	--	--	--	--	--
Uranium	3.2	--	--	--	--	240	--	>1,000,000	--	--	10500	--	>1,000,000	--	2737	--
Vanadium	85.1	--	--	--	--	400	--	--	--	--	17500	--	--	--	4563	--
Zinc	67.8	--	--	--	--	24000	--	--	--	--	>1,000,000	--	--	--	273750	--
Other Inorganics (mg/kg)																
Fluoride	2.8	--	--	--	--	4800.00	--	>1,000,000	--	--	210000	--	>1,000,000	--	54750	--
Nitrate	52	--	--	--	--	568000.00	--	--	--	--	>1,000,000	--	--	--	>1,000,000	--
Nitrogen in Nitrite and Nitrate	--	--	--	--	--	128000.00	--	--	--	--	>1,000,000	--	--	--	>1,000,000	--
Other Organics (mg/kg)																
2,4-Dinitrotoluene	--	--	--	--	3.2	160	>1,000,000	--	--	423	7000	>1,000,000	--	18.2	1420	--
4,4'-DDE (Dichlorodiphenyldichloroethylene)	--	--	--	--	2.9	--	>1,000,000	--	--	386	--	>1,000,000	--	16.7	--	--
4-Chloro-3-methylphenol	--	--	--	--	--	8000	--	--	--	--	350000	--	--	--	71289	--
Alpha-BHC	--	--	--	--	0.16	640	101322	--	--	20.8	28000	>1,000,000	--	0.90	5703	--
Bis(2-ethylhexyl) phthalate	--	--	--	--	71	1600	>1,000,000	--	--	9375	70000	>1,000,000	--	405	14258	--
Butylbenzylphthalate	--	--	--	--	526	16000	--	--	--	69079	700000	--	--	2981	142578	--
Chlordane	--	--	--	--	2.9	40	>1,000,000	>1,000,000	--	375	1750	>1,000,000	>1,000,000	18.9	410	--
Dieldrin	--	--	--	--	0.06	4	39647.61	--	--	8.2	175	396476	--	0.35	35.6	--
Di-n-butylphthalate	--	--	--	--	--	8000	--	--	--	--	350000	--	--	--	71289	--
Endosulfan I	--	--	--	--	--	480	--	--	--	--	21000	--	--	--	4277	--

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Endosulfan II	--	--	--	--	--	480	--	--	--	--	21000	--	--	--	4277	--
Fluoranthene	--	--	--	--	--	3200	--	--	--	--	140000	--	--	--	26760	--
Methoxychlor	--	--	--	--	--	400	--	--	--	--	17500	--	--	--	3564	--
n-Nitrosodi-n-dipropylamine	--	--	--	--	0.14	--	91190	--	--	18.8	--	911895	--	0.81	--	--
Pentachlorophenol	--	--	--	--	8.3	2400	>1,000,000	--	--	1094	105000	>1,000,000	--	34.7	16103	--
Total petroleum hydrocarbons - diesel range	--	2000	2000	--	--	--	--	--	--	--	--	--	--	--	--	--
Total petroleum hydrocarbons - kerosene range	--	2000	2000	--	--	--	--	--	--	--	--	--	--	--	--	--
Total petroleum hydrocarbons - motor oil (high boiling)	--	2000	2000	--	--	--	--	--	--	--	--	--	--	--	--	--
Polyaromatic Hydrocarbons (PAHs) (mg/kg)																
2-Methylnaphthalene	--	--	--	--	--	320	--	--	--	--	14000	--	--	--	2676	--
Acenaphthene	--	--	--	--	--	4800	--	--	--	--	210000	--	--	--	40139	--
Anthracene	--	--	--	--	--	24000	--	--	--	--	>1,000,000	--	--	--	200696	--
Benzo(a)anthracene	--	--	--	--	1.4	--	>1,000,000	--	--	180	--	>1,000,000	--	1.7	--	--
Benzo(a)pyrene	--	--	--	--	0.14	--	165799	--	--	18	--	>1,000,000	--	0.17	--	--
Benzo(b)fluoranthene	--	--	--	--	1.4	--	>1,000,000	--	--	180	--	>1,000,000	--	1.7	--	--
Benzo(k)fluoranthene	--	--	--	--	1.4	--	>1,000,000	--	--	180	--	>1,000,000	--	1.7	--	--
Chrysene	--	--	--	--	13.7	--	>1,000,000	--	--	1798	--	>1,000,000	--	17.2	--	--
Dibenz[a,h]anthracene	--	--	--	--	1.4	--	>1,000,000	--	--	180	--	>1,000,000	--	1.7	--	--
Fluorene	--	--	--	--	--	3200	--	--	--	--	140000	--	--	--	26760	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	1.4	--	>1,000,000	--	--	180	--	>1,000,000	--	1.7	--	--
Naphthalene	--	--	--	--	--	1600	1.4	25.3	--	--	70000	13.6	55.3	61.6	2241	--
Pyrene	--	--	--	--	--	2400	--	--	--	--	105000	--	--	--	20070	--
Polychlorinated Biphenyls (PCBs) (mg/kg)																
Aroclor 1016	--	--	--	--	14.3	5.6	>1,000,000	--	--	1875	245	>1,000,000	--	73.8	45.9	--
Aroclor 1221	--	--	--	--	0.50	--	319963	--	--	66	--	>1,000,000	--	2.0	--	--
Aroclor 1232	--	--	--	--	0.50	--	319963	--	--	66	--	>1,000,000	--	2.0	--	--

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Aroclor 1242	--	--	--	--	0.50	--	319963	--	--	66	--	>1,000,000	--	2.6	--	--
Aroclor 1248	--	--	--	--	0.50	--	319963	--	--	66	--	>1,000,000	--	2.6	--	--
Aroclor 1254	--	--	--	--	0.50	1.6	319963	--	--	66	70	>1,000,000	--	2.6	13.1	--
Aroclor 1260	--	--	--	--	0.50	--	319963	--	--	66	--	>1,000,000	--	2.6	--	--
Volatile Organic Compounds (VOCs) (mg/kg)																
1,1,2,2-Tetrachloroethane	--	--	--	--	5.0	320	0.39	--	--	656	14000	3.9	--	12.1	3650	--
1,2,4-Trichlorobenzene	--	--	--	--	34.5	800	--	14.2	--	4526	35000	--	31	257	1296	--
1,4-Dichlorobenzene	--	--	--	--	185	5600	1.5	2375	--	24306	245000	14.8	5195	63.9	51000	--
2-Butanone	--	--	--	--	--	48000	--	28673	--	--	>1,000,000	--	62722	--	464234	--
2-Butoxyethanol	--	--	--	--	--	8000	--	475961	--	--	>1,000,000	--	1041165	--	356445	--
2-Chlorophenol	--	--	--	--	--	400	--	--	--	--	17500	--	--	--	4563	--
Acetone	--	--	--	--	--	72000	--	189926	--	--	>1,000,000	--	415463	--	789195	--
Aldrin	--	--	--	--	0.06	2.4	37220	--	--	7.7	105	372202	--	0.33	21.4	--
Chloroform	--	--	--	--	32.3	800	0.24	100	--	4234	35000	2.4	218	10.5	4908	--
Dibenzofuran	--	--	--	--	--	80	--	--	--	--	5833	--	--	--	913	--
Diethyl ether	--	--	--	--	--	16000	--	--	--	--	700000	--	--	--	182500	--
Heptachlor epoxide	--	--	--	--	0.11	1.04	70146	--	--	14.4	45.5	701458	--	0.62	9.3	--
Hexachlorobutadiene	--	--	--	--	12.8	80	>1,000,000	--	--	1683	3500	>1,000,000	--	72.6	713	--
Hexachloroethane	--	--	--	--	71.4	80	>1,000,000	--	--	9375	3500	>1,000,000	--	405	713	--
Methylene chloride	--	--	--	--	133	4800	11.2	965	--	17500	210000	112	2111	337	35713	--
Phenol	--	--	--	--	--	24000	--	11614	--	--	>1,000,000	--	25405	--	213867	--
Tetrachloroethene	--	--	--	--	1.9	800	0.88	256	--	243	35000	8.8	560	10.3	6838	--
Toluene	--	--	--	--	--	6400	--	4774	--	--	280000	--	10444	--	63832	--
Trichloroethene	--	--	--	--	11.2	--	0.17	27.6	--	1475	--	1.7	60	7.2	2940	--
Trichloromonofluoromethane	--	--	--	--	--	24000	--	335	--	--	>1,000,000	--	732	--	31527	--

-- = not applicable

6.2.3.4.2 Calculation of Industrial PRGs using RESRAD

The radionuclide PRGs for the industrial exposure scenario are calculated using the RESRAD, Version 6.5 (ANL, 2009) model and code according to the guidance specified in *User's Manual for RESRAD Version 6* (ANL/EAD-4). The RESRAD model was used to calculate single radionuclide concentrations that correspond to a target cancer risk level of 1×10^{-4} for the industrial exposure scenario. For the purpose of this risk evaluation, the single radionuclide concentrations described in this section are used as PRGs for the industrial/commercial scenario.

The RESRAD model allows for the use of site-specific chemical and physical parameters to estimate single radionuclide concentrations. The potentially complete exposure pathways considered are direct contact and the inhalation pathway. Exposure routes associated with the direct contact and inhalation pathways include external gamma exposure, incidental ingestion, and inhalation of dust. A list of the site-specific RESRAD input parameters is provided in Table G-7 (Appendix G). A detailed description of methodology, inputs, and assumptions and the results of the calculations are presented in *Calculation of Radiological Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports* (ECF-HANFORD-10-0452).

6.2.3.4.3 Calculation of Unrestricted and Industrial Land Use PRGs using MTCA Equations

The direct contact nonradiological PRGs for unrestricted land use (i.e., the resident) are calculated using equations and input parameters described in "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740 (3)). The Standard Method B soil cleanup levels for unrestricted land use are based on ingestion. These levels were calculated for noncarcinogens and carcinogens using equation 740-1 and equation 740-2, respectively. Default exposure parameters for calculating the PRGs are defined in Table G-8 (Appendix G). Standard Method B soil cleanup levels for unrestricted land use are based on an acceptable cancer risk level of 1×10^{-6} for carcinogens or a hazard quotient (HQ) of 1 for noncarcinogens.

The direct contact nonradiological PRGs for industrial land use (i.e., the industrial worker) are calculated using equations and input parameters described in "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745(5)(b)). The Standard Method C industrial soil cleanup levels are based on soil ingestion. These levels were calculated for noncarcinogens and carcinogens using equation 745-1 and equation 745-2, respectively. Default exposure parameters for calculating the PRGs are defined in Table G-9 (Appendix G). Standard Method C industrial soil cleanup levels are based on an acceptable cancer risk level of 1×10^{-5} for carcinogens or an HQ of 1 for noncarcinogens.

Reference dose (RfD) and carcinogenic potency factors are determined using the recommended reference hierarchy as described in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). Methodology, inputs, assumptions, and results of the calculations are described in *Calculation of Documentation of Standard Method B Direct Contact Soil Cleanup Levels for Unrestricted Land Use* (ECF-HANFORD-10-0444) and *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports* (ECF-HANFORD-10-0453) (Appendix G).

The inhalation nonradiological PRGs for unrestricted land use (i.e., the resident) are calculated using equations and input parameters described in "Cleanup Standards to Protect Air Quality" (WAC 173-340-750 (3)), "Method B air cleanup levels." The inhalation nonradiological PRGs for industrial/commercial land use (i.e., the industrial worker) are calculated using equations and input parameters described in "Cleanup Standards to Protect Air Quality" (WAC 173-340-750(4)(b)), "Standard Method C air cleanup levels." The Method B and Method C air cleanup levels are were calculated for noncarcinogens and carcinogens using equation 750-1 and equation 750-2, respectively.

Air PRGs are converted to soil concentrations using EPA published volatilization factors for analytes that meet the operational definition of a volatile and a PEF for analytes that are not volatile. Default exposure parameters for calculating the inhalation PRGs are defined in Tables G-10 (Method B) and G-11 (Method C) (Appendix G). Method B soil PRGs for the inhalation pathway are based on an acceptable cancer risk level of 1×10^{-6} for carcinogens or an HQ of 1 for noncarcinogens. Method C soil PRGs for the inhalation pathway are based on an acceptable cancer risk level of 1×10^{-5} for carcinogens or an HQ of 1 for noncarcinogens. Inhalation RfD and inhalation carcinogenic potency factors are determined using the recommended reference hierarchy as described in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). Methodology, inputs, assumptions, and the results of the calculations are described in *Calculation of Inhalation Pathway Preliminary Remediation Goals Using Standard Method B Air Cleanup Levels for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports* (ECF-HANFORD-11-0033) and *Calculation of Inhalation Pathway Preliminary Remediation Goals Using Standard Method C Air Cleanup Levels for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports* (ECF-HANFORD-11-0454) (Appendix G).

Direct Contact. The following represents the Standard Method B and Standard Method C direct contact soil PRG equations for noncarcinogens and carcinogens. The parameters used for calculating the soil PRGs are defined in Tables G-8 and G-9 (Appendix G).

Noncarcinogens. The equation below is obtained from "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740(3)(b)(iii)(B)(I)) Equation 740-1 and "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745(5)(b)) Equation 745-1.

$$Soil\ PRG\left(\frac{mg}{kg}\right)=\frac{RfD\times ABW\times UCF\times HQ\times AT_{nc}}{SIR\times AB1\times EF\times ED}$$

where:

RfD	=	reference dose (mg/kg-day)
ABW	=	average body weight (kg)
UCF	=	unit conversion factor (mg/kg)
HQ	=	hazard quotient (unitless)
AT_{nc}	=	averaging time- noncarcinogens (years)
SIR	=	soil ingestion rate (mg/day)
$AB1$	=	gastrointestinal absorption fraction (unitless)
EF	=	exposure frequency (unitless)
ED	=	exposure duration (years)

Carcinogens. The equation below is obtained from "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740(3)(b)(iii)(B)(II)) Equation 740-2 and "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745(5)(b)) Equation 745-2.

$$Soil\ PRG\left(\frac{mg}{kg}\right)=\frac{RISK\times ABW\times AT_{c}\times UCF}{CPF\times SIR\times AB1\times ED\times EF}$$

where:

$RISK$	=	acceptable cancer risk level (unitless)
ABW	=	average body weight (kg)

AT_c = averaging time-carcinogens (years)
UCF = unit conversion factor (mg/kg)
CPF = carcinogenic potency factor (kg-day/mg)
SIR = soil ingestion rate (mg/day)
$AB1$ = gastrointestinal absorption fraction (unitless)
ED = exposure duration (years)
EF = exposure frequency (unitless)

Inhalation. The following represents the Standard Method B and Standard Method C inhalation soil PRG equations for noncarcinogens and carcinogens. The parameters used for calculating the soil PRGs are defined in Tables G-10 and G-11 (Appendix G).

Noncarcinogens. The equation below is obtained from "Cleanup Standards to Protect Air Quality" (WAC 173-340-750(3)(b)(ii)(A) and WAC 173-340-750(4)(b)(ii)(A)) Equation 750-1.

$$Air\ PRG\left(\frac{\mu g}{m^3}\right) = \frac{RfD \times ABW \times UCF \times HQ \times AT}{BR \times ABS \times ED \times EF}$$

where:

RfD = reference dose (mg/kg-day)
ABW = average body weight-noncarcinogen (kg)
UCF = unit conversion factor (µg/mg)
HQ = target hazard quotient (unitless)
AT = averaging time-noncarcinogen (years)
BR = breathing rate-noncarcinogen (m^3/day)
ABS = inhalation absorption fraction (unitless)
ED = exposure duration-noncarcinogen (years)
EF = exposure frequency (unitless)

Carcinogens. The equation below is obtained from "Cleanup Standards to Protect Air Quality" (WAC 173-340-750(3)(b)(ii)(B) and WAC 173-340-750(4)(b)(ii)(B)) Equation 750-2.

$$Air\ PRG\left(\frac{\mu g}{m^3}\right) = \frac{RISK \times ABW \times AT \times UCF}{CPF \times BR \times ABS \times ED \times EF}$$

where:

$RISK$ = target risk (unitless)
ABW = average body weight-carcinogen (kg)
AT = averaging time-carcinogen (years)
UCF = unit conversion factor (µg/mg)
CPF = cancer potency factor ($[mg/kg\text{-}day]^{-1}$)
BR = breathing rate-carcinogen (m^3/day)
ABS = inhalation absorption fraction (unitless)
ED = exposure duration-carcinogen (years)
EF = exposure frequency (unitless)

Air PRG to Soil PRG Conversion. The air PRGs calculated using the above equations are intended to protect air quality. However, concentrations of contaminants in air were not directly measured; therefore, emission and dispersion modeling are used to estimate a soil PRG protective of residential or industrial use. Conversion of air concentrations to soil PRGs is consistent with the methodology presented in *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (OSWER 9355.4-24). The air PRGs calculated using the above equation are converted to a soil PRG using the equation shown below.

$$Soil\ PRG\ (mg/kg) = \frac{Air\ Cleanup\ Level\ (\mu g/m^3) \times (UCF)^{-1}}{\left(\left(\frac{1}{PEF}\right) + \left(\frac{1}{VF}\right)\right)}$$

where:

UCF	=	unit conversion factor (µg/mg)
PEF	=	particulate emission factor (m^3/kg)
VF	=	volatilization factor (m^3/kg)—volatiles only

6.2.3.4.4 Calculation of Resident Monument Worker PRGs for Radiological Analytes using EPA Equations

The radiological PRGs for the resident Monument worker are calculated using equations consistent with those published on the *Superfund Radionuclide Preliminary Remediation Goal (PRG) Download and Calculation Website* (EPA, 2010). As described in Section 6.2.3.3, the resident Monument worker is a site-specific exposure scenario; site-specific exposure parameters for calculating the PRGs are defined in Table G-12 (Appendix G). Resident Monument worker PRGs are based on an acceptable cancer risk level of 1×10^{-4} for carcinogens. A detailed description of methodology, inputs, assumptions, and results of the calculations is presented in *Documentation of Radiological Preliminary Remediation Goals in Soil for a Resident Monument Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Reports* (ECF-HANFORD-11-0142).

PRG Equations for Incidental Soil Ingestion. The exposure assumptions used to calculate PRGs for the incidental soil ingestion route are presented and defined in Table G-12 (Appendix G). The following equations were used to calculate the risks from incidental ingestion of broad area soils for the occupational portion of the resident Monument worker exposure scenario:

$$CDI_{rmw_rad_ing_occ} = \frac{\left(1 - e^{(-\lambda \times t_{rmw})}\right) \times C_s \times IRS_{rmw_occ_adj} \times EF_{rmw_occ} \times ED_{rmw} \times UCF\,1}{t_{rmw} \times \lambda}$$

where:

$$IRS_{rmw_occ_adj} = IRS_{rmw} \times \frac{EF_{rmw_occ}}{EF_{rmw_res}} \times \frac{ET_{rmw_occ}}{24hr/day}$$

and:

$CDI_{rmw_rad_ing_occ}$	=	chronic daily intake-ingestion, occupational fraction (pCi)
λ	=	decay constant ($years^{-1}$)
t_{rmw}	=	time (years)
C_s	=	concentration in soil-broad area (pCi/g)
$IRS_{rmw_occ_adj}$	=	soil ingestion rate, occupational fraction, adjusted (mg/day)

IRS_{rmw} = soil ingestion rate (mg/day)
EF_{rmw_occ} = exposure frequency, occupation fraction (days/year)
EF_{rmw_res} = exposure frequency, residential fraction (days/year)
ED_{rmw} = exposure duration (years)
ET_{rmw_occ} = exposure time, occupational fraction (hours/day)
$UCF1$ = unit conversion factor (g/mg)

Radiological cancer risk is calculated using the following equation:

$$RISK_{rmw_rad_ing_occ} = CDI_{rmw_rad_ing_occ} \times SF_s$$

where:

$RISK_{rmw_rad_ing_occ}$ = cancer risk, broad area exposure, occupational fraction, incidental ingestion (unitless)
$CDI_{rmw_rad_ing_occ}$ = chronic daily intake, ingestion, occupational fraction (pCi)
SF_s = slope factor-soil ingestion (risk/pCi)

The following equations were used to calculate PRGs from incidental ingestion of local area soils for the residential portion of the resident Monument worker exposure scenario:

$$PRG_{rmw_rad_ing_res} = \frac{\left(TR_{_rad} - RISK_{rmw_rad_ing_occ}\right) \times t_{rmw} \times \lambda}{\left(1 - e^{(-\lambda \times t_{rmw})}\right) \times SF_s \times IRS_{rmw_res_adj} \times EF_{rmw_res} \times ED_{rmw} \times UCF1}$$

where:

$$IRS_{rmw_res_adj} = IRS_{rmw} \times \left[\left(\frac{EF_{rmw_occ}}{EF_{rmw_res}} \times \frac{ET_{rmw_res}}{24\,hrs\,/\,day}\right) + \left(\frac{EF_{rmw_res} - EF_{rmw_occ}}{EF_{rmw_res}}\right)\right]$$

and:

$PRG_{rmw_rad_ing_res}$ = preliminary remediation goal, ingestion, residential fraction (pCi/g)
$TR_{_rad}$ = target risk-radioisotopes (unitless)
$RISK_{rmw_rad_ing_occ}$ = cancer risk, broad area exposure, occupational fraction, incidental ingestion (unitless)
t_{rmw} = time (years)
λ = decay constant (years^{-1})
SF_s = slope factor-soil ingestion (risk/pCi)
$IRS_{rmw_res_adj}$ = soil ingestion rate, residential fraction, adjusted (mg/day)
EF_{rmw_res} = exposure frequency, residential fraction (days/year)
ED_{rmw} = exposure duration (years)
$UCF1$ = unit conversion factor (g/mg)
IRS_{rmw} = soil ingestion rate (mg/day)
EF_{rmw_occ} = exposure frequency, occupation fraction (days/year)
ET_{rmw_res} = exposure time, residential fraction (hours/day)
EF_{rmw_res} = exposure frequency, residential fraction (days/year)

PRG Equations for External Exposure to Ionizing Radiation. The exposure assumptions used to calculate PRGs for the external exposure to ionizing radiation route are presented and defined in Table G-12 (Appendix G). The following equations were used to calculate risks from external exposure to ionizing radiation from broad area soils for the occupational portion of the resident Monument worker exposure scenario:

$$CDI_{rmw_rad_ext_occ} = \frac{\left(1-e^{(-\lambda \times t_{rmw})}\right) \times C_s \times \left[\left(ET_{rmw_occ_out} \times GSF_{out}\right) + \left(ET_{rmw_occ_in} \times GSF_{in}\right)\right] \times EF_{rmw_occ} \times ED_{rmw} \times UCF3}{t_{rmw} \times \lambda}$$

where:

$CDI_{rmw_rad_ext_occ}$ = chronic daily intake-external exposure, occupational fraction (pCi-year/g)
λ = decay constant (years^{-1})
t_{rmw} = time (years)
C_s = concentration in soil-broad area (pCi/g)
$ET_{rmw_occ_out}$ = exposure time, occupational fraction, outdoors (hours/day)
GSF_{out} = gamma shielding factor, outdoors (unitless)
$ET_{rmw_occ_in}$ = exposure time, occupational fraction, indoors (hours/day)
GSF_{in} = gamma shielding factor, indoors (unitless)
EF_{rmw_occ} = exposure frequency, occupation fraction (days/year)
ED_{rmw} = exposure duration (years)
$UCF3$ = unit conversion factor (years/hour)

Radiological cancer risk is calculated using the following equation:

$$RISK_{rmw_rad_ext_occ} = CDI_{rmw_rad_ext_occ} \times SF_x$$

where:

$RISK_{rmw_rad_ext_occ}$ = cancer risk, broad area exposure, ionizing radiation, occupational fraction (unitless)
$CDI_{rmw_rad_ext_occ}$ = chronic daily intake, external exposure, occupational fraction (pCi-year/g)
SF_x = slope factor-external exposure (risk/pCi)

The following equation was used to calculate PRGs for the external exposure to ionizing radiation from local area soils for the residential portion of the resident Monument worker exposure scenario:

$$PRG_{rmw_rad_ext_res} = \frac{\left(TR_{_rad} - RISK_{rmw_rad_ext_occ}\right) \times t_{rmw} \times \lambda}{\left(1-e^{(-\lambda \times t_{rmw})}\right) \times SF_x \times \left[\left(ET_{rmw_res_out} \times GSF_{out}\right) + \left(ET_{rmw_res_in} \times GSF_{in}\right)\right] \times EF_{rmw_res} \times ED_{rmw} \times UCF3}$$

and:

$PRG_{rmw_rad_ext_res}$ = preliminary remediation goal, external exposure, residential fraction (pCi/g)
$TR_{_rad}$ = target risk-radioisotopes (unitless)
$RISK_{rmw_rad_ext_occ}$ = cancer risk, ionizing radiation, occupational fraction, (unitless)
t_{rmw} = time (years)
λ = decay constant (years^{-1})
SF_x = slope factor-external exposure ([risk/year]/[pCi/g])
$ET_{rmw_res_out}$ = exposure time, residential fraction, outdoors (hours/day)

GSF_{out} = gamma shielding factor, outdoors (unitless)
$ET_{rmw_res_in}$ = exposure time, residential fraction, indoors (hours/day)
GSF_{in} = gamma shielding factor, indoors (unitless)
EF_{rmw_res} = exposure frequency, residential fraction (days/year)
ED_{rmw} = exposure duration (years)
$UCF3$ = unit conversion factor (years/hour)

PRG Equations for the Inhalation of Dust in Soil. The exposure assumptions used to calculate PRGs for the inhalation of vapors and dust route are presented and defined in Table G-12 (Appendix G). The following equations were used to calculate risks from inhalation of dust from broad area soils for the occupational portion of the resident Monument worker exposure scenario:

$$CDI_{rmw_rad_inh_occ} = \frac{\left(1 - e^{(-\lambda \times t_{rmw})}\right) \times C_s \times UCF2 \times \frac{1}{PEF_B} \times IRA_{rmw} \times ET_{rmw_occ} \times EF_{rmw_occ} \times ED_{rmw}}{t_{rmw} \times \lambda}$$

where:

$CDI_{rmw_rad_inh_occ}$ = chronic daily intake-inhalation, occupational fraction (pCi)
λ = decay constant (years^{-1})
t_{rmw} = time (years)
C_s = concentration in soil (broad area) (pCi/g)
$UCF2$ = unit conversion factor (g/kg)
PEF_B = particulate emission factor-broad area (m^3/kg)
IRA_{rmw} = inhalation rate (m^3/hour)
ET_{rmw_occ} = exposure time, occupational fraction (hours/day)
EF_{rmw_occ} = exposure frequency, occupation fraction (days/year)
ED_{rmw} = exposure duration (years)

Radiological cancer risk is calculated using the following equation:

$$RISK_{rmw_rad_inh_occ} = CDI_{rmw_rad_inh_occ} \times SF_i$$

where:

$RISK_{rmw_rad_inh_occ}$ = cancer risk, broad area exposure, inhalation, occupational fraction (unitless)
$CDI_{rmw_rad_inh_occ}$ = chronic daily intake, inhalation, occupational fraction (pCi)
SF_i = slope factor-inhalation (risk/pCi)

The following equation was used to calculate PRGs from inhalation of dust from local area soils for the residential portion of the resident Monument worker exposure scenario:

$$PRG_{rmw_rad_inh_res} = \frac{\left(TR_{_rad} - RISK_{rmw_rad_inh_occ}\right) \times t_{rmw} \times \lambda}{\left(1 - e^{(-\lambda \times t_{rmw})}\right) \times SF_i \times UCF2 \times \frac{1}{PEF_L} \times IRA_{rmw} \times ET_{rmw_res} \times EF_{rmw_res} \times ED_{rmw}}$$

and:

$PRG_{rmw_rad_inh_res}$	=	preliminary remediation goal, inhalation residential fraction (pCi/g)
$TR_{_rad}$	=	target risk-radioisotopes (unitless)
$RISK_{rmw_rad_inh_occ}$	=	cancer risk, inhalation, occupational fraction, (unitless)
t_{rmw}	=	time (years)
λ	=	decay constant (years^{-1})
SF_i	=	slope factor-soil inhalation (risk/pCi)
$UCF2$	=	unit conversion factor (g/kg)
PEF_L	=	particulate emission factor-local area (m^3/kg)
IRA_{rmw}	=	inhalation rate (m^3/hour)
ET_{rmw_res}	=	exposure time, residential fraction (hours/day)
EF_{rmw_res}	=	exposure frequency, residential fraction (days/year)
ED_{rmw}	=	exposure duration (years)

PRG Equation Summing all Exposure Routes. The following presents the equation used to calculate the PRGs for all exposure routes combined. The basis for the equation is provided in *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals): Interim* (EPA/540/R-92/003).

$$PRG_{rmw_rad_total_res} = \frac{1}{\left(\left(\frac{1}{PRG_{rmw_rad_ing_res}}\right)+\left(\frac{1}{PRG_{rmw_rad_ext_res}}\right)+\left(\frac{1}{PRG_{rmw_rad_inh_res}}\right)\right)}$$

6.2.3.4.5 *Calculation of Casual Recreational User PRGs for Radiological Analytes using EPA Equations*

The radiological PRGs for the casual recreational user are calculated using equations consistent with those published on the *Superfund Radionuclide Preliminary Remediation Goal (PRG) Download and Calculation Website* (EPA, 2010). As described in Section 6.2.3.3, the casual recreational user is a site-specific exposure scenario. Site-specific exposure parameters for calculating the PRGs are defined in Table G-13 (Appendix G). Casual recreational user radiological PRGs are based on an acceptable cancer risk level of 1×10^{-4} for carcinogens. A detailed description of methodology, inputs, assumptions, and results of the calculations is presented in *Calculation of Radiological Preliminary Remediation Goals in Soil for a Casual Recreational User Scenario for the 100 Areas and 300 Areas Remedial Investigation/Feasibility Study (RI/FS) Reports* (ECF-HANFORD-10-0446).

PRG Equations for Incidental Soil Ingestion. The exposure assumptions used to calculate PRGs for the incidental soil ingestion route are presented and defined in Table G-13 (Appendix G). The following equations were used to calculate the PRG for the incidental soil ingestion route:

$$PRG_{cu_rad_ing} = \frac{TR_{_rad} \times t_{cu} \times \lambda}{\left(1 - e^{(-\lambda t_{cu})}\right) \times SF_s \times IRS_{adj_cu_rad} \times EF_{cu} \times ED_{a+ccu} \times UCF3}$$

where:

$$IRS_{adj_cu_rad} = \frac{\left(ED_{ccu} \times IRS_{ccu}\right) + \left(\left(ED_{a+ccu} - ED_{ccu}\right) \times IRS_a\right)}{ED_{a+ccu}}$$

and:

$PRG_{cu_rad_ing}$ = preliminary remediation goal, radionuclide, incidental soil ingestion (pCi/g)
$TR_{_rad}$ = target risk-radioisotopes (unitless)
t_{cu} = time (years)
λ = decay constant (years^{-1})
SF_s = slope factor-soil ingestion (risk/pCi)
$IRS_{adj_cu_rad}$ = soil ingestion rate, age-adjusted, radioisotopes (mg/day)
EF_{cu} = exposure frequency (days/year)
ED_{a+ccu} = exposure duration, adult +child (years)
$UCF3$ = unit conversion factor (g/mg)
ED_{ccu} = exposure duration, child (years)
IRS_{ccu} = soil ingestion rate, child (mg/day)
IRS_a = soil ingestion rate, adult (mg/day)

PRG Equations for External Exposure to Ionizing Radiation. The exposure assumptions used to calculate PRGs for the external exposure to ionizing radiation route are presented and defined in Table G-13 (Appendix G). The following equation was used to calculate the PRG for the external exposure to ionizing radiation route:

$$PRG_{cu_rad_ext} = \frac{TR_{_rad} \times t_{cu} \times \lambda}{\left(1 - e^{(-\lambda t_{cu})}\right) \times SF_x \times ACF \times EF_{cu} \times ED_{a+ccu} \times ET_{cu} \times \frac{1\,day}{24\,hours} \times UCF5}$$

where:

$PRG_{cu_rad_ext}$ = preliminary remediation goal, radionuclide, external exposure (pCi/g)
$TR_{_rad}$ = target risk-radioisotopes (unitless)
t_{cu} = time (years)
λ = decay constant (years^{-1})
SF_x = slope factor-external exposure ([risk/year]/[pCi/g])
ACF = area correction factor (unitless)
EF_{cu} = exposure frequency (days/year)
ED_{a+ccu} = exposure duration, adult +child (years)
ET_{cu} = exposure time (hours/day)
$UCF5$ = unit conversion factor (years/day)

PRG Equations for the Inhalation of Vapors and Dust. The exposure assumptions used to calculate PRGs for the inhalation of vapors and dust route are presented and defined in Table G-13 (Appendix G). The following equations were used to calculate the PRG for the inhalation of vapors and dust route:

$$PRG_{cu_rad_inh} = \frac{TR_{_rad} \times t_{cu} \times \lambda}{\left(1 - e^{(-\lambda t_{cu})}\right) \times SF_i \times IRA_{adj_cu} \times EF_{cu} \times ED_{a+ccu} \times ET_{cu} \times \left(\frac{1}{PEF} or \frac{1}{VF}\right) \times UCF4}$$

where:

$$IRA_{adj_cu} = \frac{(ED_{ccu} \times IRA_{ccu}) + ((ED_{a+ccu} - ED_{ccu}) \times IRA_a)}{ED_{a+ccu}}$$

and:

$PRG_{cu_rad_inh}$	=	preliminary remediation goal, radionuclide, inhalation (pCi/g)
$TR_{_rad}$	=	target risk-radioisotopes (unitless)
t_{cu}	=	time (years)
λ	=	decay constant (years^{-1})
SF_i	=	slope factor-inhalation (risk/pCi)
IRA_{adj_cu}	=	inhalation rate, age-adjusted (m^3/hour)
EF_{cu}	=	exposure frequency (days/year)
ED_{a+ccu}	=	exposure duration, adult +child (years)
ET_{cu}	=	exposure time (hours/day)
PEF	=	particulate emission factor (m^3/kg)
VF	=	volatilization factor (m^3/kg)
$UCF4$	=	unit conversion factor (g/kg)
ED_{ccu}	=	exposure duration, child (years)
IRA_{ccu}	=	inhalation rate, child (m^3/hour)
IRa_a	=	inhalation rate, adult (m^3/hour)

PRG Equations Summing all Exposure Routes. The following presents the equation used to calculate the PRGs for all exposure routes combined. The basis for the equation is provided in *Risk Assessment Guidance Volume I, Part B* (EPA/540/R-92/003).

$$PRG_{cu_rad_total} = \frac{1}{\left(\left(\frac{1}{PRG_{cu_rad_ing}}\right) + \left(\frac{1}{PRG_{cu_rad_ext}}\right) + \left(\frac{1}{PRG_{cu_rad_inh}}\right)\right)}$$

6.2.3.4.6 Calculation of Casual Recreational User PRGs for Nonradiological Analytes using EPA Equations

The nonradiological PRGs for the casual recreational user are calculated using equations consistent with those published on the EPA Regional Screening Values Web site. As described in Section 6.2.3.3, the casual recreational user is a site-specific exposure scenario. Exposure parameters for calculating the PRGs are defined in Table G-13 (Appendix G). Casual recreational user nonradiological PRGs are based on an acceptable cancer risk level of 1×10^{-6} for carcinogens or an HQ of 1 for noncarcinogens. Reference dose and carcinogenic potency factors are determined using the recommended reference hierarchy as described in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). A detailed description of methodology, inputs, assumptions, and results of the calculations is presented in *Calculation of Nonradiological Preliminary Remediation Goals in Soil for a Casual Recreational User Scenario for the 100 Areas and 300 Areas Remedial Investigation/Feasibility Study (RI/FS) Reports* (ECF-HANFORD-10-0445).

PRG Equations for Incidental Soil Ingestion. The exposure assumptions used to calculate PRGs for the incidental soil ingestion route are presented and defined in Table G-13 (Appendix G).

Incidental Soil Ingestion—Carcinogenic and Noncarcinogenic Effects. The following equations are used to calculate the carcinogenic PRG for incidental soil ingestion:

$$PRG_{cu_ca_ing} = \frac{TR \times AT_{ca}}{CSF_o \times IRS_{adj_cu} \times EF_{cu} \times UCF1}$$

where:

$$IRS_{adj_cu} = \left(\frac{ED_{ccu} \times IRS_{ccu}}{BW_{ccu}} \right) + \left(\frac{(ED_{a+ccu} - ED_{ccu}) \times IRS_a}{BW_a} \right)$$

and:

$PRG_{cu_ca_ing}$	=	preliminary remediation goal, carcinogen, incidental soil ingestion (mg/kg)
TR	=	target risk (unitless)
AT_{ca}	=	averaging time-carcinogen (days)
CSF_o	=	cancer slope factor-oral (mg/kg-day)$^{-1}$
IRS_{adj_cu}	=	soil ingestion rate, age-adjusted (mg-yr/kg-day)
EF_{cu}	=	exposure frequency (days/year)
$UCF1$	=	unit conversion factor (kg/mg)
ED_{ccu}	=	exposure duration, child (years)
ED_{a+ccu}	=	exposure duration, adult + child (years)
IRS_{cu}	=	soil ingestion rate, child (mg/day)
IRS_a	=	soil ingestion rate, adult (mg/day)
BW_{ccu}	=	body weight, child (kg)
BW_a	=	body weight, adults (kg)

The following equation is used to calculate the noncarcinogenic PRG for incidental soil ingestion:

$$PRG_{cu_nc_ing} = \frac{THQ \times AT_{nc_ccu} \times BW_{ccu}}{\frac{1}{RfD_o} \times IRS_{ccu} \times EF_{cu} \times ED_{ccu} \times UCF1}$$

where:

$PRG_{cu_nc_ing}$	=	PRG, noncarcinogen, incidental soil ingestion (mg/kg)
THQ	=	target hazard quotient (unitless)
AT_{nc_cu}	=	averaging time-noncarcinogen, child (days)
BW_{ccu}	=	body weight, child (kg)
RfD_o	=	reference dose-oral (mg/kg-day)
IRS_{ccu}	=	soil ingestion rate, child (mg/day)
EF_{cu}	=	exposure frequency (days/year)
ED_{ccu}	=	exposure duration, child (years)
$UCF1$	=	unit conversion factor (kg/mg)

Incidental Soil Ingestion—Mutagenic Effects. The following equations are used to calculate the mutagenic mode of action PRG for incidental soil ingestion:

$$PRG_{cu_mu_ing} = \frac{TR \times AT_{ca}}{CSF_o \times IRSM_{adj_cu} \times EF_{cu} \times UCF1}$$

where:

$$IRSM_{adj_cu} = \frac{ED_{0-2} \times IRS_{ccu} \times 10}{BW_{ccu}} + \frac{ED_{2-6} \times IRS_{ccu} \times 3}{BW_{ccu}} + \frac{ED_{6-16} \times IRS_a \times 3}{BW_a} + \frac{ED_{16-30} \times IRS_a \times 1}{BW_a}$$

and:

$PRG_{cu_mu_ing}$	=	preliminary remediation goal, mutagen, incidental soil ingestion (mg/kg)
TR	=	target risk (unitless)
AT_{ca}	=	averaging time-carcinogen (days)
CSF_o	=	cancer slope factor, oral (mg/kg-day)$^{-1}$
$IRSM_{adj_cu}$	=	soil ingestion rate, age-adjusted-mutagens (mg-yr/kg-day)
BW_{ccu}	=	body weight, child (kg)
EF_{cu}	=	exposure frequency (days/year)
$UCF1$	=	unit conversion factor (kg/mg)
ED_{0-2}	=	exposure duration, 0-2 years (years)
IRS_{ccu}	=	soil ingestion rate, child (mg/day)
ED_{2-6}	=	exposure duration, 2-6 years (years)
ED_{6-16}	=	exposure duration, 6-16 years (years)
IRS_a	=	soil ingestion rate, adult (mg/day)
ED_{16-30}	=	exposure duration, 16-30 years (years)
BW_a	=	body weight, adult (kg)

Incidental Soil Ingestion—Vinyl Chloride. The following equations are used to calculate the vinyl chloride PRG for incidental soil ingestion:

$$PRG_{cu_vc_ing} = \frac{TR}{\left(\frac{CSF_o \times IRS_{adj_cu} \times EF_{cu} \times UCF1}{AT_{ca}} + \frac{CSF_o \times IRS_{ccu} \times UCF1}{BW_{ccu}} \right)}$$

where:

$$IRS_{adj_cu} = \left(\frac{ED_{ccu} \times IRS_{ccu}}{BW_{ccu}} \right) + \left(\frac{(ED_{a+ccu} - ED_{ccu}) \times IRS_a}{BW_a} \right)$$

and:

$PRG_{cu_vc_ing}$	=	preliminary remediation goal, vinyl chloride, incidental soil ingestion (mg/kg)
TR	=	target risk (unitless)
CSF_o	=	cancer slope factor, oral (mg/kg-day)$^{-1}$
IRS_{adj_cu}	=	soil ingestion rate, age-adjusted (mg-yr/kg-day)
EF_{cu}	=	exposure frequency (days/year)
$UCF1$	=	unit conversion factor (kg/mg)
AT_{ca}	=	averaging time-carcinogen (days)
ED_{ccu}	=	exposure duration, child (years)
IRS_{ccu}	=	soil ingestion rate, child (mg/day)

BW_{ccu}	=	body weight, child (kg)
ED_{a+ccu}	=	exposure duration, adult+child (years)
IRS_a	=	soil ingestion rate, adult (mg/day)
BW_a	=	body weight, adult (kg)

PRG Equations for Dermal Contact with Soil. The exposure assumptions used to calculate PRGs for the dermal contact with soil route are presented and defined in Table G-13 (Appendix G). The following equations were used to calculate the PRG for the dermal contact with soil route:

Dermal Contact with Soil—Carcinogenic and Noncarcinogenic Effects. The following equations are used to calculate the carcinogenic PRG for the dermal contact route:

$$PRG_{cu_ca_dc} = \frac{TR \times AT_{ca}}{\left(\frac{CSF_o}{GIABS}\right) \times EF_{cu} \times DFS_{adj_cu} \times ABS_d \times UCF1}$$

where:

$$DFS_{adj_cu} = \left(\frac{ED_{ccu} \times SA_{ccu} \times AF_{ccu}}{BW_{ccu}}\right) + \left(\frac{(ED_{a+ccu} - ED_{ccu}) \times SA_a \times AF_a}{BW_a}\right)$$

and:

$PRG_{cu_ca_dc}$	=	preliminary remediation goal, dermal contact (mg/kg)
TR	=	target risk (unitless)
AT_{ca}	=	averaging time-carcinogen (days)
CSF_o	=	cancer slope factor, oral (mg/kg-day)$^{-1}$
$GIABS$	=	gastro-intestinal absorption fraction (unitless)
EF_{cu}	=	exposure frequency (days/year)
DFS_{adj_cu}	=	dermal contact rate, age-adjusted (mg-year/kg-day)
ABS_d	=	dermal absorption fraction (unitless)
$UCF1$	=	unit conversion factor (kg/mg)
ED_{ccu}	=	exposure duration, child (years)
SA_{ccu}	=	skin surface area, child (cm^2/day)
AF_{ccu}	=	skin adherence factor, child (mg/cm^2)
BW_{ccu}	=	body weight, child (kg)
ED_{a+ccu}	=	exposure duration, adult+child (years)
SA_a	=	skin surface area, adult (cm^2/day)
AF_a	=	skin adherence factor, adult (mg/cm^2)
BW_a	=	body weight, adult (kg)

The following equation is used to calculate the noncarcinogenic PRG for the dermal contact route:

$$PRG_{cu_nc_dc} = \frac{THQ \times AT_{nc_cu} \times BW_{ccu}}{\left(\frac{1}{RfD_o} \times GIABS\right) \times SA_{ccu} \times AF_{ccu} \times EF_{cu} \times ED_{ccu} \times ABS_d \times UCF1}$$

where:

$PRG_{cu_nc_dc}$	=	preliminary remediation goal, noncarcinogen, dermal contact (mg/kg)
THQ	=	target hazard quotient (unitless)
AT_{nc_cu}	=	averaging time-noncarcinogen, child (days)
BW_{ccu}	=	body weight, child (kg)
RfD_o	=	reference dose, oral (mg/kg-day)
$GIABS$	=	gastro-intestinal absorption fraction (unitless)
SA_{ccu}	=	skin surface area, child (cm^2/day)
AF_{ccu}	=	skin adherence factor, child (mg/cm^2)
EF_{cu}	=	exposure frequency (days/year)
ED_{ccu}	=	exposure duration, child (years)
ABS_d	=	dermal absorption fraction (unitless)
$UCF1$	=	unit conversion factor (kg/mg)

Dermal Contact with Soil—Mutagenic Effects. The following equations are used to calculate the mutagenic mode of action PRG for the dermal contact route:

$$PRG_{cu_mu_dc} = \frac{TR \times AT_{ca}}{\frac{CSF_o}{GIABS} \times DFSM_{adj_cu} \times EF_{cu} \times ABS_d \times UCF1}$$

where:

$$DFSM_{adj_cu} = \frac{ED_{0-2} \times SA_{ccu} \times AF_{ccu} \times 10}{BW_{ccu}} + \frac{ED_{2-6} \times SA_{ccu} \times AF_{ccu} \times 3}{BW_{ccu}} + \frac{ED_{6-16} \times SA_a \times AF_a \times 3}{BW_a} + \frac{ED_{16-30} \times SA_a \times AF_a \times 1}{BW_a}$$

and:

$PRG_{cu_mu_dc}$	=	preliminary remediation goal, mutagen, dermal contact (mg/kg)
TR	=	target risk (unitless)
AT_{ca}	=	averaging time, carcinogen (days)
CSF_o	=	cancer slope factor, oral $(mg/kg\text{-}day)^{-1}$
$GIABS$	=	gastro-intestinal absorption fraction (unitless)
$DFSM_{adj_cu}$	=	dermal contact rate, age-adjusted-mutagens (mg-year/kg-day)
EF_{cu}	=	exposure frequency (days/year)
ABS_d	=	dermal absorption fraction (unitless)
$UCF1$	=	unit conversion factor (kg/mg)
$ED_{0\text{-}2}$	=	exposure duration, 0-2 years (years)
SA_{ccu}	=	skin surface area, child (cm^2/day)
AF_{ccu}	=	skin adherence factor, child (mg/cm^2)
BW_{ccu}	=	body weight, child (kg)
$ED_{2\text{-}6}$	=	exposure duration, 2-6 years (years)
$ED_{6\text{-}16}$	=	exposure duration, 6-16 years (years)
$ED_{16\text{-}30}$	=	exposure duration, 16-30 years (years)
SA_a	=	skin surface area, adult (cm^2/day)
AF_a	=	skin adherence factor, adult (mg/cm^2)
BW_a	=	body weight, adult (kg)

Dermal Contact with Soil—Vinyl Chloride. The following equations are used to calculate the vinyl chloride PRG for the dermal contact route:

$$PRG_{cu_vc_dc} = \frac{TR}{\left(\frac{\frac{CSF_o}{GIABS} \times DSF_{adj_cu} \times EF_{cu} \times ABS_d \times UCF1}{AT_{ca}} + \frac{\frac{CSF_o}{GIABS} \times SA_{ccu} \times AF_{ccu} \times ABS_d \times UCF1}{BW_{ccu}} \right)}$$

where:

$$DFS_{adj_cu} = \left(\frac{ED_{ccu} \times SA_{ccu} \times AF_{ccu}}{BW_{ccu}} \right) + \left(\frac{(ED_{a+ccu} - ED_{ccu}) \times SA_a \times AF_a}{BW_a} \right)$$

and:

$PRG_{cu_vc_dc}$	=	preliminary remediation goal, vinyl chloride, dermal contact (mg/kg)
TR	=	target risk (unitless)
CSF_o	=	cancer slope factor, oral (mg/kg-day)$^{-1}$
$GIABS$	=	gastro-intestinal absorption fraction (unitless)
DFS_{adj_cu}	=	dermal contact rate, age-adjusted (mg-year/kg-day)
EF_{cu}	=	exposure frequency (days/year)
ABS_d	=	dermal absorption fraction (unitless)
$UCF1$	=	unit conversion factor (kg/mg)
AT_{ca}	=	averaging time-carcinogenic (days)
SA_{ccu}	=	skin surface area, child (cm^2/day)
AF_{ccu}	=	skin adherence factor, child (mg/cm^2)
BW_{ccu}	=	body weight, child (kg)
ED_{a+ccu}	=	exposure duration, adult+child (years)
ED_{ccu}	=	exposure duration, child (years)
SA_a	=	skin surface area, adult (cm^2/day)
AF_a	=	skin adherence factor, adult (mg/cm^2)
BW_a	=	body weight, adult (kg)

PRG Equations for the Inhalation of Vapors and Dust in Soil. The exposure assumptions used to calculate PRGs for the inhalation of vapors and dust route are presented and defined in Table G-13 (Appendix G). The following equations were used to calculate the PRG for the inhalation route:

Inhalation of Vapors and Dust in Soil—Carcinogenic and Noncarcinogenic Effects. The following equation is used to calculate the carcinogenic PRG for the inhalation route:

$$PRG_{cu_ca_inh} = \frac{TR \times AT_{ca} \times 24 \frac{hours}{day}}{IUR \times UCF2 \times EF_{cu} \times ED_{a+ccu} \times ET_{cu} \times \left(\frac{1}{VF} + \frac{1}{PEF} \right)}$$

where:

$PRG_{cu_ca_inh}$	=	preliminary remediation goal, carcinogen, inhalation (mg/kg)
TR	=	target risk (unitless)
AT_{ca}	=	averaging time-carcinogen (days)
IUR	=	inhalation unit risk $(\mu g/m^3)^{-1}$
$UCF2$	=	unit conversion factor (µg/mg)
EF_{cu}	=	exposure frequency (days/year)
ED_{a+ccu}	=	exposure duration, adult+child (years)
ET_{cu}	=	exposure time, (hours/day)
VF	=	volatilization factor (m^3/kg)
PEF	=	particulate emission factor (m^3/kg)

The following equation is used to calculate the noncarcinogenic PRG for the inhalation route:

$$PRG_{cu_nc_inh} = \frac{THQ \times AT_{nc_cu} \times 24 \frac{hours}{day}}{EF_{cu} \times ED_{ccu} \times ET_{cu} \times \frac{1}{RfC} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

where:

$PRG_{cu_nc_inh}$	=	preliminary remediation goal, noncarcinogen, inhalation (mg/kg)
THQ	=	target hazard quotient (unitless)
AT_{nc_cu}	=	averaging time-noncarcinogen, child (days)
EF_{cu}	=	exposure frequency (days/year)
ED_{ccu}	=	exposure duration, child (years)
ET_{cu}	=	exposure time, (hours/day)
RfC	=	reference concentration (mg/m^3)
VF	=	volatilization factor (m^3/kg)
PEF	=	particulate emission factor (m^3/kg)

Inhalation of Vapors and Dust in Soil—Mutagenic Effects. The following equation is used to calculate the mutagenic mode of action PRG for the inhalation route:

$$PRG_{cu_mu_inh} = \frac{TR \times AT_{ca} \times 24 \frac{hours}{day}}{UCF\,2 \times ET_{cu} \times EF_{cu} \times [(ED_{0-2} \times IUR \times 10) + (ED_{2-6} \times IUR \times 3) + (ED_{6-16} \times IUR \times 3) + (ED_{16-30} \times IUR \times 1)] \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

where:

$PRG_{cu_mu_inh}$	=	preliminary remediation goal, mutagen, inhalation (mg/kg)
TR	=	target risk (unitless)
AT_{ca}	=	averaging time-carcinogen (days)
$UCF2$	=	unit conversion factor (µg/mg)
ET_{cu}	=	exposure time, (hours/day)
EF_{cu}	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration, 0-2 years (years)
IUR	=	inhalation unit risk $(\mu g/m^3)^{-1}$

$ED_{2\text{-}6}$	=	exposure duration, 2-6 years (years)
$ED_{6\text{-}16}$	=	exposure duration, 6-16 years (years)
$ED_{16\text{-}30}$	=	exposure duration, 16-30 years (years)
VF	=	volatilization factor (m^3/kg)
PEF	=	particulate emission factor (m^3/kg)

Inhalation of Vapors and Dust in Soil—Vinyl Chloride. The following equation is used to calculate the vinyl chloride PRG for the inhalation route:

$$PRG_{cu_vc_inh} = \frac{TR}{\left(\frac{IUR \times ED_{a+ccu} \times EF_{cu} \times ET_{cu} \times UCF2}{AT_{ca} \times 24\frac{hours}{day} \times VF}\right) + \left(\frac{IUR}{VF} \times UCF2\right)}$$

where:

$PRG_{cu_vc_inh}$	=	preliminary remediation goal, vinyl chloride, inhalation (mg/kg)
TR	=	target risk (unitless)
IUR	=	inhalation unit risk $(\mu g/m^3)^{-1}$
ED_{a+ccu}	=	exposure duration, adult+child (years)
EF_{cu}	=	exposure frequency (days/year)
ET_{cu}	=	exposure time (hour/day)
$UCF2$	=	unit conversion factor (µg/mg)
AT_{ca}	=	averaging time-carcinogen (days)
VF	=	volatilization factor (m^3/kg)

6.2.3.4.7 Calculation of Particulate Emission Factor and Volatilization Factors

The default input parameters used to calculate the PEF for the resident Monument worker are presented and defined in Table G-14 (Appendix G). The default input parameters used to calculate the PEF and volatilization factors for the casual recreational user are presented and defined in Table G-15 (Appendix G). The input parameters used to calculate chemical-specific volatilization factors are listed in Table G-16 (Appendix G). Volatilization factors are only calculated for VOCs. A VOC is defined by EPA/540/R-96/018 as a chemical with a Henry's Law constant of 1×10^{-5} or greater and with a molecular weight of less than 200 g/mole.

The volatilization factor for tritium is not a calculated value, but is a default value published in *Superfund Radionuclide Preliminary Remediation Goal (PRG) Download and Calculation Website* (EPA, 2010). The following presents the equations used to calculate the chemical-specific volatilization factors.

$$VF = \frac{\frac{Q}{C} \times \left(3.14 \times D_A \times T\right)^{\frac{1}{2}} \times 10^{-4}\left(\frac{m^2}{cm^2}\right)}{2 \times \rho_b \times D_A}$$

where:

$$\frac{Q}{C} = A \times \exp\left[\frac{(\ln[A_S] - B)^2}{C}\right]$$

and:

$$D_A = \left[\frac{\dfrac{\left(\theta_a^{\frac{10}{3}} \times D_i \times H' + \theta_w^{\frac{10}{3}} \times D_w\right)}{n^2}}{\rho_b \times k_{oc} \times f_{oc} + \theta_w + \theta_a \times H'}\right]$$

and:

VF	=	volatilization factor (mg^3/kg)
Q/C	=	inverse of the mean concentration at center of a source ([g/m^2-s]/[kg/m^3])
D_A	=	apparent diffusivity (cm^2/second)
T	=	exposure time (seconds)
ρ_b	=	dry soil bulk density (kg/liter)
A	=	constant (unitless)
A_s	=	site area (acres)
B	=	constant (unitless)
C	=	constant (unitless)
θ_a	=	air-filled porosity ($liters_{air}/liter_{soil}$)
D_i	=	diffusivity in air (cm^2/second)
H'	=	Henry's constant (dimensionless)
θ_w	=	water-filled porosity ($liters_{water}/liter_{soil}$)
D_w	=	diffusivity in water (cm^2/second)
n	=	soil porosity (unitless)
k_{oc}	=	soil organic carbon/water partition coefficient (liters/kg)
f_{oc}	=	fraction organic carbon in soil (gram/gram)

Particulate Emission Factor. The PEF is calculated using the following equations:

$$PEF = \frac{Q}{C} \times \frac{3{,}600}{0.036 \times (1 - V) \times \left(\dfrac{u_m}{u_t}\right)^3 \times F(x)}$$

where:

$$\frac{Q}{C} = A \times \exp\left[\frac{(\ln(A_S) - B)^2}{C}\right]$$

and:

$$F(x) = 0.18\,(8\,x^3 + 12\,x)\exp - (x^2)$$

and:

$$x = 0.886\left(\frac{u_t}{u_m}\right)$$

and:

PEF	=	particulate emission factor (mg^3/kg)
Q/C	=	inverse of the mean concentration at center of a source ([g/m^2-s]/[kg/m^3]
V	=	fraction of vegetative cover (unitless)
u_m	=	annual average wind speed (m/second)
u_t	=	wind speed at anemometer height equivalent to corrected threshold friction velocity (m/second)
F(x)	=	wind speed distribution function (unitless)
A	=	constant (unitless)
A_s	=	site area (acres)
B	=	constant (unitless)
C	=	constant (unitless)
X	=	constant (unitless)

PRG Equations Summing all Exposure Routes. The following presents the equations used to calculate the PRGs for all exposure routes combined. The basis for the equation is provided in *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals): Interim* (EPA/540/R-92/003).

Carcinogenic Effects

$$PRG_{cu_ca_total} = \frac{1}{\left(\left(\frac{1}{PRG_{cu_ca_ing}}\right) + \left(\frac{1}{PRG_{cu_ca_dc}}\right) + \left(\frac{1}{PRG_{cu_ca_inh}}\right)\right)}$$

Noncarcinogenic Effects

$$PRG_{cu_nc_total} = \frac{1}{\left(\left(\frac{1}{PRG_{cu_nc_ing}}\right) + \left(\frac{1}{PRG_{cu_nc_dc}}\right) + \left(\frac{1}{PRG_{cu_nc_inh}}\right)\right)}$$

Mutagenic Effects

$$PRG_{cu_mu_total} = \frac{1}{\left(\left(\frac{1}{PRG_{cu_mu_ing}}\right) + \left(\frac{1}{PRG_{cu_mu_dc}}\right) + \left(\frac{1}{PRG_{cu_mu_inh}}\right)\right)}$$

Vinyl Chloride

$$PRG_{cu_vc_total} = \frac{1}{\left(\left(\frac{1}{PRG_{cu_vc_ing}}\right) + \left(\frac{1}{PRG_{cu_vc_dc}}\right) + \left(\frac{1}{PRG_{cu_vc_inh}}\right)\right)}$$

6.2.4 Toxicity Assessment

This toxicity assessment evaluates the relationship between the magnitude of exposure to a contaminant at the 300 Area Source OU and the likelihood of adverse health effects to potentially exposed populations. This assessment provides, where possible, a numerical estimate of the increased likelihood of adverse effects associated with contaminant exposure. The toxicity assessment contains two steps—hazard characterization and dose-response evaluation—as discussed in the following subsections.

6.2.4.1 Hazard Characterization

Hazard characterization identifies the types of toxic effects that a chemical can exert. For the toxicity assessment, chemicals can be divided into two broad groups—noncarcinogens and carcinogens—based on their effects on human health.

Carcinogens are those contaminants that are known or suspected causes of cancer following exposure; noncarcinogenic compounds are associated with a wide variety of systemic effects, such as liver toxicity or developmental effects. Some contaminants (e.g., arsenic) are capable of eliciting both carcinogenic and noncarcinogenic responses; therefore, these contaminants are evaluated for both effects.

For cancer effects, EPA has developed a carcinogen classification system (*Guidelines for Carcinogen Risk Assessment* [EPA/630/P-03/001F]) that uses a weight of evidence approach for classifying the likelihood that a chemical is a human carcinogen. Information considered in developing the classification includes human studies of the association between cancer incidence and exposure, as well as long-term animal studies under controlled laboratory conditions. Other supporting evidence considered includes short-term tests for genotoxicity, metabolic and pharmacokinetic properties, toxicological effects other than cancer, structure-activity relationships, and physical and chemical properties of the chemical.

For noncancer effects, toxicity values are derived based on the critical toxic endpoint (i.e., the most sensitive adverse effect following exposure). Table G-17 (Appendix G) lists the COPCs detected at the 300 Area Source OU that have been identified as having documented systemic effects.

6.2.4.1.1 Dose Response Evaluation

The magnitude of toxicity of a contaminant depends on the dose to a receptor. Dose refers to exposure to a contaminant concentration over a specified period. Human exposures are generally classified as acute (typically less than 2 weeks), subchronic (about 2 weeks to 7 years), or chronic (7 years to a lifetime). This HHRA specifically addresses chronic exposure. Acute exposures and risks are evaluated only when chronic exposure estimates pose a high risk. A dose response curve describes the relationship between the

degree of exposure (i.e., dose) and the incidence of the adverse effects (i.e., response) in the exposed population. EPA uses this dose response information to establish toxicity values for particular chemicals, as described in the following sections.

Reference Doses for Noncancer Effects. The toxicity value describing the dose-response relationship for noncancer effects is the RfD value. For noncarcinogenic effects, the body's protective mechanisms must be overcome before an adverse effect is manifested. If exposure is high enough and these protective mechanisms (or thresholds) are exceeded, adverse health effects can occur. EPA attempts to identify the upper bound of this tolerance range in the development of noncancer toxicity values. EPA uses the apparent toxic threshold value, in conjunction with uncertainty factors based on the strength of the toxicological evidence, to derive an RfD value. EPA defines an RfD value as follows:

> *In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is generally expressed in units of mg/kg-day.*

Available chronic RfD values for the oral and inhalation exposure routes are used to calculate PRGs. Because EPA has not derived toxicity values specific to skin contact, dermal slope factors and RfD values were derived from oral toxicity factors in accordance with EPA guidance. The RfD values for the contaminants evaluated in the 300 Area Source OU are summarized in Table G-17 (Appendix G).

Slope Factors for Cancer Effects. The dose-response relationship for cancer effects is expressed as a cancer slope factor that converts estimated intake directly to excess lifetime cancer risk (ELCR). Slope factors are expressed in units of risk per level of exposure (or intake). The data used for estimating the dose-response relationship are taken from lifetime animal studies or human occupational or epidemiological studies where excess cancer risk has been associated with exposure to the chemical. However, because risk at low intake levels cannot be directly measured in animal or human epidemiological studies, a number of mathematical models and procedures have been developed to extrapolate from the high doses used in the studies to the low doses typically associated with environmental exposures. The model choice leads to uncertainty associated with the carcinogenic response at very low levels of exposure. EPA assumes linearity at low doses when uncertainty exists about the mechanism of action of a carcinogen and when information suggesting nonlinearity is absent.

It is assumed, therefore, that if a cancer response occurs at the dose levels used in the study, then there is some probability that a response will occur at all lower exposure levels (i.e., a dose response relationship with no threshold is assumed). Moreover, the dose-response slope chosen is usually the UCL-95 on the actual dose-response curve observed in the laboratory studies. As a result, uncertainty and conservatism are built into the EPA risk extrapolation approach. EPA has stated that cancer risks estimated by this method produce estimates that "provide a rough but plausible upper limit of risk." The cancer slope factors used in this assessment are summarized in Table G-17 (Appendix G).

6.2.4.2 Toxicity Values

The analyte-specific toxicity values presented in Table G-17 (Appendix G) are determined using the recommended reference hierarchy as described in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). The hierarchy is summarized below.

- Tier 1—The EPA Integrated Risk Information System (IRIS) database
- Tier 2—The EPA Provisional Peer Reviewed Toxicity Values
- Tier 3—Other Toxicity Values

6.2.4.2.1 Tier 1—IRIS

The preferred source of toxicity data is EPA's IRIS database. Expert toxicologists at EPA have derived the values in this database and the values have undergone a thorough review and validation both within and outside EPA. If a toxicity value is available in IRIS, that value is used in preference to any other value.

6.2.4.2.2 Tier 2—Provisional Peer Reviewed Toxicity Values

If a toxicity value is not available in IRIS, the next source is EPA's Provisional Peer Reviewed Toxicity Values. This source includes toxicity values that have been developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center. This database is not available to the public, but is accessible to EPA risk assessors via EPA's intranet. These values are also published at "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a).

6.2.4.2.3 Tier 3—Other Toxicity Values

Tier 3 includes additional EPA and nonEPA sources of toxicity information, including the following:

- The California Environmental Protection Agency (CalEPA)'s Toxicity Criteria Database contains toxicity values that are peer reviewed and address both cancer and noncancer effects.
- The Agency for Toxic Substances and Disease Registry (ATSDR) database Minimal Risk Levels for Hazardous Substances are peer-reviewed estimates of the daily human exposure to hazardous substances that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure.
- The toxicity values in *Health Effects Assessment Summary Tables: FY 1997 Update* (EPA 540-R-97-036).

When Tier 1, Tier 2, or Tier 3 toxicity values are not available for a COPC, the toxicity values from the National Center for Environmental Assessment are used. These values can be found in the Risk Assessment Information System (ORNL, 2010).

A derived RfD for nitrate was calculated from the RfD reported in IRIS (1.6 mg/kg-day) for nitrate as nitrogen (NO3--N) using the mass fraction of nitrogen in nitrate. The mass fraction of nitrogen in nitrate = mol wt N/mol wt NO3- = (14 g/mol)/(62 g/mol) = 0.226. The derived RfD for nitrate = (1.6 mg NO3- -N/kg-day) × (1 mg NO3-/0.226 mg NO3--N) = 7.1 mg NO3-/kg-day.

A derived RfD for nitrite was calculated from the RfD reported in IRIS (0.1 mg/kg-day) for nitrite as nitrogen (NO2--N) using the mass fraction of nitrogen in nitrite. The mass fraction of nitrogen in nitrite = mol wt N/mol wt NO2- = (14 g/mol)/(46 g/mol) = 0.304. The derived RfD for nitrite = (0.1 mg NO2--N/kg-day) × (1 mg NO2-/0.304 mg NO2--N) = 0.3 mg NO2-/kg-day.

Toxic equivalence factors were used to calculate toxicity values for dioxins, furans, and carcinogenic PAHs as described in "Human Health Risk Assessment Procedures" (WAC 173-340-708(8)(D)(iii)(A)).

For several nonradionuclide analytes, the toxicity value used was obtained from a different source than recommended by the EPA Superfund hierarchy ("Human Health Toxicity Values in Superfund Risk Assessments" [Cook, 2003]). The differences in toxicity values are summarized as follows:

- For consistency with previous Hanford Site analyses of TCE, the oral cancer slope factor of 0.089 $(mg/kg\text{-}day)^{-1}$ and inhalation unit risk of 2.5E-05 $(\mu g/m^3)^{-1}$ published in Health Effects Assessment Summary Table (HEAST) are used for this assessment. HEAST has not been updated

since 1997; therefore, it does not reflect the most current source of information. The oral cancer slope factor and inhalation unit risk currently implemented by EPA in the "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a) are established by the CalEPA Office of Health Hazard Assessment (OEHHA). The oral slope factor of 0.0059 $(mg/kg\text{-}day)^{-1}$ and the Inhalation Unit Risk of 2.0E-06 $(\mu g/m^3)^{-1}$ derived by OEHHA are presented in *Public Health Goal for Trichloroethylene in Drinking Water* (OEHHA, 2009). Use of the HEAST values in this assessment has the potential to overestimate cancer risk.

- For fluoride, the oral RfD of 0.06 mg/kg-day published on IRIS is used for this assessment. The value reported on IRIS has not been updated since 1989; therefore, it does not reflect the most current source of information. The oral RfD currently implemented by EPA in the "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a) is established by the CalEPA OEHHA. The oral RfD derived by OEHHA is 0.04 mg/kg-day as documented in *Chronic Toxicity Summary: Fluorides including Hydrogen Fluoride* (OEHHA, 2003). Use of the IRIS value in this assessment has the potential to underestimate noncancer hazards.

- For Cr(VI), the current assessment considers cancer effects only for inhalation exposures. An oral cancer slope factor has recently been published by the New Jersey Department of Environmental Protection (NJDEP). The oral cancer slope factor derived by NJDEP is 0.5 $(mg/kg\text{-}day)^{-1}$, as presented in *Derivation of an Ingestion-Based Soil Remediation Criterion for Cr+6 Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate* (NJDEP, 2009). Assessing only inhalation cancer effects from Cr(VI) has the potential to underestimate cancer risk.

- When evaluating toxicity, 1,1-DCE is not considered a carcinogen by Ecology. Therefore, the oral slope factor of 5.7E-03 $(mg/kg\text{-}day)^{-1}$ and inhalation unit risk of 1.5E-06 $(\mu g/m^3)^{-1}$ presented in "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a) are not used to evaluate toxicity. This is consistent with Ecology's "Cleanup Levels and Risk Calculations" (CLARC) database (Ecology, 2010). In addition, the reference concentration of 0.7 mg/m^3 published by HEAST is used to evaluate noncarcinogenic inhalation risk. This is also consistent with the "Cleanup Levels and Risk Calculations" (CLARC) database (Ecology, 2010).

- For consistency with previous Hanford analyses of CCl_4, the toxicity assessment uses an oral cancer slope factor of 0.13 $(mg/kg\text{-}day)^{-1}$, an oral RfD of 0.0007 (mg/kg-day), and an inhalation unit risk factor of 1.5E-05 $(\mu g/m^3)^{-1}$ previously published in IRIS, as well as the inhalation reference concentration of 0.19 (mg/m^3) published by ATSDR. These values do not reflect the most current toxicity values published for CCl_4. The oral cancer slope factor of 0.07 $(mg/kg\text{-}day)^{-1}$, oral RfD of 0.004 (mg/kg-day), inhalation unit risk of 6E-06 $(\mu g/m^3)^{-1}$, and inhalation reference concentration of 0.1 (mg/m^3) for CCl_4 is currently implemented by "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a) and established by IRIS. Use of the current IRIS values in this assessment has the potential to overestimate both cancer risks and noncancer hazards.

The analyte-specific toxicity values, decay constants, and half-life presented in Table G-17 (Appendix G) are determined using the recommended values from the HEAST Radionuclides Table.

6.2.5 Risk Characterization

The risk characterization step is completed through the comparison of the EPC to the PRG. This comparison step is used to determine whether the post remediation soil concentrations are protective of human health. It is also used to determine if current material concentrations have the potential to exceed an HI greater than 1 or the upper end of the NCP risk range for cumulative carcinogenic site risk to an individual based on RME for both current and future land use.

Although this risk evaluation produces numerical estimates of risk, it should be recognized that these numbers might not predict actual health outcomes because they are based largely on hypothetical assumptions. Their purpose is to provide a frame of reference for risk management decision making. Interpretation of the risk estimates provided should consider the nature and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding them.

For the purpose of this risk characterization step, the potential for unacceptable human health risk is identified using the following risk thresholds:

- ELCR values are compared to the "target range" of 10^{-6} to 10^{-4} that is generally used by regulatory agencies. MTCA (WAC 173-340) states that cancer risks resulting from multiple hazardous substances should not exceed 1×10^{-5} for unrestricted land use. ELCR values within or exceeding this target range require a risk management decision that includes evaluating site-specific characteristics and exposure scenario factors to assess whether remedial action is warranted.
- An HI (the sum of the ratios of the chemical intake to the RfDs for all COPCs) greater than 1 indicates that some potential exists for adverse noncancer health effects associated with exposure to the COPCs.

6.2.5.1 Cancer Risk Estimation Method

To estimate the cancer risks from exposure to an individual nonradiological carcinogen from all exposure routes considered, the following equation is used:

$$Risk_I = \frac{EPC_{soil}}{PRG_{carcinogen}} \times TR$$

where:

$Risk_I$ = ELCR for individual chemical or radioisotope (unitless)

EPC_{soil} = Exposure point concentration in soil (µg/kg or pCi/g)

$PRG_{carcinogen}$ = Soil PRG based on 10^{-6} carcinogenic effect for chemical (µg/kg) or 10^{-4} carcinogenic effect for radioisotope (pCi/g)

TR = Target ELCR of 10^{-6} for individual hazardous substance or 10^{-4} for individual radioisotope for unrestricted land use

To estimate the cancer risks from exposure to multiple carcinogens from all exposure routes considered, the following equation is used. The equation presented below is consistent with that published on "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a).

$$Risk_T = \sum_i \frac{EPC_{soil}}{PRG_{carcinogen}} \times TR$$

where:

$Risk_T$ = Total ELCR for all chemicals and radioisotopes

EPC_{soil} = Exposure point concentration in soil (µg/kg or pCi/g)

$PRG_{carcinogen}$ = Soil PRG based on 10^{-6} carcinogenic effect for chemical (µg/kg) or 10^{-4} carcinogenic effect for radioisotope (pCi/g)

TR = Target ELCR of 10^{-6} for individual hazardous substance or 10^{-4} for individual radioisotope for unrestricted land use

i = The sum of the ratios for the ith chemical

6.2.5.2 Noncancer Risk Estimation Method

For noncancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular chemical with the highest level of exposure that is considered protective (i.e., its RfD). The ratio of the chronic daily intake divided by RfD is termed the HQ. To estimate the HQ from all exposure routes considered for an individual hazardous substance, the following equation is used:

$$HQ = \frac{EPC_{soil}}{PRG_{noncarcinogen}}$$

where:

HQ = HQ for individual chemical

EPC_{soil} = Exposure point concentration in soil (µg/kg)

$PRG_{noncarcinogen}$ = PRG based on HQ=1 noncarcinogenic effects (µg/kg)

To estimate the HI from all exposure routes considered for multiple hazardous substances, the following equation is used. The equation presented below is consistent with that published on the "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2009a).

$$HI_T = \sum_i \frac{EPC_{soil}}{PRG_{noncarcinogen}}$$

where:

HI_T = Total HI for all chemicals

EPC_{soil} = Exposure point concentration in soil (µg/kg)

$PRG_{noncarcinogen}$ = PRG based on HQ=1 noncarcinogenic effects (µg/kg)

i = The sum of the ratios for the ith chemical

6.2.5.3 Comparisons of Lead and Arsenic to MTCA A Soil Cleanup Levels

Potential risks from lead concentrations were evaluated using a different method than what is conventionally used for other carcinogens and noncarcinogens. For direct contact pathways, the EPCs for lead were compared to the "Tables" (WAC 173-340-900), Table 740-1 Method A, Soil Cleanup Level for Unrestricted Land Use of 250 mg/kg. The EPCs for lead were also compared to the "Tables" (WAC 173-340-900), Table 745-1, Method A soil cleanup level for Industrial Properties of 1,000 mg/kg.

The Method A cleanup level is based on the EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model, which is available on the EPA Web site. The IEUBK model is designed to predict probable blood-lead concentrations for children between 6 months and 84 months (i.e., up to 7 years) of age who

have been exposed to lead through various sources (e.g., air, water, soil, dust, and in utero contributions from the mother).

Additionally, arsenic EPCs were compared to the "Tables" (WAC 173-340-900), Table 740-1, Method A soil cleanup level for Unrestricted Land Use of 20 mg/kg. Arsenic EPCs were also compared to the WAC 173-340-900, Table 745-1, Method A soil cleanup level for Industrial Properties of 20 mg/kg. The concentration of 20 mg/kg is based on the 90th percentile background value for Washington State documented in *Natural Background Soil Metals Concentrations in Washington State* (Ecology Publication 94-115).

6.2.5.4 Consideration of Background in Risk Assessment

Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA 540-R-01-003) provides national policy considerations for application of background data in risk assessment and remedy selection. This policy recommends an approach that addresses site-specific background issues in the risk characterization. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-R-01-003) indicates the following:

> *COPCs that have both release-related and background-related sources should be included in the risk assessment. When concentrations of naturally occurring elements at a site exceed risk-based screening levels, that information should be discussed qualitatively in the risk characterization.*

Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA 540-R-01-003) defines background constituents as the following:

- Anthropogenic—natural and artificial substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question).
- Naturally occurring—substances present in the environment in forms that have not been influenced by human activity.

6.2.5.4.1 Sources of Background Concentrations

The 90th percentile and maximum background concentrations for the Hanford Site have been developed for both inorganic chemicals and radionuclides and are considered representative of both naturally occurring and anthropogenic substances. The maximum inorganic background concentrations used in this evaluation are identified as the "overall maximum concentrations" in the Non-Rad Soil Background document (DOE/RL-92-24), Summary Table 1 and the 90th percentile inorganic background concentrations are identified as the "lognormal distribution 90th percentiles" in the Non-Rad Soil Background document (DOE/RL-92-24), Summary Table 2. The exceptions to this are described in the following paragraph. Two types of sampling were conducted to determine the inorganic background values: systematic random sampling and judgment sampling. The overall maximum concentrations were determined by considering the analytical results from both systematic random samples and judgmental samples. The 90th percentile values were calculated using the analytical results from the systematic random samples only.

The Hanford Site background values for antimony, boron, cadmium, lithium, mercury, molybdenum, selenium, silver, and thallium are documented in *Soil Background Data for Interim Use at the Hanford Site* (ECF-HANFORD-11-0038). Boron was not analyzed for in the Non-Rad Soil Background document (DOE/RL-92-24) and the analytical data associated with the remaining analytes in the Non-Rad Soil Background document (DOE/RL-92-24) are considered unusable for statistical analyses because of elevated MDLs. The background concentration values, documented in *Soil Background Data for Interim*

Use at the Hanford Site (ECF-HANFORD-11-0038), reference *A Review of Metal Concentrations Measured in Surface Soil Samples Collected On and Around the Hanford Site*, hereafter referred to as Review of Metal Concentrations (PNNL-18577). The *Soil Background Data for Interim Use at the Hanford Site* (ECF-HANFORD-11-0038) documents a review of the data sets from the Non-Rad Soil Background document (DOE/RL-92-24) and Review of Metal Concentrations (PNNL-18577), which indicates the data are comparable and issues associated with elevated detection limits were eliminated because of improvements in analytical methods used for Review of Metal Concentrations (PNNL-18577). It is noted that *Soil Background Data for Interim Use at the Hanford Site* (ECF-HANFORD-11-0038) recalculates the percentile values using a nonparametric (Kaplan-Meier) method, consistent with the methodology used in the Non-Rad Soil Background document (DOE/RL-92-24). Review of Metal Concentrations (PNNL-18577) calculated the 90th percentile values based on an assumption of normally distributed data.

The background concentration values documented in *Soil Background Data for Interim Use at the Hanford Site* (ECF-HANFORD-11-0038) for selenium reference *Natural Background Soil Metals Concentrations in Washington State* (Ecology Publication 94-115) because neither the Non-Rad Soil Background document (DOE/RL-92-24) nor Review of Metal Concentrations (PNNL-18577) had adequate analytical results.

Radionuclide background values (lognormal 90th percentile and maximum) are identified in the Rad Soil Background document (DOE/RL-96-12), Table 5-1. The background values for naturally occurring radionuclides were determined primarily by analyzing a subset of the inorganic systematic random samples from the vadose zone (upper 30 cm of the soil column). The background values for the anthropogenic radionuclides were determined from analytical results from surface sampling (upper 2.5 cm of the soil column).

The composition of background samples described in the Non-Rad Soil Background document (DOE/RL-92-24), Rad Soil Background document (DOE/RL-96-12), and Review of Metal Concentrations (PNNL-18577) is representative of the sedimentary facies in the vadose zone at the 300 Area Source OU. These background data are recommended for use in environmental-restoration activities on the Hanford Site to maintain consistency between projects, and they have been peer reviewed for technical credibility. Table G-18 (Appendix G) lists the maximum and 90th percentile background concentration values for inorganic chemicals and radionuclides.

6.2.5.4.2 Comparison of Site and Background Risk Contributions

Understanding the contribution to risk from naturally occurring elements is important because cleanup levels are not set at concentrations below natural background levels under CERCLA. Similarly, "Overview of Cleanup Standards" (WAC 173-340-700(6)(d)), "Requirements for Setting Cleanup Levels, Natural Background and Analytical Considerations," states that:

> *In some cases, cleanup levels calculated using the methods specified in this chapter are less than natural background levels or levels that can be reliably measured. In those situations, the cleanup level shall be established at a concentration equal to the practical quantitation limit or natural background concentration, whichever is higher.*

Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA 540-R-01-003) states:

> *When background concentrations are high relative to the concentrations of released hazardous substances, pollutants, and contaminants, a comparison of site and background concentrations may help risk managers make decisions concerning appropriate remedial actions. The*

contribution of background concentrations to risks associated with CERCLA releases may be important for refining specific cleanup levels for contaminants of concern that warrant remedial action.

The 90th percentile value is used as a fixed benchmark concentration for determining which contaminants should be evaluated for purposes of background risk. To assist risk managers make decisions concerning appropriate remedial actions, a comparison of background risks to risks from CERCLA releases is provided using the approach described in the following text.

- EPCs from each decision unit are compared to the background value for metals and radionuclides listed in Table G-18 (Appendix G). A comparison of EPCs to the lognormal 90th percentile value for each decision unit is provided in Table G-19 (Appendix G) for the 300 Area Source OU.
- If the EPC is less than or equal to the background value, then a risk estimate or an HQ is not calculated.
- If the EPC is greater than the background value, then a risk estimate or an HQ is calculated.
- If a background value is not available for an analyte, then a risk estimate or an HQ is calculated.
- The total ELCR is summed for all analytes with EPCs greater than their background value.
- The HI is summed for all analytes with EPCs greater than their respective background value.

6.2.5.5 Summary of Risk Estimates by Exposure Scenario

This section summarizes the risk estimates for each of the exposure scenarios considered for the 300 Area Source OU.

6.2.5.5.1 Residential Scenario

PRGs developed for the residential scenario are the numeric values that represent the RAOs presented in Chapter 8. The results of comparing EPCs to the RBSLs in this supplemental risk evaluation will be used to help determine whether additional remedial action is necessary for waste sites where remediation has been completed, and whether the goals and objectives of the interim action RODs have been met, as demonstrated by verification sampling and analysis. A complete description of the residential exposure scenario is provided in Section 6.2.3.3.

For completeness in analysis, all risk estimates for each waste site decision unit are provided in Appendix G. The risk estimates, which include all COPCs regardless of their EPCs relative to background value, are presented in Tables G-20 through G-28 (Appendix G).

Appendix G also includes risk estimates for each waste site decision unit, which includes only those COPCs with EPCs greater than background values or do not have a background value. These risk estimates are presented in Tables G-29 through G-38 (Appendix G). Only these risk estimates without background contributions are discussed in the risk characterization because it is this information that is used for decisions concerning appropriate remedial actions.

Risk estimates were calculated for each decision unit within a waste site including shallow vadose zone material, deep vadose zone material, overburden material, and staging pile area footprint material. The results without background contribution for the residential scenario are presented in Tables G-29 through G-31 (Appendix G). An overall summary of the cumulative risk estimates for each of the waste sites evaluated are provided in Table 6-12 for the shallow zone and Table 6-13 for the deep zone.

Table 6-12. Summary of Total Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Residential Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
300 Area Industrial Complex					
300-FF-1					
Closed Out	316-1	300 RFBP UPR-300-32 UPR-300-33 UPR-300-34 UPR-300-35 UPR-300-36 UPR-300-37 UPR-300-FF-1	Shallow 3	1.5×10^{-4}	Cobalt-60 (7.5×10^{-5} - 51%) Uranium-238 (3.9×10^{-5} - 26%)
	316-2	--	Shallow 1	2.7×10^{-4}	Uranium-238 (1.3×10^{-4} - 47%)
			Shallow 2	3.5×10^{-4}	Uranium-238 (1.8×10^{-4} - 51%)
	316-5	UPR-300-15 UPR-300-19 UPR-300-20 UPR-300-21 UPR-300-22 UPR-300-23 UPR-300-24 UPR-300-25 UPR-300-26 UPR-300-27 UPR-300-28 UPR-300-29 UPR-300-30 UPR-300-47 UPR-300-8 UPR-300-9	Shallow 1	3.3×10^{-4}	Uranium-235 (1.1×10^{-4} - 34%) Uranium-238 (1.7×10^{-4} - 50%)
			Shallow 2	2.2×10^{-4}	Uranium-238 (1.3×10^{-4} - 56%)
			Shallow Focused	1.7×10^{-4}	Cesium-137 (4.2×10^{-5} - 24%) Uranium-235 (4.7×10^{-5} - 27%) Uranium-238 (8.4×10^{-5} - 49%)
	300-44 300-49 300-50 618-12	--	None	1×10^{-4} to 1×10^{-6}	None
	300 Ash Pits	--	None	$< 1 \times 10^{-6}$	None
300-FF-2					
Closed Out	See 316-1 (300-FF-1)	300-262			
Interim Closed Out	300-37 300-45 300-33 300-41 300-256 300-259 300-275 618-2 UPR-300-17 UPR-300-46 300-10	--	None	1×10^{-4} to 1×10^{-6}	None

Table 6-12. Summary of Total Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Residential Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
	300-109 300-260				
	618-1	300-110 303-M UOF 303-M SA 333 ESHWSA			
	300-23 300-272 300 VTS 300-18 300-8 300-223	--	None	No COPCs reported above background	None
No Action	331 LSLDF	--	None	1×10^{-4} to 1×10^{-6}	None
600 Area Subregion					
300-FF-1					
Closed Out	618-4 628-4	--	None	1×10^{-4} to 1×10^{-6}	None
300-FF-2					
Interim Closed Out	618-3	--	Shallow Focused	2.4×10^{-4}	Uranium-238 (1.5×10^{-4} - 62%)
	600-47 618-7 618-9	--	None	1×10^{-4} to 1×10^{-6}	None
	618-13	600-290:1			
	600-243 618-8	--	None	$< 1 \times 10^{-6}$	None
	618-5 600-259	--	None	No COPCs reported above background	None

Note: Results summarized from Table G-29. Residential Scenario Risk Estimates and Noncancer Hazards for 300 Area Source Operable Unit Waste Site Decision Units Without Background Contribution.

a. Associated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. Total ELCR represents risk contributions from both radiological and nonradiological COPCs.

Table 6-13. Summary of Total Risks for 300-FF-1 OU and 300-FF-2 OU Deep Zone Waste Sites for the Residential Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	ELCR[b]	Risk Driver and % Contribution
300 Area Industrial Complex					
300-FF-2					
Interim Closed Out	618-1	300-110 303-M SA 303-M UOF 333 ESHWSA	Deep	1.0×10^{-4}	Uranium-233/234 (2.5×10^{-5} - 25%) Uranium-238 (5.9×10^{-5} - 59%)
			Deep Focused	3.5×10^{-4}	Cesium-137 (1.5×10^{-4} - 43%) Uranium-238 (1.2×10^{-4} - 35%)
	618-2	--	Deep	9.9×10^{-4}	Sr-90 (5.1×10^{-4} - 52%) Uranium-233/234 (1.2×10^{-4} - 12%) Uranium-238 3.1×10^{-4} - 31%)
			Deep Focused	5.4×10^{-4}	Sr-90 (3.2×10^{-4} - 59%)
600 Area Subregion					
300-FF-1					
Closed Out	618-4	--	None	1×10^{-4} to 1×10^{-6}	None
300-FF-2					
Interim Closed Out	618-5	--	None	1×10^{-4} to 1×10^{-6}	None

Note: Results summarized from Table G-29. Residential Scenario Risk Estimates and Noncancer Hazards for 300 Area Source Operable Unit Waste Site Decision Units Without Background Contribution.

a. Associated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. ELCR represents risk contributions from radiological COPCs.

Shallow Zone. A total of 40 waste sites are reported with CVP/RSVP data in the 300 Area Source OU. The following lists the sample designs that were applied to the 40 waste sites evaluated:

- Eleven waste sites were sampled using a focused sampling design.
- Twenty waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units and two waste sites with three statistically distinct decision units).
- Nine waste sites were sampled using both a statistical and a focused sampling design (with one site having two statistically distinct decision units and one waste sites with four statistically distinct decision units).

The overall total risk summary for the residential scenario from all shallow zone waste sites evaluated is provided in Table 6-12. Table 6-12 lists the OU and subarea that each waste site resides in, the reclassification status, the remediated waste site, the consolidated waste site (if applicable), the decision unit reported with an exceedance (if applicable), the total ELCR, and the risk driver and percent contribution (if applicable).

As presented in Table 6-12, the potential cumulative ELCR is greater than the upper risk threshold of 1×10^{-4} at four remediated waste sites, is within the regulatory target risk range of 10^{-6} to 10^{-4} at 25 remediated waste sites, and is less than the lower risk threshold of 1×10^{-6} at three remediated waste sites. Risks were not reported at eight remediated waste sites because there were no COPCs reported above background concentrations.

Four waste sites report concentrations of site-related COPCs that exceed the upper range of the regulatory target threshold for the residential scenario. The four remediated waste sites listed below are located in the 300 Area industrial complex and were remediated using industrial RAGs. The cancer risks levels for the residential scenario are as follows:

- The 316-1 waste site (shallow 3 decision unit) reports a cumulative ELCR of 1.5×10^{-4}. The primary contributors to risk include Co-60 (7.5×10^{-5}; 51 percent contribution) and U-238 (3.9×10^{-5}; 26 percent contribution).
- The 316-2 waste site (shallow 1 decision unit) reports a cumulative ELCR of 2.7×10^{-4}. The primary contributor to risk is U-238 (1.3×10^{-4}; 47 percent contribution). The EPC of U-238 is 69 pCi/g which is greater than the residential RBSL of 54 pCi/g and is also greater than the current U-238 unrestricted direct exposure RAG of 26 pCi/g published in the 300 Area RDR/RAWP (DOE/RL-2001-47).
- The 316-2 waste site (shallow 2 decision unit) reports a cumulative ELCR of 3.5×10^{-4}. The primary contributor to risk is U-238 (1.8×10^{-4}; 51 percent contribution). The EPC of U-238 is 96 pCi/g which is greater than the residential RBSL of 54 pCi/g and is also greater than the current U-238 unrestricted direct exposure RAG of 26 pCi/g published in the 300 Area RDR/RAWP (DOE/RL-2001-47).
- The 316-5 waste site (shallow 1 decision unit) reports a cumulative ELCR of 3.3×10^{-4}. The primary contributors to risk are U-235 (1.1×10^{-4}; 34 percent contribution) and U-238 (1.7×10^{-4}; 50 percent contribution). The EPCs of U-235 and U-238 are 19 pCi/g and 89 pCi/g, respectively, which are greater than the residential RBSLs of 16 pCi/g and 54 pCi/g, respectively. These EPCs are also greater than the current U-235 and U-238 unrestricted direct exposure RAGs of 2.7 pCi/g and 26 pCi/g, respectively, published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

- The 316-5 waste site (shallow 2 decision unit) reports a cumulative ELCR of 2.2×10^{-4}. The primary contributor to risk is U-238 (1.3×10^{-4}; 56 percent contribution). The EPC of U-238 is 68 pCi/g which is greater than the residential RBSL of 54 pCi/g and is also greater than the current U-238 unrestricted direct exposure RAG of 26 pCi/g published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

- The 316-5 waste site (shallow focused decision unit) reports a cumulative ELCR of 1.7×10^{-4}. The primary contributors to risk include Cs-137 (4.2×10^{-5}; 24 percent contribution), U-235 (4.7×10^{-5}; 27 percent contribution), and U-238 (8.4×10^{-5}; 49 percent contribution).

- The 618-3 waste site (shallow focused decision unit) reports a cumulative ELCR of 2.4×10^{-4}. The primary contributor to risk is U-238 (1.5×10^{-4}; 62 percent contribution). The EPC of U-238 is 79 pCi/g which is greater than the residential RBSL of 54 pCi/g and is also greater than the current U-238 unrestricted direct exposure RAG of 26 pCi/g published in 300 Area RDR/RAWP (DOE/RL-2001-47).

The residential scenario results for shallow vadose zone materials are summarized in Tables G-32 for the direct contact exposure pathway and Table G-33 for the inhalation pathway (Appendix G). As presented in Table G-32 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 8.6 × 10-7 to 3.5 × 10-4 for the 38 waste sites evaluated.

As presented in Table G-32 (Appendix G), the potential cumulative ELCR from direct contact for all nonradiological carcinogenic COPCs without background contribution ranges from 3.8×10^{-11} to 5.6×10^{-5} for 30 of the 54 shallow zone decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for 14 decision units and is less than the lower risk threshold of 1×10^{-6} for 16 decision units. In addition, the potential cumulative ELCR is greater than the "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)) cumulative risk threshold of 1×10^{-5} for six decision units. Nonradiological carcinogenic COPCs were not reported at 24 decision units. Thirteen waste sites were reported with individual carcinogens greater than the target risk level of 1×10^{-6}.

Arsenic is a primary contributor to risk at six of the 13 shallow zone decision units. EPCs of arsenic range from 8 mg/kg to 19 mg/kg at these six decision units. Although the EPCs are greater than the lognormal 90th percentile value of 6.5 mg/kg, they are consistent with naturally occurring levels at the Hanford Site (see Table G-19 in Appendix G). The EPCs are considered naturally occurring and are not the result of a site release. Additionally, all of the EPCs for arsenic are less than the residential direct exposure RAG of 20 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

In addition to arsenic, nine decision units report concentrations of site-related COPCs that result in cancer risk levels for individual carcinogens that exceed the "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) acceptable cancer risk level of 1×10^{-6} for individual carcinogens. The individual cancer risk levels are as follows:

- 300-37 shallow focused decision unit (Aroclor-1260–6.4×10^{-6})
- 316-1 shallow 1 decision unit (Aroclor-1248–6.0×10^{-6})
- 316-2 shallow 2 decision unit (Aroclor-1248–1.4×10^{-6})
- 331 LSLDF shallow focused decision unit (Aroclor-1254–1.7×10^{-6})
- 618-1 shallow focused decision unit (Aroclor-1254–2.0×10^{-6})

- 618-9 shallow focused decision unit (Aldrin–6.6×10^{-6}, Aroclor-1221–3.8×10^{-6}, Aroclor-1232–3.8×10^{-6}, Aroclor-1242–3.8×10^{-6}, Aroclor-1248–3.8×10^{-6}, Aroclor-1254–7.8×10^{-6}, Aroclor-1260–7.8×10^{-6})
- 628-4 shallow decision unit (Aroclor-1248–2.2×10^{-6})
- UPR-300-17 shallow decision unit (Aroclor-1248–3.9×10^{-6})
- UPR-300-46 shallow decision unit (Aroclor-1248–1.8×10^{-6})

The individual risk estimates for each of the PCB Aroclors and aldrin is greater than the acceptable risk threshold of 1×10^{-6} for individual carcinogens. However, the risk is less than the "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)) cumulative risk threshold of 1×10^{-5} for multiple contaminants and multiple pathways for each of the above decision units except for the 618-9 shallow focused decision unit. The cumulative risk at the 618-9 shallow focused decision unit is 5.6×10^{-5}, which is greater than the "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)) cumulative risk threshold of 1×10^{-5} for multiple contaminants and multiple pathways.

As presented in Table G-32 (Appendix G), the potential HI from direct contact for noncancer effects, without background contribution, ranges from less than 1 to 3.7 for the shallow zone decision units. The HI is greater than the EPA target HI of 1 and the "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) target HI of 1 for one shallow zone decision unit. With the exception of the one decision unit, no individual analytes were reported with an HQ greater than 1. At the 618-9 shallow focused decision unit, an HQ of 2.4 is associated with aroclor-1254.

As presented in Table G-33 (Appendix G), the potential cumulative ELCR for the MTCA Method B inhalation pathway from all nonradiological carcinogenic COPCs without background contribution ranges from 9.1×10^{-15} to 1.6×10^{-6} for 31 of the 54 shallow zone decision units. The potential cumulative ELCR is greater than "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B risk threshold of 1×10^{-6} for one decision unit and less than the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B risk threshold of 1×10^{-6} for 30 decision units. All individual COPCs were reported with a risk less than or equal to 1×10^{-6}. Nonradiological carcinogenic COPCs were not reported at 23 decision units.

As presented in Table G-33 (Appendix G), the potential HI for the MTCA Method B inhalation pathway from noncancer effects without background contribution is less than 1 for all shallow zone decision units. The potential HI is less than the EPA target HI of 1 and the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B target HI of 1.

As shown in Table G-31 (Appendix G), all arsenic and lead EPCs are less than their Method A soil cleanup levels for unrestricted land use of 20 mg/kg and 250 mg/kg, respectively.

Overburden. A total 11 waste sites are reported with CVP/RSVP data associated with overburden in the 300 Area Source OU. Of the 11 waste sites, three waste sites were sampled using a focused sampling design and eight waste sites were sampled using a statistical sampling design (with one site having three statistically distinct decision units). One decision unit (300-23) did not report any analytes with an associated RBSL, resulting in 12 overburden decision units for evaluation. The residential scenario results for overburden materials are summarized in Tables G-34 and G-35 (Appendix G).

As presented in Table G-34 (Appendix G), potential cumulative ELCR from all radiological COPCs without background contribution ranges from 3.6×10^{-6} to 5.2×10^{-5} for four of the 12 overburden

decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for the four decision units. Radiological COPCs were not reported at eight decision units.

As presented in Table G-34 (Appendix G), the potential cumulative ELCR for direct contact from all nonradiological carcinogenic COPCs without background contribution ranges from 8.5×10^{-10} to 1.4×10^{-5} for 4 of the 12 overburden decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for three decision units, is less than the lower risk threshold of 1×10^{-6} for one decision unit; and is greater than the "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)) cumulative risk threshold of 1×10^{-5} for two decision units. Nonradiological carcinogenic COPCs were not reported at eight decision units. Three decision units were reported with individual carcinogens greater than the target risk level of 1×10^{-6}.

Arsenic is a primary contributor to risk at two of the three decision units. The EPCs of arsenic are 6.9 mg/kg (300-50) and 9.1 mg/kg (300-44) at the two decision units. Although the EPCs are greater than the lognormal 90th percentile value of 6.5 mg/kg, they are consistent with naturally occurring levels at the Hanford Site (see Table G-19 in Appendix G) and are considered naturally occurring and not the result of a site release. Additionally, the EPCs for arsenic are less than the residential direct exposure RAG of 20 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

In addition to arsenic, one decision unit reports a concentration of a site-related COPC that results in a cancer risk level for individual carcinogens that exceed the WAC 173-340-740 acceptable cancer risk level of 1×10^{-6} for individual carcinogens. The cancer risk level is greater than 1×10^{-6} at 300-49 overburden (Aroclor-1254–6.0×10^{-6}).

Although the individual risk estimate for Aroclor-1254 exceeds the acceptable risk threshold of 1×10^{-6} for individual carcinogens, the cumulative risk for this decision unit does not exceed the cumulative risk threshold of 1×10^{-5} for multiple contaminants and multiple pathways of exposure defined in "Human Health Risk Assessment Procedures" (WAC 173-340-708).

As presented in Table G-34 (Appendix G), the potential HI for direct contact from noncancer effects, without background contribution, ranges from less than 1 to 2.1 for the overburden decision units. The HI is greater than the EPA target HI of 1 and the "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) target HI of 1 for one decision unit. With the exception of the one overburden decision unit, no individual analytes were reported with a HQ greater than 1. At the 300-49 overburden decision unit, a HQ of 1.9 is associated with Aroclor-1254.

As presented in Table G-35 (Appendix G), the potential cumulative ELCR for the MTCA Method B inhalation pathway from all nonradiological carcinogenic COPCs without background contribution ranges from 8.0×10^{-16} to 2.0×10^{-8} for 4 of the 12 overburden decision units. The potential cumulative ELCR is less than the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B risk threshold of 1×10^{-6} for the four decision units. Nonradiological carcinogenic COPCs were not reported at eight decision units.

As presented in Table G-35 (Appendix G), the potential HI for the MTCA Method B inhalation pathway from noncancer effects without background contribution is less than 1 for all overburden decision units. The potential HI is less than the EPA target HI of 1 and the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B target HI of 1.

As presented in Table G-31 (Appendix G), all arsenic and lead EPCs are less than the Method A soil cleanup levels for unrestricted land use of 20 mg/kg and 250 mg/kg, respectively.

Staging Pile Area. A total three waste sites are reported with CVP/RSVP data associated with staging pile areas in the 300 Area Source OU. Of the three waste sites, one waste site was sampled using a focused sampling design and two waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units). The residential scenario results for staging pile area footprint materials are summarized in Tables G-36 and G-37 (Appendix G).

As presented in Table G-36 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 3.0×10^{-6} to 1.2×10^{-5} for the four staging pile area decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for all four decision units.

As presented in Table G-36 (Appendix G), the potential cumulative ELCR for direct contact from all nonradiological carcinogenic COPCs without background contribution is 1.6×10^{-7} for one of the four staging pile area decision units. The potential cumulative ELCR is less than the lower risk threshold of $1 \text{ x } 10^{-6}$ for the decision unit. Nonradiological carcinogenic COPCs were not reported at three decision units.

As presented in Table G-36 (Appendix G), the potential HI for direct contact from noncancer effects without background contribution is less than 1 for the four staging pile area decision units. The potential HI is less than the EPA target HI of 1 and the "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) target HI of 1.

As presented in Table G-37 (Appendix G), the potential cumulative ELCR for the MTCA Method B inhalation pathway from all nonradiological carcinogenic COPCs without background contribution is 2.2×10^{-13} for one of the four staging pile area decision units. The potential cumulative ELCR is less than the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B risk threshold of 1×10^{-6} for the decision unit. Nonradiological carcinogenic COPCs were not reported at three decision units.

As presented in Table G-37 (Appendix G), the potential HI for the MTCA Method B inhalation pathway from noncancer effects without background contribution is less than 1 for the four staging pile area decision units. The potential HI is less than the EPA target HI of 1 and the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method B target HI of 1.

As presented in Table G-31 (Appendix G), all arsenic and lead EPCs are less than the Method A soil cleanup levels for unrestricted land use of 20 mg/kg and 250 mg/kg, respectively.

Deep Zone. Deep vadose zone samples are compared to RBSLs developed for the residential exposure scenario, although residents are unlikely to be exposed to contaminants in the deep vadose zone. Deep vadose zone samples are collected from depths greater than 4.6 m (15 ft) bgs, as a result direct contact within the point of compliance is incomplete. Additionally, the residential exposure scenario does not reflect reasonably anticipated future land use in the River Corridor. This comparison is included because it is the most conservative land use basis for the evaluation of waste sites and presentation of these results is only included to provide additional information for risk management decisions.

There are four waste sites reported with CVP/RSVP from deep zone decision units in the 300 Area Source OU. The four waste sites were sampled using both a statistical and a focused sampling design. The residential scenario results for deep vadose zone materials are summarized in Table G-38 (Appendix G).

The overall risk summary for the residential scenario from all deep zone waste sites evaluated is provided in Table 6-13. Table 6-13 lists the OU and subarea that each waste site resides in, the reclassification status, the remediated waste site, the consolidated waste site (if applicable), the decision unit reported

with an exceedance (if applicable), the total ELCR, and the risk driver and percent contribution (if applicable).

As presented in Table 6-13, the total ELCR is greater than the upper risk threshold of 1×10^{-4} at two remediated waste sites and is within the regulatory target risk range of 10^{-6} to 10^{-4} at two remediated waste sites. The two remediated waste sites listed below are located in the 300 Area industrial complex and were remediated using industrial RAGs. The cancer risks levels for the residential scenario are as follows:

- The 618-1 waste site (deep decision unit) reports a cumulative ELCR of 1.0×10^{-4}. The primary contributors to risk include U-233/234 (2.5×10^{-5}; 25 percent contribution) and U-238 (5.9×10^{-5}; 59 percent contribution).
- The 618-1 waste site (deep focused decision unit) reports a cumulative ELCR of 3.5×10^{-4}. The primary contributors to risk include Cs-137 (1.5×10^{-4}; 43 percent contribution) and U-238 (1.2×10^{-4}; 35 percent contribution).The EPCs of Cs-137 and U-238 are 6.5 pCi/g and 65 pCi/g, respectively, which are greater than the residential RBSLs of 4.4 pCi/g and 54 pCi/g, respectively. These EPCs are also greater than the current Cs-137 and U-238 unrestricted direct exposure RAGs of 6.2 pCi/g and 26 pCi/g, respectively, published in the 300 Area RDR/RAWP (DOE/RL-2001-47).
- The 618-2 waste site (deep decision unit) reports a cumulative ELCR of 9.9×10^{-4}. The primary contributors to risk include Sr-90 (5.1×10^{-4}; 52 percent contribution), U-233/234 (1.2×10^{-4}; 12 percent contribution) and U-238 (3.1×10^{-4}; 31 percent contribution). The EPCs of Sr-90, U-233/234, and U-238 are 12 pCi/g, 161 pCi/g, and 165 pCi/g, respectively, which are greater than the residential RBSLs of 2.3 pCi/g, 133 pCi/g, and 54 pCi/g, respectively. These EPCs are also greater than the Sr-90, U-233/234, and U-238 unrestricted direct exposure RAGs of 4.5 pCi/g, 27 pCi/g, and 26 pCi/g, respectively, published in the 300 Area RDR/RAWP (DOE/RL-2001-47).
- The 618-2 waste site (deep focused decision unit) reports a cumulative ELCR of 5.4×10^{-4}. The primary contributors to risk includes Sr-90 (3.2×10^{-4}; 59 percent contribution), The EPC of Sr-90 is 7.2 pCi/g, which is greater than the residential RBSL of 2.3 pCi/g. This EPC is also greater than the Sr-90 unrestricted direct exposure RAG of 4.5 pCi/g, published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

As presented in Table G-38 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 2.1×10^{-5} to 9.9×10^{-4} for the four waste sites (eight decision units).

6.2.5.5.2 Industrial Exposure Scenario

The industrial exposure scenario represents reasonable anticipated future land use for the 300 Area. The results of this comparison are used to confirm that cleanup actions are protective of the reasonably foreseeable land use that DOE and the USFWS anticipate for the 300 Area. The industrial exposure scenario is described in Section 6.2.3.3.

For completeness in analysis, all risk estimates for each waste site decision unit are provided in Appendix G. The risk estimates, which include all COPCs regardless of their EPCs relative to background concentrations, are presented in Tables G-39 through G-47 (Appendix G).

Appendix G also includes risk estimates for each waste site decision unit, which includes only those COPCs with EPCs greater than background values or do not have a background value. These risk estimates are presented in Tables G-48 through G-57 (Appendix G). Only these risk estimates without

background contributions are summarized and discussed in the risk characterization because it is this information that is used for decisions concerning appropriate remedial actions.

Risk estimates were calculated for each decision unit within a waste site including shallow vadose zone material, deep vadose zone material, overburden material, and staging pile area footprint material. The results without background contribution for the industrial exposure scenario are presented in Tables G-48 through G-57 (Appendix G). An overall summary of the cumulative risk estimates for each of the waste sites evaluated are provided in Table 6-14 for the shallow zone and in Table 6-15 for the deep zone.

Shallow Zone. A total of 40 waste sites are reported with CVP/RSVP data in the 300 Area Source OU. The following lists the sample designs that were applied to the 40 waste sites evaluated:

- Eleven waste sites were sampled using a focused sampling design.
- Twenty waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units and two waste sites with three statistically distinct decision units).
- Nine waste sites were sampled using both a statistical and a focused sampling design (with one site having two statistically distinct decision units and one waste sites with four statistically distinct decision units).

An overall summary of the cumulative risk estimates for each of the waste sites evaluated are provided in Table 6-14. Table 6-14 lists the OU and subarea that each waste site resides in, the reclassification status, the remediated waste site, the consolidated waste site (if applicable), the decision unit reported with an exceedance (if applicable), the total ELCR, and the risk driver and percent contribution (if applicable).

As presented in Table 6-14, the total ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} at 15 waste sites and is less than the lower risk threshold of 1×10^{-6} at 17 remediated waste sites. Risks were not reported at eight remediated waste sites because there were no COPCs reported above background concentrations.

The industrial exposure scenario results for shallow vadose zone materials are summarized in Tables G-51 and G-52 (Appendix G). As presented in Table G-51 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 6.5×10^{-8} to 7.5×10^{-5} for 36 of the 54 shallow zone decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for 23 decision units, and is less than the lower risk threshold of 1×10^{-6} for 13 decision units. Radiological COPCs were not reported at 18 decision units.

Table 6-14. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Industrial Scenario

Classification Status	Remediated Waste Site	Associated Waste Sites[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
300 Area Industrial Complex					
300-FF-1					
Closed Out	316-1	300 RFBP UPR-300-32 UPR-300-33 UPR-300-34 UPR-300-35 UPR-300-36 UPR-300-37 UPR-300-FF-1	None	1×10^{-4} to 1×10^{-6}	None
	316-2	--			
	316-5	UPR-300-15 UPR-300-19 UPR-300-20 UPR-300-21 UPR-300-22 UPR-300-23 UPR-300-24 UPR-300-25 UPR-300-26 UPR-300-27 UPR-300-28 UPR-300-29 UPR-300-30 UPR-300-47 UPR-300-8 UPR-300-9			
	300-50 618-12 300 Ash Pits 300-44 300-49	--	None	$<1 \times 10^{-6}$	None

Table 6-14. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Industrial Scenario

Classification Status	Remediated Waste Site	Associated Waste Sites[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
300-FF-2					
Closed Out	See 316-1 (300-FF-1)	300-262			
Interim Closed Out	300-260 300-275 618-2 UPR-300-17 UPR-300-46 300-33 300-41 300-256	--	None	1×10^{-6} <ELCR< 1×10^{-4}	None
	618-1	300-110 303-M SA 303-M UOF 333 ESHWSA	None	<1×10^{-6}	None
	300-259 300-10 300-109 300-37 300-45	--			
	300 VTS 300-18 300-8 300-223 300-23 300-272	--	None	No COPCs reported above background	None
No Action	331 LSLDF		None	<1×10^{-6}	None

Table 6-14. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Industrial Scenario

Classification Status	Remediated Waste Site	Associated Waste Sites[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
600 Area Subregion					
300-FF-1					
Closed Out	618-4	--	None	1×10^{-4} to 1×10^{-6}	None
	628-4	--	None	$<1 \times 10^{-6}$	None
300-FF-2					
Interim Closed Out	618-9 618-3 618-7		None	1×10^{-4} to 1×10^{-6}	None
	600-243 600-47 618-8		None	$<1 \times 10^{-6}$	None
	618-13	600-290:1			
	618-5 600-259		None	No COPCs reported above background	None

Note: Results summarized from Table G-48, Industrial Worker Scenario Risk Estimates and Noncancer Hazards for 300 Area Source OU Waste Site Decision Units Without Background Contribution.

a. Associated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. Total ELCR represents risk contributions from both radiological and nonradiological COPCs.

Table 6-15. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Deep Zone Waste Sites for the Industrial Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	ELCR[b]	Risk Driver and % Contribution
300 Area Industrial Complex					
300-FF-2					
Interim Closed Out	618-1	300-110 303-M UOF 303-M SA 333 ESHWSA	None	1×10^{-4} to 1×10^{-6}	None
	618-2	--			
600 Area Subregion					
300-FF-1					
Closed Out	618-4	--	None	1×10^{-4} to 1×10^{-6}	None
300-FF-2					
Interim Closed Out	618-5	--	None	1×10^{-4} to 1×10^{-6}	None

Note: Results summarized from Table G-48, Industrial Worker Scenario Risk Estimates and Noncancer Hazards for 300 Area Source OU Waste Site Decision Units Without Background Contribution.

a. Associated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. ELCR represents risk contributions from radiological COPCs.

As presented in Table G-51 (Appendix G), the potential cumulative ELCR from direct contact for all nonradiological carcinogenic COPCs without background contribution ranges from 2.9×10^{-13} to 4.3×10^{-7} for 30 of the 54 shallow zone decision units. The potential cumulative ELCR is less than the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C risk threshold of 1×10^{-5} at the 30 decision units. Nonradiological carcinogenic analytes were not reported at 24 decision units.

As presented in Table G-51 (Appendix G), the potential HI from direct contact for noncancer effects without background contribution is less than 1 for all shallow zone decision units. The potential HI is less than the EPA target HI of 1 and the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C target HI of 1.

As presented in Table G-52 (Appendix G), the potential cumulative ELCR for the MTCA C inhalation pathway from all nonradiological carcinogenic COPCs without background contribution ranges from 9.1×10^{-16} to 1.6×10^{-7} for 31 of the 54 shallow zone decision units. The potential cumulative ELCR is less than the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method C risk threshold of 1×10^{-5} at the 31 decision units. Nonradiological carcinogenic COPCs were not reported at 23 decision units.

As presented in Table G-52 (Appendix G), the potential HI for the MTCA Method C inhalation pathway from noncancer effects without background contribution is less than 1 for all shallow zone decision units. The potential HI is less than the EPA target HI of 1 and the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method C target HI of 1.

As presented in Table G-50 (Appendix G), all arsenic and lead EPCs are less than the Method A soil cleanup levels for industrial properties of 20 mg/kg and 1,000 mg/kg, respectively.

Overburden. A total 11 waste sites are reported with CVP/RSVP data associated with overburden are in the 300 Area Source OU. Of the 11 waste sites, three waste sites were sampled using a focused sampling design and eight waste sites were sampled using a statistical sampling design (with one site having three statistically distinct decision units). One decision unit (300-23) did not report any analytes with an associated RBSL, resulting in 12 overburden decision units for evaluation. The industrial exposure scenario results for overburden materials are summarized in Tables G-53 and G-54 (Appendix G).

As presented in Table G-53 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 5.7×10^{-7} to 1.1×10^{-5} for 4 of the 12 overburden decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for three decision units, and is less than the lower risk threshold of 1×10^{-6} for one decision unit. Radiological COPCs were not reported at eight decision units.

As presented in Table G-53 (Appendix G), the potential cumulative ELCR from direct contact for all nonradiological carcinogenic COPCs without background contribution ranges from 6.5×10^{-12} to 1.0×10^{-7} for 4 of the 12 overburden decision units. The potential cumulative ELCR is less than the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C risk threshold of 1×10^{-5} for the four decision units. Nonradiological carcinogenic analytes were not reported at eight decision units.

As presented in Table G-53 (Appendix G), the potential HI from direct contact for noncancer effects without background contribution is less than 1 for all overburden decision units. The potential HI is less than the EPA target HI of 1 and the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C target HI of 1.

As presented in Table G-54 (Appendix G), the potential cumulative ELCR for the MTCA C inhalation pathway from all nonradiological carcinogenic COPCs without background contribution ranges from 8.0×10^{-17} to 2.0×10^{-9} for 4 of the 12 overburden decision units. The potential cumulative ELCR is less than the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method C risk threshold of 1×10^{-5} for the four decision units. Nonradiological carcinogenic COPCs were not reported at eight decision units.

As presented in Table G-54 (Appendix G), the potential HI for the MTCA Method C inhalation pathway from noncancer effects without background contribution is less than 1 for all overburden decision units. The potential HI is less than the EPA target HI of 1 and the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method C target HI of 1.

As shown in Table G-50 (Appendix G), all arsenic and lead EPCs are less than the Method A soil cleanup levels for industrial properties of 20 mg/kg and 1,000 mg/kg, respectively.

Staging Pile Area. A total three waste sites are reported with CVP/RSVP data associated with staging pile areas in the 300 Area Source OU. Of the three waste sites, one waste site was sampled using a focused sampling design and two waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units). The industrial exposure scenario results for staging pile area footprint materials are summarized in Tables G-55 and G-56 (Appendix G).

As presented in Table G-55 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 4.7×10^{-7} to 1.5×10^{-6} for the four staging pile area decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for one decision unit, and is less than the lower risk threshold of 1×10^{-6} for three decision units.

As presented in Table G-55 (Appendix G), the potential cumulative ELCR from direct contact for all nonradiological carcinogenic COPCs without background contribution is 1.2×10^{-9} for one of the four overburden decision units. The potential cumulative ELCR is less than the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C risk threshold of 1×10^{-5} for the one decision unit. Carcinogenic analytes were not reported at three decision units.

As presented in Table G-55 (Appendix G), the potential HI from direct contact for noncancer effects without background contribution is less than 1 for all staging pile area decision units. The potential HI is less than the EPA target HI of 1 and the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C target HI of 1.

As presented in Table G-56 (Appendix G), the potential cumulative ELCR for the MTCA C inhalation pathway from all nonradiological carcinogenic COPCs without background contribution is 2.2×10^{-14} for one of the four staging pile area decision units. The potential cumulative ELCR is less than the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) Method C risk threshold of 1×10^{-5} for the one decision unit. Nonradiological carcinogenic COPCs were not reported at three decision units.

As presented in Table G-56 (Appendix G), the potential HI for the MTCA Method C inhalation pathway from noncancer effects without background contribution is less than 1 for all staging pile area decision units. The potential HI is less than the EPA target HI of 1 and the "Cleanup Standards to Protect Air Quality" (WAC 173-340-750) Method C target HI of 1.

As presented in Table G-50 (Appendix G), all arsenic and lead EPCs are less than the Method A soil cleanup levels for industrial properties of 20 mg/kg and 1,000 mg/kg, respectively.

Deep Zone. Deep vadose zone samples are compared to RBSLs developed for the industrial exposure scenario although an industrial worker is unlikely to be exposed to contaminants in the deep vadose zone. Deep vadose zone samples are collected from depths greater than 4.6 m (15 ft) bgs, as a result direct contact within the point of compliance is incomplete. However, the industrial exposure scenario reflects reasonably anticipated future land use in 300 Area portion of the River Corridor. This comparison is included to determine if deep vadose zone concentrations are protective of reasonably anticipated future land use and to provide additional information for risk management decisions.

There are four waste sites reported with CVP/RSVP from deep zone decision units in the 300 Area Source OU. The four waste sites were sampled using both a statistical and a focused sampling design. The industrial scenario results for deep vadose zone materials are summarized in Table G-57 (Appendix G).

The overall risk summary for the industrial scenario from all deep zone waste sites evaluated is provided in Table 6-15. Table 6-15 lists the OU and subarea that each waste site resides in, the reclassification status, the remediated waste site, the consolidated waste site (if applicable), the decision unit reported with an exceedance (if applicable), the total ELCR, and the risk driver and percent contribution (if applicable).

As presented in Table 6-15, the total ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} at all four of the remediated waste sites.

As presented in Table G-57 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 3.7×10^{-6} to 7.4×10^{-5} for the eight deep zone decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for all eight decision units.

6.2.5.5.3 Resident Monument Worker Scenario

The resident Monument worker represents reasonably anticipated future land use. The results of this comparison are used to confirm that cleanup actions are protective of the reasonably foreseeable land uses that DOE and the USFWS anticipate for the River Corridor. The resident Monument worker scenario is described in Section 6.2.3.3.

For completeness in analysis, risk estimates for each waste site decision unit are provided in Appendix G. Appendix G includes all radiological COPCs regardless of their EPCs relative to the background value (Tables G-58 through G-61).

Appendix G also includes risk estimates for each waste site decision unit, which includes only those radiological COPCs with EPCs greater than background values or that do not have a background value (Tables G-62 through G-65 in Appendix G). Only these results are discussed in the risk characterization because it is this information that is used for decisions concerning appropriate remedial actions.

Risk estimates were calculated for the shallow zone, overburden and staging pile area decision units within a waste site. Risk estimates were not calculated for the deep zone decision units because the direct contact exposure pathway is incomplete (i.e. samples are collected from depths greater than 4.6 m [15 ft] bgs). The results without background contribution for the resident Monument worker scenario are presented in Table G-62 (Appendix G). An overall summary of the cumulative risk estimates for each of the waste sites evaluated is provided in Table 6-16 for the shallow zone.

Table 6-16. Summary of Total Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Resident Worker Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	ELCR[b]	Risk Driver and % Contribution
300 Area Industrial Complex					
300-FF-1					
Closed Out	316-1	300 RFBP UPR-300-32 UPR-300-33 UPR-300-34 UPR-300-35 UPR-300-36 UPR-300-37 UPR-300-FF-1	Shallow 3	1.1×10^{-4}	Cobalt-60 (7.0×10^{-5} - 66%) Uranium-238 (2.2×10^{-5} - 21%)
	316-2	--	Shallow 1	1.4×10^{-4}	Uranium-235 (5.6×10^{-5} - 39%) Uranium-238 (7.4×10^{-5} - 52%)
			Shallow 2	1.8×10^{-4}	Uranium-235 (5.1×10^{-5} - 28%) Uranium-238 (1.0×10^{-4} - 57%)
	316-5	UPR-300-15 UPR-300-19 UPR-300-20 UPR-300-21 UPR-300-22 UPR-300-23 UPR-300-24 UPR-300-25 UPR-300-26 UPR-300-27 UPR-300-28 UPR-300-29 UPR-300-30 UPR-300-47 UPR-300-8 UPR-300-9	Shallow 1	2.2×10^{-4}	Cesium-137 (3.7×10^{-5} - 17%) Uranium-235 (8.5×10^{-5} - 39%) Uranium-238 (9.6×10^{-5} - 44%)
			Shallow 2	1.5×10^{-4}	Cesium-137 (2.8×10^{-5} - 19%) Uranium-235 (4.1×10^{-5} - 28%) Uranium-238 (7.3×10^{-5} - 50%)
			Shallow Focused	1.1×10^{-4}	Cesium-137 (2.9×10^{-5} - 26%) Uranium-235 (3.5×10^{-5} - 31%) Uranium-238 (4.9×10^{-5} - 43%)
	300-49 300-50 618-12	--	None	1×10^{-4} to 1×10^{-6}	None
	300 Ash Pits 300-44	--	None	No COPCs reported above background	None

Table 6-16. Summary of Total Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Resident Worker Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	ELCR[b]	Risk Driver and % Contribution
300-FF-2					
Closed Out	See 316-1 (300-FF-1)	300-262			
Interim Closed Out	300-259 300-275 618-2 UPR-300-17 UPR-300-46 300-10 300-109 300-260 300-45 300-33 300-41 300-256	--	None	1×10^{-4} to 1×10^{-6}	None
	618-1	300-110 303-M SA 303-M UOF 333 ESHWSA			
	300 VTS 300-18 300-8 300-223 300-23 300-272 300-37	--	None	No COPCs reported above background	None
No Action	331 LSLDF	--	None	No COPCs reported above background	None
600 Area Subregion					
300-FF-1					
Closed Out	618-4	--	None	1×10^{-4} to 1×10^{-6}	None
	628-4	--	None	$< 1 \times 10^{-6}$	None

Table 6-16. Summary of Total Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Resident Worker Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	ELCR[b]	Risk Driver and % Contribution
300-FF-2					
Interim Closed Out	618-3	--	Shallow Focused	1.2×10^{-4}	Uranium-235 (2.2×10^{-5} - 19%) Uranium-238 (8.5×10^{-5} - 74%)
	600-47 618-7 618-9	--	None	1×10^{-4} to 1×10^{-6}	None
	618-13	600-290:1			
	618-8	--	None	$<1 \times 10^{-6}$	None
	600-243 618-5 600-259	--	None	No COPCs reported above background	None

Note: Results summarized from Table G-62, Resident Monument Worker Scenario Risk Estimates and Noncancer Hazards for 300 Area Source Operable Unit Waste Site Decision Units Without Background Contribution.

a. Associated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. ELCR represents risk contributions from radiological COPCs.

Shallow Zone. A total of 40 waste sites are reported with CVP/RSVP data in the 300 Area Source OU. The following lists the sample designs that were applied to the 40 waste sites evaluated:

- Eleven waste sites were sampled using a focused sampling design.
- Twenty waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units and two waste sites with three statistically distinct decision units).
- Nine waste sites were sampled using both a statistical and a focused sampling design (with one site having two statistically distinct decision units and one waste sites with four statistically distinct decision units).

The overall total risk summary for the worker from all shallow zone waste sites evaluated is provided in Table 6-16. Table 6-16 lists the OU and subarea that each waste site resides in, the reclassification status, the remediated waste site, the consolidated waste site (if applicable), the decision unit reported with an exceedance (if applicable), the total ELCR, and the risk driver and percent contribution (if applicable).

As presented in Table 6-16, the total ELCR is greater than the upper risk threshold of 1×10^{-4} at four remediated waste sites, is within the regulatory target risk range of 10^{-6} to 10^{-4} at 21 remediated waste sites, and is less than the lower risk threshold of 1 x 10-6 at two remediated waste sites. Risks were not reported at 10 remediated waste sites because there were no radiological COPCs reported above background concentrations. The four remediated waste sites listed below are located in the 300 Area industrial complex and were remediated using industrial RAGs. The cancer risks levels for the resident worker scenario are as follows:

- The 316-1waste site (shallow 3 decision unit) reports a cumulative ELCR of 1.1×10^{-4} for the resident Monument worker. The primary contributors to risk are Co-60 (7.5×10^{-5}; 66 percent contribution) and U-238 (2.2×10^{-5}; 21 percent contribution) The total risk for the residential scenario at this waste site is 1.5×10^{-4} which is approximately 37 percent greater than the total risk for the resident Monument worker.
- The 316-2 waste site (shallow 1 decision unit) reports a cumulative ELCR of 1.4×10^{-4} for the resident Monument worker. The primary contributors to risk are U-235 (5.6×10^{-5}; 39 percent contribution) and U-238 (7.4×10^{-5}; 52 percent contribution). The total risk for the residential scenario at this waste site is 2.7×10^{-4}, which is approximately two times greater than the total risk for the resident Monument worker.
- The 316-2 waste site (shallow 2 decision unit) reports a cumulative ELCR of 1.8×10^{-4} for the resident Monument worker. The primary contributors to risk are U-235 (5.1×10^{-5}; 38 percent contribution) and U-238 (1.0×10^{-4}; 57 percent contribution). The total risk for the residential scenario at this waste site is 3.5×10^{-4}, which is approximately two times greater than the total risk for the resident Monument worker.
- The 316-5 waste site (shallow 1 decision unit) reports a cumulative ELCR of 2.2×10^{-4} for the resident Monument worker. The primary contributors to risk are Cs-137 (3.7×10^{-5}; 17 percent contribution), U-235 (8.5×10^{-5}; 39 percent contribution), and U-238 (9.6×10^{-5}; 44 percent contribution). The total risk for the residential scenario at this waste site is 3.3×10^{-4}, which is approximately 1.5 times greater than the total risk for the resident Monument worker.
- The 316-5 waste site (shallow 2 decision unit) reports a cumulative ELCR of 1.5×10^{-4} for the resident Monument worker. The primary contributors to risk are Cs-137 (2.8×10^{-5}; 19 percent contribution), U-235 (8.5×10^{-5}; 31 percent contribution), and U-238 (7.3×10^{-4}; 50 percent

contribution). The total risk for the residential scenario at this waste site is 2.2×10^{-4}, which is approximately 1.5 times greater than the total risk for the resident Monument worker.

- The 316-5 waste site (shallow focused decision unit) reports a cumulative ELCR of 1.1×10^{-4} for the resident Monument worker. The primary contributors to risk include Cs-137 (2.9×10^{-5}; 26 percent contribution), U-235 (3.5×10^{-5}; 31 percent contribution), and U-238 (4.9×10^{-5}; 43 percent contribution). The total risk for the residential scenario at this waste site is 1.7×10^{-4}, which is approximately 1.5 times greater than the total risk for the resident Monument worker.

- The 618-3 waste site (shallow focused decision unit) reports a cumulative ELCR of 1.2×10^{-4} for the resident Monument worker. The primary contributors to risk are U-235 (2.2×10^{-5}; 19 percent contribution) and U-238 (8.5×10^{-5}; 74 percent contribution). The total risk for the residential scenario at this waste site is 2.4×10^{-4}, which is approximately two times greater than the total risk for the resident Monument worker.

The resident Monument worker scenario results for shallow vadose zone materials are summarized in Table G-63 (Appendix G). As presented in Table G-63 (Appendix G), the potential cumulative ELCR from direct contact for all radiological COPCs without background contribution ranges from 1.2×10^{-7} to 2.2×10^{-4} for 36 of the 54 shallow zone decision units. The potential cumulative ELCR is greater than the upper range of the regulatory target risk threshold value of 1×10^{-4} for seven decision units; is within the regulatory target risk range of 10^{-6} to 10^{-4} for 26 decision units and is less than the lower risk threshold of 1×10^{-6} for three decision units. Radiological COPCs were not reported at 18 decision units. All individual radiological COPCs were reported with a risk less than or equal to 1×10^{-4}.

Overburden. A total 11 waste sites are reported with CVP/RSVP data associated with overburden in the 300 Area Source OU. Of the 11 waste sites, three waste sites were sampled using a focused sampling design and eight waste sites were sampled using a statistical sampling design (with one site having three statistically distinct decision units). One decision unit (300-23) did not report any analytes with an associated RBSL, resulting in 12 overburden decision units for evaluation. The resident Monument worker scenario results for overburden materials are summarized in Table G-64 (Appendix G).

As presented in Table G-64 (Appendix G), potential cumulative ELCR from all radiological COPCs without background contribution ranges from 1.7×10^{-6} to 3.0×10^{-5} for 4 of the 12 overburden decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for the four decision units. Radiological COPCs were not reported at eight decision units.

Staging Pile Area. A total three waste sites are reported with CVP/RSVP data associated with staging pile areas in the 300 Area Source OU. Of the three waste sites, one waste site was sampled using a focused sampling design and two waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units). The resident Monument worker scenario results for staging pile area footprint materials are summarized in Table G-65 (Appendix G).

As presented in Table G-65 (Appendix G), the potential cumulative ELCR from all radiological COPCs without background contribution ranges from 1.3×10^{-6} to 5.0×10^{-6} for the four staging pile area decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for the four decision units.

6.2.5.5.4 Casual Recreational User Scenario

The casual recreational user represents reasonably anticipated future land use. The results of this comparison are used to confirm that cleanup actions are protective of the reasonably foreseeable land uses

that DOE and USFWS anticipate for the River Corridor. The casual recreational user scenario is described in Section 6.2.3.3.

For completeness in analysis, risk estimates for each waste site decision unit are provided in Appendix G, which includes all COPCs regardless of their EPCs relative to the background value (Tables G-66 through G-69).

Appendix G also includes risk estimates for each waste site decision unit, which includes only those COPCs with EPCs greater than background values or that do not have a background value (Tables G-70 through G-73). Only these results are discussed in the risk characterization because it is this information that is used for decisions concerning appropriate remedial actions.

Risk estimates were calculated for the shallow zone, overburden, and staging pile area decision units within a waste site. Risk estimates were not calculated for the deep zone decision units because the direct contact exposure pathway is incomplete (i.e. samples are collected from depths greater than 4.6 m [15 ft] bgs). The results without background contribution for the casual recreational user scenario are presented in Table G-70 (Appendix G). An overall summary of the cumulative risk estimates for each of the waste sites evaluated is provided in Table 6-17 for the shallow zone.

Shallow Zone. A total of 40 waste sites are reported with CVP/RSVP data in the 300 Area Source OU. The following lists the sample designs that were applied to the 40 waste sites:

- Eleven waste sites were sampled using a focused sampling design.
- Twenty waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units and two waste sites with three statistically distinct decision units).
- Nine waste sites were sampled using both a statistical and a focused sampling design (with one site having two statistically distinct decision units and one waste sites with four statistically distinct decision units).

The overall total risk summary for the casual recreational user from all shallow zone waste sites evaluated is provided in Table 6-17. Table 6-17 lists the OU and subarea that each waste site resides in, the reclassification status, the remediated waste site, the consolidated waste site (if applicable), the decision unit reported with an exceedance (if applicable), the total ELCR, and the risk driver and percent contribution (if applicable).

As presented in Table 6-17, the total ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} at 15 remediated waste sites and is less than the lower risk threshold of 1×10^{-6} at 17 remediated waste sites. Risks were not reported at eight remediated waste sites because no COPCs were reported above background concentrations. The four remediated waste sites listed below are located in the 300 Area industrial complex and were remediated using industrial RAGs. The cancer risks levels for the casual recreational user scenario are as follows.

The casual recreational user scenario results for shallow vadose zone materials are summarized in Table G-71 (Appendix G).

As presented in Table G-71 (Appendix G), the potential cumulative ELCR from direct contact for all radiological COPCs without background contribution ranges from 2.0×10^{-8} to 1.7×10^{-5} for 36 of the 54 shallow zone decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for 16 decision units and is less than the lower risk threshold of 1×10^{-6} for 20 decision units. Radiological COPCs were not reported at 18 decision units.

Table 6-17. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Casual User Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
300 Area Industrial Complex					
300-FF-1					
Closed Out	316-1	300 RFBP UPR-300-32 UPR-300-33 UPR-300-34 UPR-300-35 UPR-300-36 UPR-300-37 UPR-300-FF-1	None	1×10^{-4} to 1×10^{-6}	None
	316-5	UPR-300-15 UPR-300-19 UPR-300-20 UPR-300-21 UPR-300-22 UPR-300-23 UPR-300-24 UPR-300-25 UPR-300-26 UPR-300-27 UPR-300-28 UPR-300-29 UPR-300-30 UPR-300-47 UPR-300-8 UPR-300-9			
	316-2 300-44 300-50 618-12	--			
	300 Ash Pits 300-49	--	None	$<1 \times 10^{-6}$	None
300-FF-2					
Closed Out	See 316-1 (300-FF-1)	300-262			

Table 6-17. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Casual User Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
Interim Closed Out	300-275 618-2 UPR-300-17 300-10 300-37	--	None	1×10^{-4} to 1×10^{-6}	None
	618-1	300-110 303-M UOF 303-M SA 333 ESHWSA			
	300-259 UPR-300-46 300-109 300-260 300-45 300-33 300-41 300-256	--	None	$<1 \times 10^{-6}$	None
	300 VTS 300-18 300-8 300-223 300-23 300-272	--	None	No COPCs reported above background	None
No Action	331 LSLDF	--	None	$<1 \times 10^{-6}$	None
600 Area Subregion					
300-FF-1					
Closed Out	618-4 628-4	--	None	$<1 \times 10^{-6}$	None

Table 6-17. Summary of Risks for 300-FF-1 OU and 300-FF-2 OU Shallow Zone Waste Sites for the Casual User Scenario

Classification Status	Remediated Waste Site	Consolidated Waste Site[a]	Decision Unit with Exceedance	Total ELCR[b]	Risk Driver and % Contribution
300-FF-2					
Interim Closed Out	618-3 618-7 618-9	--	None	1×10^{-4} to 1×10^{-6}	None
	600-243 600-47 618-8	--	None	$<1 \times 10^{-6}$	None
	618-13	600-290:1			
	618-5 600-259	--	None	No COPCs reported above background	None

Note: Results summarized from Table G-70, Casual Recreational User Scenario Risk Estimates and Noncancer Hazards for 300 Area Source OU Waste Site Decision Units Without Background Contribution.

a. Associated waste sites are those sites for which remediation and closeout documentation were consolidated with another remediated waste site.

b. Total ELCR represents risk contributions from both radiological and nonradiological COPCs.

As presented in Table G-71 (Appendix G), the potential cumulative ELCR for direct contact from all nonradiological COPCs without background contribution ranges from 6.6×10^{-13} to 1.0×10^{-5} for 31 of the 54 shallow zone decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for eight decision units and is less than the lower risk threshold of 1×10^{-6} for 23 decision units. No individual nonradiological carcinogenic COPCs were reported with risk of greater than 1×10^{-4}. Nonradiological carcinogenic COPCs were not reported at 23 decision units.

As shown in Table G-71 (Appendix G), the potential HI from noncancer effects without background is less than 1 for all shallow zone decision units. The potential HI is less than the EPA target HI of 1.

Overburden. A total of 13 overburden decision units (from 11 waste sites) are in the 300 Area Source OU. Of the 11 waste sites, three waste sites were sampled using a focused sampling design and eight waste sites were sampled using a statistical sampling design (with one site having three statistically distinct decision units). One decision unit (300-23) did not report any analytes with an associated RBSL, resulting in 12 overburden decision units for evaluation. The casual recreational user scenario results for overburden soils are summarized in Table G-72 (Appendix G).

As shown in Table G-72 (Appendix G), the potential cumulative ELCR from direct contact for all radiological COPCs without background contribution ranges from 1.5×10^{-7} to 2.3×10^{-6} for four of the 12 overburden decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for one decision unit and is less than the lower risk threshold of 1×10^{-6} for three decision units. Radiological COPCs were not reported at eight decision units.

As presented in Table G-72 (Appendix G), the potential cumulative ELCR for direct contact from all nonradiological COPCs without background contribution ranges from 1.5×10^{-10} to 2.0×10^{-6} for four of the 12 overburden decision units. The potential cumulative ELCR is within the regulatory target risk range of 10^{-6} to 10^{-4} for three decision units and is less than the lower risk threshold of 1×10^{-6} for one decision unit. No nonradiological carcinogenic COPCs were reported with an individual ELCR greater than 1×10^{-4}. Nonradiological carcinogenic COPCs were not reported at eight decision units.

As shown in Table G-72 (Appendix G), the potential HI from noncancer effects without background contribution is less than 1 for all overburden decision units. The potential HI is less than the EPA target HI of 1.

Staging Pile Area. There are four staging pile area decision units from three waste sites in the 300 Area Source OU. Of the three waste sites, one waste site was sampled using a focused sampling design and two waste sites were sampled using a statistical sampling design (with one site having two statistically distinct decision units). The casual user scenario results for staging pile area footprint materials are summarized in Table G-73 (Appendix G).

As shown in Table G-73 (Appendix G), the potential cumulative ELCR from direct contact for all radiological COPCs without background contribution ranges from 1.2×10^{-7} to 6.0×10^{-7} for the four staging pile area decision units. The potential cumulative ELCR is less than the lower risk threshold of 1×10^{-6} for all four decision units.

As presented in Table G-73 (Appendix G), the potential cumulative ELCR for direct contact from all nonradiological COPCs without background contribution is 6.0×10^{-8} for one of the four staging pile area decision units. The potential cumulative ELCR is less than the lower risk threshold of 1×10^{-6} for the decision unit. Nonradiological carcinogenic COPCs were not reported at three decision units.

As shown in Table G-73 (Appendix G), the potential HI from noncancer effects without background contribution is less than 1 for all staging pile area decision units. The potential HI is less than the EPA target HI of 1.

6.2.6 Uncertainties in the Supplemental Soil Risk Evaluation

The purpose of this risk assessment is to determine whether a further remedial action is warranted under CERCLA. Waste sites included in this supplemental risk evaluation represent current site conditions following remedial actions documented in the 300 Area RDR/RAWP (DOE/RL-2001-47). Estimating and evaluating health risk from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge, and simplifying assumptions must be made to quantify health risks.

In this assessment, uncertainties are associated with sampling and analysis data, sampling design, the EPCs, radiological decay, exposure, toxicity assumptions, and risk characterization.

6.2.6.1 Uncertainties Associated with Sampling and Analysis Data

Sampling and analysis data used in this supplemental soil risk evaluation represent post-remediation conditions of waste sites with a "no action," "closed," or an "interim closed" remediation status. All samples were collected in accordance with the requirements stated in *300 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-48). These data were collected specifically to determine if the remedial action processes implemented under the work plan met the RAOs and RAGs stated in the records of decisions listed in Section 6.2.1.1.

Some uncertainties may be associated with the changing requirements associated with the analysis of COCs identified in each ROD. When remediation initially began in 1997, only those analytes identified as COCs were analyzed and reported by the laboratory. However, as remediation continued, analytical methods improved, guidance was superseded, and reporting requirements changed. Currently, analytes identified as COCs are analyzed using a methods-based approach, which requires each laboratory to report the concentration of the COC and all associated target analytes included in the analytical method.

Waste sites associated with the earliest interim action RODs are generally the radioactive high volume liquid effluent sites. In general, verification samples collected to determine if RAOs had been met report fewer analytes than those that have been remediated more recently. Waste sites that are associated with the remaining sites interim action ROD tend to have verification samples analyzed using a methods-based approach. These generally include burial grounds and waste sites identified during discovery process. Risks may be understated for waste sites that did not implement a method-based approach for sampling because fewer analytes are reported.

6.2.6.2 Uncertainties Associated with Sampling Design and Exposure Point Concentrations

Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10) recommends using a UCL-95 for estimating EPCs. Section 6.2.2.2 describes the methodology for calculating the EPCs for detected analytes.

When the following conditions were met, the maximum concentration rather than the UCL-95 was selected as the EPC:

- When samples are collected using a focused sampling design
- When a valid UCL-95 cannot be calculated due to small sample size
- When a valid UCL-95 is greater than the maximum detected concentration

When these conditions are met, statistical bias is introduced resulting in the potential to overstate risk.

In addition, EPCs selected for shallow zone and deep zone decision units represent verification data collected from the floor and the sidewall of the excavated waste site. As a result, risks are likely overstated because the EPC does not take credit for the existing clean backfill that covers the remediated waste site.

6.2.6.3 Uncertainties Associated with Decay of Radioisotopes

Section 6.2.5.1 provides a summary of the risk estimates by exposure scenario evaluated. The results of the supplemental risk evaluation for the residential scenario identified a group of waste sites with concentrations of site-related COPCs that result in individual risks greater than the upper range of the regulatory target threshold of 1×10^{-4}. Table G-74 (Appendix G) lists the 300 Area waste sites, the radioisotopes reported with concentrations greater than their respective residential RBSL for each waste site, the year the samples were collected, the EPCs, the half-life for each radioisotope, and the year that each radioisotope decays to an activity level less than the residential RBSL. Deep zone soil samples are collected from depths greater than 4.6 m (15 ft) bgs. As a result, contact within the point of compliance is incomplete. Additionally, the residential exposure scenario does not reflect reasonably anticipated future land use in the River Corridor. This comparison is included because it is the most conservative land use basis for the evaluation of waste sites and presentation of these results is only included to provide additional information for risk management decisions.

The elapsed time at which the activity level would decay below the residential RBSL is based on the radioactive decay law using the following equation:

$$\tau = \frac{\log \frac{A_E}{A_O}}{\log 0.5} \times \tau \frac{1}{2}$$

where:

A_E = The remaining amount of substance (the PRG) (pCi/g)
A_O = The original amount of substance (the EPC) (pCi/g)
$\tau ½$ = The half-life of the substance (years)
τ = The elapsed amount of time (years)

Concentrations of radioisotopes currently measured at depths greater than 4.6 m (15 ft) bgs or deep decision units decay to activity levels less than residential RBSLS, specifically at 618-2 waste site, deep focused will decay to levels less than residential RBSLs in 2054.

Uranium-233/234 is reported at the 618-2 waste site, U-235 is reported at the 316-5 waste site, and U-238 is reported at the 618-1, 618-2, 316-2, 316-5, and 618-3 waste sites at concentrations that result in risks above 1×10^{-4}. Decay does not occur within a reasonable period for uranium isotopes and are not included above.

6.2.6.4 Uncertainties Associated with Exposure Assumptions

The exposure assumptions used to develop the RBSLs for each exposure scenario represent an RME. For estimating the RME, 95 percentile values (or upper-bound estimates of national averages) are generally used for exposure assumptions, and exposed populations and exposure scenarios are selected to represent upper-bound exposures. The intent of the RME, as discussed by the EPA Deputy Administrator and the Risk Assessment Council in "Guidance on Risk Characterization for Risk Managers and Risk Assessors"

(Habicht, 1992), is to present risks as a range from central tendency to high-end risk (above the 90th percentile of the population distribution). This descriptor is intended to estimate the risks that are expected to occur in small but definable "high-end" segments of the subject population ("Guidance on Risk Characterization for Risk Managers and Risk Assessors" [Habicht, 1992]). EPA distinguishes between those scenarios that are possible but highly improbable and those that are conservative but more likely to occur within a population, with the latter being favored in risk assessment. In general, these assumptions are intended to be conservative and yield an upper bound of the true risk or hazard.

6.2.6.5 Uncertainties Associated with Toxicity Assessment

The toxicological database was also a source of uncertainty. EPA has outlined some of the sources of uncertainty as defined in *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final* (EPA/540/1-89/002) and in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). These sources may include or result from the extrapolation from high to low doses and from animals to humans. This is contingent on the species, gender, age, and strain differences in the uptake, metabolism, organ distribution, and target site susceptibility of a toxin. The human population's variability with respect to diet, environment, activity patterns, and cultural factors are also sources of uncertainty.

Traditionally, EPA has developed toxicity criteria for carcinogens by assuming that all carcinogens are nonthreshold contaminants. However, EPA has recently published revised cancer guidelines (*Guidelines for Carcinogen Risk Assessment* [EPA/630/P-03/001F]) where they have modified their former position of assuming nonthreshold action for all carcinogens. This new guidance emphasizes establishing the specific toxicokinetic mode of action that leads to development of cancer. In the future, toxicity criteria for carcinogens in the United States will be developed assuming no threshold for contaminants that exhibit genotoxic modes of action, or where the mode of action is not known. However, currently available EPA toxicity criteria for carcinogens were all derived assuming a nonthreshold model.

In most of the world, nonthreshold toxicity criteria are developed only for those carcinogens that appear to cause cancer through a genotoxic mechanism (Health Canada, Netherlands). Specifically, for genotoxic contaminants, the cancer dose-response model is based on high-dose to low-dose extrapolation. In addition, the model assumes there is no lower threshold for the initiation of toxic effects. Cancer effects observed at high doses are found in laboratory animals or are extrapolated from occupational or epidemiological studies. Cancer effects observed at low doses are commonly found in environmental exposures. These models are essentially linear at low doses, so no dose is without some risk of cancer.

6.2.6.6 Slope Factors for Cr(VI)

The oral RfD of 0.003 mg/kg day published by IRIS is used to develop the "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) and "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745) direct contact soil cleanup levels for Cr(VI). NJDEP has recently published an oral carcinogenic potency factor of 0.5 $(mg/kg\text{-}day)^{-1}$ (*Derivation of an Ingestion-Based Soil Remediation Criterion for Cr+6 Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate* [NJDEP, 2009]). If the NJDEP value were used, the direct contact soil cleanup levels would decrease from 240 mg/kg to 2.0 mg/kg for the "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740) and from 10,500 mg/kg to 26 mg/kg for the "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745). The use of the oral RfD published by IRIS may result in underestimating risk.

6.2.6.7 Uncertainties Associated with Risk Characterization

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, did not account for the possibility that constituents act synergistically or antagonistically, resulting in an overestimation or underestimation of risk.

6.2.6.8 Uncertainties Associated with Risks and Health Effects Calculated for Total Uranium

For comparison purposes, isotopic uranium concentrations (expressed as pCi/g) were converted to total uranium as mass (expressed as µg/kg) and compared to the U-238 cancer effects PRG converted to a total uranium PRG (expressed as µg/kg) and the MTCA B direct contact PRG for uranium (metal). The results for the shallow zone decision units are summarized in Table G-75 (Appendix G).

As presented in Table G-75 (Appendix G), the potential cumulative ELCR from calculated total uranium without background contributions ranges from 2.2×10^{-6} to 1.8×10^{-4} for 32 of the 54 shallow zone decision units. Isotopic uranium was analyzed for but not detected at three decision units and isotopic uranium was not analyzed at five decision units. The potential cumulative ELCR is greater than the upper range of the regulatory target risk threshold value of 1×10^{-4} for five decision units, is within the regulatory target risk range of 10^{-6} to 10^{-4} for 27 decision units. The calculated total uranium concentration did not exceed Hanford Site background at 14 decision units.

As presented in Table G-76 (Appendix G), the potential uranium HQ from direct contact for noncancer effects, without background contribution, ranges from less than 1 to 1.2 for the shallow zone decision units. Uranium was reported with an HQ greater than 1 at two decision units, 316-2 Shallow 2 (1.2) and 316-5 Shallow 1 (1.1).

As shown in Table G-76 (Appendix G), the results for this comparison are similar to those presented for the residential scenario in Section 6.2.5.1 which are based on isotopic uranium activities. Three waste sites (five decision units) report concentrations of total uranium that exceed the upper range of the regulatory target threshold, described as follows:

- The total calculated uranium EPC at 316-2 (shallow decision unit 1) is 210 mg/kg which is greater than the residential RBSL of 161 mg/kg and results in a risk of 1.3×10^{-4} and an HQ of 0.88. The EPC is also greater than the current total uranium unrestricted direct exposure RAG of 81 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

- The total calculated uranium EPC at 316-2 (shallow decision unit 2) is 291 mg/kg which is greater than the residential RBSL of 161 mg/kg and results in a risk of 1.8×10^{-4} and an HQ of 1.21. The EPC is also greater than the current total uranium unrestricted direct exposure RAG of 81 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

- The total calculated uranium EPC at 316-5 (shallow decision unit 1) is 272 mg/kg which is greater than the residential RBSL of 161 mg/kg which results in a risk of 1.7×10^{-4} and an HQ of 1.13. The EPCs is also greater than the current total uranium unrestricted direct exposure RAGs of 81 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

- The total calculated uranium EPC at 316-5 (shallow decision unit 2) is 205 mg/kg which is greater than the residential RBSL of 161 mg/kg and results in a risk of 1.3×10^{-4} and an HQ of 0.85. The

EPC is also greater than the current total uranium unrestricted direct exposure RAG of 81 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

- The total calculated uranium EPC at 618-3 (shallow focused decision unit) is 239 mg/kg which is greater than the residential RBSL of 161 mg/kg and results in a risk of 1.5×10^{-4} and HQ of 0.99. The EPC is also greater than the current total uranium unrestricted direct exposure RAG of 81 mg/kg published in the 300 Area RDR/RAWP (DOE/RL-2001-47).

As shown above, the primary contributors to risk in shallow zone decision units is uranium and both calculation methods result in a comparable risk estimate.

6.3 Supplemental Groundwater Risk Evaluation

EPA guidance provided in a "Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration" (Woolford and Redder, 2009, page 4), clarifies EPA's policies for determining whether a groundwater remedial action is warranted under CERCLA. In discussing the role of the BRA, "Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration" (Woolford and Redder, 2009) quotes the preamble to the NCP (40 CFR 300):

> *The results of the baseline risk assessment are used to determine whether remediation is necessary, to help provide justification for performing remedial action, and to assist in determining what exposure pathways need to be remediated.*

"Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration" (Woolford and Redder, 2009) then continues to clarify when a CERCLA remedial action is appropriate (page 5):

> *A CERCLA remedial action generally is appropriate[9] in various circumstances, including: a regulatory standard that helps define protectiveness (e.g., a federal or state MCL or nonzero MCLG for current or potential drinking water aquifers) is exceeded; when the estimated risk calculated in a risk assessment exceeds a noncarcinogenic level for an adverse health effect or the upper end of the NCP risk range for 'cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use;[10] the noncarcinogenic hazard index is greater than one (using reasonable maximum exposure assumptions for either the current or reasonably anticipated future land use); or the site contaminants cause adverse environmental impacts.[11] It is important to note that all conditions do not need to be present for action and the conditions may be independent of each other.*

EPA guidance provided in "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (Clay, 1991), describes how to use the BRA to make risk management decisions such as determining whether remedial action under CERCLA Section 104 or Section 106 is necessary. The "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (Clay, 1991), describes the following conditions when a CERCLA action is generally warranted:

- The BRA indicates that a cumulative site risk to an individual using RME assumptions for either current or future land use exceeds the 10^{-4} ELCR end of the risk range.
- For groundwater actions, MCLs and non-zero maximum contaminant limit goals (MCLGs) will generally be used to gauge whether remedial action is warranted.

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[9] See EPA 540-R-97-013, *Rules of Thumb for Superfund Remedy Selection*.

[10] See Clay, 1991, "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions."

[11] See EPA 540-R-97-013, *Rules of Thumb for Superfund Remedy Selection*.

- Chemical-specific standards that define acceptable risk levels also may be used to determine whether an exposure is associated with an unacceptable risk to HHE and whether remedial action is warranted.

Protectiveness of human health is evaluated by comparing groundwater concentrations to existing federal or state MCLs or nonzero MCLGs. Similarly, protectiveness of aquatic receptors is determined by the comparison of groundwater concentrations to water quality criteria established under Section 304 or Section 303 of the *Clean Water Act of 1977* as well as Washington State water quality standards. Groundwater concentrations are compared to MTCA "Ground Water Cleanup Standards" (WAC 173-340-720) and MTCA "Surface Water Cleanup Standards" (WAC 173-340-730), to determine whether EPCs exceed an HI greater than one. The EPCs also are used to calculate ELCRs that are compared to the upper end of the NCP risk range for cumulative carcinogenic site risk to an individual based on RME for both current and future land use.

EPA guidance provided in "Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA" (Fields, 1997) clarifies the relationship between two statutory mandates of CERCLA: (1) protect HHE, and (2) attain or waive, if justified, based on site-specific circumstances, ARARs. It remains EPA's policy that ARARs will generally be considered protective, absent multiple contaminants or pathways of exposure. However, the guidance clarifies that, in rare situation, even absent multiple pathways or contaminants PRGs should be set at levels more protective than required by a given ARAR, where application of the ARAR would not be protective of HHE.

A supplemental groundwater risk evaluation was performed for the 300-FF-5 Groundwater OU. The 300-FF-5 Groundwater OU includes all groundwater in the 300, 400, and 600 Areas impacted by waste sites. There are two primary groundwater plumes within the 300-FF-5 Groundwater OU, The first plume is located within the 300 Area Subregion beneath the Hanford Site Industrial Complex and is comprised of uranium, TCE, nitrate, and cis-1,2-dichloroethene. The second plume is located within the 600 Area Subregion that is beneath the 618-11 Burial Ground and the 618-10/316-4 Cribs and is comprised of tritium and nitrate.. The supplemental groundwater risk evaluation for the 300-FF-5 Groundwater OU followed the strategy outlined as follows:

- Evaluate current groundwater data to identify contaminants present in groundwater. Analytical measurement data collected to resolve spatial, chemical, and temporal uncertainties described in the Integrated Work Plan (DOE/RL-2008-46) were used.
- Identify action levels for detected contaminants, using ARARs to establish a basis for screening COPCs.
- Compare the detected contaminant concentrations to ARARs in order to identify initial COPCs within the 300-FF-5 Groundwater OU and for 600 Area Subregion.
- Further evaluate the COPCs to identify and refine a set of COPCs for each of the exposure areas (the 300-FF-5 Groundwater OU and the 600 Area Subregion).
- Conduct the risk characterization step on the set of COPCs, including a determination that ARARs have been exceeded.

Results of this supplemental groundwater risk evaluation indicate that concentrations of contaminants in the 300-FF-5 Groundwater OU exceed action levels, and warrant investigation in an FS to address groundwater contamination within the OU. The COPCs represent contaminants that will be evaluated in the FS to define the COCs and select remedial alternatives. The conceptual exposure model shows that exposure to groundwater contaminants is through direct contact and fish consumption, while other

exposure pathways are considered incomplete or insignificant. The supplemental groundwater risk evaluation identifies multiple contaminants within the 300-FF-5 Groundwater OU that exceed chemical-specific ARARs. MTCA, HHRA Procedures (WAC 173-340-708(5)(a) and WAC 173-340-708(6)(b)) require that cleanup levels be adjusted downward to take into account exposure to multiple hazardous substances or multiple pathways of exposure. This adjustment needs to be made only if, without this adjustment, the HI would exceed 1, or the total ELCR would exceed 1 in 100,000 (1×10^{-5}). As a result, the supplemental groundwater risk evaluation does not identify the need to develop cleanup levels that are more protective than ARARs because the risk characterization indicates that concentrations of contaminants do result in cumulative risks greater than 1 in 100,00 or a HI of 1.

Additionally, several local and regional Tribes have ancestral ties to the Hanford Reach of the Columbia River and surrounding lands. DOE has requested that each Tribe provide an exposure scenario that reflects their traditional activities. At this time, the CTUIR (Harris and Harper, 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*) and the Yakama Nation (*Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* [Ridolfi Inc., 2007]) have provided scenarios. A quantitative risk evaluation is included for both Tribal use scenarios to evaluate each of the potentially complete groundwater exposure pathways. The results for the Native American Risk Assessment are provided in *Native American Risk Assessment for the 300-FF-5 Groundwater Operable Unit* (hereinafter called Native American Risk Assessment for 300-FF-5 [ECF-300FF5-11-0132]) (Appendix G) and in *Native American Risk Assessment for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (hereinafter called Native American Risk Assessment for 600 Area Subregion [ECF-300FF5-11-0132]) (Appendix G). Section 6.3.6 provides a summary of this evaluation. A quantitative evaluation of human health risk to a resident from exposure to tap water is included for comparison to the Native American Risk Assessment. The results of the Tap Water Risk Assessment are provided in *Tap Water Risk Assessment for the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0134) and *Tap Water Risk Assessment for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0135).

6.3.1 Findings of the River Corridor Baseline Risk Assessment

The RCBRA Report (DOE/RL-2007-21) provides a screening level groundwater risk assessment to evaluate potential risks associated with groundwater exposure for the southern portion of the 300 and 600 Areas and within the 300 Area. The results of the groundwater screening-level risk assessment indicate potential risk above the EPA thresholds within the 300-FF-5 Groundwater OU. Noncancer chemical hazard results were also above the EPA's threshold value of 1.

Uncertainties associated with the groundwater data set were identified in the RCBRA Report (DOE/RL-2007-21). These uncertainties relate to the ability of the groundwater data set collected from 1998 to 2008 to represent current baseline conditions and potential exposure within each groundwater OU. Analytical data used for the screening level assessment were collected to fulfill a variety of state and federal regulations, including RCRA, CERCLA, AEA, and Section 173 of the WAC. While the monitoring data can be used for risk assessment purposes, there are uncertainties associated with its use. Specifically, target analytes, sampling frequencies, and MDLs (or reporting limits) are different between programs because the information is used to meet different requirements.

As a result of the uncertainties identified in RCBRA, the 300 Area Work Plan (DOE/RL-2008-43) added activities that would help reduce uncertainties, verify conclusions of the HHRA presented in RCBRA Volume II (DOE/RL-2007-21), and ensure that no contaminants were inadvertently overlooked based on the use of the existing data set. Section 3.6.5.1 of the 300 Area Work Plan (DOE/RL-2008-43) identifies the following activities to reduce uncertainties:

- Identify existing and/or install new monitoring wells that are spatially representative of the groundwater. This set of wells will represent locations where a receptor potentially could contact groundwater.
- Conduct multiple rounds of sampling to obtain temporal representation of the unconfined aquifer from influence of river stage. Additional rounds of sampling at spatially representative monitoring wells will represent current groundwater conditions and capture the influence of river fluctuations on COPC concentrations.
- Analyze all spatially representative monitoring wells for a focused list of groundwater COPCs identified for each round of sampling. Analyzing each of the monitoring wells for COPCs will provide a data set that is representative of potential releases to the groundwater.
- Evaluate sample results from characterization activities to support final remedial action decisions for groundwater.

The RCBRA evaluated exposure to groundwater for three residential scenarios (subsistence farmer, CTUIR resident, and Yakama resident scenarios) and the residential component of the resident Monument worker exposure scenario. Direct exposure to contaminants in groundwater was evaluated for household uses of groundwater in each of these scenarios, such as drinking and cooking (ingestion) and bathing (dermal absorption). If VOCs were measured in groundwater, indirect exposure by inhalation of VOCs in air may occur while bathing or when using groundwater in the home for other purposes. The inhalation pathway for VOCs associated with household use of groundwater is evaluated for VOCs that are identified as COPCs in groundwater. Additionally, ingestion, inhalation, and dermal exposures to COPCs in groundwater used in a sweat lodge were evaluated in the CTUIR resident and Yakama resident scenarios.

The results of the screening level groundwater risk assessment provided in the RCBRA identified tritium and uranium as the primary contributors to risk through ingestion of groundwater.

6.3.2 Identification of Contaminants of Potential Concern

The first step of this supplemental groundwater risk evaluation is data evaluation to select the COPCs for protection of HHE. A preliminary COPC evaluation was conducted to support preparation of the 300 Area RI/FS Work Plan (DOE/RL-2009-30) and 300 Area SAP (DOE/RL-2009-45). The work plan effort evaluated groundwater analytical data from the 300-FF-5 Groundwater OU that includes groundwater plumes from the 300 Area Subregion and the 600 Area Subregion collected over a 16-year period (1992 to 2008). Table 6-18 presents the 32 COPCs based on the evaluation of historic data in the work plan for the groundwater plume from the 300 Area Subregion of the 300-FF-5 Groundwater OU, and Table 6-19 presents the 22 COPCs for the 600 Area Subregion of the 300-FF-5 Groundwater OU.

The COPCs identified during the work plan phase were validated by using groundwater samples analyzed for the methods documented in the 300 Area SAP (DOE/RL-2009-45), Tables 2-7 and 2-8, respectively. The groundwater data set used for COPC identification consists of sampling and analysis data collected from 15 monitoring wells within the 300 Area Subregion and 17 monitoring wells within the 600 Area Subregion. The monitoring well network represents locations where human or ecological receptors could potentially encounter groundwater within the OU. The primary exposure pathway for humans is through groundwater obtained from a residential or community water well, assuming development of the land for future human habitation.

Table 6-18. List of Historical Contaminants of Potential Concern in the 300 Area Subregion

Contaminants of Potential Concern			
Metals			
Antimony	Arsenic	Cadmium	Chromium
Cobalt	Copper	Lead	Manganese
Mercury	Nickel	Selenium	Silver
Thallium	Uranium	Zinc	
Volatile Organic Compounds			
1,2-Dichloroethene (total)	Carbon tetrachloride	Chloroform	cis-1,2-Dichloroethene
Tetrachloroethene	Trichloroethene	Vinyl Chloride	
Radiological			
Strontium-90	Tritium	Uranium-233/234	Uranium-235
Uranium-238			
Anions			
Cyanide	Fluoride	Nitrate (as N)	Nitrite (as N)
Sulfate			

Source: DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2 and 300-FF-5 Operable Units*, Table 1-4.

Table 6-19. List of Historical Contaminants of Potential Concern in the 600 Area Subregion

Contaminants of Potential Concern			
Metals			
Antimony	Arsenic	Cadmium	Chromium
Copper	Lead	Manganese	Nickel
Uranium	Zinc		
Volatile Organic Compounds			
Carbon tetrachloride	Tetrachloroethene	Tributyl phosphate	Trichloroethene
Vinyl Chloride			
Radiological			
Iodine-129	Strontium-90	Tritium	
Anions			
Fluoride	Nitrate (as N)	Nitrite (as N)	Sulfate

Source: DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2 and 300-FF-5 Operable Units*, Table 1-5.

Identification of groundwater COPCs for the 300 Area Subregion and for the 600 Area Subregion is a two-step process. The first step of the process identifies analytes that will be carried forward to identify a set of COPCs for each of the groundwater subregions (i.e. 300 Area Subregion and the 600 Area Subregion). The set of COPCs are evaluated in the risk characterization step of the supplemental groundwater risk evaluation where a focused set of COPCs are identified for each groundwater subregion that will be evaluated in the FS. The process used to identify data for COPC selection and the selection of action levels for this supplemental groundwater risk evaluation is described in Sections 6.3.2.1 and 6.3.2.2. The process used to identify the COPCs and the methodology used to calculate EPCs is described in Section 6.3.2.3. The exposure assessment and toxicity assessment are presented in Sections 6.3.3 and 6.3.4, respectively. Finally, the risk characterization step is described in Section 6.3.5. The primary objective of this evaluation is to provide information necessary to identify what remedial actions will be necessary in the remedy selected for the 300 Area Subregion and the 600 Area Subregion.

6.3.2.1 Data Used to Identify Contaminants of Potential Concern

The sampling and analysis data used to identify COPCs for the 300 Area and the 600 Area Subregions were collected over a 6-month period between June 4, 2010 and December 20, 2010. Three sampling events were used to capture the effects that temporal fluctuations of river stage have on groundwater conditions. Samples collected in June to early July 2010 represent the aquifer when the river stage is at its highest elevation. Samples collected in August to mid-September 2010 represent the aquifer when the river is transitioning from high to low river stage. Samples collected from November through December 2010 represent the aquifer when the river is at its lowest elevation.

All monitoring wells used in this monitoring network were screened in the unconfined aquifer. All of the wells in the network were existing monitoring or compliance wells. Table 6-20 lists each well in the 300 Area Subregion and the 600 Area Subregion and Figure 6-6 shows their location.

Table 6-20. Monitoring Wells Used in the Supplemental Groundwater Risk Evaluation from the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

300 Area Subregion Groundwater Monitoring Wells		
399-1-10A	399-2-1	399-3-9
399-1-12	399-2-2	399-4-1
399-1-17A	399-3-12	399-4-12
399-1-21A	399-3-20	399-4-14
399-1-6	399-3-6	399-4-9
600 Area Subregion Groundwater Monitoring Wells		
99-S0-7	699-13-1E	699-S19-11
499-S0-8	699-13-2D	699-S28-E0
499-S1-8J	699-13-3A	699-S3-E12
699-1-18	699-15-15B	699-S6-E4A
699-12-4D	699-20-E5A	699-S8-19
699-13-1A	699-S18-E2B	

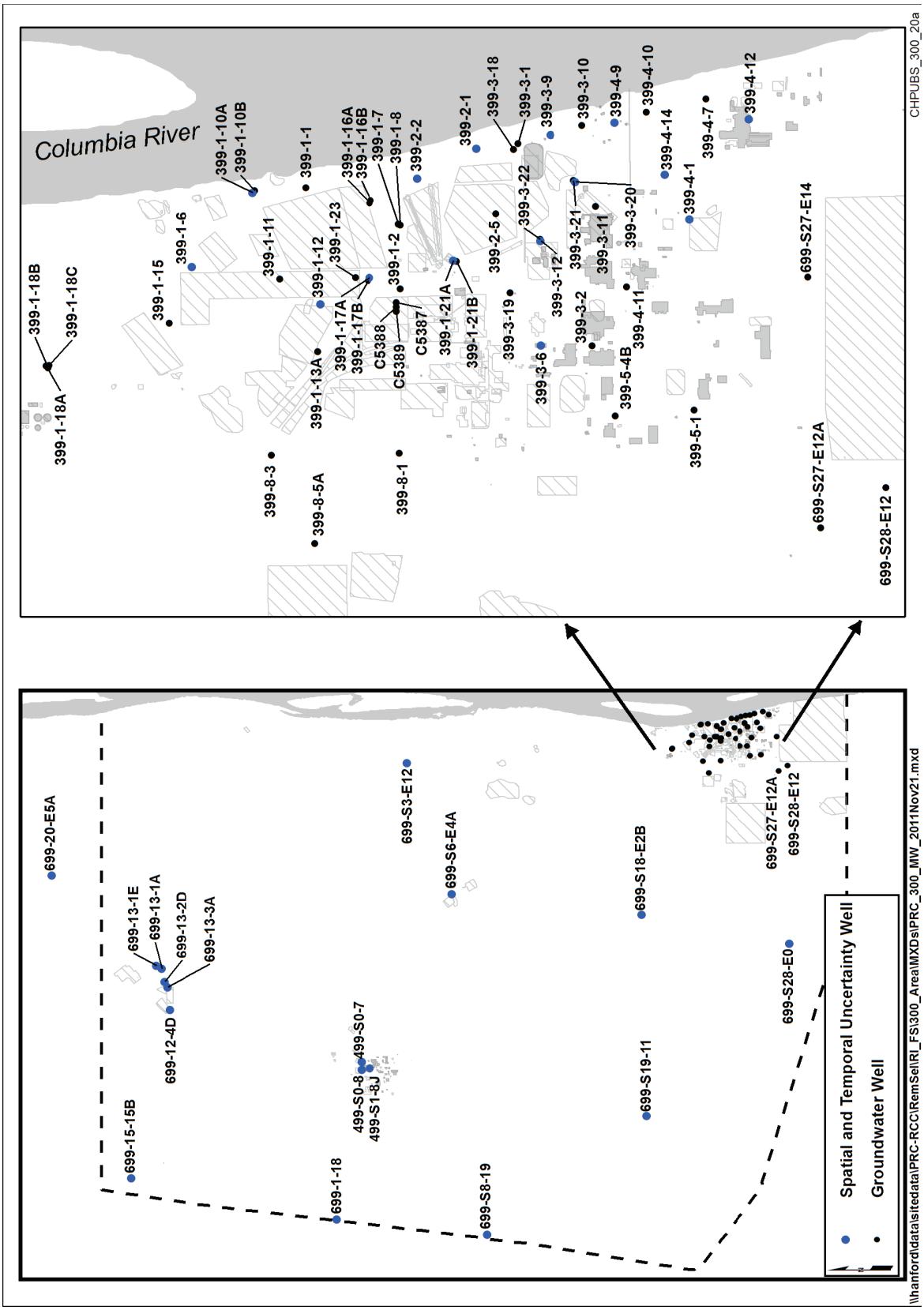

Figure 6-6. Groundwater Monitoring Wells within the 300 Area Subregion and the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

The analytical data set for the 300 Area Subregion and 600 Area Subregion evaluations are extracted from the HEIS database. After extraction, the analytical data are processed to obtain a single set of results per sampling location and time of collection. For the 300 Area Subregion data set, 7,978 records were obtained from HEIS. A total of 105 analytes were included in the data set prior to analytical data processing. After analytical data processing (as described in the next section), the final data set used for the COPC identification process contained 4,645 records, with 105 analytes included in the data set.

For the 600 Area Subregion data set, 15,023 records were obtained from HEIS. A total of 227 analytes were included in the data set prior to analytical data processing. After analytical data processing (as described in the next section), the final data set used for the COPC identification process contained 11,321 records, with 227 analytes included in the data set.

6.3.2.1.1 Analytical Data Processing

The data set obtained from HEIS included the following types of information:

- Analytical results from both unfiltered and filtered samples
- Data qualification and data validation flags, including rejected results
- Results for a given analyte reported by more than one analytical method
- Parent, field duplicate, and field split sample results

The analytical data were processed using the steps described below and thus identify one set of results per sampling location and date of sample collection. The data processing steps and the numbers of records associated with each step are presented in Figure 6-7 for the 300 Area Subregion and in Figure 6-8 for the 600 Area Subregion. Descriptions of the data processing steps follow.

6.3.2.1.2 Sample Results

Only analytical results from unfiltered samples are used in identifying COPCs; results from filtered samples that may have been collected in support of other monitoring or compliance programs are excluded. Unfiltered sample results represent total concentrations of the analytes, while filtered sample results represent only dissolved concentrations. Use of filtered sampling results might lead to underestimation of chemical and radiological concentrations (e.g., in water from an unfiltered tap). *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final* (EPA/540/1-89/002) addresses this issue in providing guidance on estimating exposure concentrations in groundwater:

> *While filtration of ground-water samples provides useful information for understanding chemical transport within an aquifer, the use of filtered samples for estimating exposure is very controversial, because these data may underestimate chemical concentrations in water from an unfiltered tap. Therefore, data from unfiltered samples should be used to estimate exposure concentrations.*

6.3.2.1.3 Laboratory and Data Validation Flags

Analytical data are received from the laboratory with data qualification flags. Validation qualifiers are assigned during the data validation process. The following rules determine how flagged and/or qualified sample results are used in identifying COPCs.

- Sample results flagged with a “U” qualifier or combinations of qualifiers that include a “U,” such as a “UJ,” are considered nondetected results.

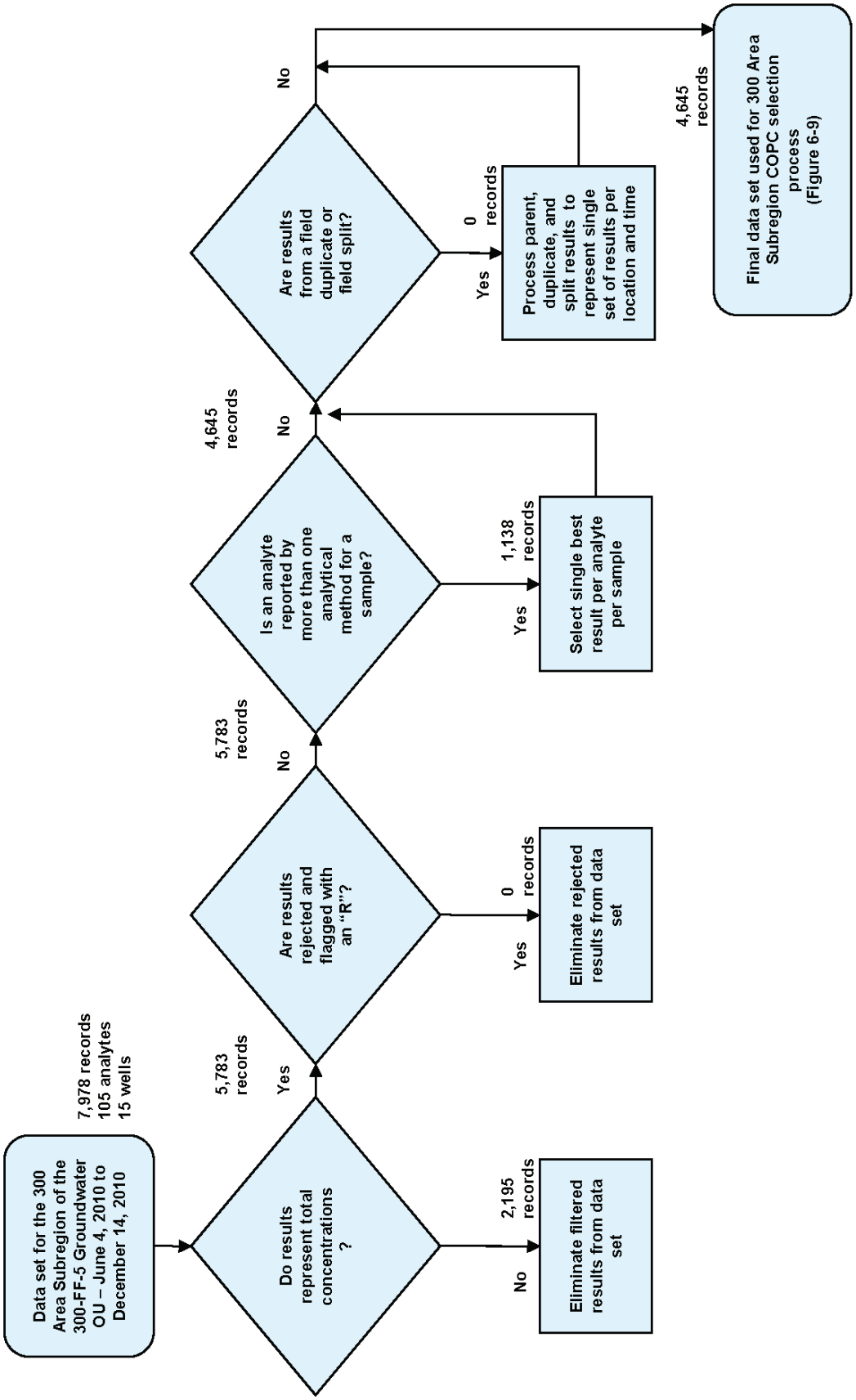

Figure 6-7. Data Processing and Reduction Steps for the 300 Area Subregion of the 300-FF-5 Groundwater OU Data Set

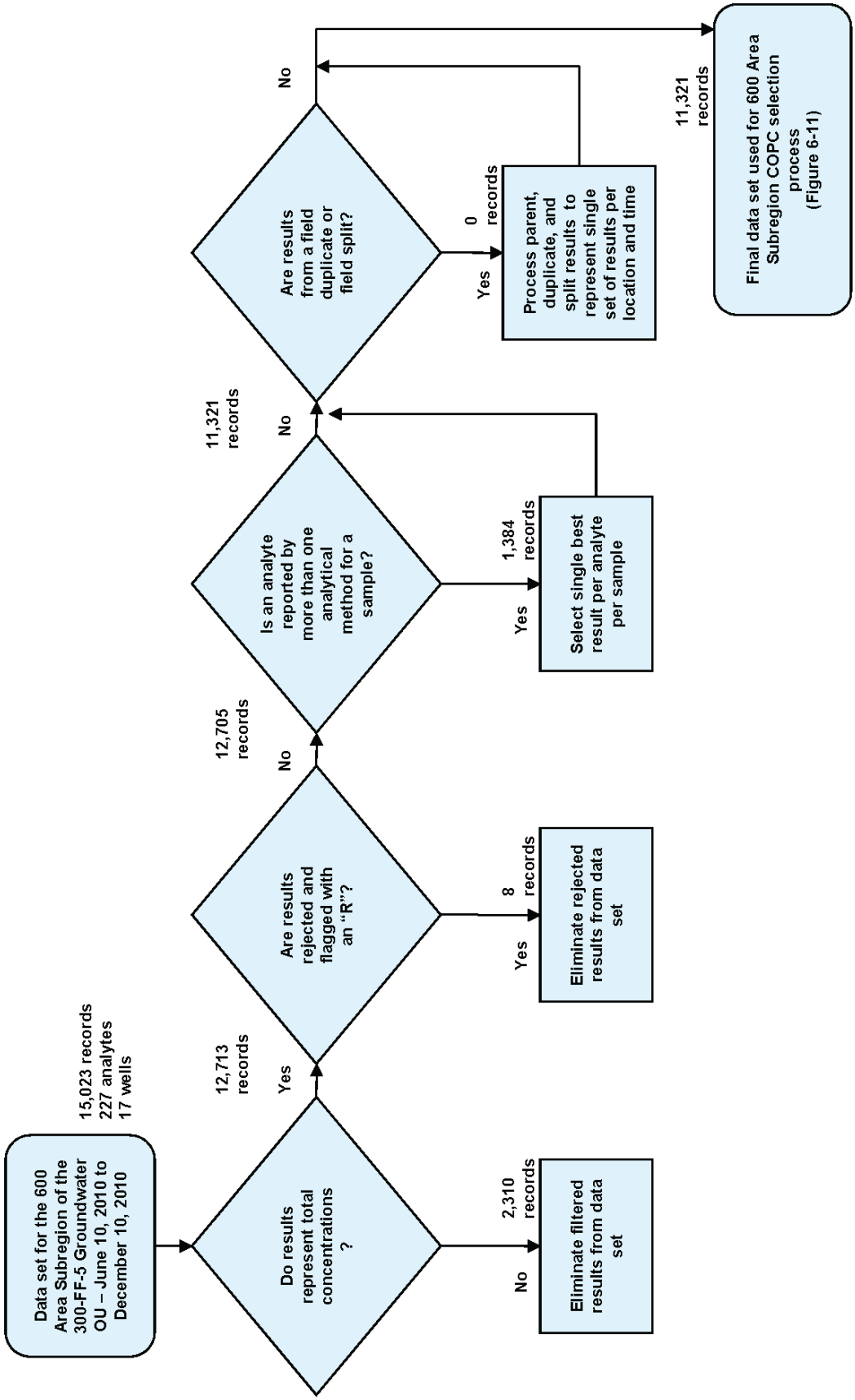

Figure 6-8. Data Processing and Reduction Steps for the 600 Area Subregion of the 300-FF-5 Groundwater OU Data Set

- Sample results without a "U" qualifier are considered detected concentrations, including results with no qualifier or with a "J" qualifier.
- Sample results that are rejected and flagged with an "R" qualifier are not used in identifying COPCs.

where:

U	=	Analyzed for but not detected above limiting criteria.
J	=	Estimated value.
R	=	Do not use. Further review indicates the result is not valid.

6.3.2.1.4 Analytes Reported by Numerous Analytical Methods

Often analytes are reported by more than one analytical method. This results in multiple results for an analyte at the same location and sample date. Because multiple sets of analytical results cannot be used to quantify risk (i.e., this would result in multiple-counting of a chemical), the set of data that best represents the actual concentration will be retained. The results are processed to select the method that provides the most reliable results. Considerations for determining data to be retained include method-associated sample size, detection frequency, and detection limits. The most conservative (i.e., health-protective) use of these types of data will be the goal. Larger sample size, higher detection frequencies, and lower detection limits are given higher priority for method selection.

For example, lead may be analyzed using EPA Method 200.8 *Methods for the Determination of Metals in Environmental Samples, Supplement I* [EPA-600/R-94/111]) with an EQL of 2 µg/L or EPA Method 6010 in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B* [SW-846]) with an EQL of 50 µg/L. For a sample with lead concentrations reported using both methods, the result reported by EPA Method 200.8 is selected over EPA Method 6010 because of the more sensitive detection limit.

6.3.2.1.5 Field Duplicate and Field Split Results

Field QC samples (field duplicates and field splits) are collected in the field and analyzed by the laboratory as unique samples. The parent sample and QC samples are collected from the same location (i.e., monitoring well) on the same date, resulting in more than one sample per location/date. The following criteria are used to reduce multiple sample results for an individual location/date to a single result:

- If two or more detections exist, the maximum concentration is used
- If at least one detection and one or more nondetected results exist, the detected concentration is used
- If only (two or more) nondetected results exist, the lowest detection limit is used

6.3.2.2 Identify Action Levels

Action levels are derived from available sources of chemical-specific ARARs and default exposure assumptions. All sources of chemical-specific ARARs for each of the 105 analytes reported in the HEIS database for the 300 Area Subregion and the 227 analytes reported in the HEIS data base for the 600 Area Subregion are identified in Table 6-21.

For the COPC identification process, the action level is the lowest of the available chemical-specific ARARs for protection of human health and aquatic receptors.

6.3.2.2.1 ARAR Based Remediation Goals

The sources of the chemical-specific ARARs from federal regulations are:

- 40 CFR 141, "National Primary Drinking Water Regulations," MCLs, secondary MCLs, and non-zero MCLGs established under the *Safe Drinking Water Act of 1974* (SDWA)
- *National Recommended Water Quality Criteria* (EPA, 2009b), aquatic water quality criteria (AWQC) established under Section 304 of the *Clean Water Act of 1977*
- 40 CFR 131 "Water Quality Standards," for states not complying with Section 303 of the *Clean Water Act of 1977*

The sources of the chemical-specific ARARs from Washington State regulations are:

- WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington" (hereinafter called Surface Water Quality Standards)
- WAC 173-340-720, "Groundwater Cleanup Standards"
- WAC 173-340-730, "Surface Water Cleanup Standards"
- WAC 246-290-310, "Group A Public Water Supplies," "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)"

Derivation of State of Washington groundwater cleanup levels is provided in a separate calculation brief (*Environmental Calculation of WAC 173-340-720 Method B Groundwater Cleanup Levels for Potable Groundwater in the 100 Areas and 300 Area* [ECF-100NPL-10-0462]). Derivation of State of Washington surface water cleanup levels is provided in a separate calculation brief (*Environmental Calculation of WAC 173-340-730 Method B Surface Water Cleanup Levels for Potable Groundwater in the 100 Areas and 300 Area* [ECF-100NPL-10-0463]).

6.3.2.3 COPC Identification Process

Section 6.3.2.1 defined the analytical data set and described the analytical data processing steps used in this section for identifying groundwater COPCs. Section 6.3.2.2 identified the action levels used in this section for identifying groundwater COPCs. The COPC identification process described in this section is used to identify a subset of analytes from each exposure area into the risk characterization step provided in Section 6.3.5. This step of the process uses sampling and analysis data collected from the 15 monitoring wells in the 300 Area Subregion and the 17 monitoring wells in the 600 Area Subregion. The purpose of grouping all sampling and analysis data together from each exposure area (i.e., the 300 Area Subregion and the 600 Area Subregion) is to identify those analytes with detected concentrations above the lowest available action level before an EPC is calculated. Comparison to the lowest of available ARARs (considered protective of HHE) is used to confirm that potential analytes are identified for evaluation before the data are separated into the two exposure areas discussed in Section 6.3.3. A detailed description of the screening process is provided in *Identification of Contaminants of Potential Concern for Groundwater Risk Assessment at the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0128) (Appendix G) and *Identification of Contaminants of Potential Concern for Groundwater Risk Assessment at the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0129) (Appendix G). The COPC identification steps, number of records, and number of analytes associated with each step are depicted in Figure 6-9 and Figure 6-10 for the 300 Area Subregion and in Figure 6-11 and Figure 6-12 for the 600 Area Subregion and listed as follows:

- Apply exclusion criteria
- Identify nondetected analytes
- Identify analytes with maximum detected concentrations less than action levels
- Identify analytes with maximum detected concentrations greater than action levels
- Calculate EPCs for analytes with maximum detected concentrations greater than action levels
- Identify analytes with EPCs less than action level
- Identify analytes with EPCs greater than action level

6.3.2.3.1 Summary of Nature and Extent Evaluation

Section 4.4 presents the nature and extent of contamination in groundwater based on the last five years of data (i.e., samples collected between September 14, 2006 and September 8, 2011). All monitoring wells within the 300 Area Subregion and 600 Area Subregion that are screened in the unconfined aquifer were included in the nature and extent evaluation (see Figure 6-6). The nature and extent evaluation reviewed all analytes identified as historic COPCs. As described previously, historic COPCs were identified in the work plan using data collected over a 16-year period (1992 to 2008) (see Table 6-18 and Table 6-19 for a list of historic COPCs). The nature and extent evaluation also includes the review of analytes that were not identified in Table 6-18 and Table 6-19 but reported concentrations greater than an action level using the current RI data. The data set used for the nature and extent evaluation is considered to be representative of current groundwater conditions based on the overall spatial coverage of monitoring wells within each of the subregions and based on the inclusion of RI data that were collected to resolve uncertainties identified in the RCBRA and the 300 Area Work Plan. This analysis is included to confirm that analytes that are identified as COPCs using RI data are consistent with the observations and characteristics of the data from a larger population of wells and analytical results collected over a longer time frame.

6.3.2.3.2 Apply Exclusion Criteria

The first step in the groundwater COPC identification process is to apply certain exclusion criteria. Analytes that met one or more of the exclusion criteria were eliminated as COPCs. The eliminated analytes are listed in Table 6-22 for the 300 Area Subregion and in Table 6-23 for the 600 Area Subregion. Analytes that did not meet any of the exclusion criteria were carried forward into the next step. The exclusion criteria are:

- Naturally occurring radionuclides associated with background radiation
- Radionuclides that have half-lives of less than 3 years and are not significant daughter products
- Essential nutrients (minerals)
- Analytes without known toxicity information

No naturally occurring radionuclides associated with background radiation were measured in groundwater from the 300 Area Subregion or the 600 Area Subregion (see Tables 6-22 and 6-23).

Radioisotopes with half-lives less than or equal to 3 years are eliminated from further consideration, because only a small fraction of their original activity remains after 30 years of decay since the reactors ceased operation. No radioisotopes that meet this exclusion criterion were measured in groundwater for the 300 Area Subregion or the 600 Area Subregion.

Essential nutrients are those analytes considered essential for human nutrition. The essential nutrients calcium, magnesium, potassium, and sodium were detected in the groundwater in the 300 Area Subregion and the 600 Area Subregion, and are excluded from further consideration as COPCs.

Some analytes do not have an action level, because a promulgated chemical-specific ARAR is not available in any of the sources listed in Table 6-21. For some analytes without an action level, there is also no available toxicological information that could be considered in assessing any risks they may present. Sixteen analytes were eliminated from further consideration as COPCs from the 300 Area Subregion and 37 analytes were eliminated from further consideration from the 600 Area Subregion because they do not have an action level and they do not have available toxicological information.

Uranium isotopes (U-233/234, U-235, and U-238) were analyzed in groundwater samples collected for RI; however, these isotopes do not have a promulgated MCL. However, all groundwater samples were analyzed for total uranium (metal), which is evaluated in the nature and extent of contamination in groundwater and is identified as a COPC in the work plan. The elimination of these isotopes from further consideration in the supplemental groundwater risk evaluation is not anticipated to understate risk because the MCL for total uranium (metal) is protective of human health and considers both noncarcinogenic and carcinogenic effects from exposure to uranium.

6.3.2.3.3 Identify Nondetected Analytes

The next step in the groundwater COPC identification process was to identify nondetected analytes. Chemicals and radionuclides that have been analyzed for, but not detected in any sample (collected from appropriate locations with adequate detection limits), were eliminated as COPCs. All analytes detected at least once were carried forward to the next step.

For the 300 Area Subregion, 46 analytes were not detected in any of the groundwater samples collected for the RI. For the 600 Area Subregion, 143 analytes were not detected in any of the groundwater samples collected for the RI. The nondetected analytes are listed in Tables 6-24 and 6-25, respectively, each with sampling dates, minimum and maximum MDLs, the action level, the basis of the action level, and the level of exceedance.

300 Area Subregion. The conclusions of the nature and extent evaluation for those nondetected analytes that were identified as historic COPCs in the 300 Area SAP (DOE/RL-2009-45) support the findings of this risk evaluation for mercury and vinyl chloride. Both analytes were not detected in samples collected specifically for the RI nor was vinyl chloride detected in any groundwater sample collected over the past five years. All MDLs associated with these analytes were less than the EQL listed in the 300 Area SAP (DOE/RL-2009-45). Therefore, both analytes are not COPCs and will not be carried forward into the risk characterization section or into the FS.

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Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
630-20-6	1,1,1,2-Tetrachloroethane	--	µg/L	--	--	--	--	1.7	--	--	--	--	--	--	--	6.2	1.7	WAC 173-340-720(4)(b)(iii)(A) and (B)
71-55-6	1,1,1-Trichloroethane	--	µg/L	200	200	--	--	16,000	--	--	--	--	--	--	--	925,926	200	40 CFR 141 - Federal MCL-Primary
79-34-5	1,1,2,2-Tetrachloroethane	--	µg/L	--	--	--	--	0.22	--	--	0.17	--	--	--	0.17	6.5	0.17	Clean Water Act -- Human Health Water + Organism
79-00-5	1,1,2-Trichloroethane	--	µg/L	5.0	3.0	--	--	0.77	--	--	0.59	--	--	--	0.60	25	0.59	Clean Water Act -- Human Health Water + Organism
75-34-3	1,1-Dichloroethane	--	µg/L	--	--	--	--	1,600	--	--	--	--	--	--	--	73,549	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-35-4	1,1-Dichloroethene	1,1-Dichloroethylene	µg/L	7.0	7.0	--	--	400	--	--	330	--	--	--	0.057	23,148	0.057	40 CFR 131 -- Human Health Water + Organism
96-18-4	1,2,3-Trichloropropane	--	µg/L	--	--	--	--	0.0015	--	--	--	--	--	--	--	0.017	0.0015	WAC 173-340-720(4)(b)(iii)(A) and (B)
95-94-3	1,2,4,5-Tetrachlorobenzene	--	µg/L	--	--	--	--	4.8	--	--	0.97	--	--	--	--	0.28	0.28	WAC 173-340-730(3)(b)(iii)(A) and (B)
120-82-1	1,2,4-Trichlorobenzene	--	µg/L	70	70	--	--	1.5	--	--	35	--	--	--	--	--	1.5	WAC 173-340-720(4)(b)(iii)(A) and (B)
96-12-8	1,2-Dibromo-3-chloropropane	--	µg/L	0.20	--	--	--	0.055	--	--	--	--	--	--	--	0.70	0.055	WAC 173-340-720(4)(b)(iii)(A) and (B)
106-93-4	1,2-Dibromoethane	--	µg/L	0.050	--	--	--	0.022	--	--	--	--	--	--	--	0.22	0.022	WAC 173-340-720(4)(b)(iii)(A) and (B)
95-50-1	1,2-Dichlorobenzene	--	µg/L	600	600	--	--	720	--	--	420	--	--	--	--	2,700	420	Clean Water Act -- Human Health Water + Organism
107-06-2	1,2-Dichloroethane	--	µg/L	5.0	--	--	--	0.48	--	--	0.38	--	--	--	0.38	59	0.38	Clean Water Act -- Human Health Water + Organism
540-59-0	1,2-Dichloroethene (Total)	1,2-Dichloroethylene Mixed Isomers	µg/L	--	--	--	--	72	--	--	--	--	--	--	--	2,102	72	WAC 173-340-720(4)(b)(iii)(A) and (B)
78-87-5	1,2-Dichloropropane	--	µg/L	5.0	--	--	--	1.2	--	--	0.50	--	--	--	--	44	0.50	Clean Water Act -- Human Health Water + Organism
541-73-1	1,3-Dichlorobenzene	--	µg/L	--	--	--	--	--	--	--	320	--	--	--	--	400	320	Clean Water Act -- Human Health Water + Organism
106-46-7	1,4-Dichlorobenzene	--	µg/L	75	75	--	--	8.1	--	--	63	--	--	--	400	22	8.1	WAC 173-340-720(4)(b)(iii)(A) and (B)
123-91-1	1,4-Dioxane	--	µg/L	--	--	--	--	4.0	--	--	--	--	--	--	--	--	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)
130-15-4	1,4-Naphthoquinone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
71-36-3	1-Butanol	N-Butanol	µg/L	--	--	--	--	800	--	--	--	--	--	--	--	82,044	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
134-32-7	1-Naphthylamine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
58-90-2	2,3,4,6-Tetrachlorophenol	--	µg/L	--	--	--	--	480	--	--	--	--	--	--	--	--	480	WAC 173-340-720(4)(b)(iii)(A) and (B)
95-95-4	2,4,5-Trichlorophenol	--	µg/L	--	--	--	--	800	--	--	1,800	--	--	--	--	--	800	WAC 173-340-720(4)(b)(iii)(A) and (B)

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
88-06-2	2,4,6-Trichlorophenol	--	µg/L	--	--	--	--	4.0	--	--	1.4	--	--	--	--	2.1	1.4	Clean Water Act -- Human Health Water + Organism
120-83-2	2,4-Dichlorophenol	--	µg/L	--	--	--	--	24	--	--	77	--	--	--	--	93	24	WAC 173-340-720(4)(b)(iii)(A) and (B)
105-67-9	2,4-Dimethylphenol	--	µg/L	--	--	--	--	160	--	--	380	--	--	--	--	--	160	WAC 173-340-720(4)(b)(iii)(A) and (B)
51-28-5	2,4-Dinitrophenol	--	µg/L	--	--	--	--	32	--	--	69	--	--	--	--	70	32	WAC 173-340-720(4)(b)(iii)(A) and (B)
121-14-2	2,4-Dinitrotoluene	--	µg/L	--	--	--	--	0.28	--	--	0.11	--	--	--	--	0.11	0.11	Clean Water Act -- Human Health Water + Organism
87-65-0	2,6-Dichlorophenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
606-20-2	2,6-Dinitrotoluene	--	µg/L	--	--	--	--	16	--	--	--	--	--	--	--	--	16	WAC 173-340-720(4)(b)(iii)(A) and (B)
53-96-3	2-Acetylaminofluorene	--	µg/L	--	--	--	--	0.023	--	--	--	--	--	--	--	--	0.023	WAC 173-340-720(4)(b)(iii)(A) and (B)
78-93-3	2-Butanone	Methyl Ethyl Ketone	µg/L	--	--	--	--	4,800	--	--	--	--	--	--	--	492,264	4,800	WAC 173-340-720(4)(b)(iii)(A) and (B)
91-58-7	2-Chloronaphthalene	--	µg/L	--	--	--	--	640	--	--	1,000	--	--	--	--	--	640	WAC 173-340-720(4)(b)(iii)(A) and (B)
95-57-8	2-Chlorophenol	--	µg/L	--	--	--	--	40	--	--	81	--	--	--	--	--	40	WAC 173-340-720(4)(b)(iii)(A) and (B)
591-78-6	2-Hexanone	--	µg/L	--	--	--	--	80	--	--	--	--	--	--	--	3,429	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
91-57-6	2-Methylnaphthalene	--	µg/L	--	--	--	--	32	--	--	--	--	--	--	--	--	32	WAC 173-340-720(4)(b)(iii)(A) and (B)
95-48-7	2-Methylphenol (cresol, o-)	--	µg/L	--	--	--	--	400	--	--	--	--	--	--	--	--	400	WAC 173-340-720(4)(b)(iii)(A) and (B)
91-59-8	2-Naphthylamine	--	µg/L	--	--	--	--	0.049	--	--	--	--	--	--	--	--	0.049	WAC 173-340-720(4)(b)(iii)(A) and (B)
88-74-4	2-Nitroaniline	--	µg/L	--	--	--	--	160	--	--	--	--	--	--	--	--	160	WAC 173-340-720(4)(b)(iii)(A) and (B)
88-75-5	2-Nitrophenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
109-06-8	2-Picoline	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
91-94-1	3,3'-Dichlorobenzidine	--	µg/L	--	--	--	--	0.19	--	--	0.021	--	--	--	--	0.040	0.021	Clean Water Act -- Human Health Water + Organism
119-93-7	3,3'-Dimethylbenzidine	--	µg/L	--	--	--	--	0.0080	--	--	--	--	--	--	--	--	0.0080	WAC 173-340-720(4)(b)(iii)(A) and (B)
56-49-5	3-Methylcholanthrene	--	µg/L	--	--	--	--	0.0040	--	--	--	--	--	--	--	--	0.0040	WAC 173-340-720(4)(b)(iii)(A) and (B)
99-09-2	3-Nitroaniline	--	µg/L	--	--	--	--	4.2	--	--	--	--	--	--	--	--	4.2	WAC 173-340-720(4)(b)(iii)(A) and (B)
534-52-1	4,6-Dinitro-2-methylphenol	--	µg/L	--	--	--	--	1.6	--	--	13	--	--	--	--	13	1.6	WAC 173-340-720(4)(b)(iii)(A) and (B)
92-67-1	4-Aminobiphenyl	--	µg/L	--	--	--	--	0.0042	--	--	--	--	--	--	--	--	0.0042	WAC 173-340-720(4)(b)(iii)(A) and (B)
101-55-3	4-Bromophenylphenyl ether	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
59-50-7	4-Chloro-3-methylphenol	--	µg/L	--	--	--	--	1,600	--	--	--	--	--	--	--	--	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)

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				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
106-47-8	4-Chloroaniline	--	µg/L	--	--	--	--	0.22	--	--	--	--	--	--	--	--	0.22	WAC 173-340-720(4)(b)(iii)(A) and (B)
7005-72-3	4-Chlorophenylphenyl ether	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108-10-1	4-Methyl-2-pentanone	4-Methyl-2-Penatone	µg/L	--	--	--	--	640	--	--	--	--	--	--	--	61,002	640	WAC 173-340-720(4)(b)(iii)(A) and (B)
106-44-5	4-Methylphenol (cresol, p-)	--	µg/L	--	--	--	--	40	--	--	--	--	--	--	--	--	40	WAC 173-340-720(4)(b)(iii)(A) and (B)
100-01-6	4-Nitroaniline	--	µg/L	--	--	--	--	4.4	--	--	--	--	--	--	--	--	4.4	WAC 173-340-720(4)(b)(iii)(A) and (B)
100-02-7	4-Nitrophenol	--	µg/L	--	--	--	--	128	--	--	--	--	--	--	--	--	128	WAC 173-340-720(4)(b)(iii)(A) and (B)
56-57-5	4-Nitroquinoline-1-oxide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
99-55-8	5-Nitro-o-toluidine	--	µg/L	--	--	--	--	2.7	--	--	--	--	--	--	--	--	2.7	WAC 173-340-720(4)(b)(iii)(A) and (B)
57-97-6	7,12-Dimethylbenz[a]anthracene	--	µg/L	--	--	--	--	0.0004	--	--	--	--	--	--	--	--	0.0004	WAC 173-340-720(4)(b)(iii)(A) and (B)
83-32-9	Acenaphthene	--	µg/L	--	--	--	--	960	--	--	670	--	--	--	--	--	670	Clean Water Act -- Human Health Water + Organism
208-96-8	Acenaphthylene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
67-64-1	Acetone	--	µg/L	--	--	--	--	7,200	--	--	--	--	--	--	--	738,397	7,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-05-8	Acetonitrile	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
98-86-2	Acetophenone	--	µg/L	--	--	--	--	800	--	--	--	--	--	--	--	--	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
107-02-8	Acrolein	--	µg/L	--	--	--	--	4.0	--	3.0	6.0	--	--	--	320	--	3.0	Clean Water Act -- Freshwater CCC
107-05-1	Allyl chloride	--	µg/L	--	--	--	--	2.1	--	--	--	--	--	--	--	62	2.1	WAC 173-340-720(4)(b)(iii)(A) and (B)
122-09-8	alpha,alpha-Dimethylphenethylamine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7429-90-5	Aluminum	--	µg/L	50	--	--	--	16,000	750	87	--	--	--	--	--	5,185	50	40 CFR 141 - Federal MCL-Secondary
62-53-3	Aniline	--	µg/L	--	--	--	--	7.7	--	--	--	--	--	--	--	--	7.7	WAC 173-340-720(4)(b)(iii)(A) and (B)
120-12-7	Anthracene	--	µg/L	--	--	--	--	4,800	--	--	8,300	--	--	--	--	9,600	4,800	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-36-0	Antimony	Antimony (metallic)	µg/L	6.0	6.0	6.0	--	6.4	--	--	5.6	--	--	--	14	1,037	5.6	Clean Water Act -- Human Health Water + Organism
140-57-8	Aramite	--	µg/L	--	--	--	--	3.5	--	--	--	--	--	--	--	--	3.5	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-38-2	Arsenic	Arsenic, Inorganic	µg/L	10	--	10	--	0.058	340	150	0.018	190	360	190	0.018	0.098	0.018	Clean Water Act -- Human Health Water + Organism
103-33-3	Azobenzene	--	µg/L	--	--	--	--	0.80	--	--	--	--	--	--	--	--	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-39-3	Barium	--	µg/L	2,000	2,000	2,000	--	3,200	--	--	1,000	--	--	--	--	129,630	1,000	Clean Water Act -- Human Health Water + Organism

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
71-43-2	Benzene	--	µg/L	5.0	--	--	--	0.80	--	--	2.2	--	--	--	1.2	23	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)
56-55-3	Benzo(a)anthracene	--	µg/L	--	--	--	--	0.12	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
50-32-8	Benzo(a)pyrene	--	µg/L	0.20	--	--	--	0.012	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
205-99-2	Benzo(b)fluoranthene	--	µg/L	--	--	--	--	0.12	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
191-24-2	Benzo(ghi)perylene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
207-08-9	Benzo(k)fluoranthene	--	µg/L	--	--	--	--	0.12	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
100-51-6	Benzyl alcohol	--	µg/L	--	--	--	--	800	--	--	--	--	--	--	--	--	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-41-7	Beryllium	Beryllium and Compounds	µg/L	4.0	4.0	4.0	--	32	--	--	--	--	--	--	--	273	4.0	40 CFR 141 - Federal MCL-Primary
108-60-1	Bis(2-chloro-1-methylethyl)ether	--	µg/L	--	--	--	--	0.63	--	--	1,400	--	--	--	--	1,400	0.63	WAC 173-340-720(4)(b)(iii)(A) and (B)
111-91-1	Bis(2-Chloroethoxy)methane	--	µg/L	--	--	--	--	48	--	--	--	--	--	--	--	--	48	WAC 173-340-720(4)(b)(iii)(A) and (B)
111-44-4	Bis(2-chloroethyl) ether	--	µg/L	--	--	--	--	0.040	--	--	0.030	--	--	--	--	0.031	0.030	Clean Water Act -- Human Health Water + Organism
117-81-7	Bis(2-ethylhexyl) phthalate	--	µg/L	6.0	--	--	--	6.3	--	--	1.2	--	--	--	--	1.8	1.2	Clean Water Act -- Human Health Water + Organism
7440-69-9	Bismuth	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-42-8	Boron	Boron and Borates Only	µg/L	--	--	--	--	3,200	--	--	--	--	--	--	--	--	3,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
24959-67-9	Bromide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75-27-4	Bromodichloromethane	--	µg/L	--	--	--	--	0.71	--	--	0.55	--	--	--	0.27	28	0.27	40 CFR 131 -- Human Health Water + Organism
75-25-2	Bromoform	--	µg/L	--	80	--	--	5.5	--	--	4.3	--	--	--	4.3	219	4.3	Clean Water Act -- Human Health Water + Organism
74-83-9	Bromomethane	--	µg/L	--	--	--	--	11	--	--	47	--	--	--	48	968	11	WAC 173-340-720(4)(b)(iii)(A) and (B)
85-68-7	Butylbenzylphthalate	--	µg/L	--	--	--	--	46	--	--	1,500	--	--	--	--	--	46	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-43-9	Cadmium	Cadmium (Water)	µg/L	5.0	5.0	5.0	--	8.0	2.0	0.25	--	0.91	3.9	1.0	--	20	0.25	Clean Water Act -- Freshwater CCC
7440-70-2	Calcium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
86-74-8	Carbazole	--	µg/L	--	--	--	--	4.4	--	--	--	--	--	--	--	--	4.4	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-15-0	Carbon disulfide	--	µg/L	--	--	--	--	800	--	--	--	--	--	--	--	13,295	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
56-23-5	Carbon tetrachloride	--	µg/L	5.0	--	--	--	0.34	--	--	0.23	--	--	--	0.25	2.7	0.23	Clean Water Act -- Human Health Water + Organism
16887-00-6	Chloride	--	µg/L	250,000	--	250,000	--	--	860,000	230,000	--	230,000	--	--	--	--	230,000	Clean Water Act -- Freshwater CCC

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
108-90-7	Chlorobenzene	--	µg/L	100	100	--	--	160	--	--	130	--	--	--	680	5,034	100	40 CFR 141 - Federal MCL-Primary
510-15-6	Chlorobenzilate	--	µg/L	--	--	--	--	0.80	--	--	--	--	--	--	--	--	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-00-3	Chloroethane	Ethylchloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
67-66-3	Chloroform	--	µg/L	80	--	80	--	1.4	--	--	5.7	--	--	--	5.7	56	1.4	WAC 173-340-720(4)(b)(iii)(A) and (B)
74-87-3	Chloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
126-99-8	Chloroprene	2-Chloro-1,3-butadiene	µg/L	--	--	--	--	160	--	--	--	--	--	--	--	2,412	160	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-47-3	Chromium	--	µg/L	100	100	100	--	24,000	570	65	--	156	550	180	--	19,444	65	Clean Water Act -- Freshwater CCC
218-01-9	Chrysene	--	µg/L	--	--	--	--	1.2	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
156-59-2	cis-1,2-dichloroethene	--	µg/L	70	70	--	--	80	--	--	--	--	--	--	--	2,336	70	40 CFR 141 - Federal MCL-Primary
10061-01-5	cis-1,3-Dichloropropene	--	µg/L	--	--	--	--	0.44	--	--	0.34	--	--	--	--	34	0.34	Clean Water Act -- Human Health Water + Organism
7440-48-4	Cobalt	--	µg/L	--	--	--	--	4.8	--	--	--	--	--	--	--	2.6	2.6	WAC 173-340-730(3)(b)(iii)(A) and (B)
7440-50-8	Copper	--	µg/L	1,300	1,300	--	--	640	13	9.0	1,300	--	17	11	--	2,881	9.0	Clean Water Act -- Freshwater CCC
57-12-5	Cyanide	--	µg/L	200	200	200	--	320	22	5.2	140	5.2	22	5.2	700	51,852	5.2	Clean Water Act -- Freshwater CCC
2303-16-4	Diallate	--	µg/L	--	--	--	--	1.4	--	--	--	--	--	--	--	--	1.4	WAC 173-340-720(4)(b)(iii)(A) and (B)
53-70-3	Dibenz[a,h]anthracene	--	µg/L	--	--	--	--	0.12	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
132-64-9	Dibenzofuran	--	µg/L	--	--	--	--	16	--	--	--	--	--	--	--	--	16	WAC 173-340-720(4)(b)(iii)(A) and (B)
124-48-1	Dibromochloromethane	--	µg/L	60	60	--	--	0.52	--	--	0.40	--	--	--	0.41	21	0.40	Clean Water Act -- Human Health Water + Organism
74-95-3	Dibromomethane	Methylene Bromide	µg/L	--	--	--	--	80	--	--	--	--	--	--	--	4,216	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-71-8	Dichlorodifluoromethane	--	µg/L	--	--	--	--	1,600	--	--	--	--	--	--	--	84,312	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
84-66-2	Diethylphthalate	--	µg/L	--	--	--	--	12,800	--	--	17,000	--	--	--	--	23,000	12,800	WAC 173-340-720(4)(b)(iii)(A) and (B)
60-51-5	Dimethoate	--	µg/L	--	--	--	--	3.2	--	--	--	--	--	--	--	--	3.2	WAC 173-340-720(4)(b)(iii)(A) and (B)
131-11-3	Dimethyl phthalate	--	µg/L	--	--	--	--	--	--	--	270,000	--	--	--	--	313,000	270,000	Clean Water Act -- Human Health Water + Organism
84-74-2	Di-n-butylphthalate	--	µg/L	--	--	--	--	1,600	--	--	2,000	--	--	--	--	2,700	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
117-84-0	Di-n-octylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
88-85-7	Dinoseb(2-secButyl-4,6-dinitrophenol)	--	µg/L	7.0	7.0	--	--	16	--	--	--	--	--	--	--	--	7.0	40 CFR 141 - Federal MCL-Primary

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
298-04-4	Disulfoton	--	µg/L	--	--	--	--	0.64	--	--	--	--	--	--	--	--	0.64	WAC 173-340-720(4)(b)(iii)(A) and (B)
107-12-0	Ethyl cyanide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
97-63-2	Ethyl methacrylate	--	µg/L	--	--	--	--	720	--	--	--	--	--	--	--	26,365	720	WAC 173-340-720(4)(b)(iii)(A) and (B)
62-50-0	Ethyl methanesulfonate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
100-41-4	Ethylbenzene	--	µg/L	700	700	--	--	4.0	--	--	530	--	--	--	3,100	16	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)
52-85-7	Famphur	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
206-44-0	Fluoranthene	--	µg/L	--	--	--	--	640	--	--	130	--	--	--	--	300	130	Clean Water Act -- Human Health Water + Organism
86-73-7	Fluorene	--	µg/L	--	--	--	--	640	--	--	1,100	--	--	--	--	1,300	640	WAC 173-340-720(4)(b)(iii)(A) and (B)
16984-48-8	Fluoride	--	µg/L	4,000	4,000	4,000	--	960	--	--	--	--	--	--	--	15600	960	WAC 173-340-720(4)(b)(iii)(A) and (B)
12587-46-1	Gross alpha	--	µg/L	15	--	--	--	--	--	--	--	--	--	--	--	--	15	40 CFR 141 - Federal MCL-Primary
12587-47-2	Gross beta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
118-74-1	Hexachlorobenzene	--	µg/L	1.0	--	--	--	0.055	--	--	0.0003	--	--	--	--	0.0008	0.0003	Clean Water Act -- Human Health Water + Organism
87-68-3	Hexachlorobutadiene	--	µg/L	--	--	--	--	0.56	--	--	0.44	--	--	--	--	0.44	0.44	WAC 173-340-730(3)(b)(iii)(A) and (B)
77-47-4	Hexachlorocyclopentadiene	--	µg/L	50	50	--	--	48	--	--	40	--	--	--	--	240	40	Clean Water Act -- Human Health Water + Organism
67-72-1	Hexachloroethane	--	µg/L	--	--	--	--	3.1	--	--	1.4	--	--	--	--	1.9	1.4	Clean Water Act -- Human Health Water + Organism
70-30-4	Hexachlorophene	--	µg/L	--	--	--	--	4.8	--	--	--	--	--	--	--	--	4.8	WAC 173-340-720(4)(b)(iii)(A) and (B)
1888-71-7	Hexachloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
193-39-5	Indeno(1,2,3-cd)pyrene	--	µg/L	--	--	--	--	0.12	--	--	0.0038	--	--	--	--	0.0028	0.0028	WAC 173-340-730(3)(b)(iii)(A) and (B)
15046-84-1	Iodine-129	--	µg/L	1.0	--	--	--	--	--	--	--	--	--	--	--	--	1.0	40 CFR 141 - Federal MCL-Primary
74-88-4	Iodomethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7439-89-6	Iron	--	µg/L	300	--	300	--	11,200	--	1,000	300	--	--	--	--	9,074	300	40 CFR 141 - Federal MCL-Secondary
78-83-1	Isobutyl alcohol	--	µg/L	--	--	--	--	2,400	--	--	--	--	--	--	--	246,132	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)
465-73-6	Isodrin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
78-59-1	Isophorone	--	µg/L	--	--	--	--	46	--	--	35	--	--	--	--	8.4	8.4	WAC 173-340-730(3)(b)(iii)(A) and (B)
120-58-1	Isosafrole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
143-50-0	Kepone	--	µg/L	--	--	--	--	0.0088	--	--	--	--	--	--	--	--	0.0088	WAC 173-340-720(4)(b)(iii)(A) and (B)

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
7439-92-1	Lead	Lead and Compounds	µg/L	15	--	--	15	--	65	2.5	--	2.1	65	2.5	--	--	2.1	WAC 173-201A
7439-93-2	Lithium	--	µg/L	--	--	--	--	32	--	--	--	--	--	--	--	--	32	WAC 173-340-720(4)(b)(iii)(A) and (B)
7439-95-4	Magnesium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7439-96-5	Manganese	Manganese (Water)	µg/L	50	--	50	--	2,240	--	--	50	--	--	--	--	907	50	40 CFR 141 - Federal MCL-Secondary
99-65-0	m-Dinitrobenzene	--	µg/L	--	--	--	--	1.6	--	--	--	--	--	--	--	--	1.6	WAC 173-340-720(4)(b)(iii)(A) and (B)
7487-94-7	Mercury	Mercuric chloride	µg/L	2.0	2.0	2.0	--	4.8	1.4	0.77	--	0.012	2.1	0.012	0.14	0.78	0.012	40 CFR 131 -- Freshwater CCC
126-98-7	Methacrylonitrile	--	µg/L	--	--	--	--	0.80	--	--	--	--	--	--	--	82	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)
91-80-5	Methapyrilene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80-62-6	Methyl methacrylate	--	µg/L	--	--	--	--	11,200	--	--	--	--	--	--	--	960,219	11,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
66-27-3	Methyl methanesulfonate	--	µg/L	--	--	--	--	0.88	--	--	--	--	--	--	--	--	0.88	WAC 173-340-720(4)(b)(iii)(A) and (B)
298-00-0	Methyl parathion	--	µg/L	--	--	--	--	4.0	--	--	--	--	--	--	--	--	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-09-2	Methylene chloride	--	µg/L	5.0	--	--	--	5.8	--	--	4.6	--	--	--	4.7	960	4.6	Clean Water Act -- Human Health Water + Organism
7439-98-7	Molybdenum	--	µg/L	--	--	--	--	80	--	--	--	--	--	--	--	1,296	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
91-20-3	Naphthalene	--	µg/L	--	--	--	--	160	--	--	--	--	--	--	--	--	160	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-02-0	Nickel	Nickel Soluble Salts	µg/L	--	100	100	--	320	470	52	610	137	1,400	160	610	1,103	52	Clean Water Act -- Freshwater CCC
14797-55-8	Nitrate	--	µg/L	45,000	45,000	45,000	--	113,600	--	--	45,000	--	--	--	--	--	45,000	40 CFR 141 - Federal MCL-Primary
14797-65-0	Nitrite	--	µg/L	3,300	3,300	3,300	--	5,280	--	--	--	--	--	--	--	--	3,300	40 CFR 141 - Federal MCL-Primary
98-95-3	Nitrobenzene	--	µg/L	--	--	--	--	16	--	--	17	--	--	--	--	17	16	WAC 173-340-720(4)(b)(iii)(A) and (B)
930-55-2	Nitrosopyrrolidine	--	µg/L	--	--	--	--	0.021	--	--	0.016	--	--	--	--	--	0.016	Clean Water Act -- Human Health Water + Organism
55-18-5	n-Nitrosodiethylamine	--	µg/L	--	--	--	--	0.0003	--	--	0.0008	--	--	--	--	--	0.0003	Clean Water Act -- Human Health Water + Organism
62-75-9	n-Nitrosodimethylamine	--	µg/L	--	--	--	--	0.0009	--	--	0.0007	--	--	--	--	0.0007	0.0007	Clean Water Act -- Human Health Water + Organism
924-16-3	n-Nitrosodi-n-butylamine	--	µg/L	--	--	--	--	0.0081	--	--	0.0063	--	--	--	--	--	0.0063	Clean Water Act -- Human Health Water + Organism
621-64-7	n-Nitrosodi-n-dipropylamine	--	µg/L	--	--	--	--	0.013	--	--	0.0050	--	--	--	--	--	0.0050	Clean Water Act -- Human Health Water + Organism

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
86-30-6	n-Nitrosodiphenylamine	--	µg/L	--	--	--	--	18	--	--	3.3	--	--	--	--	5.0	3.3	Clean Water Act -- Human Health Water + Organism
10595-95-6	n-Nitrosomethylethylamine	--	µg/L	--	--	--	--	0.0040	--	--	--	--	--	--	--	--	0.0040	WAC 173-340-720(4)(b)(iii)(A) and (B)
59-89-2	n-Nitrosomorpholine	--	µg/L	--	--	--	--	0.013	--	--	--	--	--	--	--	--	0.013	WAC 173-340-720(4)(b)(iii)(A) and (B)
100-75-4	n-Nitrosopiperidine	--	µg/L	--	--	--	--	0.0093	--	--	--	--	--	--	--	--	0.0093	WAC 173-340-720(4)(b)(iii)(A) and (B)
126-68-1	O,O,O-Triethyl phosphorothioate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
297-97-2	O,O-Diethyl O-2-pyrazinyl phosphorothioate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
95-53-4	o-Toluidine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
56-38-2	Parathion	--	µg/L	--	--	--	--	96	0.065	0.013	--	0.065	0.013	--	--	--	0.013	Clean Water Act -- Freshwater CCC
60-11-7	p-Dimethylaminoazobenzene	--	µg/L	--	--	--	--	0.019	--	--	--	--	--	--	--	--	0.019	WAC 173-340-720(4)(b)(iii)(A) and (B)
608-93-5	Pentachlorobenzene	--	µg/L	--	--	--	--	13	--	--	1.4	--	--	--	--	--	1.4	Clean Water Act -- Human Health Water + Organism
76-01-7	Pentachloroethane	--	µg/L	--	--	--	--	0.97	--	--	--	--	--	--	--	--	0.97	WAC 173-340-720(4)(b)(iii)(A) and (B)
82-68-8	Pentachloronitrobenzene (PCNB)	--	µg/L	--	--	--	--	0.34	--	--	--	--	--	--	--	--	0.34	WAC 173-340-720(4)(b)(iii)(A) and (B)
87-86-5	Pentachlorophenol	--	µg/L	1.0	--	--	--	0.73	19	15	0.27	20	--	20	13	0.28	0.27	Clean Water Act -- Human Health Water + Organism
62-44-2	Phenacetin	--	µg/L	--	--	--	--	40	--	--	--	--	--	--	--	--	40	WAC 173-340-720(4)(b)(iii)(A) and (B)
85-01-8	Phenanthrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108-95-2	Phenol	--	µg/L	--	--	--	--	2,400	--	--	10,000	--	--	--	--	21,000	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)
298-02-2	Phorate	--	µg/L	--	--	--	--	3.2	--	--	--	--	--	--	--	--	3.2	WAC 173-340-720(4)(b)(iii)(A) and (B)
14265-44-2	Phosphate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-09-7	Potassium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
106-50-3	p-Phenylenediamine	--	µg/L	--	--	--	--	3,040	--	--	--	--	--	--	--	--	3,040	WAC 173-340-720(4)(b)(iii)(A) and (B)
23950-58-5	Pronamide	--	µg/L	--	--	--	--	1,200	--	--	--	--	--	--	--	--	1,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
129-00-0	Pyrene	--	µg/L	--	--	--	--	480	--	--	830	--	--	--	--	960	480	WAC 173-340-720(4)(b)(iii)(A) and (B)
110-86-1	Pyridine	--	µg/L	--	--	--	--	8.0	--	--	--	--	--	--	--	--	8.0	WAC 173-340-720(4)(b)(iii)(A) and (B)
94-59-7	Safrol	--	µg/L	--	--	--	--	0.40	--	--	--	--	--	--	--	--	0.40	WAC 173-340-720(4)(b)(iii)(A) and (B)
7782-49-2	Selenium	--	µg/L	50	50	50	--	80	--	5.0	170	5.0	20	5.0	--	2,701	5.0	Clean Water Act -- Freshwater CCC

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
7440-21-3	Silicon	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-22-4	Silver	--	µg/L	100	--	100	--	80	3.2	--	--	2.6	3.4	--	--	25,926	2.6	WAC 173-201A
7440-23-5	Sodium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-24-6	Strontium	Strontium, Stable	µg/L	--	--	--	--	9,600	--	--	--	--	--	--	--	25,926	9,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
10098-97-2	Strontium-90	--	pCi/L	8.0	--	--	--	--	--	--	--	--	--	--	--	--	8.0	40 CFR 141 - Federal MCL-Primary
100-42-5	Styrene	--	µg/L	100	100	--	--	1,600	--	--	--	--	--	--	--	38,409	100	40 CFR 141 - Federal MCL-Primary
14808-79-8	Sulfate	--	µg/L	250,000	--	250,000	--	--	--	--	--	--	--	--	--	--	250,000	40 CFR 141 - Federal MCL-Secondary
99-35-4	sym-Trinitrobenzene	--	µg/L	--	--	--	--	480	--	--	--	--	--	--	--	--	480	WAC 173-340-720(4)(b)(iii)(A) and (B)
127-18-4	Tetrachloroethene	Perchloroethylene (PCE)	µg/L	5.0	--	--	--	0.081	--	--	0.69	--	--	--	0.80	0.39	0.081	WAC 173-340-720(4)(b)(iii)(A) and (B)
3689-24-5	Tetraethyl dithiopyrophosphate (Sulfotepp)	--	µg/L	--	--	--	--	8.0	--	--	--	--	--	--	--	--	8.0	WAC 173-340-720(4)(b)(iii)(A) and (B)
109-99-9	Tetrahydrofuran	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-28-0	Thallium	Thallium (Soluble Salts)	µg/L	2.0	0.50	2.0	--	--	--	--	0.24	--	--	--	1.7	--	0.24	Clean Water Act -- Human Health Water + Organism
7440-31-5	Tin	--	µg/L	--	--	--	--	9,600	--	--	--	--	--	--	--	519	519	WAC 173-340-730(3)(b)(iii)(A) and (B)
108-88-3	Toluene	--	µg/L	1,000	1,000	--	--	640	--	--	1,300	--	--	--	6,800	19,384	640	WAC 173-340-720(4)(b)(iii)(A) and (B)
156-60-5	trans-1,2-Dichloroethylene	--	µg/L	100	100	--	--	160	--	--	140	--	--	--	--	32,818	100	40 CFR 141 - Federal MCL-Primary
10061-02-6	trans-1,3-Dichloropropene	--	µg/L	--	--	--	--	0.44	--	--	0.34	--	--	--	--	34	0.34	Clean Water Act -- Human Health Water + Organism
110-57-6	trans-1,4-Dichloro-2-butene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
126-73-8	Tributyl phosphate	--	µg/L	--	--	--	--	9.5	--	--	--	--	--	--	--	--	9.5	WAC 173-340-720(4)(b)(iii)(A) and (B)
79-01-6	Trichloroethene	Trichloroethylene (TCE)	µg/L	5.0	--	--	--	0.49	--	--	2.5	--	--	--	2.7	6.6	0.49	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-69-4	Trichloromonofluoromethane	Trichlorofluoro-methane	µg/L	--	--	--	--	2,400	--	--	--	--	--	--	--	--	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)
10028-17-8	Tritium	--	pCi/L	20,000	--	--	--	--	--	--	--	--	--	--	--	--	20,000	40 CFR 141 - Federal MCL-Primary
7440-61-1	Uranium	Uranium (Soluble Salts)	µg/L	30	--	--	--	48	--	--	--	--	--	--	--	778	30	40 CFR 141 - Federal MCL-Primary
U-233/234	Uranium-233/234	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13966-29-5	Uranium-234	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15117-96-1	Uranium-235	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 6-21. Summary of Federal and State Water Quality Criteria Used as Action Levels for the 300 Area Subregion and 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

				Groundwater					Surface Water								Action Level Value	
				40 CFR 141[a]		WAC 246-290-310[b]	WAC 173-340-720[c]		Clean Water Act National Recommended Water Quality Criteria[d]			WAC 173-201A[e]	40 CFR 131 Water Quality Standards[f]			WAC 173-340-730[g]		
CAS#	Analyte Name	Alternate Analyte Name	Units	Federal MCL	Federal MCLG	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Freshwater CCC	Freshwater CMC	Freshwater CCC	Human Health Water + Organism	Surface Water Method B Unrestricted Land Use	Action Level	Action Level Basis
U-238	Uranium-238	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-62-2	Vanadium	Vanadium and Compounds	µg/L	--	--	--	--	80	--	--	--	--	--	--	--	--	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
108-05-4	Vinyl acetate	--	µg/L	--	--	--	--	8,000	--	--	--	--	--	--	--	820,441	8,000	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-01-4	Vinyl chloride	--	µg/L	2.0	--	--	--	0.061	--	--	0.025	--	--	--	2.0	7.7	0.025	Clean Water Act -- Human Health Water + Organism
1330-20-7	Xylenes (total)	Xylenes (mixture)	µg/L	10,000	10,000	--	--	1,600	--	--	--	--	--	--	--	--	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-66-6	Zinc	Zinc (Metallic)	µg/L	5,000	--	5,000	--	4,800	120	120	7,400	91	110	100	--	16,548	91	WAC 173-201A

Source: Ecology, 2007, The Model Toxics Control Act Cleanup Regulation Chapter 173-340 WAC, Publication No. 94-06, amended 1996, Washington State Department of Ecology, Olympia, Washington.

a. 40 CFR 141, National Primary Drinking Water Regulations. Available at: http://www.epa.gov/waterscience/criteria/wqctable/.

b. Washington Department of Ecology, 2008, Group A Public Water Supplies 246-290-310 WAC, Publication No. 08-03-061.

c. WAC 173-340-720(4)(b)(ii)(A) and (B), Ground water cleanup standards, Method B ground water cleanup levels, Noncarcinogens and Carcinogens.

d. Clean Water Act - National Recommended Water Quality Criteria.

e. WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=173-201A.

f. 40 CFR 131, "Water Quality Standards." Available at: http://ecfr.gpoaccess.gov.

g. WAC 173-340-730(3)(b)(iii)(A) and (B), Surface water cleanup standards, Method B surface water cleanup levels, Noncarcinogens and Carcinogens.

CCC = criteria continuous concentration

CMC = criteria maximum concentration

MCL = maximum contaminant limit

MCLG = maximum contaminant limit goal

Table 6-22. Summary of Groundwater Analytes That Meet Exclusion Criteria for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Basis for Exclusion
Bromide	ANION	6/4/2010	12/14/2010	44	36	82%	µg/L	90	110	104	236	No Action Level/No Toxicity Values
Phosphate	ANION	6/4/2010	12/14/2010	44	9	20%	µg/L	429	429	598	6,750	No Action Level/No Toxicity Values
Bismuth	METAL	6/4/2010	12/14/2010	45	4	9%	µg/L	23	37	26	47	No Action Level/No Toxicity Values
Calcium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	27,600	67,000	Essential Nutrient
Magnesium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	6,220	14,300	Essential Nutrient
Potassium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	3,030	8,390	Essential Nutrient
Silicon	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	7,870	18,000	No Action Level/No Toxicity Values
Sodium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	13,500	27,000	Essential Nutrient
Gross beta	RAD	6/4/2010	12/14/2010	28	28	100%	pCi/L	--	--	2.7	49	No Action Level/No Toxicity Values
Uranium-233/234	RAD	6/4/2010	12/14/2010	45	45	100%	pCi/L	--	--	2.5	72	No Action Level/No Toxicity Values
Uranium-234	RAD	8/9/2010	8/9/2010	1	1	100%	pCi/L	--	--	32	32	No Action Level/No Toxicity Values
Uranium-235	RAD	6/4/2010	12/14/2010	45	45	100%	pCi/L	--	--	0.11	5.5	No Action Level/No Toxicity Values
Uranium-238	RAD	6/4/2010	12/14/2010	45	45	100%	pCi/L	--	--	2.1	69	No Action Level/No Toxicity Values
Acetonitrile	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	2.0	2.0	--	--	No Action Level/No Toxicity Values
Chloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.099	0.099	--	--	No Action Level/No Toxicity Values
Chloromethane	VOC	6/4/2010	12/14/2010	45	4	9%	µg/L	0.077	0.077	0.10	0.21	No Action Level/No Toxicity Values
Ethyl cyanide	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	1.4	1.4	--	--	No Action Level/No Toxicity Values
Iodomethane	VOC	6/4/2010	12/14/2010	45	4	9%	µg/L	0.092	0.092	0.68	0.75	No Action Level/No Toxicity Values
Tetrahydrofuran	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	1.1	1.1	--	--	No Action Level/No Toxicity Values
trans-1,4-Dichloro-2-butene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.29	0.29	--	--	No Action Level/No Toxicity Values

Table 6-23. Summary of Groundwater Analytes That Meet Exclusion Criteria for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Basis for Exclusion
Bromide	ANION	6/10/2010	12/20/2010	51	13	25%	µg/L	45	110	111	242	No Action Level/No Toxicity Values
Phosphate	ANION	6/10/2010	12/20/2010	51	0	0%	µg/L	215	429	--	--	No Action Level/No Toxicity Values
Bismuth	METAL	6/10/2010	12/20/2010	50	3	6%	µg/L	23	37	31	31	No Action Level/No Toxicity Values
Calcium	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	19,400	80,500	Essential Nutrient
Magnesium	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	6,390	17,100	Essential Nutrient
Potassium	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	4,460	8,280	Essential Nutrient
Silicon	METAL	6/10/2010	12/20/2010	50	50	100%	µg/L	--	--	13,700	29,300	No Action Level/ No Toxicity Values
Sodium	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	11,900	41,500	Essential Nutrient
Gross beta	RAD	6/10/2010	12/20/2010	22	22	100%	pCi/L	--	--	3.6	61	No Action Level/No Toxicity Values
Uranium-234	RAD	12/19/2010	12/19/2010	1	1	100%	pCi/L	--	--	3.8	3.8	No Action Level/No Toxicity Values
Uranium-235	RAD	12/19/2010	12/19/2010	1	1	100%	pCi/L	--	--	0.20	0.20	No Action Level/No Toxicity Values
Uranium-238	RAD	12/19/2010	12/19/2010	1	1	100%	pCi/L	--	--	4.4	4.4	No Action Level/No Toxicity Values
1,4-Naphthoquinone	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
1-Naphthylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
2,6-Dichlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
2-Nitrophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
2-Picoline	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	--	--	No Action Level/No Toxicity Values
4-Bromophenylphenyl ether	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
4-Chlorophenylphenyl ether	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
4-Nitroquinoline-1-oxide	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	5.0	5.0	--	--	No Action Level/No Toxicity Values
Acenaphthylene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
alpha,alpha-Dimethylphenethylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	22	22	--	--	No Action Level/No Toxicity Values
Benzo(ghi)perylene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
Di-n-octylphthalate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
Ethyl methanesulfonate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
Famphur	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.7	1.7	--	--	No Action Level/No Toxicity Values
Hexachloropropene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values

Table 6-23. Summary of Groundwater Analytes That Meet Exclusion Criteria for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Basis for Exclusion
Isodrin	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
Isosafrole	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.3	1.3	--	--	No Action Level/No Toxicity Values
Methapyrilene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.3	1.3	--	--	No Action Level/No Toxicity Values
O,O,O-Triethyl phosphorothioate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
O,O-Diethyl O-2-pyrazinyl phosphorothioate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
o-Toluidine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
Phenanthrene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	--	--	No Action Level/No Toxicity Values
Acetonitrile	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	--	--	No Action Level/No Toxicity Values
Chloroethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.099	0.099	--	--	No Action Level/No Toxicity Values
Chloromethane	VOC	6/10/2010	12/20/2010	51	16	31%	µg/L	0.077	2.0	0.088	0.29	No Action Level/No Toxicity Values
Ethyl cyanide	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.4	1.4	--	--	No Action Level/No Toxicity Values
Iodomethane	VOC	6/10/2010	12/20/2010	51	2	4%	µg/L	0.092	0.092	0.83	0.88	No Action Level/No Toxicity Values
Tetrahydrofuran	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.1	1.1	--	--	No Action Level/No Toxicity Values
trans-1,4-Dichloro-2-butene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.29	0.29	--	--	No Action Level/No Toxicity Values

Table 6-24. Summary of Groundwater Analytes that Were Not Detected for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
Nitrite	ANION	6/4/2010	12/14/2010	45	0	0%	µg/L	9.9	118	3,300	40 CFR 141 - Federal MCL-Primary	0.003
Antimony	METAL	6/4/2010	12/14/2010	45	0	0%	µg/L	0.3	1.1	5.6	Clean Water Act -- Human Health Water + Organism	0.05
Beryllium	METAL	6/4/2010	12/14/2010	45	0	0%	µg/L	0.050	0.35	4.0	40 CFR 141 - Federal MCL-Primary	0.01
Cadmium	METAL	6/4/2010	12/14/2010	45	0	0%	µg/L	0.055	0.20	0.25	Clean Water Act -- Freshwater CCC	0.22
Mercury	METAL	6/4/2010	12/14/2010	45	0	0%	µg/L	0.05	0.1	0.012	40 CFR 131 -- Freshwater CCC	4.2
Strontium-90	RAD	6/4/2010	12/14/2010	45	0	0%	pCi/L	-11	0.78	8.0	40 CFR 141 - Federal MCL-Primary	-1.38
1,1,1,2-Tetrachloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.09	0.09	1.7	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.05
1,1,1-Trichloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.069	0.069	200	40 CFR 141 - Federal MCL-Primary	0.0003
1,1,2,2-Tetrachloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.098	0.098	0.17	Clean Water Act -- Human Health Water + Organism	0.58
1,1,2-Trichloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.15	0.15	0.59	Clean Water Act -- Human Health Water + Organism	0.25
1,1-Dichloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.068	0.068	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00004
1,1-Dichloroethene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.083	0.083	0.057	40 CFR 131 -- Human Health Water + Organism	1.5
1,2,3-Trichloropropane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.15	0.15	0.0015	WAC 173-340-720(4)(b)(iii)(A) and (B)	103
1,2-Dibromo-3-chloropropane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.41	0.41	0.055	WAC 173-340-720(4)(b)(iii)(A) and (B)	7.5
1,2-Dibromoethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.13	0.13	0.022	WAC 173-340-720(4)(b)(iii)(A) and (B)	5.9
1,2-Dichloroethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.1	0.1	0.38	Clean Water Act -- Human Health Water + Organism	0.26
1,2-Dichloropropane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.097	0.097	0.50	Clean Water Act -- Human Health Water + Organism	0.19
1,4-Dichlorobenzene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.12	0.12	8.1	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.01
1,4-Dioxane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	7.6	7.6	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)	1.9
1-Butanol	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	12	12	800	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.02
2-Butanone	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.52	0.52	4,800	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0001
2-Hexanone	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.22	0.22	80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.003
4-Methyl-2-pentanone	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.12	0.12	640	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0002
Allyl chloride	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.11	0.11	2.1	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.05
Benzene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.064	0.064	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.08
Bromoform	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.17	0.17	4.3	Clean Water Act -- Human Health Water + Organism	0.04
Chlorobenzene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.15	0.15	100	40 CFR 141 - Federal MCL-Primary	0.002
Chloroprene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.097	0.097	160	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.001

Table 6-24. Summary of Groundwater Analytes that Were Not Detected for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
cis-1,3-Dichloropropene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.073	0.073	0.34	Clean Water Act -- Human Health Water + Organism	0.21
Dibromochloromethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.13	0.13	0.40	Clean Water Act -- Human Health Water + Organism	0.33
Dibromomethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.21	0.21	80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.003
Dichlorodifluoromethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.084	0.084	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0001
Ethyl methacrylate	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.11	0.11	720	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0002
Ethylbenzene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.086	0.086	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.02
Isobutyl alcohol	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	8.7	8.7	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.004
Methacrylonitrile	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.50	0.50	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.63
Methyl methacrylate	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.26	0.26	11,200	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00002
Methylene chloride	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.11	0.11	4.6	Clean Water Act -- Human Health Water + Organism	0.02
Styrene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.074	0.074	100	40 CFR 141 - Federal MCL-Primary	0.001
Toluene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.072	0.072	640	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0001
trans-1,2-Dichloroethylene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.083	0.083	100	40 CFR 141 - Federal MCL-Primary	0.001
trans-1,3-Dichloropropene	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.083	0.083	0.34	Clean Water Act -- Human Health Water + Organism	0.24
Trichloromonofluoromethane	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.11	0.11	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00005
Vinyl acetate	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.18	0.18	8,000	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00002
Vinyl chloride	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.084	0.084	0.025	Clean Water Act -- Human Health Water + Organism	3.4
Xylenes (total)	VOC	6/4/2010	12/14/2010	45	0	0%	µg/L	0.20	0.20	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0001

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units.*

Table 6-25. Summary of Groundwater Analytes that Were Not Detected for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
Nitrite	ANION	6/10/2010	12/20/2010	51	0	0%	µg/L	59	118	3,300	40 CFR 141 - Federal MCL-Primary	0.018
Antimony	METAL	6/10/2010	12/20/2010	51	0	0%	µg/L	0.60	0.60	5.6	Clean Water Act -- Human Health Water + Organism	0.11
Cadmium	METAL	6/10/2010	12/20/2010	51	0	0%	µg/L	0.20	0.20	0.25	Clean Water Act -- Freshwater CCC	0.80
Mercury	METAL	6/10/2010	12/5/2010	14	0	0%	µg/L	0.10	0.10	0.012	40 CFR 131 -- Freshwater CCC	8.3
Silver	METAL	6/10/2010	12/20/2010	51	0	0%	µg/L	0.20	0.20	2.6	WAC 173-201A	0.077
Thallium	METAL	6/10/2010	12/20/2010	51	0	0%	µg/L	0.10	0.10	0.24	Clean Water Act -- Human Health Water + Organism	0.42
Strontium-90	RAD	6/10/2010	12/20/2010	51	0	0%	pCi/L	-12	4.7	8.0	40 CFR 141 - Federal MCL-Primary	-1.50
1,2,4,5-Tetrachlorobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.28	WAC 173-340-730(3)(b)(iii)(A) and (B)	3.6
1,2,4-Trichlorobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.5	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.66
1,2-Dichlorobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	420	Clean Water Act -- Human Health Water + Organism	0.0024
1,3-Dichlorobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	320	Clean Water Act -- Human Health Water + Organism	0.0031
2,3,4,6-Tetrachlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	480	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0021
2,4,5-Trichlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	486	WAC 173-340-730(3)(b)(iii)(A) and (B)	0.0021
2,4,6-Trichlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.4	Clean Water Act -- Human Health Water + Organism	0.71
2,4-Dichlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	24	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.042
2,4-Dimethylphenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	160	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0063
2,4-Dinitrophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	32	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.063
2,4-Dinitrotoluene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.11	Clean Water Act -- Human Health Water + Organism	9.1
2,6-Dinitrotoluene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.2	2.2	16	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.14
2-Acetylaminofluorene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.023	WAC 173-340-720(4)(b)(iii)(A) and (B)	43
2-Chloronaphthalene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	640	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0016
2-Chlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	40	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.025
2-Methylnaphthalene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	32	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.031
2-Methylphenol (cresol, o-)	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	400	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0025
2-Naphthylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.049	WAC 173-340-720(4)(b)(iii)(A) and (B)	21
2-Nitroaniline	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	160	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0063
3,3'-Dichlorobenzidine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.021	Clean Water Act -- Human Health Water + Organism	48
3,3'-Dimethylbenzidine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.6	2.6	0.0080	WAC 173-340-720(4)(b)(iii)(A) and (B)	327
3-Methylcholanthrene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.00004	WAC 173-340-730(3)(b)(iii)(A) and (B)	27,174
3-Nitroaniline	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	4.2	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.24
4,6-Dinitro-2-methylphenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.6	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.63

Table 6-25. Summary of Groundwater Analytes that Were Not Detected for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
4-Aminobiphenyl	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0042	WAC 173-340-720(4)(b)(iii)(A) and (B)	240
4-Chloro-3-methylphenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0006
4-Chloroaniline	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.22	WAC 173-340-720(4)(b)(iii)(A) and (B)	4.6
4-Methylphenol (cresol, p-)	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	10	10	40	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.25
4-Nitroaniline	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	4.4	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.23
4-Nitrophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	128	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.016
5-Nitro-o-toluidine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	2.7	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.38
7,12-Dimethylbenz[a]anthracene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.00001	WAC 173-340-730(3)(b)(iii)(A) and (B)	120,337
Acenaphthene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	643	WAC 173-340-730(3)(b)(iii)(A) and (B)	0.0016
Acetophenone	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	800	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0013
Aniline	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	7.7	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.13
Anthracene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	4,800	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0002
Aramite	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	20	20	0.37	WAC 173-340-730(3)(b)(iii)(A) and (B)	54
Azobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)	1.3
Benzo(a)anthracene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Benzo(a)pyrene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Benzo(b)fluoranthene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Benzo(k)fluoranthene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Bis(2-chloro-1-methylethyl)ether	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.63	WAC 173-340-720(4)(b)(iii)(A) and (B)	1.6
Bis(2-Chloroethoxy)methane	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	48	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.021
Bis(2-chloroethyl) ether	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.030	Clean Water Act -- Human Health Water + Organism	33
Carbazole	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.9	WAC 173-340-730(3)(b)(iii)(A) and (B)	0.52
Chlorobenzilate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.12	WAC 173-340-730(3)(b)(iii)(A) and (B)	8.2
Chrysene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Diallate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	0.25	WAC 173-340-730(3)(b)(iii)(A) and (B)	8.0
Dibenz[a,h]anthracene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Dibenzofuran	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.7	WAC 173-340-730(3)(b)(iii)(A) and (B)	0.58
Dimethoate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	3.2	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.31
Dimethyl phthalate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	270,000	Clean Water Act -- Human Health Water + Organism	0.000004
Dinoseb(2-secButyl-4,6-dinitrophenol)	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	7.0	40 CFR 141 - Federal MCL-Primary	0.29

Table 6-25. Summary of Groundwater Analytes that Were Not Detected for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
Disulfoton	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.48	WAC 173-340-730(3)(b)(iii)(A) and (B)	2.1
Fluoranthene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	90	WAC 173-340-730(3)(b)(iii)(A) and (B)	0.011
Fluorene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	640	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0016
Hexachlorobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0003	Clean Water Act -- Human Health Water + Organism	3,571
Hexachlorobutadiene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.44	Clean Water Act -- Human Health Water + Organism	2.3
Hexachlorocyclopentadiene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	40	Clean Water Act -- Human Health Water + Organism	0.025
Hexachloroethane	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.4	Clean Water Act -- Human Health Water + Organism	0.71
Hexachlorophene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	10	10	4.8	WAC 173-340-720(4)(b)(iii)(A) and (B)	2.1
Indeno(1,2,3-cd)pyrene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0028	40 CFR 131 -- Human Health Water + Organism	357
Isophorone	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	8.4	40 CFR 131 -- Human Health Water + Organism	0.12
Kepone	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	20	20	0.0004	WAC 173-340-730(3)(b)(iii)(A) and (B)	47,847
m-Dinitrobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.6	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.63
Methyl methanesulfonate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.88	WAC 173-340-720(4)(b)(iii)(A) and (B)	1.1
Methyl parathion	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.25
Naphthalene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	160	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0063
Nitrobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	16	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.063
Nitrosopyrrolidine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.016	Clean Water Act -- Human Health Water + Organism	63
n-Nitrosodiethylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0003	WAC 173-340-720(4)(b)(iii)(A) and (B)	3,425
n-Nitrosodimethylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	0.0007	Clean Water Act -- Human Health Water + Organism	2,899
n-Nitrosodi-n-butylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0063	Clean Water Act -- Human Health Water + Organism	159
n-Nitrosodi-n-dipropylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0050	Clean Water Act -- Human Health Water + Organism	200
n-Nitrosodiphenylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	3.3	Clean Water Act -- Human Health Water + Organism	0.30
n-Nitrosomethylethylamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0040	WAC 173-340-720(4)(b)(iii)(A) and (B)	251
n-Nitrosomorpholine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.013	WAC 173-340-720(4)(b)(iii)(A) and (B)	76
n-Nitrosopiperidine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.0093	WAC 173-340-720(4)(b)(iii)(A) and (B)	107
Parathion	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.013	Clean Water Act -- Freshwater CCC	77
p-Dimethylaminoazobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.019	WAC 173-340-720(4)(b)(iii)(A) and (B)	53
Pentachlorobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1.4	Clean Water Act -- Human Health Water + Organism	0.71
Pentachloroethane	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.97	WAC 173-340-720(4)(b)(iii)(A) and (B)	1.0
Pentachloronitrobenzene (PCNB)	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.046	WAC 173-340-730(3)(b)(iii)(A) and (B)	22
Pentachlorophenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.3	1.3	0.27	Clean Water Act -- Human Health Water + Organism	4.8

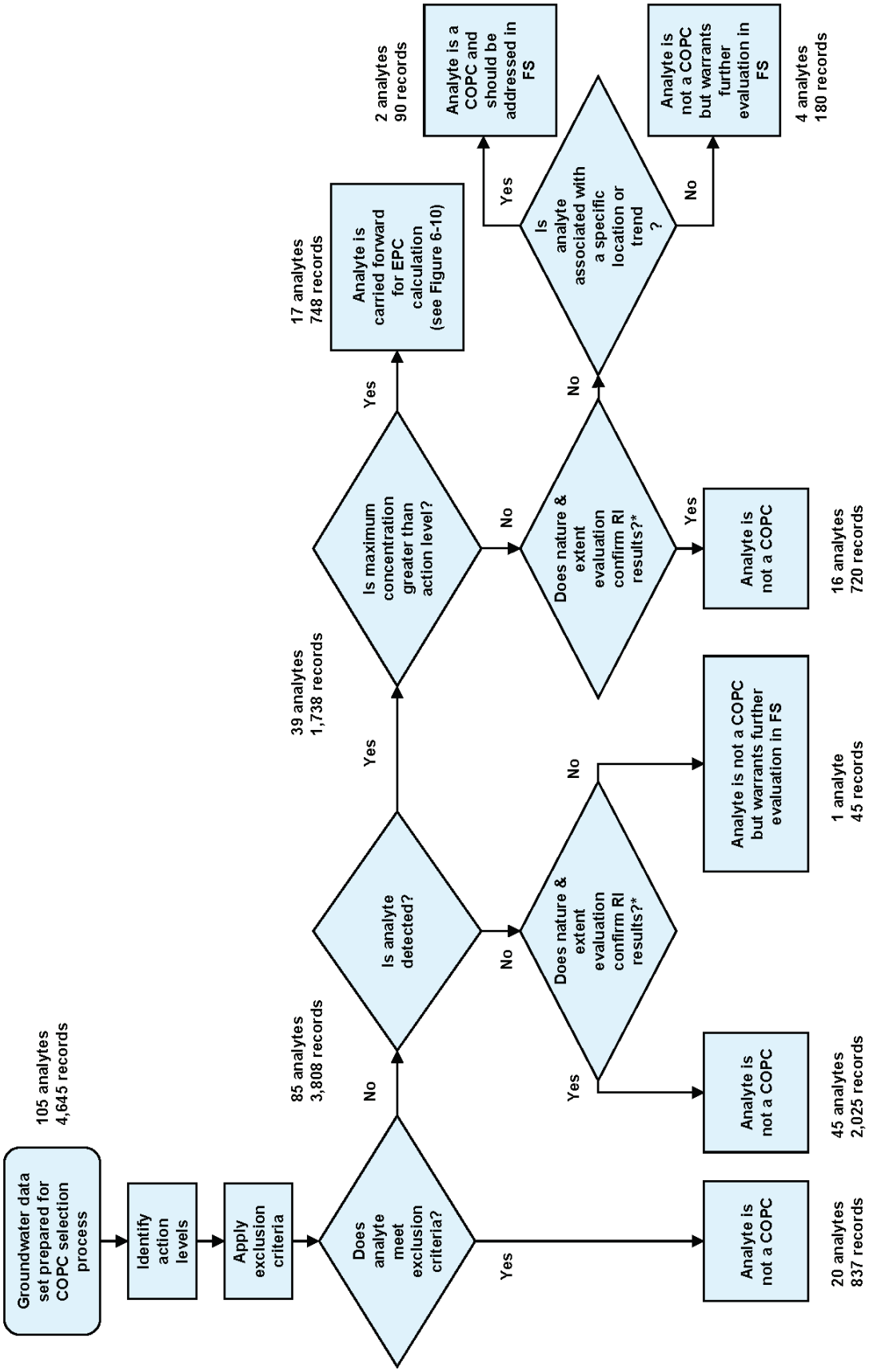
Table 6-25. Summary of Groundwater Analytes that Were Not Detected for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
Phenacetin	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	40	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.025
Phenol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0008
Phorate	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	3.2	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.31
p-Phenylenediamine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	3,040	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0003
Pronamide	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	1,200	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0008
Pyrene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	480	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0021
Pyridine	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.0	2.0	8.0	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.25
Safrol	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	0.34	WAC 173-340-730(3)(b)(iii)(A) and (B)	3.0
sym-Trinitrobenzene	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	480	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0021
Tetraethyl dithiopyrophosphate (Sulfotepp)	SVOC	6/10/2010	12/20/2010	51	0	0%	µg/L	1.0	1.0	6.5	WAC 173-340-730(3)(b)(iii)(A) and (B)	0.15
1,1,1,2-Tetrachloroethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.090	0.090	1.7	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.054
1,1,1-Trichloroethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.069	0.069	200	40 CFR 141 - Federal MCL-Primary	0.0003
1,1,2,2-Tetrachloroethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.098	0.098	0.17	Clean Water Act -- Human Health Water + Organism	0.58
1,1,2-Trichloroethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.15	0.15	0.59	Clean Water Act -- Human Health Water + Organism	0.25
1,1-Dichloroethene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.083	0.083	0.057	40 CFR 131 -- Human Health Water + Organism	1.5
1,2,3-Trichloropropane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.15	0.15	0.0015	WAC 173-340-720(4)(b)(iii)(A) and (B)	103
1,2-Dibromo-3-chloropropane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.41	0.41	0.055	WAC 173-340-720(4)(b)(iii)(A) and (B)	7.5
1,2-Dibromoethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.13	0.13	0.022	WAC 173-340-720(4)(b)(iii)(A) and (B)	5.9
1,2-Dichloroethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.10	0.10	0.38	Clean Water Act -- Human Health Water + Organism	0.26
1,2-Dichloroethene (Total)	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.15	0.15	72	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0021
1,2-Dichloropropane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.097	0.097	0.50	Clean Water Act -- Human Health Water + Organism	0.19
1,4-Dichlorobenzene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.12	0.12	8.1	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.015
1,4-Dioxane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	7.6	7.6	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)	1.9
1-Butanol	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	12	12	800	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.015
2-Butanone	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.52	0.52	4,800	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0001
2-Hexanone	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.22	0.22	80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0028
4-Methyl-2-pentanone	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.12	0.12	640	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0002
Acrolein	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	2.8	2.8	3.0	Clean Water Act -- Freshwater CCC	0.93
Allyl chloride	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.11	0.11	2.1	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.053
Benzene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.064	0.064	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.080

Table 6-25. Summary of Groundwater Analytes that Were Not Detected for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Action Level	Action Level Basis	Level of Exceedence
Chlorobenzene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.15	0.15	100	40 CFR 141 - Federal MCL-Primary	0.0015
Chloroprene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.097	0.097	160	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0006
cis-1,2-dichloroethene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.087	0.087	70	40 CFR 141 - Federal MCL-Primary	0.0012
cis-1,3-Dichloropropene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.073	0.073	0.34	Clean Water Act -- Human Health Water + Organism	0.21
Dibromomethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.21	0.21	80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0026
Dichlorodifluoromethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.084	0.084	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00005
Ethyl methacrylate	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.11	0.11	720	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0002
Ethylbenzene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.086	0.086	4.0	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.022
Isobutyl alcohol	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	8.7	8.7	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0036
Methacrylonitrile	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.50	0.50	0.80	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.63
Methyl methacrylate	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.26	0.26	11,200	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00002
Methylene chloride	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.11	0.11	4.6	Clean Water Act -- Human Health Water + Organism	0.024
Styrene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.074	0.074	100	40 CFR 141 - Federal MCL-Primary	0.0007
Tetrachloroethene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.18	0.18	0.081	WAC 173-340-720(4)(b)(iii)(A) and (B)	2.2
trans-1,2-Dichloroethylene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.083	0.083	100	40 CFR 141 - Federal MCL-Primary	0.0008
trans-1,3-Dichloropropene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.083	0.083	0.34	Clean Water Act -- Human Health Water + Organism	0.24
Trichloroethene	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.21	1.0	0.49	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.43
Trichloromonofluoromethane	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.11	0.11	2,400	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00005
Vinyl acetate	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.18	0.18	8,000	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.00002
Vinyl chloride	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.084	0.084	0.025	Clean Water Act -- Human Health Water + Organism	3.4
Xylenes (total)	VOC	6/10/2010	12/20/2010	51	0	0%	µg/L	0.20	0.20	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)	0.0001

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units.*



* RI results = results from three rounds of spatial and temporal sampling from monitoring well network defined in DOE/RL-2009-45.

Figure 6-9. COPC Identification Process for the 300 Area Subregion of the 300-FF-5 Groundwater OU: Part 1

Nitrite, cadmium, and Sr-90 were not detected in any of the samples collected for the RI; however, these analytes were detected in groundwater over the past five years. Nitrite concentrations over the past 5 years have been detected in unfiltered groundwater at concentrations less than the DWS. Nitrite concentrations in filtered samples are less than the 90th percentile Hanford Site background value of 94 µg/L. Sr-90 concentrations have been detected in groundwater over the past five years at a low frequency at concentrations less than their action level. Cadmium concentrations (detected once) and MDLs greater than the action level and above background were reported by Method 6010. Cadmium concentrations reported by Method 6010 are considered uncertain because this method cannot accurately report trace concentrations. Groundwater samples analyzed by Method 6010 generally report MDLs greater than the action level resulting in nondetected concentrations greater than the action level. Similarly, detected concentrations are reported as estimates (flagged with a "J" qualifier) at concentrations greater than the action level and are outside of the calibration range of the instrument. Whereas, cadmium concentrations reported by Method 200.8 are less than the 90th percentile Hanford Site background value of 0.92 µg/L. Although nitrite, cadmium, and Sr-90 have been detected in the past five years, concentrations of these analytes were less than their action levels. Therefore, nitrite, cadmium, and Sr-90 are not COPCs, and will not be carried forward into the risk characterization section or the FS.

Antimony was not detected in any of the samples collected for the RI; however, it was detected in groundwater over the past five years at a low frequency. All antimony concentrations and MDLs greater than the action level were reported by Method 6010. Antimony concentrations reported by Method 6010 are considered uncertain because this method cannot accurately report trace concentrations. Groundwater samples analyzed by Method 6010 generally report MDLs greater than the action level resulting in nondetected concentrations greater than the action level. Similarly, detected concentrations are reported as estimates (flagged with a "J" qualifier) at concentrations greater than the action level and are outside of the calibration range of the instrument. Additionally, antimony concentrations above the action level are not associated with a specific location or with a trend. Although antimony was not detected in the samples analyzed for the RI by Method 200.8, its historic presence with infrequent detections above the action level result in an uncertain status. Therefore, antimony is not considered a COPC; however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

600 Area Subregion. The conclusions of the nature and extent evaluation for those nondetected analytes that were identified as historic COPCs in DOE/RL-2009-45 support the findings of this risk evaluation for cadmium, Sr-90, PCE, TCE, and vinyl chloride. These five analytes were not detected in samples collected specifically for the RI nor were they detected in any groundwater sample collected over the past five years. All MDLs associated with Sr-90, PCE, TCE, and vinyl chloride were less than the action level or the EQL (as applicable) listed in the 300 Area SAP (DOE/RL-2009-45). With the exception of groundwater samples analyzed by Method 6010, all MDLs for cadmium were less than the action level. Groundwater samples analyzed by Method 6010 generally report MDLs greater than the action level resulting in nondetected concentrations greater than the action level. Therefore, these five analytes are not COPCs and will not be carried forward into the risk characterization section or into the FS.

Nitrite and antimony were not detected in any of the samples collected for the RI; however, these analytes were detected in groundwater over the past five years. Nitrite has historically been detected in unfiltered groundwater at a low frequency with concentrations and MDLs less than the DWS. Antimony has historically been detected in groundwater at a low frequency at concentrations less than their action level (with the exception of the Method 6010 results); antimony concentrations are also less than the 90th percentile Hanford Site background value of 55 µg/L. Antimony concentrations reported by Method 6010 are considered uncertain because this method cannot accurately report trace concentrations. Groundwater samples analyzed by Method 6010 generally report MDLs greater than the action level resulting in nondetected concentrations greater than the action level. Similarly, detected concentrations

are reported as estimates (flagged with a "J" qualifier) at concentrations greater than the action level and are outside of the calibration range of the instrument. Additionally, antimony concentrations above the action level are not associated with a specific location or with a trend. Although nitrite and antimony have been detected in the past five years, concentrations of these analytes were less than their action level or less than background. Therefore, nitrite and antimony are not COPCs, and will not be carried forward into the risk characterization section or the FS.

6.3.2.3.4 Identify Analytes with Maximum Detected Concentrations Less than Action Levels.

This step identifies analytes with maximum concentrations less than action levels. In this screening, the maximum concentration of each analyte detected in groundwater was compared to its action level, to identify analytes not likely to contribute significantly to overall risk. If the maximum detected concentration of an analyte was less than its action level, the analyte was eliminated as a COPC, unless the nature and extent evaluation described below indicates otherwise.

300 Area Subregion. Twenty-two analytes were detected at least once and had maximum detected concentrations less than their respective action levels. A list of these analytes is presented in Table 6-26, each with sampling dates, minimum and maximum MDLs, minimum and maximum detected concentrations, the action levels, and the basis for each action level.

Chloroform, chromium, cis-1,2-dichloroethene, cobalt, cyanide, fluoride, manganese, nickel, silver, sulfate, and tritium were identified as historic COPCs in the work plan. The conclusions of the nature and extent evaluation for analytes that were identified as historic COPCs support the findings of this risk evaluation except for chromium and cis-1,2-dichloroethene. Chromium[12] and cis-1,2-dichloroethene are identified as COPCs that will be carried forward into the FS (see Section 8.1.1.2). Because of inconclusive analytical results, cobalt, nickel, silver, and sulfate are not identified as COPCs but warrant further monitoring.

Chloroform, cyanide, manganese, and tritium were detected in groundwater samples collected for the RI at concentrations below their respective action level. The results of the nature and extent evaluation are similar; these four analytes have historically been detected in groundwater at concentrations below their action level or EQL (as applicable). Based on these similarities, chloroform, cyanide, manganese, and tritium are not COPCs and will not be carried forward into the risk characterization section or into the FS. It should also be noted that concentrations of cyanide in groundwater samples are less than their 90th percentile Hanford Site background value of 8.4 µg/L.

Cobalt, nickel, silver, and sulfate were detected in groundwater samples collected for the RI at concentrations below their respective action level. However, the nature and extent evaluation indicates that cobalt, nickel, silver, and sulfate have been detected in groundwater over the past five years. Detections of cobalt, nickel, silver, and sulfate above the action level or EQL (as applicable) were from a larger population of wells as described earlier; however, their presence was not associated with a specific location or with a trend. The results of this evaluation indicate that although cobalt, nickel, silver, and sulfate were detected at concentrations less than the action level in samples collected for the RI, their historic presence in a larger population of wells with infrequent detections above the action level result in an uncertain status. Therefore, cobalt, nickel, silver, and sulfate are not considered COPCs; however, they warrant further evaluation in the FS (see Section 8.1.1.2) where they should be monitored.

Chromium was detected in groundwater samples collected for the RI at concentrations below the action level of 65 µg/L. The nature and extent evaluation indicates that chromium was detected infrequently in 399-8-5A and 399-8-1 with concentrations ranging up to 1.4 times the AWQC of 65 µg/L over the past

[12] Chromium is likely in the form of hexavalent chromium at Wells 388-8-1 and 399-8-5A.

5 years. Groundwater samples from the 300-FF-5 Groundwater OU have not been analyzed for Cr(VI). However, chromium concentrations at 399-8-5A in unfiltered (5.1 to 105 µg/L) and filtered (4.9 to 91 µg/L) samples are essentially the same. Chromium concentrations at 399-8-1 in unfiltered (5.1 to 69 µg/L) and filtered at 399-8-1 (5.1 to 69 µg/L) are the same. Based on these results, it is likely that the chromium measured at these wells is hexavalent. The results of this evaluation indicate that the presence of chromium at 399-8-5A and 399-8-1 is likely hexavalent and concentrations are greater than the AWQC of 10 µg/L. Therefore, Cr(VI) is identified as a COPC; however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

cis-1,2-dichloroethene was detected in groundwater samples collected for the RI at concentrations below the action level of 70 µg/L. The nature and extent evaluation indicates that cis-1,2-dichloroethene was detected in 399-1-16B where concentrations have ranged between less than the MDL of 1 µg/L and 270 µg/L over the last five years. All remaining wells in the 300-FF-5 OU are reported with concentrations less than the action level of 70 µg/L. Well 399-1-16B was not included in the monitoring well network used in the spatial and temporal sampling for the RI and therefore these results were not included in the calculation of EPCs. The presence of cis-1,2-dichloroethene is associated with a long-term trend associated with the north process ponds. Cis-1,2-dichloroethene is identified as a COPC, because cis-1,2-dichloroethene results from this well were not included in the calculation of EPCs, it is not carried forward into the risk characterization section; however, it should be addressed in the FS (see Section 8.1.1.2) to evaluate potential remedial technologies.

Fluoride was detected in groundwater samples collected for the RI at concentrations below the action level of 960 µg/L. The results of the nature and extent evaluation indicate that fluoride has been detected in groundwater over the past five years. Minimum, maximum, and 90th percentile concentrations for (unfiltered) background concentrations of fluoride are 267, 5,850, and 1,047 µg/L, respectively. Except for two fluoride results reported at 399-1-21B and 399-1-23, fluoride concentrations range between 12 µg/L and 1,720 µg/L, which are within the range of naturally occurring levels. Fluoride concentrations above the action level were reported in one of ten sampling rounds at 399-1-21B (534 to 16,700 µg/L) and one of 16 rounds at 399-1-23 (184 to 8,410 µg/L). The results of this evaluation indicate that fluoride concentrations are generally within the range of naturally occurring levels. Fluoride concentrations above naturally occurring levels are not associated with a specific location or a trend. Therefore, fluoride is not a COPC and will not be carried forward into the risk characterization section or into the FS.

600 Area Subregion. Thirty analytes were detected at least once and had maximum detected concentrations less than their respective action levels. A list of these analytes is presented in Table 6-27, each with sampling dates, minimum and maximum MDLs, minimum and maximum detected concentrations, the action levels, and the basis for each action level .

Carbon tetrachloride, chromium, fluoride, I-129, lead, nickel, sulfate, tributyl phosphate, uranium, and zinc were identified as historic COPCs in the work plan. The conclusions of the nature and extent evaluation for analytes that were identified as historic COPCs support the findings of this risk evaluation. Because of inconclusive analytical results, CCl_4, lead, uranium, and zinc are not identified as COPCs but warrant further monitoring.

Table 6-26. Summary of Groundwater Analytes that Do Not Exceed an Action Level for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Action Level	Action Level Basis
Chloride	ANION	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	6,890	29,000	230,000	Clean Water Act -- Freshwater CCC
Cyanide	ANION	6/4/2010	12/14/2010	45	1	2%	µg/L	4.0	4.0	3.7	3.7	5.2	Clean Water Act -- Freshwater CCC
Fluoride	ANION	6/4/2010	12/14/2010	45	43	96%	µg/L	60	60	86	340	960	WAC 173-340-720(4)(b)(iii)(A) and (B)
Sulfate	ANION	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	25,700	59,500	250,000	40 CFR 141 - Federal MCL-Secondary
Barium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	37	83	1,000	Clean Water Act -- Human Health Water + Organism
Boron	METAL	6/4/2010	12/14/2010	45	12	27%	µg/L	19	41	19	118	3,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
Chromium	METAL	6/4/2010	12/14/2010	45	44	98%	µg/L	1.0	1.0	1.4	17	65	Clean Water Act -- Freshwater CCC
Cobalt	METAL	6/4/2010	12/14/2010	45	3	7%	µg/L	0.050	0.22	0.14	0.16	2.6	WAC 173-340-730(3)(b)(iii)(A) and (B)
Manganese	METAL	6/4/2010	12/14/2010	45	3	7%	µg/L	4.0	6.0	6.0	12	50	40 CFR 141 - Federal MCL-Secondary
Molybdenum	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	3.5	5.8	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
Nickel	METAL	6/4/2010	12/14/2010	45	11	24%	µg/L	4.0	4.0	4.0	12	52	Clean Water Act -- Freshwater CCC
Silver	METAL	6/4/2010	12/14/2010	45	2	4%	µg/L	0.10	0.20	0.099	0.72	2.6	WAC 173-201A
Strontium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	5.0	280	9,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
Tin	METAL	6/4/2010	12/14/2010	45	3	7%	µg/L	0.050	0.10	0.10	0.20	519	WAC 173-340-730(3)(b)(iii)(A) and (B)
Vanadium	METAL	6/4/2010	12/14/2010	45	10	22%	µg/L	12	17	12	34	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
Tritium	RAD	6/4/2010	12/14/2010	45	39	87%	pCi/L	2.7	130	180	7,700	20,000	40 CFR 141 - Federal MCL-Primary
1,2-Dichloroethene (Total)	VOC	6/4/2010	12/14/2010	45	10	22%	µg/L	0.15	0.15	0.18	0.69	72	WAC 173-340-720(4)(b)(iii)(A) and (B)
Acetone	VOC	6/4/2010	12/14/2010	45	8	18%	µg/L	0.34	0.34	0.71	31	7,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
Bromomethane	VOC	6/4/2010	12/14/2010	45	3	7%	µg/L	0.13	0.25	0.44	0.77	11	WAC 173-340-720(4)(b)(iii)(A) and (B)
Carbon disulfide	VOC	6/4/2010	12/14/2010	45	4	9%	µg/L	0.051	0.051	0.056	0.075	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
Chloroform	VOC	6/4/2010	12/14/2010	45	12	27%	µg/L	0.10	0.10	0.13	0.87	1.4	WAC 173-340-720(4)(b)(iii)(A) and (B)
cis-1,2-dichloroethene	VOC	6/4/2010	12/14/2010	45	11	24%	µg/L	0.087	0.087	0.12	0.69	70	40 CFR 141 - Federal MCL-Primary

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*.

Table 6-27. Summary of Groundwater Analytes that Do Not Exceed an Action Level for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Action Level	Action Level Basis
Chloride	ANION	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	1,860	26,100	230,000	Clean Water Act -- Freshwater CCC
Fluoride	ANION	6/10/2010	12/20/2010	51	43	84%	µg/L	60	60	39	851	960	WAC 173-340-720(4)(b)(iii)(A) and (B)
Sulfate	ANION	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	3,980	87,200	250,000	40 CFR 141 - Federal MCL-Secondary
Barium	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	15	118	1,000	Clean Water Act -- Human Health Water + Organism
Beryllium	METAL	6/10/2010	12/20/2010	51	1	2%	µg/L	0.10	0.10	0.19	0.19	4.0	40 CFR 141 - Federal MCL-Primary
Boron	METAL	6/10/2010	12/20/2010	50	14	28%	µg/L	19	41	20	107	3,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
Chromium	METAL	6/10/2010	12/20/2010	51	34	67%	µg/L	1.0	1.0	1.1	5.9	65	Clean Water Act -- Freshwater CCC
Cobalt	METAL	6/10/2010	12/20/2010	51	10	20%	µg/L	0.10	0.10	0.13	1.0	2.6	WAC 173-340-730(3)(b)(iii)(A) and (B)
Lead	METAL	6/10/2010	12/20/2010	51	15	29%	µg/L	0.20	0.20	0.24	1.4	2.1	WAC 173-201A
Lithium	METAL	6/10/2010	12/20/2010	50	36	72%	µg/L	4.0	4.0	4.0	31	32	WAC 173-340-720(4)(b)(iii)(A) and (B)
Molybdenum	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	1.0	11	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
Nickel	METAL	6/10/2010	12/20/2010	51	4	8%	µg/L	4.0	4.0	4.0	8.0	52	Clean Water Act -- Freshwater CCC
Strontium	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	115	407	9,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
Tin	METAL	6/10/2010	12/20/2010	51	4	8%	µg/L	0.10	0.10	0.12	0.26	519	WAC 173-340-730(3)(b)(iii)(A) and (B)
Uranium	METAL	6/10/2010	12/20/2010	51	49	96%	µg/L	0.10	0.10	0.094	13	30	40 CFR 141 - Federal MCL-Primary
Vanadium	METAL	6/10/2010	12/20/2010	51	19	37%	µg/L	12	17	12	33	80	WAC 173-340-720(4)(b)(iii)(A) and (B)
Zinc	METAL	6/10/2010	12/20/2010	51	24	47%	µg/L	4.0	6.0	4.0	71	91	WAC 173-201A
Iodine-129	RAD	6/10/2010	12/20/2010	51	1	2%	pCi/L	-0.10	0.24	0.38	0.38	1.0	40 CFR 141.66
Benzyl alcohol	SVOC	6/10/2010	12/20/2010	51	1	2%	µg/L	1.0	1.0	1.1	1.1	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
Butylbenzylphthalate	SVOC	6/10/2010	12/20/2010	51	1	2%	µg/L	1.0	1.0	1.3	1.3	8.2	WAC 173-340-730(3)(b)(iii)(A) and (B)
Diethylphthalate	SVOC	6/10/2010	12/20/2010	51	2	4%	µg/L	1.0	1.0	1.7	42	12,800	WAC 173-340-720(4)(b)(iii)(A) and (B)
Di-n-butylphthalate	SVOC	6/10/2010	12/20/2010	51	1	2%	µg/L	1.0	1.0	1.0	1.0	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
Tributyl phosphate	SVOC	6/10/2010	12/20/2010	51	1	2%	µg/L	1.0	1.0	6.7	6.7	9.5	WAC 173-340-720(4)(b)(iii)(A) and (B)
1,1-Dichloroethane	VOC	6/10/2010	12/20/2010	51	3	6%	µg/L	0.068	0.068	0.15	0.20	1,600	WAC 173-340-720(4)(b)(iii)(A) and (B)
Acetone	VOC	6/10/2010	12/20/2010	44	5	11%	µg/L	0.34	0.34	0.40	2.5	7,200	WAC 173-340-720(4)(b)(iii)(A) and (B)
Bromoform	VOC	6/10/2010	12/20/2010	51	6	12%	µg/L	0.17	0.17	1.6	2.9	4.3	Clean Water Act -- Human Health Water + Organism
Bromomethane	VOC	6/10/2010	12/20/2010	51	9	18%	µg/L	0.13	2.0	0.31	0.95	11	WAC 173-340-720(4)(b)(iii)(A) and (B)
Carbon disulfide	VOC	6/10/2010	12/20/2010	51	3	6%	µg/L	0.051	0.051	0.060	0.11	800	WAC 173-340-720(4)(b)(iii)(A) and (B)
Carbon tetrachloride	VOC	6/10/2010	12/20/2010	51	2	4%	µg/L	0.12	0.12	0.13	0.16	0.23	Clean Water Act -- Human Health Water + Organism
Toluene	VOC	6/10/2010	12/20/2010	51	2	4%	µg/L	0.072	0.072	0.083	0.14	640	WAC 173-340-720(4)(b)(iii)(A) and (B)

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, 300 *Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units.*

Chromium, I-129, nickel, sulfate and tributyl phosphate were detected in groundwater samples collected for the RI at concentrations below their respective action level. The results of the nature and extent evaluation are similar; these five analytes have been detected historically in groundwater at concentrations below their action level. Based on these similarities, chromium, I-129, nickel, sulfate, and tributyl phosphate are not COPCs and will not be carried forward into the risk characterization section or into the FS.

Carbon tetrachloride, lead, uranium, and zinc were detected in groundwater samples collected for the RI at concentrations below their respective action level. The nature and extent evaluation indicates that CCl_4, lead, uranium, and zinc have historically been detected in groundwater. Historic detections of CCl_4, lead, uranium, and zinc were above the action level or EQL (as applicable); however, their presence was not associated with a specific location or with a trend. The results of this evaluation indicate that although CCl_4, lead, uranium, and zinc were detected at concentrations less than the action level in samples collected for the RI, their historic presence with infrequent detections above the action level result in an uncertain status. Therefore, CCl_4, lead, uranium, and zinc are not considered COPCs, however, they warrant further evaluation in the FS (see Section 8.1.1.2) where they should be monitored.

Fluoride was detected in groundwater samples collected for the RI at concentrations less than the action level. The nature and extent evaluation indicates that except for one sample result (1,200 µg/L), all fluoride concentrations in unfiltered samples are below the 90th percentile Hanford Site background level of 1,047 µg/L. All fluoride concentrations are within the range of naturally occurring levels. Therefore, fluoride is not a COPC and will not be carried forward into the risk characterization section or into the FS.

6.3.2.3.5 Identify Analytes with Maximum Detected Concentrations Greater than Action Levels

This step identifies analytes with maximum concentrations greater than their respective action levels. Such analytes have the potential to contribute to overall risk. If the maximum detected concentration of an analyte is greater than its action level, the analyte is carried forward into the next step of the analysis for calculation of EPCs.

For the 300 Area Subregion, 17 analytes were detected in the RI data at least once, with maximum detected concentrations greater than their respective action levels. For the 600 Area Subregion, 13 analytes were detected in the RI data at least once, with maximum detected concentrations greater than their respective action levels. A list of these analytes is presented in Tables 6-28 and 6-29 respectively, each with sampling dates, minimum and maximum MDLs, minimum and maximum detected concentrations, the action level, and the basis of the action level.

6.3.2.3.6 Calculate EPCs for Each Analyte with Maximum Detected Concentrations Greater than Action Levels

A flowchart depicting the COPC identification process and the number of analytes associated with each process step is provided in Figure 6-10 for the 300 Area Subregion and in Figure 6-12 for the 600 Area Subregion. The steps in the sequence are described below.

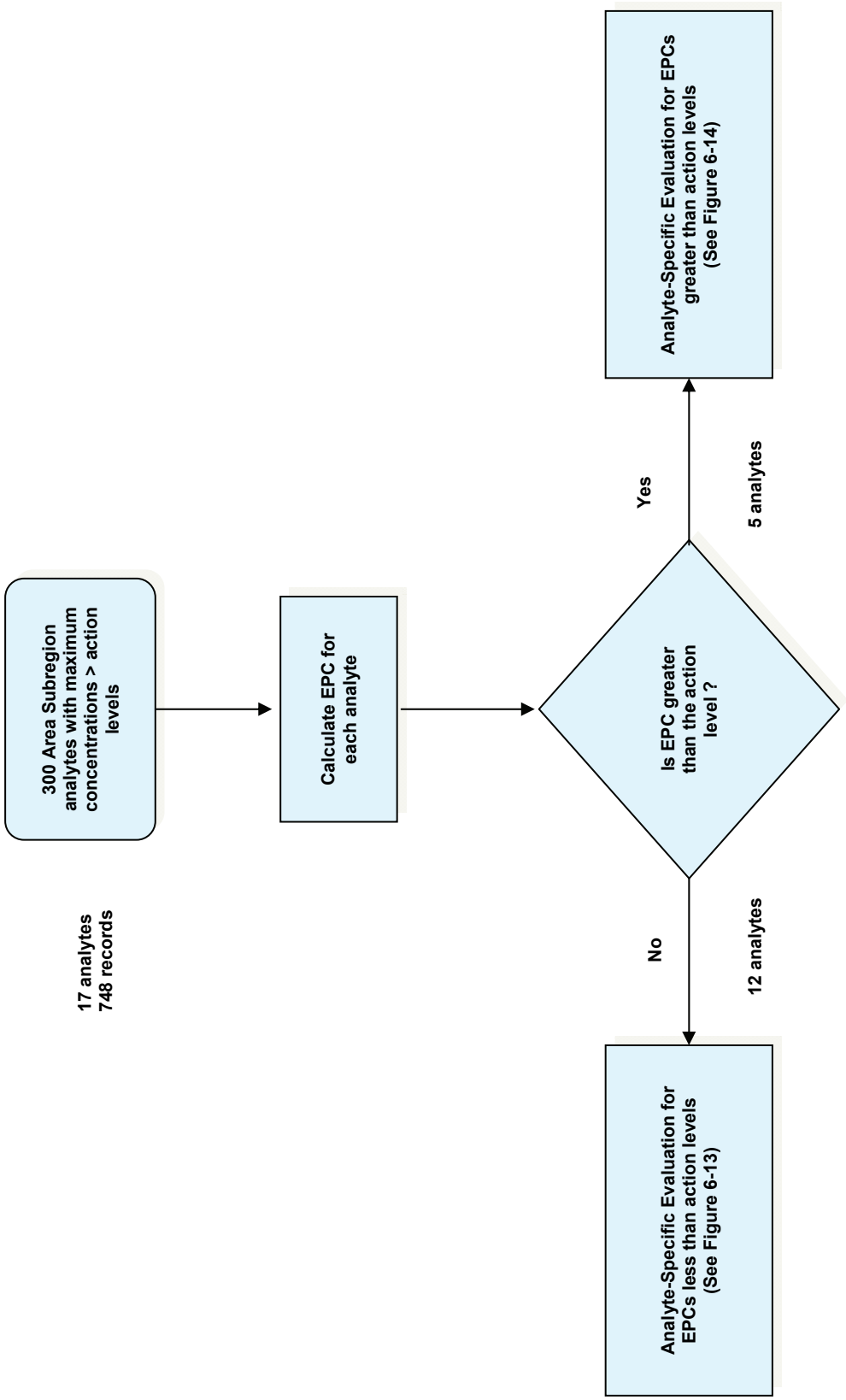
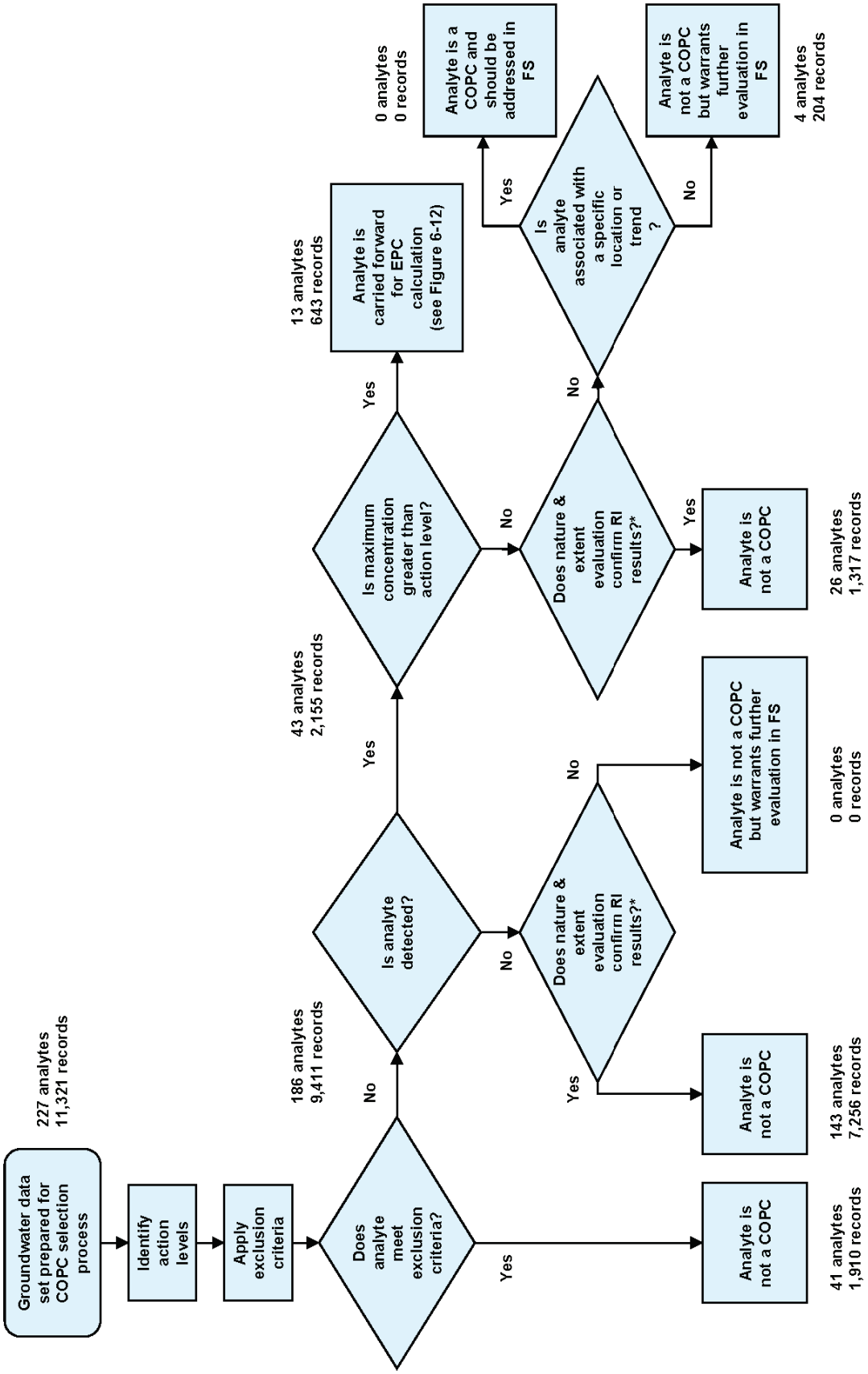


Figure 6-10. COPC Identification Process for the 300 Area Subregion of the 300-FF-5 Groundwater OU: Part 2



* RI results = results from three rounds of spatial and temporal sampling from monitoring well network defined in DOE/RL-2009-45.

Figure 6-11. COPC Identification Process for the 600 Area Subregion of the 300-FF-5 Groundwater OU: Part 1

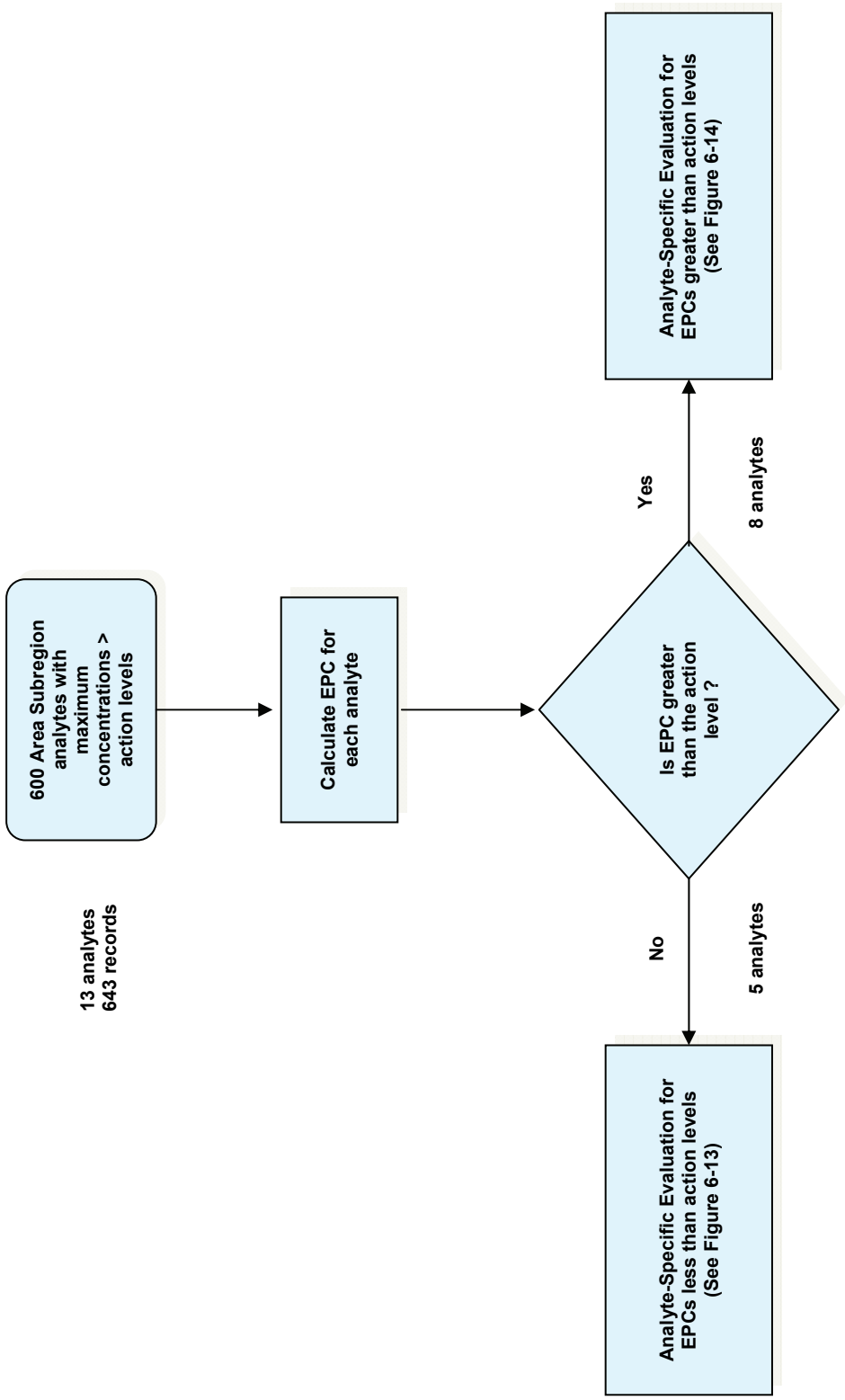


Figure 6-12. COPC Identification Process for the 600 Area Subregion of the 300-FF-5 Groundwater OU: Part 2

Table 6-28. Summary of Groundwater Analytes that Exceed an Action Level for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Action Level	Action Level Basis
Nitrate	ANION	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	7,080	62,000	45,000	40 CFR 141 - Federal MCL-Primary
Aluminum	METAL	6/4/2010	12/14/2010	45	4	9%	µg/L	5.0	10	9.3	100	50	40 CFR 141 - Federal MCL-Secondary
Arsenic	METAL	6/4/2010	12/14/2010	45	43	96%	µg/L	0.80	0.80	0.93	6.5	0.018	Clean Water Act -- Human Health Water + Organism
Copper	METAL	6/4/2010	12/14/2010	45	23	51%	µg/L	0.10	0.45	0.21	31	9.0	Clean Water Act -- Freshwater CCC
Iron	METAL	6/4/2010	12/14/2010	45	19	42%	µg/L	18	38	18	647	300	40 CFR 141 - Federal MCL-Secondary
Lead	METAL	6/4/2010	12/14/2010	45	3	7%	µg/L	0.10	0.20	0.29	3.5	2.1	WAC 173-201A
Lithium	METAL	6/4/2010	12/14/2010	45	33	73%	µg/L	4.0	4.0	4.0	33	32	WAC 173-340-720(4)(b)(iii)(A) and (B)
Selenium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	0.48	5.8	5.0	Clean Water Act -- Freshwater CCC
Thallium	METAL	6/4/2010	12/14/2010	45	1	2%	µg/L	0.050	0.10	1.2	1.2	0.24	Clean Water Act -- Human Health Water + Organism
Uranium	METAL	6/4/2010	12/14/2010	45	45	100%	µg/L	--	--	6.4	177	30	40 CFR 141 - Federal MCL-Primary
Zinc	METAL	6/4/2010	12/14/2010	45	12	27%	µg/L	4.0	6.0	4.0	456	91	WAC 173-201A
Gross alpha	RAD	6/4/2010	12/14/2010	28	28	100%	pCi/L	--	--	3.4	77	15	40 CFR 141 - Federal MCL-Primary
Acrolein	VOC	6/4/2010	12/14/2010	45	1	2%	µg/L	2.8	2.8	3.8	3.8	3.0	Clean Water Act -- Freshwater CCC
Bromodichloromethane	VOC	6/4/2010	12/14/2010	45	3	7%	µg/L	0.088	0.088	0.68	0.69	0.27	40 CFR 131 -- Human Health Water + Organism
Carbon tetrachloride	VOC	6/4/2010	12/14/2010	45	3	7%	µg/L	0.12	0.12	0.13	0.59	0.23	Clean Water Act -- Human Health Water + Organism
Tetrachloroethene	VOC	6/4/2010	12/14/2010	45	3	7%	µg/L	0.18	0.18	0.19	0.38	0.081	WAC 173-340-720(4)(b)(iii)(A) and (B)
Trichloroethene	VOC	6/4/2010	12/14/2010	45	35	78%	µg/L	0.21	0.25	0.31	3.0	0.49	WAC 173-340-720(4)(b)(iii)(A) and (B)

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*.

Table 6-29. Summary of Groundwater Analytes that Exceed an Action Level for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Begin Sample Date	End Sample Date	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	Action Level	Action Level Basis
Nitrate	ANION	6/10/2010	12/20/2010	51	48	94%	µg/L	84	274	227	136,000	45,000	40 CFR 141 - Federal MCL-Primary
Aluminum	METAL	6/10/2010	12/20/2010	51	15	29%	µg/L	10	10	12	539	50	40 CFR 141 - Federal MCL-Secondary
Arsenic	METAL	6/10/2010	12/20/2010	51	51	100%	µg/L	--	--	1.6	15	0.018	Clean Water Act -- Human Health Water + Organism
Copper	METAL	6/10/2010	12/20/2010	51	31	61%	µg/L	0.20	0.20	0.24	12	9.0	Clean Water Act -- Freshwater CCC
Iron	METAL	6/10/2010	12/20/2010	51	40	78%	µg/L	18	38	23	3,340	300	40 CFR 141 - Federal MCL-Secondary
Manganese	METAL	6/10/2010	12/20/2010	51	27	53%	µg/L	4.0	6.0	5.0	261	50	40 CFR 141 - Federal MCL-Secondary
Selenium	METAL	6/10/2010	12/20/2010	51	33	65%	µg/L	0.60	6.0	0.63	13	5.0	Clean Water Act -- Freshwater CCC
Gross alpha	RAD	6/10/2010	12/20/2010	22	14	64%	pCi/L	-1.3	1.2	2.3	40	15	40 CFR 141 - Federal MCL-Primary
Tritium	RAD	6/10/2010	12/20/2010	51	31	61%	pCi/L	-57	180	290	890,000	20,000	40 CFR 141 - Federal MCL-Primary
Bis(2-ethylhexyl) phthalate	VOC	6/10/2010	12/20/2010	51	3	6%	µg/L	1.0	1.0	1.3	3.0	1.2	Clean Water Act -- Human Health Water + Organism
Bromodichloromethane	VOC	6/10/2010	12/20/2010	51	10	20%	µg/L	0.088	0.088	0.17	2.1	0.27	40 CFR 131 -- Human Health Water + Organism
Chloroform	VOC	6/10/2010	12/20/2010	51	15	29%	µg/L	0.10	0.10	0.11	7.1	1.4	WAC 173-340-720(4)(b)(iii)(A) and (B)
Dibromochloromethane	VOC	6/10/2010	12/20/2010	51	7	14%	µg/L	0.13	0.13	1.6	3.3	0.40	Clean Water Act -- Human Health Water + Organism

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*.

COPCs are identified by comparing statistical EPC estimates to action levels for each detected analyte and exposure area. EPCs are calculated as the 90th percentile value for each analyte with a maximum detected concentration greater than the action level from the groundwater data set collected specifically for the RI. The MDL is used as the concentration for nondetect results in the percentile calculations. The 90th percentile exposure is identified in *Guidelines for Exposure Assessment* (EPA/600/Z-92/001) for describing and characterizing health risks and produces risk estimates corresponding to an RME. A description of the methodology used to calculate the 90th percentile values is provided in *Calculation of Exposure Point Concentrations for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0130) (Appendix G) and in *Calculation of Exposure Point Concentrations for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0131) (Appendix G).

In general, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) recommends using a UCL-95 on the average for estimating EPCs. However, experience at the Hanford Site indicates that averages and UCLs cannot be reliably calculated for groundwater data sets. The 300 Area Subregion and the 600 Area Subregion both exhibit an aquifer setting where multiple groundwater contaminants are present in overlapping plumes, and the highest concentrations of the various analytes have different locations within the plumes.

Use of the 90th percentile value from a distribution of groundwater concentration data as an estimate of the EPC is a different approach for estimating EPCs than that provided in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10). However, as described below, the 90th percentile exposure concentration is identified in other EPA risk assessment guidance as appropriate for describing and characterizing health risks; its use yields risk estimates that correspond to an RME.

According to *An Examination of EPA Risk Assessment Principles and Practices (*EPA/100/B-04/001), the RME is an appropriate exposure scenario for risk calculations, within the realistic range of exposure, since the goal of the Superfund program is to protect against high-end, not average, exposures. The "high end" is defined as that part of the exposure distribution that is above the 90th percentile, but below the 99.9th percentile. The approach is consistent with the peer-reviewed *Guidelines for Exposure Assessment* (EPA/600/Z-92/001). Groundwater concentrations directly reflect potential exposures and risks; so, a 90th percentile concentration reflects an RME scenario.

Groundwater data sets at the Hanford Site are highly skewed, with a large proportion of below detection limit (BDL) values. *Data Quality Assessment: Statistical Methods for Practitioners* (EPA/240/B-06/003) provides guidance for estimating statistical parameters (whether means or upper percentiles) depending on the variability in the data set. The variability of the data set is assed in terms of the CV and the proportion of observations that are BDL. For data sets with CVs greater than 0.5 and 50 percent or more observations that are BDL, EPA recommends using upper percentiles as opposed to means to develop summary statistics.

Therefore, the rationale for using a 90th percentile value as an estimate of the EPC is consistent with the definition of an RME scenario, and is an appropriate statistic for groundwater data sets at the Hanford Site. Additional statistical evaluation of the 300-FF-5 OU and 600 Area Subregion data sets that support the selection of the 90th percentile value as the EPC is provided in *Calculation of Exposure Point Concentrations for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0130) (Appendix G) and *Calculation of Exposure Point Concentrations for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0131) (Appendix G). This evaluation includes an estimation of the UCL-95 value for each detected analyte, along with the analysis of variability, to assess the reliability of the UCL-95 estimates. Results of the evaluation indicate

that, for the majority of analytes, a reliable and meaningful UCL-95 estimate cannot be calculated, because of (1) an insufficient number of samples, (2) an insufficient number of detections, or (3) a high variance of the data. Therefore, the 90th percentile is adopted as the estimated EPC for all analytes. A comparison of the 90th percentile and UCL-95 values for the 300 Area Subregion and the 600 Area Subregion is provided in the uncertainty analysis Section (6.3.6.2).

6.3.2.3.7 Identify Analytes with 90th Percentile Values Less than Action Levels in Each Exposure Area

The 90th percentile values are compared to the lowest available chemical-specific ARARs for protection of human health and aquatic receptors (i.e., action levels). A comparison of EPCs to action levels for the 300 Area Subregion is provided in Table 6-30. A comparison of EPCs to action levels for the 600 Area Subregion is provided in Table 6-31. A flowchart depicting this comparison is provided in Figure 6-13.

300 Area Subregion. Twelve of the 17 analytes have been detected at least once in groundwater and have a 90th percentile value less than their respective action levels (see Table 6-30). Of these 12 analytes, nitrate is retained as a COPC. Of the 12 analytes, CCl_4, copper, lead, nitrate, selenium, thallium, and zinc were identified as historic COPCs in the work plan. The conclusions of the nature and extent evaluation for analytes identified as historic COPCs support the findings of this risk evaluation except for nitrate. Nitrate is identified as a COPC that will be carried forward into the FS (see Section 8.1.1.2). Because of inconclusive analytical results, aluminum, CCl_4, copper, iron and zinc are not identified as COPCs but warrant further monitoring. A discussion of all analytes reported with an EPC less than the action level is provided below.

The results of the nature and extent evaluation indicate that acrolein was only analyzed for the RI. A single detection of acrolein was reported in groundwater (1 of 45 samples) above the action level and was not associated with a specific location or with a trend. Acrolein, commonly used as a biocide, is not known to be associated with a Hanford Site release; therefore, acrolein is not a COPC and is not carried forward into the risk characterization or into the FS.

Bromodichloromethane is reported infrequently (3 of 73 samples) above the action level and was not associated with a specific location or with a trend. Bromodichloromethane is a trihalomethane that is formed as a by-product when chlorine is added to water supply systems. Bromodichloromethane is not associated with a Hanford Site release; therefore, it is not identified as a COPC and is not carried forward into the risk characterization section or the FS.

The results of the nature and extent evaluation indicate that lithium was only analyzed for the RI. Lithium was detected in 33 of 45 (73 percent) unfiltered and 35 of 45 (78 percent) filtered groundwater samples. Lithium concentrations above the action level (32 µg/L) are infrequent (2 of 90 samples) and are not associated with a specific location or with a trend. Lithium was detected at the 399-1-17A in the unfiltered (33 µg/L) and filtered (33 µg/L) sample from the same round; however, two subsequent rounds report concentrations less than the action levels. Based on infrequent detections and the slight exceedance of the action level, lithium is not identified as a COPC and will not be carried forward into the risk characterization section or the FS.

The results of the nature and extent evaluation indicate that aluminum and iron have historically been detected in groundwater. A single aluminum concentration above the AWQC was reported in a filtered sample and was not associated with a specific location or a trend. Except for three iron results, iron concentrations in filtered samples are less than the AWQC. The infrequent detection of aluminum and iron at concentrations above their action level results in an uncertain status. Therefore, aluminum and iron are not identified as COPCs; however, they warrant further evaluation in the FS (see Section 8.1.1.2) where they should be monitored.

Table 6-30. Exposure Point Concentration Summary for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit

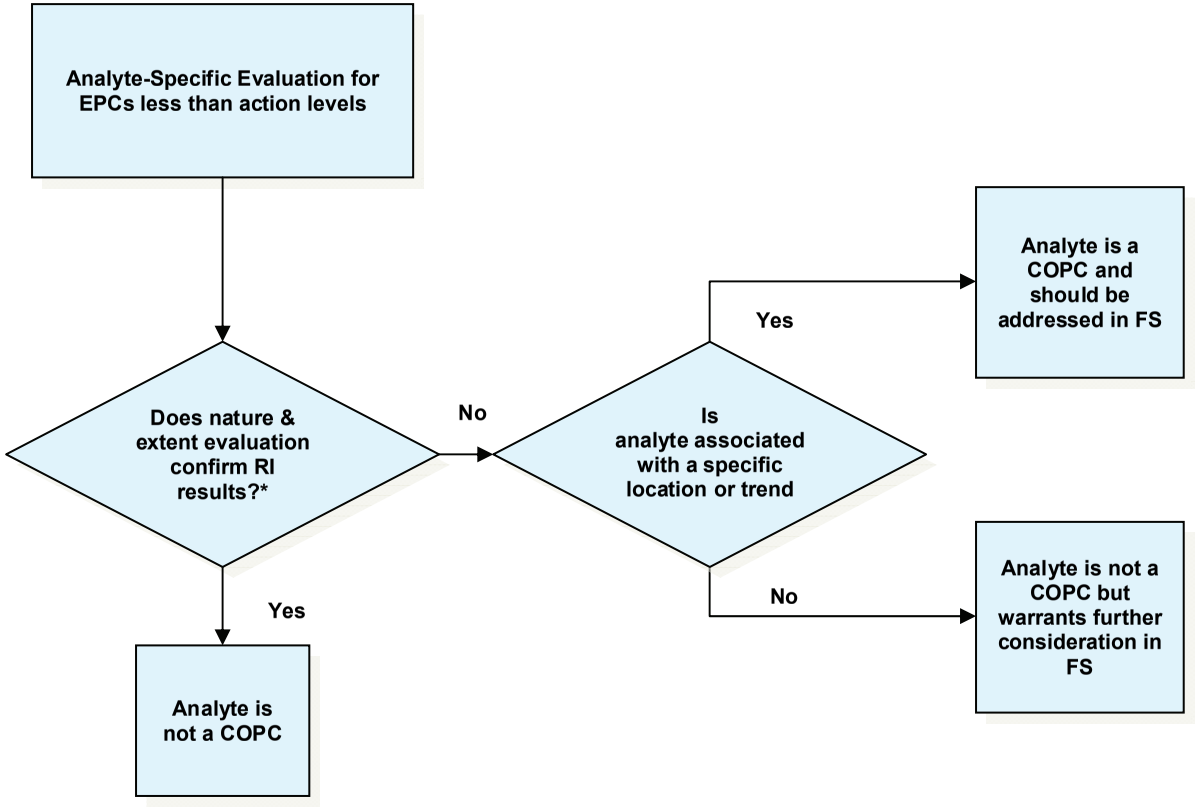
Analyte Name	Analyte Class	Total Samples	Total Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	90th Percentile	Action Level	Action Level Basis	90th Percentile > Action Level?	Level of Exceedance
Acrolein	VOC	45	1	2%	µg/L	2.8	2.8	3.8	3.8	2.8	3.0	Clean Water Act -- Freshwater CCC	No	0.93
Aluminum	METAL	45	4	9%	µg/L	5.0	10	9.3	100	10	50	40 CFR 141 - Federal MCL-Secondary	No	0.20
Arsenic	METAL	45	43	96%	µg/L	0.80	0.80	0.93	6.5	5.2	0.018	Clean Water Act -- Human Health Water + Organism	Yes	290
Bromodichloromethane	VOC	45	3	7%	µg/L	0.088	0.088	0.68	0.69	0.088	0.27	40 CFR 131 -- Human Health Water + Organism	No	0.33
Carbon tetrachloride	VOC	45	3	7%	µg/L	0.12	0.12	0.13	0.59	0.12	0.23	Clean Water Act -- Human Health Water + Organism	No	0.52
Copper	METAL	45	23	51%	µg/L	0.10	0.45	0.21	31	1.4	9.0	Clean Water Act -- Freshwater CCC	No	0.15
Gross alpha	RAD	28	28	100%	pCi/L	--	--	3.4	77	71	15	40 CFR 141 - Federal MCL-Primary	Yes	4.7
Iron	METAL	45	19	42%	µg/L	18	38	18	647	106	300	40 CFR 141 - Federal MCL-Secondary	No	0.35
Lead	METAL	45	3	7%	µg/L	0.10	0.20	0.29	3.5	0.20	2.1	WAC 173-201A	No	0.095
Lithium	METAL	45	33	73%	µg/L	4.0	4.0	4.0	33	25	32	WAC 173-340-720(4)(b)(iii)(A) and (B)	No	0.77
Nitrate	ANION	45	45	100%	µg/L	--	--	7,080	62,000	31,250	45,000	40 CFR 141 - Federal MCL-Primary	No	0.69
Selenium	METAL	45	45	100%	µg/L	--	--	0.48	5.8	3.7	5.0	Clean Water Act -- Freshwater CCC	No	0.74
Tetrachloroethene	VOC	45	3	7%	µg/L	0.18	0.18	0.19	0.38	0.18	0.081	WAC 173-340-720(4)(b)(iii)(A) and (B)	Yes	2.2
Thallium	METAL	45	1	2%	µg/L	0.050	0.10	1.2	1.2	0.10	0.24	Clean Water Act -- Human Health Water + Organism	No	0.42
Trichloroethene	VOC	45	35	78%	µg/L	0.21	0.25	0.31	3.0	2.2	0.49	WAC 173-340-720(4)(b)(iii)(A) and (B)	Yes	4.5
Uranium	METAL	45	45	100%	µg/L	--	--	6.4	177	114	30	40 CFR 141 - Federal MCL-Primary	Yes	3.8
Zinc	METAL	45	12	27%	µg/L	4.0	6.0	4.0	456	42	91	WAC 173-201A	No	0.46

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*.

Table 6-31. Exposure Point Concentration Summary for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit

Analyte Name	Analyte Class	Total Number of Samples	Number of Detects	Frequency of Detection	Units	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Result	Maximum Detected Result	90th Percentile	Action Level	Action Level Basis	90th Percentile > Action Level?	Level of Exceedance
Aluminum	METAL	51	15	29%	µg/L	10	10	12	539	87	50	40 CFR 141 - Federal MCL-Secondary	Yes	1.73
Arsenic	METAL	51	51	100%	µg/L	--	--	1.6	15	11	0.018	Clean Water Act -- Human Health Water + Organism	Yes	601
Bis(2-ethylhexyl) phthalate	SVOC	51	3	6%	µg/L	1.0	1.0	1.3	3.0	1.0	1.2	Clean Water Act -- Human Health Water + Organism	No	0.83
Bromodichloromethane	VOC	51	10	20%	µg/L	0.088	0.088	0.17	2.1	0.72	0.27	40 CFR 131 -- Human Health Water + Organism	Yes	2.67
Chloroform	VOC	51	15	29%	µg/L	0.10	0.10	0.11	7.1	0.62	1.4	WAC 173-340-720(4)(b)(iii)(A) and (B)	No	0.44
Copper	METAL	51	31	61%	µg/L	0.20	0.20	0.24	12	3.3	9.0	Clean Water Act -- Freshwater CCC	No	0.37
Dibromochloromethane	VOC	51	7	14%	µg/L	0.13	0.13	1.6	3.3	2.0	0.40	Clean Water Act -- Human Health Water + Organism	Yes	5.0
Gross alpha	RAD	22	14	64%	pCi/L	-1.30	1.2	2.3	40	8.0	15	40 CFR 141 - Federal MCL-Primary	No	0.53
Iron	METAL	51	40	78%	µg/L	18	38	23	3,340	477	300	40 CFR 141 - Federal MCL-Secondary	Yes	1.59
Manganese	METAL	51	27	53%	µg/L	4.0	6.0	5.0	261	40	50	40 CFR 141 - Federal MCL-Secondary	No	0.79
Nitrate	ANION	51	48	94%	µg/L	84	274	227	136,000	50,000	45,000	40 CFR 141 - Federal MCL-Primary	Yes	1.11
Selenium	METAL	51	33	65%	µg/L	0.60	6.0	0.63	13	6.1	5.0	Clean Water Act -- Freshwater CCC	Yes	1.21
Tritium	RAD	51	31	61%	pCi/L	-57	180	290	890,000	290,000	20,000	40 CFR 141 - Federal MCL-Primary	Yes	14.5

Note: Shading indicates that a constituent is identified in the list of contaminants of potential concern in DOE/RL-2009-45, *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units.*



* RI results = results from three rounds of spatial and temporal sampling from monitoring well network defined in DOE/RL-2009-45.

Figure 6-13. Analyte Specific Evaluation Process for EPCs Less Than Action Levels

Carbon tetrachloride was detected in groundwater samples collected for the RI and the EPC is less than the action level. The action level for CCl_4 is 0.23 µg/L based on the *National Recommended Water Quality Criteria* (EPA, 2009b), Human Health Water + Organism" value; however, it defaults to the EQL of 2 µg/L reported in DOE/RL-2009-45 when the analytical method cannot achieve the action level. The nature and extent evaluation indicates that CCl_4 was detected in 399-2-5 and 399-3-22 where concentrations have ranged from the detection limit to 2.8 times greater than the EQL over the last five years. Infrequent detections (one result per well) of CCl_4 above the EQL were reported at 399-1-18A (2.5 µg/L), 399-1-18B (2.6 µg/L), 399-1-8 (2.4 µg/L), 399-3-19 (7.9 µg/L), 399-3-2 (6 µg/L), 399-4-11 (6.1 µg/L), and 699-S27-E14 (3.4 µg/L) but do not appear to be associated with a trend. The highest concentrations of CCl_4 (6 to 7.9 µg/L) in these wells are flagged with a "Y" [13] review qualifier; remaining concentrations are flagged with a 'J" qualifier. The wells listed above were not included in the monitoring well network used in the spatial and temporal sampling for the RI; therefore, these results are not included in the calculation of EPCs. The presence of low-level concentrations of CCl_4 at 399-2-5 and 399-3-22 may be associated with a low-concentration trend and analytical data from these wells are not included in the calculation of EPCs, resulting in an uncertain status. Therefore, CCl_4 is not a COPC; however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

Copper was detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that copper has historically been detected in groundwater. Historic detections of copper and zinc were above the action level; however, the presence of copper was not associated with a specific location or with a trend and many results were flagged with a combination of "B" and "C" qualifiers. The results of this evaluation indicate that although copper was detected at concentrations less than the action level in samples collected for the RI, its historic presence with infrequent detections above the action level result in an uncertain status. Therefore, copper is not a COPC, however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

Lead was detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that the lead was only analyzed for the RI and the concentration reported in one unfiltered sample was 3.5 µg/L, which is greater than the AWQC of 2.1 µg/L; however, all filtered groundwater samples are less than the AWQC. Based on the results of this evaluation, lead is not a COPC and will not be carried forward into the risk characterization section or into the FS.

Nitrate was detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that nitrate concentrations above the DWS appear to be associated with a trend at 399-5-4B, 399-8-5A, 699-S27-E12A, 699-S27-E14, and 699-S28-E12. Wells 399-5-4B, 399-8-5A, 699-S27-E12A, 699-S27-E14, and 699-S28-E12 were not included in the monitoring well network used in the spatial and temporal sampling for the RI and therefore these results were not included in the calculation of EPCs. Because nitrate results from these wells were not included in the calculation of EPCs, it is not carried forward into the risk characterization section. However, nitrate is identified as a COPC and it should be addressed in the FS (see Section 8.1.1.2) to evaluate potential remedial technologies.

Selenium and thallium were detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that selenium and thallium were only analyzed for the RI. Concentrations of selenium and thallium in filtered and unfiltered samples are less than the 90th percentile Hanford site background value of 11 and 1.7 µg/L, respectively. Therefore, selenium and

[13] "Y" review qualifier indicates that the result is suspect; review—insufficient evidence to show result is valid or invalid.

thallium are not COPCs and will not be carried forward into the risk characterization section or into the FS.

Zinc was detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that zinc has been detected historically in groundwater. Historic detections of zinc were above the action level; many of the results are not associated with a specific location or with a trend and many results were flagged with a combination of "B" [14] and "C" [15] qualifiers. However, zinc concentrations in filtered samples from 399-3-20 appear to be associated with a trend. The results of this evaluation indicate that although most zinc concentrations are less than the action level in samples collected for the RI, its historic presence with infrequent detections above the action level and the apparent trend at 399-202- result in an uncertain status. Therefore, zinc is not a COPC; however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

600 Area Subregion. Five of the 13 analytes have been detected at least once in groundwater and have a 90th percentile value less than their respective action levels (see Table 6-31). None of these analytes is carried forward into the risk characterization section.

Of the five analytes, copper, and manganese were identified as historic COPCs in the work plan. The conclusions of the nature and extent evaluation for analytes identified as historic COPCs support the findings of this risk evaluation. Because of inconclusive analytical results, copper and chloroform are not identified as COPCs but warrant further monitoring. A discussion of all analytes reported with an EPC less than the action level is provided below. BEHP was detected in groundwater samples collected for the RI and the EPCs are less than the action level. The nature and extent evaluation indicates that BEHP has been detected in groundwater at a low frequency (3 of 60 unfiltered groundwater samples). The presence of BEHP above the action level is not associated with a specific location or a trend. Additionally, BEHP is considered a common laboratory contaminant that is introduced into the sample after collection in the field. The results of this evaluation indicate that BEHP was detected infrequently at concentrations above the action level. Therefore, BEHP is not a COPC; and will not be carried forward into the risk characterization section or the FS.

Chloroform was detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that chloroform has been detected historically in groundwater. The presence of chloroform above its EQL is not associated with a specific location or a trend. The results of this evaluation indicate that chloroform was detected infrequently at concentrations above its EQL. Its presence is not associated with a specific location or trend that results in an uncertain status. Therefore, chloroform is not a COPC; however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

Copper was detected in groundwater samples collected for the RI and the EPC is less than the action level. Copper was detected in groundwater samples collected for the RI and the EPC is less than the action level. The nature and extent evaluation indicates that copper has been detected historically in groundwater. Historic detections of copper were above the action level; however, its presence was not associated with a specific location or with a trend and many results were flagged with a combination of "B" and "C" qualifiers. The results of this evaluation indicate that although copper was detected at concentrations less than the action level in samples collected for the RI, their historic presence with infrequent detections above

[14] "B" laboratory qualifier indicates that the analyte (inorganics) was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit or the method detection limit, as appropriate.

[15] "C" laboratory qualifier indicates that the analyte (inorganics) was detected in both the sample and the associated QC blank, and the sample concentration was less than or equal to five times the blank concentration

the action level result in an uncertain status. Therefore, copper is not a COPC; however, it warrants further evaluation in the FS (see Section 8.1.1.2) where it should be monitored.

Manganese was detected in groundwater samples collected for the RI and the EPC is less than the action level. The action level for manganese is based on the secondary MCL. Manganese affects aesthetic qualities relating to public acceptance of drinking water. These regulations are not federally enforceable, but are intended as guidelines for states. Because the action level is based on a secondary MCL, manganese concentrations in groundwater are compared to the "Surface Water Cleanup Standards" (WAC 173-340-730) surface water cleanup level of 907 µg/L. The nature and extent evaluation indicates that manganese has been detected historically in groundwater samples (48 percent of unfiltered samples and 33 percent of filtered samples) at concentrations less than the surface water cleanup level of 907 µg/L. Therefore, manganese is not a COPC and will not be carried forward into the risk characterization section or into the FS.

Gross alpha was detected in groundwater samples collected for the RI and the EPC is less than the action level. The results of the nature and extent evaluation indicate that gross alpha has been detected historically in groundwater samples at concentrations less than the DWS of 15 pCi/L. Gross alpha was reported once at a concentration above the DWS but is not associated with a specific location or with a trend. Therefore, gross alpha is not a COPC and will not be carried forward into the risk characterization section or into the FS.

6.3.2.3.8 Identify Analytes with 90th Percentile Values Greater than Action Levels

The 90th percentile values are compared to the lowest available chemical-specific ARARs for protection of human health and aquatic receptors (i.e., action levels). A comparison of EPCs to action levels for the 300 Area Subregion is provided in Table 6-30. A comparison of EPCs to action levels for the 600 Area Subregion is provided in Table 6-31. A flow-chart depicting this comparison is provided in Figure 6-14.

300 Area Subregion. Five of the 17 analytes have been detected at least once in groundwater and have 90th percentile values greater than their respective action levels (see Table 6-30). Of these five analytes, TCE, and uranium are identified as COPCs that are carried forward into the risk characterization section. Arsenic, gross alpha, and PCE are not identified as COPCs.

Of the five analytes, arsenic, PCE, TCE, and uranium were identified as historic COPCs in the work plan. The conclusions of the nature and extent evaluation for analytes identified as historic COPCs support the findings of this risk evaluation. A discussion of all analytes reported with an EPC greater than the action level is provided below.

Arsenic is detected in groundwater samples collected for the RI and the EPC is above the action level. The nature and extent evaluation indicates that arsenic has historically been detected in groundwater at concentrations greater than the EQL. Infrequent detections of arsenic above the action level were not associated with a specific location or with a trend. Arsenic concentrations in unfiltered and filtered samples are less than the 90th percentile Hanford site background concentration of 7.9 µg/L. Based on the results of the nature and extent evaluation, arsenic is not a COPC and will not be carried forward into the risk characterization section or into the FS.

Gross alpha is detected in groundwater samples collected for the RI and the EPC is above the DWS. The findings of the nature and extent evaluation conclude that concentrations of gross alpha are widely distributed and are consistently present at concentrations above the DWS. Gross alpha is an indicator parameter and its presence above the DWS is consistent with the presence of uranium, as such, gross alpha is not considered a COPC because it indicates the presence of uranium and will not be carried forward into the risk characterization section or the FS.

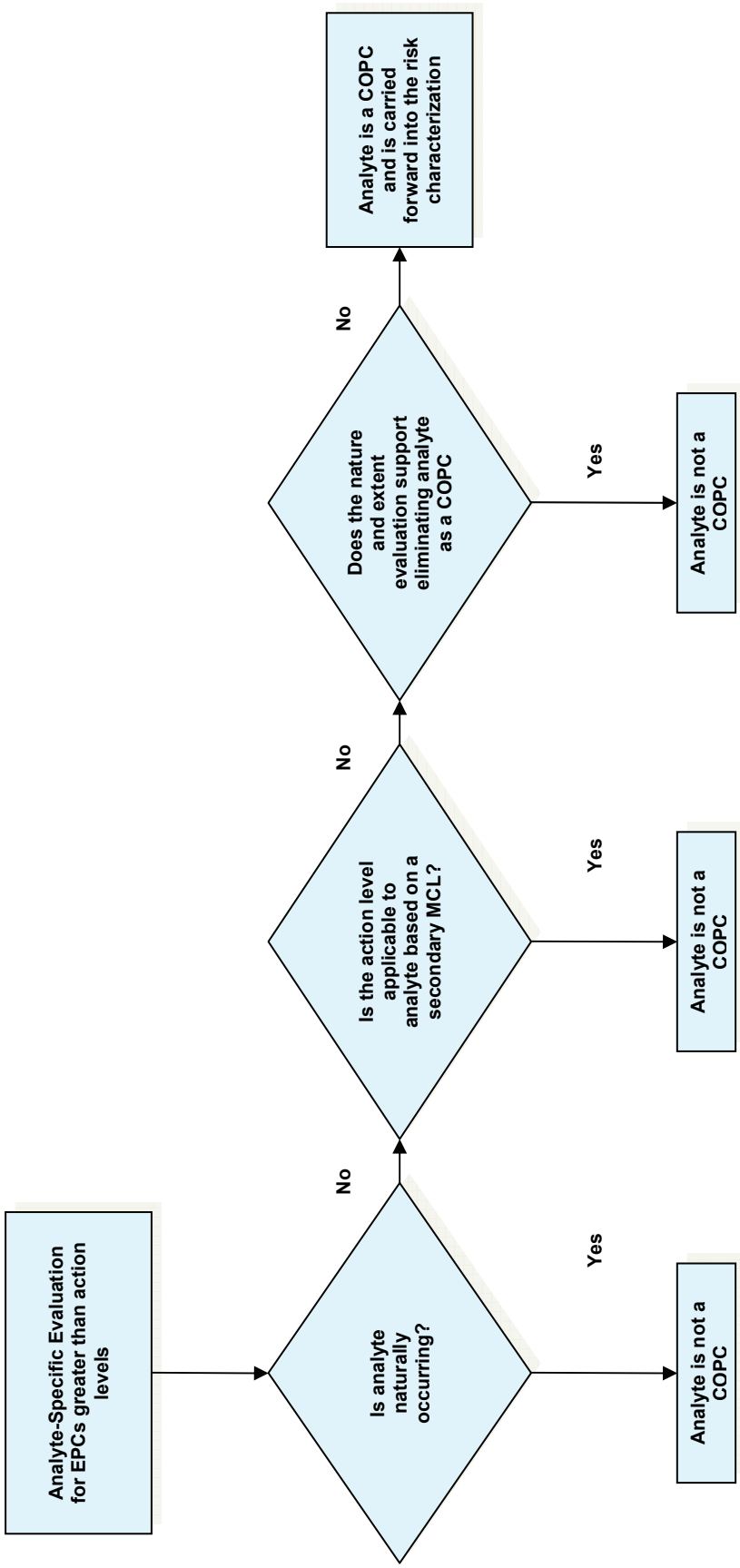


Figure 6-14. Analyte Specific Evaluation Process for EPCs Greater than Action Levels

Uranium was detected in groundwater samples collected for the RI and the EPC is greater than the DWS. The findings of the nature and extent evaluation conclude that concentrations of uranium are widely distributed and are consistently present at concentrations above the DWS. The distribution of uranium within the groundwater OU is discussed in detail in Section 4.4. Based on the results of the nature and extent evaluation and the risk evaluation, uranium is a COPC and is carried forward into the risk characterization section.

TCE was detected in groundwater samples collected for the RI and the EPC is greater than the action level. The findings of the nature and extent evaluation conclude that concentrations of TCE are widely distributed and are consistently present at concentrations above the "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level. The nature and extent evaluation also indicates that TCE concentrations are above the DWS are associated with a trend at 399-3-21 and 399-4-14.

PCE was detected in groundwater samples collected for the RI and the EPC is greater than the EQL. The nature and extent evaluation indicates that PCE was detected in groundwater at a low frequency and was only analyzed in samples collected for the RI. A single PCE concentration was reported above the EQL. It is not associated with a specific location or with a trend. Therefore, PCE is not a COPC and will not be carried forward into the risk characterization section or into the FS.

600 Area Subregion. Eight of the 13 analytes have been detected at least once in groundwater and have 90th percentile values greater than their respective action levels (see Table 6-31). Of these eight analytes, nitrate and tritium are identified as COPCs that are carried forward into the risk characterization section. Aluminum, arsenic, bromodichloromethane, dibromochloromethane, iron, and selenium are not identified as COPCs.

Of the eight analytes, arsenic, nitrate, and tritium were identified as historic COPCs in the work plan. The conclusions of the nature and extent evaluation for analytes identified as historic COPCs support the findings of this risk evaluation. A discussion of all analytes reported with an EPC greater than the action level is provided below.

Aluminum is detected in groundwater samples collected for the RI and the EPC is above the action level. The action level for aluminum is based on the secondary MCL. Aluminum affects aesthetic qualities relating to public acceptance of drinking water. These regulations are not federally enforceable, but are intended as guidelines for states. Because the action level is based on a secondary MCL, aluminum concentrations in groundwater are compared to the AWQC of 87 µg/L. The nature and extent evaluation indicates that aluminum has only been analyzed in samples collected for the RI. A single aluminum concentration in a filtered sample was reported above the AWQC and was not associated with a specific location or a trend. Therefore, aluminum is not identified as a COPC and will not be carried forward into the risk characterization section.

Arsenic is detected in groundwater samples collected for the RI and the EPC is above the action level. The nature and extent evaluation indicates that arsenic has historically been detected in groundwater at concentrations greater than the action level. Infrequent detections of arsenic above the action level were not associated with a specific location or with a trend. With the exception of 699-13-1A and 699-S8-1A, arsenic concentrations in unfiltered and filtered samples are less than the 90th percentile Hanford Site background concentration of 7.9µg/L. Arsenic concentrations at 699-13-1A and 699-S8-19 slightly exceed (less than two times) the range of background concentrations and are likely associated with naturally occurring levels. Based on the results of the nature and extent evaluation, arsenic is not a COPC and will not be carried forward into the risk characterization section or into the FS.

Bromodichloromethane is detected in groundwater samples collected for the RI and the EPC is above the action level. The results of the nature and extent evaluation indicate that bromodichloromethane is present in groundwater at a low frequency. Bromodichloromethane concentrations above the action level were reported in two or more rounds and appear to be associated with trend at 499-S0-7 (0.51 to 2.1 µg/L), 499-S0-8 (0.71 to 1.6 µg/L), and 699-13-1A (0.30 to 0.56 µg/L). An infrequent detection of bromodichloromethane was reported at 499-S1-8J (0.17 to 1 µg/L). The 499-S0-7 and 499-S0-8 wells and their associated pumps, P-14 and P-15, serve as a backup water supply to the 400 Area. Bromodichloromethane is a trihalomethane that is formed as a by-product when chlorine is added to water supply systems. Bromodichloromethane is not associated with a Hanford Site release; therefore, it is not identified as a COPC and is not carried forward into the risk characterization section or the FS.

Dibromochloromethane is detected in groundwater samples collected for the RI and the EPC is above the action level. The results of the nature and extent evaluation indicate that dibromochloromethane is present in groundwater at a low frequency. Dibromochloromethane concentrations above the action level were reported in three rounds and appear to be associated with trend at 499-S0-7 (1.6 to 3.3 µg/L) and 499-S0-8 (1.8 to 2.8 µg/L). An infrequent detection of dibromochloromethane was reported at 499-S1-8J (2.2 µg/L). The 499-S0-7 and 499-S0-8 wells and their associated pumps, P-14 and P-15, serve as a backup water supply to the 400 Area. Dibromochloromethane is a trihalomethane that is formed as a by-product when chlorine is added to water supply systems. Dibromochloromethane is not associated with a Hanford Site release; therefore, it is not identified as a COPC and is not carried forward into the risk characterization section or the FS.

Iron is detected in groundwater samples collected for the RI and the EPC is above the action level. The action level for iron is based on the secondary MCL. Iron affects aesthetic qualities relating to public acceptance of drinking water. These regulations are not federally enforceable, but are intended as guidelines for states. Because the action level is based on a secondary MCL, iron concentrations in groundwater are compared to the AWQC of 1,000 µg/L. The nature and extent evaluation indicates that only two iron concentrations in unfiltered samples exceed the AWQC and no filtered samples are greater than the AWQC. Except for one iron result, iron concentrations in filtered water samples are less than the background level of 570 µg/L. Therefore, iron is not identified as a COPC and it will not be carried forward into the risk characterization section or into the FS.

Nitrate was detected in groundwater samples collected for the RI and the EPC is greater than the DWS. The findings of the nature and extent evaluation conclude that concentrations of nitrate are widely distributed and concentrations above the DWS are in localized areas. The distribution of nitrate within the groundwater OU is discussed in detail in Section 4.4. Based on the results of the nature and extent evaluation and the risk evaluation, nitrate is a COPC and is carried forward into the risk characterization section.

Selenium is detected in groundwater samples collected for the RI and the EPC is above the action level. The nature and extent evaluation indicates that all filtered samples are less than or equal to the 90th percentile Hanford Site background level of 11 µg/L. Therefore, selenium is not identified as a COPC and will not be carried forward into the risk characterization or the FS.

Tritium was detected in groundwater samples collected for the RI and the EPC is greater than the DWS. The findings of the nature and extent evaluation conclude that concentrations of tritium are widely distributed and concentrations above the DWS are in localized areas. The distribution of tritium within the groundwater OU is discussed in detail in Section 4.4. Based on the results of the nature and extent evaluation and the risk evaluation, tritium is a COPC and is carried forward into the risk characterization section.

6.3.2.4 Summary of COPCs

Table 6-32 presents a summary of the COPCs identified for the 300 Area Subregion and the 600 Area Subregion, respectively. This list of COPCs represents the analytes most likely to contribute to overall risk within the300 Area Subregion and the 600 Area Subregion. These COPCs are evaluated in the risk characterization section.

Table 6-32. Summary of Groundwater COPCs Identified for the 300-FF-5 Groundwater OU

300 Area Subregion		
Metals	**VOCs**	**Nonradioactive Anions**
Uranium	Trichloroethene*	Nitrate*
Chromium/Hexavalent Chromium*	Cis-1,2-dichloroethene*	
600 Area Subregion		
Tritium		Nitrate

* EPC did not exceed action level, analyte retained as COPC due to localized contamination. Analyte is not included in risk characterization but moves directly into FS.

With the exception of cis-1,2-dichloroethene, chromium/Cr(VI), TCE, and nitrate, the COPCs listed on Table 6-32 and Table 6-33 were identified because the 90th percentile concentration exceeded the action level. As described in Section 6.3.2.3, cis-1,2-dichloroethene, chromium/Cr(VI), TCE, and nitrate are identified as COPCs because they are associated with a long-term trend in localized areas in the 300 Area Subregion. However, it should be noted that the monitoring wells with these COPCs were not wells that were included in the spatial and temporal sampling associated with the RI; therefore results for these COPCs are not included in the calculation of EPCs. As a result, cis-1,2-dichloroethene chromium/Cr(VI), and nitrate are not carried forward into the risk characterization section but move directly into the FS where remedial technologies should be evaluated.

The 90th percentile concentration for TCE is greater than the action level; however a monitoring well (399-3-21) that reports concentrations greater than the DWS is not included in the calculation of the EPC and therefore the EPC is understated. Because of this, TCE is evaluated in the risk characterization section, but because the EPC is underestimated, it will also move directly into the FS where remedial technologies should be evaluated.

The 90th percentile concentration for chromium/Cr(VI) is not greater than the AWQC of 10 µg/L. The monitoring wells that report elevated concentrations of chromium were not included in the calculation of the EPC and therefore the EPC is understated. Because of this, chromium is not evaluated in the risk characterization section, but it will move directly into the FS (See Section 8.1.1.2).

The COPC identification process identified 11 analytes for the 300 Area subregion and six analytes for the 600 Area subregion that are not COPCs but move forward into the FS because they have uncertainty associated with the data set and their occurrence in groundwater. The analytes in the 300 Area subregion include aluminum, antimony, carbon tetrachloride, chloform, cobalt, copper, iron, nickel, silver, sulfate, and zinc. The analtyes in the 600 Area subregion include carbon tetrachloride, chloform, copper, lead, uranium, and zinc. The nature and extent evaluation indicates these analytes historically have been

detected in groundwater at concentrations above their respective action level, but their presence was not associated with a specific location or a trend. Therefore, monitoring of these analytes will be performed to understand their persistence in the environment. A summary of the analytes that require monitoring because of uncertainties associated with the data set are listed in Table 6-33 for the 300 Area Subregion and the 600 Area Subregion.

Table 6-33. Summary of Groundwater Analytes that Require Additional Monitoring in the 300-FF-5 Groundwater OU

300 Area Subregion		
Metals	**VOCs**	**Nonradioactive Anions**
Aluminum	Carbon tetrachloride	
Antimony	Chloroform	Sulfate
Cobalt		
Copper		
Iron		
Nickel		
Silver		
Zinc		
600 Area Subregion		
Metals	**VOCs**	
Copper	Carbon tetrachloride	
Lead	Chloroform	
Uranium		
Zinc		

Note: The analytes listed in this table have uncertainty associated with the data set and their occurrence in ground. Monitoring of these analytes will be performed to understand their persistence in the environment.

6.3.3 Exposure Assessment

The exposure assessment component of the risk assessment typically identifies the populations that may be exposed, the routes by which these receptors may become exposed, and the magnitude, frequency, and duration of potential exposures.

6.3.3.1 Contaminant Sources

Sources of contamination in the 300 Area originated with the years of uranium fuel production operations and various R&D activities focused on improving uranium fuel production methods and improving the plutonium extraction operations carried out in the 200 Areas. During 300 Area operations, there were intentional releases of waste materials to the environment, most notably in the form of process liquids

discharged to the large, unlined infiltration ponds and trenches. Additionally, there were several UPRs of both solids and liquids to the soil below and around the uranium production laboratories and waste handling facilities. These sources of contamination are represented by the remaining structures, foundations/pads, and contaminated soils resulting from operations performed in uranium production facilities, R&D laboratories, and waste-handling facilities. Sources with the greatest potential for contamination to be driven through the vadose zone to groundwater are the high-volume, liquid waste disposal facilities. These include the unlined infiltration process ponds and trenches that received several million liters per day of contaminated and uncontaminated liquid effluent. Sources with a moderate potential for release of contamination to the environment are represented by the liquid waste handling facilities that were used to transport and treat waste streams produced during fuel production and research operations, and the early solid waste burial grounds located in and near the 300 Area complex. Additional sources of contamination in the 300 Area include the burial grounds containing various solid waste and debris from 300 Area operations.

The most significant potential sources of contamination in the 600 Area are two solid waste burial grounds (618-10 and 618-11) and a liquid waste disposal facility (316-4 Crib). Additional burial grounds grouped within the 600 Area constitute the remaining sources of contamination. Contaminant sources (i.e. facilities and waste sites) are listed in Sections 4.2.1 and 5.2 of this report.

6.3.3.2 Release Mechanisms and Environmental Transport Media

The primary COPC release mechanisms and transport pathways at the 300 Area and 600 Area Source OU are discussed in Sections 5.3 and 5.4. They include the following:

- Direct contact with groundwater containing COPCs
- Volatilization of COPCs in groundwater from showering or household activities
- Discharge of groundwater to the Columbia River through upwelling and seeps

6.3.3.3 300 Area Subregion and 600 Area Subregion Exposure Areas

The 300-FF-5 Groundwater OU is generally distinguished by the presence of uranium and tritium above the federal MCL as discussed in Chapter 4. The 300-FF-5 Groundwater OU is evaluated as a two exposure areas. The 300 Area Subregion represents the groundwater plume that is located beneath the Hanford Site Industrial Complex. The 300 Area Subregion is distinguished by the presence of TCE and uranium at concentrations above the federal MCL. The 600 Area Subregion represents the groundwater plume that is located beneath the 618-11 Burial Ground and the 618-10 Burial Ground/316-4 Cribs. The 600 Area Subregion is distinguished by the presence of nitrate and tritium at concentrations above the federal MCL.

The primary objectives for evaluating each exposure area are to provide information necessary to determine the need for remedial action and to use this information to select the best remedy. These objectives are achieved by performing the following steps for each exposure area:

1. EPCs for each COPC are compared to contaminant-specific ARARs for understanding the potential for exposure to groundwater contaminants and the associated health risks.

2. Specific locations are identified within the exposure area for evaluating remedial alternatives in the FS.

The basis for each exposure area and the known or suspected sources are described above. The location of each well within the 300 Area Subregion of the 300-FF-5 Groundwater OU and the 600 Area Subregion

of the 300-FF-5 Groundwater OU is shown in Figure 6-6. Table 6-20 lists the monitoring wells for the 300 Area Subregion and the 600 Area Subregion, respectively.

6.3.3.4 Potentially Complete Human and Aquatic Exposure Pathways and Receptors

This section describes the potentially complete exposure pathways and receptors that are specifically addressed in the federal and State chemical-specific ARARs evaluated in this supplemental groundwater risk evaluation.

6.3.3.4.1 Chemical-Specific ARARs for Protection of Human Health

All of the chemical-specific ARARs for use as a drinking water source consider ingestion as a complete and significant pathway for exposure. Washington State regulations assume that inhalation of vapors for VOCs are also a complete and significant exposure pathway. Washington State regulations do not include the dermal contact exposure route in the equations for calculation of potable groundwater cleanup levels, whereas federal regulations consider dermal contact exposure a complete but insignificant groundwater contaminant exposure pathway. Elimination of the dermal contact exposure route from chemical-specific ARARs may result in an underestimation of the cleanup level; uncertainties associated with exclusion of this exposure route are addressed in Section 6.3.6.4.

For groundwater with the potential to impact surface water, federal water quality standards assume that exposure to humans occurs through ingestion of water and consumption of fish tissue. These federal standards are developed for protection of human health where groundwater discharges to surface water that is used as a drinking water source and used for fishing. Washington State regulations as defined in WAC 173-340-730(3)(b) developed surface water standards that assume that exposure occurs through consumption of fish tissue.

6.3.3.4.2 Chemical-Specific ARARs for Protection of Aquatic Receptors

The objectives and methodology for deriving the numerical AWQC are described in *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (PB85-227049). The AWQC are intended to provide a reasonable level of protection of all except a small fraction (0.05) of the taxa, unless a commercially or recreationally important species is very sensitive. Protection of the following aquatic organisms and their uses are defined in *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (PB85-227049), as prevention of unacceptable long-term and short-term effects:

- Commercially, recreationally, and other important species
- Fish and benthic invertebrate assemblages in rivers and streams
- Fish, benthic invertebrate, and zooplankton assemblages in lakes, reservoirs, estuaries, and oceans

Numeric values are expressed as two numbers, the criteria maximum concentration (CMC) and criteria continuous concentration (CCC), which provide an appropriate degree of protection of aquatic organisms and their uses from acute and chronic toxicity to animals, toxicity to plants, and bioaccumulation by aquatic organisms. The CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. EPA derives acute criteria from 48- to -96 hour tests of lethality or immobilization. The CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. EPA derives chronic criteria from longer-term (often greater than 28 days) tests that measure survival, growth, reproduction or, in some cases, bioconcentration. The CMC and the CCC are two of the six parts of the aquatic life criterion. The other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed

exceedance, and chronic frequency of allowed exceedance. The lower of the CMC or the CCC is the numeric water quality criteria used as the chemical-specific ARAR for protection of freshwater species.

6.3.4 Toxicity Assessment

The toxicity assessment component evaluates the relationship between the magnitude of exposure to an analyte and the likelihood of adverse health effects to potentially exposed populations. Similar to the exposure assessment, the comparison to chemical-specific ARARs takes into consideration the likelihood of an adverse health effect to occur to the potentially exposed population. The risk-based concentrations, such as the "Groundwater Cleanup Standards" (WAC 173-340-720), are developed using toxicological information published at EPA's IRIS database and EPA's hierarchy of toxicity values described in Section 6.3.2. The assignment of chemical-specific ARARs to COPCs is described in Section 6.3.2.2.

6.3.4.1 State and Federal Maximum Contaminant Levels for Nonradionuclides

The MCLG is the maximum level of a contaminant in drinking water at which no known or anticipated adverse health effects occur, allowing for an adequate margin of safety. MCLGs are nonenforceable health goals. EPA establishes the MCL, an enforceable standard, based on the MCLG. The MCL is the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. Prior to the *Safe Drinking Water Act of 1974* (SDWA) amendments in 1996, the MCL was set as close to the MCLG as was feasible. The 1996 Amendments to the SDWA permit consideration of costs and benefits in establishing an MCL. Primary MCLs are legally enforceable standards and protect public health by limiting the levels of contaminants in drinking water. Secondary MCLs are nonenforceable guidelines regulating those contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

The *Six-Year Review Chemical Contaminants Health Effects Technical Support Document* (EPA 822-R-03-008) describes how MCLGs are derived. MCLGs are developed using an oral RfD for contaminants that exhibit a threshold toxic effect. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer effects during a lifetime. EPA generally assumes that the relative source contribution from drinking water is 20 percent of the RfD, unless other exposure data for the chemical are available. This allows 80 percent of the total exposure to come from sources other than drinking water, such as exposure from food, inhalation, or dermal contact.

6.3.4.2 Maximum Contaminant Levels for Radionuclides in Drinking Water

Current MCLs for radionuclides are set at 4 mrem/yr for the sum of the doses from beta particle and photon emitters, 15 pCi/L for gross alpha emitter activity (including radium-226, but excluding uranium and radon), and 5 pCi/L combined for radium-226 and radium-228. A mass-based concentration MCL of 30 μg/L has been established for uranium. The current MCLs for beta emitters specify that MCLs be calculated based upon an annual dose equivalent of 4 mrem to the total body or any internal organ. It is further specified that the calculation be performed based on a 2 L (0.5 gal) /day drinking water intake using the 168-hour data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure* (NBS Handbook 69).

6.3.4.3 Washington State Regulations

Toxicological parameter values are obtained from the "Cleanup Levels and Risk Calculations" (CLARC) (Ecology, 2010) compendium of technical information related to the calculation of cleanup levels under MTCA (WAC 173-340). The sources for the oral cancer potency values and RfDs are provided in the "Cleanup Levels and Risk Calculations" (CLARC) database (Ecology, 2010). The sources for identifying

RfDs and carcinogenic potency factors are defined in "Human Health Risk Assessment Procedures" (WAC 173-340-708(7) and WAC 173-340-708(8)).

6.3.4.4 Toxicity Values

The sources of toxicity values for human health are the same as those described in Section 6.2.4.2 of the report.

As discussed in Section 6.3.3.4, the lower of the CMC or the CCC is the numeric water quality criteria used as the chemical-specific ARAR for protection of freshwater species. *Technical Support Document for Water Quality-based Toxics Control* (EPA/505/2-90/001) explains that development of national numerical water quality criteria for the protection of aquatic organisms is a complex process that uses information from many areas of aquatic toxicology. After a decision is made that a national criterion is needed for a particular material, all available information concerning toxicity to and bioaccumulation by aquatic organisms is collected and reviewed for acceptability. If enough acceptable data for 48- to 96-hour toxicity tests on aquatic animals are available, they are used to derive the acute criterion. If sufficient data on the ratio of acute to chronic toxicity concentrations are available, they are used to derive the chronic or long-term exposure criteria. The chronic criteria can also be calculated directly if sufficient data are available. If justified, one or both of the criteria may be related to another water quality characteristic (e.g., pH, temperature, or hardness). Separate criteria are developed for fresh water and salt water.

6.3.5 Risk Characterization

Risk characterization is the final step of the HHRA process. In this step, the toxicity values are combined with the estimated chemical intakes for the receptor populations to estimate quantitatively both carcinogenic risk and risks from non-carcinogens. The risk characterization step is completed through the comparison of the EPC to the chemical-specific ARAR using the equations presented in Section 6.3.5.1. As described earlier in this section, the comparison to chemical-specific ARARs determines whether existing groundwater concentrations are protective of HHE. It is also used to determine if current groundwater concentrations have the potential to exceed an HI greater than 1 or the upper end of the NCP risk range for cumulative carcinogenic site risk to an individual based on RME for both current and future land use.

6.3.5.1 Protectiveness Evaluation

Protectiveness of human health is determined by the comparison of 90th percentile groundwater concentrations to existing federal or state MCLs. Similarly, protectiveness of human and aquatic receptors is determined by the comparison of 90th percentile groundwater concentrations to water quality criteria established under Section 304 or 303 of the *Clean Water Act of 1977* and Washington State water quality standards.

This risk characterization step is included to address the presence of multiple exposure pathways or the potential for exposure to multiple contaminants. The presence of either one of these conditions may render ARARs to be not adequately protective. This step is also included to address the requirements of "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)(a) and WAC 173-340-708(6)(b)). These regulations require that cleanup levels be adjusted downward to take into account exposure to multiple hazardous substances or multiple pathways of exposure. This adjustment needs to be made only if without this adjustment, the HI would exceed 1 or the total ELCR would exceed 1 in 100,000 (1×10^{-5}).

To determine the potential to exceed an HI greater than 1 or the upper end of the NCP risk range for cumulative carcinogenic site risk to an individual based on RME for both current and future land use the following standards are used:

- WAC 173-340-720, "Groundwater Cleanup Standards"
- WAC 173-340-730, "Surface Water Cleanup Standards"
- *National Recommended Water Quality Criteria* (EPA, 2009b)

For the purposes of this evaluation, the potential for unacceptable human health risk is identified using the following risk thresholds:

- ELCR values are compared to the "target range" of 10^{-6} to 10^{-4} that is generally used by EPA. MTCA (WAC 173-340) states that cancer risks resulting from multiple hazardous substances should not exceed 1×10^{-5} for unrestricted land use. ELCR values within or exceeding the target range require a risk management decision that includes evaluating site-specific characteristics and exposure scenario factors to assess whether remedial action is warranted.

- An HI (the sum of the ratios of the chemical intake to the RfDs for all COPCs) greater than 1 indicates that some potential exists for adverse noncancer health effects associated with exposure to the COPCs.

Although this supplemental groundwater risk evaluation produces numerical estimates of risk, it should be recognized that these numbers might not predict actual health outcomes because they are based largely on hypothetical assumptions. Their purpose is to provide a frame of reference for risk management decision making. Interpretation of the risk estimates provided should consider the nature and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding them.

Protectiveness of humans from exposure to beta/photon emitters is determined by an annual dose equivalent to the body or any internal organ and determined by comparison to activity concentrations in drinking water for alpha emitters; therefore, a risk evaluation is not conducted for COPCs that are radionuclides.

6.3.5.1.1 Cancer Risk Estimation Method

The potential for cancer effects is evaluated by estimating the ELCRs. This risk is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer (that is, if no exposure to site chemicals occurs). To estimate the cancer risks from exposure to an individual carcinogen from all exposure routes considered, the following equation is used:

$$Risk_I = \frac{EPC_{water}}{CUL_{carcinogen}} \times TR$$

where:

$Risk_I$ = ELCR for individual chemical

EPC_{water} = 90th percentile concentration in groundwater (µg/L)

$CUL_{carcinogen}$ = Groundwater cleanup level based on 10^{-6} carcinogenic effect (µg/L)

TR = Target ELCR for individual hazardous substance for unrestricted land use (10^{-6})

To estimate the cancer risks from exposure to multiple carcinogens from all exposure routes considered, the following equation is used:

$$Risk_T = \sum_i \frac{EPC_{water}}{CUL_{carcinogen}} \times TR$$

where:

$Risk_T$ = Total ELCR for all chemicals

EPC_{water} = 90th percentile concentration in groundwater (µg/L)

$CUL_{carcinogen}$ = Groundwater cleanup level based on 10^{-6} carcinogenic effect (µg/L)

TR = Target ELCR for individual hazardous substance for unrestricted land use (10^{-6})

i = The sum of the ratios for the ith chemical

6.3.5.1.2 Noncancer Risk Estimation Method

For noncancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular chemical with the highest level of exposure that is considered protective (i.e., its RfD). The ratio of the chronic daily intake divided by RfD is the HQ.

When the HQ for a chemical exceeds 1 (i.e., exposure exceeds RfD), a concern exists for potential noncancer health effects. To estimate the HQ from all exposure routes considered for an individual hazardous substance, the following equation is used:

$$HQ = \frac{EPC_{water}}{CUL_{noncarcinogen}}$$

where:

HQ = HQ for individual chemical

EPC_{water} = 90th percentile concentration in groundwater (µg/L)

$CUL_{noncarcinogen}$ = Groundwater cleanup level based on HQ = 1 noncarcinogenic effects (µg/L)

To estimate the HI from all exposure routes considered for multiple hazardous substances, the following equation is used:

$$HI_T = \sum_i \frac{EPC_{water}}{CUL_{noncarcinogen}}$$

where:

HI_T = Total HI for all chemicals

EPC_{water} = 90th percentile concentration in groundwater (µg/L)

$CUL_{noncarcinogen}$ = Groundwater cleanup level based on HQ=1 noncarcinogenic effects (µg/L)

i = The sum of the ratios for the ith chemical

6.3.5.1.3 Estimating the Sum of Fractions and 4 mrem/yr Dose Equivalent

An annual cumulative dose equivalent of 4 mrem to the total body or any internal organ from beta and photon emitters is considered protective of human health. The sum-of-fractions (SOF) is used to determine whether the contribution of each radioisotope is greater than the cumulative annual dose equivalent of 4 mrem. The following equation is used to determine if the 4 mrem standard is exceeded when a mixture of radioisotopes is present:

$$Sum\ of\ Fractions = \left(\frac{A\left(\frac{pCi}{L}\right)}{MCL_A\left(\frac{pCi}{L}\right)} + \frac{B\left(\frac{pCi}{L}\right)}{MCL_B\left(\frac{pCi}{L}\right)} + \bullet\bullet\bullet \right)$$

where:

A = The EPC activity concentration of specific beta/photon emitting nuclide A

B = The EPC activity concentration of specific beta/photon emitting nuclide B

MCL_A = The derived single-nuclide beta/photon emitting MCL-equivalent activity concentration for nuclide A

MCL_B = The derived single-nuclide beta/photon emitting MCL-equivalent activity concentration for nuclide B

The 4 mrem standard is not exceeded if the SOF is less than 1. Each fraction is converted to a dose equivalent of 4 mrem/year by multiplying the fraction by 4.

6.3.6 Risk Characterization Results Using Chemical-Specific ARARs

A comprehensive set of chemical-specific ARARs that are considered protective of HHE were used to identify COPCs that warrant further evaluation in the FS. The lowest of the available chemical-specific ARARs was selected for comparison if more than one chemical-specific ARAR exists for a certain analyte. The analytes listed in Table 6-34, Table 6-35, Table 6-36, and Table 6-37 are considered COPCs because the 90th percentile groundwater concentration is greater than the lowest available chemical-specific ARAR or the analyte is measured at concentrations above the lowest chemical-specific ARAR in a localized area.

Table 6-34. Summary of Current Conditions 90th Percentile Groundwater Concentrations, Federal and State MCLs and WAC 173-340-720 Groundwater Cleanup Levels for the 300 Area Subregion of the 300-FF-5 Groundwater OU (Human Health Action Levels)

					WAC 173-340-720 Cleanup Levels		
COPC	Units	90th Percentile Value	Federal MCL	State MCL	Non-Carcinogens	Carcinogens at 10^{-6} Risk Level	Carcinogens at 10^{-5} Risk Level
Trichloroethene	µg/L	2.2	5.0	5.0	--	0.49	4.9
Uranium	µg/L	114	30	--	48	--	--

COPC = contaminant of potential concern
MCL = maximum contaminant level

Table 6-35. Summary of Current Conditions 90th Percentile Groundwater Concentrations, Federal and State Water Quality Standards for the 300 Area Subregion of the 300-FF-5 Groundwater OU (Aquatic Action Levels)

			AWQC		WAC 173-201A	40 CFR 131	
COPC	Units	90th Percentile Value	Freshwater CMC (Acute)	Freshwater CCC (Chronic)	Freshwater CCC (Chronic)	Freshwater CMC (Acute)	Freshwater CCC (Chronic)
Trichloroethene	µg/L	2.2	--	--	--	--	--
Uranium	µg/L	114	--	--	--	--	--

COPC = contaminant of potential concern

Table 6-36. Summary of 90th Percentile Current Groundwater Concentrations and Associated Cancer Risk and Noncancer Hazard Index for the 300 Area Subregion of the 300-FF-5 Groundwater OU

			WAC 173-340-720 Cleanup Levels			
COPC	Units	90th Percentile Value	Non Carcinogens	Hazard Quotient	Carcinogens at 10^{-6} Risk Level	ELCR
Trichloroethene	µg/L	2.2	--	--	0.49	**4.5×10^{-6}**
Total ELCR						**4.5×10^{-6}**
Uranium	µg/L	114	48	2.4	--	--
Hazard Index				**2.4**		

COPC = contaminant of potential concern
ELCR = excess lifetime cancer risk

6.3.6.1 300 Area Subregion

Groundwater in the 300 Area Subregion is evaluated as a potential drinking water source and has the potential to discharge to the Columbia River. Table 6-34 provides a summary of the COPCs, the 90th percentile groundwater concentration, federal and state MCLs, and the WAC 173-340-720 groundwater cleanup standards for carcinogenic and noncarcinogenic effects for the 300 Area Subregion. Table 6-35 provides a summary of the COPCs, the 90th percentile groundwater concentration, and federal and state surface water quality standards for the 300 Area Subregion. These standards (listed in Tables 6-34 and 6-35) represent the chemical-specific ARARs that were exceeded by at least one COPC.

Table 6-37. Summary of Current Conditions 90th Percentile Groundwater Concentrations, Federal and State MCLs and WAC 173-340-720 Groundwater Cleanup Levels for the 600 Area Subregion of the 300-FF-5 Groundwater OU (Human Health Action Levels)

					WAC 173-340-720 Cleanup Levels		
COPC	Units	90th Percentile Value	Federal MCL	State MCL	Non-Carcinogens	Carcinogens at 10^{-6} Risk Level	Carcinogens at 10^{-5} Risk Level
Tritium	pCi/L	290,000	20,000	--	--	--	--
Nitrate	µg/L	50,000	45,000	45,000	113,600	--	--

COPC = contaminant of potential concern

6.3.6.1.1 Protectiveness Evaluation for Human Health

The protectiveness evaluation for human health is performed to help determine if a CERCLA remedial action is appropriate. *Rules of Thumb for Superfund Remedy Selection* (EPA 540-R-97-013) states that a remedial action is generally appropriate when a regulatory standard that helps define protectiveness (a federal or state MCL) is exceeded.

The 90th percentile groundwater concentration for uranium is greater than the federal and State MCL developed for the protection of human health. Uranium is identified as a COPC indicating the need to evaluate potential remedial technologies for uranium in the FS. Of the 15 monitoring wells in the 300 Area Subregion, 11 monitoring wells were reported with concentrations of uranium above 30 µg/L. Section 4.4.1.3 provides a detailed discussion of the distribution of uranium in the 300-FF-5 Groundwater OU. A detailed discussion of the uranium plume in the 300 Area is provided in Section 4.4.3.3.

The 90th percentile groundwater concentration for TCE is less than the federal MCL developed for the protection of human health. TCE is not identified as a COPC and a need for further review in the FS is not established based on the results of this evaluation. As discussed in Section 6.3.2.4, two monitoring wells report concentrations of TCE greater than the DWS and are not included in the calculation of the EPC and therefore the EPC is understated. Because of this, TCE warrants further evaluation in the FS where remedial technologies should be evaluated.

6.3.6.1.2 Protectiveness Evaluation for Aquatic Receptors

The protectiveness evaluation for aquatic receptors is performed to help determine if a CERCLA remedial action is appropriate. *Rules of Thumb for Superfund Remedy Selection* (EPA 540-R-97-013) states that a remedial action is generally appropriate when a regulatory standard that helps define protectiveness (*National Recommended Water Quality Criteria* [EPA, 2009b]) is exceeded. As described in the exposure assessment, groundwater discharges to the Columbia River through upwelling and seeps. The point of compliance for surface water cleanup levels is defined in "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. "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. Groundwater EPCs from the 300 Area Subregion are compared to the ambient water quality standards to determine if groundwater concentrations discharging to the Columbia River comply with federal and state standards.

Federal and state water quality standards for the protection of freshwater organisms are not published for TCE and uranium, therefore a protectiveness evaluation is not included in this section (see Table 6-35).

TCE and uranium are evaluated in the protectiveness evaluation for human health in Section 6.3.5.4 and the risk evaluation is presented in Section 6.3.5.6. Chapter 7 includes an evaluation of uranium and TCE and its potential impacts to aquatic receptors. The evaluation provided in Chapter 7 indicates that uranium is present in groundwater and porewater at concentrations that may be of ecological concern and warrantes the need to evaluate potential remedial technologies in the FS. However, TCE is not present at concentrations in groundwater or porewater that is of ecological concern and does not warrant further evaluation in the FS.

6.3.6.1.3 Risk Evaluation

The risk evaluation is also performed to help determine whether a CERCLA remedial action is appropriate. *Rules of Thumb for Superfund Remedy Selection* (EPA 540-R-97-013) states that a remedial action is generally appropriate when the estimated risk calculated in a risk assessment exceeds a noncarcinogenic level for an adverse health effect or the upper end of the NCP risk range for "cumulative carcinogenic site risk" to an individual based on RME for both current and future land use.

The potential cumulative ELCR for the 300 Area Subregion from all nonradiological carcinogenic COPCs is 4.5×10^{-6}, which is less than the WAC 173-340-708 risk threshold of 1×10^{-5} for multiple hazardous substances and less than the upper NCP threshold of 1×10^{-4}. Table 6-36 shows the only contributor to risk is TCE (4.5×10^{-6}, 100 percent contribution). TCE is not identified as a COPC based on the results of this evaluation.

The HI for the 300 Area Subregion is 2.4, which is greater than the EPA and MTCA (WAC 173-340) target HI of 1. The primary contributor to the noncancer HI is uranium (HQ = 2.4, 100 percent contribution). The primary noncancer health effects associated with exposure to uranium is nephrotoxicity. Uranium is identified as a COPC based on the results of this evaluation.

6.3.6.2 600 Area Subregion

Groundwater in the 600 Area Subregion is evaluated as a potential drinking water source and has the potential to discharge to the Columbia River. Table 6-37 provides a summary of the COPCs, the 90th percentile groundwater concentration, federal and state MCLs, and the WAC 173-340-720 groundwater cleanup standards for carcinogenic and noncarcinogenic effects for the 600 Area Subregion exposure area. Table 6-38 provides a summary of the COPCs, the 90th percentile groundwater concentration, and federal and state surface water quality standards for the 600 Area Subregion exposure area. These standards (listed in Table 6-37 and 6-38) represent the chemical-specific ARARs that were exceeded by at least one COPC.

Table 6-38. Summary of Current Conditions 90th Percentile Groundwater Concentrations, Federal and State Water Quality Standards for the 600 Area Subregion of the 300-FF-5 Groundwater OU (Aquatic Action Levels)

			AWQC		WAC 173-201A	40 CFR 131	
COPC	Units	90th Percentile Value	Freshwater CMC (Acute)	Freshwater CCC (Chronic)	Freshwater CCC (Chronic)	Freshwater CMC (Acute)	Freshwater CCC (Chronic)
Tritium	pCi/L	290,000	--	--	--	--	--
Nitrate	µg/L	50,000	--	--	--	--	--

6.3.6.2.1 Protectiveness Evaluation for Human Health

The protectiveness evaluation for human health is performed to help determine if a CERCLA remedial action is appropriate. *Rules of Thumb for Superfund Remedy Selection* (EPA 540-R-97-013) states that a remedial action is generally appropriate when a regulatory standard that helps define protectiveness (a federal or state MCL) is exceeded.

The 90th percentile groundwater concentration for tritium is greater than the federal MCL developed for the protection of human health. Tritium is identified as a COPC for the 600 Area Subregion exposure area indicating the need to evaluate potential remedial technologies for tritium in the FS. Of the 17 monitoring wells in the 600 Area Subregion, four monitoring wells were reported with concentrations of tritium above 20,000 pCi/L. Section 4.4.4.2 provides a detailed discussion of the distribution of tritium in the 600 Area Subregion. A discussion of the footprint of the plume, wells with concentrations above the MCL, and trends is also provided in Section 4.4.4.2.

The 90th percentile groundwater concentration for nitrate is greater than the federal and State MCL of 45,000 µg/L developed for the protection of human health. Nitrate is identified as a COPC indicating the need to evaluate potential remedial technologies for nitrate in the FS. Of the 17 monitoring wells in the 600 Area Subregion exposure area, three monitoring wells were reported with concentrations of nitrate above 45,000 µg/L.

6.3.6.2.2 Protectiveness Evaluation for Aquatic Receptors

The protectiveness evaluation for aquatic receptors is performed to help determine if a CERCLA remedial action is appropriate. *Rules of Thumb for Superfund Remedy Selection* (EPA 540-R-97-013) states that a remedial action is generally appropriate when a regulatory standard that helps define protectiveness (*National Recommended Water Quality Criteria* [EPA, 2009b]) is exceeded.

Federal and State water quality standards for the protection of freshwater organisms are not published for tritium or nitrate, therefore a protectiveness evaluation is not included (see Table 6-38). Tritium is evaluated in the protective evaluation for human health in Section 6.3.5.8. Nitrate is evaluated in the protectiveness evaluation for human health and the risk evaluation, presented in Section 6.3.5.10. Chapter 7 includes an evaluation of nitrate and its potential impacts to aquatic receptors. The evaluation provided in Chapter 7 indicates that nitrate is not present at concentrations in groundwater or porewater that warrants further evaluation in the FS.

6.3.6.2.3 Risk Evaluation

The risk evaluation is also performed to help determine whether a CERCLA remedial action is appropriate. *Rules of Thumb for Superfund Remedy Selection* (EPA 540-R-97-013) states that a remedial action is generally appropriate when the estimated risk calculated in a risk assessment exceeds a noncarcinogenic level for an adverse health effect or the upper end of the NCP risk range for "cumulative carcinogenic site risk" to an individual based on RME for both current and future land use. Table 6-39 shows that no carcinogenic COPCs were identified in the 600 Area Subregion exposure area.

The HI for the 600 Area Subregion exposure area is 0.44, which is less than the EPA and MTCA (WAC 173-340) target HI of 1. The individual HQ for nitrate is less than one. Nitrate is not identified as a COPC based on the results of this evaluation.

6.3.7 Risk Characterization Results of the Supplemental Native American Risk Evaluations

Several local and regional Tribes have ancestral ties to the Hanford Reach of the Columbia River and surrounding lands. DOE has requested that each Tribe provide an exposure scenario that reflects their traditional activities. At this time, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* (Harris

and Harper, 2004), and *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* (Harris, 2008) have been provided by the CTUIR. *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* (Ridolfi, 2007) has been provided by the Yakama Nation.

Table 6-39. Summary of 90th Percentile Current Groundwater Concentrations and Associated Cancer Risk and Noncancer Hazard Index for the 600 Area Subregion

			WAC 173-340-720 Cleanup Levels			
Contaminant of Potential Concern	**Units**	**90th Percentile Value**	**Non Carcinogens**	**Hazard Quotient**	**Carcinogens at 10^{-6} Risk Level**	**ELCR**
Nitrate	µg/L	50,000	113,600	0.44	--	--
Hazard Index				**0.44**		

ELCR = excess lifetime cancer risk

The CTUIR and Yakama Nation scenarios reflect exposure conditions that assume groundwater from the 300-FF-5 Groundwater OU (including the 300 Area Subregion and the 600 Area Subregion) is restored to its highest beneficial use. Groundwater would be used as a drinking water source and for steam in a sweat lodge. Use of groundwater to irrigate crops and water livestock is not evaluated in this risk evaluation because those exposure pathways, although potentially complete, are considered insignificant and secondary to the drinking water and sweat lodge exposure pathways. Food chain pathways are generally evaluated quantitatively in the source area OUs because the RESRAD, Version 6.5 (ANL, 2009) estimates exposure from these pathways.

Potentially complete exposure routes for adult and child Tribal members associated with use of groundwater as a drinking water source are as follows:

- Ingestion of drinking water
- Inhalation of volatiles when showering and other domestic purposes
- Dermal contact with skin while showering and using groundwater for other domestic purposes (such as, washing dishes)

Potentially complete exposure routes for adult Tribal members associated with the use of groundwater to generate steam in a sweat lodge are as follows:

- Inhalation of tritium, volatiles, and semivolatiles as vapors
- Inhalation of aerosolized nonvolatiles
- Dermal contact with vapors from volatile and semivolatile compounds
- Dermal contact with vapor and aqueous condensate

A complete description of each of the Tribal use exposure scenarios is provided in *Native American Risk Assessment for the 300 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0132) (Appendix G) and in *Native American Risk Assessment for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0133) (Appendix G). These calculations describe the methodology, assumptions, and inputs, and the calculation of risks and hazards, and discusses the results of the risk assessment for each of the Native American scenarios.

6.3.7.1 Summary of the CTUIR Supplemental Risk Evaluation

This section summarizes the results for each of the exposure pathways associated with use of groundwater as a drinking water source and use of groundwater to generate steam in a sweat lodge.

6.3.7.1.1 Use of Groundwater as a Potential Drinking Water Source

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact,[16] and inhalation of volatiles during household activities. Table 6-40 provides a summary of the risk estimates by exposure route for the 300 Area Subregion and the 600 Area Subregion. Additional detail including COPC-specific risk contributions is provided in ECF-300FF5-11-0132 and ECF-300FF5-11-0133.

Table 6-40. Confederated Tribes of the Umatilla Indian Reservation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source

Exposure Route	300 Area Subregion		600 Area Subregion	
	ELCR	Hazard Index	ELCR	Hazard Index
Nonradionuclide Contaminants of Potential Concern				
Ingestion	4.7×10^{-4}	4.9	9.6×10^{-4}	4.4
Dermal	4.4×10^{-6}	0.02	4.1×10^{-6}	0.02
Inhalation	8.7×10^{-7}	<0.01	1.2×10^{-6}	<0.01
Total	**4.8×10^{-4}**	**4.9**	**9.6×10^{-4}**	**4.5**
Radionuclide Contaminant of Potential Concern				
Ingestion	3.0×10^{-5}	--	1.4×10^{-3}	--
Inhalation	2.7×10^{-6}	--	1.3×10^{-4}	--
Total	**3.3×10^{-5}**	**--**	**1.5×10^{-3}**	**--**
Total ELCR*	**5.1×10^{-4}**	**--**	**2.5×10^{-3}**	**--**

* Total ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

-- = hazard index is not applicable

ELCR = excess lifetime cancer risk

300 Area Subregion. The cumulative ELCR is 4.8×10^{-4} for nonradiological COPCs and 3.3×10^{-5} for radiological COPCs. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA range of 1×10^{-4} to 1×10^{-6}. Individual ELCR values for CCl_4, chloroform, PCE, TCE, and tritium are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 4.9, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI is uranium, with a HQ of 2.2.

[16] The dermal contact exposure route is only evaluated for nonradionuclide COPCs.

Although the individual ELCR value associated with arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4}, the 90th percentile value of 5.2 µg/L is considered to be within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

600 Area Subregion. The cumulative ELCR is 9.6×10^{-4} for nonradiological COPCs and 1.5×10^{-3} for radiological COPCs. Both ELCRs are greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR value for tritium is greater than the EPA upper target risk threshold of 1×10^{-4}. Individual ELCR values for bromodichloromethane, CCl_4, chloroform, dibromochloromethane, and I-129 are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 4.5, which is greater than the EPA target HI of 1.0. No individual COPCs in the 600 Area Subregion had a HQ greater than the EPA target HQ of 1.0.

Although the individual ELCR value for arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4} and the HQ is greater than 1.0, the 90th percentile value of 11 µg/L is within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

Although the individual ELCR value for BEHP is within the EPA range of 1×10^{-4} to 1×10^{-6}, BEHP is not considered a contributor to the ELCR. BEHP was detected in 3 of 51 samples analyzed (6 percent frequency) with concentrations ranging from 1.3 to 3 µg/L. However, observed concentrations of BEHP do not appear to be associated with a long-term trend or local exposure point. Therefore, BEHP is not considered a contributor to risk or hazard.

6.3.7.1.2 Use of Groundwater to Generate Steam for Sweat Lodge Use

Potential exposure to groundwater as a source of steam in a sweat lodge is evaluated under this scenario. Potential routes of exposure to steam generated from groundwater while spending time in a sweat lodge include 1) inhalation of vaporized volatiles and semivolatiles and aerosolized nonvolatiles, and 2) dermal contact with vaporized volatiles and semivolatiles, aerosolized nonvolatiles, and condensed liquid. Table 6-41 provides a summary of the risk estimates by exposure route for the 300 Area Subregion and the 600 Area Subregion. Additional detail including COPC-specific risk contributions is provided in the calculation spreadsheets presented in *Native American Risk Assessment for the 300 Area Subregion of the300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0132) and *Native American Risk Assessment for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0133).

300 Area Subregion. The cumulative ELCR is 2.1×10^{-4} for nonradiological COPCs and 8.5×10^{-6} for radiological COPCs. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA range of 1×10^{-4} to 1×10^{-6}. The individual ELCR values for TCE and tritium are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 9.4, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI is uranium, with a HQ of 3.3.

Although the individual ELCR value for arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4} and the HQ is greater than 1.0, the 90th percentile value of 5.2 µg/L is within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

**Table 6-41. CTUIR Exposure Scenario—
Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge**

Exposure Route	300 Area Subregion		600 Area Subregion	
	ELCR	HI	ELCR	HI
Nonradionuclide Contaminants of Potential Concern				
Inhalation in Sweat Lodge				
Volatile and Semivolatile (vapor)	3.5×10^{-6}	<0.01	4.9×10^{-6}	0.02
Nonvolatile (aerosol)	2.1×10^{-4}	9.4	4.2×10^{-4}	16
Total	**2.1×10^{-4}**	**9.4**	**4.2×10^{-4}**	**16**
Dermal Exposure in Sweat Lodge				
Volatile and Semivolatile (vapor only)	1.4×10^{-9}	<0.01	4.3×10^{-10}	<0.01
Nonvolatile (vapor and aqueous condensate)	2.0×10^{-6}	0.03	4.1×10^{-6}	0.03
Total	**2.0×10^{-6}**	**0.03**	**4.1×10^{-6}**	**0.03**
Total Nonradionuclide COPCs	**2.1×10^{-4}**	**9.4**	**4.3×10^{-4}**	**16**
Radionuclide Contaminants of Potential Concern				
Inhalation in Sweat Lodge				
Volatile and Semivolatile (vapor)	8.5×10^{-6}	--	4.0×10^{-4}	--
Nonvolatile (aerosol)	--	--	3.0×10^{-8}	--
Total	8.5×10^{-6}	--	4.0×10^{-4}	--
Total ELCR*	**2.2×10^{-4}**	--	**8.4×10^{-4}**	--

* Total ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

-- = HI is not applicable
ELCR = excess lifetime cancer risk
HI = hazard index

Although the individual ELCR associated with cobalt is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 0.12 µg/L is considered to be within the range of naturally occurring concentrations of cobalt. Therefore, cobalt is not considered a contributor the ELCR.

Although the individual ELCR associated with nickel is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 6 µg/L is considered to be within the range of naturally occurring concentrations of nickel. Therefore, nickel is not considered a contributor the ELCR.

Although the individual HQ associated with barium is greater than 1.0, the 90th percentile value of 71 µg/L is considered to be within the range of naturally occurring concentrations of barium. Therefore, barium is not considered a contributor to the HI.

Although the individual HQ associated with manganese is greater than 1.0, manganese is not considered a contributor to the HI because the 90th percentile value of 6.0 µg/L is below the secondary MCL of 50 µg/L and the secondary MCL is based on aesthetic qualities and is not federally enforceable.

600 Area Subregion. The cumulative ELCR is 4.3×10^{-4} for nonradiological COPCs and 4.0×10^{-4} for radiological COPCs. Both ELCRs are greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR value for tritium is greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR values for bromodichloromethane and dibromochloromethane are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 16, which is greater than the EPA target HI of 1.0. No individual COPCs had a HQ greater than the EPA target HQ of 1.0.

Although the individual ELCR value for arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4} and the HQ is greater than 1.0, the 90th percentile value of 11 µg/L is within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

Although the individual ELCR associated with beryllium is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 0.10 µg/L is considered to be within the range of naturally occurring concentrations of beryllium. Therefore, beryllium is not considered a contributor the ELCR.

Although the individual ELCR associated with cobalt is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 0.36 µg/L is considered to be within the range of naturally occurring concentrations of cobalt. Therefore, cobalt is not considered a contributor the ELCR.

Although the individual ELCR associated with nickel is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 4.0 µg/L is considered to be within the range of naturally occurring concentrations of nickel. Therefore, nickel is not considered a contributor the ELCR.

Although the individual HQ associated with barium is greater than 1.0, the 90th percentile value of 69 µg/L is considered to be within the range of naturally occurring concentrations of barium. Therefore, barium is not considered a contributor to the HI.

Although the individual HQ associated with manganese is greater than 1.0, manganese is not considered a contributor to the HI because the 90th percentile value of 40 µg/L is below the secondary MCL of 50 µg/L and the secondary MCL is based on aesthetic qualities and is not federally enforceable.

6.3.7.2 Summary of the Yakama Nation Supplemental Risk Evaluation

This section summarizes the results for each of the exposure pathways associated with use of groundwater as a drinking water source and use of groundwater to generate steam in a sweat lodge.

6.3.7.2.1 Use of Groundwater as a Potential Drinking Water Source

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact,[17] and inhalation of volatiles during household activities. Table 6-42 provides a summary of the risk estimates by exposure route for the 300 Area Subregion and the 600 Area Subregion. Additional detail including COPC-specific risk contributions is provided in the calculation spreadsheets presented in ECF-300FF5-11-0132 and ECF-300FF5-11-0133.

[17] The dermal contact exposure route is only evaluated for nonradionuclide COPCs.

**Table 6-42. Yakama Nation Exposure Scenario—
Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source**

Exposure Route	300 Area Subregion		600 Area Subregion	
	ELCR	Hazard Index	ELCR	Hazard Index
Nonradionuclide Contaminants of Potential Concern				
Ingestion	5.1×10^{-4}	4.9	1.0×10^{-3}	4.4
Dermal	4.3×10^{-6}	0.02	4.1×10^{-6}	0.02
Inhalation	8.7×10^{-7}	<0.01	1.2×10^{-6}	<0.01
Total	**5.2×10^{-4}**	**4.9**	**1.1×10^{-3}**	**4.5**
Radionuclide Contaminants of Potential Concern				
Ingestion	3.1×10^{-5}	--	1.4×10^{-3}	--
Inhalation	2.9×10^{-6}	--	1.3×10^{-4}	--
Total	**3.3×10^{-5}**	**--**	**1.6×10^{-3}**	**--**
Total ELCR*	**5.5×10^{-4}**	**--**	**2.6×10^{-3}**	**--**

* Total ELCR represents the sum of total nonradionuclides ELCR and the total radionuclide ELCR.

-- = hazard index is not applicable

ELCR = excess lifetime cancer risk

300 Area Subregion. The cumulative ELCR is 5.2×10^{-4} for nonradiological COPCs and 3.3×10^{-5} for radiological COPCs. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA range of 1×10^{-4} to 1×10^{-6}. Individual ELCR values for CCl_4, chloroform, PCE, TCE, and tritium are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 4.9, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI is uranium, with a HQ of 2.2.

Although the individual ELCR value associated with arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4}, the 90th percentile value of 5.2 µg/L is considered to be within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

600 Area Subregion. The cumulative ELCR is 1.1×10^{-3} for nonradiological COPCs and 1.6×10^{-3} for radiological COPCs. Both ELCRs are greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR value for tritium is greater than the EPA upper target risk threshold of 1×10^{-4}. Individual ELCR values for bromodichloromethane, CCl_4, chloroform, dibromochloromethane, and I-129 are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI for is 4.5, which is greater than the EPA target HI of 1.0. No individual COPCs had a HQ greater than the EPA target HQ of 1.0.

Although the individual ELCR value for arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4} and the HQ is greater than 1.0, the 90th percentile value of 11 µg/L is within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

Although the individual ELCR value for BEHP is within the EPA range of 1×10^{-4} to 1×10^{-6}, BEHP is not considered a contributor to the ELCR. BEHP was detected in 3 of 51 samples analyzed (6 percent frequency) with concentrations ranging from 1.3 to 3 µg/L. However, observed concentrations of BEHP do not appear to be associated with a long-term trend or local exposure point. Therefore, BEHP is not considered a contributor to risk or hazard.

6.3.7.2.2 Use of Groundwater to Generate Steam for Sweat Lodge Use

Potential exposure to groundwater as a source of steam in a sweat lodge is evaluated under this scenario. Potential routes of exposure to steam generated from groundwater while spending time in a sweat lodge include 1) inhalation of vaporized volatiles and semivolatiles and aerosolized nonvolatiles, and 2) dermal contact with vaporized volatiles and semivolatiles, aerosolized nonvolatiles, and condensed liquid. Table 6-43 provides a summary of the risk estimates by exposure route for the 300 Area Subregion and the 600 Area Subregion. Additional detail including COPC-specific risk contributions is provided in the calculation spreadsheets presented in ECF-300FF5-11-0132 and ECF-300FF5-11-0133.

300 Area Subregion. The cumulative ELCR is 4.4×10^{-4} for nonradiological COPCs and 1.8×10^{-5} for radiological COPCs. The nonradiological ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA range of 1×10^{-4} to 1×10^{-6}. The individual ELCR values for chloroform, TCE, and tritium are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 20, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI is uranium with a HQ of 6.8.

Although the individual ELCR value for arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4} and the HQ is greater than 1.0, the 90th percentile value of 5.2 µg/L is within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

Although the individual ELCR associated with cobalt is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 0.12 µg/L is considered to be within the range of naturally occurring concentrations of cobalt. Therefore, cobalt is not considered a contributor the ELCR.

Although the individual ELCR value for nickel is within the EPA range of 1×10^{-4} to 1×10^{-6} and the HQ is greater than 1.0, the 90th percentile value of 6 µg/L is within the range of naturally occurring concentrations of nickel. Therefore, nickel is not considered a contributor to risk or hazard.

Table 6-43. Yakama Nation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge

Exposure Route	300 Area Subregion		600 Area Subregion	
	ELCR	Hazard Index	ELCR	Hazard Index
Nonradionuclide Contaminants of Potential Concern				
Inhalation in Sweat Lodge				
Volatile and Semivolatile (vapor)	7.2×10^{-6}	0.01	1.0×10^{-5}	0.04
Nonvolatile (aerosol)	4.3×10^{-4}	20	8.8×10^{-4}	33
Total	**4.3×10^{-4}**	**20**	**8.9×10^{-4}**	**33**

**Table 6-43. Yakama Nation Exposure Scenario—
Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge**

Exposure Route	300 Area Subregion		600 Area Subregion	
	ELCR	Hazard Index	ELCR	Hazard Index
Dermal Exposure in Sweat Lodge				
Volatile and Semivolatile (vapor only)	2.8×10^{-9}	<0.01	8.5×10^{-10}	<0.01
Nonvolatile (vapor and aqueous condensate)	3.9×10^{-6}	0.05	8.1×10^{-6}	0.07
Total	**3.9×10^{-6}**	**0.05**	**8.1×10^{-6}**	**0.07**
Total Nonradionuclide COPCs	**4.4×10^{-4}**	**20**	**9.0×10^{-4}**	**33**
Radionuclide Contaminants of Potential Concern				
Inhalation in Sweat Lodge				
Volatile and Semivolatile (vapor)	1.8×10^{-5}	--	8.4×10^{-4}	--
Nonvolatile (aerosol)	--	--	6.3×10^{-8}	--
Total	**1.8×10^{-5}**	**--**	**8.4×10^{-4}**	**--**
Total ELCR*	**4.6×10^{-4}**	**--**	**1.7×10^{-3}**	**--**

* Total ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.
-- = hazard index is not applicable
ELCR = excess lifetime cancer risk

Although the individual HQ associated with barium is greater than 1.0, the 90th percentile value of 71 µg/L is considered to be within the range of naturally occurring concentrations of barium. Therefore, barium is not considered a contributor to the HI.

Although the individual HQ associated with manganese is greater than 1.0, manganese is not considered a contributor to the HI because the 90th percentile value of 6.0 µg/L is below the secondary MCL of 50 µg/L and the secondary MCL is based on aesthetic qualities and is not federally enforceable.

600 Area Subregion. The cumulative ELCR is 9.0×10^{-4} for nonradiological COPCs and 8.4×10^{-4} for radiological COPCs. Both ELCRs are greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR value for tritium is greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR values for bromodichloromethane, chloroform, and dibromochloromethane are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 33, which is greater than the EPA target HI of 1.0. No individual COPCs had a HQ greater than the EPA target HQ of 1.0.

Although the individual ELCR value for arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4} and the HQ is greater than 1.0, the 90th percentile value of 11 µg/L is within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

Although the individual ELCR associated with beryllium is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 0.10 µg/L is considered to be within the range of naturally occurring concentrations of beryllium. Therefore, beryllium is not considered a contributor the ELCR.

Although the individual ELCR associated with cobalt is within the EPA range of 1×10^{-4} to 1×10^{-6} and the HQ is greater than 1.0, the 90th percentile value of 0.36 µg/L is considered to be within the range of naturally occurring concentrations of cobalt. Therefore, cobalt is not considered a contributor the ELCR.

Although the individual ELCR associated with nickel is within the EPA range of 1×10^{-4} to 1×10^{-6}, the 90th percentile value of 4.0 µg/L is considered to be within the range of naturally occurring concentrations of nickel. Therefore, nickel is not considered a contributor the ELCR.

Although the individual HQ associated with barium is greater than 1.0, the 90th percentile value of 69 µg/L is considered to be within the range of naturally occurring concentrations of barium. Therefore, barium is not considered a contributor to the HI.

Although the individual HQ associated with manganese is greater than 1.0, manganese is not considered a contributor to the HI because the 90th percentile value of 40 µg/L is below the secondary MCL of 50 µg/L and the secondary MCL is based on aesthetic qualities and is not federally enforceable.

6.3.8 Risk Characterization Results of the EPA Tap Water Scenario

This section summarizes the results for each of the exposure pathways associated with use of groundwater as a drinking water source. The EPA tap water scenario is included in this section to provide a similar scenario using exposure assumptions that represent RME. The EPA tap water scenario is consistent with a residential exposure scenario as it incorporates default residential exposure assumptions. The results of the Tap Water Risk Evaluation are provided in *Tap Water Risk Assessment for the 300 Area Subregion of 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0134) (Appendix G) and *Tap Water Risk Assessment for the 600 Area Subregion of the 300-FF-5 Groundwater Operable Unit* (ECF-300FF5-11-0135) (Appendix G). Potentially complete exposure routes for EPA tap water scenario include exposure of adult and children residents to groundwater used as a drinking water source and include the following:

- Ingestion of drinking water
- Inhalation of volatiles when showering and other domestic purposes
- Dermal contact with skin while showering and using groundwater for other domestic purposes (such as, washing dishes)

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact, and inhalation of volatiles during household activities. Table 6-44 provides a summary of the risk estimates by exposure route for the 300 Area Subregion and the 600 Area Subregion.

6.3.8.1 300 Area Subregion

The cumulative ELCR is 1.2×10^{-4} for nonradiological COPCs and 6.8×10^{-6} for radiological COPCs. The nonradionuclide ELCR is greater than the EPA upper target risk threshold of 1×10^{-4} and the radiological ELCR is within the EPA range of 1×10^{-4} to 1×10^{-6}. The individual ELCR values for PCE, TCE, and tritium are within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 2.4, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI is uranium, with a HQ of 1.1.

Although the individual ELCR value associated with arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4}, the 90th percentile value of 5.2 µg/L is considered to be within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

6.3.8.2 600 Area Subregion

The cumulative ELCR is 2.5×10^{-4} for nonradiological COPCs and 3.2×10^{-4} for radiological COPCs. Both ELCRs are greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR value for tritium is greater than the EPA upper target risk threshold of 1×10^{-4}. The individual ELCR value for dibromochloromethane is within the EPA range of 1×10^{-4} to 1×10^{-6}. The HI is 2.2, which is greater than the EPA target HI of 1.0. No individual COPCs had a HQ greater than the EPA and MTCA (WAC 173-340) target HQ of 1.0.

Although the individual ELCR value associated with arsenic is greater than EPA's regulatory target risk threshold of 1×10^{-4}, the 90th percentile value of 11 µg/L is considered to be within the range of naturally occurring concentrations of arsenic. Therefore, arsenic is not considered a contributor to risk or hazard.

6.3.9 Comparison of Native American and EPA Tap Water Risk Characterization Results

Table 6-45 provides a summary of the risk estimates and hazard indices for each of the Native American Scenarios and the EPA tap water scenario. Results are provided for ingestion, dermal contact, and inhalation of volatiles during household activities.

Exposure parameters for the Native American exposure scenarios and the EPA tap water scenario differ in the following ways:

- Exposure frequency (Native American 365 day/yr; EPA tap water 350 day/yr)
- Exposure duration (Native American 70 years; EPA tap water 30 years)
- Drinking water ingestion rate (Native American 4 L [1 gal]/day; EPA tap water 2 L [0.5 gal]/day)
- Inhalation rate (CTUIR 25 m^3 [883 ft^3]/day, Yakama Nation 26 m^3 [918 ft^3]/day; EPA tap water 20 m^3 [706 ft^3]/day)

Table 6-44. Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source Using EPA Tap Water Equations

	300 Area Subregion		600 Area Subregion	
Exposure Route	**ELCR**	**Hazard Index**	**ELCR**	**Hazard Index**
Nonradionuclide Contaminants of Potential Concern				
Ingestion	1.2×10^{-4}	2.4	2.5×10^{-4}	2.1
Dermal	2.0×10^{-6}	0.02	2.0×10^{-6}	0.02
Inhalation	3.6×10^{-7}	<0.01	4.8×10^{-7}	<0.01
Total	**1.2×10^{-4}**	**2.4**	**2.5×10^{-4}**	**2.2**
Radionuclide Contaminants of Potential Concern				
Ingestion	5.9×10^{-6}	--	2.8×10^{-4}	--

Table 6-44. Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source Using EPA Tap Water Equations

	300 Area Subregion		600 Area Subregion	
Exposure Route	**ELCR**	**Hazard Index**	**ELCR**	**Hazard Index**
Inhalation	9.0×10^{-7}	--	4.3×10^{-5}	--
Total	$\mathbf{6.8 \times 10^{-6}}$	--	$\mathbf{3.2 \times 10^{-4}}$	--
Total ELCR*	$\mathbf{1.3 \times 10^{-4}}$	--	$\mathbf{5.7 \times 10^{-4}}$	--

* Total ELCR represents the sum of the total nonradionuclide ELCR and the total radionuclide ELCR.

-- = hazard index is not applicable

ELCR = excess lifetime cancer risk

As a result, the EPA tap water scenario has a lower total ELCR and HI than the Native American exposure scenarios.

6.3.9.1 300 Area Subregion

The total ELCRs for the CTUIR and Yakama Nation exposure scenarios are 5.1×10^{-4} and 5.5×10^{-4} respectively. The primary contributors to risk for the CTUIR scenario are arsenic (4.6×10^{-4}; 95 percent contribution), tritium (3.3×10^{-5}; 6.4 percent contribution), TCE (1.3×10^{-5}; 2.6 percent contribution), PCE (7.5×10^{-6}; 1.5 percent contribution); CCl_4 (1.1×10^{-6}; 0.21 percent contribution), and chloroform (1.0×10^{-6}; 0.2 percent contribution). The primary contributors to risk for the Yakama Nation scenario are arsenic (4.9×10^{-4}; 90 percent contribution), tritium (3.3×10^{-5}; 6.0 percent contribution), TCE (1.4×10^{-5}; 2.6 percent contribution), PCE (7.9×10^{-6}; 1.4 percent contribution); CCl_4 (1.1×10^{-6}; 0.21 percent contribution), and chloroform (1.1×10^{-6}; 0.2 percent contribution). The total ELCR for the EPA tap water equations is 1.3×10^{-4}. The primary contributors to risk for the tap water scenario are arsenic (1.2×10^{-4}; 90 percent contribution), tritium (6.8×10^{-6}; 5.2 percent contribution), TCE (3.7×10^{-6}; 2.8 percent contribution), and PCE (2.3×10^{-6}; 1.8 percent contribution). Arsenic is a primary contributor to risk for each of the scenarios; however, levels of arsenic in groundwater are considered naturally occurring. The remaining analytes that are reported contribute less than six percent of the total cumulative risk. The total HI is 4.9 for both the CTUIR and Yakama Nation exposure scenarios. The HI for the EPA tap water equations is 2.4. Uranium is the primary contributors to the noncancer HI for the Native American scenario as well as the primary contributor to the EPA tap water exposure scenario.

6.3.9.2 600 Area Subregion.

The total ELCRs for the CTUIR and Yakama Nation exposure scenarios are 2.5×10^{-3} and 2.6×10^{-3} respectively. The primary contributors to risk for the CTUIR scenario are tritium (1.5×10^{-3}, 61 percent contribution), arsenic (9.4×10^{-4}; 38 percent contribution), dibromochloromethane (1.1×10^{-5}; 0.43 percent contribution), bromodichloromethane (3.0×10^{-6}; 0.12 percent contribution), I-129 (1.7×10^{-6}; 0.07 percent contribution), chloroform (1.3×10^{-6}; 0.05 percent contribution); CCl_4 (1.1×10^{-6}; 0.04 percent contribution). The primary contributors to risk for the Yakama Nation scenario are the following:

- Tritium (1.6×10^{-3}, 60 percent contribution)
- Arsenic (1.0×10^{-3}; 39 percent contribution)
- Dibromochloromethane (1.2×10^{-5}; 0.44 percent contribution)
- Bromodichloromethane (3.3×10^{-6}; 0.12 percent contribution)
- Iodine-129 (1.7×10^{-6}; 0.06 percent contribution)
- Chloroform (1.4×10^{-6}; 0.05 percent contribution)
- Carbon tetrachloride (1.1×10^{-6}; 0.04 percent contribution)

The total ELCR for the EPA tap water equations is 5.7×10^{-4}. The primary contributors to risk for the tap water scenario are tritium (3.2×10^{-4}, 56 percent contribution), arsenic (2.4×10^{-4}; 43 percent contribution), and dibromochloromethane (3.0×10^{-6}; 0.52 percent contribution). The primary contributor to risk in groundwater is tritium, however it is anticipated that tritium concentrations will decay to levels less than the DWS within 20 years. Arsenic is also a primary contributor to risk for each of the scenarios; however, levels of arsenic in groundwater are considered naturally occurring. The remaining analytes that are reported contribute less than one percent of the total cumulative risk. The total HI is 4.5 for both the CTUIR and Yakama Nation exposure scenarios. The HI for the EPA tap water equations is 2.2. No individual COPCs in the 600 Area Subregion exposure area had a HQ greater than the EPA and MTCA (WAC 173-340) target HI of 1.0 for the Native American scenarios as well as the EPA tap water exposure scenario.

6.3.10 Uncertainties in the Supplemental Groundwater Risk Evaluation

The purpose of this supplemental groundwater risk evaluation is to determine whether a groundwater remedial action is warranted under CERCLA. Estimating and evaluating health risk from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge, and simplifying assumptions must be made to quantify health risks.

In this assessment, uncertainties relate to the selection of COPCs and the development of media concentrations to which receptors may be exposed, the assumptions about exposure and toxicity, and the characterization of health risks. Uncertainties exist regarding the quantification of health risks in terms of several assumptions about exposure and toxicity, including site-specific and general uncertainties. Based on the anticipation of uncertainty when quantifying exposure and toxicity, the health risks and hazards presented in this risk evaluation are more likely to provide an upper bound on risk.

6.3.10.1 Uncertainties Associated with Sampling and Analysis Data

Sampling and analysis data used in this risk assessment were collected specifically to address the uncertainties identified in the RCBRA Report (DOE/RL-2007-21) and the *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2009-30). These uncertainties were generally associated with the chemical, spatial and temporal representativeness of the data set used to evaluate current baseline conditions in RCBRA Report Volume II (DOE/RL-2007-21). Uncertainties with chemical representativeness were related to the analysis of varying analytical methods between monitoring wells within the OU. Uncertainties with spatial and temporal representativeness were associated with varying sampling frequencies between monitoring wells due to differing monitoring programs.

Table 6-45. Comparison of Risk Estimates and Hazard Indices for the CTUIR, Yakama Nation, and EPA Tap Water Equations

		Drinking Water Ingestion		Inhalation of Volatiles		Dermal Contact with Water		Total			
Exposure Scenario	**COPC Type**	**ELCR**	**Hazard Index**	**ELCR**	**Hazard Index**	**ELCR**	**Hazard Index**	**ELCR**	**Primary Contributors to Risk**	**Hazard Index**	**Primary Contributors to Hazard Index**
300 Area Subregion											
CTUIR	Nonradiological	4.7×10^{-4}	4.9	8.7×10^{-7}	<0.01	4.4×10^{-6}	0.02	4.8×10^{-4}	Arsenic (4.6E-04; 95%); H-3 (3.3E-05; 6.4%), TCE (1.3E-05; 2.6%), PCE (7.5E-06; 1.5%), CCl_4 (1.1E-06; 0.21%), Chloroform (1.0E-06; 0.20%)	**4.9**	**Uranium (2.2)**
	Radiological	3.0×10^{-5}	--	2.7×10^{-6}	--	--	--	3.3×10^{-5}		--	
	Total	5.0×10^{-4}	4.9	3.6×10^{-6}	<0.01	4.4×10^{-6}	0.02	5.1×10^{-4}		**4.9**	
Yakama Nation	Nonradiological	5.1×10^{-4}	4.9	8.7×10^{-7}	<0.01	4.3×10^{-6}	0.02	5.2×10^{-4}	Arsenic (4.9E-04; 90%), H-3 (3.3E-05; 6.0%), TCE (1.4E-05; 2.6%), PCE (7.9E-06; 1.4%), CCl_4 (1.1E-06; 0.21%), Chloroform (1.1E-06; 0.20%)	**4.9**	**Uranium (2.2)**
	Radiological	3.1×10^{-5}	--	2.9×10^{-6}	--	--	--	3.3×10^{-5}		--	
	Total	5.4×10^{-4}	4.9	3.8×10^{-6}	<0.01	4.3×10^{-6}	0.02	5.5×10^{-4}		**4.9**	
EPA Tap Water	Nonradiological	1.2×10^{-4}	2.4	3.6×10^{-7}	<0.01	2.0×10^{-6}	0.02	1.2×10^{-4}	Arsenic (1.2E-04; 90%); H-3 (6.8E-06; 5.2%), TCE (3.7E-06; 2.8%), PCE (2.3E-06; 1.8%)	**2.4**	**Uranium (1.1)**
	Radiological	5.9×10^{-6}	--	9.0×10^{-7}	--	--	--	6.8×10^{-6}		--	
	Total	1.3×10^{-4}	2.4	1.3×10^{-6}	<0.01	2.0×10^{-6}	0.02	1.3×10^{-4}		**2.4**	
600 Area Subregion											
CTUIR	Nonradiological	9.6×10^{-4}	4.4	1.2×10^{-6}	<0.01	4.1×10^{-6}	0.02	9.6×10^{-4}	**H-3 (1.5E-03; 61%)**, Arsenic (9.4E-04; 38%); Dibromochloromethane (1.1E-05; 0.43%), Bromodichloromethane (3.0E-06; 0.12%), I-129 (1.7E-06; 0.07%) Chloroform (1.3E-06; 0.05%), CCl_4 (1.1E-06; 0.04%)	**4.5**	None
	Radiological	1.4×10^{-3}	--	1.3×10^{-4}	--	--	--	1.5×10^{-3}		--	
	Total	2.4×10^{-3}	4.4	1.3×10^{-4}	<0.01	4.1×10^{-6}	0.02	2.5×10^{-3}		**4.5**	
Yakama Nation	Nonradiological	1.0×10^{-3}	4.4	1.2×10^{-6}	<0.01	4.1×10^{-6}	0.02	1.1×10^{-3}	**H-3 (1.6E-03; 60%)**, Arsenic (1.0E-03; 39%); Dibromochloromethane (1.2E-05; 0.44%), Bromodichloromethane (3.3E-06; 0.12%), I-129 (1.7E-06; 0.06%) Chloroform (1.4E-06; 0.05%), CCl_4 (1.1E-06; 0.04%),	**4.5**	None
	Radiological	1.4×10^{-3}	--	1.3×10^{-4}	--	--	--	1.6×10^{-3}		--	
	Total	2.4×10^{-3}	4.4	1.3×10^{-4}	<0.01	4.1×10^{-6}	0.02	2.6×10^{-3}		**4.5**	
EPA Tap Water	Nonradiological	2.5×10^{-4}	2.1	4.8×10^{-7}	<0.01	2.0×10^{-6}	0.02	2.5×10^{-4}	**H-3 (3.2E-04; 56%)**, arsenic (2.4E-04; 43%); Dibromochloromethane (3.0E-06; 0.52%)	**2.2**	None
	Radiological	2.8×10^{-4}	--	4.3×10^{-5}	--	--	--	3.2×10^{-4}		--	
	Total	5.2×10^{-4}	2.1	4.3×10^{-5}	<0.01	2.0×10^{-6}	0.02	5.7×10^{-4}		**2.2**	

Notes: Bolded COPCs indicate that the individual ELCR is greater than 1×10^{-4} or has a HQ greater than 1.

CCl_4 = carbon tetrachloride
COPC = contaminant of potential concern
CTUIR = Confederated Tribes of the Umatilla Indian Reservation
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
H-3 = tritium
I-129 = Iodine-129
PCE = tetrachloroethene
TCE = trichloroethene

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Current baseline conditions for the 300 Area Subregion of the 300-FF-5 Groundwater OU exposure area and the 600 Area Subregion of the 300-FF-5 Groundwater OU are represented by groundwater data collected over a 6-month period between June 4, 2010 and December 14, 2010. Three sampling events were used to capture the effects that temporal fluctuations of river stage have on groundwater conditions. The COPCs identified during the work plan phase were validated by using groundwater samples analyzed for the analytical methods documented in DOE/RL-2009-45. The groundwater data set used for COPC identification consists of sampling and analysis data collected from 15 monitoring wells within the 300 Area Subregion and 17 monitoring wells within the 600 Area Subregion. The monitoring well network represents locations where human or ecological receptors could potentially encounter groundwater within the OU or Area. The primary exposure pathway for humans is through groundwater obtained from a residential or community water well, assuming development of the land for future human habitation. The primary exposure pathways for aquatic organisms are direct discharge of groundwater to the Columbia River or through seeps.

All samples were analyzed using methods that could accurately measure analytes to concentrations equal or less than the lowest chemical-specific ARAR. When analytical methods could not achieve the lowest chemical-specific ARAR the action level defaulted to the MDL that could be reasonably achieved. The detection limits for the 300 Area Subregion and 600 Area Subregion are documented in Tables 2-7 and 2-8 of the 300 Area SAP (DOE/RL-2009-45), respectively.

6.3.10.2 Uncertainties Associated with Exposure Point Concentrations

The EPCs for groundwater are calculated as the 90th percentile concentration. The protectiveness and risk evaluation methodology uses an RME concentration for each COPC for each exposure area rather than performing the evaluation on a specific well or location. In general, EPA Superfund guidance recommends using a UCL-95 on the arithmetic mean for estimating EPCs. However, experience at the Site indicates that averages and UCLs cannot be reliably calculated for groundwater data sets using this approach.

Groundwater data sets at the Hanford Site are highly skewed, with a large proportion of BDL values. Guidance from *Data Quality Assessment: Statistical Methods for Practitioners* (EPA/240/B-06/003) is for estimating statistical parameters (whether means or upper percentiles) depending on the variability in the data set. The variability of the data set is assed in terms of the CV and the proportion of observations that are BDL. For data sets with CVs greater than 0.5 and 50 percent or more observations that are BDL, EPA recommends using upper percentiles as opposed to means to develop summary statistics.

Use of the 90th percentile value from a distribution of groundwater concentration data as an estimate of the EPC is a different approach for estimating EPCs than that provided in some Superfund guidance (*Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* [OSWER 9285.6-10]). However, as described below, the 90th percentile exposure concentration is identified in other EPA risk assessment guidance as appropriate for describing and characterizing health risks; its use yields risk estimates that correspond to a RME.

Table 6-46 provides the percentile concentrations used for the protectiveness and risk evaluations, as well as the number of measurements, number of detections, maximum, average, UCL-95 concentrations, and action levels using all of the data within each of the separate subregion. It also lists the CVs and percent of nondetected results for identifying if the data set meets the criteria for calculation of upper percentiles. Table 6-46 represents the list of analytes that were reported with a maximum detected concentration greater than the action level (see Table 6-28 for the 300 Area Subregion and Table 6-29 for the 600 Area Subregion).

Table 6-46. Percentile Concentrations and Summary Statistics for the 300 Area Subregion and 600 Area Subregion Data Set

COPC	Units	Number of Detections	Number of Nondetects	Frequency of Nondetects	Coefficient of Variation	90th Percentile	Max	Mean	UCL-95	Is UCL-95 > 90th percentile?	Action Level[a]
300 Area Subregion											
Acrolein	µg/L	1	44	98%	N/A	2.8	3.8	3.8	Not Calculated	N/A	3.0
Aluminum	µg/L	4	41	91%	1.3	10	100	34	15	Yes	50
Arsenic	µg/L	43	2	4%	0.3	5.2	6.5	3.8	4.0	No	0.018 (4.0)
Bromodichlor omethane	µg/L	3	42	93%	0.0085	0.088	0.69	0.68	0.68	Yes	0.27
Carbon tetrachloride	µg/L	3	42	93%	0.73	0.12	0.59	0.33	0.59	Yes	0.23 (2.0)
Copper	µg/L	23	22	49%	2.9	1.4	31	2.2	4.3	Yes	9.0
Gross alpha	pCi/L	28	0	0%	0.90	71	77	23	31	No	15
Iron	µg/L	19	26	58%	1.4	106	647	129	102	No	300
Lead	µg/L	3	42	93%	1.2	0.2	3.5	1.5	3.5	Yes	2.1
Lithium	µg/L	33	12	27%	0.68	25	33	13	13	No	32
Nitrate	µg/L	45	0	0%	0.29	31,250	62,000	25,900	27,800	No	45,000
Selenium	µg/L	45	0	0%	0.41	3.7	5.8	2.5	2.8	No	5.0
PCE	µg/L	3	42	93%	0.33	0.18	0.38	0.29	0.38	Yes	0.081 (5.0)
Thallium	µg/L	1	44	98%	N/A	0.10	1.2	1.2	Not Calculated	N/A	0.24 (2.0)
TCE	µg/L	35	10	22%	0.54	2.2	3.0	1.3	1.3	No	0.49 (2.0)
Uranium	µg/L	45	0	0%	0.70	114	177	55	66	No	30

Table 6-46. Percentile Concentrations and Summary Statistics for the 300 Area Subregion and 600 Area Subregion Data Set

COPC	Units	Number of Detections	Number of Nondetects	Frequency of Nondetects	Coefficient of Variation	90th Percentile	Max	Mean	UCL-95	Is UCL-95 > 90th percentile?	Action Level[a]
Zinc	µg/L	12	33	73%	1.6	42	456	105	95	Yes	91
600 Area Subregion											
Aluminum	µg/L	15	36	71%	1.5	87	539	106	66	No	50
Arsenic	µg/L	51	0	0%	0.57	11	15	5.8	6.7	No	0.018 (4.0)
Bis(2-ethylhexyl) phthalate	µg/L	3	48	94%	0.48	1.0	3.0	1.9	3.0	Yes	1.2
Bromodichlor omethane	µg/L	10	41	80%	0.68	0.72	2.1	0.89	0.64	No	0.27
Chloroform	µg/L	15	36	71%	1.7	0.62	7.1	1.1	0.75	Yes	1.4 (5.0)
Copper	µg/L	31	20	39%	1.4	3.3	12	1.8	1.7	No	9.0
Dibromochlor omethane	µg/L	7	44	86%	0.25	2.0	3.3	2.4	2.3	Yes	0.40
Fluoride	µg/L	43	8	16%	0.76	333	851	242	322	No	960
Gross alpha	pCi/L	14	8	36%	1.5	8	40	6.7	22	Yes	15
Iron	µg/L	40	11	22%	1.7	477	3,340	306	541	Yes	300
Manganese	µg/L	27	24	47%	1.4	40	261	34	30	No	50
Nitrate	µg/L	48	3	6%	1.1	50,000	136,000	26,630	50,500	Yes	45,000
Selenium	µg/L	33	18	35%	0.88	6.1	13	3.4	3.2	No	5.0
Tritium	pCi/L	31	20	39%	2.0	290,000	890,000	128,200	367,000	Yes	20,000

With the exception of arsenic, nitrate, and selenium in the 300 Area Subregion, the data set reports CVs greater than 0.5 and greater than 50 percent or more of observations that are nondetect. As a result, the data set does not meet EPA's recommendation for calculating means to develop summary statistics.

The groundwater data set is considered robust when the 90th percentile value is greater than the UCL-95 value. For analytes within the 300 Area Subregion, the 90th percentile concentration is greater than the UCL-95 value for10 of 17 analytes and a UCL-95 value could not be calculated for two analytes. For the 600 Area Subregion, the 90th percentile concentration is greater than the UCL-95 value for 7 of the 14 analytes. For analytes with a 90th percentile concentration greater than the UCL-95, the conclusions of the risk evaluation may overstate risks. For these analytes, the same conclusions would be reached using either set of values. For analytes with a UCL-95 greater than the 90th percentile concentration, the risk evaluation may have the potential to understate risks. For these analytes, the same conclusions would be reached using either set of values.

6.3.10.3 Uncertainties Associated with Exposure Assumptions

The exposure assumptions used to develop the chemical-specific ARARs represent an RME. For estimating the RME, UCL-95 values (or upper-bound estimates of national averages) under residential exposure scenarios are generally used for exposure assumptions, and exposed populations and exposure scenarios are selected to represent upper-bound exposures. The intent of the RME, as discussed by the EPA Deputy Administrator and the Risk Assessment Council ("Guidance on Risk Characterization for Risk Managers and Risk Assessors" [Habicht, 1992]), is to present risks as a range from central tendency to high-end risk (above the 90th percentile of the population distribution). This descriptor is intended to estimate the risks that are expected to occur in small but definable "high-end" segments of the subject population ("Guidance on Risk Characterization for Risk Managers and Risk Assessors" [Habicht, 1992]). EPA distinguishes between those scenarios that are possible but highly improbable and those that are conservative but more likely to occur within a population, with the latter being favored in risk assessment. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard.

6.3.10.4 Uncertainties Associated with Dermal Contact Exposure

The chemical-specific ARARs for use as a drinking water source consider ingestion and inhalation of vapors as complete and significant pathways for exposure. For the chemical-specific ARARs, the dermal contact pathway is considered a complete but insignificant pathway of exposure for the contaminants detected in groundwater. The exclusion of the dermal contact exposure route from the chemical-specific ARARs may have the potential to underestimate the actual cleanup level.

EPA considers the dermal contact route to be significant if it contributes at least 10 percent of the exposure derived from the oral pathway. These results are based on comparing two main household daily uses of water: as a source for drinking and for showering or bathing (*Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final* [EPA/540/R/99/005]). Exhibit B-3 and Exhibit B-4 of *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final* (EPA/540/R/99/005) provide a screening tool to focus the dermal risk assessment on those chemicals that are more likely to make a contribution to the overall risk. Exhibit B-3 indicates that dermal exposure exceeds 10 percent of drinking water for TCE. The ratio of the dermal absorbed dose from dermal to oral is 17 percent for TCE. Based on this comparison, the chemical-specific ARARs concentrations may have the potential to underestimate exposure to these COPCs.

6.3.10.5 Uncertainties Associated with Toxicity Assessment

The toxicological database was also a source of uncertainty. EPA has outlined some of the sources of uncertainty as defined in *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final* (EPA/540/1-89/002) and in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). These sources may include or result from the extrapolation from high to low doses and from animals to humans. This is contingent on the species, gender, age, and strain differences in the uptake, metabolism, organ distribution, and target site susceptibility of a toxin. The human population's variability with respect to diet, environment, activity patterns, and cultural factors are also sources of uncertainty.

Traditionally, EPA has developed toxicity criteria for carcinogens by assuming that all carcinogens are non-threshold contaminants. However, EPA has recently published revised cancer guidelines (*Guidelines for Carcinogen Risk Assessment* [EPA/630/P-03/001F]) where they have modified their former position of assuming non-threshold action for all carcinogens. This new guidance emphasizes establishing the specific toxicokinetic mode of action that leads to development of cancer. In the future, toxicity criteria for carcinogens in the U.S. will be developed assuming no threshold for contaminants that exhibit genotoxic modes of action, or where the mode of action is not known. However, currently available EPA toxicity criteria for carcinogens were all derived assuming a non-threshold model.

In most of the world, nonthreshold toxicity criteria are developed only for those carcinogens that appear to cause cancer through a genotoxic mechanism (Health Canada, Netherlands). Specifically, for genotoxic contaminants, the cancer dose-response model is based on high- to low-dose extrapolation. The model assumes there is no lower threshold for the initiation of toxic effects. Cancer effects observed at high doses are found in laboratory animals or are extrapolated from occupational or epidemiological studies. Cancer effects observed at low doses are commonly found in environmental exposures. These models are essentially linear at low doses, so no dose is without some risk of cancer.

6.3.10.6 Slope Factors for Carbon Tetrachloride

For consistency with previous Hanford analyses of CCl_4, an oral slope factor of 0.13 $(mg/kg\text{-}day)^{-1}$ and oral RfD of 0.0007 (mg/kg-day) are used to develop the "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level and were previously published in IRIS (December 7, 2009). These values do not reflect the most current oral toxicity values published for CCl_4.

The oral slope factor and oral RfD currently recommended by EPA for CCl_4 are established by IRIS. The source of these toxicity values are consistent with the hierarchy of toxicity values recommended in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). The current oral slope factor is 0.07 $(mg/kg\text{-}day)^{-1}$ and the oral RfD is 0.004 (mg/kg-day) (IRIS, 2010). The current IRIS slope factor is lower than the value of 0.13 $(mg/kg\text{-}day)^{-1}$ previously published in IRIS, and the current IRIS oral RfD is higher than the value of 0.0007 (mg/kg-day) previously published in IRIS.

If the current oral slope factor was used to calculate the "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level, the groundwater concentration would increase from 0.34 µg/L to 0.63 µg/L. The groundwater risk for CCl_4 in the 300-FF-5 Groundwater OU and the 600 Area Subregion would decrease from 3.5×10^{-7} to 1.9×10^{-7} and the cumulative risk would remain less than 1×10^{-5}.

If the current oral RfD were used to calculate the "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level, the groundwater concentration would increase from 5.6 µg/L to 32 µg/L. The HQ at the 90th percentile would decrease from 0.35 to 0.004. Use of the oral cancer potency factor and

oral RfD previously published in IRIS provides an upper bound on risks when compared to the oral slope factor and oral RfD currently published in IRIS.

6.3.10.7 Slope Factors for Trichloroethene

The oral cancer potency factor of 0.089 (mg/kg-day)$^{-1}$ is used to develop the WAC 173-340-720 groundwater cleanup level was obtained from the CLARC database. The factor is obtained from a draft EPA risk assessment prepared in 2001, which has since been updated; therefore, in this case, the oral cancer potency factor does not reflect the most current source of information.

The oral slope factor currently recommended by EPA for TCE was published in IRIS in September 2011. The source of this toxicity value is consistent with the hierarchy of toxicity values recommended in "Human Health Toxicity Values in Superfund Risk Assessments" (Cook, 2003). The oral slope factor is 0.046 (mg/kg-day)$^{-1}$ (IRIS). TCE is considered an "early-life exposure" carcinogen for kidney cancer, because it acts through a mutagenic mode-of-action. Accounting for kidney cancer risks from early-life exposure would result in slightly more conservative value (by a factor of 2) for the oral slope factor.

The newly revised EPA value is lower than the value of 0.089 (mg/kg-day)$^{-1}$ for oral exposures published in the CLARC database. However, the EPA value accounting for early life exposure is slightly greater than the value published by Ecology in the "Cleanup Levels and Risk Calculations" (CLARC) database.

If the revised EPA value were used to calculate the "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level, the groundwater concentration would increase from 0.49 µg/L to 0.95 µg/L. The groundwater risks at the 90th percentile for the 300-FF-5 Groundwater OU would decrease from 4.5×10^{-6} to 2.3×10^{-6} in groundwater. If the revised EPA value based on early life exposure were used to calculate the WAC 173-340-720 groundwater cleanup level, the groundwater concentration would decrease slightly from 0.49 to 0.48 µg/L. The groundwater risks at the 90the percentile for the 300 FF-5 Groundwater OU would remain essentially unchanged. However, in both cases, the cumulative risk would remain above 1×10^{-5}. Use of the oral cancer potency factor from CLARC either slightly overstates risks, or results in no differences in risks when compared to the oral slope factor developed by EPA.

6.3.10.8 Slope Factors for Hexavalent Chromium

The oral RfD of 0.003 mg/kg-day published by IRIS is used to develop the WAC 173-340-720 groundwater cleanup level for Cr(VI). An oral carcinogenic potency factor has recently been published by the NJDEP. The oral carcinogenic potency factor derived by NJDEP is 0.5 (mg/kg-day)$^{-1}$ (*Derivation of an Ingestion-Based Soil Remediation Criterion for Cr+6 Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate* [NJDEP, 2009]). If the NJDEP value were used to calculate the "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level, the groundwater concentration would decrease from 48 to 0.18 µg/L

6.3.10.9 Uncertainties Associated with Risk Characterization

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, did not account for the possibility that constituents act synergistically or antagonistically.

As discussed in Section 6.2.4, MCLs for radionuclides are set at 4 mrem/yr for the sum of the doses from beta particle and photon emitters, 15 pCi/L for gross alpha emitter activity (including Ra-226, but excluding uranium and radon), and 5 pCi/L combined for Ra-226 and Ra-228. A mass concentration

MCL has been established for uranium as 30 µg/L. At this time, no additional federal or state standards are associated with evaluating the effects of exposure to radionuclides. Risks were estimated for radioisotopes identified as COPCs using inputs and equation 720-2 from "Groundwater Cleanup Standards" (WAC 173-340-720(4)(iii)(B)) and radionuclide slope factors from HEAST.

Table 6-47 shows that the EPC concentration for tritium reported in the 600 Area Subregion individually exceeds the 10^{-4} ELCR end of the NCP risk range.

Table 6-47. Summary of 90th Percentile Current Groundwater Concentrations for the 600 Area Subregion, Associated Cancer Risk and Associated Sum-of-Fractions for Radioactive COPCs

COPC	90th Percentile Value (pCi/L)	Federal or State MCL (pCi/L)	ELCR at Federal MCL	Individual Fraction	Individual ELCR
Tritium	290,000	20,000	1.9×10^{-5}*	14.5	2.8×10^{-4}
Sum-of-Fractions				**14.5**	**-**
Cumulative Annual Dose (mrem)				**58**	**-**
Cumulative ELCR for Radioactive COPCs				**-**	**2.8×10^{-4}**

* An ELCR for tritium, which includes the ingestion and inhalation exposure routes, would be 1.3×10^{-4}. The ELCR for tritium would be 1.9×10^{-5} for the ingestion exposure route only.

COPC = contaminant of potential concern

ELCR = excess lifetime cancer risk

MCL = maximum contaminant level

6.4 Risk Assessment Conclusions of the Riparian and Near-Shore Environment from RCBRA and the Columbia River Component

The assessment of human health risks was based on "broad-area" environmental data that characterized concentrations of COPCs in upland and riparian surface soils, river water and sediment, and fish tissue.

The exposure scenarios considered for riparian and near-shore areas were avid angler, casual user, and Tribal scenarios, including nonresident Tribal scenario, and ingestion of fish in the CTUIR and Yakama residential scenarios. The casual user scenario addresses occasional recreational use. The scenario is focused on activities such as walking and picnicking in riparian areas near the river. The avid angler is focused on individuals who are not engaged in a subsistence lifestyle. The avid angler application is associated with exposure in the near-shore region of the River Corridor, and takes into consideration potential exposures to sediments and fish. The nonresident Tribal scenario is focused on individuals engaged in a subsistence lifestyle who reside offsite but use the River Corridor for various activities such as hunting, gathering plants, and fishing.

EPCs in soil in the riparian environment were calculated using MULTI-INCREMENT® sampling from riparian locations in the 300 Area (*100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan* [DOE/RL-2005-42]). Discrete sediment samples used to calculate EPCs were obtained from sites in the River Corridor selected from locations of known groundwater plumes, areas of

groundwater discharge to the river, results of past biota sampling locations, or areas of fine-grained sediment deposits. Data from sculpin, clams, and benthic macroinvertebrates (primarily crayfish and clams) were used to estimate fish ingestion risks to avid angler and nonresident Tribal receptors.

The results of the broad area risk assessment in the 300 Area for the casual user and avid angler scenarios showed that lifetime cancer risks both were 2×10^{-6} and were below a noncancer HI of one for direct exposures to soil, sediment, and surface water.

Risks for riparian soils were higher than 1×10^{-4} cancer risk and above a noncancer HI of one for the nonresident Tribal scenario. Modeled concentrations of arsenic from riparian soil into native revegetation provided the largest contribution to cancer risks and noncancer hazard indices. However, as discussed in the RCBRA, uncertainties in the food chain modeling methods considerably overstate risks from plant ingestion exposure pathways, particularly for arsenic. No carcinogenic COPCs were identified in fish, based on data in sculpin, clams, crayfish, and juvenile suckers. The noncancer HIs associated with fish ingestion, based on these biota data in sculpin, clams, crayfish and juvenile suckers was higher than one for the Tribal scenarios. The COPC providing the major contribution to noncancer hazard was copper detected in clams and crayfish. As discussed in the RCBRA, it is likely that the calculated HI values for copper considerably overstate the risks from ingestion of this metal. Copper is normally present in hemocyanin for carrying oxygen in the blood, both in crayfish and clams. In addition, HI values for ingestion of crayfish from reference areas are similar to the 300 Area. In addition, human health risks from copper are associated with gastrointestinal irritation by free copper ions in drinking water, which is an effect that may not be relevant to ingestion of copper in food.

6.4.1 Risk Assessment Conclusions from the Columbia River Component

The CRC HHRA provides a comprehensive assessment of human health risks for the Hanford Reach. The intent of the CRC risk assessment was to complete the assessment of the "bank-to-bank" Hanford Reach and downstream areas (i.e., Lake Wallula) of the Columbia River, characterizing risk in areas not previously addressed under the RCBRA. Human exposure scenarios addressed in the CRC HHRA were an avid angler, casual user, hypothetical future resident, and a Native American (Yakama Nation) subsistence fisher. As discussed in *Columbia River Component Risk Assessment, Volume II: Baseline Human Health Risk Assessment* (DOE/RL-2010-117, Volume II), fish ingestion exposure provided the largest contribution to overall human health risks. A fish sampling program was specifically created to support the HHRA within the CRC RI, and provided a consistent sampling and analysis approach among species, tissue types, and analytes (*Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* [DOE/RL-2008-11]). The fish species targeted in the sampling program were intended to be the most representative of the exposure scenarios identified in the HHRA, and included the following:

- Common carp (*Cyprinus carpio*)
- Mountain whitefish (*Prosophium williamsoni*)
- Walleye (*Stizostedion vitrium*)
- Smallmouth bass (*Micropterus dolomieui*)
- Bridgelip sucker (*Catostomus columbianus*)
- White sturgeon (*Acipenser transmonatnus*)

Separate fillets, carcass (including the head and skeleton), and combined livers and kidneys were analyzed. Fillet samples for all species except sturgeon were prepared with the skin on, as skin for these types of fish is often left on during preparation and consumption.

As described previously, the fish consumption pathway provided the largest contribution (99 percent contribution) to human health risks (evaluated for the avid angler and Native American scenarios). The fish consumption pathway was evaluated using two separate approaches. In the first approach, risk was quantified assuming a receptor consumed a varied diet consisting of all six species evaluated. In a second approach, risk was quantified for each individual fish species. Although the concentrations of COPCs, and hence, estimated hazard/risk, varied among the different species, the relative magnitude of risk remained similar among all six fish species. Relative magnitude of risk for the avid angler scenario was generally in the range of 2×10^{-3} to 8×10^{-3}, with bass and carp having the overall lowest and highest associated cancer risk. PCBs, chlorinated pesticides, cobalt, arsenic, and mercury were the primary risk drivers through fish ingestion. Throughout the Hanford Site study area, nearly all of the risk drivers also were identified as COPCs in upstream reference areas, with the exception of Cr(VI) in the 300 Area. It is unlikely that Cr(VI) bioaccumulates through the foodweb and the CRC is currently evaluating the uncertainties associated with this conclusion. Several radionuclides were detected in some fish tissue samples, at a very low (1 percent) frequency of detection. These radionuclides were eliminated as COPCs because it was concluded the concentrations were erroneous data quality or data consistency issues.

PCBs, mercury, and chlorinated pesticides in fish tissue, which are primary risk drivers, are prevalent in fish tissue in many waterbodies, due to their widespread historical use, atmospheric deposition and, consequently, high prevalence in abiotic media. The results from Chapter 4 and Riparian and Near-Shore CSM in Appendix M show that there are unlikely to be sources or transport pathways from Hanford Site soils or groundwater that would have resulted in transport of PCBs, mercury, or chlorinated pesticides to Columbia River media (sediment or surface water) where they could have been accumulated into fish tissue. Based on the absence of transport pathways from 300 Area sites or groundwater, coupled with comparable risks associated with fish caught in reference areas, it is unlikely that Hanford Site activities in the 300 Area are associated with the fish ingestion risks projected in the CRC HHRA.

Results from the risk characterization indicate that the risks related to exposure to surface water, sediment, and island soil are very small relative to that from the fish ingestion pathway. For abiotic media, reference COPCs account for the majority of noncancer hazard and, in most cases, chemical cancer risk in all sub-areas. Arsenic in sediment within most of the exposure points accounted for over half of the cumulative risk. Of the radionuclides, Co-60, europium-152, and Cs-137 constitute the majority of radiation cancer risk. Cs-137 is a known constituent of worldwide atmospheric fallout and was found largely in reference areas.

Risks from island soil exposures were relatively minor compared to risks from other abiotic media, with the exception of soils near Johnson Island. Europium-152 in soils collected from Johnson Island constituted a significant risk driver; however risks from europium-152 will decrease over time as a result of radioactive decay. As a result of radioactive decay, it is concluded that no further remedial action is warranted for Johnson Island.

6.5 Summary and Conclusions

The supplemental soil and groundwater risk evaluation for the 300-FF-1 and 300-FF-2 Source OUs and 300-FF-5 Groundwater OU accomplishes the following objectives:

- Proposes direct contact PRGs in soil from values presented in the RCBRA for use in the FS.
- Evaluates the effectiveness of source interim actions for the 300-FF-1 and 300-FF-2 OUs.
- Confirms that wastes sites are remediated to the RAOs and RAGs published in the 300 Area RDR/RAWP (DOE/RL-2001-47). In addition, confirms that waste sites achieve the direct contact

PRGs proposed for the FS. (In other words, sites cleaned up under interim action do not need to be revisited in the FS to demonstrate protection of human health.)

- Identifies the waste sites and COCs in soil that require further evaluation in the FS.
- Waste sites that have not been remediated are carried forward into the FS.
- Identifies the COCs in groundwater that require further evaluation in the FS.

The methodology used to assess risks for the RI/FS uses PRGs developed in the RCBRA, and incorporates the most current agency guidance. COPCs in soil and groundwater were identified in a conservative manner, using exclusions identified in the RCBRA to identify COPCs. The methods for developing EPCs are based on EPA's ProUCL guidance manual. The residential scenario used to develop RBSLs and characterize risks to human health from contaminants in soil is drawn from the scenario that was used to develop cleanup levels for the 100 Area RDR/RAWP (DOE/RL-96-17), and was brought up to date to be consistent with most recent regulatory guidance. PRGs for the vadose zone were developed to reflect a range of exposure scenarios and include those that represent the RAOs (the residential scenario and industrial scenario) and reasonably anticipated future land use (resident Monument worker and casual recreational user).

Contaminant concentrations in groundwater were compared with a range of groundwater and surface water standards for protection of human health and aquatic organisms. In addition, risks from contaminants in groundwater were assessed using Tribal scenarios based on assumptions provided by the CTUIR and Yakama Nation. The EPA tap water scenario is also evaluated to provide a similar scenario using exposure assumptions that represent RME.

Cumulative risks were calculated for multiple contaminants and multiple exposure pathways by exposure media (i.e., soil or groundwater). Cumulative risks summed across soil and groundwater were not calculated for the residential scenario because the RME for this scenario does not include combined exposures to both media, therefore, they are presented separately.

The protection of groundwater and surface water from contaminants currently in the vadose zone was discussed in Chapter 5. The supplemental ecological risk evaluation that evaluates the protection of terrestrial receptors is discussed in Chapter 7.

6.5.1 Conclusions for the Supplemental Soil Risk Evaluation

The principal contaminants in soil are radionuclides and PCB Aroclors. The radionuclides can be categorized as being related to waste disposal, including Cs-137, Sr-90, U-233/234, U-235, and U-238. Cancer risks associated with radionuclides within the top 4.6 m (15 ft) of soil are in the 10^{-4} range, based on the residential exposure scenario. The risks from those radionuclides in the top 4.6 m (15 ft) of soil that are related to waste disposal are no greater than 2×10^{-4}. Cancer risks associated with the resident Monument worker scenario are similar to the residential scenario, with cumulative ELCRs approximately 0.5 to 0.73 times lower than the unrestricted (resident) scenario ELCRs. Cancer risks for a casual recreational user scenario are approximately two orders of magnitude lower than the residential scenarios.

Three waste sites (316-1, 316-2 and 316-5) report an exceedance of 1×10^{-4} based on the residential scenario, these waste sites were remediated under the 300-FF-1 ROD using RAGs for industrial land use. Similarly, the 618-3 Burial Ground waste site reported an exceedance of 1×10^{-4} based on the residential scenario. This waste site was remediated under the 300-FF-2 ROD using RAGs for industrial land use. The land use is designated industrial for the 316-1, 316-2, 316-5, and 618-3 waste sites and associated risks are less than 1×10^{-4} for the industrial scenario. The industrial exposure scenario represents the reasonably anticipated future land use and no further action is warranted.

Deep zone soil samples are compared to RBSLs developed for the residential exposure scenario, although residents are unlikely to be exposed to contaminants in deep zone soil. Deep zone soil samples are collected from depths greater than 4.6 m (15 ft) bgs, as a result direct contact within the point of compliance is incomplete. Additionally, the residential exposure scenario does not reflect reasonably anticipated future land use in the River Corridor. This comparison is included because it is the most conservative land use basis for the evaluation of waste sites and presentation of these results is only included to provide additional information for risk management decisions.

Two waste sites are reported with concentrations of site-related COPCs at depths greater than 4.6 m (15 ft) bgs and warrant further evaluation in Chapter 8. The following two waste sites report concentrations of Cs-137, Sr-90, U-233/234, or U-238 at concentrations greater than the residential RBSL.

- 618-1 deep focused decision unit contained Cs-137 at a concentration of 7 pCi/g when sampled in 2010. The Cs-137 will decay to a concentration less than the residential RBSL by year 2027. U-238 is reported at a concentration of 65 pCi/g, which is greater than the residential RBSL of 54 pCi/g and results in a risk of 1.2×10^{-4}.

- 618-2 deep decision unit contained Sr-90 at a concentration of 12 pCi/g when sampled in 2006. The Sr-90 will decay to a concentration less than the residential RBSL by year 2074. U-233/234 is reported at a concentration of 165 pCi/g, which is greater than the residential RBSL of 133 pCi/g and results in a risk of 1.2×10^{-4}. U-238 is reported at a concentration of 161 pCi/g, which is greater than the residential RBSL of 54 pCi/g and results in a risk of 3.1×10^{-4}.

The principal nonradioactive COPCs are metals and PCB Aroclors. With the exception of PCB Aroclor results at the 618-9 shallow decision unit, the cancer risks and noncancer hazard indices for non-radioactive contaminants fell within EPA's target risk ranges. Concentrations of arsenic in soil are associated with cancer risks higher than 10^{-6} under unrestricted (residential) exposure assumptions. The concentrations of arsenic in soil posing risks greater than 10^{-6} are consistent with sitewide naturally occurring background in soil. Three waste sites were reported with PCB Aroclor concentrations greater than the acceptable risk value of 1×10^{-6} for individual carcinogens but less than the "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)) cumulative risk threshold of 1×10^{-5} for multiple contaminants and multiple pathways. The 618-9 shallow decision unit reported PCB Aroclor concentrations greater than the acceptable risk value of 1×10^{-6} for individual carcinogens and greater than the "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)) cumulative risk threshold of 1×10^{-5} for multiple contaminants and multiple pathways. The 618-9 waste sites require further evaluation in the FS based on the presence of PCB Aroclors.

The results from several of the waste sites are based on small data sets, which create uncertainties in obtaining reliable EPCs in soil. The uncertainties relating to small data sets could result in risks either being over- or understated. EPCs selected for shallow zone and deep zone decision units represent verification data collected from the floor and the sidewall of the excavated waste site. EPCs developed from the floor and sidewall of the excavated waste site overstate risk because the contaminant is assumed to be uniformly distributed across the entire decision unit. Exposure is assumed to occur at the surface. Whereas these sample locations are actually at depth and take no credit for the existing clean backfill that covers the remediated waste site. Should the contaminants be distributed in the future, their distribution within decision unit would be blended with the clean backfill resulting in an overall reduction of the EPC for the decision unit. The approach for identifying COPCs is conservative because it excludes few contaminants, and therefore probably overstates risks. The exposure factors and toxicity values used to develop the RBSLs generally are conservative and tend to provide upper bound estimates of risks in soil.

Based on the results of the supplemental soil risk evaluation for the 300-FF-1 and 300-FF-2 Source OU, cleanups in vadose zone material conducted as part of the interim actions appear to have been effective in reducing human health risks to within EPA's target risk range. In some cases, residual risks are higher than the state of Washington's cancer risk threshold; however, in most of those cases, the contaminant exceeding the state of Washington's cancer risk threshold is arsenic and is present at concentrations consistent with naturally occurring background. Cleanup of shallow vadose zone material (4.6 m [15 ft]) to achieve residential or unrestricted uses is also protective of a range of exposure scenarios, including a casual recreational user, a resident Monument worker, and an industrial user.

6.5.2 Conclusions for the Supplemental Groundwater Risk Evaluation

The 300-FF-5 Groundwater OU is evaluated as a two exposure areas. The 300 Area Subregion represents the groundwater plume that is located beneath the Hanford Site Industrial Complex. The 300 Area Subregion is distinguished by the presence of TCE, 1,2-DCE, and uranium at concentrations above the federal MCL. The 600 Area Subregion represents the groundwater plume that is located beneath the 618-11 Burial Ground and the 618-10 Burial Ground/316-4 Cribs. The 600 Area Subregion is distinguished by the presence of nitrate and tritium at concentrations above the federal MCL.

6.5.2.1 300 Area Subregion of the 300-FF-5 Groundwater OU

The principal contaminants in groundwater within the 300 Area Subregion of the 300-FF-5 Groundwater OU are gross alpha, cis-1,2-dichloroethene, chromium/Cr(VI), nitrate, TCE, and uranium. The EPCs in groundwater were compared with federal and state surface water standards for protection of human health and aquatic organisms, federal and state primary and secondary MCLs, and state groundwater cleanup levels.

The EPCs for gross alpha and uranium are greater than their respective federal MCLs developed for the protection of human health. Uranium is identified as a COPC, indicating the need to evaluate potential remedial technologies for uranium in the FS. Gross alpha is an indicator parameter and its presence above the DWS is consistent with the presence of uranium. Gross alpha is not a COPC; however, it should continue to be monitored as an indicator parameter.

Cis-1,2-dichloroethene was reported in one well (399-1-16B) with concentrations greater than the DWS. This well was not included in the spatial and temporal monitoring network used for the RI; therefore, it was not included in the calculation of EPCs or in the supplemental groundwater risk evaluation. However, cis-1,2-DCE identified as a COPC because it is reported with localized concentrations above the DWS. Therefore, its presence warrants design considerations for any engineered controls or remedial actions performed in this OU.

Chromium was detected in groundwater samples collected for the RI at concentrations below the action level of 65 µg/L. However, chromium concentrations in two wells (399-8-5A and 399-8-1) are likely in the form of Cr(VI). Cr(VI) was reported above the AWQC in these wells. These wells were not included in the spatial and temporal monitoring network used for the RI and therefore were not included in the calculation of EPCs or in the supplemental groundwater risk evaluation. Therefore, its presence warrants design considerations for any engineered controls or remedial actions performed in this OU.

The EPC for TCE was greater than the MTCA B groundwater cleanup level, which is based on a 1×10^{-6} target cancer risk level. However, the cumulative risk for this VOC is less than the WAC 173-340-708 cumulative risk level of 1×10^{-5} for multiple contaminants. The EPC for TCE is less than the federal MCL. However, TCE was reported in two wells (399-3-21 and 399-4-14) with concentrations greater than the DWS. Of these two wells, 399-3-21 was not included in the spatial and temporal monitoring network used for the RI and therefore was not included in the calculation of EPCs or in the supplemental

groundwater risk evaluation. As a result, TCE is identified as a COPC because it is reported with localized concentrations above the DWS. Therefore, its presence warrants design considerations for any engineered controls or remedial actions performed in this OU.

Nitrate was reported above the DWS in localized areas (399-5-4B, 399-8-5A, 699-S27-E12A, 699-S27-E14, and 699-S28-E12). These wells were not included in the spatial and temporal monitoring network used for the RI and therefore were not included in the calculation of EPCs or in the supplemental groundwater risk evaluation. Therefore, its presence warrants design considerations for any engineered controls or remedial actions performed in this OU.

The analytes identified with an uncertain status, thus warranting further evaluation in the FS, include aluminum, antimony, CCl_4, chloroform, cobalt, copper, iron, nickel, silver, sulfate, and zinc.

Based on the results of the supplemental groundwater risk evaluation, uranium is identified as a COPC for the 300 Area Subregion. This indicates the need to evaluate potential remedial technologies in the FS.

In addition to the chemical-specific ARARs analysis, risks were evaluated using the Native American scenarios and the EPA tap water scenario. The total ELCR for the 300 Area Subregion for the CTUIR and Yakama Nation exposure scenarios are 5.1×10^{-4} and 5.5×10^{-4}, respectively. The total ELCR for the EPA tap water scenario is 1.3×10^{-4}. The cumulative risk for the Native American scenarios and the EPA tap water scenario are greater than the EPA upper target risk threshold of 1×10^{-4}. No individual COPCs are reported with an ELCR greater than the EPA upper target risk threshold of 1×10^{-4}. The total HI for the 300 Area Subregion is 4.9 for both the CTUIR and Yakama Nation exposure scenarios. The HI for the EPA tap water scenario is 2.4. The only contributor to the noncancer HI for the Native American scenarios and EPA tap water scenario is uranium. The HI for the Native American scenarios and EPA tap water scenario is greater than the EPA target HI of 1.

The cumulative ELCR is 2.2×10^{-4} for the CTUIR scenario and is 4.6×10^{-4} for the Yakama Nation scenario when groundwater is used as a source of steam for a sweat lodge. The cumulative risk for the Native American scenarios is greater than the EPA upper target risk threshold of 1×10^{-4}. No individual COPCs are reported with an ELCR greater than the EPA upper target risk threshold of 1×10^{-4}. The HI for the 300 Area Subregion is 9.4 for the CTUIR scenario and 20 for the Yakama Nation scenario when groundwater is used as a source of steam for a sweat lodge, which is greater than the EPA target HI of 1.0. The primary contributor to the noncancer HI is uranium.

6.5.2.2 600 Area Subregion of the 300-FF-5 Groundwater OU

The principal contaminants in groundwater within the 600 Area Subregion of the 300-FF-5 Groundwater OU are tritium and nitrate. The EPCs in groundwater were compared with federal and state surface water standards for protection of human health and aquatic organisms, federal and state primary and secondary MCLs, and state groundwater cleanup levels.

The EPC for nitrate and tritium are greater than their respective federal and state MCLs. Nitrate and tritium are identified as COPCs, indicating the need to evaluate potential remedial technologies for nitrate and tritium in the FS.

Based on the results of the supplemental groundwater risk evaluation, nitrate and tritium are identified as COPCs for the 600 Area Subregion. These indicate the need to evaluate potential remedial technologies in the FS.

The analytes identified with an uncertain status, thus warranting further evaluation in the FS, include CCl_4, chloroform, copper, lead, uranium, and zinc.

In addition to the chemical-specific ARARs analysis, risks were evaluated using the Native American scenarios and the EPA tap water scenario. The total ELCR for the 600 Area Subregion for the CTUIR and Yakama Nation exposure scenarios are 2.5×10^{-3} and 2.6×10^{-3}, respectively. The total ELCR for the EPA tap water scenario is 5.7×10^{-4}. The primary contributor to risk for the Native American scenarios and the EPA tap water scenario is tritium. The total HI for the 600 Area Subregion is 4.5 for both the CTUIR and Yakama Nation exposure scenarios. The HI for the EPA tap water scenario is 2.2. No individual COPCs in the 600 Area Subregion report a HQ greater than 1.

The cumulative ELCR is 8.4×10^{-4} for the CTUIR scenario and is 1.7×10^{-3} for the Yakama Nation scenario when groundwater is used as a source of steam for a sweat lodge. The cumulative risk for the Native American scenarios is greater than the EPA upper target risk threshold of 1×10^{-4}. The primary contributor to risk is tritium. The HI for the 600 Area Subregion is 16 for the CTUIR scenario and 33 for the Yakama Nation scenario when groundwater is used as a source of stream for a sweat lodge, which is greater than the EPA target HI of 1.0. No individual COPCs in the 600 Area Subregion of the 300-FF-5 Groundwater OU had a HQ greater than the EPA target HI of 1.0 after considering the contribution of naturally occurring metals.

7 Supplemental Ecological Risk Evaluation

The integration of past and ongoing ecological risk assessments supports the development of remedial alternatives for waste sites and contaminated groundwater in the 300 Area. These risk assessments have been integrated with the cleanups performed under the interim action RODs to identify the need for further remedial action and development of ecological PRGs.

Highlights

- The supplemental ecological risk evaluation evaluated soil contaminant concentrations at 38 interim closed and no action waste sites.
- The screening levels for radionuclides were not exceeded.
- An examination of the interrelationships between potential contaminant sources, transport mechanisms, exposure pathways, and receptors in the Columbia River concluded that 300 Area waste sites are not contributing to potential risks identified in the Columbia River except for elevated uranium in groundwater
- The supplemental ecological risk evaluation indicated that interim remedial actions that have been completed at the 300 Area under interim action ROD RAGs are protective of the environment at all but six waste sites.

As described in the previous chapters, the remedial actions completed to date in the River Corridor were implemented under interim action RODs. The RAOs in the 300 Area interim action RODs were developed to achieve protection of human health from direct contact with vadose zone material or to protect groundwater and surface water from contaminants leaching from vadose zone material. Protection of ecological receptors from direct contact with contaminated vadose zone material was not addressed directly in the interim action RODs, but indirectly, with the assumptions that attainment of standards for protection of human health or that reduced contaminant leaching would also be protective of ecological receptors.

CERCLA requires a baseline risk assessment to characterize current and potential threats to HHE prior to issuance of the ROD. The source and groundwater component of the RCBRA was prepared to address the regulatory requirement to perform a baseline risk assessment. The RCBRA was a comprehensive examination of current and potential risks in areas potentially affected by Hanford Site processes within the 100 and 300 Area OUs. One of the objectives of the RCBRA was to determine if the interim actions were protective of ecological receptors (*Risk Assessment Work Plan for the 100 Area and 300 Area Component of the RCBRA* [DOE/RL 2004-37]). The scope of the RCBRA addressed the following portions of the River Corridor:

- Upland areas, including remediated CERCLA waste sites within 100-BC, 100-D, 100-F, 100-H, 100-K, and 100-N Areas; the White Bluffs and Hanford townsites; and the 300 Area
- Riparian and nearshore aquatic zones on the south and west shoreline of the Columbia River on the Hanford Site
- Groundwater and areas of groundwater emergence on the south and west shoreline of the Columbia River on the Hanford Site

The RCBRA used multiple measures of exposure, ecological effect, and ecosystem/receptor characteristics to evaluate risks at 20 study sites across the River Corridor associated with remediated waste sites (10 excavated/backfilled sites and 10 surface removal/native soil sites) and 10 reference areas, as described in the RCBRA SAP (DOE/RL-2005-42). The sites studied were selected from high priority waste sites that had been remediated when the study was developed. The sites represent the types of waste sites and remedial actions addressed by the interim action RODs. Based on this set of study sites, the results from the RCBRA identified some contaminants in soil as contaminants of ecological concern. Contaminants of ecological concern principally were metals and pesticides.

The study design of the ecological risk assessment in the RCBRA provided risk conclusions that applied across the entire River Corridor. The study design, coupled with results that identified contaminants of ecological concern across the River Corridor, required development of a supplemental ecological risk evaluation approach for the RI/FS that allowed evaluation of risks on a site-by-site basis as well as supported development of PRGs. That approach incorporates the use of ecological SSLs and ecological PRGs, which have been developed using the tiered process outlined in *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-00784) and *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-01311), respectively. This tiered process allows the incorporation of more sophisticated ecological risk assessment methods and increasing levels of ecological site-specific information, to provide SSLs and PRGs that are more representative of Hanford Site conditions. Development of the risk-based concentration values (SSLs) and PRGs incorporates the problem formulation, the conceptual ecological exposure models, and selected bioaccumulation data sets developed in the RCBRA. These values were used to screen the 38 waste sites in the 300 Area with verification sampling and analytical information, to provide site-specific ecological risk information for each site.

The following approach has been used for addressing ecological risks potentially associated with waste sites in the 300 Area:

- **Updating the identification of COPCs (Section 7.1).** The RCBRA went through a process to identify COPCs for ecological receptors, based on a sitewide review of River Corridor data. This identification process has been updated to account for verification sampling data specifically in individual 300 Area waste sites. Seventeen waste sites from the 300 Area OUs were evaluated in the RCBRA. It is noted that the JA Jones site was evaluated as part of the 300 Area in the RCBRA. The JA Jones site was relocated from the 300-FF-2 OU to the 100-IU-6 OU; therefore, it is not included in the supplemental risk evaluation. Fifty-three additional waste sites have been remediated at the 300 Area OUs since 2005, and are not addressed in the RCBRA.

- **Presenting the problem formulation (Section 7.2).** This section summarizes the problem formulation used in developing the risk-based concentration values used in this evaluation as ecological SSLs. This problem formulation reflects conditions in upland environments across the Hanford Site, and incorporates information developed from the RCBRA.

- **Presenting effects and exposure assessments (Section 7.3).** This section summarizes the quantitative assessments used in developing the SSL and PRG risk-based concentration values, including the wildlife exposure factors, biotransfer factors, and wildlife toxicity reference values (TRVs). The data and methods used to develop risk-based concentrations protective of plants and soil invertebrates are discussed in this section. More detailed descriptions of the data and methods used to calculate all of the ecological risk-based concentrations in soil are presented in *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-00784) and *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-01311). In addition, these values are also incorporated into the ecological risk assessment volume (Volume 1) of the RCBRA.

- **Updating the ecological risk characterization for 300 Area OUs waste sites (Section 7.4).** Verification sampling and analysis data for the 16 300 Area OUs waste sites were used to calculate EPCs, which were then compared with the ecological SSLs, and as appropriate, the PRGs. The results from these comparisons were used to identify receptors of interest and contaminants of ecological concern, for purposes of identifying the need for further action at 300 Area OU sites. In addition, the

results of this risk characterization were used to determine which of the risk-based concentration values should be recommended for use as PRGs.

Section 6.3 evaluates the protection of aquatic receptors from groundwater that has the potential to discharge to the Columbia River because the approach used to identify COPCs that warrant further evaluation in the FS is based on comparison of groundwater concentrations to the lowest available chemical-specific ARARs published for the protection of human health and aquatic receptors. Combining the evaluation of human health provides a streamlined approach that addresses the restoration of groundwater to highest beneficial use and the protection of aquatic receptors.

In addition to the analysis of waste sites, Chapter 7 summarizes an evaluation of ecological risks in riparian and nearshore areas based on the analysis developed in the RCBRA and risk in the Columbia River developed for the CRC (DOE/RL-2010-117). Chapter 4 evaluates ecological risks identified within the Columbia River and the relationship between potential sources to the Columbia River in the 300 Area OUs, transport pathways, and ecological receptors. The RCBRA evaluated risks to an array of assessment endpoints using multiple measures of exposure, effect, and ecosystem/receptor characteristics at representative nearshore study sites. The study sites were selected to represent locations that may be adjacent to or directly affected by known contaminated media (groundwater seeps and springs, soil, sediment). The assessment conducted in the RCBRA has been supplemented through the development of a conceptual model depicting the relationships between sources in the 300 Area OUs and riparian and nearshore media (soil, sediment, porewater, and surface water). This conceptual model is presented as Appendix M.

7.1 Identification of Contaminants of Potential Concern

This section describes the sources of data used in the supplemental ecological risk evaluation, the DQA and data validation process, and process for identifying COPCs in soil. Three different data sets were evaluated for this supplemental ecological risk evaluation: CVP data collected within 38 waste sites in the 300 Area OUs, riparian and nearshore data collected for the RCBRA, and the data collected for the CRC (DOE/RL-2010-117). Only the CVP data are discussed at length in Chapter 7, with the RCBRA data discussion in Appendix M, and the CRC (DOE/RL-2010-117) data discussion in Chapter 4. During the course of this risk evaluation, COPCs were examined to identify COPECs estimated to pose a site-related ecological risk to receptor populations and to provide input to required risk management decisions. The COPECs will be carried into the risk management decisions at the end of this supplemental risk evaluation, which will identify the chemicals of ecological concern (COECs), which will be carried into the FS.

7.1.1 Data Summary

Remediation of waste sites in the 300 Area began in 1997. As described in the introduction to this chapter, the RCBRA evaluated risks at 20 study sites across the River Corridor associated with remediated waste sites (10 excavated/backfilled sites and 10 surface removal/native soil sites), and at 10 reference areas. Of the 20 waste sites directly evaluated, only two were from within the 300 Area OUs. However, the 20 evaluated in the RCBRA represent the range of residual conditions at the surface.

This supplemental risk evaluation included CVP verification sampling and analysis data for 70 waste sites in the 300 Area OUs. Ten 300-FF-1 OU waste sites have verification sampling and analysis data and are included in this risk evaluation. Nine of these 10 300-FF-1 OU waste sites were evaluated in the RCBRA Report (DOE/RL-2007-21). An additional 24 300-FF-1 waste sites, referred to as consolidated waste sites, have been remediated but are included in another waste site's sampling and closeout documentation. Thirty 300-FF-2 OU waste sites have verification sampling and analysis data and are included in this risk

evaluation. Eight of these 30 300-FF-2 OU waste sites were evaluated in the RCBRA Report (DOE/RL-2007-21). Six additional 300-FF-2 waste sites, referred to as consolidated waste sites, have been remediated, but are included in another waste site's sampling and closeout documentation. Focus was on data characterized as being collected from shallow depth defined as upper and lower sampling depths from ground surface to no more than 4.6 (15 ft) bgs. Table G-1 summarizes the waste sites, associated decision unit(s)[1], and reclassification status for 300 Area Source OUs. The waste sites listed in Table G-1 are a subset of the waste sites that were listed in Appendix A, Table A-1 (300 Area RI/FS Work Plan [DOE/RL-2009-30]). A summary of the remediated waste sites and consolidated waste sites for the 300-FF-1 and 300-FF-2 OUs was provided in Chapter 6, Table 6-8. Verification sampling and analysis soil data residing in the HEIS database were used in the soil risk assessment. All of the closeout verification data used in this risk evaluation is included as Appendix D of this report.

Additional data were considered as part of a discussion of the conceptual model for the riparian and nearshore environment within the reach of the Columbia River adjacent to the 300 Area. Data for this evaluation included the collection of multiple abiotic media samples as part of the RCBRA from 2005 to 2007 including soil, sediment, surface water, groundwater, seeps, aquifer tubes, porewater, and surface water. Biotic media included within the conceptual model evaluation, as described in Appendix M, included tissues of fish, clams, mussels, and other aquatic life, and ex-situ bioassays conducted on a number of species. Other community measures were also collected and discussed in Appendix M. The data from the RCBRA was supplemented with similar data collected for the CRC (DOE/RL-2010-117] Volume 1) in 2008. The CRC (DOE/RL-2010-117) was a screening level assessment, so data focused only on sampling of abiotic media and fish tissue without the analysis of additional bioassays or other community measures. PNNL collected a final set of data included within the conceptual model discussion and evaluation (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]) before either the RCBRA or CRC was conducted.

Other data from the RCBRA were included indirectly. As described in documents included as appendices to this RI/FS (*Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [CHPRC-00784]; *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [CHPRC-01311]; and *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site* [ECF-HANFORD-11-0158]). As described later in this chapter, plant, invertebrate, and small mammal tissue data, as well as Hanford Site-specific bioassays on blue grass and nematodes were used in the development of PRGs protective of ecological receptors for the Hanford Site.

7.1.2 Data Quality Evaluation

A DQA is performed and reported in each closeout documentation report. The DQA compares the verification sampling approach and resulting analytical data with the sampling and data quality requirements specified by the project objectives and performance specifications. The DQA determines if the data are of the right type, quality, and quantity to support site cleanup verification decisions within specified error tolerances. The DQA also determines if the analytical data are found acceptable for decision-making purposes and if the sample design was sufficient for the purpose of clean site verification. The cleanup verification sample analytical data and detailed DQA are summarized in the appendices associated with the CVPs. The results of each DQA are incorporated by reference and no further DQA was performed as part of this risk assessment.

[1] As described in Section 6.2.2.2, the floor and sidewalls of an excavated waste site are divided into one or more decision units (e.g., shallow zone and overburden). A sample design was developed for each decision unit.

All of the analytical data are evaluated and a portion is validated for compliance with QAPjP requirements as documented in the 100 Area RDR/RAWP (DOE/RL-96-17). Data evaluation is performed to determine if the laboratory carried out all steps required by the SAP and the laboratory contract governing the conduct of analysis and reporting of the data. This evaluation also examines the available laboratory data to determine if an analyte is present or absent in a sample and the degree of overall uncertainty associated with that determination.

7.1.3 Identification of COPCs

All analytes detected at least once in a waste site decision unit for the 38 waste sites included in the risk evaluation are identified as COPCs. Verification sampling and analysis data are collected according to sample design requirements for the type of decision unit. For this supplemental ecological risk evaluation, an "exposure area" and a "decision unit" are operationally defined as being the same. Verification sampling and analysis data are subsequently grouped to calculate EPCs.

The contribution from naturally occurring metals and anthropogenic radioisotopes is discussed in the risk characterization section in accordance with *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-R-01-003). The risk characterization will discuss elevated background concentrations and their contribution to site risks as well as naturally occurring elements that are not CERCLA hazardous substances, pollutants, and contaminants but exceed the risk-based screening levels.

The RCBRA identifies a subset of analytes that are excluded from consideration as COPCs by agreement among the Tri-Parties based on relevant Hanford Site data. The following exclusion lists employed in the RCBRA Report (DOE/RL-2007-21) were also applied to the waste site verification data during the data reduction steps described in Section 6.2.2.2:

- **Radionuclides with a half-life of less than three years:** Radionuclides with half-lives less than 3 years would not be present because of historical Hanford Site operations due to radioactive decay that would have occurred since operations ceased.
- **Essential nutrients:** Essential nutrients that are present at relatively low concentrations and are toxic only at high concentrations need not be considered in a quantitative risk assessment.
- **Water quality or soil physical property measurements:** These analytes were measured to obtain information on water quality or soil properties to understand potential confounding factors for bioassays conducted for soil, sediment, or water or to interpret their influence on the toxicity of COPCs (e.g., grain size for soils, water hardness for metal effects).
- **Background radionuclides (potassium-40, radium-226, radium-228, thorium-228, thorium-230, and thorium-232):** As identified and implemented in the RCBRA, these background radionuclides were identified by consensus of Tri-Party managers as not directly related to Hanford Site operations or processes.

The RCBRA includes two additional steps to identify COPCs that the supplemental soil risk evaluation did not apply:

- Analytes that are commonly reported in waste site cleanup verification reports based on frequency of detection. Inclusion list analytes were not consistently reported in the CVP and RSVP data; therefore, this step was not implemented.
- Evaluate remaining analytes as candidate COPCs, based on comparisons to Hanford Site background, reference areas, and an "analyte-specific" evaluation.

Because of not applying the last two steps used in the RCBRA to identify COPCs, more analytes are identified as COPCs in the ecological risk assessment than were identified in the RCBRA. Identifying all detected analytes (except those on the exclusion list) as COPCs is a more streamlined approach that is consistent with *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-R-01-003).

In addition to the steps described above, aluminum and iron were excluded as COPCs for all decision units within the 300 Area OUs. The Eco-SSLs for aluminum and iron are based on soil pH (*Ecological Soil Screening Level for Aluminum: Interim Final* [OSWER Directive 9285.7-60]), and the potential for toxicity is only identified in soils when the pH is 5.5 or less. While some concentrations of aluminum may have exceeded this risk-based value, all measurements of soil pH in the River Corridor are greater than the 5.5 threshold. Data collected during the RCBRA (RCBRA Report [DOE/RL-2007-21]) indicated that pH in soils range between 7 and 9. Thus, aluminum and iron concentrations are not bioavailable and do not pose a risk to ecological receptors.

The COPC list will be evaluated to develop a COPEC list in this risk. A COPEC is defined as a COPC with concentrations exceeding both the background concentration and ecological screening value. The process to identify COPECs is discussed in Section 7.4.

7.2 Problem Formulation

The problem formulation includes the physical layout of the site, its history and ecology, and the development of an ecological CSM that evaluates potential exposure pathways and identifies the representative species that were used to assess ecological risk to those and other similar species. The problem formulation includes identification of the important aspects of the 300 Area waste site areas to be protected (referred to as “assessment endpoints”) and the means by which the assessment endpoints are evaluated (measures of exposure and effects).

7.2.1 Site Setting

The 300 Area extends from north of Energy Northwest to south of the 300 Area Industrial Complex and from the west bank of the Columbia River to the west to Horn Road. Two source OUs within the 300 Area with facilities and waste sites are related to Hanford Site operations. For this risk assessment, the 300 Area is divided into three distinct geographic subregions: 300, 400, and 600 Area subregions. The 300 Area consists of the buildings, facilities, and process units located in the industrial complex located north of Richland, Washington, where the vast majority of uranium fuel production and R&D activities took place. The 600 Area subregion consists of the 618-10 and 618-11 Burial Grounds, and the 316-4 Crib. As described in Chapter 1, a major portion of the 600 Area subregion, the large area of historically unused land, is void of known waste sites and facilities.

The 400 Area consists of the FFTF and associated facilities. The operations associated with the FFTF did not result in any documented incidents of contamination being released to the environment. None of the 400 Area waste sites appears to provide a significant threat of widespread release to environmental pathways. The current conceptual model for contamination in environmental pathways at the 400 Area does not indicate the need for additional characterization (300 Area RI/FS Work Plan [DOE/RL-2009-30]). The 400 Area is not included in this risk assessment.

The southeastern portion of the Hanford Site within which the 300 Area resides is characterized by relatively flat topography, with land surface elevations ranging between 115 and 118 m (377 and 387 ft) at the 300 Area, and between 135 and 137 m (443 and 449 ft) at the 618-11 Burial Ground subregion and

Energy Northwest complex. The elevation of the Columbia River as it flows past the 300 Area typically falls in the range of 104 to 108 m (341 to 354 ft).

The predominant plant community in the 300 Area is sagebrush/Sandberg's bluegrass/cheatgrass. Currently, no plant species on the Hanford Site are federally listed as threatened or endangered under the *Endangered Species Act of 1973*. Plant species listed as threatened or endangered by Washington State includes the awned halfchaff sedge (*Lipocarpha aristulata*), grand redstem (*Ammannia robusta*), lowland toothcup (*Rotala ramosior*), and persistent sepal yellowcress (*Rorippa columbiae*). All of these plant species are restricted to wetlands in the riparian zone of the Columbia River (NEPA Characterization Report [PNNL-6415]). Table 3-13 presents the complete list of state-listed flora.

While shrub and grassland habitats supporting a variety of wildlife species dominate the Hanford Site, the 300 Area is predominantly developed and use of this area by wildlife is expected to be minimal. Common species include large animals like Rocky Mountain elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*); predators such as coyote (*Canis latrans*), bobcat (*Lynx rufus*), and badger (*Taxidea taxus*); and herbivores including deer mice (*Peromyscus maniculatus*), harvest mice (*Riethrodontonomys megalotis*), ground squirrels (*Spermophilus* spp.), voles (*Lemmiscus curtatus, Microtus* spp.), and black-tailed jackrabbits (*Lepus californicus*). The most abundant mammal on the Hanford Site is the Great Basin pocket mouse (*Perognathus parvus*). Other non-burrowing animals including cottontails (*Sylvilagus nutalli*), jackrabbits, snakes, and burrowing owls (*Athene cunicularia*) may use abandoned burrows of other animals.

Peregrine falcons, rare visitors to the Hanford Site, are listed currently as threatened or endangered under the *Endangered Species Act of 1973*. These species, which generally use the same areas as the bald eagles (rivershores), are addressed under the *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* (DOE/RL-94-150). Species listed as threatened or endangered by Washington State include such species as the burrowing owl (*Athene cunicularia*), merriam's shrew (*Sorex merriami*), and Washington ground squirrel (*Urocitellus washingtoni*). However, no species are known to be located onsite or expected to occur onsite due to the highly developed nature of this area. Appendix H presents the complete list of state-listed fauna.

Although the bald eagle has been removed from the list of federally endangered species, it is still protected under the *Bald and Golden Eagle Protection Act of 1940*. In addition, DOE has decided to continue to protect nest and roost sites on the Hanford Site under the *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* (DOE/RL-94-150). This plan is currently under revision to account for the de-listing of the bald eagle. Changes have been made to reduce the buffer zones surrounding winter night roosts and nest sites from 800 to 400 m (2,625 to 1,312 ft).

Bald eagles have generally been observed at the Hanford Site from November to March (Fitzner and Hanson, 1979). During daylight hours bald eagles perch along the Hanford Reach of the Columbia River and a few kilometers inland (*Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* [DOE/RL-94-150]). The primary perching areas occur in trees from the Hanford townsite to the Vernita Bridge. Perch sites and roosting sites are located north of the 300 Area, along the Columbia River (*Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* [DOE/RL-94-150]). Bald eagles predominantly forage on the banks of the river and the islands where waterfowl rest and salmon carcasses can be found. The 300 Area is outside of the nesting buffer zones and important foraging areas. Additional consideration of these species is not required for this risk assessment. Additional site setting discussion is located in Section 3.9 and site history is described in Section 1.2.

7.2.2 Simplified Ecological Exposure Model

Development of the ecological CSM involves characterizing the exposure pathways and ecological receptors that might be associated with the habitat types in the upland environment of the waste sites within the 300 Area OUs. Appropriate exposure pathways and representative endpoint species for the upland environment of the 300 Area were developed based on information from earlier ecological risk assessments, primarily the RCBRA.

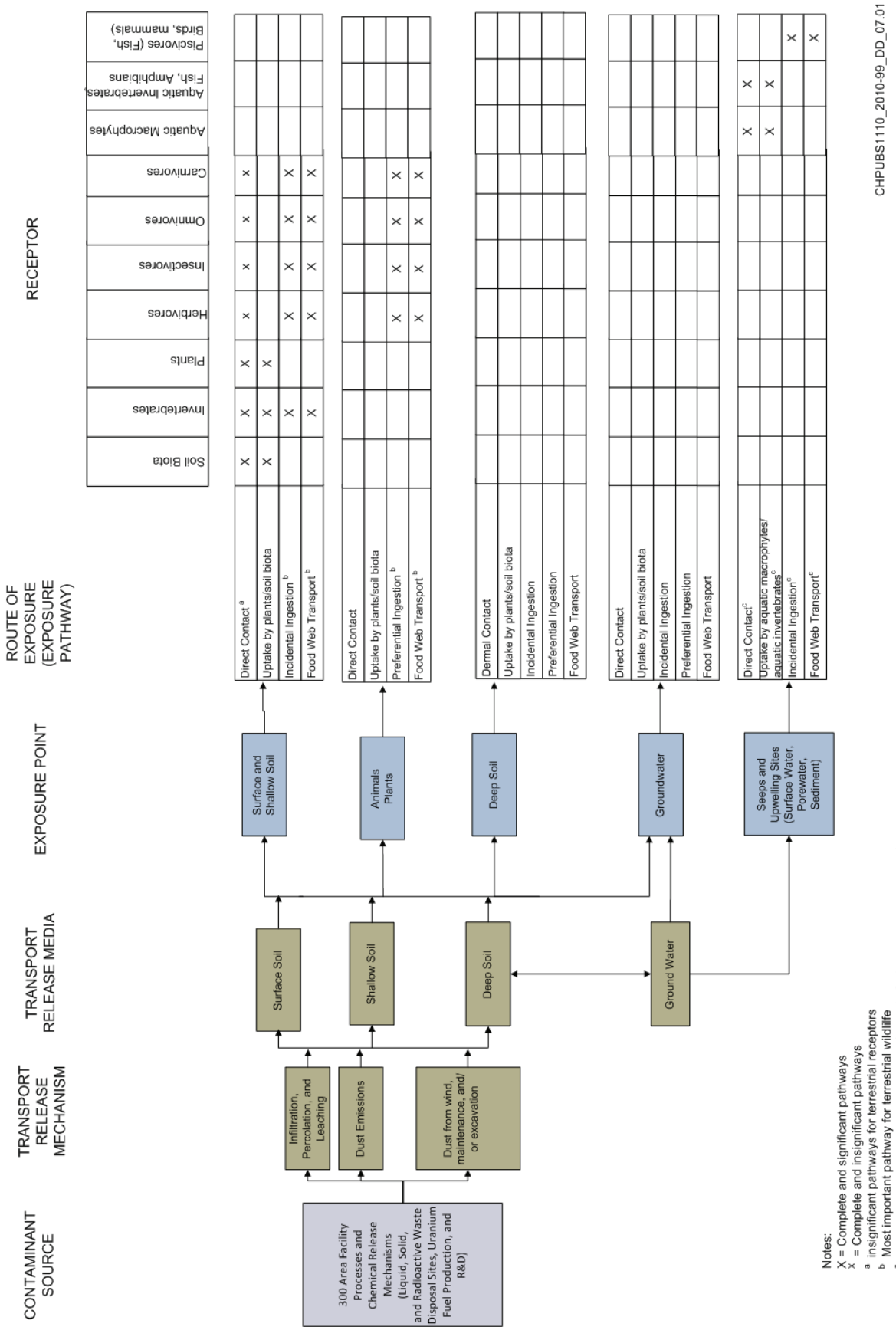
With consideration of the ecological setting, land use, and COPC release mechanisms and transport pathways known at the 300 Area upland environments, the ecological exposure pathways considered most plausible are displayed in Figure 7-1 and include the following:

- Direct contact of vegetation with analytes in surface soil (less than 4.6 m [15 ft]) bgs) as defined by the Standard Point of Compliance in MTCA (WAC 173-340).
- Direct contact with, or ingestion of, surface soil by terrestrial invertebrates (e.g., beetles and ants).
- Direct contact with, or ingestion of, surface soil by terrestrial avian and mammalian wildlife.
- Dietary exposure of terrestrial and mammalian wildlife to COPCs bioaccumulated in food items (e.g., plants or prey).
- Dietary exposure to emissions from radionuclides bioaccumulated and retained within the tissues of plants, terrestrial invertebrates, and terrestrial wildlife.
- External exposure of plants, terrestrial invertebrates, and terrestrial wildlife to emissions from radionuclides in soil. Ecological receptors are not likely to have complete exposure pathways to soils below 4.6 m (15 ft bgs) (*Model Toxics Control Act Cleanup Regulation Chapter 173-340 WAC* [Ecology Publication 94-06]). Therefore, deep soil was not evaluated in this ecological risk evaluation.

A food web model for the upland environment of the Hanford Site (Figure 7-2) has been developed based upon an understanding of the ecology of the area and documented in the previous ecological risk assessments. Entities (represented by tropic guilds), and their associated organizational level that have been identified for evaluation, are as follows:

- Terrestrial plants—community level
- Terrestrial invertebrates—community level
- Soil micro-organisms and microbial processes—community level
- Herbivorous birds—population level
- Herbivorous mammals—population level
- Insectivorous birds—population level
- Insectivorous mammals—population level
- Omnivorous birds—population level
- Omnivorous mammals—population level
- Carnivorous birds—population level
- Carnivorous mammals—population level
- Reptiles and amphibians[2]

[2] Although part of the food web for the upland environment, effects data for reptiles and amphibians are limited. Therefore, SSLs were not developed for this trophic guild.



Notes:
X = Complete and significant pathways
x = Complete and insignificant pathways
a insignificant pathways for terrestrial receptors
b Most important pathway for terrestrial wildlife
c These pathways are evaluated in the RCBRA (DOE/RL-2007-21 Volume 1)

Figure 7-1. Ecological Conceptual Site Model for Terrestrial Habitats in Hanford Site Upland Environment

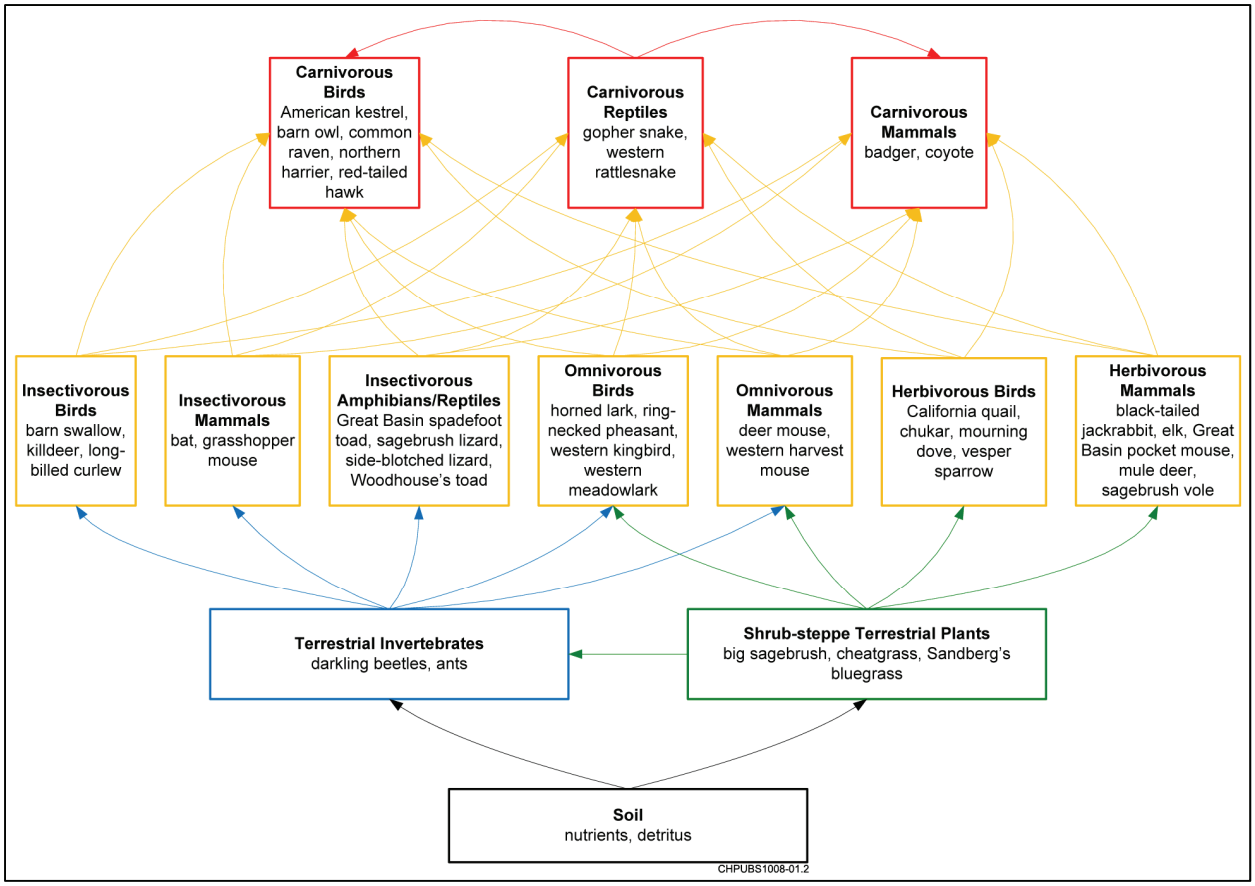


Figure 7-2. Hanford Site Upland Environment Terrestrial Food Web

To calculate ecological SSLs, endpoint representative species of functional groups that could use the site were identified. For example, a red-tailed hawk may be considered representative of raptors visiting the site. Consistent with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final,* hereinafter called ERAGS [EPA 540-R-97-006]; *Guidelines for Ecological Risk Assessment* [EPA/630/R-95/002F]; and WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures," endpoint species should preferably be ones that have ecological relevance, are of societal value, are susceptible to chemical stressors at the site, and allow risk managers to meet policy goals. These factors were used to select representative receptor species common to the Hanford Site upland environment that are within the trophic guilds identified above. Selected receptors are conservative indicators of the potential for risk to the trophic guilds identified for evaluation. The representative receptor species selected for each of the trophic guilds are as follows:

- Herbivorous birds—California quail (*Callipepla californica*)
- Herbivorous mammals—Great Basin pocket mouse (*Perognathus parvus*)
- Insectivorous birds—killdeer (*Charadrius vociferus*)
- Insectivorous mammals—northern grasshopper mouse (*Onychomys leucogaster*)
- Omnivorous birds—western meadowlark (*Sturnella neglecta*)
- Omnivorous mammals—deer mouse (*Peromyscus maniculatus*)
- Carnivorous birds (raptors)—red-tailed hawk (*Buteo jamaicensis*)
- Carnivorous mammals—badger (*Taxidea taxus*)

Unlike birds and mammals, methods to differentiate exposure and/or effects among different plant species or among different invertebrate species are unavailable. Therefore, individual terrestrial vegetation and invertebrate species were not selected to represent the plant or invertebrate populations/communities for evaluation.

7.2.3 Assessment Endpoints

Assessment endpoints are an expression of the important ecological values that are to be protected at a site (*Guidelines for Ecological Risk Assessment* [EPA/630/R-95/002F]; *Ecological Risk Assessment* [Suter, 1993]; and *Ecological Risk Assessment for Contaminated Sites* [Suter et al., 2000]). Assessment endpoints are based on known information concerning the analytes present, the study area, the ecological CSM, and risk hypotheses. There are three components to each assessment endpoint: an *entity* (e.g., migratory birds), an *attribute* of that entity (e.g., individual survival), and a *measure* (e.g., a measurable value, such as an effect level). Measures are described following the general description of assessment endpoints (*Guidelines for Ecological Risk Assessment* [EPA/630/R-95/002F] and *Ecological Risk Assessment for Contaminated Sites* [Suter et al., 2000]).

The assessment endpoint entities for the 300 Area OUs waste sites were selected based on the following principal criteria:

- Ecological relevance
- Societal relevance
- Susceptibility (or high exposure) to known or potential stressors at the Hanford Site

The attribute selected for each entity was based on the organizational level of the entity and the primary criteria that were used to select it. Entities and attributes were selected for community and population levels of assessment.

7.2.4 Measures of Exposure and Effects

Measures (formerly referred to as measurement endpoints) are measurable attributes used to evaluate the risk hypotheses and are predictive of effects on the assessment endpoints (*Guidelines for Ecological Risk Assessment* [EPA/630/R-95/002F]). The three categories of measures include the following:

- Measures of exposure are used to evaluate intake of a contaminant from contact with environmental media (e.g., soil). Measures of exposure can be an EPC of a COPC in an environmental medium or food item. A measure of exposure also can be a dose occurring through ingestion, inhalation, or dermal contact with a contaminant in an environmental medium. SSLs were estimated by back-calculating from a target dose associated with the selected assessment endpoint to a corresponding concentration in soil (Section 7.3.1 for further discussion).

- Measures of effect are used to evaluate the response of an organism that is exposed to a stressor. Measures of effects included TRVs for wildlife and lowest observed effect concentrations (LOECs) in soil for plants and soil invertebrates (Section 7.3.1). The maximum acceptable adverse effect levels generally selected for population- and community-level assessment endpoints are LOECs or lowest observed adverse effects levels (LOAELs), when available.

- Measures of ecosystem and receptor characteristics are used to evaluate the ecosystem characteristics that influence the assessment endpoints, the distribution of stressors, and the characteristics of the assessment endpoints that may affect exposure or response to the stressor. Measures of ecosystem and receptor characteristics are used to characterize ecological risks as part of a baseline ecological risk assessment. These kinds of ecological information were not used directly in calculating SSLs.

However, measures of ecosystem and receptor characteristics may represent additional lines of evidence that can be used along with SSLs in evaluating remedial alternatives in the RI/FS.

7.3 Effects and Exposure Assessment

The effects and exposure assessments were conducted and then integrated to develop two levels of thresholds for evaluating the 300 Area OUs data. This follows the tiered-process referred to earlier and as described in ERAGS (EPA 540-R-97-006). The initial evaluation versus conservative thresholds (SSLs) helps to focus the evaluation down to those COPEC-receptor-waste sites combinations that might require further evaluation. The additional evaluation completed with a comparison to PRGs helps identify which COPEC-receptor-waste sites combinations should be brought forward to the scientific management decision point (SMDP) at the end of Chapter 7.

The effects assessment presents TRVs that have been derived from available literature-based toxicity information on COPCs and that can be used in determining the potential for adverse effects to ecological receptors. Two types of effects-based values are presented in this supplemental risk evaluation; initial conservative values from the published literature (e.g., Ecology, EPA, and DOE guidance or compendiums) and the more Hanford Site-specific values (values established using data collected at the Hanford Site).

The exposure assessment identifies exposure pathways associated with the representative receptor species listed in Section 7.2.2. As with the effects values, the exposure assessment employs two types of exposure evaluations: the avian and mammalian SSLs and the more site-specific avian and mammalian PRGs. It also describes the models used to calculate SSLs and PRGs.

The TRVs were combined with the exposure information to calculate SSLs and PRGs. This section presents the salient features of the effects and exposure assessments as they were used to calculate the SSLs and PRGs. An overview of the development of the nonradionuclide and radionuclide SSLs and PRGs is described in the exposure assessment for each receptor group (i.e., plants, soil invertebrates, and wildlife).This methodology used to develop the SSLs is detailed in *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-00784). The methodology used to develop the PRGs for wildlife is detailed in *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-01311). The methodology used to develop the Hanford Site-specific risk thresholds and to select PRGs for plants and invertebrates is detailed in *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site* (ECF-HANFORD-11-0158). These documents are presented within an appendix to *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units* [DOE/RL-2010-97].

7.3.1 Effects Assessment

The ecological effects assessment consists of an evaluation of available toxicity or other effects information that can be used to interpret the significance of the exposures to COPCs relative to potential adverse effects to ecological receptors. Data that can be used include literature derived or site-specific single-chemical toxicity data, site-specific ambient media toxicity tests, and site-specific field surveys (*Ecological Risk Assessment for Contaminated Sites* [Suter et al., 2000]). The effects data used in this ecological risk assessment are represented by single-chemical toxicity data from literature sources and are summarized below for radionuclides and nonradionuclides.

7.3.1.1 Radionuclides

Radionuclide toxicity data for plants and wildlife are represented by DOE's Biota Concentration Guides (BCGs) for radionuclides that are presented in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002). Two radionuclide effect thresholds, as determined by consensus of international radiation regulatory agencies, form the basis for effect thresholds used to develop screening levels of radionuclides in soil for protection of plants and animals. General guidance from the International Council for Radiological Protection, *Recommendations of the International Commission on Radiological Protection* (ICRP-60); the International Atomic Energy Agency, *Proliferation Resistance Fundamentals for Future Nuclear Energy Systems* (STR-332); and the United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation* (UNSCEAR, 2000), with scientific annexes (Sales No. E.00.IX.4), concluded that radiological doses to terrestrial plants and terrestrial vertebrates should not exceed 1.0 and 0.1 rad/day, respectively. If radiation exposure does not exceed these biota dose levels, the consensus opinion of the international radiological organizations is that ecological populations will be protected. DOE has adopted these effect thresholds and integrated them into *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002).

A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE-STD-1153-2002) includes a screening method and three more detailed levels of analysis for demonstrating compliance with applicable dose limits for protection of biota:

- A general screening that involves comparing maximum radionuclide concentrations in environmental media (i.e., soil) with a set of BCGs to evaluate compliance with the biota dose limits.
- Site-specific screening using more realistic site-representative lumped parameters (e.g., bioaccumulation factors [BAFs]) in place of conservative default parameters, using mean radionuclide concentrations in place of maximum values, and taking into account time dependence and spatial extent of contamination.
- Site-specific analysis employing a kinetic-allometric modeling methodology. Multiple parameters, which represent contribution to an organism's internal dose, can be modified to represent site- and organism-specific characteristics. These parameters include body mass, consumption rates of food or soil, inhalation rate, lifespan, and biological elimination rates. Development of the organism-specific characteristics involves using allometric equations that relate these parameters to body mass.
- Site-specific biota dose assessment involving the collection and analysis of biota samples.

BCGs can be calculated using dose models, equations, and default parameters that are presented in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002). The values in soil, calculated using these default methods, are found in Table 6.4 of *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002). These dose models, equations, and default parameters are also incorporated into the RESRAD-BIOTA Version 1.5 model (*RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation, User's Guide, Version 1* [DOE/EH-0676]). RESRAD-BIOTA presents three levels of analysis, which correspond to the following levels in the graded approach:

- Level 1—general screening approach
- Level 2—site-specific screening with representative parameters
- Level 3—site-specific analysis using the kinetic/allometric modeling methodology

The BCGs for plants for this supplemental ecological risk assessment were calculated using the Level 1 analysis in RESRAD-BIOTA and are shown in Table 7-1. For wildlife (animals), more site-specific SSLs

were developed using RESRAD-Biota Version 1.5 with Level 3 assumptions. While the resulting SSLs have less site-specific data in the models than what was used for nonradionuclides, there is some site-specificity. Values were established for eight different species representing feeding guilds found at the site. However, Hanford Site-specific tissue residue of radionuclides was insufficient for developing models so values from relevant published literature were employed ("Derivation of Transfer Parameters for Use Within the ERICA Tool and the Default Concentration Ratios for Terrestrial Biota" [Beresford et al., 2008]). Final radionuclide SSLs for wildlife are shown in Table 7-2.

Because the dose from radionuclides is additive ("Principles and Issues in Radiological Ecological Risk Assessment" [Jones et al., 2003]), the total contribution of radionuclides known to be associated with Hanford Site processes was also calculated. A total radionuclide exposure estimate was calculated using the SOF method. With the SOF method, the contributions of various radionuclides were reviewed to determine their contribution to dose. Contributions were considered significant if the radionuclide EPC was greater than the SSL and detected frequently.

7.3.1.2 Nonradionuclides

Effects data for the nonradionuclide COPCs are presented below for plants and invertebrates and for wildlife.

Plants and Invertebrates. Single-chemical screening-level toxicity values for terrestrial plants and soil invertebrates were available from the following sources:

- EPA Eco-SSLs, Ecological Soil Screening Levels.
- Screening benchmark concentrations in soil developed by the Oak Ridge National Laboratory (ORNL), many of the Ecological Indicator Soil Concentrations published by Ecology (see below) were drawn from ORNL screening benchmark concentrations.
- Washington Department of Ecology's Ecological Indicator Soil Concentrations, found in "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493(2)(a)(i)), Table 749-3.

The lowest available plant or invertebrate value from these sources was selected as the SSL for each analyte. These SSLs are presented in Table 7-1. A brief discussion of each source is provided below.

EPA's Eco-SSLs for plants and soil invertebrates were derived using data from tests performed within soil conditions favoring relatively high bioavailability for upland soils. The soil chemistry conditions of relatively high bioavailability were defined by low soil pH and organic matter content. From the studies reviewed, the measure of toxic effects to either plants or soil invertebrates were grouped into one of four ecologically relevant endpoints: reproduction, population characteristics, growth, or physiological changes. Toxicity parameters used in deriving the Eco-SSLs were the EC20 (effective concentration affecting 20 percent of a test population), the maximum acceptable toxicant concentration (MATC), and the EC10 (effect concentration affecting 10 percent of a test population). The MATC was calculated by EPA from studies that reported a no observed adverse effects concentration (NOAEC) and a lowest observed adverse effects concentration (LOAEC). The MATC was calculated as the geometric mean of the LOAEC and NOAEC. Studies that reported only a LOAEC or only a NOAEC were not considered to provide a reliable assessment of the dose response, and were not used for Eco-SSL development. The Eco-SSL for plants and soil invertebrates was calculated as the geometric mean of all the toxicity parameters from studies conducted under conditions of high bioavailability. Note that use of the EC20, MATC, and EC10 as toxicity parameters means that Eco-SSLs for plants and soil invertebrates are not based on NOAECs, thus the recommended value is at a level where effects have been observed but to a percent of individuals considered acceptable within the ecological risk assessment practice.

Table 7-1. SSL in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA Eco-SSLs			ORNL—ES/ER/TM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington Dept. of Ecology—MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type		
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark
Radionuclides	Americium-241	pCi/g	---	---	---	---	---	21,500	3,890	---	---	21,500	---	21,500
	Antimony-125	pCi/g	---	---	---	---	---	---	---	---	---	---	---	---
	Carbon-14	pCi/g	---	---	---	---	---	60,700	4,760	---	---	60,700	---	60,700
	Cesium-134	pCi/g	---	---	---	---	---	1,090	11.3	---	---	1,090	---	1,090
	Cesium-137	pCi/g	---	---	---	---	---	2,210	20.8	---	---	2,210	---	2,210
	Cobalt-60	pCi/g	---	---	---	---	---	6,130	692	---	---	6,130	---	6,130
	Curium-244	pCi/g	---	---	---	---	---	153,000	4,060	---	---	153,000	---	153,000
	Europium-152	pCi/g	---	---	---	---	---	14,700	1,520	---	---	14,700	---	14,700
	Europium-154	pCi/g	---	---	---	---	---	12,500	1,290	---	---	12,500	---	12,500
	Europium-155	pCi/g	---	---	---	---	---	153,000	15,800	---	---	153,000	---	153,000
	Hydrogen-3 (tritium)	pCi/g	---	---	---	---	---	1,680,000	174,000	---	---	1,680,000	---	1,680,000
	Neptunium-237	pCi/g	---	---	---	---	---	8,150	3,860	---	---	8,150	---	8,150
	Nickel-63	pCi/g	---	---	---	---	---	---	---	---	---	---	---	---
	Plutonium-238	pCi/g	---	---	---	---	---	17,500	5,270	---	---	17,500	---	17,500
	Plutonium-239/240	pCi/g	---	---	---	---	---	12,700	6,110	---	---	12,700	---	12,700
	Radium-226	pCi/g	---	---	---	---	---	288	50.6	---	---	288	---	288
	Radium-228	pCi/g	---	---	---	---	---	245	43.9	---	---	245	---	245
	Strontium 90	pCi/g	---	---	---	---	---	3,580	22.5	---	---	3,580	---	3,580
	Technetium-99	pCi/g	---	---	---	---	---	21,900	4,490	---	---	21,900	---	21,900
	Thorium-232	pCi/g	---	---	---	---	---	23,500	1,510	---	---	23,500	---	23,500
	Uranium-234	pCi/g	---	---	---	---	---	51,600	5,130	---	---	51,600	---	51,600
	Uranium-235	pCi/g	---	---	---	---	---	27,400	2,770	---	---	27,400	---	27,400
	Uranium-238	pCi/g	---	---	---	---	---	15,700	1,580	---	---	15,700	---	15,700
Metals	Aluminum	mg/kg	Narrative Statement		OSWER Dir. 9285.7-60	50	---	---	---	50	---	50	---	50
	Antimony	mg/kg	---	78	OSWER Dir. 9285.7-61	5	---	---	---	5	---	5	78	5
	Arsenic, Total all valence states	mg/kg	18	---	OSWER Dir. 9285.7-62	10	60	---	---	---	---	10	60	10
	Arsenic (III)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Arsenic (V)	mg/kg	---	---	---	---	---	---	---	10	60	10	60	10
	Barium	mg/kg	---	330	OSWER Dir. 9285.7- 63	500	---	---	---	500	---	500	330	330
	Beryllium	mg/kg	---	40	OSWER Dir. 9285.7- 64	10	---	---	---	10	---	10	40	10
	Bismuth	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---

Table 7-1. SSL in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA Eco-SSLs			ORNL—ES/ER/TM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington Dept. of Ecology—MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type		
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark
Metals (cont.)	Boron	mg/kg	---	---	---	0.5	---	---	---	0.5	---	0.5	---	0.5
	Cadmium	mg/kg	32	140	OSWER Dir. 9285.7-65	4	20	---	---	4	20	4	20	4
	Chromium (total) [a,b]	mg/kg	---	---	OSWER Dir. 9285.7- 66	1	0.4	---	---	42	42	1	0.4	0.4
	Chromium (+3)	mg/kg	---	---	OSWER Dir. 9285.7- 66	1	0.4	---	---	42	42	1	0.4	0.4
	Chromium (+6)	mg/kg	---	---	OSWER Dir. 9285.7- 66	---	---	---	---	---	---	---	---	---
	Cobalt	mg/kg	13	---	OSWER Dir. 9285.7-67	20	---	---	---	20	---	13	---	13
	Copper	mg/kg	70	80	OSWER Dir. 9285.7-68	100	50	---	---	100	50	70	50	50
	Lead	mg/kg	120	1700	OSWER Dir. 9285.7-70	50	500	---	---	50	500	50	500	50
	Lithium [b]	mg/kg	---	---	---	2	---	---	---	35	---	2	---	2
	Manganese [b]	mg/kg	220	450	OSWER Dir. 9285.7-71	500	---	---	---	1,100	---	220	450	220
	Mercury	mg/kg	---	---	---	0.3	0.1	---	---	0.3	0.1	0.3	0.1	0.1
	Molybdenum	mg/kg	---	---	---	2	---	---	---	2	---	2	---	2
	Nickel	mg/kg	38	280	OSWER Dir. 9285.7-76	30	200	---	---	30	200	30	200	30
	Selenium	mg/kg	0.52	4.1	OSWER Dir. 9285.7-72	1	70	---	---	1	70	0.52	4.1	0.52
	Silver	mg/kg	560	---	OSWER Dir. 9285.7-77	2	---	---	---	2	---	2	---	2
	Strontium	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Thallium	mg/kg	---	---	---	1	---	---	---	1	---	1	---	1
	Tin	mg/kg	---	---	---	50	---	---	---	50	---	50	---	50
	Uranium	mg/kg	---	---	---	5	---	---	---	5	---	5	---	5
	Vanadium	mg/kg	---	---	OSWER Dir. 9285.7-75	2	---	---	---	2	---	2	---	2
	Zinc [b]	mg/kg	160	120	OSWER Dir. 9285.7-73	50	200	---	---	86	200	50	120	50
General Inorganics	Ammonia/Ammonium	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Chloride	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Cyanide	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Fluoride	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Iodine	mg/kg	---	---	---	4	---	---	---	4	---	4	---	4
	Nitrate/Nitrite	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Phosphate	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Sulfate/Sulfite	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Total Organic Carbon	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---

Table 7-1. SSL in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA Eco-SSLs			ORNL—ES/ER/TM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington Dept. of Ecology—MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type		
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark
Volatile Organics	1,1-dichloroethane	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,1-dichloroethene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,1,1-trichloroethane	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,1,2-trichloroethane	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,1,2,2-tetrachloroethane	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,2-dichlorobenzene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,2-dichloroethane (DCA)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	1,3-dichlorobenzene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	2-butanone (Methyl Ethyl Ketone/MEK)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	2-hexanone	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Benzene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Butanol	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Carbon Tetrachloride	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Chlorobenzene	mg/kg	---	---	---	---	40	---	---	---	40	---	40	40
	Chloroform	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Cis-1,2-dichloroethylene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Dichloromethane (Methylene Chloride)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Ethyl Benzene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Methyl Isobutyl Ketone	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	n-butyl Benzene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Tetrachloroethylene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Toluene	mg/kg	---	---	---	200	---	---	---	200	---	200	---	200
	Trans-1,2-dichloroethylene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Trichloroethylene (TCE)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Xylene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---

Table 7-1. SSL in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA Eco-SSLs			ORNL—ES/ER/TM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington Dept. of Ecology—MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type		
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark
Polycyclic Aromatic Hydrocarbons	Acenaphthene	mg/kg	---	29	OSWER Dir. 9285.7-75	20	---	---	---	20	---	20	29	20
	Acenaphthylene	mg/kg	---	29	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	29	29
	Anthracene	mg/kg	---	29	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	29	29
	Benzo(a)pyrene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Benzo(a)anthracene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Benzo(b)fluoranthene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Benzo(ghi)perylene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Benzo[k]fluoranthene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Chrysene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Dibenz(ah)anthracene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Fluoranthene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Fluorene	mg/kg	---	29	OSWER Dir. 9285.7-75	---	30	---	---	---	30	---	29	29
	Indeno[1,2,3-cd]pyrene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	2-Methylnaphthalene	mg/kg	---	29	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	29	29
	Naphthalene	mg/kg	---	29	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	29	29
	Phenanthrene	mg/kg	---	29	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	29	29
	Pyrene	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
	Total PAHs	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Low MW PAHs [c]	mg/kg	---	29	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	29	29
	High MW PAHs [d]	mg/kg	---	18	OSWER Dir. 9285.7-75	---	---	---	---	---	---	---	18	18
Petroleum	Gasoline Range Organics	mg/kg	---	---	---	---	---	---	---	---	100	---	100	100
	TPH - diesel	mg/kg	---	---	---	---	---	---	---	---	200	---	200	200
	TPH - kerosene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---

Table 7-1. SSL in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA Eco-SSLs			ORNL—ES/ER/TM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington Dept. of Ecology—MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type		
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark
Semivolatile Organics	Normal paraffin hydrocarbons	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Phenol	mg/kg	---	---	---	70	30	---	---	70	30	70	30	30
	2-methylphenol (ocresol)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	4-methylphenol (pcresol)	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	2,4-dinitrotoluene	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Bis(2-ethylhexyl)phthalate [e]	mg/kg	---	---	---	100	---	---	---	100	---	100	---	100
	Polychlorinated Biphenyls (PCB)[f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1016 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1221 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1232 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1242 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1248 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1254 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor 1260 [f,g]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
	Aroclor-1262 [f,g,h]	mg/kg	---	---	---	40	---	---	---	40	---	40	---	40
Herbicide	Dichloroprop	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
Pesticide	Aldrin	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	beta-1,2,3,4,5,6-Hexachlorocyclohexane[i,j]	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	alpha-Chlordane[k]	mg/kg	---	---	---	---	---	---	---	---	1	---	1	1
	gamma-Chlordane[k]	mg/kg	---	---	---	---	---	---	---	---	1	---	1	1
	Dichlorodiphenyldichloroethylene[l,m]	mg/kg	---	---	OSWER Dir. 9285.7-57	---	---	---	---	---	---	---	---	---
	Dichlorodiphenyltrichloroethane[m]	mg/kg	---	---	OSWER Dir. 9285.7-57	---	---	---	---	---	---	---	---	---
	Dieldrin	mg/kg	---	---	OSWER Dir. 9285.7-56	---	---	---	---	---	---	---	---	---
	Endosulfan I	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Endosulfan II	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Endosulfan sulfate	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Endrin aldehyde[n]	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---
	Methoxychlor	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---

Table 7-1. SSL in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA Eco-SSLs			ORNL—ES/ER/TM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington Dept. of Ecology—MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type		
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark

a. When Cr (total) not available, the lower of either Cr(III) or Cr(VI), as available, were used as a surrogate.

b. MTCA plant and soil biota benchmarks were replaced by Washington State natural background concentration.

c. The Low MW PAHs screening values from EPA (OSWER Directive 9285.7-78, *Ecological Soil Screening Levels for Polycyclic Aromatic Cydrocarbons (PAHs): Interim Final*) represents the sum of the low molecular weight polyaromatic hydrocarbons (PAHs).

d. The High MW PAHs screening values from EPA (OSWER Directive 9285.7-78, *Ecological Soil Screening Levels for Polycyclic Aromatic Cydrocarbons (PAHs): Interim Final*) represents the sum of the high molecular weight polyaromatic hydrocarbons (PAHs). For the purposes of this assessment, the benchmark was also applied to the individual high molecular weight PAHs.

e. Values for diethyl phthalate were used as a surrogate for bis(2-ethylhexyl)phthalate.

f. Aroclor 1254 value was used as surrogate.

g. MTCA values represent screening values for PCB mixtures.

h. MTCA Aroclor 1260 values used as surrogate for Aroclor 1262.

i. Form of HCB not identified in ES/ER/TM-126/R2, *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.*

j. MTCA value based on benzene hexachloride, including lindane.

k. MTCA values based on chlordane.

l. DDT values used as a surrogate for DDE.

m. MTCA value based on total DDT/DDE/DDD.

n. MTCA endrin aldehyde values based on endrin.

--- = value not available
DOE BCG = U.S. Department of Energy biota concentration guide. Summary of media screening values (BCGs) for radionuclides at the former McClellan Air Force Base. All values extracted from DOE/EH-0676 or DOE-STD-1153-2002.
Ecology = Washington State Department of Ecology
Eco-SSL = ecological soil screening level
EPA = U.S. Environmental Protection Agency
High MW PAHs = high molecular weight polycyclic aromatic hydrocarbons
Low MW PAHs = low molecular weight polycyclic aromatic hydrocarbons
MTCA = "Model Toxics Control Act" (WAC 173-340)
ORNL = Oak Ridge National Laboratory
OSWER = Office of Solid Waste and Emergency Response (EPA)
SSL = soil screening level
TPH = total petroleum hydrocarbons

Table 7-2. SSLs for Wildlife (Birds and Mammals)

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	NOAEL Lowest	California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Radionuclides	Americium-241	pCi/g	---	---	---	---	---	---	---	---	---	28900	25000	11900	17800	72100	48700	41400	4840	4840
	Carbon-14	pCi/g	---	---	---	---	---	---	---	---	---	54	60	56	50	61	60	135	32	32
	Curium-244	pCi/g	---	---	---	---	---	---	---	---	---	389000	252000	105000	207000	2300000	722000	499000	50800	50800
	Cobalt-60	pCi/g	---	---	---	---	---	---	---	---	---	805	805	805	863	805	805	806	1000	805
	Cesium-134	pCi/g	---	---	---	---	---	---	---	---	---	1140	1190	1200	854	1160	1180	1270	562	562
	Cesium 137	pCi/g	---	---	---	---	---	---	---	---	---	2390	2700	2800	1430	2510	2630	3280	924	924
	Europium-152	pCi/g	---	---	---	---	---	---	---	---	---	1740	1740	1740	1880	1740	1740	1740	2220	1740
	Europium-154	pCi/g	---	---	---	---	---	---	---	---	---	1610	1610	1610	1740	1610	1610	1610	2060	1610
	Europium-155	pCi/g	---	---	---	---	---	---	---	---	---	33400	33400	33400	37300	33400	33400	33400	48600	33400
	Hydrogen-3 (tritium)	pCi/g	---	---	---	---	---	---	---	---	---	1430	1280	936	1130	3270	2290	2830	420	420
	Neptunium-237	pCi/g	---	---	---	---	---	---	---	---	---	8190	8140	7880	9150	8250	8170	8180	11200	7880
	Nickel-63	pCi/g	---	---	---	---	---	---	---	---	---									
	Plutonium-238	pCi/g	---	---	---	---	---	---	---	---	---	36300	56200	20900	26800	291000	161000	161000	5980	5980
	Plutonium-239/240	pCi/g	---	---	---	---	---	---	---	---	---	38800	60300	22300	28400	324000	175000	176000	6270	6270
	Radium-226	pCi/g	---	---	---	---	---	---	---	---	---	168	142	58	377	285	165	199	193	58
	Radium-228	pCi/g	---	---	---	---	---	---	---	---	---	169	140	55	418	306	165	203	193	55
	Antimony-125	pCi/g	---	---	---	---	---	---	---	---	---	4580	4580	4580	5040	4580	4580	4580	6130	4580
	Strontium 90	pCi/g	---	---	---	---	---	---	---	---	---	521	302	151	112	706	519	413	91	91
	Technetium-99	pCi/g	---	---	---	---	---	---	---	---	---	5360	11500	137000	280000	8670	12100	412000	128000	5360
	Thorium-232	pCi/g	---	---	---	---	---	---	---	---	---	5070	12900	5340	12400	34400	32500	86200	4560	4560
	Uranium-234	pCi/g	---	---	---	---	---	---	---	---	---	12700	21800	6370	40900	30300	24800	51600	14200	6370
	Uranium-235	pCi/g	---	---	---	---	---	---	---	---	---	6340	7810	4360	10200	8600	8130	9630	8060	4360
	Uranium-238	pCi/g	---	---	---	---	---	---	---	---	---	8020	10400	5150	22100	11900	11000	13900	13400	5150

Table 7-2. SSLs for Wildlife (Birds and Mammals)

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	NOAEL Lowest	California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Metals	Aluminum	mg/kg	22020	18602	4921	61782	687	271	380	710	271	---	---	---	---	6872	2708	3799	7101	2708
	Antimony	mg/kg	---	---	---	---	8.82	0.66	0.60	16.66	0.60	---	---	---	---	97	7	6	167	6
	Arsenic, Total all valence states	mg/kg	1800	1981	425	10344	265	105	171	549	105	8104	10559	2132	45439	459	190	318	881	190
	Arsenic (III)	mg/kg	1800	1981	425	10344	265	105	171	549	105	8104	10559	2132	45439	459	190	318	881	190
	Arsenic (V)	mg/kg	1800	1981	425	10344	265	105	171	549	105	8104	10559	2132	45439	459	190	318	881	190
	Barium	mg/kg	1229	1271	660	14442	2082	1889	4605	18843	660	2464	2548	1323	28954	3470	3148	7676	31405	1323
	Beryllium	mg/kg	---	---	---	---	14	18	101	283	14	---	---	---	---	---	---	---	---	---
	Bismuth	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Boron	mg/kg	64	86	140	797	40	50	284	767	40	222	300	485	2766	133	167	949	2563	133
	Cadmium	mg/kg	151	2.8	0.9	1375	76	1.5	1.3	455	0.9	278	5	2	2335	2065	28	24	5228	2
	Chromium (total)	mg/kg	334	97	37	1286	320	75	78	752	37	349	101	38	1355	1284	299	313	3536	38
	Chromium (+3)	mg/kg	334	97	37	1286	320	75	78	752	37	349	101	38	1355	1284	299	313	3536	38
	Chromium (+6)	mg/kg	---	---	---	---	1233	288	300	3380	288	---	---	---	---	5340	1245	1300	16583	1245
	Cobalt	mg/kg	1425	305	109	1601	2174	261	250	1346	109	1461	313	111	1633	3233	388	372	1869	111
	Copper	mg/kg	485	85	36	3728	873	100	109	2640	36	1914	272	107	13021	1894	176	182	4672	107
	Lead	mg/kg	247	49	16	979	1204	151	153	2005	16	537	115	36	2433	2544	332	336	4108	36
	Lithium	mg/kg	---	---	---	---	3189	1258	1749	257	257	---	---	---	---	6379	2517	3498	515	515
	Manganese	mg/kg	16369	24184	9588	113951	4227	4115	18430	20464	4115	31823	48820	19636	221536	5828	5798	27720	28213	5798
	Mercury	mg/kg	3.1	0.4	0.04	25	0.5	0.03	0.03	8.7	0.03	36	21	4	134	8	2	3	43	2
	Molybdenum	mg/kg	35	27	18	98	1.7	1.4	2.8	7.1	1.4	345	270	179	977	17	14	28	71	14
	Nickel	mg/kg	1081	79	31	6037	303	18	16	637	16	1912	136	53	11078	676	36	33	1438	33
	Selenium	mg/kg	5.6	3.7	1.7	158	2.1	1.2	1.8	32	1.2	10	8	4	417	3	2	3	60	2
	Silver	mg/kg	345	13	5.0	2044	1442	35	30	3097	5.0	3453	128	50	20437	14418	346	300	30969	50
	Strontium	mg/kg	---	---	---	---	9442	4849	6476	4228	4228	---	---	---	---	---	---	---	---	---
	Thallium	mg/kg	---	---	---	---	5.1	1.8	2.4	2.6	1.8	---	---	---	---	25	9	12	13	9
	Tin	mg/kg	82	128	231	1852	187	252	2691	5107	82	204	318	575	4603	279	377	4025	7639	204
	Uranium	mg/kg	2502	2691	785	18730	610	393	748	1694	393	---	---	---	---	1217	786	1494	3383	786
	Vanadium	mg/kg	67	58	16	268	1363	577	835	1864	16	134	116	31	537	2723	1153	1668	3723	31

Table 7-2. SSLs for Wildlife (Birds and Mammals)

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	NOAEL Lowest	California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Metals (cont.)	Zinc	mg/kg	4973	714	67	70825	4612	633	794	38590	67	5015	726	68	71294	4661	644	810	38866	68
General Inorganics	Ammonia/Ammonium	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Chloride	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Cyanide	mg/kg	---	---	---	---	27971	20693	78123	38061	20693	---	---	---	---	---	---	---	---	---
	Fluoride (fluorine)	mg/kg	1492	2812	556	9206	9825	8216	35673	17379	556	6123	11539	2281	37771	16521	13816	59985	29224	2281
	Iodine	mg/kg	---	---	---	---	159	183	1558	759	159	---	---	---	---	1594	1834	15579	7590	1594
	Nitrate/Nitrite	mg/kg	---	---	---	---	206422	152711	576537	280885	152711	---	---	---	---	460073	340361	1284984	626035	340361
	Phosphate	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Sulfate/Sulfite	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Total Organic Carbon	%	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Volatile Organics	1,1-dichloroethane	mg/kg	3615	217	83	13955	20357	574	502	22894	83	7230	435	165	27909	---	---	---	---	165
	1,1-dichloroethene	mg/kg	3615	217	83	11433	12214	344	301	12238	83	7230	434	165	22866	---	---	---	---	165
	1,1,1-trichloroethane	mg/kg	3615	217	82	8936	407144	11444	10016	349074	82	7230	433	165	17871	---	---	---	---	165
	1,1,2-trichloroethane	mg/kg	3615	217	83	12031	407144	11472	10041	420572	83	7230	434	165	24063	---	---	---	---	165
	1,1,2,2-tetrachloroethane	mg/kg	3615	217	82	9549	3636	102	89	3255	82	7230	433	165	19098	36358	1022	894	32554	165
	1,2-dichlorobenzene	mg/kg	88	91	82	4343	282	294	854	17612	82	176	182	164	8687	---	---	---	---	164
	1,2-dichloroethane (DCA)	mg/kg	3615	222	84	16084	20357	586	513	24710	84	7230	444	169	32168	---	---	---	---	169
	1,3-dichlorobenzene	mg/kg	96	96	82	4051	310	314	854	16652	82	192	192	164	8103	---	---	---	---	164
	2-butanone (Methyl Ethyl Ketone/MEK)	mg/kg	2102	1041	312	11538	721052	159713	176661	970851	312	21017	10406	3123	115382	1861055	412224	455968	2505793	3123
	2-hexanone	mg/kg	2102	548	186	9653	2036	244	237	2512	186	21017	5483	1856	96532	14698	1759	1708	18135	1708
	Benzene	mg/kg	8554	513	195	27053	285	8	7	286	7	---	---	---	---	2850	80	70	2856	70
	Butanol	mg/kg	---	---	---	---	50893	2906	2626	67049	2626	---	---	---	---	203572	11625	10503	268194	10503
	Carbon Tetrachloride	mg/kg	3615	216	82	7382	6514	183	160	4904	82	7230	433	165	14765	---	---	---	---	165
	Chlorobenzene	mg/kg	3615	216	82	6672	7939	223	195	5561	82	7230	433	165	13345	15756	442	387	11036	165
	Chloroform	mg/kg	3615	217	83	13003	6107	172	151	6600	83	7230	434	165	26006	16693	470	412	18041	165
	Cis-1,2-dichloroethylene	mg/kg	3615	217	83	13446	18403	518	453	20271	83	7230	434	165	26892	---	---	---	---	165
	Dichloromethane (Methylene Chloride)	mg/kg	3615	218	83	17281	2382	67	59	2999	59	7230	436	166	34562	20357	576	504	25632	166

Table 7-2. SSLs for Wildlife (Birds and Mammals)

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	NOAEL Lowest	California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Volatile Organics (cont.)	Ethyl Benzene	mg/kg	159	183	194	12721	342	384	1357	33025	159	---	---	---	---	1027	1151	4075	99076	1027
	Methyl Isobutyl Ketone	mg/kg	2102	573	193	10211	721052	90040	87996	915292	193	21017	5729	1927	102114	1861055	232395	227119	2362393	1927
	n-butyl Benzene	mg/kg	301	263	193	7857	530	485	1092	18135	193	---	---	---	---	1589	1454	3275	54406	1454
	Tetrachloroethylene	mg/kg	3615	216	82	7733	570	16	14	443	14	7230	431	164	15467	2850	80	70	2216	70
	Toluene	mg/kg	8554	512	195	17200	21171	594	520	15763	195	---	---	---	---	211715	5944	5202	157633	5202
	Trans-1,2-dichloroethylene	mg/kg	3615	217	83	11881	18403	518	453	18869	83	7230	434	165	23763	---	---	---	---	165
	Trichloroethylene (TCE)	mg/kg	3615	217	82	7498	285	8	7	217	7	7230	434	165	14996	2850	80	70	2169	70
	Xylene	mg/kg	149	175	194	13419	422	481	1787	45266	149	---	---	---	---	826	940	3494	88509	826
Polycyclic Aromatic Hydrocarbons	Acenaphthene	mg/kg	6831	285	110	38362	71250	1396	1211	96952	110	68306	2849	1096	383617	142500	2793	2422	193905	1096
	Acenaphthylene	mg/kg	3506	19	7	38362	24321	91	78	96952	7	43766	186	74	383617	54132	183	156	193905	74
	Anthracene	mg/kg	3405	170	68	38362	178811	4784	4213	554013	68	43405	1716	678	383617	---	---	---	---	678
	Benzo(a)pyrene	mg/kg	47	6.0	2.4	767	60	8.1	7.6	554	2.4	---	---	---	---	635	81	76	5540	76
	Benzo(a)anthracene	mg/kg	118	5.2	2.0	767	307	7.3	6.4	554	2.0	---	---	---	---	3636	73	64	5540	64
	Benzo(b)fluoranthene	mg/kg	22	3.0	1.3	767	25	4.1	3.9	554	1.3	---	---	---	---	247	41	39	5540	39
	Benzo(ghi)perylene	mg/kg	12	2.6	1.1	767	13	3.5	3.5	554	1.1	---	---	---	---	89	32	35	5540	32
	Benzo[k]fluoranthene	mg/kg	136	3.2	1.3	767	406	4.6	3.9	554	1.3	---	---	---	---	4069	46	39	5540	39
	Chrysene	mg/kg	118	3.6	1.4	767	307	5.1	4.5	554	1.4	---	---	---	---	3636	51	45	5540	45
	Dibenz(ah)anthracene	mg/kg	44	3.5	1.4	767	54	4.9	4.4	554	1.4	---	---	---	---	543	49	44	5540	44
	Fluoranthene	mg/kg	15	2.5	1.1	767	1957	421	420	69252	1.1	---	---	---	---	3915	841	839	138503	839
	Fluorene	mg/kg	6831	45	18	38362	50893	157	134	69252	17.5	68306	446	175	383617	101786	313	267	138503	175
	Indeno[1,2,3-cd]pyrene	mg/kg	49	2.9	1.2	767	63	4.0	3.6	554	1.2	---	---	---	---	626	40	36	5540	36
	2-Methylnaphthalene	mg/kg	5	5.7	155	38362	5.0	5.5	500	27867	5.0	8	9	1547	383617	6	7	1132	63047	6
	Naphthalene	mg/kg	34	37	416	38362	33	36.2	116	27701	33.3	340	369	378	383617	100	109	348	83102	100
	Phenanthrene	mg/kg	4329	236	94	38362	301134	6731	5919	554013	94.3	56061	2406	943	383617	---	---	---	---	943
	Pyrene	mg/kg	11	3.9	1.9	767	825	360	436	41551	1.9	---	---	---	---	1375	600	727	69252	600
	Total PAHs	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Low MW PAHs	mg/kg	6592	12623	2316	38362	25369	19170	74597	36343	2316	67600	128679	23165	383617	130652	97560	372987	181716	23165

Table 7-2. SSLs for Wildlife (Birds and Mammals)

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	NOAEL Lowest	California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Polycyclic Aromatic Hydrocarbons (cont.)	High MW PAHs	mg/kg	40	72	46	767	29	39	699	341	29					157	209	3491	1701	157
Petroleum	Gasoline Range Organics	mg/kg																		
	TPH–diesel	mg/kg	105086	199535	35638	590179	407144	301205	1137154	554013	35638	1050862	1995354	356382	5901794	610716	451807	1705732	831020	356382
	TPH–kerosene	mg/kg	105086	199535	35638	590179	407144	301205	1137154	554013	35638	1050862	1995354	356382	5901794	610716	451807	1705732	831020	356382
Semivolatile Organics	Normal paraffin hydrocarbons	mg/kg	170870	324445	57948	959632	407144	301205	1137154	554013	57948	---	---	---	---	610716	451807	1705732	831020	451807
	Phenol	mg/kg	---	---	---	---	4886	526	504	5919	504	---	---	---	---	14657	1578	1511	17756	1511
	2-methylphenol (ocresol)	mg/kg	---	---	---	---	127436	10038	9293	134503	9293	---	---	---	---	---	---	---	---	---
	4-methylphenol (pcresol)	mg/kg	---	---	---	---	127436	10102	9358	136361	9358	---	---	---	---	---	---	---	---	---
	2,4-dinitrotoluene	mg/kg	0.29	0.30	0.20	7.17	13.78	13.46	35.58	285.89	0.20	38	39	26	932	29	28	74	597	26
	Bis[2-ethylhexyl] phthalate [a]	mg/kg	111.06	0.35	0.14	263.03	1733.20	5.35	4.55	3599.39	0.14	---	---	---	---	17332	54	45	35994	45
	Polychlorinated Biphenyls (PCB) [b]	mg/kg	10.01	0.65	0.33	25.09	2.92	0.30	0.27	8.47	0.27	100	3.6	1.8	251	29	1.6	1.5	85	1.5
	Aroclor 1016 [b]	mg/kg	6.45	0.64	0.33	21.75	35.21	2.75	2.47	150.41	0.33	64	3.6	1.8	218	88	5.3	4.8	377	1.8
	Aroclor 1221 [b]	mg/kg	2.73	0.61	0.33	24.02	0.69	0.25	0.27	8.15	0.25	27	3.4	1.8	240	7	1.5	1.5	82	1.5
	Aroclor 1232 [b]	mg/kg	2.19	0.59	0.33	26.24	0.55	0.24	0.27	8.81	0.24	22	3.4	1.8	262	5	1.4	1.5	88	1.4
	Aroclor 1242 [b]	mg/kg	10.36	0.65	0.33	25.55	3.09	0.30	0.27	8.74	0.27	104	3.6	1.8	256	31	1.6	1.5	87	1.5
	Aroclor 1248 [b]	mg/kg	9.41	0.65	0.33	24.33	0.35	0.06	0.06	1.06	0.06	94	3.6	1.8	243	3	0.3	0.3	11	0.3
	Aroclor 1254	mg/kg	11.52	0.65	0.33	27.26	3.48	0.30	0.27	9.11	0.27	115	3.6	1.8	273	35	1.6	1.5	91	1.5
	Aroclor 1260 [b]	mg/kg	20.38	0.66	0.33	51.49	7.67	0.30	0.27	15.42	0.27	204	3.6	1.8	515	77	1.6	1.5	154	1.5
	Aroclor-1262 [b]	mg/kg	37.83	71.83	12.83	212.46	27.69	20.48	77.33	37.67	12.83	378	718	128	2125	277	205	773	377	128
Herbicide	Dichloroprop	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pesticide	Aldrin	mg/kg	0.45	0.08	0.03	1.1	10.2	2.0	2.0	27	0.03	2.2	0.4	0.2	5.3	51	9.9	9.8	134	0.2
	beta-1,2,3,4,5,6-Hexachlorocyclohexane	mg/kg	4.1	3.6	2.7	112.2	1.9	1.7	4.0	67	1.7	6.2	5.5	4.1	168	9.4	8.7	20	335	4.1
	alpha-Chlordane	mg/kg	122	24	10	302	93	21	21	264	10	608	121	50	1508	925	205	207	2641	50
	gamma-Chlordane	mg/kg	122	24	10	302	93	20	21	264	10	608	121	50	1508	925	204	206	2641	50
	Dichlorodiphenyldichloroethane (DDD) [c]	mg/kg	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Table 7-2. SSLs for Wildlife (Birds and Mammals)

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	NOAEL Lowest	California Quail	Meadow-lark	Killdeer	Red-tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Pesticide (cont.)	Dichlorodiphenyldichloroethylene (DDE) [c]	mg/kg	30.4	0.21	0.07	0.06	20.48	0.11	0.09	0.03	0.03	300	2.3	0.8	1.7	136	0.7	0.6	0.4	0.4
	Dichlorodiphenyltrichloroethane	mg/kg	30.4	0.30	0.10	2.53	20.48	0.16	0.14	1.41	0.10	300	3.5	1.2	46.3	136	1.0	0.9	12.7	0.9
	Dieldrin	mg/kg	1.9	0.06	0.02	1.64	0.28	0.01	0.01	0.35	0.01	6.1	0.20	0.08	5.2	0.57	0.02	0.02	0.69	0.02
	Endosulfan I	mg/kg	93.4	66.32	41.40	1671.48	0.92	0.71	1.29	21.88	0.71	---	---	---	---	---	---	---	---	---
	Endosulfan II	mg/kg	93.4	66.32	41.40	1671.48	0.92	0.71	1.29	21.88	0.71	---	---	---	---	---	---	---	---	---
	Endosulfan sulfate	mg/kg	62.9	55.40	41.40	2159.84	0.61	0.56	1.29	27.15	0.56	---	---	---	---	---	---	---	---	---
	Endrin aldehyde	mg/kg	2.6	0.52	0.23	52.86	0.51	0.14	0.14	14.04	0.14	---	---	---	---	5.1	1.4	1.4	140.4	1.4
	Methoxychlor	mg/kg	---	---	---	---	59.78	11.20	10.92	441.01	10.92	---	---	---	---	120	22	22	882	22

a. Values for diethyl phthalate and di-n-butyl phthalate were used as a surrogate for bis(2)ethylhexyl phthalate.

b. Aroclor 1254 value was used as surrogate.

c. DDT values used as a surrogate for DDE and DDD.

'--- = value not available
High MW PAHs = high molecular weight polycyclic aromatic hydrocarbons
LOAEL = lowest observed adverse effect level
Low MW PAHs = low molecular weight polycyclic aromatic hydrocarbons
NOAEL = no observed adverse effect level
SSL = soil screening level
TPH = total petroleum hydrocarbons

The ORNL benchmarks for the toxicity to plants from chemical analytes in soil were based on thresholds for effects on growth and reproduction derived from published toxicity studies conducted in soil or solution. The benchmarks are concentrations of chemicals that correspond to the LOEC for the 10th percentile of plant species tested. The ORNL benchmarks for toxicity to soil invertebrates and heterotrophic processes from analytes in soil represent thresholds (LOECs) for statistically significant effects on growth, reproduction, or activity. The toxicity benchmarks were derived by rank ordering the LOEC values and then selecting a value that approximated the 10th percentile.

If 10 or fewer values were available for a chemical, the lowest LOEC was used. If the 10th percentile fell between LOEC values, a value was chosen by interpolation. If a chemical concentration in soil represented a 50 percent or higher reduction in survivorship of plants, the concentration was divided by 5 to approximate the more sensitive endpoints of growth or production. Plant toxicity benchmarks for metals are usually lower than benchmarks for soil invertebrates or microbial processes. The benchmarks are lower than most PRGs calculated for wildlife.

Ecology's Ecological Indicator Soil Concentrations presented in Table 749-3 represent soil concentrations that are expected to be protective at any MTCA site and are provided for use in eliminating hazardous substances from further consideration under "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493(2)(a)(i)). The Ecological Indicator Soil Concentrations for plants are based on benchmarks published in ORNL's *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision* (ES/ER/TM-85/R3). The Ecological Indicator Soil Concentrations for soil biota are based on benchmarks published in ORNL's *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision* (ES/ER/TM-126/R2).

Wildlife (Birds and Mammals). Bird and mammal TRVs for both the NOAELs and LOAELs, used in the SSL and PRG development, were obtained from various sources and focus was given to the most recent sources and those derived or endorsed by EPA and Ecology (as evidenced by their use in either Eco-SSLs or in MTCA [WAC 173-340]). The primary literature source used was Eco-SSLs. The toxicity studies used were selected initially from the following sources, which have been listed in order of preference:

- Office of Solid Waste and Emergency Response (OSWER) Directives:
  - 9285.7-56, Ecological Soil Screening Levels for Dieldrin: Interim Final
  - 9285.7-57, Ecological Soil Screening Levels for DDT and Metabolites: Interim Final
  - 9285.7-60, Ecological Soil Screening Level for Aluminum: Interim Final
  - 9285.7-61, Ecological Soil Screening Levels for Antimony: Interim Final
  - 9285.7-62, Ecological Soil Screening Levels for Arsenic: Interim Final
  - 9285.7-63, Ecological Soil Screening Levels for Barium: Interim Final
  - 9285.7-64, Ecological Soil Screening Levels for Beryllium: Interim Final
  - 9285.7-65, Ecological Soil Screening Levels for Cadmium: Interim Final
  - 9285.7-66, Ecological Soil Screening Levels for Chromium: Interim Final
  - 9285.7-67, Ecological Soil Screening Levels for Cobalt: Interim Final
  - 9285.7-68, Ecological Soil Screening Levels for Copper: Interim Final

  - 9285.7-69, Ecological Soil Screening Level for Iron: Interim Final
  - 9285.7-70, Ecological Soil Screening Levels for Lead: Interim Final
  - 9285.7-71, Ecological Soil Screening Levels for Manganese: Interim Final
  - 9285.7-72, Ecological Soil Screening Levels for Selenium: Interim Final
  - 9285.7-73, Ecological Soil Screening Levels for Zinc: Interim Final
  - 9285.7-75, Ecological Soil Screening Levels for Vanadium: Interim Final
  - 9285.7-76, Ecological Soil Screening Levels for Nickel: Interim Final
  - 9285.7-77, Ecological Soil Screening Levels for Silver: Interim Final
  - 9285.7-78, Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs): Interim Final
- MTCA (WAC 173-340), Table 749-5
- Other available literature—primarily *Toxicological Benchmarks for Wildlife: 1996 Revision* (ES/ER/TM-86/R3)
- NOAEL and LOAEL values selected for chemicals and reported in Integrated Risk Information System
- NOAEL and LOAEL values presented in Wildlife Toxicity Assessments developed by United States Army Center for Health Promotion and Preventive Medicine

For analytes with Eco-SSLs for birds and mammals, the NOAEL used to derive the final Eco-SSL was selected as the NOAEL for SSL development. In some cases, this value was the highest NOAEL below the lowest LOAEL for studies evaluating growth and reproduction endpoints. In these cases, the paired LOAEL from the study was selected as the LOAEL for this risk evaluation. In other cases, the geometric mean of the NOAELs for growth and reproduction endpoints was selected to derive the Eco-SSL. A LOAEL in these cases was selected as the lowest LOAEL above the geometric mean NOAEL. In rare cases (e.g., arsenic TRVs for birds), a study not cited in the available Eco-SSLs, was selected because the study was of higher quality and had more ecologically relevant endpoints than those used to develop the Eco-SSL values.

For analytes lacking Eco-SSLs, other primary and secondary sources of studies were utilized. Whenever possible, the primary literature sources were obtained and evaluated. Appropriate toxicity studies were selected from these sources based on several criteria:

- Studies were of chronic exposures or exposures during a critical stage of life (e.g., reproduction).
- Exposure was oral through food ingestion to ensure data were representative of oral exposures expected for wildlife in the field.
- Emphasis was placed on studies of reproductive impacts to ensure relevancy to population level effects.
- Studies presented adequate information to evaluate and determine the magnitude of exposure and effects (or no-effects concentrations).

Specifically, toxicity studies were selected to serve as the TRV if exposure was chronic or during reproduction (a critical life stage), the dosing regime was sufficient to identify both a NOAEL and a LOAEL, and the study considered ecologically relevant effects (e.g., growth, reproduction, or survival). If multiple studies for a given COPC meet these criteria, the study generating the lowest reliable toxicity value was selected to be the TRV. The selected bird and mammal TRVs and study descriptions are presented in Appendix H, Tables H-1 and H-2, respectively.

7.3.2 Exposure Assessment

A summary of the exposure assessment for plants and invertebrates, wildlife, and radionuclide exposures is provided below. Additionally, a brief description of SSL development is provided.

7.3.2.1 Terrestrial Plants and Soil Invertebrates

Terrestrial plants and soil invertebrates experience exposure primarily through the soil in which they live. This exposure occurs because of living in a contaminated medium (i.e., receptors are directly exposed to COPCs). Although other exposure pathways (e.g., dietary exposure for invertebrates or foliar uptake) may contribute to total exposure for these receptors, exposure through the soil predominates. Consequently, estimates of exposure for terrestrial plants and soil invertebrates are represented directly by the concentration of COPCs in the soil (mg/kg).

7.3.2.2 Wildlife (Birds and Mammals)

In contrast to plants and soil invertebrates, birds and mammals experience chemical exposure through multiple pathways, including ingestion of surface water and sediment/soil and biotic media (food), in addition to inhalation and dermal contact. To assess this multiple pathway exposure, modeling can be/or is often employed. The product, or exposure estimate, for birds and mammals is a dosage (amount of chemical in milligrams per kilogram receptor body weight per day [mg/kg/day]). Following is the general form of the model used to estimate exposure of birds and mammals to chemicals in environmental media (Suter et al., 2000):

$$E_t = E_o + E_d + E_i$$

where:

E_t = the total chemical exposure experienced by wildlife
E_o = oral exposure
E_d = dermal exposure
E_i = inhalation exposure

As described in *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-00784) and *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* (CHPRC-01311), both dermal and inhalation exposure were assumed negligible. Additionally, exposure pathways associated with water were not addressed because drinking water sources for wildlife are not available at the 300 Area waste sites. Therefore, only oral exposures via ingestion of soil and food were included in the development of risk-based concentrations for birds and mammals. By replacing E_o with a generalized exposure model modified from *Ecological Risk Assessment for Contaminated Sites* (Suter et al., 2000) to include only soil and food ingestion, the previous equation was rewritten as follows:

$$E_t = \left[\left[\sum_{i=1}^{n} B_{ij} \times P_i \times FIR\right] + \left[Soil_j \times P_s \times FIR\right]\right] x\, AUF$$

where:

E_t	=	total exposure (mg/kg/day)
$Soil_j$	=	chemical concentration in soil (mg/kg dry weight)
P_s	=	soil ingestion rate as proportion of diet (unitless)
FIR	=	food intake rate (kg food/kg body weight/day, dry weight)
B_{ij}	=	chemical concentration in biota type (i) (mg/kg, dry weight)
P_i	=	proportion of biota type (i) in diet (unitless)
AUF	=	area use factor (area of site/home range of receptor) (unitless).

The bird and mammal effects data (Section 7.3.1.1) were combined with the wildlife exposure model to calculate avian/mammal SSLs and PRGs for nonradionuclides. These SSLs and PRGs consist of soil concentrations that are associated with estimated dietary exposures equivalent to a selected effect level, and were calculated using the following basic equation:

$$1 = \frac{TRV}{\sum (SSLorPRG \times DFI) \times \left[(Frac_v \times C_v) + (Frac_i \times C_i) + (Frac_m \times C_m) + (Frac_s)\right]}$$

where:

TRV	=	toxicity reference value (mg/kg body weight/day)
SSL	=	soil screening level (mg/kg)
PRG	=	preliminary remediation goal (mg/kg)
$Frac_v$	=	fraction of diet represented by vegetation (unitless)
DFI	=	daily ingestion rate of all food items (kg/kg body weight/day dry wt.)
C_v	=	concentration in vegetation tissue (mg/kg dry wt.)
$Frac_i$	=	fraction of diet represented by terrestrial invertebrates (unitless)
C_i	=	concentration in soil invertebrate tissue (mg/kg dry wt.)
$Frac_m$	=	fraction of diet represented by small mammals/birds (unitless)
C_m	=	concentration in small mammal tissue (mg/kg dry wt.)
$Frac_s$	=	fraction of diet represented by incidentally ingested soil (unitless)

The TRV denotes the level of toxicity of the chemical, as reported from literature sources. The wildlife SSLs and PRGs use the LOAELs, which is consistent with protecting ecological receptors at the population and community level. The daily ingestion rate and dietary fractions are specific to bird and mammal receptors identified for the upland environment of the Hanford Site. The chemical concentration in the food item (vegetation, soil invertebrate, and small mammal) is estimated by using BAFs or bioaccumulation regression models to extrapolate to the food source. This equation is solved for wildlife SSLs or PRGs using the Microsoft Office Excel® goal-seek tool, such that exposure (the denominator) equals the TRV (the numerator).

For the purposes of this risk assessment, the LOAEL-based wildlife SSLs and wildlife PRGs were used to evaluate residual risks at the 300 Area Source OUs remediated waste sites. The SSLs and PRGs were compared to EPCs developed for the 300 Area as described in Section 7.4.1 below.

® Microsoft Office Excel is a registered trademark of Microsoft Corporation.

Wildlife Exposure Factors. Species-specific exposure parameters are required to estimate exposure. These include body weight, food ingestion rate, diet composition represented by dietary fractions, and percent or fraction of diet as incidental soil ingestion. The following assumptions were part of the calculation of wildlife exposures used to develop the wildlife SSLs and wildlife PRGs:

- For the purposes of this supplemental ecological risk evaluation, 100 percent site use was conservatively assumed, resulting in an AUF of 1.
- Incidental soil ingestion was not included as part of the total dietary composition, but instead was added to the total; for calculation purposes, it was treated as a percentage of total dietary intake.
- All animals were assumed year-round residents, and migration away from areas contaminated with COPCs was not assumed to occur.
- Bioavailability of analytes was assumed equivalent to the chemical form used for developing TRVs in the toxicity studies.
- 100 percent of the estimated soil concentrations (the EPCs) were assumed bioavailable for uptake into tissues within the exposure models.

The exposure parameters and source references used for each representative receptor species are summarized in Appendix H, Table H-3. All weight-based exposure parameters are listed on a dry-weight basis. Species-specific biological information was unavailable for some parameters. When this occurred, allometric equations that express general biological relationships for broader classes of animals were used to estimate the exposure parameters ("Food Requirements of Wild Animals: Predictive Equations for Free-living Mammals, Reptiles, and Birds" [Nagy, 2001]). These allometric conversions are detailed in the Environmental Calculation document (Appendix G).

Estimation of Bioaccumulation into Food Items. The bioaccumulation models and assumptions for calculation of wildlife SSLs and PRGs are as follows:

- **SSL**—the concentrations of COPCs in each food item were estimated rather than measured. For the purposes of exposure estimation, partitioning of analytes from environmental media to prey was estimated from literature values and models. The models presented in the EPA Eco-SSLs methodology (*Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* [OSWER Directive 9285.7-55]) were used preferentially for estimation of bioaccumulation into biota from soil. Consistent with the approach employed for the Eco-SSLs, regression-based models (if available) and median BAFs from the source selected by EPA were used. In the absence of applicable bioaccumulation models, a default value of 1 was assumed. In all cases, it was assumed that tissue uptake occurs under steady state conditions. Bioaccumulation models used to derive wildlife SSLs are presented in Appendix H, Table H-4.
- **PRG**—Development of the PRGs for birds and mammals focused on the integration of available site-specific bioaccumulation data for plants, terrestrial arthropods and small mammals with data from existing bioaccumulation models (i.e., those from *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* [OSWER Directive 9285.7-55] used to develop the Eco-SSLs) to develop a set of partially-site-specific bioaccumulation models[3]. The following Hanford Site-specific and literature-based data sets were used to develop the partially-site-specific bioaccumulation models:

[3] These bioaccumulation models are defined as partially site-specific because they are based on both site-specific data and data from published literature sources. This combining of Hanford Site-specific and literature data was

- Hanford Site-specific bioaccumulation data have been collected in support of the RCBRA and other projects at the site. Data representing tissue from terrestrial plants (foliage, shoots, and other aboveground parts of grasses, shrubs, and trees), small mammals (whole single mice or composites of multiple whole mice), and terrestrial arthropods (whole single or composites of multiple whole invertebrates), and collocated soil data were extracted from HEIS. Only paired samples in which the target analytes were detected in both tissue and in soil were retained for the bioaccumulation database; observations in which either soil or tissue concentrations were below detection limits were excluded from consideration.

- Data from previously developed and published bioaccumulation models for plants and small mammals were used to augment the Hanford Site-specific data. Specifically, the plant bioaccumulation database from *Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants* (BJC/OR-133) and "Ecotoxicity Test Data for Total Petroleum Hydrocarbons in Soil: Plants and Soil-Dwelling Invertebrates" (Efroymson et al., 2004) was used. In addition, the small mammal bioaccumulation database from *Development and Validation of Bioaccumulation Models for Small Mammals* (ES/ER/TM-219) was used. Electronic copies of the original databases were obtained from the authors to facilitate integration with Hanford Site-specific data.

- Estimating exposures to insectivorous or omnivorous wildlife involved estimating bioaccumulation into soil invertebrates. Soil invertebrate bioaccumulation models used for SSLs consisted of the earthworm models from "Literature-Derived Bioaccumulation Models for Earthworms: Development and Validation" (Sample et al., 1999), and *Development and Validation of Bioaccumulation Models for Earthworms* (ES/ER/TM-220). Hanford Site-specific observations (as detailed in the RCBRA Report [DOE/RL-2007-21] and *Central Plateau Ecological Risk Assessment Data Package Report* [DOE/RL-2007-50]) indicate that earthworms are nonexistent in upland soils, and have little or no contribution to the invertebrate portion of bird and mammal diets at the Hanford Site. Rather, insects and other arthropods (e.g., beetles, ants, spiders, etc.) are the primary prey of invertebrate-feeding birds and mammals at the Site. Consequently, the data collected to address site-specific bioaccumulation into invertebrate prey of birds and mammals focused on arthropods (RCBRA Report [DOE/RL-2007-21]). Additional bioaccumulation data for terrestrial arthropods were identified and extracted from published literature to supplement the Hanford Site-specific data.

- A literature search was performed for studies that reported chemical concentrations in co-located biota and media samples. Literature databases searched included those hosted by EPA (*ECOTOXicology database*), and the U.S. National Library of Medicine (TOXLINE: Toxicology Data Network).

- The Hanford Site-specific plant, soil invertebrate, and small mammal data were integrated with the literature-derived bioaccumulation data. Bioaccumulation analyses were performed once biota data were converted to standard units (mg/kg-dry weight). Analyses were restricted to observations where the chemical of interest was detected in both soil and the matched tissue sample; all observations in which either soil or tissue concentrations were nondetects were excluded from the analyses. Analyses consisted of development of BAFs and nonlinear regression analyses. BAFs are simply the ratio between concentrations measured in tissue and that in soil. BAFs for all paired soil-tissue observations and summary statistics (arithmetic mean, standard deviation, minimum, maximum, median, and 90th percentile) were calculated.

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performed to maximize utility of the Hanford Site-specific data collected over comparatively narrow concentration ranges by expanding the data set to include literature data collected across a wider concentration range.

- To evaluate if a log-linear relationship between the chemical concentration in soil and that in terrestrial biota existed, simple log-linear regressions were performed using SAS PROC REG (*SAS/STAT User's Guide* [SAS Institute, 1999]). Chemical concentrations in both soil and biota tissues were transformed to natural-log (ln) prior to regression analyses. Regression analyses were considered significant and suitable for estimation purposes if all three of the following criteria were met: $p \geq 0.05$, $r^2 > 0.1$, and a positive slope. If regression analyses did not meet any one of these criteria, the median BAFs were used to estimate tissue concentrations in exposure models.

The wildlife SSLs are presented in Table 7-2 and the wildlife PRGs (metals only) are presented in Table 7-3. For the purposes of this supplemental risk evaluation, the LOAEL-based SSLs were used to evaluate residual risks at the 300 Area remediated waste sites. To focus the evaluation down to those COPEC-receptor-waste sites combinations that might require further evaluation, the SSLs were compared to EPCs developed for the 300 Area as described in Section 7.4.1. Then, to identify which COPEC-receptor-waste sites combinations should be brought forward to the SMDP, PRGs were compared to EPCs for COPCs that exceeded SSLs and background as described in Section 7.4.3.

7.3.2.3 Radionuclide Exposures

Exposure to radionuclides differs from chemical exposure. Terrestrial biota receives exposure to radionuclides through a combination of both internal and external pathways. Internal exposure is a function of radiation emitted from radionuclides that are retained in tissues. At a terrestrial site such as the 300 Area, external exposure is due to radiation from radionuclides in soil with which biota come into contact (or come near). For the purposes of developing SSLs, radionuclide exposure was estimated based on the internal and external radiation exposure models used to develop BCGs as described in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002).

The BCGs for terrestrial plants and animals represent SSLs for radionuclides in soil for assessing ecological risks at the 300 Area OUs waste sites (Table 7-1). The BCGs for radionuclides use conservative assumptions for internal and external exposure. While existing effects data support the application of these dose limits to representative individuals within populations of plants and animals, the assumptions and parameters applied in the derivation of the BCGs are based on a maximally exposed individual, representing a conservative approach for screening purposes. The following assumptions are used for estimating doses from external exposure for purposes of developing BCGs:

- The source medium is infinite in extent and contains uniform concentrations of radionuclides (i.e., there are no "hot spots").
- The exposed organism is very small; consequently, 100 percent of the radionuclide energies are absorbed.
- Organisms exposed to soil are uniformly surrounded by the source medium.

The following assumptions are used in estimating doses from internal exposure for purposes of developing BCGs:

- All radionuclide decay energies are retained in tissue (100 percent of energies absorbed).
- Exposure for a given radionuclide includes all decay chain progeny.
- All radionuclides are uniformly distributed such that all target tissues may be affected.

7.3.3 PRGs

The PRGs presented in this report represent Hanford Site-specific values. Much of the modeling used to develop PRGs for wildlife is presented in this report as the PRGs build on the SSLs (*Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [CHPRC-00784]), using the same receptors, exposure models, life history parameters, and TRVs. Use of bioaccumulation models that reflect a food chain for an arid environment such as the Hanford Site and integration of Hanford Site-specific bioaccumulation data represent the differences between the SSLs and PRGs.

The development of PRGs corresponds to an exposure and effects assessment, conducted as part of a baseline ecological risk assessment within ERAGS (EPA 540-R-97-006), and reflects OSWER Directive 9385.7-28P, *Ecological Risk Assessment and Management Principles for Superfund Sites*, which encourages the use of site-specific ecological risk data to support cleanup decisions, whenever practicable. The process for development of PRGs also is consistent with Ecology's "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493). These PRGs are intended to be applied to all upland environments across the Hanford Site. Though additional receptors may also be present in riparian areas, the wildlife PRGs and the supporting bioaccumulation and exposure models and TRVs are applicable for riparian areas and can be used in conjunction with values for those additional receptors.

Wildlife PRGs are presented in Table 7-3. PRGs were researched for inorganic and organic constituents, but not radionuclides. Ultimately, PRGs were only recommended for inorganics, as data were limited for organics. Confidence in the PRGs as a whole is greater than for the SSLs as they were developed specifically for use at Hanford using site-specific data. Relative to each other, confidence in some PRGs is greater than in others. The additional confidence is due to a combination of the total number of Hanford Site-specific paired soil and tissue samples and the strength of the relationship between tissue and soil concentration (correlation). Details regarding the confidence in specific PRGs were included in the SMDP in Section 7.5 as needed.

PRGs for plants and invertebrates are presented in Table 7-4. The plant and soil invertebrate PRGs were selected from among the following sources:

- Hanford Site-specific values from bioassays conducted in 2011 (*Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site* [ECF-HANFORD-11-0158] Appendix H)
- Published values from Ecology and EPA
- Hanford Site-specific values previously established for the RCBRA Report (DOE/RL-2007-21)
- Values recently published by Ecology for the based on Hanford Site-specific bioassays (*Ecological Soil Screening Levels for Arsenic and Lead in the Tacoma Smelter Plume Footprint and Hanford Site Old Orchards Ecology* [Ecology Publication 11-03-006])
- Values published by ORNL (*Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision* [ES/ER/TM-85/R3] and *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision* [ES/ER/TM-126/R2])
- Hanford Site-specific background

Table 7-3. PRGs for Wildlife (Birds and Mammals)

Analyte Group	Analyte	Units	California Quail	Western Meadowlark	Killdeer	Red-Tailed Hawk	Lowest Avian PRG	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	Lowest Mammal PRG	Lowest Wildlife PRG
General Inorganic	Fluorine	mg/kg	NBD	2,686	**845**	11,074	845	NBD	3,877	4,061	13,833	3,877	845
Metal	Silver	mg/kg	4,238	3,973	**983**	20,186	983	24,465	9,806	14,362	30,778	9,806	983
Metal	Aluminum	mg/kg	19,217	31,220	7,214	74,599	7,214	4,883	**3,988**	13,059	7,811	3,988	3,988
Metal	Arsenic	mg/kg	4,776	7,403	2,284	40,102	2,284	201	**127**	302	847	127	127
Metal	Boron	mg/kg	248	144	91	2,714	91	122	**91**	170	2,516	91	91
Metal	Barium	mg/kg	1,721	2,335	**1,687**	8,101	1,687	2,265	2,617	11,873	12,430	2,265	1,687
Metal	Beryllium	mg/kg	NTD	NTD	NTD	NTD	NTD	**18**	22	181	NBD	18	18
Metal	Cadmium	mg/kg	294	103	**29**	1,711	29	2,203	624	858	4,704	624	29
Metal	Cobalt	mg/kg	1,397	2,050	**484**	4,798	484	2,901	2,136	5,610	4,234	2,136	484
Metal	Chromium	mg/kg	193	221	**109**	2,595	109	544	517	1,424	4,918	517	109
Metal	Copper	mg/kg	2,020	1,532	**213**	12,881	213	2,176	579	1,217	4,631	579	213
Metal	Mercury	mg/kg	36	4.7	2	92	2	7.9	**1.6**	1.8	33	1.6	1.6
Metal	Lithium	mg/kg	--	--	--	--	--	**1,664**	1,797	8,347	6,522	1,664	1,664
Metal	Manganese	mg/kg	20,746	26,026	14,407	150,899	14,407	**3,322**	3,467	11,780	21,916	3,322	3,322
Metal	Molybdenum	mg/kg	125	117	95	515	95	5.9	**5.7**	14	38	5.7	5.7
Metal	Nickel	mg/kg	2,051	1,127	361	11,625	361	711	**247**	342	1,520	247	247
Metal	Lead	mg/kg	559	664	**156**	2,300	156	2,672	1,578	3,807	3,966	1,578	156
Metal	Antimony	mg/kg	--	--	--	--	--	231	**146**	366	NBD	146	146
Metal	Selenium	mg/kg	10	4.9	2.4	24	2	2.7	**1.4**	1.9	8.8	1.4	1.4
Metal	Strontium (Elemental)	mg/kg	--	--	--	--	--	**1,214**	1,449	6,540	8,256	1,214	1,214
Metal	Tin	mg/kg	97	98	**84**	335	84	130	133	365	693	130	84
Metal	Thallium	mg/kg	--	--	--	--	--	8.7	**6.2**	12	25	6.2	6.2
Metal	Uranium (Calculated Total)	mg/kg	2,002	339	139	82	82	812	123	119	**40**	40	40
Metal	Vanadium	mg/kg	81	107	**43**	505	43	260	297	4,531	3,596	260	43
Metal	Zinc	mg/kg	6,289	4,662	**856**	906	856	6,711	3,331	12,666	1,037	1,037	856

Table 7-3. PRGs for Wildlife (Birds and Mammals)

Analyte Group	Analyte	Units	California Quail	Western Meadowlark	Killdeer	Red-Tailed Hawk	Lowest Avian PRG	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	Lowest Mammal PRG	Lowest Wildlife PRG

Notes: **Bold values** represent lowest PRG for that analyte.

Shaded values are based on NOAELs due to the lack of LOAELs.

NBD = no (or incomplete) bioaccumulation data (for estimation of dietary exposure)

NTD = No toxicity data (for selected analyte)

PRG = preliminary remediation goal

Table 7-4. Final Recommended Soil PRGs for Plants and Invertebrates

Chemical	Plant NOEC (mg/kg)	Invertebrate NOEC (mg/kg)
Antimony	842	842
Arsenic	128	128
Barium	500	358
Beryllium	10	40
Boron	29.6	58
Cadmium	9.84	20
Chromium	259	149
Cobalt	15.7	15.7
Copper	70	58
Lead	9090	1700
Manganese	1260	1260
Mercury	0.3	12.5
Molybdenum	2	28
Nickel	38	280
Selenium	2.02	4.1
Silver	560	2.99
Thallium	1	0.459
Tin	838	838
Uranium	250	100
Vanadium	89.4	116
Zinc	621	8980

NOEC = no observed effect concentration
PRG = preliminary remediation goal

The final recommended PRG represented the most appropriate value, which was that PRG of the highest confidence or the lower of two values with equally high confidence. The site-specific values are preferred over those from published literature in that they reflect the potential for toxicity under conditions found at the site. However, with some COPECs, site-specific sampling efforts were unable to obtain concentration ranges above those form published literature. With all of the site-specific studies conducted for the RCBRA, by Ecology, and recently by CH2M HILL Plateau Remediation Company in the central plateau,

toxicity to plants and invertebrates was not observed and recommended toxicological values are unbound NOECs. Hence, in some cases, published literature values were selected as PRGs over site-specific values. Final selection of the PRGS for plants and invertebrates is discussed in detail in *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site* (ECF-HANFORD-11-0158). As with the wildlife PRGs, details regarding the confidence in specific PRGs were included in the SMDP in Section 7.5 as needed.

7.3.4 Estimation of Exposure Point Concentrations in Waste Sites

A total of 38 interim remediated waste sites at the 300 Area were verification sampled and data were included in this supplemental risk evaluation.

Section 6.1.2 details the computation of the EPCs for the waste sites at the 300 Area. Briefly, the 95 percent UCL of the arithmetic mean was calculated as the EPC for each decision unit (shallow, overburden, and footprint staging pile soil) within each waste site. Two separate statistical evaluations were performed, one used for the closeout documentation and one used for human health and ecological risk evaluations, as follows:

- **Statistical Evaluation Used for Closeout Documentation:** For the closeout documentation, the primary statistical calculation to support cleanup verification was the 95 percent UCL on the arithmetic mean of the data. As in *Statistical Guidance for Ecology Site Managers* (Ecology Publication 92-54), a 95 percent UCL on the mean based on the Student's t-test statistic was used for normally distributed data, and the Land method (WSDOE, 1992) using the H-statistic was used for lognormal data. This guidance also employs the use of proxy values of one-half the detection limits for nondetect values. For small data sets (n<10), the calculations were performed assuming a nonparametric distribution, so no test for distribution was performed (i.e., the maximum detected concentration was used as the EPC).

- **Statistical Evaluation Used for Soil Risk Evaluation:** Both *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10) (the most recent EPA guidance for UCL calculation) and ProUCL 4.00.05 were used to recalculate EPCs for the human health and ecological risk evaluations of the 300 Area OUs. Although *Statistical Guidance for Ecology Site Managers* (Ecology Publication 92-54) has been used to calculate EPCs for all closeout documentation to date, EPCs were recalculated according to *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (OSWER 9285.6-10). This was to allow for the use of more rigorous statistical methods to estimate exposure concentration and to eliminate the use of the one-half the detection limit used in *Statistical Guidance for Ecology Site Managers* (Ecology Publication 92-54), which has the potential to underestimate exposure concentrations.

The process used to calculate EPCs for each waste site and decision unit is documented in *Computation of Exposure Point Concentrations for the 300-FF-2 Source Operable Unit* (ECF-300NPL-11-0037, Appendix G) to document the data processing and reduction steps, methodology, decision logic, assumptions, input files, and output files used to determine the EPCs. A summary of EPCs generated for use in this evaluation for each waste site, decision unit, and detected analyte at the 300 Area is provided in Appendix H, Table H-5.

7.4 Risk Characterization

The outcome of this step is a list of COPECs for each medium-pathway-receptor combination evaluated. Risks at the 300 Area OU waste sites were estimated using the HQ method as follows:

$$HQ = EPC/SSL \text{ or } PRG$$

where:

HQ = ecological hazard quotient (unitless)

EPC = soil concentration (µg/kg for nonradionuclides and pCi/g for radionuclides)

SSL = plant/invertebrate or wildlife soil screening level (µg/kg for nonradionuclides and pCi/g for radionuclides)

PRG = plant/invertebrate or wildlife preliminary remediation goal (µg/kg for nonradionuclides

HQ values less than 1.0 indicate that adverse effects associated with exposure to a given analyte are unlikely (ERAGS [EPA 540-R-97-006]). These analytes were not considered to present a significant risk and were excluded from further evaluation. An HQ greater than or equal to 1.0 indicates data are insufficient to exclude the potential for risk, but does not indicate that risks are actually present; therefore, these COPCs were carried forward for further evaluation.

In the screening evaluation, the soil EPC for each waste site and decision unit (as applicable) was compared to the plant/invertebrate SSL and the wildlife SSL for all COPCs. The HQs for these comparisons are provided in Appendix H, Table H-5. COPCs with HQs equal to or greater than 1.0 were carried forward to the background comparison for further evaluation. COPCs for which appropriate toxicity data were unavailable were not evaluated further, but were retained as uncertainties. In some instances (Aroclors), HIs were calculated to capture known additive effects.

Because the dose from radionuclides and Aroclors are additive, the total contributions of radionuclides and Aroclors were also calculated using SOF and HI respectively. With the SOF and HI methods, contributions were considered significant if the EPC was greater than the SSL. The SOF method and HI equation is as follows:

$$\text{HI or SOF} = \sum_{j=1}^{n} \text{Exposure}_j / \text{SSL}_j$$

where:

HI = hazard index
SOF = sum-of-fractions
Exposure_j = exposure concentration for radionuclides
SSL_j = soil screening level for radionuclides

For the purposes of this evaluation, the HQs for each radionuclide and each Aroclor were summed within each decisional unit to equal an SOF or HI, respectively. If the SOF or HI was greater than 1, then individual detected radionuclide isotope COPCs or individual detected Aroclor COPCs were carried forward to the background evaluation.

For those COPCs that exceeded one or more SSLs, the EPC was then compared to the background value and summarized in the subsequent table (Appendix H, Table H-6), in Section 7.4.2. Because the plant/invertebrate and/or wildlife SSL values for 10 COPCs (arsenic, boron, lithium, mercury, manganese, molybdenum, selenium, strontium, thallium, and uranium) were higher than the corresponding PRG values, these COPCs were reviewed to confirm they were below both the SSL and PRG. Any of these 10 COPCs greater than either the SSL or PRG were then carried into the background evaluation.

Background concentrations for inorganic analytes in soil at the Hanford Site are described in the Non-Rad Soil Background document (DOE/RL-92-24). That document provides the 90th percentile background concentrations for several inorganic analytes. For selected inorganic analytes not included in the Non-Rad Soil Background document (DOE/RL-92-24), the 90th percentile concentrations were obtained from PNNL as summarized in *Soil Background Data for Interim Use at the Hanford Site* (ECF-HANFORD-11-0038), and in the 100 Area RDR/RAWP (DOE/RL-96-17) for uranium. Background concentrations for radiological analytes in soil at the Hanford Site are described in the Rad Soil Background document (DOE/RL-96-12), which provides the 90th percentile concentration of background concentrations for several radiological analytes. Background concentrations were not identified for organics. Therefore, those with HQs greater than or equal to 1.0 were carried forward. COPC EPCs less than the 90th percentile were excluded from further evaluation. In addition, COPCs with concentrations outside of the range of site background were carried forward for comparison to the PRGs.

In the PRG evaluation, the soil EPC for each waste site and decision unit (as applicable) was compared to the plant/invertebrate PRG and the wildlife PRG for all remaining COPCs. COPCs with HQs equal to or greater than 1.0 were retained as COPECs. COPECs were then given further consideration under the SMDP. The methodology used in this step of the risk characterization is provided in Appendix H (*ECF-300NPL-11-0139, Ecological Risk Evaluation for the 300-FF-2 Source Operable Unit* [ECF-300NPL-11-0137]).

7.4.1 Screening Evaluation Results

The comparisons to plant/invertebrate and wildlife SSLs are provided in Appendix H, Table H-5 for the 300 Area OUs. A detailed description of the results of the screening evaluation (i.e., comparison of EPCs with SSLs) in soil is provided below and summary of exceedances is in Table 7-5.

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
300-10_Shallow_Focused	Arsenic (1.35e00)	--	Arsenic (1.35e00)	--
300-109_Shallow_Focused	Boron (1.26e00) Chromium (1.74e01) Manganese (1.26e00) Vanadium (2.38e01)	Vanadium (1.53e00)	--	--
300-109_Staging Pile Area_Focused	Boron (2.12e00) Chromium (2.04e01) Manganese (1.30e00) Total Uranium Isotopes (1.38e00) Vanadium (2.26e01)	Vanadium (1.45e00)	Total Uranium Isotopes (1.38e00)	--
300-18_Shallow	Chromium (1.73e01)	--	--	--

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
300-259_Shallow	Boron (2.61e00) Chromium (1.98e01) Manganese (1.45e00) Vanadium (2.13e01) Zinc (9.59e00)	Vanadium (1.37e00) Zinc (7.07e00)	Zinc (9.59e00)	Zinc (7.07e00)
300-260_Shallow_Focused	Boron (1.67e01) Chromium (2.47e01) Copper (1.47e00) Manganese (1.49e00) Total Uranium Isotopes (2.56e00) Vanadium (2.95e01) Zinc (1.55e00)	Vanadium (1.90e00) Zinc (1.14e00)	Boron (1.67e01) Copper (1.47e00) Total Uranium Isotopes (2.56e00) Zinc (1.55e00)	Zinc (1.14e00)
300-275_Shallow_1	Boron (2.93e00) Chromium (2.01e01) Lithium (3.34e00) Manganese (1.26e00) Total Uranium Isotopes (4.45e00) Vanadium (2.26e01)	Vanadium (1.45e00)	Total Uranium Isotopes (4.45e00)	--
300-275_Shallow_2	Boron (2.29e00) Chromium (2.25e01) Lithium (3.53e00) Manganese (1.33e00) Vanadium (2.58e01)	Vanadium (1.66e00)	--	--
300-33, 300-41, 300-256_Shallow	Boron (2.97e00) Chromium (2.20e01) Lithium (2.75e00) Manganese (1.43e00) Total Uranium Isotopes (1.07e00) Uranium (1.45e00) Vanadium (2.63e01)	Vanadium (1.69e00)	Total Uranium Isotopes (1.07e00) Uranium (1.45e00)	--
300-33, 300-41, 300-256_Shallow_Focused	Boron (2.06e00) Chromium (2.02e01) Lithium (3.29e00) Manganese (1.18e00) Total Uranium Isotopes (1.29e00) Vanadium (2.57e01)	Aroclor-1248 (1.02e00) Aroclor HI (1.32e00) Vanadium (1.65e00)	Total Uranium Isotopes (1.29e00)	Aroclor-1248 (1.02e00) Aroclor HI (1.32e00)

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
300-37_Shallow_Focused	--	Aroclor-1260 (2.18e00) Aroclor HI (2.25e00)	--	Aroclor-1260 (2.18e00) Aroclor HI (2.25e00)
300-44_Shallow_Focused	Arsenic (1.69e00) Chromium (2.33e01) Manganese (1.38e00) Vanadium (2.16e01)	Vanadium (1.39e00)	Arsenic (1.69e00)	--
300-49_Overburden	Chromium (4.53e01) Copper (1.07e01) Manganese (1.44e00) Vanadium (2.52e01) Zinc (2.84e00)	Aroclor-1254 (2.05e00) Copper (5.01e00) Lead (1.04e00) Vanadium (1.62e00) Zinc (2.09e00)	Copper (1.07e01) Zinc (2.84e00)	Aroclor-1254 (2.05e00) Copper (5.01e00) Lead (1.04e00) Zinc (2.09e00)
300-49_Shallow	Chromium (2.29e01) Manganese (1.64e00) Vanadium (2.93e01) Zinc (1.09e00)	Vanadium (1.89e00)	--	--
300-50_Overburden	Chromium (3.05e01) Copper (1.29e00) Manganese (1.43e00) Total Uranium Isotopes (3.58e00) Vanadium (2.26e01)	Vanadium (1.45e00)	Copper (1.29e00) Total Uranium Isotopes (3.58e00)	--
300-50_Shallow	Chromium (4.21e01) Manganese (1.45e00) Silver (1.50e00) Total Uranium Isotopes (4.59e00) Vanadium (2.35e01)	Vanadium (1.51e00)	Silver (1.50e00) Total Uranium Isotopes (4.59e00)	--
316-1_Overburden	Total Uranium Isotopes (8.11e00)	--	Total Uranium Isotopes (8.11e00)	--
316-1_Shallow_1	Arsenic (1.90e00) Total Uranium Isotopes (1.66e01)	Aroclor-1248 (9.23e00)	Arsenic (1.90e00) Total Uranium Isotopes (1.66e01)	Aroclor-1248 (9.23e00)

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
316-1_Shallow_3	Chromium (1.26e02) Copper (2.73e01) Manganese (1.79e00) Mercury (1.11e01) Nickel (3.16e00) Selenium (2.78e00) Silver (6.60e00) Total Uranium Isotopes (1.26e01) Vanadium (2.84e01) Zinc (1.64e00)	Chromium (1.32e00) Copper (1.28e01) Nickel (2.90e00) Vanadium (1.82e00) Zinc (1.21e00)	Chromium (1.26e02) Copper (2.73e01) Mercury (1.11e01) Nickel (3.16e00) Total Uranium Isotopes (1.26e01) Selenium (2.78e00) Silver (6.60e00) Zinc (1.64e00)	Chromium (1.32e00) Copper (1.28e01) Nickel (2.90e00) Zinc (1.21e00)
316-1_Shallow_4	Total Uranium Isotopes (8.59e00)	--	Total Uranium Isotopes (8.59e00)	--
316-2_Shallow_1	Total Uranium Isotopes (4.21e01)	--	Total Uranium Isotopes (4.21e01)	--
316-2_Shallow_2	Total Uranium Isotopes (5.83e01)	Aroclor-1248 (2.14e00) Aroclor HI (2.24e00)	Total Uranium Isotopes (5.83e01)	Aroclor-1248 (2.14e00) Aroclor HI (2.24e00)
316-2_Shallow_3	Total Uranium Isotopes (1.46e01)	--	Total Uranium Isotopes (1.46e01)	--
316-5_Shallow_1	Total Uranium Isotopes (5.44e01)	--	Total Uranium Isotopes (5.44e01)	--
316-5_Shallow_2	Chromium (1.73e01) Silver (1.80e00) Total Uranium Isotopes (4.09e01)	--	Silver (1.80e00) Total Uranium Isotopes (4.09e01)	--
316-5_Shallow_Focused	Total Uranium Isotopes (2.76e01)	--	Total Uranium Isotopes (2.76e01)	--
331 LSLDF_Shallow_ Focused	Boron (3.40e00) Chromium (2.58e01) Manganese (1.59e00) Mercury (1.10e00) Vanadium (2.66e01) Zinc (2.74e00)	Vanadium (1.71e00) Zinc (2.02e00)	Mercury (1.10e00) Zinc (2.74e00)	Zinc (2.02e00)

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
600-243_Shallow	Boron (5.89e02) Chromium (4.50e01) Copper (1.08e00) Selenium (1.10e01) Vanadium (2.35e01) Zinc (1.68e00)	Boron (2.21e00) Lead (1.13e00) Selenium (3.00e00) Vanadium (1.51e00) Zinc (1.24e00)	Boron (5.89e02) Copper (1.08e00) Selenium (1.10e01) Zinc (1.68e00)	Boron (2.21e00) Lead (1.13e00) Selenium (3.00e00) Zinc (1.24e00)
600-47_Shallow	Chromium (1.38e01)	--	--	--
618-1_Shallow	Boron (2.38e00) Chromium (1.98e01) Lithium (3.19e00) Manganese (1.36e00) Vanadium (2.82e01)	Vanadium (1.81e00)	--	--
618-1_Shallow_Focused	Boron (7.48e00) Chromium (4.88e01) Lithium (6.65e00) Manganese (1.83e00) Mercury (1.98e00) Total Uranium Isotopes (4.99e00) Uranium (1.42e00) Vanadium (3.24e01) Zinc (1.36e00)	Vanadium (2.08e00) Zinc (1.00e00)	Boron (7.48e00) Chromium (4.88e01) Mercury (1.98e00) Total Uranium Isotopes (4.99e00) Uranium (1.42e00) Zinc (1.36e00)	Zinc (1.00e00)
618-12_Shallow	Total Uranium Isotopes (6.42e00)	--	Total Uranium Isotopes (6.42e00)	--
618-13_Shallow	Boron (2.10e00) Chromium (2.68e01) Manganese (1.56e00) Total Uranium Isotopes (1.01e00) Vanadium (2.79e01)	Vanadium (1.79e00)	Total Uranium Isotopes (1.01e00)	--
618-13_ Shallow_Focused	Boron (1.92e00) Chromium (2.19e01) Manganese (1.22e00) Vanadium (2.43e01)	Vanadium (1.56e00)	--	--
618-2_Overburden	Chromium (1.65e01) Selenium (1.92e00)	--	Selenium (1.92e00)	--

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
618-2_Shallow	Chromium (1.78e01) Selenium (1.46e00) Total Uranium Isotopes (1.17e00)	--	Total Uranium Isotopes (1.17e00)	--
618-2_Staging Pile	Chromium (1.61e01) Total Uranium Isotopes (1.84e00) Uranium (1.00e00)	--	Total Uranium Isotopes (1.84e00) Uranium (1.00e00)	--
618-3_Shallow	Chromium (2.43e01) Selenium (1.27e00)	--	--	--
618-3_Shallow_Focused	Total Uranium Isotopes (4.77e01)	--	Total Uranium Isotopes (4.77e01)	--
618-4_Shallow	Total Uranium Isotopes (1.49e00)	Lead (1.38e00)	Total Uranium Isotopes (1.49e00)	Lead (1.38e00)
618-5_Overburden	Chromium (2.43e01) Total Uranium Isotopes (1.95e00)	--	Total Uranium Isotopes (1.95e00)	--
618-5_Shallow	Chromium (2.83e01)	--	--	--
618-5_Staging Pile_4	Chromium (2.95e01)	--	--	--
618-5_Staging Pile_5	Chromium (2.58e01)	--	--	--
618-7_Shallow_1	Chromium (2.56e01) Manganese (1.48e00) Total Uranium Isotopes (2.16e00) Vanadium (3.73e01)	Vanadium (2.40e00)	Total Uranium Isotopes (2.16e00)	--
618-7_Shallow_2	Chromium (1.70e01) Manganese (1.65e00) Vanadium (3.74e01)	Vanadium (2.40e00)	--	--
618-7_Shallow_3	Chromium (2.53e01) Manganese (1.62e00) Vanadium (3.41e01)	Vanadium (2.19e00)	--	--
618-7_Shallow_4	Chromium (2.85e01) Manganese (1.30e00) Vanadium (2.74e01)	Vanadium (1.76e00)	--	--

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
618-7_Shallow_Focused	Cadmium (1.55e00) Chromium (1.65e02) Manganese (1.93e00) Total Uranium Isotopes (3.91e00) Vanadium (4.03e01) Zinc (1.05e00)	Cadmium (3.80e00) Chromium (1.73e00) Vanadium (2.59e00)	Cadmium (1.55e00) Chromium (1.65e02) Total Uranium Isotopes (3.91e00)	Cadmium (3.80e00) Chromium (1.73e00)
618-8_Shallow	Chromium (3.10e01) Selenium (1.63e00)	--	Selenium (1.63e00)	--
618-9_Shallow_Focused	Arsenic (1.16e00) Chromium (2.43e01) Manganese (1.63e00) Mercury (3.30e00) Total Uranium Isotopes (1.79e00) Vanadium (2.97e01) Zinc (1.05e00)	Aldrin (2.36e00) Aroclor-1016 (1.04e00) Aroclor-1221 (1.29e00) Aroclor-1232 (1.32e00) Aroclor-1242 (1.28e00) Aroclor-1248 (5.85e00) Aroclor-1254 (2.65e00) Aroclor-1260 (2.65e00) Aroclor HI (1.61e+01) Vanadium (1.91e00)	Arsenic (1.16e00) Mercury (3.30e00) Total Uranium Isotopes (1.79e00)	Aldrin (2.36e00) Aroclor-1016 (1.04e00) Aroclor-1221 (1.29e00) Aroclor-1232 (1.32e00) Aroclor-1242 (1.28e00) Aroclor-1248 (5.85e00) Aroclor-1254 (2.65e00) Aroclor-1260 (2.65e00) Aroclor HI (1.61e+01)
628-4_Shallow	Lead (1.98e00)	Aroclor-1248 (3.43e00) Aroclor HI (3.76e00) Lead (2.79e00)	Lead (1.98e00)	Aroclor-1248 (3.43e00) Aroclor HI (3.76e00) Lead (2.79e00)
UPR-300-17_Shallow	Boron (7.81e00) Chromium (3.45e01) Manganese (1.30e00) Nickel (1.88e01) Total Uranium Isotopes (2.48e00) Vanadium (2.61e01) Zinc (3.14e00)	Aroclor-1248 (6.06e00) Aroclor HI (6.44e00) Nickel (1.73e01) Vanadium (1.68e00) Zinc (2.32e00)	Boron (7.81e00) Nickel (1.88e01) Total Uranium Isotopes (2.48e00) Zinc (3.14e00)	Aroclor-1248 (6.06e00) Aroclor HI (6.44e00) Nickel (1.73e01) Zinc (2.32e00)

Table 7-5. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on SSLs and Background for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	SSL-Based Exceedances		Exceedances Based on Comparisons to SSLs and Background*	
	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ	Plant/Invertebrate SSL-Based HQ	Wildlife SSL-Based HQ
UPR-300-46_Shallow	Boron (3.43e00) Chromium (2.54e01) Manganese (1.41e00) Vanadium (2.69e01)	Aroclor-1248 (2.70e00) Aroclor HI (3.09e00) Vanadium (1.73e00)	--	Aroclor-1248 (2.70e00) Aroclor HI (3.09e00)

* 90th percentile of Hanford Site background concentration.

HQ = hazard quotient

LSLDF Life Sciences Laboratory Drainfield

SSL = soil screening level

OU = operable unit

The 300 Area has 38 waste sites evaluated in this screening risk evaluation and reclassified as "interim closed" "closed" or "no action." The plant/invertebrate and wildlife SSL HQs for all 38 waste sites are provided in Appendix H, Table H-5. Radionuclide SOFs and individual radionuclide isotope SSL based HQs were less than 1 for all waste sites; therefore, radionuclide isotopes were eliminated from further evaluation. SSLs, background, and PRGs were not available for nitrogen, dibenzofuran, two pesticides (alpha-BHC and heptachlor epoxide), TPH, nine SVOCs (2-butoxyethanol, 2-chlorophenol, 4-chloro-3-methylphenol, butylbenzylphthalate, di-n-butylphthalate, hexachlorobutadiene, hexachloroethane, n-nitrosodi-n-dipropylamine, and pentachlorophenol), and three VOCs (1,2,4-trichlorobenzene, 1,4-dichlorobenzene, and acetone). These COPCs were retained as an uncertainty, as further discussed in Section 7.4.4. At waste site 300-23, only TPH-motor oil was detected. This site is also discussed in the uncertainty section.

The SSL-based HQs were less than 1.0 for all COPCs in all of the decision units evaluated at 6 of the 38 waste sites. These waste sites did not require further evaluation of ecological risk and are provided below:

- 300 Ash Pits
- 300 VTS
- 300-272
- 300-45
- 300-8
- 600-259

The Aroclor HI was greater than 1 for several sites. All detected individual Aroclors were carried forward from those sites. The EPCs for arsenic, boron, cadmium, chromium, copper, lead, lithium, manganese, mercury, nickel, selenium, silver, total uranium isotopes, uranium, vanadium, zinc, aldrin, Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260 exceeded one

or both of the SSLs. Within the remaining 30 waste sites, EPCs of analytes exceeded the plant/invertebrate SSLs for at least one decision unit, while fewer analytes exceeded the wildlife SSLs. These waste site-decision unit combinations were carried forward into the background evaluation.

7.4.2 Background Evaluation

Although in exceedance of a SSL, EPCs for many of the COPCs within the remaining 30 waste sites were below the 90th percentile background concentrations, so were eliminated from further evaluation. The comparisons of COPC EPCs to the 90th percentile background for the remaining 30 waste sites are provided in Appendix H, Table H-6.

COPCs did not exceed the 90th percentile background concentrations in all of the decision units evaluated at 2 of the remaining 30 waste sites. The two waste sites that did not require further evaluation of ecological risks are provided below:

- 300-18
- 600-47

Within the remaining 28 waste sites, 52 decision units had COPC EPCs in exceedance of both an SSL and background or an unresolved uncertainty. The COPCs arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, total uranium isotopes, uranium, zinc, aldrin, Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260 were either detected outside of the range of background or a background value was not available. These COPCs were carried forward to the PRG evaluation. A summary of exceedances from the SSLs and background evaluations in soil is provided in Table 7-5.

7.4.3 PRG Evaluation Results

Further evaluation was conducted on those waste sites that were not eliminated in the screening and background evaluations. Risks were evaluated based on the resulting PRG-based HQs and are provided and summarized in Table 7-6 and in Appendix H, Table H-7. The following 13 waste sites did not exceed the plant/invertebrate or the wildlife PRGs (HQs were less than 1), and were eliminated from further evaluation:

- 300-10
- 300-109
- 300-259
- 300-275
- 300-44
- 331 LSLDF
- 618-1
- 618-12
- 618-13
- 618-2
- 618-4
- 618-5
- 618-8

Table 7-6. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on PRGs for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	Plant/Invertebrate HQ	Wildlife HQ
300-260_Shallow_Focused	Copper (1.3)	
300-49_Overburden	Copper (9.2)	Copper (2.5)
300-50_Overburden	Copper (1.1)	--
300-8_Shallow	--	--
316-1_Overburden	--	Total Uranium Isotopes (1.0e00)
316-1_Shallow_1	--	Aroclor-1248 (No PRG) Total Uranium Isotopes (2.1e00)
316-1_Shallow_3	Copper (2.3e01) Mercury (3.7e00) Nickel (2.5e00) Silver (4.4e00)	Copper (6.4e00) Selenium (1.0e00) Total Uranium Isotopes (1.6e00)
316-1_Shallow_4	--	Total Uranium Isotopes (1.1e00)
316-2_Shallow_1	Total Uranium Isotopes (2.1e00)	Total Uranium Isotopes (5.2e00)
316-2_Shallow_2	Total Uranium Isotopes (2.9e00)	Aroclor-1248 (No PRG) Aroclors HI (No PRGs) Total Uranium Isotopes (7.2e00)
316-2_Shallow_3	--	Total Uranium Isotopes (1.8e00)
316-5_Shallow_1	Total Uranium Isotopes (2.7e00)	Total Uranium Isotopes (6.7e00)
316-5_Shallow_2	Silver (1.2e00) Total Uranium Isotopes (2.1e00)	Total Uranium Isotopes (5.1e00)
316-5_Shallow_Focused	Total Uranium Isotopes (1.4e00)	Total Uranium Isotopes (3.4e00)
300-33, 300-41, 300-256_Shallow_Focused	--	Aroclor-1248 (No PRG) Aroclors HI (No PRGs)
300-37_Shallow_Focused	--	Aroclor-1260 (No PRG) Aroclors HI (No PRGs)
331 LSLDF_Shallow_Focused	--	--
600-243_Shallow	Boron (9.9e00) Selenium (2.8e00)	Boron (3.3e00) Selenium (4.0e00)
618-1_Shallow	--	--
618-1_Shallow_Focused	--	--
618-13_Shallow	--	--
618-13_Shallow_Focused	--	--

Table 7-6. Summary of 300 Area OUs Waste Sites Ecological Evaluation Based on PRGs for Surface Soils (0 to 15 ft)

Waste Site/Decision Unit	Plant/Invertebrate HQ	Wildlife HQ
618-3_Shallow_Focused	Total Uranium Isotopes (2.4e00)	Total Uranium Isotopes (5.9e00)
618-7_Shallow_1	--	--
618-7_Shallow_2	--	--
618-7_Shallow_3	--	--
618-7_Shallow_4	--	--
618-7_Shallow_Focused	--	--
618-9_Shallow_Focused	Mercury (1.1e00)	Aldrin (3.9e01) Aroclor-1016 (No PRG) Aroclor-1221 (No PRG) Aroclor-1232 (No PRG) Aroclor-1242 (No PRG) Aroclor-1248 (No PRG) Aroclor-1254 (No PRG) Aroclor-1260 (No PRG) Aroclors HI (No PRGs)
628-4_Shallow		Aroclor-1248 (No PRG) Aroclors HI (No PRGs)
UPR-300-17_Shallow	Nickel (1.5e01)	Aroclor-1248 (No PRG) Aroclors HI (No PRGs) Nickel (2.3e00)
UPR-300-46_Shallow	--	Aroclor-1248 (No PRG) Aroclors HI (No PRGs)

PRG = preliminary remediation goal
HQ = hazard quotient

When the SSL-based HI for Aroclors were greater than one within a waste site decision unit, the individual detected Aroclors for that decision unit were carried forward into the PRG evaluation. PRGs were not available for Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260, so these COPCs were carried forward to the SMDP.

Boron, copper, mercury, nickel, selenium, silver, total uranium isotopes, aldrin, Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260 were retained as COPECs due to concentrations exceeding one or both groups of PRGs (plants/invertebrates and wildlife) or because PRGs were not available. These COPCs will be retained as COPECs in one or more of the remaining 20 waste site-decision units (Appendix H, Table H-8).

The risk evaluation identified COPECs for decision units in 13 waste sites due to potential ecological risks to plants or invertebrates, which may be attributable to past site practices. The waste sites listed below move forward into the SMDP considerations described in Section 7.5 and listed in Table 7-7:

- 300-260_Shallow_Focused: Copper
- 300-223_Shallow_Focused: TPH-motor oil[4]
- 300-23_Shallow_Focused: TPH-motor oil
- 300-49_Overburden: Copper
- 300-50_Overburden: Copper
- 316-1_Shallow_3: Copper, Mercury, Nickel, Silver
- 316-2_Shallow_1: Total Uranium Isotopes
- 316-2_Shallow_2: Total Uranium Isotopes
- 316-5_Shallow_1: Total Uranium Isotopes
- 316-5_Shallow_2: Silver, Total Uranium Isotopes
- 316-5_Shallow_Focused: Total Uranium Isotopes
- 600-243_Shallow: Boron, Selenium, TPH-motor oil
- 618-3_Shallow_Focused: Total Uranium Isotopes
- 618-7_Shallow_Focused: TPH-motor oil
- 618-9_Shallow_Focused: Mercury
- UPR-300-17_Shallow: Nickel, TPH-motor oil

The risk evaluation identified COPECs for decision units in 12 waste sites due to potential ecological risks to wildlife that may be attributable to past site practices. The waste sites listed below move forward into the SMDP considerations described in Section 7.5 and listed in Table 7-7 :

- 300-49_Overburden: Copper
- 316-1_Overburden: Total Uranium Isotopes
- 316-1_Shallow_1: Aroclor-1248, Total Uranium Isotopes
- 316-1_Shallow_3: Copper, Selenium, Total Uranium Isotopes
- 316-1_Shallow_4: Total Uranium Isotopes
- 316-2_Shallow_1: Total Uranium Isotopes
- 316-2_Shallow_2: Aroclor-1248, Aroclors HI, Total Uranium Isotopes
- 316-2_Shallow_3: Total Uranium Isotopes
- 316-5_Shallow_1: Total Uranium Isotopes
- 316-5_Shallow_2: Total Uranium Isotopes
- 316-5_Shallow_Focused: Total Uranium Isotopes
- 300-33, 300-41, 300-256_Shallow_Focused: Aroclor-1248, Aroclors HI,

[4] TPH is included for five waste sites based upon results of the uncertainty analysis as described in the Section 7.4.4.

- 300-37_Shallow_Focused: Aroclor-1260, Aroclors HI
- 600-243_Shallow: Boron, Selenium
- 618-3_Shallow_Focused: Total Uranium Isotopes
- 618-9_Shallow_Focused: Aldrin, Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260, Aroclors HI
- 628-4_Shallow: Aroclor-1248, Aroclors HI
- UPR-300-17_Shallow: Aroclor-1248, Aroclors HI, Nickel
- UPR-300-46_Shallow: Aroclor-1248, Aroclors HI
- UPR-300-17_Shallow: Nickel

7.4.4 Uncertainties Assessment

Uncertainties are present in all risk assessments because of the limitations of the available data and the need to make certain assumptions and extrapolations based on incomplete information. In addition, the use of various models (e.g., uptake and food web exposures) carries with it some associated uncertainty as to how well the model reflects actual conditions. Since conservative assumptions were generally used in the exposure and effects assessments, these uncertainties are more likely to result in an overestimation rather than an underestimation of the likelihood and magnitude of risks to ecological receptor. The following uncertainties and limitations associated with the proposed methodology and available data for the ecological risk assessment are discussed:

- **Data Use**—The quantitative evaluation of chemical concentrations in soils included surface soils from the 0 to 4.6 m (0 to 15 ft) depth range. Ecology uses a standard point of compliance in soil of 4.6 m (15 ft) for demonstrating protection of ecological receptors ("Terrestrial Ecological Evaluation Procedures" [WAC 173-340-7490(4)(b)]). This depth range may over estimate the depth to which many terrestrial receptors would be exposed. MTCA (WAC 173-340) identifies the biologically active zone in 0 to 1.8 m (0 to 6 ft). Evaluation of data that extends beyond the biologically active zone could either over or under estimate risk. For this ecological evaluation, the depth from 1.8 to 4.6 m (6 to 15 ft) is also included because human activities could bring materials from that depth to the surface, creating a complete exposure pathway.

  No toxicological data or background were available for some COPCs (nitrogen, dibenzofuran, 2 pesticides, TPH, 9 SVOCs, and 3 VOCs) or were limited for some COPC/receptor combinations. Therefore, SSLs could not be calculated for all receptors or COPCs. Exclusion of COPCs from SSL development may not adequately address aggregate risk at a site, though it should be noted that remedial alternatives that are protective of receptors with SSLs might also be protective of receptors lacking sufficient toxicity data. In addition, the absence of SSLs for plants and soil invertebrates can be addressed through performing site-specific bioassays, which are a component of Tier 2.

  With respect to TPH-motor oil, though no SSL or PRG was previously developed for soils at the Hanford Site, published literature is available to provide some prospective. In "Ecotoxicity Test Data for Total Petroleum Hydrocarbons in Soil: Plants and Soil-Dwelling Invertebrates" (Efroymson et al., 2004), the authors compiled a literature review on toxicological effects to plant and invertebrates with the results suggesting invertebrates are more sensitive to some petroleum hydrocarbons than plants. Using lube oil to represent motor oil, no effect thresholds ranged from 15 to 1,490 mg/kg in soil and EC20 were found as low as 15 to 149 mg/kg. Conversely, lube oil NOAECs for plants ranged from

969 mg/kg to 12,000 mg/kg. MTCA lists ecological indicator soil concentrations (WAC 173-340, Table 749-3) for soil biota for diesel and gasoline range organics at 200 mg/kg and 100 mg/kg respectively based on original work published at ORNL (*Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision* [ES/ER/TM-126/R2]). Although motor oil specifically was not measured in any of these studies, with concentrations as high as 680 mg/kg measured at waste sites within the 300 Area, decision units within waste sites with detected motor oil should be considered in the SMDP. These include 300-223_Shallow_Focused; 300-23-Shallow_Focused; 600-243_Shallow; 618-7_Shallow_Focused; and UPR-300-17_Shallow.Bioavailability and toxicity of metals are functions of many factors including soil pH, with metals (e.g., aluminum, lead, mercury) generally being more bioavailable and toxic at low pHs (OSWER Directive 9285.7-55). The pH range for soil used to develop plant toxicity values range from 3 to 8, (mean=6.3) (*Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [CHPRC-00784]). The pH range for soil used to develop invertebrate toxicity values range from 3.8 to 8.1 (mean=5.6) (*Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [CHPRC-00784]). The minimum soil pH reported in the RCBRA Report (DOE/RL-2007-21) in riparian and upland soil was 6.6. Soil pH in the Outer Area of the Central Plateau ranges from 3.6 to 9.9, with 93 percent of observations greater than 6.6. Because the range of pH values in soils associated with plant and soil invertebrate toxicity values within the published literature include values that are substantially lower than those present throughout most of the Hanford Site, it is likely that the resulting SSLs for plants and soil invertebrates do not accurately represent toxicity. Since metals are more bioavailable at lower pH, the SSLs may overestimate concentrations in Hanford Site soils that would be toxic to plants and soil invertebrates; thus, risk estimates may be overly conservative. Evaluating this potential overestimation of bioavailability was one of the aims of a 2011 Hanford field effort to collect soil with a pH range more reflective of Hanford Site soils. With the exception of four samples collected within the 100-K area, the range of pH values from samples collected for the 2011 study was between 5.8 and 8.7 with all but 5 of 67 samples above the minimum pH of 6.6 identified in previous RCBRA soil samples. Thus, the PRGs more accurately reflect the actual bioavailability of potential contaminants within the Hanford Site soils than SSLs developed using published data from laboratory studies and other sites.

- **Wildlife Toxicity Reference Values**—Data on the toxicity of many chemicals to the receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with nonwildlife species. This is a typical limitation and extrapolation for ecological risk assessments because so few wildlife species have been tested directly for most chemicals. The uncertainties associated with toxicity extrapolation were minimized through the selection of the most appropriate test species for which suitable toxicity data were available. The factors considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method, and similarity of diet.

A second uncertainty related to the derivation of TRVs applies to metals. Most of the toxicological studies on which the TRVs for metals were based used forms of the metal (such as salts) that have high water solubility and high bioavailability to receptors. Since the analytical samples on which site-specific exposure estimates were based measured total metal, regardless of form, and these highly bioavailable forms are expected to compose only a fraction of the total metal concentration, this is likely to result in an overestimation of potential risks for these chemicals. A recent study was conducted comparing the toxicity of laboratory-spiked soils versus aged field-collected soils and the predictive ability of the European Union's predicted no effect concentrations for five metals. The study concluded that total metals concentrations in field collected soils are poor indicators of toxicity

("Toxicity of Trace Metals in Soil as Affected by Soil Type and Aging After Contamination: Using Calibrated Bioavailability Models to Set Ecological Soil Standards" [Smolders et al., 2009]).

- **Chemical Mixtures**—The SSLs employed in this assessment are based on exposure to individual analytes. Information on the ecotoxicological effects of chemical interactions is generally lacking, which required (as is standard for ecological risk assessments) that the chemicals be evaluated on a compound-by-compound basis during the comparison to SSLs. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals). Assessment of data in this report resulted in a description of potential exposure risks due to metals, which are typically known to be additive. In this case, effects may be underestimated.

- **Receptor Species Selection**—Reptiles were identified as being part of the food web present at the Hanford Site, but were not evaluated quantitatively even when exposure pathways were complete. A qualitative assessment of potential risk to these taxa can be made by using the results of quantitative evaluation for other fauna with similar diets and assumed similarity in metabolizing COPECs to make inferences. Considering the results of quantitative evaluation of avian receptors can provide some idea as to the potential for risks to these taxa.

  The uncertainty associated with the lack of toxicological data for reptiles and inferring risk from other fauna either could over- or underestimate risks.

  It was also assumed that reptiles neither were exposed to significantly higher concentrations of chemicals nor were more sensitive to chemicals than the other receptor species evaluated in the food web model. This assumption was a source of uncertainty in the supplemental ecological risk evaluation. In addition, there is some uncertainty associated with the use of specific receptor species to represent larger groups of organisms (e.g., guilds).

  Food Web Exposure Modeling—No life history data specific to the Hanford Site were available; therefore, exposure parameters were either modeled based on allometric relationships (e.g., FIRs) or were based on data from the same species in other portions of its range. Because diet composition as well as food, water, and soil ingestion rates can differ among individuals and locations, published parameter values may not accurately reflect individuals present at the Hanford Site. Consequently, SSLs may be either over-conservative or under-conservative. For example, the wildlife Eco-SSLs were derived with a model that incorporates prey tissue items that comprise 100 percent of the receptor's diet coming from the site, not accounting for any food obtained in adjacent uncontaminated areas, whereas MTCA values do account for some offsite prey consumption. Therefore, the assumed contributions of ingestion of analytes in prey tissues for the wildlife Eco-SSLs are greater than those used to develop the MTCA values and would be expected to overestimate risk. Ultimately, there is some uncertainty with both the MTCA and EPA values used as SSLs with respect to site-specificity. The wildlife PRGs employed in this supplemental risk evaluation are more site-specific than the SSLs since prey concentrations were estimated with Hanford-Site data. However, there is also some uncertainty in those values associated with the percentage of diet obtained from the site. In applying the PRGs, the assumption was that 100 percent of the food ingestion was from the site, which in many cases is an overestimate. This assumption was evaluated on a case-by-case basis to aid the SMDP presented in Section 7.6.

- **Central Tendency Versus Maximum Exposure Concentration Estimates**—As is typical in an ecological risk assessment, a finite number of samples of environmental media are used to develop the exposure estimates. The maximum measured concentration provides a conservative estimate for

immobile biota or those with a limited home range. The most realistic exposure estimates for mobile species with relatively large home ranges and for species populations (even those that are immobile or have limited home ranges) are those based upon an estimate of central tendency of chemical concentrations in each medium to which these receptors are exposed. This is reflected in the wildlife dietary exposure models contained in *Wildlife Exposure Factors Handbook*, Volumes I and II (EPA/600/R-93/187). It is possible, however, that receptors could spend additional time foraging at a nearby waste site and thus be exposed to analytes from more than one site. Thus, EPC estimates of contaminants in individual waste site media and food sources may not accurately represent contaminant exposure to a receptor ranging into other sites. It is likely, however, that assuming an AUF of 1 will result in a conservative estimate of exposure because it is likely that offsite foraging would be conducted in uncontaminated areas than at other waste sites. Given the mobility of the upper trophic level receptor species used in the ecological risk assessment, the use of maximum chemical concentrations as EPCs when UCLs were not calculated by ProUCL to estimate the exposure via food webs is very conservative. This conservatism was reduced to levels that are more realistic when the number of samples collected in a site was adequate in sample size to develop a UCL on the mean.

- **Comparisons to Background Concentrations**—Background concentrations were used to judge whether measured concentrations within waste sites are reflective of site-related activities, background, or a combination thereof. If site chemical concentrations were consistent with these background levels, it was assumed that the concentrations were not site-related. Comparisons to background in this supplemental evaluation include the use of the 90th percentile of the background data set as compared to the EPC. Thus, 10 percent of the background data set is even higher than the 90th percentile. Concentrations measured above background may be within the distribution of background variability and could represent a false positive risk. There also exists the possibility that concentrations below background were indeed site-related, rendering the assumption false. However, the impact of this possibility is minimal since metals and radioisotopes at concentrations consistent with background conditions should exhibit no different ecological effects than commonly occurring in areas not affected by releases, regardless of their source.

7.5 SMDP Considerations

Within the process for conducting ecological risk assessments at CERCLA sites, there are several decision points at which risk managers, risk assessors, and other stakeholders agree on a path forward with respect to ecological risk associated with a site. Outcomes typically include variations of the following risk assessment outcomes:

- There is no unacceptable potential risk to ecological receptors, e.g., risks are sufficiently low and below risk-based thresholds such as SSLs or PRGs.
- There is the potential for risks to ecological receptors but the risks do not warrant the evaluation of remedial alternatives in the FS due to a number of considerations[5].
- There is the potential for risks to ecological receptors but there is uncertainty in one or more components of the ecological risk assessment that warrants the evaluation of remedial alternatives in the FS.

[5] For example, a wildlife risk for a specific contaminant was driven by an estimated exposure to a badger but the size of the site is 20 m^2, representing a minimal portion of the total required foraging area for a badger and the site does not represent a preferential feeding area.

- There is the need to evaluate remedial alternatives in the FS based on the protection of another receptor or exposure pathway (e.g., human health) that would address any potential ecological risks.
- There is the potential for risk to ecological receptors warranting evaluation of remedial alternatives in the FS.

With the various risk assessment outcomes listed above, agreement is needed on the following elements to assist in the evaluation of remedial alternatives in the FS: the COCs, the assessment endpoints, the exposure pathways, and the risk questions. To achieve one of the risk assessment outcomes confidently, a number of factors and supporting information are considered in the conclusion of the risk assessment to assist risk management decisions. Often, these outcomes are considered within the context of other exposure pathways and receptors evaluated at the same site. Some of the factors that are considered to interpret the results of the risk characterization and determine if the site requires evaluation of remedial alternatives in the FS include the following:

- The spatial characteristics of the remediated waste site (area and excavation depth of the remediated waste site)
- The proximity and size of nearby unremediated waste sites and unimpacted habitat
- The number and location of samples collected at the site
- The data quality (presence of qualifiers, adequacy of detection limits)
- The frequency that risk-based thresholds are exceeded and the location(s) of those exceedances
- The chemical-specific properties of each COPC (e.g., does it have the potential to biomagnify in the food web or is it persistent in the environment?)
- The identification of specific receptors that have the potential for adverse health effects (feeding guild [plants or omnivorous wildlife], proportion of receptors affected, likelihood of population or community level effects, home range of the receptors at risk relative to the area exceeding risk-based thresholds)
- Recalculation of EPC based on the home range of the receptor or to estimate the residual risk after the removal action has been implemented
- Evaluation of PRG (i.e., level of confidence, basis, relation to other PRGs such as those for human health or groundwater protection)

Fourteen waste sites within the 300 Area OUs were reported with concentrations of COPECs greater than their respective PRGs or were retained due to an uncertainty needing further consideration. Figures showing the location and concentration of COPECs reported with a HQ greater than 1 are provided in Appendix H. During development of the evaluation, the factors above were evaluated and resulted in a recommendation that no waste sites be carried forward into the FS for evaluation of remedial alternatives. The decisions for 300 Area OUs were based on a subset of the factors described above, including the following:

- The depth of samples[6] exceeding thresholds relative to the 4.6 m (15 ft) bgs standard point of compliance for ecological receptors defined by MTCA (WAC 173-340)
- The number and frequency of exceedances of the risk thresholds (PRGs)
- The magnitude of exceedance relative to the risk thresholds (the HQ)
- The confidence in the ecological risk thresholds defining the exceedances
- The quality of the sample data defining the exceedances
- The location of the samples exceeding thresholds, sample frequency, and proximity of other exceedances
- The area of exceedance relative to home range of receptor exceeding and relative to area of unimpacted nearby habitat

As indicated in Table 7-7, consideration of factors listed above resulted in the conclusion of no unacceptable risks to wildlife or plants and invertebrates and a recommendation of no further action for any of the waste sites within the 300 Area.

7.6 Assessment of Risks in Riparian, Nearshore Media, and Columbia River

RCBRA evaluated soil, sediment, and water located in riparian and nearshore areas. The RAGs used in the interim actions addressed risks to human health from direct contact with soil and threats to groundwater and surface water from leaching from soil, but did not directly address risks to ecological receptors except those protected through compliance with AWQC. The ecological risk assessment conducted as part of the RCBRA addresses residual contaminant concentrations at remediated waste sites in the upland zones and the transport of contaminants from waste sites to the Columbia River riparian and nearshore zones (Integrated Work Plan [DOE/RL-2008-46]). CRC (DOE/RL-2010-117) evaluated island soil, sediment, water, and fish tissue located in the Columbia River beyond the nearshore environment. A study by PNNL also presented the results and evaluation of radiological and chemical concentrations measured in the nearshore environment adjacent to the 300 Area (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]).

7.6.1 Results and Conclusions of RCBRA

The RCBRA evaluated ecological risks at 48 nearshore study sites potentially affected by contamination from Hanford Site sources in comparison to reference sites. Study sites were selected in areas where known contaminated groundwater plumes enter the Columbia River and in areas between the plumes. Twenty-two COPECs were identified for the nearshore environment and sixteen of these (all inorganics) were further identified as COECs. The RCBRA concluded that five (cadmium, chromium, Cr(VI), manganese, and uranium) COECs in the nearshore environment may present an unacceptable level of risk for one or more of the assessment endpoint entities (aquatic plants, aquatic invertebrates, amphibians, fish, and wildlife). These results are based primarily upon the comparisons of COPEC concentrations to toxicity benchmarks, measures of exposure and effects in biota, or the results of wildlife exposure analyses (RCBRA Report [DOE/RL-2007-21], Volume 1).

[6] For the purposes of the supplemental evaluation, it was assumed that soil up to 4.6 m (15 ft) bgs is accessible to ecological receptors because these soils can be brought to the surface by human activities, thereby becoming biologically accessible. In some cases, the database indicated soils were collected from a shallow depth, but further review conducted for the SMDP showed that soils were collected below 4.6 m (15 ft).

The RCBRA also evaluated ecological risks at 18 representative riparian study sites located adjacent to, or where they may be directly affected by known contaminated media (i.e., groundwater seeps, soil, and sediment). In addition, data from the 100-B/C Area pilot study and the 100-NR-2 ecological study were evaluated. As with the nearshore environment, 22 COPECs were identified for the riparian environment. The RCBRA identified 9 of the identified 22 COPECs (arsenic, chromium, copper, lead, mercury, selenium, TPH-diesel, vanadium, and zinc) as possibly presenting some level of risk for one or more of the assessment endpoint entities (terrestrial plants, invertebrates, and wildlife). This is based on soil bioassays, comparison of COPEC concentrations to plant or terrestrial invertebrate benchmarks, or the results of wildlife exposure analyses. However, conclusions were that only six of these COPECs should be considered further (arsenic, chromium, lead, mercury, TPH-diesel, and zinc).

Final COECs identified within the RCBRA are included in Table 7-8. These COECs were determined for the River Corridor as a whole. Discussion of these COECs with respect specifically to ecological risk within the 300 Area is provided in Appendix M of this report and is summarized below.

7.6.2 Results and Conclusions of CRC

The CRC (DOE/RL-2010-117) included an ecological risk assessment that combines both screening and baseline elements. Abiotic media were compared to screening benchmarks for surface water, sediment, and porewater to identify COPECs. Soil concentrations were compared to plant and invertebrate benchmarks while desktop food web models were used to evaluate risks to wildlife. A baseline assessment was conducted to assess risk to fish using tissue residue data. The CRC concluded that there were eight COPECs within sediment, surface water, and sediment (nitrate, nitrite, TPH-diesel, TPH-motor oil, chromium, Cr(VI), lead, and selenium). The evaluation included distinct conclusions for the reach adjacent to the100 Area versus those for the reach adjacent to the 300 Area. All eight COPECs were identified for the 300 Area, as presented below in Table 7-8. Discussion of these COPECs with respect specifically to ecological risk within the 300 Area is provided in Chapter 4, Appendix M, and in the following table.

7.6.3 Riparian Soils

The RCBRA evaluated ecological risks at representative riparian study sites located adjacent to, or where they may be directly affected by, known contaminated media (such as, groundwater seeps, soil, or sediment). The RCBRA concluded that six COPECs identified for the riparian environment (arsenic, chromium, lead, mercury, zinc, and TPH-diesel) may present an unacceptable level of risk to one or more of the assessment endpoint entities, based on soil bioassays, comparison of COPEC concentrations to plant or terrestrial invertebrate toxicity benchmarks, or the results of wildlife exposure analyses.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
300-260 – Contaminated Soil West of the 313 Building	Shallow Focused	Copper	73	58	Moderate – Invert –Hanford Site-Specific NOEC from Ecology Publication 11-03-006. Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	213	Not Exceeded	16	1,992 m^2 (21,400 ft^2)	0 to 1.0 m (0 to 3 ft)	1	10 to 73	0.17 to 1.3	--	No. EPC slightly greater than plant/invert PRG. Only 1 sample of 16 exceeding plant/invert PRG. No soil concentrations greater than lowest wildlife PRG for biomagnifying compound.
300-223	Shallow Focused	TPH-motor oil	230	15-1490[a]	Low – values are from a secondary source and may not reflect Hanford Site conditions	No value	NA	5	9 m^2 (97 ft^2)	0.3 to 2.1 m (1 to 7 ft)	5	51 to 230	NA		No. Size of site is small with ample unimpacted habitat available in adjacent area. Also, the suitability of toxicity values for the Hanford Site has not been fully assessed.
300-23 – 309-1 Underground Storage Tank	Shallow Focused	TPH-motor oil	52	15-1490[5]	Low – values are from a secondary source and may not reflect Hanford Site conditions	No value	NA	1	58 m^2 (624 ft^2)	3.7 m (12 ft)	1	<25 to 52	NA		No. Size of site is small with ample unimpacted habitat available in adjacent area. Also, risk for TPH is primarily for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
300-33, 300-41, 300-256	Shallow Focused	Aroclor-1248	0.33	40	Not Exceeded	0.325	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	2	6,469 m^2 (69632 ft^2)	1.5 m (4.9 ft)	1	<0.0136U to 0.330	.04 to 1.01		No. The combined Hazard Index for Aroclors is essentially 1 based on conservative assumptions. With ample unimpacted habitat available in adjacent area, the risk is acceptable.
300-33, 300-41, 300-256	Shallow Focused	Aroclor-1254	0.385	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data that could be higher or lower.	2	6,469 m^2 (69,632 ft^2)	1.5 m (4.9 ft)	1	.0224 to 0.385	0.26		No. The combined Hazard Index for Aroclors is essentially 1 based on conservative assumptions. With ample unimpacted habitat available in adjacent area, the risk is acceptable.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
300-37 – PCB Leak to Soil	Shallow Focused	Aroclor-1260	3.2	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data which could be higher or lower.	2	Point site, no given area	0.3 m (1 ft)	1	0.52 to 3.2	<0.35 to 2.1		No. An elevated concentration at a point site does not suggest exposure is sufficient to cause an adverse effect to the population of deer mice or other small mammals.
300-49 – Landfill 1A	Overburden	Aroclor-1254	3	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data which could be higher or lower.	12	Not Applicable	3 m (10 ft)	1	<0.03 to 3.0	<0.02 to 2.0		No. With only 1 of 12 samples exceeding the PRG, the average exposure to wildlife receptors would not present a risk. Further, samples were collected 3 m (10 ft) below ground, much deeper than the burrowing depth of small mammals at the Hanford Site (1 m [3.3 ft] pocket mouse [Cline et al., 1980]) or other similar sites (0.5 m [1.6 ft] deer mouse [Reynolds and Laundre, 1988]). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
300-49 – Landfill 1A	Overburden	Copper	536	58	Moderate – Invert –Hanford Site-Specific NOEC from Ecology Publication 11-03-006. Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	213	High – Killdeer Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	Not Applicable	3 m (10 ft)	1	13 to 536	0.22 to 9.2/ 0.06 to 2.5	--	No. With only one of six samples exceeding the PRG, the average exposure to wildlife receptors would not present a risk. Further, samples were collected 3 m (10 ft) below ground, much deeper than the burrowing depth of small mammals at Hanford (1 m [3.3 ft] for pocket mouse [Cline et al., 1980]) or other similar sites (0.5 m [1.6 ft] for deer mouse at Idaho National Engineering Laboratory [Reynolds and Laundre, 1988]). The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
300-50 – Landfill 1B	Overburden	Copper	65	58	Moderate – Invert –Hanford Site-Specific NOEC from Ecology Publication 11-03-006. Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	213	Not Exceeded	6	Not Applicable	3.1 m (10 ft)	2	20 to 82	0.34 to 1.4	--	No. Two of six samples exceed the PRG that is an unbound no-effect concentration because toxicity has not been observed up to 58 mg/kg copper. Also, the depth of samples is beyond the biologically active zone. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
316-1 – South Process Pond	Overburden	Total Uranium Isotopes	41	100	Not Exceeded	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	2	7.3 to 45	0.18 to 1.1		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_1	Total Uranium Isotopes	83	100	Not Exceeded	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	8	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	2	3.2 to 122	0.08 to 3.1		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_1	Aroclor-1248	3	40	Not Exceeded	0.33	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data which could be higher or lower.	43	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	2	<0.03 to 3.0	<0.09 to 9.1		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_3	Copper	1,370	58	Moderate – Invert – Hanford Site-Specific NOEC from Ecology Publication 11-03-006. Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	213	High – Killdeer Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	9	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	8-Sep	152 to 2,400	3.0 to 48/0.71 to 11	--	No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_3	Mercury	1.1	0.3	Low - ORNL Value Given low confidence by the authors due to limited number of studies available in the published literature and no primary literature available for effects on plants.	1.6	Not Exceeded	9	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	1-Sep	0.39 to 1.8	1.3 to 6/0.24 to 1.1	--	No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
316-1 – South Process Pond	Shallow_3	Nickel	95	38	Moderate to High – Eco-SSL Value representing geometric mean of toxicity thresholds from published literature reviewed by a panel of experts selected by EPA.	247	Not Exceeded	9	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	7	24 to 136	0.63 to 3.6	--	No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_3	Selenium	1.6	2	Not Exceeded	1.4	High – deer mouse Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	9	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	3	<0.31 to 1.6	<0.2 to 1.1		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_3	Silver	13	3	High – Invertebrate Hanford Site-Specific NOEC Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	98	Not Exceeded	9	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	9	3.5 to 19	1.2 to 9.5		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_3	Total Uranium Isotopes	63	100	Not Exceeded	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	19	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	12	3.1 to 146	0.08 to 3.7		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-1 – South Process Pond	Shallow_4	Total Uranium Isotopes	43	100	Not Exceeded	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	10	29,831 m^2 (321,000 ft^2)	5.7 m (19 ft)	2	5.1 to 87	0.13 to 2.2		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
316-2 – North Process Pond	Shallow_2	Aroclor-1248	0.7	40	Not Exceeded	0.33	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data which could be higher or lower.	18	40,583 m^2 (437,000 ft^2)	3 m (10 ft)	4	<0.03 to 0.87	<0.09 to 2.6		No. Though four samples exceed the PRG, samples were collected 3 m (10 ft) below ground, much deeper than the burrowing depth of small mammals at Hanford (1 m [3.3 ft] for pocket mouse [Cline et al., 1980]) or other similar sites (0.5 m [1.6 ft] for deer mouse at Idaho National Engineering Laboratory [Reynolds and Laundre, 1988]). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
316-2 – North Process Pond	Shallow_1	Total Uranium Isotopes	210	100	Moderate – Invertebrate Value from Sheppard et al., 2005. Value is moderate because it comes from a literature review of uranium toxicity and is not from a primary source. However, value is a PNEC with default conservative uncertainty factors that may render the value overly conservative for the Hanford Site.	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	40,583 m^2 (437,000 ft^2)	3 m (10 ft)	3	8.9 to 241	0.22 to 6.0		No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk to wildlife at this site is acceptable. The depth of samples is also beyond the biologically active zone for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
316-2 – North Process Pond	Shallow_2	Total Uranium Isotopes	291	250	Moderate – Invertebrate from Sheppard et al., 2005. Value is moderate because it comes from a literature review of uranium toxicity and is not from a primary source. However, value is a PNEC with default conservative uncertainty factors that may render the value overly conservative for the Hanford Site.	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	40,583 m^2 (437,000 ft^2)	3 m (10 ft)	2-Jun	106 to 361	2.7 to 9.0/ 0.42 to 1.4		No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk to wildlife at this site is acceptable. The depth of samples is also beyond the biologically active zone for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
316-2 – North Process Pond	Shallow_3	Total Uranium Isotopes	73	100	Not Exceeded	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	40,583 m^2 (437,000 ft^2)	3 m (10 ft)	2	2.7 to 110	0.07 to 2.8		No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk at this site is acceptable.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
316-5 – 3904 Process Waste Trenches	Shallow_1	Total Uranium Isotopes	272	100	Moderate – Invertebrate from Sheppard et al., 2005. Value is moderate because it comes from a literature review of uranium toxicity and is not from a primary source. However, value is a PNEC with default conservative uncertainty factors that may render the value overly conservative for the Hanford Site.	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	40,764 m^2 (439,000 ft^2)	4.3 m (14 ft)	3-Mar	2.1 to 363	0.05 to 9.1/ 0.01 to 1.5		No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk to wildlife at this site is acceptable. The depth of samples is also beyond the biologically active zone for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
316-5 – 3904 Process Waste Trenches	Shallow_2	Total Uranium Isotopes	205	100	Moderate – Invertebrate from Sheppard et al., 2005. Value is moderate because it comes from a literature review of uranium toxicity and is not from a primary source. However, value is a PNEC with default conservative uncertainty factors that may render the value overly conservative for the Hanford Site.	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	6	40,764 m^2 (439,000 ft^2)	4.3 m (14 ft)	6	67 to 228	1.7 to 5.7		No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk to wildlife at this site is acceptable. The depth of samples is also beyond the biologically active zone for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
316-5 – 3904 Process Waste Trenches	Shallow_2	Silver	3.6	3	High – Invertebrate Hanford Site-Specific NOEC. Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	98	Not Exceeded	1	40,764 m^2 (439,000 ft^2)	4.3 m (14 ft)	1	3.6	1	1.2	No. One sample with a low magnitude of exceedance of the invertebrate PRG and at a depth well below the biologically active zone of invertebrates at Hanford Site. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
316-5 – 3904 Process Waste Trenches	Shallow Focused	Total Uranium Isotopes	138	100	Moderate – Invertebrate from Sheppard et al., 2005. Value is moderate because it comes from a literature review of uranium toxicity and is not from a primary source. However, value is a PNEC with default conservative uncertainty factors that may render the value overly conservative for the Hanford Site.	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	3	40,764 m^2 (439,000 ft^2)	4.3 m (14 ft)	3	56 to 138	1.4 to 3.5	--	No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk to wildlife at this site is acceptable. The depth of samples is also beyond the biologically active zone for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774).
600-243 – Petroleum-Contaminated Soil Bioremediation Pad	Shallow	Boron	295	30	Moderate to high – RCBRA NOEC Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	91	Moderate to High – Killdeer Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using a combination of regression models and BAFs.	11	2249 m^2 (24,200 ft^2)	<4.6 m (15 ft)	8-Nov	12 to 497	0.40 to 17/ 0.13 to 5.5	--	No. Samples collected at a depth below maximum depth observed at Hanford Site for plants (2.98 m [9.77 ft]; PNNL-5247) invertebrates (2.7 m [8.9 ft]; PNNL-2774) and small mammals (1 m [3.3 ft] pocket mouse [Cline et al., 1980]); 0.5 m [1.6 ft] deer mouse [Reynolds and Laundre, 1988]). Exposure pathways to contaminated soils are insignificant for those receptors for which a risk was identified.
600-243 – Petroleum-Contaminated Soil Bioremediation Pad	Shallow	Selenium	5.7	2	High – Plant Hanford Site-Specific NOEC. Confidence in PRG is high with respect to a lack of toxicity at this concentration but low in that the PRG is set at the highest concentration samples thus PRG could be higher.	1.4	Moderate to High - Deer Mouse Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using a combination of regression models and BAFs.	11	2249 m^2 (24,200 ft^2)	<4.6 m (15 ft)	10-Nov	<1.3 to 11	<1.1 to 9.2/ <0.93 to 7.9	--	

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
600-243 – Petroleum-Contaminated Soil Bioremediation Pad	Shallow	TPH-motor oil	335	15-1490[b]	Low – values are from a secondary source and may not reflect Hanford Site conditions	No value	NA	11	2249 m^2 (24,200 ft^2)	<4.6 m (15 ft)	11	41 to 620	NA		No. Risk for TPH is primarily for invertebrates. Samples collected at a depth below maximum depth observed at Hanford Site for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
618-7 – Burial Ground	Shallow Focused	TPH–motor oil	680	15-1490[6]	Low – values are from a secondary source and may not reflect Hanford Site conditions	No value	NA	4	43,616 m^2 (469,500 ft^2)	6 m (20 ft)	3	6.4 to 680	NA		No. Soil samples collected from a depth greater than 4.6 m (15 ft) bgs: direct contact within point of compliance is incomplete.
618-3 – Burial Ground	Shallow Focused	Total Uranium Isotopes	239	100	Moderate – Invertebrate – Sheppard et al., Value is moderate because it comes from a literature review of uranium toxicity and is not from a primary source. However, value is a PNEC with default conservative uncertainty factors that may render the value overly conservative for the Hanford Site.	40	High – Badger Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using regression models.	3	5,446 m^2 (59,000 ft^2)	4.6 m (15 ft)	2	36 to 239	0.9 to 6.0	--	No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the badger (1.6 km^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk at this site is acceptable. Further, samples collected at a depth below maximum depth observed at Hanford Site for invertebrates (2.7 m [8.9 ft]; PNNL-2774) and small mammals (1 m [3.3 ft] pocket mouse [Cline et al., 1980]); 0.5 m [1.6 ft] deer mouse [Reynolds and Laundre, 1988]). Exposure pathways to contaminated soils are insignificant for those receptors for which a risk was identified.
618-9 – Burial Ground	Shallow Focused	Aldrin	0.39	No value	NA	0.165	Moderate - killdeer SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data that could be higher or lower.	2	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	ND to 0.39	2.4		No. The exposure estimate does not include consideration of an AUF such as foraging range. The home range of the Killdeer (>76,000 m^2) is significantly greater than the acreage of the site thus employing an AUF would yield a HQ below 1 and risk at this site is acceptable.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
618-9 – Burial Ground	Shallow Focused	Aroclor-1016	1.9	40	Not Exceeded	1.8	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.04 to 1.91	<0.02 to 1.1	--	No. With only one of twelve samples exceeding the PRG, the average exposure to wildlife receptors would not present a risk. Further, samples were collected ten feet below ground, much deeper than the burrowing depth of small mammals at Hanford (1 m [3.3 ft] pocket mouse [Cline et al., 1980]) or other similar sites (0.5 m [1.6 ft] deer mouse [Reynolds and Laundre, 1988]). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
618-9 – Burial Ground	Shallow Focused	Aroclor-1221	1.9	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.04 to 1.9	<0.03 to 1.3	--	
618-9 – Burial Ground	Shallow Focused	Aroclor-1232	1.9	40	Not Exceeded	1.4	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.04 to 1.9	<0.03 to 1.4	--	
618-9 – Burial Ground	Shallow Focused	Aroclor-1242	1.9	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.04 to 1.9	<0.03 to 1.3	--	
618-9 – Burial Ground	Shallow Focused	Aroclor-1248	1.9	40	Not Exceeded	0.33	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.04 to 1.9	<0.12 to 5.6	--	

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
618-9 – Burial Ground	Shallow Focused	Aroclor-1254	3.9	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.08 to 3.9	<0.05 to 2.6	--	
618-9 – Burial Ground	Shallow Focused	Aroclor-1260	3.9	40	Not Exceeded	1.5	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	26	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.08 to 3.9	0.05 to 2.6	--	
618-9 – Burial Ground	Shallow Focused	Mercury	0.33	0.3	Low - ORNL Value Given low confidence by the authors due to limited number of studies available in the published literature and no primary literature available for effects on plants.	1.6	Not Exceeded	33	649 m^2 (7,000 ft^2)	3 m (10 ft)	1	<0.1 to 0.33	0.33 to 1.1	--	No. Only one of 33 samples exceeding plant/invert PRG given low confidence by the authors. No soil concentrations greater than lowest wildlife PRG for biomagnifying compound.
628-4 – Landfill 1D	Shallow	Aroclor-1248	1.1	40	Not Exceeded	0.33	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	12	2,337 m^2 (25,000 ft^2)	5.7 m (19 ft)	1	<0.03 to 1.1	0.09 to 3.3	--	No. Only 1 of 12 samples exceeds a PRG. An average exposure would be below the PRG. Size of site is small with ample unimpacted habitat available in adjacent area. Further, the home range of the deer mouse (900 m^2 in Idaho desert; Bowers and Smith, 1979) is twice the acreage of the site; thus, risk levels would be even lower.
UPR-300-17 - UN-300-17, Metal Shavings Fire Waste Site	Shallow	Aroclor-1248	2	40	Not Exceeded	0.33	Moderate - deer mouse SSL- based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	12	418 m^2 (4,500 ft^2)	3 m (10 ft)	2	<0.009 to <2.0	<0.03 to <6.1	--	No. Only 2 of 12 samples above the PRG are nondetect and detection limit of other samples is below PRG. An average exposure would be below the PRG. Size of site is small with ample unimpacted habitat available in adjacent area. Further, the home range of the deer mouse (900 m^2 in Idaho dessert; Bowers and Smith, 1979) is twice the acreage of the site; thus, risk levels would be even lower.

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?
UPR-300-17 - UN-300-17, Metal Shavings Fire Waste Site	Shallow	TPH-motor oil	210	15-1490[c]	Low – values are from a secondary source and may not reflect Hanford Site conditions.	No value	NA	12	418 m^2 (4,500 ft^2)	3 m (10 ft)	9		NA		No. Small site with ample unimpacted habitat nearby. Risk for TPH is primarily for invertebrates. The maximum observed depth of invertebrates reported at the Hanford Site was 2.7 m (8.9 ft; PNNL-2774). Exposure pathways to contaminated soils are incomplete for those receptors for which a risk was identified.
UPR-300-17 – UN-300-17, Metal Shavings Fire Waste Site	Shallow	Nickel	564	38	Moderate to High – Eco-SSL Value representing geometric mean of toxicity thresholds from published literature reviewed by a panel of experts selected by EPA.	247	Moderate – High – Deer Mouse Hanford Site-specific value modeled with Hanford Site-specific prey tissue data using a combination of regression models and BAFs.	12	418 m^2 (4,500 ft^2)	3 m (10 ft)	1-Jan	7.7 to 1,250	0.20 to 33/0.03 to 5.1	--	No. Only 1 of 12 samples exceeds and size of site is small with ample unimpacted habitat available in adjacent area. Samples collected at a depth just below maximum depth observed at Hanford Site for plants (2.98 m [8.9 ft]; PNNL-5247) invertebrates (2.7 m; PNNL-2774) and well below for small mammals (1 m [3.3 ft] pocket mouse [Cline et al., 1980]; 0.5 m [1.6 ft] deer mouse [Reynolds and Laundre, 1988]). Exposed biomass at these depths is minimal. Exposure pathways to contaminated soils are insignificant for those receptors for which a risk was identified.
UPR-300-46 – Contamination North of 333 Building	Shallow	Aroclor-1248	0.88	40	Not Exceeded	0.33	Moderate - deer mouse SSL-based on conservative assumptions including published literature values for tissue accumulation as opposed to using Hanford Site-specific data, which could be higher or lower.	12	61 m^2 (657 ft^2)	3.7 m (12 ft)	1	<0.004 to 0.88	<0.01 to 2.7	--	No. Only 1 of 12 samples exceeds and size of site is small with ample unimpacted habitat available in adjacent area. Samples collected at a depth below maximum depth observed at Hanford Site for small mammals (1 m [3.3 ft] pocket mouse [Cline et al., 1980]; 0.5 m [1.6 ft] deer mouse [Reynolds and Laundre, 1988]).

Table 7-7. Summary of Factors Considered for Scientific Decision Management Process for the 300-FF-2 OU

Waste Site and Waste Site Description	Decision Unit	COPEC	EPC (mg/kg or pCi/g)	Plant/ Invertebrate PRG	Confidence and Basis	Avian/ Mammal PRG	Confidence and Basis	Number of Sampling Locations	Area or Length of Waste Site	Depth of Samples (bgs)	Number of Results that Exceed PRG	Range of Concentrations (mg/kg or pCi/g)	Range of HQ	Data Quality	Carry Waste Site into FS for Remedy Evaluation?

Sources:

Bowers and Smith, 1979, "Differential Habitat Utilization by Sexes of the Deer Mouse, *Peromyscus maniculatus*."

Cline et al., 1980, "Loose Rock as Biobarriers in Shallow Land Burial."

Ecology Publication 11-03-006, *Ecological Soil Screening Levels for Arsenic and Lead in the Tacoma Smelter Plume Footprint and Hanford Site Old Orchards Ecology*

PNNL-2774, *Characterization of the Hanford 300 Area Burial Grounds: Task IV – Biological Transport.*

PNNL-5247, *Rooting Depth and Distributions Of Deep-Rooted Plants in the 200 Area Control Zone of the Hanford Site*.

Reynolds and Laundre, 1988, "Vertical Distribution of Soil Removed by Four Species of Burrowing Rodents in Disturbed and Undisturbed Soils."

Sheppard et al., 2005, "Derivation of Ecotoxicity Thresholds for Uranium."

Note: Analytical results flagged with a "C" qualifier indicate that analyte was detected in both the sample and the associated QC blank.

a. Value for TPH Motor oil is a range of no adverse effect concentrations and does not represent a PRG. SSLs and PRGs were not developed for TPH. Values are strictly to provide some context to concentrations detected.

b. Value for TPH Motor oil is a range of no adverse effect concentrations and does not represent a PRG. SSLs and PRGs were not developed for TPH. Values are strictly to provide some context to concentrations detected.

c. Value for TPH Motor oil is a range of no adverse effect concentrations and does not represent a PRG. SSLs and PRGs were not developed for TPH. Values are strictly to provide some context to concentrations detected.

AUF = area use factor
BAF = bioaccumulation factor
Eco-SSL = ecological soil screening level
EPA = U.S. Environmental Protection Agency
EPC = exposure point concentration
HQ = hazard quotient
MTCA = Model Toxics Control Act
ND = nondetect
NOEC = no observed effect level
ORNL = Oak Ridge National Laboratory
PNEC = predicted no effect concentration
POC = point of compliance
PRG = preliminary remediation goal
RCBRA = River Corridor Baseline Risk Assessment
TPH = total petroleum hydrocarbons

Table 7-8. COPECs from the RCBRA, CRC, and PNNL for 300 Area

COPEC	Receptors	Media	Is 300 Area a Potential Source?
Cadmium	Aquatic Plants and Invertebrates	Sediment	No
Cesium-137	Aquatic Plants and Invertebrates	Sediment	No
Cr(VI)	Aquatic Plants and Invertebrates	Sediment	No
Lead	Birds	Island Soil	No
	Birds	Shoreline Sediment	No
Manganese	Aquatic Plants and Invertebrates	Sediment	No
Mercury	Terrestrial Invertebrates	Riparian Soil	No
Nitrate and Nitrite	Aquatic Biota including Fish	Surface Water	No
Selenium	Aquatic Plants and Invertebrates	Sediment	No
	Plants	Shoreline Sediment	No
Sr-90	Aquatic Plants and Invertebrates	Sediment	No
TPH–Diesel and –Motor Oil	Terrestrial Invertebrates	Riparian Soil	No
	Aquatic Plants and Invertebrates	Sediment	No
Uranium	Aquatic Plants and Invertebrates	Groundwater/Porewater	Yes
	Fish	Groundwater/Porewater	No
	Aquatic Plants and Invertebrates	Sediment	No
Zinc	Terrestrial Plants	Riparian Soil	No
	Terrestrial Invertebrates		
	Kingbird		

COPEC = contaminant of potential ecological concern
CRC = Columbia River Component
PNNL = Pacific Northwest National Laboratory
RCRBA = River Corridor Baseline Risk Assessment

7.6.3.1 Risks to Terrestrial Plants

As shown in Table 5-61 of the RCBRA, Central Tendency Estimates (CTEs) some COPECs in riparian soil collected across the Hanford Reach (i.e., estimate of central tendency across all 100 Areas and 300 Areas combined) exceeded literature-based plant SSL concentrations (i.e., Tier 1 SSLs), indicating that effects in plants might occur. CTEs for arsenic, chromium, lead, vanadium, and zinc were greater than SSLs, suggesting a potential for adverse effects. In the 300 Area riparian study areas (5c and Rip 6), the COPECs that exceeded the plant benchmark were arsenic, vanadium, and zinc. However, none of the concentrations of the COPECs detected in the 300 Area riparian study sites exceeded the plant PRGs presented earlier in this chapter. Also, other lines of evidence obtained through seven different measures in bioassay testing indicate that COPECs may not adversely affect riparian plants, including those at the rare plant sites which performed better than bioassays from reference soils. Bioassays showed no significant differences in plant seed germination, root length, stem height, root biomass, or shoot biomass between riparian study sites and reference sites. Some COPECs were detected in plant tissues, but the concentrations of the COPECs were statistically different between riparian study area site concentrations and reference site concentrations for only four COPECs: barium, copper, thallium, and zinc (Table 5-32, RCBRA). Similar to the upland plant data, COPEC concentrations found in riparian plant tissues did not correlate to those in riparian soil. Therefore, although soil concentrations are greater than plant SSLs for some COPECs, the weight attributed to this line of evidence is low and SSL HQ results do not overwhelm the conclusions of the other lines of evidence. While several analytes were detected in RCBRA plant tissue, and statistical differences between riparian study area sites and reference site concentrations were noted, there were no statistically significant relationships of COPEC concentrations in plant tissue to soil concentrations. Therefore, no COPECs in 300 Area riparian soils warrant further evaluation in the FS, based on risks to terrestrial plants.

The CRC did not identify any risks to terrestrial plants form exposure to island and riparian soils.

7.6.3.2 Risks to Terrestrial Invertebrates

Ecological risk from exposure to riparian area soils were evaluated using SSLs and PRGs developed for terrestrial exposure. As is discussed in more detailed in ECF-Hanford-11-0158, the PRGs are intended to be protective of the concentration ranges expected across the Hanford Site in the upland and riparian areas of the River Corridor and in the Central Plateau. Detected concentrations from historic data from all these areas were used in the study design to establish the PRGs. The SSLs and PRGs are only applicable to terrestrial plants and soil invertebrates, not aquatic species. While the preponderance of data used to develop invertebrate site-specific PRGs was from upland areas, the final PRGs may be used for evaluating riparian areas of the River Corridor, but only the terrestrial portions of these areas where the conceptual model indicates exposure of plants and terrestrial invertebrates (e.g., ants, spiders, beetles) to soil, not sediment. Sediment exposure is more appropriately evaluated with other data, primarily aquatic media and respective media-specific benchmarks.

Concentrations of some COPECs in riparian soil exceeded SSLs protective of terrestrial invertebrates; in the 300 Area riparian study area (Rip 6), concentrations of mercury and zinc were higher than the benchmark value for protection of terrestrial invertebrates (RCBRA Tables 5-69 and 5-70). However, none of the concentrations exceeded Hanford Site-specific PRGs. Terrestrial invertebrate tissue concentrations, which provide an indication of contaminant uptake and bioavailability, were measured at riparian study sites and reference locations and some, but not all, COPECs were detected in terrestrial invertebrates. Statistical differences were found between terrestrial invertebrate tissue concentrations for certain COPECs between riparian study sites and reference sites. However, this line of evidence was ranked low because of the lack of detections in invertebrate tissue for certain riparian COPECs and the possibility of bias due to sample collection methods. Statistical differences in tissue concentrations of

mercury and zinc in terrestrial invertebrates were noted between River Corridor and reference study sites; this relationship is based on data across the entire River Corridor, and should not be inferred as a relationship that is specific for the 300 Area. However, there is insufficient evidence for COPECs in general of a correlation between tissue concentrations in terrestrial invertebrates and concentrations in soil (RCBRA Report [DOE/RL-2007-21]). Based on this analysis, there are no COPECs in riparian soil for terrestrial invertebrates warranting further evaluation in the FS based on risks to terrestrial invertebrates.The CRC did not identify any risks to terrestrial invertebrates form exposure to island and riparian soils.

7.6.3.3 Risk to Wildlife

Ecological risk from exposure to riparian area soils were evaluated using SSLs and PRGs developed for terrestrial exposure. The PRGs were determined using paired soil and tissue concentrations that included the samples from within both the upland and riparian sites. Risk to wildlife for riparian soils focused on those wildlife receptors foraging on terrestrial plants and invertebrates exposed to the riparian soils. Exposure to wildlife through ingestion of aquatic organisms in the sediments of the riparian area and nearshore were evaluated and are discussed separately with the nearshore environment. For riparian soils, field ecological measures of the small mammal community were developed as qualitative information on the status of these populations. Estimated dietary contaminant exposures and chemical concentrations in bird or small mammal tissues were compared to ecological effects levels established for dietary ingestion or related to tissue residues. For selected COPECs (cadmium, chromium, lead, selenium, and PCBs), measured tissue concentrations in small mammals trapped in study sites were not greater than reference areas (RCBRA Table 5-48), and were less than available tissue effect levels (RCBRA Report [DOE/RL-2007-21] Volume 1, page 5-91). Dietary exposure to terrestrial birds and mammals estimated using wildlife exposure models, estimated for riparian concentrations across the River Corridor indicated potential exposure higher than LOAEL-based SSL values for copper, selenium, vanadium, and zinc. Based on RCBRA exposure data for the 300 Area (RCBRA riparian stations 5c and Rip 6), CTE NOAEL HQs were greater than 1 for the kingbird for copper and vanadium and for pocket mouse and deer mouse for selenium, and CTE LOAEL HQ was greater than greater than 1 for kingbird for vanadium and for the pocket mouse for selenium. However, concentrations of copper and vanadium in riparian soils in the 300 Area fall within Hanford Site-wide background or area background concentrations, and therefore should not warrant further evaluation in the FS. Selenium was only identified as a potential COPC based on results from the riparian study site 5c, which is located more than 8 km (5 mi) upriver from the 300 Area. There is significant uncertainty concerning the conclusions regarding the soil concentrations found at this study area and exposure and risk that is occurring within the 300 Area. PRGs for wildlife exposure to copper and vanadium developed in this chapter were compared with the highest copper and vanadium concentrations in 300 Area riparian soil. The results from this comparison show that copper concentrations fall below the PRG, while vanadium slightly exceeds the most conservative of the PRGs (HQ=1.3) for the killdeer. Vanadium concentrations in 300 Area riparian soils were below the other seven wildlife PRGs. Therefore, this analysis further supports the conclusion that neither copper nor vanadium concentrations in riparian soil warrant further evaluation in the FS, based on risks to wildlife.

Most concentrations detected in riparian soils within the 300 Area fell below SSLs. All but one was below PRGs and does not warrant further evaluation in the FS.

Within the RCBRA, information on dietary contaminant exposures were also compared to ecological effects levels for diet to assess risks to birds or mammals potentially exposed to contaminants in nearshore sediments, biota, and water. Only chromium was considered a final COEC. However, the single study site with which this risk was associated is not within the 300 Area nearshore environment.

7.6.4 Nearshore and Columbia River

The results from the evaluation in Appendix M showed that a range of inorganic and radiological contaminants was detected in near-river groundwater samples collected from the 300 Area. In some cases, these contaminants also could be detected in aquifer tube, porewater, spring/seep, and surface water samples. In most cases, the analytical results that were most relevant to assessing aquatic water quality (i.e., from filtered analyses) were at concentrations below levels protective of aquatic life (e.g., National AWQC). In other cases, where concentrations higher than aquatic criteria were observed, these results were associated with analytical data quality issues such as presence of contamination in blank samples, or elevated detection limits relative to the criteria. Though the biological measures collected do not represent all seasonal conditions and river stage fluctuations, the results of porewater bioassays on aquatic invertebrates and amphibians also suggest little or no correlation between COPEC concentrations and observed responses in the bioassays and the responses were not different from those of upstream references. Benthic invertebrate community structure data also suggest no differences between reference sites and locations adjacent to the Hanford Site. The results from this analysis confirm the results from the evaluation presented in Chapter 4, that with the exception of uranium in groundwater, there are no COECs affecting aquatic life exposed to porewater or surface water. In addition to the evaluation in Appendix M, the nature and extent evaluation reports that TCE has been found in a very low permeability, relatively finer-grained interval of Ringold Formation unit E sediment in the unconfined aquifer. The distribution of TCE in groundwater samples collected from aquifer tubes beneath the 300 Area shows results that are consistent with expectations based on monitoring wells. Because of these findings, transport pathways for TCE from groundwater to surface water are discussed below in Section 7.6.4.6.

7.6.4.1 Risk to Fish

Porewater concentrations at study sites across the Hanford Reach were greater than the water standards or criteria for five COPECs (aluminum, cadmium, chromium, Cr(VI), and lead; RCBRA Table 6-90). However, most other lines of evidence suggest that there is no unacceptable risk to fish in the Columbia River. In general across the River Corridor, fish were smaller (in length and mass) at study sites relative to reference sites. However, there are many factors that either confound or contribute to the size of fish captured such as fishing pressure or ease of capture of the target size range. Correlation with capture size and chemical concentration or any other factor (e.g., habitat, nutrient availability) was not possible since it was not considered as part of the original study design. There were no strong trends in fish histopathological observations between those collected at study sites and those from reference site locations. No tissue COPECs were correlated with histopathological endpoints associated with adverse effects at study sites. No exceedances of tissue effects levels for nearshore aquatic COPECs were measured in fish tissue. In addition, evidence of greater contaminant uptake in fish from study sites was not apparent for most COPECs and tissues. For the 300 Area nearshore sampling sites (U1 through U10), only manganese in porewater exceeded the fish surface water ecological screening level (ESL) of 655 µg/L (RCBRA Table 6-91). However, RCBRA Table 6-43 shows that manganese in porewater is not greater than reference and the maximum detected concentration in groundwater is 133 µg/L (Table M-8) while the maximum overlying surface water concentration was 28 µg/L. Therefore, manganese in groundwater (which represents a potential source for porewater concentrations that exceed surface water criteria or fish surface water SSLs) does not warrant further evaluation in the FS.

Nitrate and nitrite were identified as COPECs in the CRC. There is no ambient water quality criteria available for either compound. Screening criteria are presented in the CRC, both consisting of values for aquatic invertebrates. For nitrate, as suggested in Table 8-2 of the CRC and the supporting text, only one anomalously high detection exceeds the LOEC screening value identified at 37.64 mg/L. However, this value is actually an LC10 (effect noted in just 10% of organisms) which is an effect level more sensitive

than commonly used. More importantly, as suggested by reference concentrations as high as 20.7 mg/L, nitrate is a common constituent in the Columbia River and its tributaries, a reflection of the agricultural land use prevalent in the area. Nitrite was also identified as a COPEC in the CRC, but it exceeded the LOEC of 493 ug/L in just two of 322 samples. Thus, nitrate and nitrite are not of further concern with respect to ecological risks in the 300 area.

Unfiltered uranium concentrations in multiple nearshore wells (range of 0.076 to 218 ug/L) and aquifer tubes (range of 0.93 to 394 ug/L) and filtered uranium in aquifer tubes (range of 0.55 to 167 ug/L) exceed the aquatic media benchmark in the CRC (30 ug/L from Sheppard et al., 2005) and background (9.9 ug/L). However the final benchmark used in the CRC is the 25th percentile of effect values for aquatic invertebrates. There are seventeen effect values presented for the effects of uranium to fish ranging from 75 ug/L to 135,000 ug/L. The maximum detected uranium concentration is below the values from all but one of these 17 studies. Hence, risk to fish from uranium is not significant. Risk to aquatic invertebrates and plants is discussed in more detail in Section 7.6.4.5.

Other COPECs detected in porewater above ambient water criteria do not appear to be issues in groundwater or aquifer tubes suggesting that 300 Area is not the source of observed elevated concentrations. More detailed discussion of the exceedances for additional chemicals is provided in Appendix M. In general exceedances of ambient water quality criteria for other chemicals within various aquatic media (porewater, seeps, aquifer tubes, groundwater, surface water) were either anomalous (i.e., very low frequency) or due to various laboratory reporting issues.

7.6.4.2 Risks to Aquatic Plants

Potential effects on aquatic plants were evaluated through results of a bioassay in sediment and comparison of sediment and porewater concentrations to SSLs (RCBRA Tables 6-88 through 6-91). Based on the combined porewater and sediment concentrations the RCBRA identified cadmium, chromium, Cr(VI), manganese, and uranium as COPECs warranting further evaluation for potential effects on aquatic plants. For the River Corridor as a whole, sediment concentrations were greater than benchmarks for seven COPECs (antimony, barium, cadmium, chromium, manganese, selenium, and zinc), and this information suggests a potential for adverse effects. For the 300 Area nearshore sampling sites, five of these COPECs were detected in nearshore sediment at concentrations greater than the sediment biota SSL: antimony, cadmium, manganese, selenium, and zinc. These sediment COPECs are discussed in more detail below with risks to aquatic invertebrates. As shown in RCBRA Table 6-90, porewater concentrations across the Hanford Reach were greater than chronic water standards or criteria for the following COPECs: aluminum, cadmium, chromium, Cr(VI), and lead. For the 300 Area nearshore sampling sites (U1 through U10), the porewater concentrations of calculated total uranium ranged between 0.52 µg/L and 141 µg/L and inorganic uranium ranged between 23 and 137 µg/L in unfiltered samples. All uranium concentrations in porewater exceeded the aquatic plant-based water benchmark of 14 µg/L. Manganese concentrations in porewater ranged between 0.69 µg/L and 1,640 µg/L in unfiltered samples. Two of sixteen manganese results exceeded the aquatic plant-based water benchmark of 95 µg/L; both are from one 300 Area study site (U1).

Laboratory bioassays (i.e., toxicity tests) were conducted with field-collected sediments. Some significant relationships were determined with observed response within aquatic plant toxicity tests in association with confounding factors and some COPECs. Additionally, there were clear measures of exposure (i.e. accumulation into plants), primarily for inorganic COPECs that were detected in porewater and sediment. However, of the significant relationships determined, none was with COPECs for which porewater concentrations were greater than aquatic plant benchmarks. Further, no risks to aquatic plants were noted based on toxicity testing. Though the analysis represents only one season of sampling and analysis, the weight of the available data does not suggest risk to aquatic plants.

Of the key plume contaminants in the 300 Area, concentrations of uranium have ecological relevance in the nearshore environment (i.e., porewater concentrations above aquatic plant benchmarks). As shown in Table 6-43 of the RCBRA, statistical tests showed that the concentrations of uranium are not greater than reference porewater concentrations. However, as discussed previously, uranium concentrations in groundwater, seeps, aquifer tubes, and porewater are greater than the Hanford Site background value of 9.9 µg/L. Likewise, the PNNL study in the 300 Area (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]) noted uranium in groundwater, springs, and river water as the only contaminant with concentrations of interest. Other constituents in the PNNL study (arsenic, barium, Cs-137, chromium, I-129, selenium, Tc-99, thallium, tritium, and zinc) had concentrations above background samples from Vernita Bridge but were below AWQC or BCGs (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]).

7.6.4.3 Risks to Aquatic Invertebrates

The primary lines of evidence used to evaluate risks to aquatic invertebrates are field surveys, the results of bioassays, and comparison of sediment and water concentrations to ESLs.

Abiotic Media Concentrations Compared to Literature Values. For the River Corridor as a whole, sediment concentrations were greater than ESLs for seven COPECs (antimony, barium, cadmium, chromium, manganese, selenium, and zinc), and this information suggests a potential for adverse effects (RCBRA Table 6-88). For the 300 Area nearshore sediment sampling sites, concentrations were greater than ESLs for 10 COECs (antimony, beta-BHC, bis[2-ethylhexyl] phthalate, cadmium, endosulfan I, iron, manganese, selenium, TPH-diesel, and zinc). The PNNL study in the 300 Area (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]) noted Sr-90, Cs-137, and uranium above background, but, as shown in Table M-41, concentrations from the RCBRA data set were below SSLs. Metals concentrations in the PNNL study were reported as similar to or lower than sediment from Vernita Bridge (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]).

Porewater concentrations at study sites across the Hanford Reach were greater than chronic water standards or criteria for five COPECs (aluminum, cadmium, chromium, Cr(VI), and lead; RCBRA Table 6-90). However, there are significant uncertainties relative to many of the conclusions based on porewater sampling. Further, all of these abiotic measurements represent a single point measurement within a dynamic river system with daily and seasonal fluctuations and flow volumes that can shift the composition of the substrates that were sampled. Thus, exceedances should not be ignored. The interpretation of porewater results as an indication of adverse affects to aquatic invertebrates is the same as that for aquatic plants, given that the ESLs are protective of both plants and aquatic invertebrates. For the 300 Area nearshore sampling sites (U1 through U10), the porewater concentration of calculated total uranium ranged between 0.52 µg/L and 141 µg/L and inorganic uranium ranged between 23 and 137 µg/L in 3 of 13 unfiltered samples. Total uranium concentrations exceed the aquatic invertebrate-based water benchmark of 30 µg/L at study site U4 (RCBRA Table 6-91). Uranium in aquifer tube samples (14 of 21) and unfiltered groundwater (301 of 379) also exceeded background (Tables M-8 and M-9).

Given the uncertainty with representativeness mentioned above, a more detailed discussion of each of these 11 COECs in 300 Area nearshore sediment was presented in Appendix M. The results from the evaluation in Appendix M showed there were concentrations of beta-BHC, endosulfan I, TPH-diesel, BEHP, and inorganics detected in sediment at a concentration higher than ESLs. Likewise, selenium, lead, Cr(VI), and TPH in sediment were identified as COECs in the CRC (DOE/RL-2010-117). As described below, concentrations of some of these COECs in sediments in the 300 Area nearshore environment either are below ESLs (Cs-137, Sr-90, lead, and uranium) and/or below reference (antimony,

beta-BHC, bis(2ethylhexyl)phthalate, cadmium, endosulfan 1, iron, manganese, selenium, TPH, and zinc). This suggests that sediments upstream of the Hanford Site potentially contribute to concentrations observed in the 300 Area nearshore area. Further, riparian soils for most of the COECs are lower than upstream sediment and Hanford Site reference soil concentrations, suggesting that the riparian soils in the 300 Area are not a source of the observed sediment concentrations for the COECs identified. Biological measures such as amphipod bioassays, clam tubes, and community surveys from rock baskets show no clear indication of toxicity or correlation of response with COEC concentrations. Though they do represent only a snapshot in time and do not represent all seasonal conditions and river stage fluctuations, they do support the analysis that Hanford Site operations at 300 Area are not adversely affecting aquatic receptors exposed to sediment in the 300 Area nearshore environment. Based on these findings, only uranium in groundwater warrants further evaluation in the FS.

Direct Toxicity Measures. Risks to aquatic macroinvertebrates based on toxicity testing showed some relationships with confounding factors and some COPECs. Histopathology measures differed in study sites compared to reference sites; these measures also showed some negative relationships with COPECs. Sediment bioassays for the 300 Area study sites showed no difference in growth or higher growth in amphipod (hyalella azteca) relative to 300 Area reference sites. The survival of amphipods at 300 Area study sites was higher than that for the 300 Area reference sites, with the exception of study site U10. Likewise, survival and reproduction tests on water fleas in porewater showed no difference at four 300 Area sites (5c Aq, 5d Aq, U1, and U4) relative to reference sites. Correlation between abiotic media chemistry and any observed differences in measured effects from both bioassays was conducted across the whole Hanford Reach. Mercury was the only COPEC with a significant correlation that showed a potential negative effect with a significant regression; however, mercury was below sediment ESLs at the 300 Area study sites. Clams were also monitored for survival. There was a statistical decrease in survival at study sites compared to reference sites, but there was no correlation of clam survival with COPECs. Together these measures do not indicate substrate concentrations were toxic. However, they do represent only a snapshot in time and do not represent all seasonal conditions and river stage fluctuations.

Community Structure Measures. Key community metrics do not suggest that contaminant-related impacts to benthic macroinvertebrates are evident in aquatic study sites as a group, as evident by the comparison of EPC data from study sites relative to reference sites. Most of the aquatic community measures did not differ between the study sites and reference sites. There were exceptions among the large number of aquatic community measures evaluated, but the agreement among measures was weak and the biological significance to populations is not evident.

Measures of Exposure. Within the RCBRA, there were clear measures of exposure (accumulation), primarily for inorganic COPECs that were detected in water, sediment, and tissues. The PNNL study (Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area [PNNL-13692]) also noted elevated levels of uranium, selenium, and chromium in clam tissues adjacent to the 300 Area relative to the Vernita Bridge background. However, as shown in the RCBRA, there were no statistically significant correlations between COPEC concentrations in porewater or sediment with tissues of aquatic organisms, indicating a lack of significant COPEC bioaccumulation. Further, no tissue effect levels for COPECs in invertebrate tissue were exceeded.

Most histopathology measures of clams and mussels showed no significant differences between study sites and reference. While, there were some exceptions, COPEC concentrations generally did not correlate with differences in histopathology measures. Histopathology results in the PNNL study support these findings, as there were no abnormal frequency of lesions in target tissues in crayfish and sculpin.

In the PNNL study (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]), radiation dose estimates were conducted for aquatic and terrestrial organisms exposed to sediment and surface water with all SOFs being below 1, indicating no adverse effects are likely.

Weight of Evidence. As stated previously, both the abiotic and biotic measures collected for the RCBRA represent only a snapshot in time and do not represent all seasonal conditions and river stage fluctuations. Abiotic measurements do exceed literature-based screening values for some COPECs. Generally, this line of evidence is given the lowest weight given the lack of site-specificity in the literature-based values. Though biological measures give a different perspective than the chemistry, given the limited data set and the uncertainty with full representation of seasonal measurements, the results of the chemistry cannot be ignored.

Of the key plume contaminants investigated, only uranium had concentrations of ecological relevance in the nearshore environment for the 300 Area. As porewater concentrations of uranium were higher than chronic water quality standards or criteria, this COPEC in groundwater in the 300 Area warrants further evaluation in the FS. This conclusion is applicable to both aquatic invertebrates and amphibians.

7.6.4.4 Risk to Wildlife

The RCBRA evaluated risk to middle trophic level wildlife including the kingbird, mink, and bufflhead Risks to wildlife in the nearshore environment are primarily from ingestion of prey consisting of aquatic invertebrates, clams, and fish and from incidental ingestion of sediment. Only chromium risk to the bufflehead represented a risk warranting further evaluation and the chromium was elevated at just one study site which is not within the 300-Area nearshore environment.

Risk to wildlife in the CRC focused on exposure to island and riparian soils, not sediment. A risk to birds from lead in island and riparian soils was identified. However, the maximum island concentration of lead was 94.3 mg/kg, far below the wildlife PRG presented in Table 7-3 of this chapter. Further, the maximum concentration of lead in 300 area riparian soils is only 31 mg/kg. Thus, 300 area soils are not contributing to any potential risks to birds from lead on the islands of the Columbia River.

7.6.4.5 Transport Pathways for Uranium from Groundwater to Surface Water

The unconfined aquifer beneath the 300 Area discharges to the Columbia River via upwelling through the riverbed, and to a lesser extent, via riverbank springs that appear during periods of low river stage. Sampling locations (e.g., near-river wells, riverbank springs, aquifer tubes, and nearshore river water) used for water quality monitoring near the Columbia River are discussed in the Riparian and Nearshore CSM presented in Appendix M. As is discussed in Section 4, two prominent springs (S3-42-2 and S3-DR-42-2) along the 300 Area shoreline have been routinely monitored for many years as part of the SESP. Samples of spring water and associated fine-grained sediment collected during the late summer/early fall months have been analyzed for uranium and other waste effluent indicators. Annual sampling is done when Columbia River flow is at its seasonal low, resulting in the maximum flow of groundwater from the unconfined aquifer to the river. In addition, data were collected near 300 Area during the CRC (DOE/RL-2010-117) to address the uncertainty related to the level of contamination entering the Columbia River via upwelling, including the contaminant transport mechanisms. Porewater, surface water, and sediment sampling in the Columbia River was conducted in 2009 and 2010, as outlined in the Columbia River RI Work Plan (DOE/RL-2008-11).

While the regional gradient directs groundwater flow toward the Columbia River, at any particular time the local gradients reflect the stage of the river, which varies with daily, weekly and seasonally. Correspondingly, the concentrations of uranium detected in aquifer tubes over time vary three orders of

magnitude from near detectable to concentrations similar to the highest concentrations found in groundwater. Uranium concentrations in aquifer tube samples collected during March/April 2011 ranged between 11 and 77 µg/L (see Figure 4-54). Estimates using the specific conductance of river water and groundwater have suggested that aquifer water monitored by tubes is approximately 60 percent approaching groundwater and 40 percent intruding river water (*Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington* [PNNL-17034]). Porewater conductivity sampling performed as part of the CRC RI showed the presence of groundwater in porewater and upwelling sampling locations. Concentrations of uranium have been detected in porewater when measured under conditions of upwelling to the river. However, surface water samples collected during the SESP have detected very low concentrations of uranium in surface water, well below the concentrations detected in porewater or aquifer tube samples. As shown in the most recently available 2009 Annual Environmental Report (PNNL-19455), concentrations of uranium in surface water both upstream and downstream of the Hanford Site during 2009 were similar to results measured in recent years. Measured concentrations of total uranium in upstream and downstream surface water samples range between 0.3 and 0.45 µg/L, with concentrations detected at the city of Richland (downstream of the Hanford Site) being slightly higher than concentrations detected at Priest Rapids Dam (upstream of the Hanford Site). While uranium has been detected in porewater at the Hanford Site, uranium is also known to enter the Columbia River from non-Hanford Site sources such as phosphate fertilizers, which enters the river via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the river. There is no Washington State AWQC for uranium; however, there are aquatic plant-based thresholds and aquatic invertebrate-based thresholds that are available ("Derivation of Ecotoxicity Thresholds for Uranium" [Sheppard et al., 2005]).

Thirty-four locations were sampled and analyzed for total uranium during the Phase II(b) sampling event near the 300 Area shoreline. Phase II(b) samples were collected from late August 2009 through September 2009. Twenty-seven of the locations were collected along the shoreline of the 300 Area with uranium concentrations ranging between 0.15 and 113 µg/L. Eight of the 27 locations report concentrations greater than the aquatic plant-based water benchmark of 14 µg/L and the invertebrate-based threshold of 30 µg/L presented in the CRC. *Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington: Collection of Surface Water, Pore Water, and Sediment Samples for Characterization of Groundwater Upwelling* (WCH-380) indicates that Phase II(b) uranium results generally conformed to the isopleths generated from the Hanford Site groundwater monitoring date. Surface water samples were not analyzed for total uranium during Phase II(b).

Eight locations were sampled and analyzed for total uranium during the Phase III sampling event near the 300 Area shoreline. Phase III samples were collected from early January 2010 to late February 2010. Seven of the eight locations were collected along the shoreline of the 300 Area; a duplicate sample was collected from each location. With the exception of one uranium result, uranium concentrations ranged between 40 and 197 µg/L, which are greater than the aquatic plant-based and invertebrate-based water benchmark of 14 and 30 µg/L, respectively. During the Phase III sampling event, 18 surface water samples were collected within the 300 Area and analyzed for total uranium. Total uranium was not detected in any of the surface water samples analyzed for this constituent.

Based on the available information, there is a pathway for migration of concentrations of uranium in 300 Area near-river groundwater to shoreline porewater. In addition, there is evidence (based on conductivity measurements) of porewater entry into Columbia River surface water. However, the flux of uranium in groundwater is apparently too small to produce significant uranium impacts related to Hanford Site operation in Columbia River surface water.

7.6.4.6 Transport Pathways for Trichloroethene from Groundwater to Surface Water

TCE has been found in a very low permeability, relatively finer-grained interval of Ringold Formation unit E sediment in the unconfined aquifer. The contamination initially appeared to be limited to the area immediately east of the former 307 Process Trenches and South Process Pond. The finer grained interval has a very low permeability and does not readily yield groundwater. Groundwater moves very slowly through this hydrologic unit; however, the unit is incised by the river channel, so at least some potential exists for exposure at the riverbed. The assessment of the nature and extent of TCE contamination discussed in Chapter 4 concluded that because of the very low flow rate through the sediment, contaminant discharge through the riverbed is unlikely to cause habitat degradation or negative impacts to river water quality.

TCE in groundwater samples collected from aquifer tubes beneath the 300 Area are consistent with expectations based on monitoring wells (see Figure 4-57, Chapter 4). Some tube screens are proximal to, or within, the finer-grained interval of Ringold sediment that is contaminated by TCE. TCE was analyzed in a subset of the aquifer tube samples collected in late March/early April 2011. Two of the aquifer tubes sampled during March are proximal to, or within, the finer grained interval of Ringold sediment that is contaminated by TCE. Aquifer tube AT-3-3-D is the only tube screen known to be emplaced in the finer-grained interval of Ringold Unit E sediment. TCE concentrations up to 530 µg/L have reported at this location over the past five years; however, TCE concentrations in the sample collected during April 2011 were nondetectable. TCE has also been consistently detected in aquifer tube AT-3-7-D with concentrations of TCE reported up to 99 µg/L over the past five years. There is not Washington State AWQC for TCE; however, there is a freshwater screening benchmark of 21 µg/L published by the Canadian Water Quality Guidelines.

Limited porewater and seep analytical data are available for TCE (see Appendix M), those results show lower concentrations compared with concentrations detected in groundwater or aquifer tube samples. Twelve sample locations were sampled and analyzed for TCE during the Phase II(b) sampling event near the 300 Area shoreline. Phase II(b) samples were collected in late August 2009 through September 2009. TCE was not detected in any of the porewater samples analyzed for this constituent (all MDLs were less than the freshwater screening benchmark of 21 µg/L). Eight locations were sampled and analyzed for TCE during the Phase III sampling event near the 300 Area shoreline. Phase III samples were collected from early January 2010 to late February 2010. With the exception of one TCE result, TCE was not detected in any of the porewater samples analyzed for this constituent (all MDLs and the detected concentration were less than the freshwater screening benchmark of 21 µg/L). During the Phase II sampling event, 12 surface water samples were collected within the 300 Area and analyzed for TCE. TCE was not detected in any of the surface water samples analyzed for this constituent.

The results from porewater, seep, and surface water sampling are consistent with the environmental fate for TCE. TCE has a high Henry's Law constant and readily volatilizes from water into air. Based on the current understanding of TCE flux to the river, coupled with the available analytical results and an understanding of the volatilization fate process for TCE in surface water, indicates that TCE from Hanford Site groundwater is unlikely to be found in surface water at levels of human health or ecological concern.

7.6.5 Conclusions

Table 7-8 presents the 10 COECs identified by RCBRA Report (DOE/RL-2007-21), CRC (DOE/RL-2010-117), and the PNNL study (*Survey of Radiological and Chemical Contaminants in the*

Near-Shore Environment at the Hanford Site 300 Area (PNNL-13692)[7] in the riparian and nearshore media. Except for uranium in groundwater, there are potential sources for the COECs that are unrelated to the Hanford Site. These sources are summarized in the RCBRA Report (DOE/RL-2007-21) and the CRC (DOE/RL-2010-117). Taking into consideration what is understood to be principal threat constituents in soil and groundwater at the 300 Area, compared with the contaminants identified by RCBRA as posing ecological risks in riparian and nearshore media, additional work was warranted to understand the CSM in the riparian and nearshore environment better. The interrelationships between sources, transport mechanisms, exposure pathways, and receptors have been examined in more detail and the results of this evaluation are presented in Appendix M. Each of the COECs discussed in Table 7-8 are discussed in Appendix M in detail with respect to the possibility of media within the 300 Area being a source of the potential contamination observed. For each COEC, RCBRA and CRC (DOE/RL-2010-117) abiotic media data (soil, sediment, groundwater, porewater, aquifer tubes, seeps, and surface water) from reference areas, upstream sources, and onsite riparian and nearshore areas were presented and discussed to establish the likelihood that the 300 Area was the source of the COEC identified. Only uranium in groundwater was considered a source of the COECs in the nearshore and riparian area.

7.7 Risk Conclusions and SMDP

COPCs were identified in 38 of the 300 Area waste sites, which were reclassified as “interim closed,” “closed,” and “no action” through the TPA process. EPCs of COPCs for each decision unit (e.g., overburden, shallow-focused, shallow, and staging pile footprint) at each waste site were compared to the plant/invertebrate SSL, the wildlife SSL, background, the plant/invertebrate PRG, and wildlife PRG values.

Analytes that exceeded a SSL, background, and a PRG were considered COPECs. Within the 300 Area, 17 waste sites were retained for additional consideration in the SMDP based on EPC exceedances of 16 COPECs (boron, copper, mercury, nickel, selenium, silver, total uranium isotopes, aldrin, Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260, and TPH-motor oil).

At the SMDP, the results of the ecological risk assessment should be considered in the context of other factors (e.g., spatial coverage, data, chemical specifics, receptors at risk, and confidence in PRGs) to support recommendations on the COECs to be brought forward to the risk managers and considered for the FS. This would include agreement on the assessment endpoints, representative receptors, and complete exposure pathways that correspond to those COECs. The results of the evaluation in Appendix M also bring forth recommendations to risk managers. The final recommendation for the SMDP is a conclusion that there are no potential risks to ecological receptors warranting further evaluation in the FS. There is a recommendation from the evaluation of potential contributions to risks in the nearshore and riparian area that uranium in 300 Area groundwater warrants evaluation of remedial alternatives in the FS.

[7] The PNNL study (*Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area* [PNNL-13692]) did not specifically identify COECs, because this was not a risk assessment. However, constituents were characterized relative to background and available ecological risk-based thresholds with differences noted.

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8 Identification and Screening of Technologies

The CSM is a representation of site conditions and what is known or suspected about the contaminant sources, release mechanisms, and contaminant fate and transport. The exposure pathways, potential receptors, and risk to the receptors are considered in the conceptual exposure model. This information is presented in Chapters 4 through 7. Technologies are evaluated in this chapter to determine their effectiveness to remove the contaminants or interrupt the exposure pathway.

This chapter begins the FS of the RI/FS. The FS consists of three phases: screening of remedial technologies, development of remedial alternatives, and detailed analysis of selected alternatives. Remedial technologies are assembled into alternatives that address contamination on a media- or source-specific basis.

Chapter 8 presents the development of ARARs, PRGs, RAOs, and general response actions (GRAs), and identifies and screens remedial technologies and associated process options to clean up the contamination. Chapter 9 assembles the alternatives and Chapter 10 provides a detailed analysis of the alternatives to address contaminated media at the 300 Area.

Highlights

- RAOs were developed for groundwater, surface water, soil, land use, and resources.
- PRGs are based on the reasonably anticipated future land-use conditions that DOE has determined to be industrial or unrestricted for certain areas.
- PRGs have been proposed for waste sites that have not yet been remediated. Remedial alternatives for these sites are evaluated in the FS based on several factors, including process knowledge.
- The data from waste sites that have been remediated through interim actions were evaluated for risk to human health, ecological receptors, groundwater protection, and surface water protection in preceding chapters. Of those sites, three waste sites exceeded criteria for groundwater protection for uranium, and are considered in the FS for further remediation.
- A range of general response actions to meet RAOs was evaluated for waste sites and contaminated groundwater at the 300 Area, including no action, monitoring, institutional controls, removal, treatment, and containment. Process options and technologies under these response actions were evaluated for relative effectiveness, implementability, and cost.
- Response actions retained for waste sites include no action, institutional controls, removal, treatment, and disposal, in situ treatment, and containment.
- Response actions retained for groundwater include no action, institutional controls, MNA, and containment.

8.1 Remedial Action Objectives

RAOs are general descriptions of what the remedial action is expected to accomplish (that is, medium-specific or site-specific goals for protecting HHE. They are defined as specifically as possible to address the following concerns:

- Media of interest (soil or groundwater)
- Types of contaminants (radionuclides and chemical constituents)
- Potential receptors (human and ecological)
- Exposure pathways (external radiation, direct contact, ingestion, or inhalation)

The RAOs provide a basis for evaluating the capability of a specific remedial alternative to achieve compliance with potential ARARs and/or an intended level of risk protection for HHE in accordance with the NCP (40 CFR 300.430(e)(2)(i)) and CERCLA RI/FS Guidance (EPA/540/G-89/004). RAOs for the 300 Area are presented in Section 8.1.4. Background information used in developing the RAOs is presented in Sections 8.1.1 through 8.1.3.

8.1.1 Contaminants of Concern

In the RI/FS process, the results of the risk assessment and fate and transport evaluation are used to identify COPCs, which represent contaminants that will be evaluated in the FS to define the COCs and guide the selection of remedial alternatives.

8.1.1.1 Waste Site Soil

As evaluated in Chapters 5, 6, and 7, and further described in Section 8.3.1, 36 waste sites at the 300-FF-2 OU had close out verification data and could be quantitatively evaluated. Based on the evaluations provided in Chapters 5, 6, and 7, the following analytes were identified as COPCs in soil: aldrin, Aroclor-1216, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, Aroclor-1260, boron, Cs-137, total beta radiostrontium (Sr-90), total uranium isotopes, uranium, U-233/234, U-235, and U-238.

Additionally, remedial actions will not be started on 66 300-FF-2 OU waste sites at the 300 Area until after the ROD is signed. These sites are termed "Post-ROD To-Go Sites." Many of the sites have limited or no data available; therefore, these yet-to-be remediated waste sites could not be evaluated in Chapters 5, 6, or 7. For yet-to-be remediated waste sites, additional COPCs are identified based on LFI data and process knowledge, and are listed in Table 8-1. Section 8.2.1 presents additional information on waste sites with limited data.

8.1.1.2 Groundwater

The following contaminants were identified as COPCs for the 300-FF-5 groundwater OU: uranium, gross alpha, TCE, cis-1,2-DCE, nitrate, and chromium at the 300 Area Industrial Complex, and tritium and nitrate at the 600 Area subregion. There is no 300-FF-5 groundwater contamination at the 400 Area, thus no COPCs have been identified.

The supplemental groundwater risk evaluation in Chapter 6 identified eleven analytes for the 300 Area subregion and six analytes for the 600 Area subregion that are not final COPCs but move forward into the FS because they have uncertainty associated with the data set and occurrence in groundwater. The analytes in the 300 Area subregion include aluminum, antimony, carbon tetrachloride, chloroform, cobalt, copper, iron, nickel, silver, sulfate, and zinc. The analytes in the 600 Area subregion include carbon tetrachloride, chloroform, copper, lead, uranium, and zinc. The nature and extent evaluation indicates these analytes historically have been detected in groundwater at concentrations above their respective action levels, but their presence was not associated with a specific location or with a trend. Therefore, monitoring of these contaminants will be performed to understand their persistence in the environment.

8.1.2 Applicable or Relevant and Appropriate Requirements

Substantive standards of promulgated regulations pertaining to CERCLA response actions are identified through the ARAR identification process, which is based on CERCLA Section 121(d), "Degree of Cleanup," and CERCLA RI/FS Guidance (EPA/540/G-89/004); *CERCLA Compliance with Other Laws Manual: Interim Final* [EPA/540/G-89/006]; and *CERCLA Compliance with Other Laws Manual: Part I* [EPA/540/G-89/009]). CERCLA Section 121(d), "Degree of Cleanup," requires, with exceptions, that any promulgated substantive ARAR standard, requirement, criterion, or limitation under any federal environmental law, or any more stringent state requirement pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain onsite after completion of remedial action. Additionally, the NCP ("Remedial Design/Remedial Action, Operation and Maintenance" [40 CFR 300.435(b)(2)]) requires that ARARs be attained (unless waived) during the remedial action. Identifying ARARs is part of the 300 Area FS process.

Table 8-1. Summary of Soil COPCs Based on Process Knowledge

Radionuclides	Nonradionuclides	
Americium-241	1,1,1-Trichlorethane	Hexachloroethane
Carbon-14	1,2-Dichloroethene (total)	Hexavalent Chromium
Cesium-137	Antimony	Lead
Cobalt-60	Aroclor-1016 (PCB)	Lithium
Europium-152	Aroclor-1221 (PCB)	Manganese
Europium-154	Aroclor-1232 (PCB)	Mercury
Europium-155	Aroclor-1242 (PCB)	Methyl ethyl ketone
Iodine-129	Aroclor-1248 (PCB)	Methyl isobutyl ketone (hexone)
Nickel-63	Aroclor-1254 (PCB)	Nickel
Plutonium-238	Aroclor-1260 (PCB)	Nitrobenzene
Plutonium-239/240	Arsenic	Normal paraffin hydrocarbon
Plutonium-241	Asbestos	(kerosene)
Strontium-90	Barium	Phenanthrene
Technetium-99	Benzene	Selenium
Tritium	Benzo(a)pyrene	Silver
Uranium-233/234	Beryllium	Sodium (metal)
Uranium-235	Bis(2-ethylhexyl)phthalate	Strontium
Uranium-238	Bismuth	Tetrachloroethene
	Butylbenzylphthalate	Thallium
	Cadmium	Tin
	Carbon tetrachloride	Toluene
	Chloroform	Total petroleum hydrocarbons
	Chromium (total)	Tributyl phosphate
	Chrysene	Trichloroethene
	cis-1,2-Dichloroethylene	Uranium (total)
	Copper	Vanadium
	Cyanide	Vinyl chloride
	Ethyl acetate	Xylene
	Ethylene glycol	Zinc
	Hexachlorobutadiene	

Waste sites and groundwater in the 300 Area will be remediated under a CERCLA decision document. Any remedial action(s) implemented will be required to meet ARARs. In many cases, the ARARs form

the basis for the PRGs to which contaminants must be remediated to protect HHE. ARARs also define or restrict how specific requirements of a remedial alternative can be implemented based on the nature of the activity or the location of the site.

8.1.2.1 The ARARs Evaluation Process

The ARARs evaluation prepared for this RI/FS was conducted in accordance with the NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy" [40 CFR 300.430(f)(1)(ii)(B)(2)]).

A distinction and clarification related to ARARs involves onsite and offsite actions. Onsite actions are defined to be "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (NCP [40 CFR 300]). Onsite actions must comply with ARARs, but need only comply with the substantive parts of those requirements. Offsite actions must comply with both the substantive and administrative requirements. For onsite activities, a requirement under federal and state environmental laws may be either applicable or relevant and appropriate, but not both.

The identification of ARARs is a two-step process. First, it must be determined if the law or regulation is applicable. If not applicable, it must be determined if the law or regulation is both relevant and appropriate. The terms "applicable" and "relevant and appropriate" are defined in the NCP ("Definitions" [40 CFR 300.5] as follows.

"Applicable requirements" are those substantive standards that specifically address the situation at a CERCLA site and would legally apply to remedial actions in the absence of CERCLA authority. All jurisdictional prerequisites of the requirement must be met in order for the requirement to be applicable, including specific application to federal agencies (e.g., through a waiver of federal sovereign immunity).

"Relevant and appropriate" requirements mean those environmental requirements such as cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (NCP, "General" [40 CFR 300.400(g)(2)]). A requirement that is relevant and appropriate may not meet one or more jurisdictional prerequisites for applicability but still make sense at the site, given the circumstances of the site and the release.

In evaluating the relevance and appropriateness of a requirement, the eight comparison factors in the NCP ("General" [40 CFR 300.400(g)(2)]) are considered:

1. Purpose of the requirement and the purpose of the CERCLA action
2. Medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site
3. Substances regulated by the requirement and the substances found at the CERCLA site
4. Actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site
5. Variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site
6. Type of place regulated and the type of place affected by the release or CERCLA action
7. Type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action

8. Consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA

To be considered (TBC) information represents another category of nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of ARARs. In some circumstances, TBC information will be evaluated, along with ARARs, in determining the remedial action necessary to protect HHE. TBC information complements ARARs in determining protectiveness at a CERCLA site or in assessing implementation of certain actions. For example, because cleanup standards do not exist for all contaminants, health advisories, which would be TBC information, may be helpful in defining cleanup levels.

Section 161 of the AEA, as amended, provides DOE the authority to establish DOE Orders containing instructions and operational requirements considered important to protect HHE from nuclear material, source material, and byproduct materials. While the requirements of DOE Orders must be met, they are not ARARs and are independent of the TBC and ARARs identification process at the Hanford Site.

Potential ARARs for the 300 Area are examined to determine if they fall into one of three categories: chemical-specific, location-specific, or action-specific requirements. These categories are defined as follows:

- Chemical-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public and worker safety levels and site cleanup levels.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by remedial actions performed at the site.

8.1.2.2 Waivers from ARARs

The CERCLA lead agency delegated authority under Section 121, "Degree of Cleanup," may waive ARARs, with EPA's concurrence, and select a remedial action that does not attain the same level of cleanup as that identified by the ARARs. In *Superfund Implementation* (Executive Order 12580), the president delegated CERCLA Section 121, "Degree of Cleanup," authority to DOE for cleanup of DOE facilities. Section 121 of the *Superfund Amendments and Reauthorization Act of 1986* identifies the following six circumstances in which DOE may waive ARARs for onsite remedial actions:

- The remedial action selected is only a part of a total remedial action (such as an interim action), and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to HHE than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance using another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- In the case of Section 104 (Superfund financed remedial actions), compliance with the ARAR will not provide a balance between protecting HHE and the availability of Superfund money for response at other facilities.

During the RI/FS process, needed ARARs waivers are identified during the development of the RI/FS report, summarized in the proposed plan, and then documented in the ROD. After remedy implementation (post-ROD), if performance-monitoring data indicate that attainment of ARARs is technically impracticable from an engineering perspective, then an evaluation may be conducted to assess whether a technical impracticability (TI) waiver from one or more chemical-specific ARARs is warranted. TI waivers only apply to that portion of the groundwater contaminant plume for which restoration to ARARs is determined to be technically impracticable.

8.1.2.3 Potential ARARs Identified

Table 8-2 presents potential federal and Washington State ARARs. When the final remedy selection is documented in the ROD, all federal and state ARARs with which the final remedy must comply, are also finalized. Key potential ARARs are identified in the following text.

Potential Chemical-Specific ARARs. The chemical-specific ARARs that may affect remediation of the 300 Area OU are the elements of the *Washington Administrative Code* regulations that implement the MTCA (WAC 173-340). Within this branch of the *Washington Administrative Code*, there are detailed regulations with developing standards for remedial actions involving soil cleanup ("Soil Cleanup Standards for Industrial Properties" [WAC 173-340-745]) and groundwater cleanup standards ("Groundwater Cleanup Standards" [WAC 173-340-720]). These standards are in the form of risk-based concentrations that help establish soil and groundwater cleanup standards for nonradioactive contaminants. Following is a list of additional Washington State and Federal regulations:

- "Selection of Cleanup Actions" (WAC 173-340-360) and "Overview of Cleanup Standards" (WAC 173-340-700) through "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493)
- Nonzero MCL goals and MCLs promulgated under the SDWA ("National Primary Drinking Water Regulations" [40 CFR 141]) and/or by the State of Washington ("Group A Public Water Supplies" [WAC 246-290])
- AWQC developed under the *Clean Water Act of 1977* (Section 304) and/or promulgated by the state of Washington ("Water Quality Standards for Groundwaters of the State of Washington" [WAC 173-200] and "Water Quality Standards for Surface Waters of the State of Washington" [WAC 173-201A])
- *Toxic Substances Control Act of 1976* (TSCA) (implemented via "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" [40 CFR 761])
- "National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50)
- "National Emissions Standards for Hazardous Air Pollutants" (40 CFR 61)

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Groundwater					
***Safe Drinking Water Act of 1974* (Public Law 93-523, as amended; 42 USC 300f, et seq.); "National Primary Drinking Water Regulations" (40 CFR 141)**					
"Maximum Contaminant Levels for Organic Contaminants" (40 CFR 141.61) "Maximum Contaminant Level Goals for Organic Contaminants" (40 CFR 141.50)	Chemical	Establishes MCLs and non-zero MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of organic contaminants in the drinking water.	Groundwater in the 300 Area contains contaminants that may require remediation. Although groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River (which is used for drinking water).	ARAR	Groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater, in situ remediation of groundwater, MNA).
"Maximum Contaminant Levels for Inorganic Contaminants" (40 CFR 141.62) "Maximum Contaminant Level Goals for Inorganic Contaminants" (40 CFR 141.51)	Chemical	Establishes MCLs and non-zero MCLGs as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	Groundwater in the 300 Area contains contaminants that may require remediation. It is not currently used for drinking water but is a potential drinking water source (it discharges into the Columbia River, which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, MNA).
"Maximum Contaminant Levels for Radionuclides" (40 CFR 141.66)	Chemical	Establishes MCLs as criteria for groundwater and surface water that are or may be used for drinking water. The standards are designed to protect human health from adverse effects radionuclides in the drinking water.	Groundwater in the 300 Area contains contaminants that may require remediation. It is not currently used for drinking water but is a potential drinking water source (it discharges into the Columbia River, which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, MNA).

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Water Pollution Control" (RCW 90.48, as amended); "Underground Injection Control Program" (WAC 173-218)					
"UIC Well Classification Including Allowed and Prohibited Wells" (WAC 173-218-040)	Action	Establishes criteria and standards for an underground injection control program.	Groundwater in the 300 Area contains contaminants that may require remediation. Treated groundwater may be discharged through underground injection wells.	ARAR	Groundwater remedial activities may involve underground injection.
"Hazardous Waste Cleanup -- Model Toxics Control Act" (RCW 70.105D, as amended); "Model Toxics Control Act—Cleanup" (WAC 173-340)					
"Groundwater Cleanup Standards" (WAC 173-340-720) "Groundwater Cleanup Standards" (WAC 173-340-720(4)(b)(i-iii) (A)&(B) and WAC 173-340-720(7))	Chemical	Groundwater cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions. Method B equations (720-1 and 720-2) to calculate groundwater cleanup levels for non-carcinogens and carcinogens, respectively. Groundwater cleanup levels are established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards.	Groundwater in the 300 Area contains contaminants that may require remediation. It is not currently used for drinking water but is a potential drinking water source (it discharges into the Columbia River, which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, MNA).

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
***Washington State Hazardous Waste Management Act of 1976* (RCW 70.105, as amended); "Dangerous Waste Regulations" (WAC 173-303)**					
"Requirements" (WAC 173-303-64620(4))	Chemical	Provides standards for groundwater protection including background, MCLs, and ACLs. The MCLs are established at the same levels as SDWA MCLs; where SDWA MCLs do not exist, health-based ACLs may be established that are protective of HHE.	Some portions of the 300 Area are regulated under corrective action of the state's dangerous waste regulations and may require groundwater remediation.	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, MNA).
***Water Well Construction Act of 1971* (RCW 18.104, as amended); "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160)**					
"How Shall Each Water Well Be Planned and Constructed?" (WAC 173-160-161)	Action	Identifies well planning and construction requirements.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Requirements for the Location of the Well Site and Access to the Well?" (WAC 173-160-171)	Action	Identifies the requirements for locating a well.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?" (WAC 173-160-181)	Action	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?" (WAC 173-160-400)	Action	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the General Construction Requirements for Resource Protection Wells?" (WAC 173-160-420)	Action	Identifies the general construction requirements for resource protection wells.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Minimum Casing Standards?" (WAC 173-160-430)	Action	Identifies the minimum casing standards.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Equipment Cleaning Standards?" (WAC 173-160-440)	Action	Identifies the equipment cleaning standards.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Are the Well Sealing Requirements?" (WAC 173-160-450)	Action	Identifies the well sealing requirements.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
"What Is the Decommissioning Process for Resource Protection Wells?" (WAC 173-160-460)	Action	Identifies the decommissioning process for resource protection wells.	Groundwater monitoring and treatment wells and borings occur in the 300 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Radionuclide ARAR Dose Compliance Concentrations for Superfund Sites					
"Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" (Luftig and Weinstock, 1997 [OSWER Directive 9200.4-18]) "Distribution of OSWER Radiation Risk Assessment Q & A's Final Guidance" (Luftig and Page, 1999 [distributing OSWER Directive 9200.4-31P])	Chemical	This memorandum presents clarification for establishing protective cleanup levels in media for radioactive contamination at CERCLA sites. EPA has determined that the dose limits established by the NRC in "Radiological Criteria for License Termination" (62 FR 39058) (25 mrem/yr, which is equivalent to 5×10^{-4} increase lifetime risk), will not provide a protective basis for establishing PRGs under CERCLA. A dose of 15 mrem/yr effective dose (approximately equivalent to 3×10^{-4} increase in lifetime risk) is preferred as the maximum dose limit for humans. In the final guidance, EPA further clarifies that 15 mrem/yr is not a presumptive cleanup level under CERCLA. Rather, site decision makers should continue to use the CERCLA risk range when ARARs are not used to set cleanup levels. This is for several reasons, as using dose based guidance would result in unnecessary inconsistency regarding how radiological and non-radiological (chemical) contaminants are addressed at CERCLA sites.	Groundwater in the 300 Area contains radioactive contaminants that, if not remediated, could pose unacceptable risk to human health.	TBC	Development of groundwater cleanup levels.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (EPA/540/R-099/009 [OSWER Directive 9200.4-17P])	Action	Provides the framework and appropriateness for using MNA as a remedy component for organic and inorganic contaminants.	Groundwater in the 300 Area contains contaminants that may require remediation. The use of MNA as a remedy may be appropriate.	TBC	Groundwater remediation activities including MNA.
Surface Water					
***Clean Water Act of 1972* (Public Law 107-303, as amended; 33 USC 1251, et seq.), Section 303c; "Water Quality Standards" (40 CFR 131)**					
"Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B)" (40 CFR 131.36(b)(1))	Chemical	Establishes numeric water quality criteria for the protection of human health and aquatic organisms. Toxic criteria for the protection of aquatic life is provided in the water quality criteria regulations "Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B)" (40 CFR 131.36(b)(1)), supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	Groundwater in the 300 Area contains contaminants that may require remediation and discharges into the Columbia River.	ARAR	Groundwater remediation activities that impact surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).
"Hazardous Waste Cleanup — Model Toxics Control Act" (RCW 70.105D, as amended); "MTCA—Cleanup" (WAC 173-340)					
"Surface Water Cleanup Standards" (WAC 173-340-730)	Chemical	Surface water cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions.	Groundwater in the 300 Area contains contaminants that may require remediation and discharges into the Columbia River. The Columbia River is a current and future source of drinking water.	ARAR	Groundwater, remediation activities that impact surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Water Pollution Control" (RCW 90.48, as amended); "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A)					
"Toxic Substances" (WAC 173-201A-240(3))	Chemical	Establishes water quality standards for surface waters of the State of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife.	Groundwater in the 300 Area contains contaminants that may require remediation and discharges into the Columbia River. The Columbia River is a current and future source of drinking water. The use designations for the Columbia River include aquatic life use (spawning and rearing), primary contact recreation, water supply (drinking, irrigation, and agriculture), and miscellaneous uses (wildlife habitat, harvesting, commerce, boating, and aesthetics).	ARAR	Groundwater, remediation activities that impact surface water (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Soil and Vadose Zone					
"Model Toxics Control Act Statute and Regulation" (Chapter 70.105D RCW, as amended); "MTCA Cleanup Regulation" (Chapter 173-340 WAC)					
"Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745(5))	Chemical	Establishes soil cleanup levels where industrial land use represents the reasonable maximum exposure under both current and future site use conditions. Cleanup standards require specification of the following: • Hazardous substance concentrations that protect HHE (cleanup levels) • Location of the site where cleanup levels must be attained ("points of compliance") • Other regulatory requirements that apply to the cleanup action because of the type of action or location of the site These requirements are generally established in conjunction with the selection of a specific cleanup action.	Soil in the 300 Area contains contaminants that may require remediation. The requirements corresponding to Method B soil cleanup levels may be used to calculate cleanup levels based on an unrestricted land use, which is more conservative than the industrial land use assigned to this area.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds Method B cleanup levels.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Deriving Soil Concentrations for Groundwater Protection" (WAC 173-340-747(3) through (8))	Chemical	Establishes soil concentrations that will not cause contamination of groundwater at levels that exceed the groundwater cleanup levels established under "Groundwater Cleanup Standards" (WAC 173-340-720). Provides an overview of the methods for deriving these soil concentrations to meet relevant criteria. Certain methods are tailored for particular types of hazardous substances or sites and certain methods are more complex than others and/or require the use of site-specific data.	Soil in the 300 Area contains contaminants that may require remediation. The requirements corresponding to Method B soil cleanup levels may be used to calculate cleanup levels to ensure protection of groundwater and based on an unrestricted land use, which is more conservative than the industrial land use assigned to this area.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds soil concentration for protection of groundwater.
Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) (OSWER Directive 9285.7-55)	Chemical	Provides a set of risk-based soil screening levels (Eco-SSLs) for several soil contaminants that are of ecological concern for terrestrial plants and animals at hazardous waste sites. Also describes the process used to derive these levels and provides guidance for their use.	Soil in the 300 Area contains contaminants that may require remediation. Comparison to SSLs may be appropriate for defining potential COPCs or to default to an Eco-SSL for COPCs that lack corresponding published state cleanup criteria.	TBC	Soil cleanup actions to protect Ecological Receptors.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7490) "Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7493) "Priority Contaminants of Ecological Concern" (WAC 173-340-7494)	Chemical	Defines goals and procedures for determining whether a release of hazardous substances to soil may pose a threat to the terrestrial environment. Characterizes existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil and establishes site-specific cleanup standards for the protection of terrestrial plants and animals. "Priority Contaminants of Ecological Concern" (WAC 173-340-7494) provides for numeric concentrations of hazardous substances determined to persist, bioaccumulate, or be highly toxic to terrestrial ecological receptors. Concentrations listed in Table 749-2 are based on protection of wildlife for industrial and commercial land uses, and are protective of plants and animals for other land uses.	Soil in the 300 Area contains contaminants that may require evaluation to determine if ecological exposures have the potential to cause significant adverse effects.	ARAR	Soil remediation activities including containment, RTD, and MNA.
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (EPA/540/R-99/009 [OSWER Directive 9200.4-17P])	Action	Provides the framework and appropriateness for using MNA as a remedy component for organic and inorganic contaminants.	Soil in the 300 Area contains contaminants that may require remediation. The use of MNA as a remedy may be appropriate.	TBC	Soil remediation activities including MNA.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Air					
"Washington Clean Air Act" (RCW 70.94, as amended); "General Regulations for Air Pollution Sources" (WAC 173-400)					
"General Regulations for Air Pollution Sources" (WAC 173-400)	Action	Defines methods of control to be employed to minimize the release of air contaminants associated with fugitive emissions resulting from materials handling, construction, demolition, or other operations. Emissions are to be minimized through application of best available control technology.	Soil and/or groundwater remedial actions implemented in the 300 Area provide the potential for emissions subject to these standards because soil and groundwater hazardous contaminants detected in the 300 Area include covered hazardous air pollutants.	ARAR	Actions performed at the 300 Area that could result in the emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during a remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
"General Standards for Maximum Emissions" (WAC 173-400-040)	Action	All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emissions detrimental to health and property, sulfur dioxide, and fugitive dust.	Soil and/or groundwater remedial actions implemented in the 300 Area provide the potential for emissions subject to these standards because hazardous contaminants detected in the 300 Area include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions.
"Emission Standards for Sources Emitting Hazardous Air Pollutants" (WAC 173-400-075)	Action	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, "National Emission Standards for Hazardous Air Pollutants" (hereinafter called NESHAP [40 CFR 61]), and appendices.	Soil and/or groundwater hazardous contaminants detected in the 300 Area include covered regulated hazardous air pollutants.	ARAR	Actions performed at the 300 Area that could result in the emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during the remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Washington Clean Air Act" (RCW 70.94); "Controls for New Sources of Toxic Air Pollutants" (WAC 173-460)					
"Purpose" (WAC 173-460-010) "Applicability" (WAC 173-460-030) "Control Technology Requirements" (WAC 173-460-060) "Ambient Impact Requirement" (WAC 173-460-070) "First Tier Review" (WAC 173-460-080) "Table of ASIL, SQER and de Minimis Emission Values" (WAC 173-460-150)	Action	Establishes control of new sources emitting toxic air pollutants to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality as will protect human health and safety. Toxic air pollutants include carcinogens and noncarcinogens listed in "Table of ASIL, SQER and de Minimis Emission Values" (WAC 173-460-150). Three major requirements of this regulation are implementation of best available control technology for toxics, quantification of toxic air pollutant emissions, and demonstration of health and safety protection.	Hazardous contaminants detected in soil and/or groundwater in the 300 Area include constituents that would constitute toxic air pollutants if released to the air.	ARAR	Groundwater and soil remediation activities, such as the 300 Area treatment systems with the potential to emit hazardous air emissions and that would be considered a new source.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Washington Clean Air Act" (RCW 70.94); "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480)					
"Ambient Standard" (WAC 173-480-040)	Action	Requires that emissions of radionuclides in the air shall not cause a maximum effective dose equivalent of more than 10 mrem/y to the whole body to any member of the public. Compliance with the standard shall be determined by procedures in "Ambient Air Quality Standards and Emission Limits for Radionuclides," "Emission Monitoring and Compliance Procedures" (WAC 173-480-070) Note: Per "Ambient Air Quality Standards and Emission Limits for Radionuclides," "Applicability" (WAC 173-480-020), the ambient standard applies to the entire state, and measurements for compliance may be made at all points up to property lines of point, area, and fugitive emission sources.	Hazardous contaminants detected in residual structures and waste, soil and groundwater in the 300 Area include radionuclides that could be emitted to ambient air during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.
"General Standards for Maximum Permissible Emissions" (WAC 173-480-050)	Action	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas ALARA; airborne emissions control equipment and practices at sites operating under ALARA shall be defined as reasonably available control technology and as low as reasonably achievable control technology.	The potential for fugitive and diffuse emissions due to demolition and excavation and related activities will require efforts to minimize those emissions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides to unrestricted areas.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Emission Monitoring and Compliance Procedures" (WAC 173-480-070)	Action	Requires that radionuclide emissions shall be determined by calculating the dose to members of the public using Department of Health approved sampling procedures. Compliance is determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	Hazardous contaminants detected in residual structures and waste, soil and groundwater in the 300 Area include radionuclides that could be emitted to unrestricted areas during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, and vacuuming/exhaust) that have the potential to emit radionuclides to unrestricted areas.
"Emission Standards for New and Modified Emission Units" (WAC 173-480-060)	Action	Requires that construction, installation, or establishment of new air emission control units use best available radionuclide control technology.	Hazardous contaminants detected in residual structures and waste, soil and groundwater in the 300 Area include radionuclides that could be emitted from air emission control units during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, and vacuuming/exhaust) that require air pollution control measures and/or equipment and have the potential to emit radionuclides to the ambient air.
"Nuclear Energy and Radiation" (RCW 70.98); "Radiation Protection—Air Emissions" (WAC 246-247)					
"National Standards Adopted by Reference for Sources of Radionuclide Emissions" (WAC 246-247-035 (1)(a)(i) [adopts by reference 40 CFR 61.05, "Prohibited Activities"])	Action	Identifies prohibition of any owner or operator of any stationary source subject to a national emission standard for hazardous air pollutants from constructing or operating the new or existing source in violation of any such standard.	Substantive requirements of this standard are applicable because the remedial actions in the 300 Area would be subject to NESHAP; Radionuclide's Air Pollutant Standards and resultant requirements. The radionuclide hazardous air pollutants may be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial action.	ARAR	Investigative and remedial activities.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
(WAC 246-247-035 (1)(a)(i) [adopts by reference 40 CFR 61.12, "Compliance with Standards and Maintenance Requirements"])	Action	Requires the owner or operator of each stationary source of hazardous air pollutants subject to a national emission standard for a hazardous air pollutant to determine compliance with numerical emission limits in accordance with emission tests established in NESHAP, "Emission Tests and Waiver of Emission Tests" (40 CFR 61.13) or as otherwise specified in an individual subpart. Compliance with design, equipment, work practice, or operational standards shall be determined as specified in the individual subpart. Also, maintain and operate the source, including associated equipment for air pollution control, in a manner consistent with good air pollution control practice for minimizing emissions.	Hazardous radionuclide contaminants that would be subject to NESHAP's Air Pollutant Standards and resultant requirements may be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial actions in the 300 Area. Associated design, equipment, work practice, or equipment for radionuclide air pollution control may also be maintained and operated.	ARAR	Investigative and remedial actions involve stationary sources that provide a potential to emit regulated hazardous air pollutants (e.g., vapor extraction systems, decontamination stations, deactivation, demolition, or waste removal or storage activities). Associated design, equipment, work practice, or air emissions controls may be maintained and operated.
(WAC 246-247-035 (1)(a) (i) [adopts by reference 40 CFR 61.14, "Monitoring Requirements"])	Action	Requires the owner or operator to maintain and operate each monitoring system as specified in the applicable subpart, and in a manner consistent with good air pollution control practice for minimizing emissions. Approvals of alternatives to any monitoring requirements or procedures are obtained from the regulatory agency.	Hazardous radionuclide contaminants that would be subject to NESHAP's Air Pollutant Standards and resultant requirements may be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial actions in the 300 Area. The hazardous contaminants will be monitored as identified under each applicable NESHAP subpart.	ARAR	Investigative and remedial soil, air, and groundwater monitoring systems, and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, that may produce airborne emissions of hazardous pollutants to unrestricted areas.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
(WAC 246-247-035 (1)(a)(ii) [adopts by reference 40 CFR 61.92, "Standard"])	Chemical	Establishes emission standards for radionuclides equivalent to NESHAP, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H), by reference. DOE Hanford Site radionuclide airborne emissions shall be controlled so as not to exceed amounts that would cause an exposure to any member of the public of greater than 10 mrem/yr effective dose equivalent.	Hazardous radionuclide contaminants that would be subject to NESHAP; Radionuclide Air Pollutant Standards and resultant requirements may be detected in, and potentially emitted from, structures, components, debris, soil or groundwater involved in the remedial actions in the 300 Area.	ARAR	Investigative and remedial soil, air, groundwater monitoring systems and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, that may produce airborne emissions of hazardous radionuclide pollutants to unrestricted areas.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
(WAC 246-247-035 (1)(a)(ii) [adopts by reference 40 CFR 61.93, "Emission Monitoring and Test Procedures"])	Action	Specifies that radionuclide emissions shall be determined and effective dose equivalent values to members of the public calculated to determine compliance with the 10 mrem/yr effective dose equivalent standard. Radionuclide emissions shall be collected and measured using approved methods. A quality assurance program shall be conducted that meets the performance requirements described in Appendix B, Method 114. Measurement by methods specified in the paragraph (b) shall be made at all release points that have the potential to discharge radionuclides to the air in quantities that cause an effective dose equivalent in excess of 1 percent of the 10 mrem/yr standard. For other release points that have a potential to release radionuclides into the air, periodic confirmatory measurements shall be made to verify the low emissions.	Hazardous radionuclide contaminants that would be subject to NESHAP; Radionuclide Air Pollutant Standards and resultant requirements may be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial actions in the 300 Area. The hazardous contaminants will be monitored as identified under each applicable NESHAP subpart.	ARAR	Investigative and remedial soil, air, and groundwater monitoring systems, and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, that may produce airborne emissions of hazardous radionuclide pollutants to unrestricted areas.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"General Standards" (WAC 246-247-040(3) and (4))	Action	Requires that emissions be controlled to ensure ALARA-based and Best Available Controls standards are not exceeded.	Hazardous contaminants that would be subject to radionuclide air emission standards and resultant requirements may be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial actions in the 300 Area.	ARAR	Investigative and remedial soil, air, and groundwater monitoring systems, and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums that may produce airborne emissions of hazardous radionuclide pollutants to unrestricted areas.
"Monitoring, Testing and Quality Assurance" (WAC 246-247-075)	Action	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Requires that emissions from nonpoint and fugitive sources of airborne radioactive material be measured. Measurement techniques may include but are not limited to sampling, calculations, smears, or other reasonable method for identifying emissions as determined by the lead agency.	Hazardous contaminants in the 300 Area waste sites that would be subject to radionuclide air emission standards and resultant requirements may be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial actions.	ARAR	Investigative and remedial soil, air, and groundwater monitoring systems, and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums that may produce airborne emissions of hazardous radionuclide pollutants to unrestricted areas.
***Clean Air Act of 1990* and amendments; NESHAP, "National Emission Standard for Asbestos" (40 CFR 61, Subpart M)**					
40 CFR 61.140, "Applicability" 40 CFR 61.145, "Standard for Demolition and Renovation"	Action	Defines regulated ACM and regulated removal and handling requirements. Specifies sampling, inspection, handling, and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of ACM.	Encountering ACM on pipelines or buried asbestos within the 300 Area is possible during the during remediation activities.	ARAR	Site investigation and remediation activities that include demolition and/or renovation and associated handling, packaging, and transportation of ACM, including IDW management and disposal.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
40 CFR 61.150, "Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations"	Action	Identifies requirements for the removal and disposal of asbestos from demolition and renovation activities.	Encountering ACM on pipelines or buried asbestos within the 300 Area is possible during the during remediation activities.	ARAR	Site investigation and remediation activities that include demolition and/or renovation and associated handling, packaging, and transportation of ACM including IDW management and disposal.
Solid Wastes					
***Toxic Substances Control Act of 1976* (Public Law 107-377, as amended; 15 USC Section 2605, et seq.); "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761)**					
"Applicability" (40 CFR 761.50(b)1, 2, 3, 4 and 7 and (c))	Action	Establishes general PCB disposal requirements for the storage and disposal of PCB wastes including liquid PCB wastes, PCB items, PCB remediation waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations greater than 50 ppm.	PCB wastes may be encountered and or generated during the remediation of the 300 Area.	ARAR	Soil excavation and remediation, equipment and debris handling and disposal, and IDW management and disposal.
"Disposal Requirements" (40 CFR 761.60(a), (b), and (c))	Action	Establishes requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, and/or containers may be encountered and/or generated during the remedial actions for the 300 Area.	ARAR	Equipment and debris handling, storage, and disposal; IDW management and disposal.
"PCB Remediation Waste" (40 CFR 761.61)	Action	Provides cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation wastes may be encountered and/or generated during the remedial actions for the 300 Area.	ARAR	Soil remediation, RTD, and IDW management and disposal.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Hazardous Waste Management" (RCW 70.105); "Dangerous Waste Regulations" (WAC 173-303)					
"Identifying Solid Waste" (WAC 173-303-016) "Recycling Processes Involving Solid Waste" (WAC 173-303-017)	Action	Establishes criteria for solid and recycled solid wastes.	Solid wastes and/or recycled solid wastes may be generated during 300 Area remedial actions.	ARAR	Investigative and remediation activities.
"Designation of Dangerous Waste" (WAC 173-303-070)	Action	Establishes the method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste may be generated during 300 Area remedial actions.	ARAR	Investigative and remediation (including waste treatment) activities that generate wastes (e.g., drums, barrels, tanks, containers, bulk wastes, debris, and contaminated soil).
"Conditional Exclusion of Special Wastes" (WAC 173-303-073)	Action	Establishes the conditional exclusion and the management requirements of special wastes, as defined in "Definitions" (WAC 173-303-040)."	Special wastes may be generated during 300 Area remedial actions.	ARAR	FS remediation activities (disposal, storage, recycling, and onsite treatment) that manage special wastes consistent with the requirements of the WAC.
"Requirements for Universal Waste" (WAC 173-303-077)	Action	Identifies those wastes exempted from regulation under "Land Disposal Restrictions" (WAC 173-303-140) and "Requirements for Generators of Dangerous Waste" (WAC 173-303-170) through "Reserved" (173-303-9907) (excluding WAC 173-303-960, "Special Powers and Authorities of the Department"). These wastes are subject to regulation under "Standards for Universal Waste Management" (WAC 173-303-573).	Universal wastes may be generated during 300 Area remedial actions.	ARAR	FS remediation activities (disposal, storage, recycling, and onsite treatment) that manage universal wastes consistent with the requirements of the WAC.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120) "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120(3) and (5))	Action	Defines the requirements for the recycling of materials that are solid and dangerous waste. Specifically, "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120(3)) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. "Recycled, Reclaimed, and Recovered Wastes" (WAC 173-303-120(5)) provides for the recycling of used oil.	Recycled, reclaimed, and recovered wastes may be generated during 300 Area remedial actions.	ARAR	FS remediation recycling activities consistent with the requirements of the WAC and not otherwise subject to CERCLA as hazardous substances.
"Land Disposal Restrictions" (WAC 173-303-140)	Action	Establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates by reference ("Land Disposal Restrictions" [WAC 173-303-140(2)(a)]) the federal land disposal restrictions of "Land Disposal Restrictions" (40 CFR 268) that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with "Designation Procedures" (WAC 173-303-070(3)).	Onsite land disposal may be a selected remedy for 300 Area dangerous waste and debris.	ARAR	Investigative and remediation wastes destined for onsite land disposal.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Requirements for Generators of Dangerous Waste" (WAC 173-303-170)	Action	Establishes the requirements for dangerous waste generators. "Requirements for Generators of Dangerous Waste" (WAC 173-303-170(3)) includes the substantive provisions of "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) by reference. "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) further includes certain substantive standards from "Use and Management of Containers" (WAC 173-303-630) and "Tank Systems" (WAC 173-303-640) by reference. Specifically, the substantive standards for management of dangerous/mixed waste are applicable to the management of dangerous waste that will be generated during the remedial action.	Dangerous wastes may be generated from the remedial actions in the 300 Area.	ARAR	IDW and remediation wastes (contaminated soil and groundwater, personnel protective gear, treatment chemicals).
"Accumulating Dangerous Waste On-Site" (WAC 173-303-200)	Action	Establishes the requirements for accumulating wastes onsite. "Accumulating Dangerous Waste On-Site" (WAC 173-303-200) further includes certain substantive standards from "Use and Management of Containers" (WAC 173-303-630) and "Tank Systems" (WAC 173-303-640) by reference.	Dangerous waste may be generated from the remedial actions in the 300 Area.	ARAR	Management of dangerous waste during remedial and investigative actions.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
"Solid Waste Management—Reduction and Recycling" (RCW 70.95); "Solid Waste Handling Standards" (WAC 173-350)					
"Owner Responsibilities for Solid Waste (WAC 173-350-025) "Performance Standards" (WAC 173-350-040) "On Site Storage, Collection and Transportation Standards" (WAC 173-350-300) "Remedial Action" (WAC 173-350-900)	Action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste. Requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural and industrial operations, and other sources and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Solid, nondangerous waste will be generated during implementation of 300 Area remedial actions.	ARAR	Investigative and remedial actions that generate solid, nondangerous waste.
Historical and Archeological Resources					
***National Historic Preservation Act of 1966* (Public Law 89-665, as amended, 16 USC 470, et seq.)**					
"Protection of Historic Properties" (36 CFR 800)	Location	Legislation intended to preserve historical and archaeological sites in the U.S. Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 300 Area.	ARAR	Investigation and remediation activities that occur in areas near cultural or historic sites.
***Protection and Enhancement of the Cultural Environment* (Executive Order 11593)**					
"National Historic Landmarks Program" (36 CFR 65) "National Register of Historic Places" (36 CFR 60)	Location	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 300 Area.	ARAR	Investigation and remediation activities that occur in areas near cultural or historic sites.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Native American Graves Protection and Repatriation Act of 1990 **(Public Law 101-601, as amended, 25 USC 3001, et seq.); "Native American Graves Protection and Repatriation Regulations" (43 CFR 10)**					
"Native American Graves Protection and Repatriation Regulations" (43 CFR 10)	Location	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony. Requires Native American Tribal consultation in the event of discovery.	Native American archaeological, cultural and historic sites have been identified within the 300 Area; Native American remains and associated objects may be present.	ARAR	Investigations and remedial activities that affect Native American archaeological, cultural areas and historic sites that contain associated remains and objects.
Archeological and Historic Preservation Act of 1974 **(Public Law 93-291, as amended; 16 USC 469a-1 through 469a-2(d))**					
"Applicant Requirements" 16 USC 469a-1 through 469a-2(d)	Location	Requires that remedial actions do not cause the loss of any archaeological or historic data. This act mandates preservation of the data; it does not require protection of the actual waste site or facility.	Archaeological and historic sites have been identified within the 300 Area.	ARAR	Investigation and remediation activities that occur in areas near archeological or historic sites.
Natural and Ecological Resources					
Floodplain Management **(Executive Order 11988)**					
"Compliance with Floodplain and Wetland Environmental Review Requirements" (10 CFR 1022)	Location	Takes action to avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values of the floodplain.	Some of the waste sites within the 300 Area subject to remediation are located within the Columbia River floodplain.	ARAR	Remedial actions will occur in the floodplain.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
***Endangered Species Act of 1973* (Public Law 93-205, as amended; 7 USC 136; 16 USC 1531, et seq.)**					
"Interagency Cooperation—Endangered Species Act of 1973, as Amended" (50 CFR 402)	Location	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species, in order to protect the resource.	Federal endangered and/or threatened species including fish, plants, and animals are found within the 300 Area.	ARAR	Remediation actions and investigation activities that occur within critical habitats or designated buffer zones of federal listed species.
***Migratory Bird Treaty Act of 1918* (16 USC 703-712; Ch. 128; July 13, 1918; 40 Stat. 755), as amended**					
Migratory Bird Treaty Act of 1918 (16 USC 703-712)	Location	Protects all migratory bird species and prevents "take" of protected migratory birds, their young, or their eggs."	Migratory birds occur in the 300 Area.	ARAR	Remedial actions that require mitigation measures to deter nesting by migratory birds on, around, or within remedial action site and methods to identify and protect occupied bird nests.
"Habitat Buffer Zone for Bald Eagles—Rules" (RCW 77.12.655); "Permanent Regulations," "Bald Eagle Protection Rules" (WAC 232-12-292)					
"Permanent Regulations," "Bald Eagle Protection Rules" (WAC 232-12-292)	Location	Protects eagle habitat to maintain eagle populations so the species is not classified as threatened, endangered, or sensitive in Washington State.	Bald eagles nest, feed, and overwinter along the shores of the Columbia River.	ARAR	Investigative and remediation activities that impact bald eagle habitat.
Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) (OSWER Directive 9285.7-55)	Chemical	Provides a set of risk-based soil screening levels (Eco-SSLs) for several soil contaminants that are of ecological concern for terrestrial plants and animals at hazardous waste sites. Also describes the process used to derive these levels and provides guidance for their use.	Soil in the 300 Area contains contaminants that may require remediation. Comparison to SSLs may be appropriate for defining potential COPCs.	TBC	Soil cleanup actions to protect ecological receptors.

Table 8-2. Potential Federal and Washington State ARARs and TBCs for the 300 Area

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Fish and Wildlife Conservation Act of 1980, "Nongame Act" (Public Law 96-366, as Amended; 16 USC 2901-2911)					
"Rules Implementing the Fish and Wildlife Conservation Act of 1980" (50 CFR 83)	Location	Preserves and promotes conservation of non-game fish and wildlife and their habitats.	Nonwildlife and their habitats may occur in the 300 Area.	ARAR	Remedial action that impact nongame fish, and wildlife and/or their habitats.
Land Use and Exposure Scenarios					
Final Hanford Comprehensive Land Use Plan Environmental Impact Statement (DOE/EIS-0222-F) *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-SA-01)	Location	Establishes the future land use projections for the Central Plateau.	Land use, as stated in the Hanford Comprehensive Land Use Plan, is conservation/mining for land outside either (1) the Hanford Reach National Monument, or (2) the River Corridor, which includes the 300 Area.	TBC	

Sources: References in Chapter 11 provide complete source information.

ACM = asbestos-containing material

ALARA = as low as reasonably achievable

IDW = investigation-derived waste

MNA = monitored natural attenuation

NESHAP = National Emission Standards for Hazardous Air Pollutants

Potential Location—Specific ARARs. Potential location-specific ARARs that have been identified for 300 Area OUs include those that protect cultural, historic, and Native American sites and artifacts under the *Native American Graves Protection and Repatriation Act of 1990*, *Archeological and Historic Preservation Act of 1974*, and those that protect listed endangered and threatened species or their critical habitat under the Endangered Species Act. The *Migratory Bird Treaty Act of 1918* has been identified as a substantive standard for DOE compliance in executive orders and a Memorandum of Understanding between DOE and the USFWS, and is a TBC for CERCLA response actions when there is a potential to adversely affect protected bird species.

Potential Action—Specific ARARs. Action-specific ARARs that could be pertinent to possible remediation activities at 300 Area OUs relate to waste management activities, solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), and radioactive waste management under AEA regulations. The other major category of action-specific ARARs concerns standards for controlling emissions to the environment. When a CERCLA remedial action involves the construction or modification of drinking water systems, the SDWA is an ARAR, while such onsite work is exempt from SDWA permit requirements.

8.1.2.4 Waste Management Standards

Remedial action alternatives proposed in Chapter 9 of this FS have the potential to generate a variety of waste streams that contain both radioactive and chemical constituents. It is anticipated that most of the waste will be designated as low-level waste (LLW). However, quantities of TRU, dangerous or mixed waste, PCB-contaminated waste, and asbestos and asbestos-containing material (ACM) also could be generated. In the event that waste is managed as either spent nuclear fuel or as TRU, the appropriate management procedures as outlined in DOE Orders will be followed. The majority of the waste will be in a solid form.

The identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste generated during the remedial action would be subject to the substantive provisions of RCRA. In the State of Washington, RCRA is implemented through "Dangerous Waste Regulations" (WAC 173-303), which is an EPA-authorized state RCRA program. The substantive portions of the dangerous waste standards for generation and storage would apply to the management of any dangerous or mixed waste generated during this remedial action. Treatment standards for dangerous or mixed waste that is subject to RCRA land disposal restrictions are specified in "Land Disposal Restrictions" (WAC 173-303-140), which incorporates "Land Disposal Restrictions" (40 CFR 268) by reference. Radioactive waste is managed by DOE under the authority of the AEA.

The TSCA and regulations at "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR 761) generally govern the management and disposal of PCB wastes. The TSCA regulations contain specific provisions for PCB waste, including PCB waste that contains a radioactive component. The PCBs also are considered underlying hazardous constituents under RCRA and thus could be subject to "Dangerous Waste Regulations" (WAC 173-303) and "Land Disposal Restrictions" (40 CFR 268) requirements.

Removal and disposal of asbestos and ACM are regulated under the *Clean Air Act of 1990* and National Emission Standards for Hazardous Air Pollutants (NESHAP), "National Emission Standards for Asbestos" (40 CFR 61, Subpart M). These regulations provide for special precautions to prevent environmental releases or exposure to personnel of airborne emissions of asbestos fibers during remedial actions.

Waste generated through the CERCLA remedial actions and designated as low-level radioactive waste that meets ERDF acceptance criteria (*Environmental Restoration Disposal Facility Waste Acceptance Criteria* [WCH-191]) will presumably be disposed at ERDF, which is engineered to meet appropriate performance standards for mixed radioactive and hazardous waste. ERDF is considered onsite with Hanford Site remedial actions for the management and/or disposal of waste.[1] There is no requirement to obtain a permit to manage or dispose of CERCLA waste at ERDF.

In the unlikely event that waste is managed as TRU, the appropriate management procedures as outlined in DOE Orders will be followed. Waste designated as TRU waste will be stored at the Central Waste Complex, with eventual disposal at an approved geologic repository (e.g., Waste Isolation Pilot Plant).

Waste designated as dangerous or mixed waste would be treated as appropriate to meet land disposal restrictions and ERDF acceptance criteria and disposed of at the ERDF. The ERDF is an engineered facility that provides a high degree of protection to HHE and meets RCRA minimum technical requirements for landfills, including standards for a double-liner leachate collection system, leak detection, monitoring, and final cover. Construction and operation of ERDF was authorized using a separate CERCLA ROD (*Declaration of the Record of Decision for the Environmental Restoration Disposal Facility* [EPA/ROD/R10-95/100]; *Record of Decision Amendment: U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington*, hereinafter called ERDF ROD; *Record of Decision Amendment: U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington,* hereinafter called ERDF amended ROD [EPA/AMD/R10-02/030]). *Explanation of Significant Differences: USDOE Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington* (hereinafter called ERDF ESD [EPA/ESD/R10-96/145]) modified the ERDF amended ROD to clarify the eligibility of waste generated during cleanup of the Hanford Site. Per the ERDF ESD (EPA/ESD/R10-96/145), ERDF is eligible for disposal of any LLW, mixed waste, and hazardous/dangerous waste generated as a result of cleanup actions (e.g., remedial/removal action waste and investigation derived waste), provided the waste meets ERDF *Washington Administrative Code* and appropriate CERCLA decision documents are in place.

Some of the aqueous waste designated as LLW, dangerous, or mixed waste would be transported to the Effluent Treatment Facility for treatment and disposal. The Effluent Treatment Facility is a RCRA-permitted facility authorized to treat aqueous waste streams generated on the Hanford Site and dispose of these streams at a designated state-approved land-disposal facility in accordance with applicable requirements.

Waste designated as PCB remediation waste likely would be disposed at ERDF, depending on whether it meets the waste acceptance criteria. The PCB waste that does not meet ERDF waste acceptance criteria would be retained at a PCB storage area that meets the requirements for TSCA storage and would be

[1] CERCLA Section 104(d)(4) states "where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these facilities as one." The preamble to the NCP (40 CFR 300) clarifies the stated EPA interpretation that when noncontiguous facilities are reasonably close to one another, and wastes at these sites are compatible for a selected treatment or disposal approach, CERCLA Section 104(d)(4) allows the lead agency to treat these related facilities as one for response purposes. This allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit. The ERDF is considered to be onsite for response purposes under this remedial/removal/removal action. It should be noted that the scope of work covered in this remedial/removal/removal action is for a facility and waste contaminated with hazardous substances. Materials encountered during implementation of the selected remedial/removal/removal action that are not contaminated with hazardous substances will be dispositioned by DOE.

transported for future disposal at an appropriate disposal facility. Asbestos and ACM would be removed, packaged as appropriate, and disposed of at ERDF.

8.1.2.5 Standards Controlling Emissions to the Environment

Remedial action alternatives proposed in Chapter 9 of this FS have the potential to generate airborne emissions of both radioactive and toxic/criteria airborne emissions. Implementation of these activities and associated air monitoring will be discussed in the RD/RAWP for the 300 Area.

8.1.2.6 Radiological Air Emissions

The federal *Clean Air Act of 1990* and amendments (and the "Washington Clean Air Act" [RCW 70.94]) each require regulation of radioactive air emissions. The state implementing regulation "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480) sets standards that are as stringent or more than the standards under the federal *Clean Air Act of 1990* and amendments. These are also more stringent than the federal implementing regulation, NESHAP, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H). The EPA's partial delegation of the Subparts A and H authority to the state of Washington includes all substantive emissions monitoring, abatement, and reporting aspects of the federal regulation. These state standards protect the public by conservatively establishing exposure standards applicable to the maximally exposed public individual. Members of the public can travel on the Columbia River through the Hanford Reach, but they cannot "abide or reside" there.

"Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480) limits emissions of radionuclides to the ambient air by requirement that emissions of radionuclides in the air shall not cause a maximum effective dose equivalent of more than 10 mrem/yr to the whole body to any member of the public. Under the state implementing regulations, "Radiation Protection—Air Emissions" (WAC 246-247) in "National Standards Adopted by Reference for Sources of Radionuclide Emissions" (WAC 246-247-030(15)) defines the member of the public (real or hypothetical) who abides or resides in an unrestricted area. This member of the public may receive the highest total effective dose equivalent from the emission unit(s) under consideration, taking into account all exposure pathways affected by the radioactive air emissions. In addition, by its adoption of the federal standard at NESHAP, "Standard" (40 CFR 61.92), the state limits radionuclide airborne emissions from the DOE Hanford Site (i.e., facility) to not exceed amounts that would cause an exposure to any member of the public of greater than 10 mrem/yr effective dose equivalent. The state implementing regulation "Radiation Protection—Air Emissions" (WAC 246-247), which adopts the "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480) standards and the NESHAP, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H) standard, requires verification of compliance with the 10 mrem/yr standard. These standards would be applicable to the remedial action.

"Radiation Protection—Air Emissions" (WAC 246-247) further addresses sources emitting radioactive airborne emissions by requiring monitoring of such sources (emission units). Such monitoring may involve various methods depending upon the configuration of the source. Most stacks or vents are monitored by extracting a sample of the effluent stream from the stack or vent, with subsequent analysis of the sample. Emissions that do not pass through a stack, vent, or other orifice are termed diffuse emissions. These are normally monitored by extraction of a sample of the ambient air, with subsequent laboratory analysis. The substantive provisions of "Radiation Protection—Air Emissions" (WAC 246-247) that require monitoring of radioactive airborne emissions potentially would be applicable to remedial action and would generally be an "applicable" ARAR.

The above state implementing regulations further require control of radioactive airborne emissions to the extent economically and technologically feasible ("Radiation Protection—Air Emissions," "General Standards," and associated definitions [WAC 246-247-040(3) and -040(4)]). To address the substantive aspect of these requirements, best or reasonably achieved control technology could be addressed by ensuring that applicable emission control technologies (those successfully operated in similar applications) would be used when economically and technologically feasible (i.e., based on cost/benefit). Controls will be administered as appropriate using the best methods from among those that are reasonable and effective.

8.1.2.7 Criteria/Toxic Air Emissions

Under "General Regulations for Air Pollution Sources" (WAC 173-400) and "Controls for New Sources of Toxic Air Pollutants" (WAC 173-460), requirements are established for the regulation of emissions of criteria/toxic air pollutants. The primary nonradioactive emissions resulting from remedial actions will be fugitive particulate matter. In accordance with "General Regulations for Air Pollution Sources," "General Standards for Maximum Emissions" (WAC 173-400-040), reasonable precautions must be taken to (1) prevent the release of air contaminants associated with fugitive emissions resulting from excavation, materials handling, or other operations; and (2) prevent fugitive dust from becoming airborne from fugitive sources of emissions. The use of treatment technologies that would result in emissions of toxic air pollutants that would be subject to the substantive applicable requirements of "Controls for New Sources of Toxic Air Pollutants" (WAC 173-460) are not anticipated to be a part of remedial actions selected for the 300 Area.

If treatment of some waste encountered during the remedial action is required to meet ERDF waste acceptance criteria, the type of treatment anticipated would consist of solidification/stabilization techniques such as microencapsulation or grouting, and "Controls for New Sources of Toxic Air Pollutants" (WAC 173-460) would not be considered an ARAR. If treatment that is more aggressive is required, that would result in the emission of regulated air pollutants, the substantive requirements of "General Regulations for Air Pollution Sources," "Requirements for New Sources in Attainment or Unclassifiable Areas" (WAC 173-400-113(2)) and "Controls for New Sources of Toxic Air Pollutants," "Control Technology Requirements" (WAC 173-460-060) would be evaluated to determine potential applicability.

Emissions to the air will be minimized during implementation of remedial actions through use of standard industry practices such as the application of water sprays and fixatives. These techniques are considered reasonable precautions to control fugitive emissions as required by the regulatory standards.

8.1.2.8 Groundwater Beneficial Use

CERCLA and NCP establish separate requirements for a groundwater remedy: to be protective of HHE, and to meet ARARs. This is a concept of central importance to the development of the groundwater remedy for the 300-FF-5 OU. These separate requirements are further clarified in a memorandum ("Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA" [Fields, 1997]).

The requirement to achieve threshold protectiveness and ARAR-based requirements is established by the NCP, which also establishes the requirement to return useable groundwater to beneficial use within a reasonable time frame. EPA generally defers to state agency definitions of useable groundwater provided under the various comprehensive state groundwater protection programs, administered by the states across the United States and a state's determination of groundwater usability at CERCLA sites (*Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites* [EPA/540/G-88/003]). The State of Washington defines groundwater as potable in MTCA, "Groundwater Cleanup Standards" (WAC 173-340-720(2)), unless the exclusion criteria in MTCA, "Groundwater Cleanup Standards"

(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 within the300 Area does not meet the exclusion criteria; therefore, it is classified as potable and must be restored to beneficial use wherever practicable, and within a time frame that is reasonably consistent with NCP requirements. The State of Washington has further determined that the highest beneficial use for potable groundwater at most of the cleanup sites within the state, including the site, is as a potential source of domestic drinking water (MTCA, "Groundwater Cleanup Standards" [WAC 173-340-720(1)(a)]).

Groundwater within the 300 Area is currently contaminated, and withdrawal is prohibited as a result of ICs placed on it by DOE. However, a public water supply is in place at the 300 Area and is expected to remain in place for many years to support ongoing industrial activities. Under current site use conditions, no complete exposure pathways to the general public from groundwater are assumed to exist. Further, regardless of land use designations for soils, groundwater within this OU is not anticipated to become a future source of drinking water until cleanup criteria are met and groundwater is restored to its highest beneficial use. However, groundwater in this risk analysis is evaluated for drinking water use to support the determination of the basis for action and to support the development of PRGs for evaluating remedial alternatives in the FS.

8.1.2.9 Surface Water Beneficial Use

Surface water beneficial use is considered because groundwater within the 300-FF-5 OU currently discharges to the Columbia River through upwelling and seeps. "Water Quality Standards for Surface Waters of the State of Washington," "Use Designations—Fresh Waters" (WAC 173-201A-600) and "Water Quality Standards for Surface Waters of the State of Washington," "Table 602—Use Designations for Fresh Waters by Water Resource Inventory Area" (WAC 173-201A-602) identify the beneficial use (or designated uses) for rivers and streams of Washington State. Designated uses for waters of Washington State can include public water supply; protection for fish, shellfish, and wildlife; and recreational, agricultural, industrial, navigational, and aesthetic purposes. Water quality criteria are designed to protect the designated uses and are used to assess the general health of Washington surface waters and set permit limits.

Designated uses of the Columbia River identified in "Water Quality Standards for Surface Waters of the State of Washington," "Table 602—Use Designations for Fresh Waters by Water Resource Inventory Area" (WAC 173-201A-602), include the following:

- Aquatic life uses—spawning and rearing
- Recreational uses—primary contact
- Water supply uses—drinking water, industrial water, agricultural water, and stock water
- Miscellaneous uses—wildlife habitat, harvesting, commercial/navigation, boating, and aesthetics

The groundwater risk assessment presented in Section 6.2 of this report evaluates potential exposure of aquatic organisms to contaminants in the 300 Area. This assessment uses the most stringent federal and state water quality criteria to support the basis for action and to support PRG development.

8.1.3 Remedial Action Objectives

Under CERCLA and the NCP (40 CFR 300), a soil and groundwater remedies must be protective of HHE, and meet ARARs (or satisfy criteria for an ARAR to be waived). RAOs must be developed to address COCs, media of concern, potential receptors, and exposure pathways. Remedial action objectives are general descriptions of what a cleanup under CERCLA is expected to accomplish. They are narrative statements that define the extent to which waste sites require cleanup to protect HHE.

RAOs describe what a proposed remedial action is expected to accomplish. Typically, RAOs include information on the media, receptors, and COCs, taking into account the anticipated future land use. For the 300 Area, the anticipated future land use has been identified as industrial. However, both the unrestricted land use criteria based upon the future residential scenario and the industrial land use criteria were used for the preparation of the following RAOs:

- **RAO 1**. Prevent unacceptable risk to human health from ingestion of and exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO 2**. Prevent unacceptable risk to human health and ecological exposure to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO 3**. Prevent unacceptable risk from contaminants migrating and/or leaching through soil that will result in groundwater concentrations that exceed federal and state standards and risk based thresholds for protection of surface water and groundwater.
- **RAO 4**. Prevent unacceptable risk to human health from exposure to the upper 4.6 m (15 ft) of soil and to structures and debris contaminated with nonradiological constituents at concentrations above the unrestricted land use exposure scenario for areas outside the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- **RAO 5**. Prevent unacceptable risk to human health from exposure to the upper 4.6 m (15 ft) of soil and to structures and debris contaminated with radiological constituents at concentrations above a dose rate limit that causes an excess cancer lifetime risk threshold of 10^{-6} to 10^{-4} above background for the unrestricted land use exposure scenario for areas outside the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- **RAO 6**. Prevent unacceptable risk to human health from exposure to the upper 4.6 m (15 ft) of soil and to structures and debris contaminated with nonradiological constituents at concentrations above the industrial land use exposure scenario for the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- **RAO 7**. Prevent unacceptable risk to human health from exposure to the upper 4.6 m (15 ft) of soil and to structures and debris contaminated with radiological constituents at concentrations above a dose rate limit that causes an excess cancer lifetime risk threshold of 10^{-6} to 10^{-4} above background for the industrial land use exposure scenario for the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- **RAO 8**. Prevent unacceptable risk to ecological receptors from exposure to the upper 4.6 m (15 ft) of soil and to structures and debris contaminated with nonradiological constituents above the soil contaminant levels and radiological constituents above a dose rate limit of 0.1 rad/day for terrestrial wildlife populations.

RAO 1 is satisfied when groundwater concentrations for COCs do not exceed federal drinking water MCLs, and when groundwater concentrations for nonradiological COCs are reduced to levels that would not exceed the MTCA, "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)(a)) ELCR of 10^{-6} to 10^{-4} above background, or the HI of 1.

RAO 2 is satisfied when groundwater concentrations for COCs at the point discharge (where hazardous substances are released to the Columbia River) do not exceed state and federal water quality standards and/or risk-based thresholds.

RAO 3 is satisfied when concentrations of COCs within the soil column are less than "Deriving Soil Concentrations for Ground Water Protection" (WAC 173-340-747(4)) soil concentrations for groundwater protection, or when additional fate and transport modeling demonstrates that soil concentrations would not impact groundwater above MCLs.

RAOs 4, 6, and 8 are satisfied when direct contact exposure by human and ecological receptors is prevented or mitigated in the top 4.6 m (15 ft) of soil that would exceed the MTCA, "Human Health Risk Assessment Procedures" (WAC 173-340-708(5)(a)) ELCR of 10^{-6} to 10^{-4} above background, an HI of 1, or that would exceed an individual ecological noncancer HQ of 1 or a total ecological HI of 1.

RAOs 5, 7, and 8 are satisfied when direct contact exposure by human and ecological receptors is prevented or mitigated in the top 4.6 m (15 ft) of soil that would exceed an ELCR of 10^{-6} to 10^{-4} above background, or that would exceed a dose rate of 0.1 rad/day.

8.1.4 Preliminary Remediation Goals

To meet the RAOs, PRGs are established. These goals generally are quantitative cleanup levels that would meet ARARs and risk-based levels and would be protective of HHE. The preliminary remediation goals will be used to assess the effectiveness of the selected remedial alternatives in meeting the RAOs. A summary of the 300 Area Unrestricted and Industrial Human Health, Groundwater Protection, Surface Water Protection, and Ecological soil PRGs are listed in Tables 8-3 and 8-4, respectively.

PRGs represent a core component of the overall technology screening and remedial alternative development process in the FS. PRGs are numerical values expressed as concentrations for a chemical or radionuclide in an environmental media. A remedial actions achievement of PRGs results in residual contamination that is protective of HHE (NCP, "Remedial Investigation/Feasibility Study and Selection of Remedy" [40 CFR 300.430(e)(2)(i)]). PRGs are also used to identify the area and volume of environmental media that must be addressed; therefore, PRGs are determined prior to the development of the remedial alternatives.

Meeting PRGs and the potential ARARs and, by extension, achieving RAOs, can be accomplished by reducing concentrations (or activities) of contaminants to PRG levels or by eliminating potential exposure pathways/routes. Contaminant-specific and numeric soil PRGs for direct exposure, protection of groundwater, and protection of surface water typically are presented as concentrations, which for nonradionuclides are in mg/kg for soil and for radionuclides are in pCi/g. Contaminant-specific and numerical cleanup levels for groundwater typically are expressed in µg/L for nonradiological COCs and pCi/L for radiological COCs.

Residual risks following completion of remediation of the waste sites must meet the 1×10^{-4} to 1×10^{-6} ELCR for radiological and carcinogenic COCs and must less than or equal to a HI value of 1.0 for hazardous substances.

8.1.4.1 Development Approach

PRGs are presented for each environmental media of interest (soil and groundwater), each type of contaminant (hazardous substances and radionuclides), human and ecological receptors, and each potentially complete exposure pathway. The following sections describe the approach that was taken to develop PRGs for each media, receptor, and exposure pathway. To satisfy RAOs for protection of human health, the cleanup levels reported in the 100 Area interim action RODs were compared to the PRGs presented in Table 8-3 for the residential scenario (unrestricted land use). Similarly, the cleanup levels reported in the 300 Area interim action ROD were compared to the PRGs presented in Table 8-4 for the industrial scenario (industrial land use).

Direct Contact Exposure PRGs for Nonradiological Contaminants. Development of the PRGs for direct contact exposure to nonradiological contamination for both human and ecological receptors is described in the following subsections.

Human Exposure. For human receptors, soil PRGs developed for direct contact and inhalation exposure pathways are risk-based standards for hazardous substances. Risk-based standards for individual hazardous substances are established using applicable federal and state laws and risk equations. Risk-based standards for individual carcinogens in an industrial exposure scenario are based on an ELCR of 1×10^{-5} and an HQ of 1.0 for individual noncarcinogenic substances as described in MTCA, "Soil Cleanup Standards for Industrial Properties" (WAC 173-340-745(5)(b)(iii)(B). Risk-based standards for individual carcinogens in an unrestricted exposure scenario are based on an ELCR of 1×10^{-6} and an HQ of 1.0 for individual noncarcinogenic substances as described in MTCA, "Unrestricted Land Use Soil Cleanup Standards" (WAC 173-340-740(3)(b)(iii)(B)).

Table 8-3. Summary of 300 Area Operable Unit Unrestricted Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs							PRGs Protective of Groundwater and Surface Water						Ecological PRGs[l]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method B Soil Direct Contact PRG[b]	RI/FS Residential PRG[c]	RI/FS MTCA Method B Soil Inhalation PRG[d]	RI/FS Casual Recreational User - Direct Contact PRG[e,f]	RI/FS Resident Monument Worker-Direct Contact PRG[g]	DOE/RL-96-17 Residential RAG[h]	DOE/RL -2001-47 Residential RAG[i]	300 Area STOMP 2D Uranium Model GWP PRG[j]	300 Area STOMP 2D Uranium Model SWP PRG[j]	100:0-Contaminant Source Model GWP PRG[k]	100:0-Contaminant Source Model SWP PRG[k]	DOE/RL-2001-47 Residential GWP RAG[i]	DOE/RL-2001-47 Residential SWP RAG[i]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG
Radionuclides																				
Americium-241	14596-10-2	pCi/g	--	--	155	--	2,570	275	32	32	--	--	>1,000,000	>1,000,000	--	--	21,500	--	11,900	4,840
Carbon-14	14762-75-5	pCi/g	--	--	81	--	328,000	52,000	8.7	8.7	--	--	902	902	--	--	60,700	--	49.5	31.6
Cesium-137	10045-97-3	pCi/g	1.1	--	4.4	--	100	6.2	6.2	6.2	--	--	>1,000,000	>1,000,000	--	--	2,210	--	1,430	924
Cobalt-60	10198-40-0	pCi/g	0.0084	--	3.1	--	63	3.3	1.4	1.4	--	--	>1,000,000	>1,000,000	--	--	6,130	--	805	805
Europium-152	14683-23-9	pCi/g	--	--	3.7	--	66	3.8	3.3	3.3	--	--	>1,000,000	>1,000,000	--	--	14,700	--	1,740	1,740
Europium-154	15585-10-1	pCi/g	0.033	--	4.4	--	78	4.8	3.0	3.0	--	--	>1,000,000	>1,000,000	--	--	12,500	--	1,610	1,610
Europium-155	14391-16-3	pCi/g	0.054	--	327	--	5,870	354	125	125	--	--	>1,000,000	>1,000,000	--	--	153,000	--	33,400	33,400
Iodine-129	15046-84-1	pCi/g	--	--	0.076	--	3030	434	0.25	--	--	--	169	169	--	--	--	--	--	--
Nickel-63	13981-37-8	pCi/g	--	--	608	--	575,000	91,600	4,013	4,026	--	--	>1,000,000	>1,000,000	385	385	--	--	--	--
Plutonium-238	13981-16-3	pCi/g	0.0038	--	236	--	3,820	605	39	39	--	--	>1,000,000	>1,000,000	--	--	17,500	--	20,900	5,980
Plutonium-239/240	PU-239/240	pCi/g	0.025	--	203	--	3,340	539	35	35	--	--	>1,000,000	>1,000,000	--	--	12,700	--	22,300	6,270
Plutonium-241	14119-32-5	pCi/g	--	--	5,080	--	--	77,200	--	854	--	--	>1,000,000	>1,000,000	--	--	--	--	--	--
Technetium-99	14133-76-7	pCi/g	--	--	1.5	--	114,000	17,300	5.8	35	--	--	405	405	33	33	21,900	--	5,360	8,670
Total beta radiostrontium (Sr-90)	SR-RAD	pCi/g	0.18	--	2.3	--	5,060	518	4.5	4.5	--	--	>1,000,000	>1,000,000	70	70	3,580	--	112	91
Tritium (H-3)	10028-17-8	pCi/g	--	--	623	--	15,400	1,265,000	459	711	--	--	11,700	11,700	746	746	1,680,000	--	936	420
Uranium-233/234	U-233/234	pCi/g	1.1	--	133	--	5,810	931	1.1	27.2	--	--	--	--	17.9	17.9	51,600	--	6,370	14,200
Uranium-235	15117-96-1	pCi/g	0.11	--	16	--	295	22	0.61	2.7	--	--	--	--	1.8	1.8	27,400	--	4,360	8,060
Uranium-238	U-238	pCi/g	1.1	--	54	--	1,090	93	1.1	26.2	--	--	--	--	17.3	17.3	15,700	--	5,150	11,000
Total Uranium (summed)	Total_U	pCi/g	--	--	--	--	--	--	--	56.1	--	--	--	--	37	37	--	--	--	--
Metals																				
Antimony	7440-36-0	mg/kg	0.13	32	--	--	365	--	32	32	--	--	5,130	4,790	5.0	5.0	842	842	--	146
Arsenic	7440-38-2	mg/kg	6.5	20	--	42,414	4.5	--	20	20	--	--	39.9	12.3	20	20	128	128	2,280	127
Barium	7440-39-3	mg/kg	132	16,000	--	>1,000,000	182,000	--	5,600	1,600	--	--	388,000	388,000	200	400	500	358	1,690	2,270
Beryllium	7440-41-7	mg/kg	1.5	160	--	75,991	1,820	--	10	10	--	--	388,000	388,000	1.5	1.5	10	40	--	18
Bismuth	7440-69-9	mg/kg	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boron	7440-42-8	mg/kg	3.9	16,000	--	>1,000,000	183,000	--	7,200	16,000	--	--	388,000	--	320	--	29.6	58	91.3	90.6
Cadmium	7440-43-9	mg/kg	0.56	40	--	101,322	821	--	14	14	--	--	33,900	1,700	0.81	0.81	9.84	20	28.6	624
Chromium	7440-47-3	mg/kg	18.5	120,000	--	--	>1,000,000	--	80,000	120,000	--	--	388,000	388,000	19	19	259	149	109	517
Cobalt	7440-48-4	mg/kg	15.7	24	--	20,264	274	--	24	24	--	--	54,200	29,300	16	--	15.7	15.7	484	2,140

Table 8-3. Summary of 300 Area Operable Unit Unrestricted Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs							PRGs Protective of Groundwater and Surface Water						Ecological PRGs[l]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method B Soil Direct Contact PRG[b]	RI/FS Residential PRG[c]	RI/FS MTCA Method B Soil Inhalation PRG[d]	RI/FS Casual Recreational User - Direct Contact PRG[e,f]	RI/FS Resident Monument Worker-Direct Contact PRG[g]	DOE/RL-96-17 Residential RAG[h]	DOE/RL -2001-47 Residential RAG[i]	300 Area STOMP 2D Uranium Model GWP PRG[j]	300 Area STOMP 2D Uranium Model SWP PRG[j]	100:0-Contaminant Source Model GWP PRG[k]	100:0-Contaminant Source Model SWP PRG[k]	DOE/RL-2001-47 Residential GWP RAG[i]	DOE/RL-2001-47 Residential SWP RAG[i]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG
Copper	7440-50-8	mg/kg	22	3,200	--	--	36,500	--	2,960	2,960	--	--	388,000	44,700	59	22	70	58	213	579
Hexavalent Chromium	18540-29-9	mg/kg	--	240	--	2,171	2,740	--	2.1	2.1	--	--	4,660	971	4.8	2.0	--	--	--	1,250
Lead	7439-92-1	mg/kg	10.2	250	--	--	--	--	353	353	--	--	102,000	14,300	10	10	9,090	1,700	156	1,580
Lithium	7439-93-2	mg/kg	13.3	160	--	--	1,830	--	160	160	--	--	361,000	--	34	--	2.0	--	--	1,660
Manganese	7439-96-5	mg/kg	512	11,200	--	>1,000,000	128,000	--	3,760	3,760	--	--	388,000	388,000	512	512	1,260	1,260	14,400	3,320
Mercury	7439-97-6	mg/kg	0.013	24	--	>1,000,000	274	--	24	24	--	--	13,600	81.4	0.33	0.33	0.30	12.5	2.0	1.56
Nickel	7440-02-0	mg/kg	19.1	1,600	--	701,458	18,300	--	1,600	1,600	--	--	388,000	388,000	19	27	38	280	361	247
Selenium	7782-49-2	mg/kg	0.78	400	--	>1,000,000	4,560	--	400	400	--	--	56,700	5,670	5.0	1.0	2.02	4.1	2.44	1.43
Silver	7440-22-4	mg/kg	0.17	400	--	--	4,560	--	400	400	--	--	388,000	53,000	8.0	0.73	560	2.99	983	9,810
Strontium	7440-24-6	mg/kg	--	48,000	--	--	548,000	--	48,000	48,000	--	--	388,000	388,000	960	--	--	--	--	1,210
Thallium	7440-28-0	mg/kg	0.19	--	--	--	--	--	--	--	--	--	8,020	3,850	--	--	1.0	0.459	--	6.2
Tin	7440-31-5	mg/kg	--	48,000	--	--	548,000	--	48,000	48,000	--	--	388,000	388,000	960	--	838	838	204	279
Total Uranium Isotopes	Total_U_Isotopes	mg/kg	3.2	--	161	--	2,740	--	--	81[m]	117	3,044	--	--	53[n]	106	250	100	81.9	40
Uranium	7440-61-1	mg/kg	3.2	240	--	>1,000,000	2,740	--	240	--	117	3,044	--	--	--	--	250	100	81.9	40
Vanadium	7440-62-2	mg/kg	85.1	400	--	--	4,560	--	560	560	--	--	388,000	--	85	--	89.4	116	43.2	260
Zinc	7440-66-6	mg/kg	68	24,000	--	--	274,000	--	24,000	24,000	--	--	388,000	388,000	480	68	621	8,980	856	1,040
Nonradioactive Anions																				
Cyanide	57-12-5	mg/kg	--	1,600	--	--	18,300	--	1,600	1,600	--	--	388,000	11,700	20	1.0	--	--	--	20,700
Fluoride	16984-48-8	mg/kg	2.8	4,800	--	>1,000,000	54,700	--	4,800	4,800	--	--	388,000	--	96	400	--	--	2,280	13,800
Nitrate	14797-55-8	mg/kg	52	568,000	--	--	>1,000,000	--	567,000[o]	35,400[o]	--	--	4,500	4,500	4,430	8,860	--	--	--	340,000
Nitrite	14797-65-0	mg/kg	--	24,000	--	--	274,000	--	26,300[o]	26,300[o]	--	--	451	--	329	658	--	--	--	340,000
Sulfate	14808-79-8	mg/kg	237	--	--	--	--	--	--	--	--	--	113,000	--	25,000	--	--	--	--	--
Polychlorinated Biphenyls (PCBs)																				
Aroclor 1016	12674-11-2	mg/kg	--	5.6	--	>1,000,000	46.0	--	0.5	0.5	--	--	12,100	1.55	0.017	0.017	40	--	1.82	4.9
Aroclor 1221	11104-28-2	mg/kg	--	0.5	--	319,963	2.0	--	0.5	0.5	--	--	102	0.15	0.017	0.017	40	--	1.82	1.47
Aroclor 1232	11141-16-5	mg/kg	--	0.5	--	319,963	2.0	--	0.5	0.5	--	--	102	0.15	0.017	0.017	40	--	1.82	1.44
Aroclor 1242	53469-21-9	mg/kg	--	0.5	--	319,963	2.6	--	0.5	0.5	--	--	443	0.65	0.017	0.017	40	--	1.82	1.49
Aroclor 1248	12672-29-6	mg/kg	--	0.5	--	319,963	2.6	--	0.5	0.5	--	--	434	0.63	0.017	0.017	40	--	1.82	0.325
Aroclor 1254	11097-69-1	mg/kg	--	0.5	--	319,963	2.6	--	0.5	0.5	--	--	747	1.09	0.017	0.017	40	--	1.82	1.47
Aroclor 1260	11096-82-5	mg/kg	--	0.5	--	319,963	2.6	--	0.5	0.5	--	--	8,121	11.9	0.017	0.017	40	--	1.82	1.47

Table 8-3. Summary of 300 Area Operable Unit Unrestricted Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs							PRGs Protective of Groundwater and Surface Water						Ecological PRGs[l]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method B Soil Direct Contact PRG[b]	RI/FS Residential PRG[c]	RI/FS MTCA Method B Soil Inhalation PRG[d]	RI/FS Casual Recreational User - Direct Contact PRG[e,f]	RI/FS Resident Monument Worker-Direct Contact PRG[g]	DOE/RL-96-17 Residential RAG[h]	DOE/RL -2001-47 Residential RAG[i]	300 Area STOMP 2D Uranium Model GWP PRG[j]	300 Area STOMP 2D Uranium Model SWP PRG[j]	100:0-Contaminant Source Model GWP PRG[k]	100:0-Contaminant Source Model SWP PRG[k]	DOE/RL-2001-47 Residential GWP RAG[i]	DOE/RL-2001-47 Residential SWP RAG[i]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG
Total PCBs	1336-36-3	mg/kg	--	--	--	>1,000,000	12.9	--	0.5	0.5	--	--	--	--	0.017	0.017	40	--	1.82	1.47
Semivolatile Organic Compounds (SVOCs)																				
Benzo(a)pyrene	50-32-8	mg/kg	--	0.14	--	165,799	0.17	--	0.14	0.14	--	--	14,900	3,480	0.015	0.015	--	18	2.41	76.4
Bis(2-ethylhexyl) phthalate	117-81-7	mg/kg	--	71	--	>1,000,000	405	--	71	71	--	--	149,000	29,800	0.60	0.36	100	--	0.14	45.4
Butylbenzylphthalate	85-68-7	mg/kg	--	526	--	--	2,980	--	16,000	16,000	--	--	144,000	25,700	320	250	--	--	--	--
Chrysene	218-01-9	mg/kg	--	14	--	>1,000,000	17	--	14	14	--	--	54,100	126	0.12	0.10	--	18	1.4	44.5
Phenanthrene	85-01-8	mg/kg	--	--	--	--	--	--	24,000	24,000	--	--	--	--	240	1,920	--	29	943	5,920
Volatile Organic Compounds (VOCs)																				
1,1,1-Trichloroethane	71-55-6	mg/kg	--	160,000	--	3,658	321,000	--	--	--	--	--	778	388,000	--	--	--	--	165	10,016
1,2-Dichloroethene (total)	540-59-0	mg/kg	--	720	--	--	8,210	--	--	--	--	--	86.7	2,530	--	--	--	--	--	--
2-Butanone	78-93-3	mg/kg	--	48,000	--	28,673	464,000	--	--	--	--	--	2,500	257,000	--	--	--	--	3,120	412,000
4-Methyl-2-pentanone	108-10-1	mg/kg	--	6,400	--	13,103	69,400	--	--	--	--	--	430	41,000	--	--	--	--	1,930	227,000
Benzene	71-43-2	mg/kg	--	18	--	0.57	21.7	--	--	--	--	--	1.34	2.02	--	--	--	--	195	70
Carbon tetrachloride	56-23-5	mg/kg	--	14	--	0.24	9.3	--	7.7	7.7	--	--	1.42	0.97	0.034	0.050	--	--	165	160
Chloroform	67-66-3	mg/kg	--	32	--	0.24	10.5	--	--	--	--	--	2.07	8.35	--	--	--	--	165	412
cis-1,2-Dichloroethylene	156-59-2	mg/kg	--	800	--	--	9,130	--	--	--	--	--	77.6	2,590	--	--	--	--	165	453
Ethyl acetate	141-78-6	mg/kg	--	72,000	--	--	821,000	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylene glycol	107-21-1	mg/kg	--	160,000	--	>1,000,000	>1,000,000	--	160,000	160,000	--	--	--	--	320	--	--	--	--	--
Hexachlorobutadiene	87-68-3	mg/kg	--	13	--	>1,000,000	72.6	--	13	13	--	--	6,810	5,340	0.33	0.33	--	--	--	--
Hexachloroethane	67-72-1	mg/kg	--	71	--	>1,000,000	405	--	71	71	--	--	1,210	542	0.31	0.38	--	--	--	--
Nitrobenzene	98-95-3	mg/kg	--	160	--	2.0	90.7	--	160	160	--	--	50.6	53.7	1.6	3.4	--	--	--	--
Tetrachloroethene	127-18-4	mg/kg	--	1.9	--	0.88	10.3	--	--	--	--	--	0.82	3.94	--	--	--	--	164	69.8
Toluene	108-88-3	mg/kg	--	6,400	--	4,774	63,800	--	6,400	6,400	--	--	2,490	5,060	64	1,360	200	--	195	5,200
Trichloroethene	79-01-6	mg/kg	--	11	--	0.17	7.2	--	--	--	--	--	1.21	6.16	--	--	--	--	165	70
Vinyl chloride	75-01-4	mg/kg	--	1.4	--	0.52	0.07	--	--	--	--	--	0.048	0.020	--	--	--	--	--	--
Xylenes (total)	1330-20-7	mg/kg	--	16,000	--	103	10,300	--	16,000	16,000	--	--	12,500	--	160	--	--	--	149	826
Other Organics																				
Normal paraffin hydrocarbon	--	mg/kg	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	57,900	452,000
Total petroleum hydrocarbons-diesel range	TPH	mg/kg	--	2,000	--	--	--	--	200	200	--	--	2,000	--	200	200	--	200	357,000	452,000
Tributyl phosphate	126-73-8	mg/kg	--	109	--	--	616	--	185	185	--	--	--	--	3.3	--	--	--	--	--

Table 8-3. Summary of 300 Area Operable Unit Unrestricted Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs							PRGs Protective of Groundwater and Surface Water						Ecological PRGs[l]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method B Soil Direct Contact PRG[b]	RI/FS Residential PRG[c]	RI/FS MTCA Method B Soil Inhalation PRG[d]	RI/FS Casual Recreational User - Direct Contact PRG[e,f]	RI/FS Resident Monument Worker-Direct Contact PRG[g]	DOE/RL-96-17 Residential RAG[h]	DOE/RL -2001-47 Residential RAG[i]	300 Area STOMP 2D Uranium Model GWP PRG[j]	300 Area STOMP 2D Uranium Model SWP PRG[j]	100:0-Contaminant Source Model GWP PRG[k]	100:0-Contaminant Source Model SWP PRG[k]	DOE/RL-2001-47 Residential GWP RAG[i]	DOE/RL-2001-47 Residential SWP RAG[i]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG

Note: Yellow highlighted values are the most conservative PRGs listed above the background value for each analyte, except for Arsenic, which is compared to the WAC 173-340-900, Table 740-1, Method A soil cleanup level for unrestricted Land Use, and Cr(VI) which is compared to the interim action RAG of 2.1 mg/kg. Green highlighted values are the most conservative GWP PRG value or SWP value between the 100:0 Contaminant Source Models; except for Arsenic, which is compared to the WAC 173-340-900, Table 740-1, Method A Soil Cleanup Levels for Unrestricted Land Use, and Cr(VI) which is compared to the interim action RAG of 2.10 mg/kg

a. Hanford Site background values for nonradionuclides: DOE/RL-92-24, Vol. 1, Rev. 4, Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes, ECF-Hanford-11-0038, Soil Background Data for Interim Use at the Hanford Site; Hanford Site background values for radionuclides: DOE/RL 96-12, Rev. 0, Hanford Site Background: Part 2, Soil Background for Radionuclides.

b. ECF-HANFORD-10-0444, "Documentation of Standard Method B Contact Cleanup Levels for Unrestricted Land Use"; WAC 173-340-740 (3) Method B Soil Cleanup Levels for Unrestricted Land Use; PRGs for arsenic, lead, and Total Petroleum Hydrocarbons and Lead are based on WAC 173-340-900, Table 740-1, MTCA Method A Soil Cleanup Levels for Unrestricted Land Uses.

c. ECF-HANFORD-10-0429, "Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Report."

d. ECF-HANFORD-11-0033, "Calculation of Inhalation Pathway Preliminary Remediation Goals Using Standard Method B Air Cleanup Levels for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports; WAC 173-340-750, "Cleanup Standards to Protect Air Quality.

e. ECF-HANFORD-10-0445, "Calculation of Nonradionuclides Preliminary Remediation Goals in Soil for a Casual Recreational User Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports."

f. ECF-HANFORD-10-0446, "Calculation of Radiological Preliminary Remediation Goals in Soil for a Casual Recreational User Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports."

g. ECF-HANFORD-11-0142, "Calculation of Radiological Preliminary Remediation Goals in Soil for a Resident Monument Worker Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports."

h. DOE/RL 96-17, Remedial Design Report/Remedial Action Work Plan for the 100 Area, Rev. 6.

i. DOE/RL-2001-47, *Remedial Design Report/Remedial Action Work Plan for the 300 Area*, Rev. 3, Table 2-1 (nonradionuclides), Table 2-2 (radionuclides).

j. ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS Document.*

k. ECF-300FF5-11-0153, *Soil Modeling in Support of 300 Area FF-5 RI/FS Document.*

l. CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site.*, CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site.*, ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionculides for Use at the Hanford Site*

m. Per DOE/RL-2001-47, Table D-3, footnote f, "Value is from the 300-FF-2 ESD (EPA 2004), Table 1. Based on the calculated isotopic distribution of uranium in the 300 Area, the activity-based direct exposure cleanup level of 56 pCi/g corresponding to a dose rate of 15 mrem/yr is equivalent to a mass-based uranium concentration of 81 mg/kg."

n. Per DOE/RL-2001-47, Table D-1, footnote f, "From the 300-FF-2 ESD (EPA 2004), Table 1. Based on the calculated isotopic distribution of uranium in the 300 Area and a groundwater protective cleanup level of 37 pCi/g for total uranium, the corresponding uranium concentration is 53 mg/kg."

o. Value converted from "as nitrogen" values in DOE/RL-96-17 using the following conversion factors as applicable: 4.43 g NO3-/g N and 3.29 g NO2-/ g N.

100-0 Source	=	100 % contaminated - 0 % uncontaminated (source extends full thickness of vadose zone)
1D	=	one-dimensional
2D	=	two-dimensional
GWP	=	groundwater protection
MTCA	=	Model Toxics Control Act
PRG	=	preliminary remediation goal
RAG	=	remedial action goal
STOMP	=	Subsurface Transport Over Multiple Phases
SWP	=	surface water protection

Table 8-4. Summary of 300 Area Operable Unit Industrial Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	Human Health PRGs				PRGs Protective of Groundwater and Surface Water						Ecological PRGs[f]			
				RI/FS MTCA Method C Soil Direct Contact PRG[b]	RI/FS Industrial PRG[c]	RI/FS MTCA Method C Soil Inhalation PRG[d]	DOE/RL-2001-47 Industrial RAG[e]	300 Area STOMP 2D Uranium Model GWP PRG[g]	300 Area STOMP 2D Uranium Model SWP PRG[g]	100:0-Contaminant Source Model GWP PRG[h]	100:0-Contaminant Source Model SWP PRG[h]	DOE/RL-2001-47 Industrial GWP RAG[e]	DOE/RL-2001-47 Industrial SWP RAG[e]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG
Radionuclides																	
Americium-241	14596-10-2	pCi/g	--	--	942	--	210	--	--	--	--	--	--	21,500	--	11,900	4,840
Carbon-14	14762-75-5	pCi/g	--	--	>1,000,000	--	82	--	--	902	902	--	--	60,700	--	49.5	31.6
Cesium-137	10045-97-3	pCi/g	1.1	--	18	--	25	--	--	>1,000,000	>1,000,000	--	--	2,210	--	1,430	924
Cobalt-60	10198-40-0	pCi/g	0.0084	--	9.4	--	5.2	--	--	>1,000,000	>1,000,000	--	--	6,130	--	805	805
Europium-152	14683-23-9	pCi/g	--	--	12	--	12	--	--	--	--	--	--	14,700	--	1,740	1,740
Europium-154	15585-10-1	pCi/g	0.033	--	13	--	11	--	--	--	--	--	--	12,500	--	1,610	1,610
Europium-155	14391-16-3	pCi/g	0.054	--	966	--	518	--	--	--	--	--	--	153,000	--	33,400	33,400
Iodine-129	15046-84-1	pCi/g	--	--	1,940	--	--	--	--	169	169	--	--	--	--	--	--
Nickel-63	13981-37-8	pCi/g	--	--	>1,000,000	--	>1,000,000	--	--	>1,000,000	>1,000,000	385	385	--	--	--	--
Plutonium-238	13981-16-3	pCi/g	0.0038	--	3,370	--	155	--	--	--	--	--	--	17,500	--	20,900	5,980
Plutonium-239/240	PU-239/240	pCi/g	0.025	--	2,910	--	245	--	--	--	--	--	--	12,700	--	22,300	6,270
Plutonium-241	14119-32-5	pCi/g	--	--	31,100	--	12,900	--	--	--	--	--	--	--	--	--	--
Technetium-99	14133-76-7	pCi/g	--	--	166,000	--	410,000	--	--	405	405	33	33	21,900	--	5,360	8,670
Total beta radiostrontium (Sr-90)	SR-RAD	pCi/g	0.18	--	1,968	--	2,500	--	--	>1,000,000	>1,000,000	70	70	3,580	--	112	91
Tritium (H-3)	10028-17-8	pCi/g	--	--	49,800	--	1,980	--	--	11,700	11,700	746	746	1,680,000	--	936	420
Uranium-233/234	U-233/234	pCi/g	1.1	--	1,757	--	167	--	--	--	--	17.9	17.9	51,600	--	6,370	14,200
Uranium-235	15117-96-1	pCi/g	0.11	--	61	--	16	--	--	--	--	1.8	1.8	27,400	--	4,360	8,060
Uranium-238	U-238	pCi/g	1.1	--	283	--	167	--	--	--	--	17.3	17.3	15,700	--	5,150	11,000
Total Uranium (summed)	Total_U	pCi/g	--	--	--	--	350	--	--	--	--	37	37	--	--	--	--
Metals																	
Antimony	7440-36-0	mg/kg	0.13	1,400	--	--	1,400	--	--	5,130	4,790	5.0	5.0	842	842	--	146
Arsenic	7440-38-2	mg/kg	6.5	20	--	424,000	58	--	--	39.9	12.3	20	20	128	128	2,280	127
Barium	7440-39-3	mg/kg	132	700,000	--	>1,000,000	4,900	--	--	388,000	388,000	200	400	500	358	1,690	2,270
Beryllium	7440-41-7	mg/kg	1.5	7,000	--	760,000	104	--	--	388,000	388,000	1.5	1.5	10	40	--	18
Bismuth	7440-69-9	mg/kg	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boron	7440-42-8	mg/kg	3.9	700,000	--	>1,000,000	700,000	--	--	388,000	--	320	--	29.6	58	91.3	90.6
Cadmium	7440-43-9	mg/kg	0.56	3,500	--	730,000	139	--	--	33,900	1,700	0.81	0.81	9.84	20	28.6	624
Chromium	7440-47-3	mg/kg	19	>1,000,000	--	--	>1,000,000	--	--	388,000	388,000	19	19	259	149	109	517
Cobalt	7440-48-4	mg/kg	16	1,050	--	203,000	1,050	--	--	54,200	29,300	16	--	15.7	15.7	484	2,140

Table 8-4. Summary of 300 Area Operable Unit Industrial Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs				PRGs Protective of Groundwater and Surface Water						Ecological PRGs[f]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method C Soil Direct Contact PRG[b]	RI/FS Industrial PRG[c]	RI/FS MTCA Method C Soil Inhalation PRG[d]	DOE/RL-2001-47 Industrial RAG[e]	300 Area STOMP 2D Uranium Model GWP PRG[g]	300 Area STOMP 2D Uranium Model SWP PRG[g]	100:0-Contaminant Source Model GWP PRG[h]	100:0-Contaminant Source Model SWP PRG[h]	DOE/RL-2001-47 Industrial GWP RAG[e]	DOE/RL-2001-47 Industrial SWP RAG[e]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG
Copper	7440-50-8	mg/kg	22	140,000	--	--	130,000	--	--	388,000	44,700	59	22	70	58	213	579
Hexavalent Chromium	18540-29-9	mg/kg	--	10,500	--	21,700	21	--	--	4,660	971	4.8	2.0	--	--	--	1,250
Lead	7439-92-1	mg/kg	10	1,000	--	--	1,000	--	--	102,000	14,300	10	10	9,090	1,700	156	1,580
Lithium	7439-93-2	mg/kg	13.3	7,000	--	--	7,000	--	--	361,000	--	34	--	2.0	--	--	1,660
Manganese	7439-96-5	mg/kg	512	490,000	--	>1,000,000	165,000	--	--	388,000	388,000	512	512	1,260	1,260	14,400	3,320
Mercury	7439-97-6	mg/kg	0.013	1,050	--	>1,000,000	1,050	--	--	13,600	81.4	0.33	0.33	0.30	12.5	2.0	1.56
Nickel	7440-02-0	mg/kg	19	70,000	--	>1,000,000	70,000	--	--	388,000	388,000	19	27	38	280	361	247
Selenium	7782-49-2	mg/kg	0.78	17,500	--	>1,000,000	17,500	--	--	56,700	5,670	5.0	1.0	2.02	4.1	2.44	1.43
Silver	7440-22-4	mg/kg	0.17	17,500	--	--	17,500	--	--	388,000	53,000	8.0	0.73	560	2.99	983	9,810
Strontium	7440-24-6	mg/kg	--	>1,000,000	--	--	>1,000,000	--	--	388,000	388,000	960	--	--	--	--	1,210
Thallium	7440-28-0	mg/kg	0.19	--	--	--	--	--	--	8,020	3,850	--	--	1.0	0.459	--	6.2
Tin	7440-31-5	mg/kg	--	>1,000,000	--	--	>1,000,000	--	--	388,000	388,000	960	--	838	838	204	279
Total Uranium Isotopes	Total_U_Isotopes	mg/kg	3.2	--	842	--	505[i]	117	3,044	--	--	53[n]	106	250	100	81.9	40
Uranium	7440-61-1	mg/kg	3.2	10,500	--	>1,000,000	--	117	3,044	--	--	--	--	250	100	81.9	40
Vanadium	7440-62-2	mg/kg	85	17,500	--	--	24,500	--	--	388,000	--	85	--	89.4	116	43.2	260
Zinc	7440-66-6	mg/kg	68	>1,000,000	--	--	>1,000,000	--	--	388,000	388,000	480	68	621	8,980	856	1,040
Nonradioactive Anions																	
Cyanide	57-12-5	mg/kg	--	70,000	--	--	70,000	--	--	388,000	11,700	20	1.0	--	--	--	20,700
Fluoride	16984-48-8	mg/kg	2.8	210,000	--	>1,000,000	210,000	--	--	388,000	--	96	400	--	--	2,280	13,800
Nitrate	14797-55-8	mg/kg	--	>1,000,000	--	--	>1,000,000[j]	--	--	4,500	4,500	4,430	8,860	--	--	--	340,000
Nitrite	14797-65-0	mg/kg	--	>1,000,000	--	--	>1,000,000[j]	--	--	451	--	329	658	--	--	--	340,000
Sulfate	14808-79-8	mg/kg	237	--	--	--	--	--	--	113,000	--	25,000	--	--	--	--	--
Polychlorinated Biphenyls (PCBs)																	
Aroclor 1016	12674-11-2	mg/kg	--	245	--	>1,000,000	65.6	--	--	12,100	1.55	0.017	0.017	40	--	1.82	4.9
Aroclor 1221	11104-28-2	mg/kg	--	65.6	--	>1,000,000	65.6	--	--	102	0.15	0.017	0.017	40	--	1.82	1.47
Aroclor 1232	11141-16-5	mg/kg	--	65.6	--	>1,000,000	65.6	--	--	102	0.15	0.017	0.017	40	--	1.82	1.44
Aroclor 1242	53469-21-9	mg/kg	--	65.6	--	>1,000,000	65.6	--	--	443	0.65	0.017	0.017	40	--	1.82	1.49
Aroclor 1248	12672-29-6	mg/kg	--	65.6	--	>1,000,000	65.6	--	--	434	0.63	0.017	0.017	40	--	1.82	0.325
Aroclor 1254	11097-69-1	mg/kg	--	65.6	--	>1,000,000	65.6	--	--	747	1.09	0.017	0.017	40	--	1.82	1.47
Aroclor 1260	11096-82-5	mg/kg	--	65.6	--	>1,000,000	65.6	--	--	8,121	11.9	0.017	0.017	40	--	1.82	1.47

Table 8-4. Summary of 300 Area Operable Unit Industrial Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs				PRGs Protective of Groundwater and Surface Water						Ecological PRGs[f]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method C Soil Direct Contact PRG[b]	RI/FS Industrial PRG[c]	RI/FS MTCA Method C Soil Inhalation PRG[d]	DOE/RL-2001-47 Industrial RAG[e]	300 Area STOMP 2D Uranium Model GWP PRG[g]	300 Area STOMP 2D Uranium Model SWP PRG[g]	100:0-Contaminant Source Model GWP PRG[h]	100:0-Contaminant Source Model SWP PRG[h]	DOE/RL-2001-47 Industrial GWP RAG[e]	DOE/RL-2001-47 Industrial SWP RAG[e]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG
Total PCBs	1336-36-3	mg/kg	--	328	--	>1,000,000	65.6	--	--	--	--	0.017	0.017	40	--	1.82	1.47
Semivolatile Organic Compounds (SVOCs)																	
Benzo(a)pyrene	50-32-8	mg/kg	--	18	--	>1,000,000	18	--	--	14,900	3,480	0.015	0.015	--	18	2.41	76.4
Bis(2-ethylhexyl) phthalate	117-81-7	mg/kg	--	9,380	--	>1,000,000	9,380	--	--	149,000	29,800	0.60	0.36	100	--	0.14	45.4
Butylbenzylphthalate	85-68-7	mg/kg	--	69,100	--	--	700,000	--	--	144,000	25,700	320	250	--	--	--	--
Chrysene	218-01-9	mg/kg	--	1,800	--	>1,000,000	1,800	--	--	54,100	126	0.12	0.10	--	18	1.4	44.5
Phenanthrene	85-01-8	mg/kg	--	--	--	--	>1,000,000	--	--	--	--	240	1,920	--	29	943	5,920
Volatile Organic Compounds (VOCs)																	
1,1,1-Trichloroethane	71-55-6	mg/kg	--	>1,000,000	--	8,000	--	--	--	778	388,000	--	--	--	--	165	10,016
1,2-Dichloroethene (total)	540-59-0	mg/kg	--	31,500	--	--	--	--	--	86.7	2,530	--	--	--	--	--	--
2-Butanone	78-93-3	mg/kg	--	>1,000,000	--	62,700	--	--	--	2,500	257,000	--	--	--	--	3,120	412,000
2-Pentanone, 4-Methyl	108-10-1	mg/kg	--	280,000	--	28,700	--	--	--	430	41,000	--	--	--	--	1,930	227,000
Benzene	71-43-2	mg/kg	--	2,390	--	5.7	--	--	--	1.34	2.02	--	--	--	--	195	70
Carbon tetrachloride	56-23-5	mg/kg	--	1,010	--	2.4	1,010	--	--	1.42	0.97	0.034	0.050	--	--	165	160
Chloroform	67-66-3	mg/kg	--	4,230	--	2.4	--	--	--	2.07	8.35	--	--	--	--	165	412
cis-1,2-Dichloroethylene	156-59-2	mg/kg	--	35,000	--	--	--	--	--	77.6	2,590	--	--	--	--	165	453
Ethyl acetate	141-78-6	mg/kg	--	>1,000,000	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylene glycol	107-21-1	mg/kg	--	>1,000,000	--	>1,000,000	>1,000,000	--	--	--	--	320	--	--	--	--	--
Hexachlorobutadiene	87-68-3	mg/kg	--	1,680	--	>1,000,000	700	--	--	6,810	5,340	0.33	0.33	--	--	--	--
Hexachloroethane	67-72-1	mg/kg	--	3,500	--	>1,000,000	3,500	--	--	1,210	542	0.31	0.38	--	--	--	--
Nitrobenzene	98-95-3	mg/kg	--	7,000	--	20	7,000	--	--	50.6	53.7	1.6	3.4	--	--	--	--
Tetrachloroethene	127-18-4	mg/kg	--	243	--	8.8	--	--	--	0.82	3.94	--	--	--	--	164	69.8
Toluene	108-88-3	mg/kg	--	280,000	--	10,400	28,000	--	--	2,490	5,060	64	1,360	200	--	195	5,200
Trichloroethene	79-01-6	mg/kg	--	1,480	--	1.7	--	--	--	1.21	6.16	--	--	--	--	165	70
Vinyl chloride	75-01-4	mg/kg	--	182	--	5.2	--	--	--	0.048	0.020	--	--	--	--	--	--
Xylenes (total)	1330-20-7	mg/kg	--	700,000	--	225	700,000	--	--	12,500	--	160	--	--	--	149	826
Other Organics																	
Normal paraffin hydrocarbon	--	mg/kg	--	--	--	--	--	--	--	--	--	--	--	--	--	57,900	452,000
Total petroleum hydrocarbons-diesel range	TPH	mg/kg	--	2,000	--	--	200	--	--	--	--	200	200	--	200	357,000	452,000
Tributyl phosphate	126-73-8	mg/kg	--	14,300	--	--	24,300	--	--	--	--	3.3	--	--	--	--	--

Table 8-4. Summary of 300 Area Operable Unit Industrial Human Health, Groundwater Protection, Surface Water Protection, and Ecological Soil PRGs

				Human Health PRGs				PRGs Protective of Groundwater and Surface Water						Ecological PRGs[f]			
Analyte Name	CAS No.	Units	Hanford Site Lognormal 90th Percentile Background Concentration[a]	RI/FS MTCA Method C Soil Direct Contact PRG[b]	RI/FS Industrial PRG[c]	RI/FS MTCA Method C Soil Inhalation PRG[d]	DOE/RL-2001-47 Industrial RAG[e]	300 Area STOMP 2D Uranium Model GWP PRG[g]	300 Area STOMP 2D Uranium Model SWP PRG[g]	100:0-Contaminant Source Model GWP PRG[h]	100:0-Contaminant Source Model SWP PRG[h]	DOE/RL-2001-47 Industrial GWP RAG[e]	DOE/RL-2001-47 Industrial SWP RAG[e]	Plant PRG	Invertebrate PRG	Avian PRG	Mammal PRG

Note: Yellow highlighted values are the most conservative PRGs listed above the background value for each analyte, except for Arsenic, which is compared to the WAC 173-340-900, Table 740-1, Method A soil cleanup level for unrestricted Land Use, and Cr(VI) which is compared to the interim action RAG of 2.1 mg/kg. Green highlighted values are the most conservative GWP PRG value or SWP value between the 100:0 Contaminant Source Models; except for Arsenic, which is compared to the WAC 173-340-900, Table 740-1, Method A Soil Cleanup Levels for Unrestricted Land Use, and Cr(VI) which is compared to the interim action RAG of 2.10 mg/kg

a. Hanford Site background values for nonradionuclides: DOE/RL-92-24, Vol. 1, Rev. 4, Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes, ECF-Hanford-11-0038, Soil Background Data for Interim Use at the Hanford Site; Hanford Site background values for radionuclides: DOE/RL 96-12, Rev. 0, Hanford Site Background: Part 2, Soil Background for Radionuclides.

b. ECF-HANFORD-10-0453, "*Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports"*; PRGs for arsenic, lead, and Total Petroleum Hydrocarbons are based on WAC 173-340-900, Table 745-1, MTCA Method A Soil Cleanup Levels for Industrial Land Uses.

c. ECF-HANFORD-10-0452, "*Calculation of Radiological Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*."

d. ECF-HANFORD-10-0454, "*Calculation of Inhalation Pathway Preliminary Remediation Goals Using Standard Method C Air Cleanup Levels for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*."

e. DOE/RL-2001-47, *Remedial Design Report/Remedial Action Work Plan for the 300 Area*, Rev. 3.

f. CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*., CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*., ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionculides for Use at the Hanford Site*

g. ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS Document*.

h. ECF-300FF5-11-0153, *Soil Modeling in Support of 300 Area FF-5 RI/FS Document.*

i. Per DOE/RL-2001-47, Table D-3, footnote e, "Based on the calculated isotopic distribution of uranium in the 300 Area and an activity-based industrial direct exposure cleanup level of 350 pCi/g for total uranium, the corresponding mass-based uranium concentration is 505 mg/kg (BHI 2002) for 300-FF-2 Operable Unit sites."

j. Value converted from "as nitrogen" values in DOE/RL-96-17 using the following conversion factors as applicable: 4.43 g NO3-/g N and 3.29 g NO2-/ g N.

2D = two-dimensional
GWP = groundwater protection
MTCA = Model Toxics Control Act
PRG = preliminary remediation goal
RAG = remedial action goal
STOMP = Subsurface Transport Over Mulitple Phases
SWP = surface water protection

Consistent with this approach, the methodology described for industrial land use under MTCA (WAC 173-340-745 (5)) "Method C industrial soil cleanup levels" and for unrestricted land use under MTCA (WAC 173-340-740(3)) "Method B soil cleanup levels" is used to calculate the risk-based standards for soil ingestion. Risk-based standards for inhalation pathway use equations and input parameters described in "Method B Air Cleanup Levels" (WAC 173-750(3)), and EPA published volatilization factors and particulate emission factors.

For arsenic and lead, Table 740-1 in the MTCA Method A "Soil Cleanup Levels for Unrestricted Land Use" (WAC 173-340-900) is used as the PRG for direct contact exposure.

Table 8-3 presents a summary of the RAGs reported in the 100 Area RDR/RAWP (DOE/RL-96-17) and the "Method B soil cleanup levels". To satisfy RAOs for protection of human health for areas outside the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest), the lower of the two values will be selected to satisfy RAO 4. Table 8-4 presents a summary of the RAGs reported in the 300 Area RDR/RAWP (DOE/RL-2001-47) and the "Method C soil cleanup levels". To satisfy RAOs for protection of human health for the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest), the lower of the two values will be selected to satisfy RAO 6.

Risk-based standards for some contaminants are calculated to be less than area background values or PQLs. Where risk-based standards are less than area background concentrations, PRGs may be set at concentrations that are equal to the agreed upon site or area background concentrations. Area background values for selected nonradioactive contaminants in soil have been characterized for the Hanford Site (Non-Rad Soil Background document [DOE/RL-92-24,]). Similarly, where risk-based standards are less than PQLs, PRGs will default to the PQLs. Therefore, the PRGs for individual nonradioactive contaminants in solid waste and particulate reflect the value that is greatest among risk-based standards, area background values, or PQLs.

Direct Contact Exposure PRGs for Radiological Contaminants. The PRGs for direct contact exposure to radioactive contamination for both human and ecological receptors are described in the following subsections.

Human Exposure. PRGs for radioactive wastes and radioactively contaminated soils for human receptor direct contact exposures are based on EPA radionuclide soil cleanup guidance. As established by the NCP (40 CFR 300), CERCLA cleanup actions generally should achieve a level of risk within the 10^{-4} to 10^{-6} ELCR based on the RME for an individual. Furthermore, EPA policy has noted that the upper boundary of the risk range is not a discrete line at 10^{-4} and that a specific risk estimate around 10^{-4} may be considered acceptable, if justified based on site-specific conditions (*Radiation Risk Assessment At CERCLA Sites: Q&A* [EPA 540/R/99/006]).

PRGs for radiological contaminants are developed using a residential exposure scenario. Residents could potentially be exposed to shallow zone soil from residential yards or groundwater from domestic wells. Residents could potentially be exposed to soil from direct external exposure, incidental soil ingestion, or inhalation of dust generated from wind or from yard maintenance activities. Residents could also be potentially exposed to radiological contaminants through food chain pathways (uptake of contamination from soil to plants and animals). From the leaching pathway, residents could potentially consume drinking water from a downgradient well, use the well for irrigation of crops and watering livestock, and consume fish raised in a pond filled with water from the downgradient well. The PRGs are calculated using a target cancer risk level of 1×10^{-4}, which is comparable with the cleanup achieved through the interim actions as established by the interim RODs. An annual dose rate of 15 mrem/yr was used in the interim action RODs as an RAO for protection of human health, which is approximately equivalent to an increased lifetime cancer risk of 3×10^{-4} for the residential exposure scenario. Table 8-3 presents a

summary of the RAGs reported in the 100 Area RDR/RAWP (DOE/RL-96-17) and the PRGs developed for the residential scenario. To satisfy RAOs for protection of human health for areas outside the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest), the lower of the two values will be selected to satisfy RAO 5.

PRGs for radiological contaminants are developed using a industrial exposure scenario. Adult workers could potentially be exposed to shallow zone soil while working at an office buildingWorkers could potentially be exposed to soil from direct external exposure, incidental soil ingestion, or inhalation of dust generated from wind or from work activities. The PRGs are calculated using a target cancer risk level of 1×10^{-4}, which is comparable with the cleanup achieved through the interim actions as established by the interim RODs. An annual dose rate of 15 mrem/yr was used in the interim action RODs as an RAO for protection of human health, which is approximately equivalent to an increased lifetime cancer risk of 3×10^{-4} for the industrial exposure scenario. Table 8-4 presents a summary of the RAGs reported in the 300 Area RDR/RAWP (DOE/RL-2001-47) and the PRGs developed for the industrial scenario. To satisfy RAOs for protection of human health for the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest), the lower of the two values will be selected to satisfy RAO 7.

Soil PRG values are developed for the direct contact and inhalation pathways combined using the resident monument worker exposure scenario. This scenario assumes that the resident monument worker spends a fraction of the day on the waste site as his residence and spends the remaining fraction of the same day in a region as large as an individual ROD decision area and potentially as large as the entire River Corridor conducting worker activities. The PRG value represents the concentration of soil the resident monument worker is exposed to on the waste site. An adult potentially could be exposed to site contaminants in shallow vadose zone material from the waste site through direct external exposure, incidental soil ingestion, and inhalation of dust in ambient air. PRG values for individual radioisotopes are based on an ELCR of 1×10^{-4}. The PRG values listed in Table 8-3 for this exposure scenario are provided for information only.

Soil PRG values are also developed for the direct contact and inhalation pathways combined using the casual user exposure scenario. The casual recreational user scenario is a site-specific scenario representing occasional recreational use that focuses on activities such as walking and picnicking in areas along the Columbia River where paths and benches are likely to exist. Adults and children potentially could be exposed to site contaminants in shallow vadose zone material along the river through direct external exposure, incidental ingestion, and inhalation of dust in ambient air. PRG values for individual radioisotopes are based on an ELCR of 1×10^{-4}. The PRG values listed in Table 8-3 for this exposure scenario are provided for information only.

The following subsections describe how ecological PRGs are developed for the 300 Area. COPECs are identified using a tiered screening process for wildlife (birds and mammals), plants, and soil invertebrates. Ecological PRGs are developed using a tiered approach, and the appropriate tier is identified through answering key questions.

Ecological Exposure. Ecological PRGs for the protection of plants, soil invertebrates, and wildlife (birds and mammals) are developed using a tiered approach (*Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [CHPRC-00784]). The objective of a tiered approach is to refine available generic screening levels (Eco-SSLs in MTCA [WAC 173-340], Table 749-3, or BCGs) as needed with additional literature-derived or site-specific information to more realistically represent Hanford Site-specific ecological risks. These tiers as applied to the development of PRGs in the 300 Area RI/FS are as follows:

- Generic Screening Levels: these represent conservative literature-based screening values that are not specific to the Hanford Site-specific.
- Tier 1 PRGs: these are calculated for wildlife species found at the Hanford Site, and are intended to reflect Hanford Site-specific conditions using information obtained from the literature.
- Tier 2 PRGs: these are calculated for wildlife species, plants, and soil invertebrates. These better reflect Hanford Site-specific conditions using additional Hanford Site-specific information.

Selection of the appropriate tier for developing a PRG for a particular COPEC involves answering two questions:

- Whether the value at the lower tier is sufficient for use as a PRG.
- Whether progression to a higher tier would reduce uncertainties and/or increase confidence in the values used for cleanup decision.

For each COPEC, distinct PRGs are proposed for plants, soil invertebrates, birds, and mammals. The highest tier value available for each COPEC is proposed for use as an ecological PRG for protection of plants, soil invertebrates, and wildlife.

For plants and soil invertebrates, PRGs were selected from the following sources:

- Hanford Site-specific values from bioassays conducted in 2011 (*Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site* [ECF-HANFORD-11-0158])
- Published values from Ecology and the EPA
- Hanford Site-specific values previously established for the RCBRA Report (DOE/RL-2007-21)
- Values recently published by Ecology for the based on Hanford-Site-specific bioassays (*Ecological Soil Screening Levels for Arsenic and Lead in the Tacoma Smelter Plume Footprint and Hanford Site Old Orchards Ecology* [Ecology Publication 11-03-006])
- Values published by Oak Ridge National Laboratory (ORNL) (*Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision* [ES/ER/TM-85/R3], *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision* [ES/ER/TM-126/R2])
- Site-specific background

The final recommended PRG represented the most appropriate value, that of the highest confidence, or the lower of two values with equally high confidence.

PRGs for wildlife incorporate bioaccumulation data, both from literature sources and Hanford Site-specific studies, for the food chain present at the Hanford Site. For COPECs with insufficient Hanford Site -specific bioaccumulation data available (i.e., no matched soil and tissue residue data), PRGs rely exclusively on literature data. PRGs have been developed for a range of bird and wildlife feeding guilds found at the Hanford Site. For each COPEC, the lowest value among the avian feeding guilds has been proposed as the ecological PRG for birds. Similarly, the lowest value form mammalian feeding guilds has been proposed for mammals.

Ecological Exposure. BCGs are proposed for use as ecological PRGs for radionuclides for terrestrial plants and animals (including soil invertebrates). While these are generic screening levels, they are higher than PRGs for protection of human health. Therefore, BCGs are sufficient for use as a PRG, and refinement to higher tier values is not warranted.

Soil Concentrations Protective of Groundwater and Surface Water PRGs. Modeling was conducted to assess the fate and transport of contaminants other than uranium in the vadose zone and their potential impacts on groundwater or surface water. One-dimensional numerical simulations were constructed to represent the key factors of the conceptual model for the 300 Area using *STOMP: Subsurface Transport Over Multiple Phases Version 2.0: Theory Guide* (PNNL-12030). Modeling with STOMP (*STOMP: Subsurface Transport Over Multiple Phases Version 4.0: User's Guide* [PNNL-15782]) was performed with different waste distributions, recharge scenarios, and stratigraphic columns that represented the range of conditions expected within the 300 Area. Constituents that were persistent (i.e., do not degrade or decay in a reasonable time frame) and that had a peak concentration in groundwater occurring within 10,000 years in the future were evaluated.

For COPCs other than uranium, PRGs were calculated assuming that the contaminant source was uniformly distributed through the entire vadose zone thickness beneath the backfill and assuming recharge rates that represented the re-establishment of the native xerophytic plant communities on the land surface (Tables 8-3 and 8-4). This set of assumptions is referred to as the 50:50 base case scenario, as described in Section 5.6.

Given the complex uranium fate and transport within the vadose zone and unconfined aquifer at the 300 Area, the use of a more detailed site-specific model was warranted in determining PRG values for uranium. The uranium PRG was determined using the coupled groundwater flow and uranium transport model developed for simulating future uranium migration, as described in Section 5.6.5. The modeling results determined that the PRG for uranium protective of groundwater at the 300 Area was 117 mg/kg.

Groundwater and Surface Water Cleanup Levels. Section 6.3 presents the groundwater risk assessment. The list of COPCs presented in Table 8-5 was determined in Section 6.2 by comparing the groundwater EPCs to the DWS, federal and state water quality standards, or the MTCA cleanup level, "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup levels corresponding to a 1×10^{-5} acceptable target risk level for carcinogens or an HQ of 1.0 for noncarcinogens. Contaminants with EPCs greater than or equal to the DWS, federal or state water quality standard, or MTCA, "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup level were retained as COCs. Those with EPCs less than the DWS, federal or state water quality standard, or federal MCL, federal or state water quality standard, or MTCA "Groundwater Cleanup Standards" (WAC 173-340-720) groundwater cleanup levels were not carried forward as COCs. An uncertainty analysis was included in Section 6.3, which provides a summary of groundwater EPCs calculated for each detected analyte using the 90th percentile value and the UCL-95 value. The uncertainty analysis discusses the affect on COPC identification using the two calculation methods and determines that there is no significant difference in the identification of COPCs using either approach. Based on the results of this evaluation, the list of COPCs includes uranium, gross alpha, tritium, nitrate, TCE, cis-1,2-DCE, and chromium. Gross alpha is an indicator parameter and its presence above the DWS is consistent with the presence of uranium. Gross alpha is not a COPC; however, it should continue to be monitored as an indicator parameter.

Groundwater Risk Management. A risk management approach was applied in developing COCs to be addressed by remedial action alternatives for the groundwater COPCs. The identified COCs for groundwater at the 300 Area include uranium and tritium. The risk management approach taken for the remaining groundwater COPCs that will be carried forward for monitoring is discussed below:

- Gross alpha is considered a COPC. However, since most gross alpha is associated with uranium, it will not be carried forward as a groundwater COC. Achieving the uranium standards will also likely result in the gross alpha standard being achieved. However, continued monitoring for gross alpha is recommended. Additional discussion on the correlation between gross alpha and uranium concentrations is presented in "Other Contamination Indicators in 300 Area Groundwater", a subsection of Section 4.4.1.6 and in Figure 4-64.

- Nitrate is considered a COPC at the 300 Area subregion. However, nitrate concentrations in groundwater have exceeded the 45 mg/L DWS at the southern portion of the 300 Area where groundwater has been impacted by agricultural and industrial activities not associated with the Hanford Site. The relatively higher concentrations in the southern portion currently reflect the migration of nitrate-contaminated groundwater into the 300 Area from sources to the southwest. Gradually increasing concentrations are also observed in wells and at shoreline sites as the nitrate-laden groundwater migrates into the 300 Area. Nitrate also migrates into the 300 Area from the northwest as part of the sitewide plume that originates in the 200 East Area. Because of its likely association with offsite sources and the sitewide nitrate plume, nitrate at the 300 Area will not be addressed in the remedial alternatives but continued monitoring for nitrate in the 300 Area subregion is recommended.

- Although nitrate is considered a COPC at the 600 Area subregion (618-11 Burial Ground), the origin for nitrate observed in this area is enigmatic. Waste acids, such as nitric acid, are not known to have been placed in the burial ground. One explanation suggests that waste disposal at the 200 East Area sites may be implicated, i.e., the contamination is part of the sitewide groundwater plume assigned to the 200-PO-1 OU. The relatively higher concentrations currently observed at the burial ground may be explained by back-diffusion of nitrate from local lower permeability aquifer sediments that has sequestered higher levels of contamination from earlier periods (*Evaluation of Elevated Tritium Levels in Groundwater Downgradient from the 618-11 Burial Ground Phase I Investigations* [PNNL-13228]). Due to the likely association with the sitewide nitrate plume, nitrate at the 618-11 Burial Ground will not be addressed in the remedial alternatives but continued monitoring for nitrate in the 600 Area subregion is recommended.

- TCE is considered a COPC. Recent analytical results for TCE at several wells at the southern portion of the 300 Area show increases in concentrations, some of which now exceed the DWS of 5 µg/L (wells 399-3-21 and 399-4-14). Other VOCs do not show similar increases, and the TCE increases do not appear correlated with trends for other waste constituent indicators. Offsite groundwater from the southwest migrates into the southern portion of the 300 Area, and TCE contamination that is potentially associated with offsite sources (e.g., the AREVA facility and the DOE's former Horn Rapids Landfill) is present in that groundwater. Due to the potential association with offsite sources, TCE will not be addressed in the remedial alternatives, but continued monitoring for TCE in the 300 Area subregion is recommended.

- Cis-1,2-DCE is considered a COPC. However, cis-1,2-DCE concentrations continue to exceed the DWS at only one well (399-1-16B) located near the former North Process Pond. Well 399-1-16B is screened in Ringold Formation gravelly sediment in the lower portion of the unconfined aquifer. The origin for cis-1,2-DCE is likely degradation of TCE disposed to the former 300 Area Process Trenches and/or North Process Pond (300 Area VOC Investigation Results [PNNL-17666]). Since the areas of exceedance are localized, cis-1,2-DCE will not be addressed in the remedial alternatives, but continued monitoring for cis-1,2-DCE is recommended. Chapter 4 presents additional information on cis-1,2-DCE.

- Chromium is considered a COPC. Chromium appeared as part of the plume associated with remedial action at the 618-7 Burial Ground, which was completed in late 2008. At well 399-8-5A, which is adjacent to the eastern fence line of the former burial ground, concentrations measured as total chromium in filtered and unfiltered samples during late 2008 and 2009 had a high value of 105 µg/L in July 2009. Chromium from the eastern fence line then migrated downgradient to well 399-8-1. Since then, concentrations have declined to near the Cr(VI) AWQC of 10 µg/L. The source for the chromium is unknown but may be related to release of material from the burial ground during remedial action excavation activities, dust control water application, or corrosion of the stainless-steel well screen in well 399-8-5A, which may have occurred because of the elevated chloride level. Other constituents showing a concurrent increase at this well include calcium, chloride, gross alpha, gross beta, nitrate, and sodium. Since the areas of chromium exceedance are localized and likely associated with completed remediation activities at the 618-7 Burial Ground, chromium will not be addressed in the remedial alternatives but continued monitoring for chromium (and Cr(VI)) is recommended.

Table 8-5. 300 Area Groundwater Cleanup Levels

Contaminant[a]	Units	90th Percentile Concentration	Dose (mrem/yr) Based on 90th Percentile Concentration	ELCR Based on 90th Percentile Concentration	HI Based on 90th Percentile Concentration	Drinking Water Standard	WAC 173-340-720 Cleanup Levels		AWQC		WAC 173-201A	40 CFR 131 Water Quality Standard		300 Area Groundwater OU Cleanup Level[b]
							Noncarcinogens at HQ = 1	Carcinogens at 1×10^{-5} Risk Level	Freshwater CMC (acute)	Freshwater CCC (chronic)	Freshwater CCC (chronic	Freshwater CMC (acute)	Freshwater CCC (chronic)	
300-FF-5 Groundwater OU														
COCs—for Remedial Technology Screening and Alternative Development														
Uranium	µg/L	114	--	--	2.4	30	48	--	--	--	--	--	--	30
COPCs—Carried Forward for the Monitoring Program														
Cis-1,2-DCE	µg/L	--	--	--	--	70	80	--	--	--	--	--	--	70
Hexavalent Chromium	µg/L	--	--	--	--	--	48	--	16	11	10	15	10	10
Nitrate[c]	µg/L	50,000	--	--	0.44	45,000	113,600	--	--	--	--	--	--	45,000
Trichloroethene	µg/L	--	--	--	--	5	--	4.9	--	--	--	--	--	4.9
600 Area Subregion														
COCs—for Remedial Technology Screening and Alternative Development														
Tritium	pCi/L	290,000	58	2.8×10^{-4}	--	20,000	--	--	--	--	--	--	--	20,000
COPCs—Carried Forward for the Monitoring Program														
Nitrate[b]	µg/L	50,000	--	--	0.44	45,000	113,600	--	--	--	--	--	--	45,000

Sources:
40 CFR 131, "Water Quality Standards."
WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards."
WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."
Notes: DWS from 40 CFR 141, "National Primary Drinking Water Regulations."
a. Gross alpha is not a COPC; however, it should continue to be monitored as an indicator parameter as discussed in Chapter 6.
b. The final cleanup levels achieved at the conclusion of the remedial action will correspond to an ELCR less than 1×10^{-6} and HI of less than 1.
c. Nitrate may be expressed as nitrate (NO_3) or as nitrate-nitrogen (NO_3-N). The DWS for NO_3-N is 10,000 µg/L and 45,000 µg/L for NO_3.
COC = contaminant of concern
COPC = contaminant of potential concern
DWS = drinking water standard
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
HI = hazard index
N/A = not applicable
OU = operable unit

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8.2 General Response Actions

GRAs consistent with RAOs were identified for the 300 Area. GRAs are basic actions that might be undertaken to remediate a site, and are assembled based on nature and extent of contamination, as presented in the RI. For each GRA, several possible remedial technologies may exist, which can be further divided into a number of process options. This section discusses the remedial technology selection process.

Potential remedial technologies are selected for evaluation based on their potential ability to mitigate the identified risks or achieve compliance with ARARs for the remedial action. Technologies and process options selected for evaluation are assessed with respect to their implementability, effectiveness, and relative cost in accordance with CERCLA RI/FS Guidance (EPA/540/G-89/004) and the NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy" [40 CFR 300.430(e)]). The selected final remedy must comply with ARARs and protect HHE.

CERCLA RI/FS Guidance (EPA/540/G-89/004) suggests development and evaluation of a range of responses, including a no action alternative, to ensure identification and selection of an appropriate remedy. The technology screening process consists of the following steps:

- Identify GRAs that may meet RAOs, either individually or in combination with other GRAs.
- Identify, screen, and evaluate remedial technology types for each GRA.
- Select representative process option(s).

Following the technology screening, representative process options are assembled into remedial alternatives (presented in Chapter 9) that are evaluated further in the detailed and comparative analyses of alternatives (presented in Chapter 10).

GRAs identified for waste sites in the 300 Area include the following:

- No action
- Institutional controls
- Removal, ex situ treatment, and disposal
- In situ treatment
- Containment

GRAs identified for contaminated groundwater in the 300 Area include the following:

- No action
- Institutional controls
- Monitored natural attenuation (MNA)
- Removal, ex situ treatment, and discharge
- In situ treatment
- Containment

8.2.1 Target Remediation Areas

In accordance with CERCLA RI/FS Guidance (EPA/540/G-89/004), the FS is required to determine the areas or volumes of media to which GRAs might be applied. This section summarizes the waste sites and groundwater areas that will be evaluated in the FS, based on the PRGs and findings of the HHRA, ERA, and RI presented in the preceding chapters.

8.2.1.1 Waste Sites

As discussed in Chapter 1, the determination of which areas of the 300 Area are waste sites has been performed following specific procedures defined in the TPA (Ecology et al., 1989a) documents; TPA Action Plan (Ecology et al., 1989b). The areas that have been suspected waste sites are summarized and tracked in the WIDS database. As information is learned about the sites, or as they are remediated and confirmation data collected, they are classified or reclassified, depending on their status.

There are 552 sites (including subsites) in the 300 Area. Of theses 552 sites, 397 sites were not carried into the FS for evaluation. These 397 sites are discussed below:

- As discussed in Chapter 1, 370 waste sites were not carried forward for further evaluation because of their WIDS classification status. Of these sites, 275 waste sites were classified as "Not Accepted" or "Rejected," 13 waste sites were classified as "No Action," and 85 waste sites were classified as "Closed Out." Howwever, three of the 300-FF-1 OU waste sites that were classified as "Closed Out" in Chapter 1 (316-1,316-2, and 316-5) will be carried forward into the FS and are included in the 155 waste sites listed below. Alternatives will be developed to manage or remediate the uranium mass in the vadose zone and PRZ below these waste sites to reduce mass flux to groundwater that is causing the persistent 300-FF-5 uranium plume.

- Twenty-seven 300-FF-2 OU sites were identified with data that indicate no unacceptable risk toHHE, with the analysis presented in Chapters 5, 6, and 7:

  - Twenty-five sites had no risk exceedances.

  - One waste site (600-243) exceeded Tier 2 ecological PRGs for boron. This exceedance is attributed to the presence of coal ash at the site. This site is not carried forward for FS evaluation pending the results on an ongoing coal ash investigation. If conclusions of this investigation indicate that remediation could be required at 600-243, the site would be handled as a Post-ROD "To-Go" site (further described below and in Chapter 9).

  - One waste site (618-13) had verification data with exceedances of deep human health protection criteria (residential scenario) for select radionuclide compounds (Chapter 6). As discussed in Chapter 6, residents are unlikely to be exposed to contaminants in deep zone soil and the residential exposure scenario does not reflect reasonably anticipated future land use in the River Corridor. For this reason, this site will not be carried forward into the FS.

Table 8-6 presents the 397 sites that are not carried forward into the FS.

The remaining 155 sites will be discussed further in this RI/FS:

- Three 300-FF-1 OU waste sites that are classified as "Closed Out" (316-1,316-2, and 316-5) will be carried forward into the FS. Alternatives will be developed to manage or remediate the uranium mass in the vadose zone and PRZ below these waste sites to reduce mass flux to groundwater that is causing the persistent 300-FF-5 uranium plume. Figure 8-1 illustrates the location of these sites.

- Three 300-FF-2 OU waste sites (618-1, 618-2, and 618-3) are carried forward because they exceeded the groundwater protection PRG for total uranium isotopes and are being considered for evaluation in the FS. Chapter 6 presents additional information on these exceedances.

- Forty-three 300-FF-2 OU waste sites have or are currently being remediated under the 300-FF-2 Interim ROD (EPA/ROD/R10-01/119), or are anticipated to be by the time the final ROD is signed. These are denoted by "Pre-ROD To-Go Sites," as Figure 8-2 shows. These 43 sites include 37

"Accepted" sites from Chapter 1, and six sites that were classified as "Interim Closed Out" in Chapter 1 (300−16:2, 300-218, 300-251, 300-258, 300-80, and 3712 USSA). These sites will be evaluated against the cleanup levels once verification data are available. For this FS, they are assumed to meet the updated cleanup levels so no further action will be assigned to them (and no additional costs). If this turns out not to be the case, sites that do not meet the cleanup levels will be evaluated depending on the risk drivers that remain and a remedy will be selected from the final ROD. The selected remedial actions will be considered minor modifications to the ROD. These minor modifications to the ROD will be made through an administrative process, such as an NPL fact sheet, with public notification. These waste sites will be added to the appropriate RD/RAWP for implementation of the remedial action.

- Sixty-six 300-FF-2 OU waste sites are termed "Post-ROD To-Go Sites" for which interim remedial actions will not be completed until after the ROD is signed (Figure 8-3). For the cost estimates for this FS, a preliminary evaluation of the risk drivers has been made based on knowledge of the process that was performed at the sites and remediation results at similar sites in the River Corridor. Additionally, the remedial approaches for the major risk drivers have been developed for each alternative. These are presented in Chapter 9 and will be selected in the ROD. The remedial approach was based on the risk drivers that are estimated either through a detailed evaluation of the process history and/or from design sampling.

The final 40 300-FF-2 OU waste sites carried forward for inclusion in the FS are termed Consolidated Sites, which are sites encompassed within the remediation footprint of other sites.

Table 8-6. Sites Not Evaluated During Feasibility Study

Rationale for Exclusion From Feasibility Study	Waste Sites
Site not carried forward per discussion in Chapter 1.	4843, 300 IFBD, 300 PHWSA, 300 SSS, 300 Ash Pits, 300 RFBP, 300 SE, 300-1, 300-10, 300-100, 300-101, 300-102, 300-103, 300-104, 300-105, 300-106, 300-107, 300-108, 300-111, 300-112, 300-113, 300-114, 300-115, 300-116, 300-117, 300-118, 300-119, 300-12, 300-120, 300-122, 300-124, 300-125, 300-126, 300-127, 300-128, 300-129, 300-13, 300-130, 300-14, 300-151, 300-152, 300-153, 300-154, 300-155, 300-156, 300-157, 300-158, 300-159, 300-160, 300-161, 300-162, 300-163, 300-164, 300-165, 300-166, 300-167, 300-168, 300-169, 300-17, 300-170, 300-171, 300-172, 300-173, 300-174, 300-176, 300-177, 300-178, 300-179, 300-180, 300-181, 300-182, 300-183, 300-184, 300-185, 300-186, 300-187, 300-188, 300-189, 300-19, 300-190, 300-191, 300-192, 300-193, 300-194, 300-195, 300-196, 300-197, 300-198, 300-199, 300-200, 300-201, 300-202, 300-203, 300-204, 300-205, 300-206, 300-207, 300-208, 300-209, 300-21, 300-210, 300-211, 300-212, 300-213, 300-215, 300-217, 300-220, 300-222, 300-223, 300-225, 300-226, 300-227, 300-228, 300-23, 300-230, 300-231, 300-235, 300-236, 300-237, 300-238, 300-239, 300-240, 300-241, 300-242, 300-243, 300-244, 300-248, 300-250, 300-253, 300-26, 300-261, 300-262, 300-266, 300-267, 300-27, 300-271, 300-272, 300-278, 300-285, 300-29, 300-293:1, 300-3, 300-30, 300-35, 300-36, 300-37, 300-42, 300-44, 300-45, 300-47, 300-49, 300-50, 300-51, 300-52, 300-53, 300-55, 300-56, 300-57, 300-58, 300-59, 300-60, 300-61, 300-62 , 300-63 , 300-64, 300-65, 300-66, 300-67, 300-68, 300-69, 300-70, 300-71, 300-72, 300-73, 300-74, 300-75, 300-76, 300-77, 300-78, 300-79, 300-85, 300-86, 300-87, 300-88, 300-89, 300-90, 300-91, 300-93, 300-94, 300-95, 300-96, 300-97, 300-98, 300-99, 300-FBP:1, 300-FBP:2,

Table 8-6. Sites Not Evaluated During Feasibility Study

Rationale for Exclusion From Feasibility Study	Waste Sites
	303-K CWS, 304 CF, 304 SA, 305-B SF, 311 MT1, 311 MT2, 311-TK-40, 311-TK-50, 313 CENTRIFUGE, 313 CRO, 313 FP, 313 MT, 313 URO, 313-TK-2, 315 RSDF, 331 LSLDF, 331-C HWSA, 332 SF, 333-TK-11, 333-TK-7, 334 TFWAST, 334-A-TK-B, 334-A-TK-C, 335 & 336 RSDF, 340 CHWSA, 350 HWSA, 3713 PSHWSA, 3713 SSHWSA, 3718-F BS, 3718-F SF, 3718-F TT1, 3718-F TT2, 3746-D SR, 400 FD10, 400 FD10A, 400 FD1A, 400 FD1B, 400 FD2, 400 FD3, 400 FD4, 400 FD5, 400 FD6, 400 FD7, 400 FD8, 400 FD9, 400 RFD, 400 RSP, 400 RST, 400 SBT, 400 SS, 400 STF, 400-1, 400-10, 400-11, 400-12, 400-13, 400-14, 400-15, 400-16, 400-17, 400-18, 400-19, 400-2, 400-20, 400-21 , 400-22, 400-23, 400-24, 400-25, 400-26, 400-28, 400-29, 400-29:1, 400-29:10, 400-29:11, 400-29:12, 400-29:13, 400-29:14, 400-29:15, 400-29:16, 400-29:17, 400-29:18, 400-29:19, 400-29:2, 400-29:3, 400-29:4, 400-29:5, 400-29:6, 400-29:7, 400-29:8, 400-29:9, 400-3, 400-31, 400-32, 400-33, 400-34, 400-35, 400-36, 400-39, 400-4, 400-5, 400-6, 400-7, 400-8, 400-9, 403 FD, 427 HWSA, 437 MASF, 4713-B FD, 4713-B HWSA, 4713-B LDFD, 4721 FD, 4722 PSHWSA, 4722-B FD, 4722-C FD, 4831 LHWSA, 600-1, 600-155, 600-210, 600-22, 600-244, 600-245, 600-246, 600-247, 600-248, 600-249, 600-255, 600-265, 600-276, 600-278, 600-357, 600-366, 600-46, 600-64, 600-96, 600-97, 618-12, 618-19, 618-4, 618-6, 628-4, BTTF, PCTTF, TTTF, UPR-300-15, UPR-300-18, UPR-300-19, UPR-300-20, UPR-300-21, UPR-300-22, UPR-300-23, UPR-300-24, UPR-300-25, UPR-300-26, UPR-300-27, UPR-300-28, UPR-300-29, UPR-300-30, UPR-300-31, UPR-300-32, UPR-300-33, UPR-300-34, UPR-300-35, UPR-300-36, UPR-300-37, UPR-300-41, UPR-300-43, UPR-300-47, UPR-300-7, UPR-300-8, UPR-300-9, UPR-300-FF-1, UPR-400-1, UPR-600-15.
Site passes the quantitative risk evaluation (see Chapters 5, 6, and 7).	300 VTS, 300-109, 300-110, 300-18, 300-256, 300-259, 300-275, 300-33, 300-41, 300-8, 303-M SA, 303-M UOF, 333 ESHWSA, 618-1:1, 618-1:2, UPR-300-17, UPR-300-46, 600-243, 600-259, 600-259:1, 600-259:2, 600-290:1, 600-47, 618-13, 618-5, 618-7, 618-8.

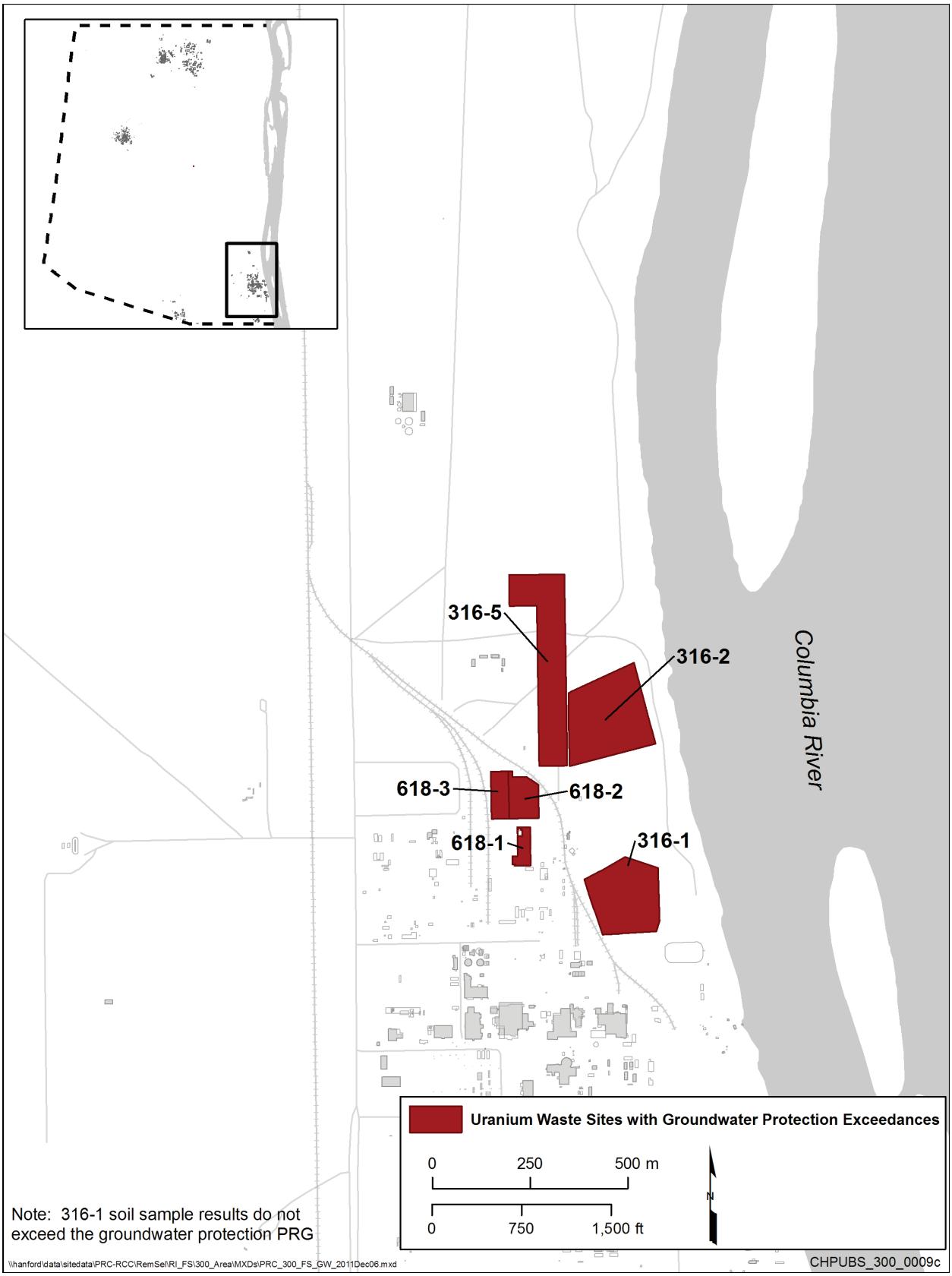

Figure 8-1. Interim Closed Waste Sites with Groundwater Protection Risk (Uranium)

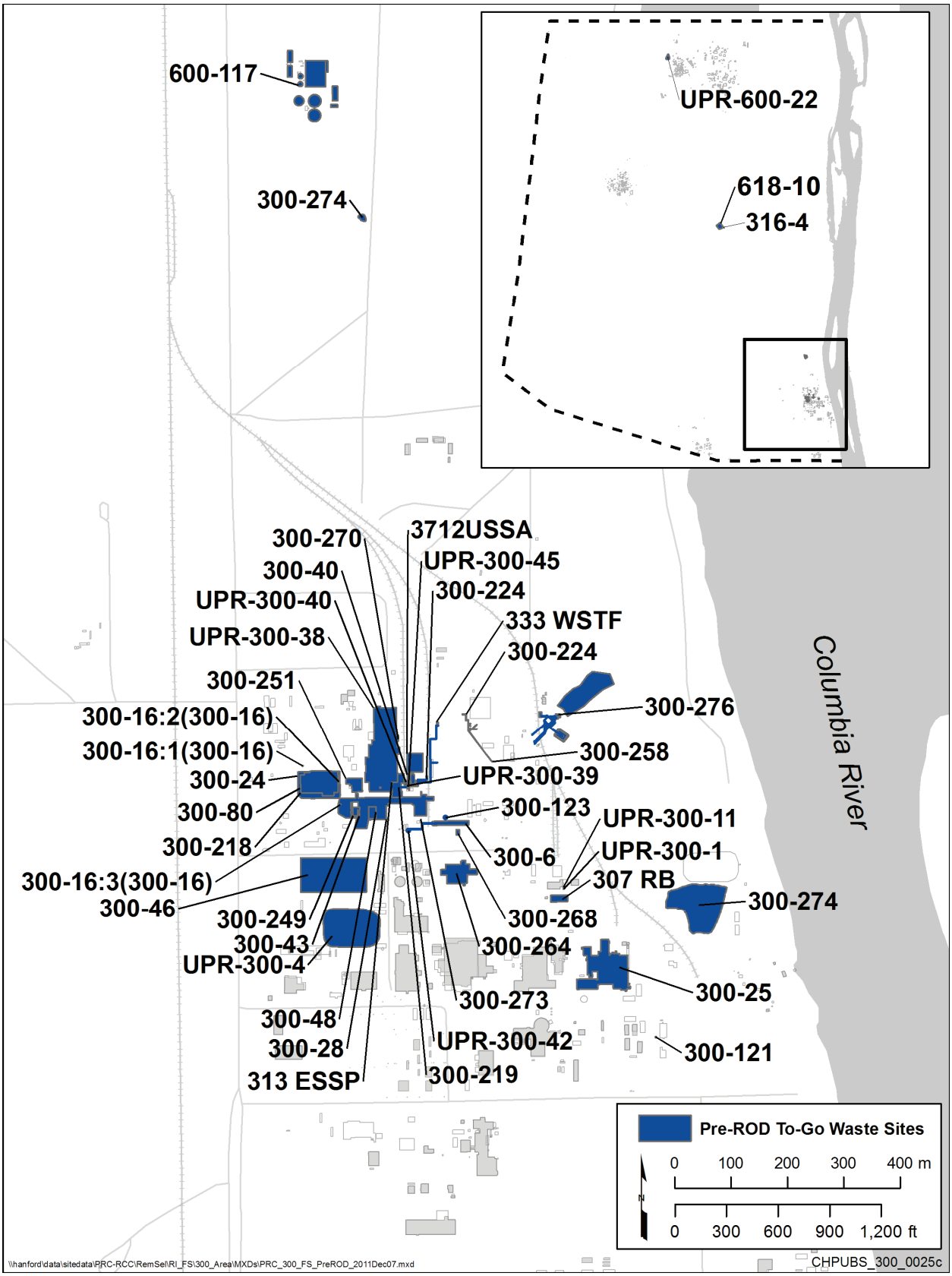

Figure 8-2. Pre-ROD To-Go Waste Sites

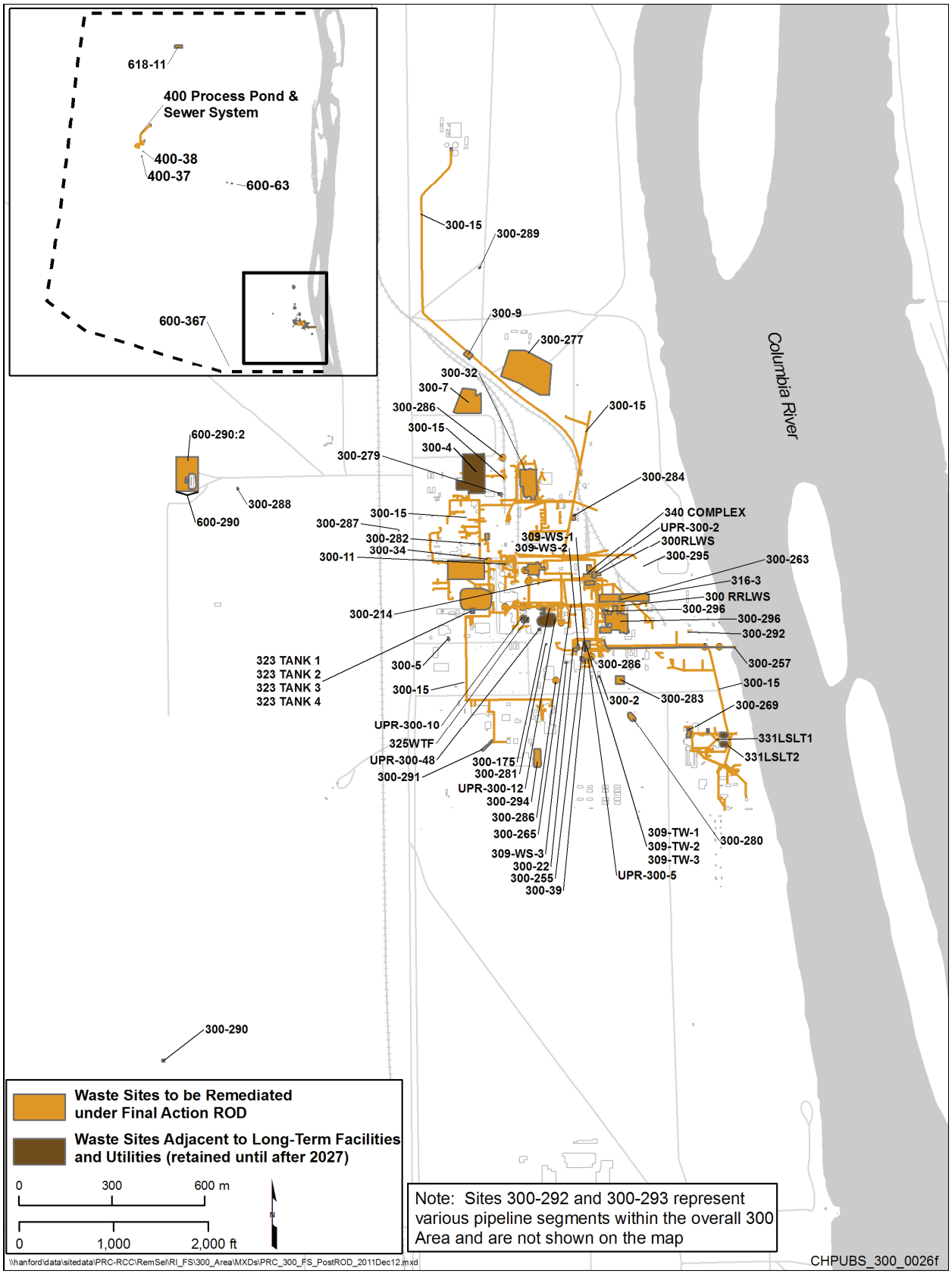

Figure 8-3. Post-ROD To-Go Waste Sites

Table 8-7 presents the 155 sites that are carried forward into the FS.

Appendix I presents site dimensions (area and depth) for the evaluated waste sites. For the Pre-ROD "To-Go" Sites, it is assumed that the cleanup levels will be met during remediation. Therefore, for cost estimating purposes in this FS, the volume of soil requiring remediation at these sites is assumed to be zero. The assumption that the cleanup levels are met Pre-ROD will be confirmed once the remediation is complete and verification data are available. For the Post-ROD "To-Go" Sites, the areal and depth dimensions that require remediation are estimated based on process knowledge.

8.2.1.2 Groundwater

Figures 4-41 through 4-46 illustrate areas exceeding the uranium groundwater cleanup level of 30 µg/L. Figure 4-68 illustrates areas exceeding tritium groundwater cleanup level of 20,000 pCi/L.

Table 8-7. Sites Evaluated During Feasibility Study

Rationale for Inclusion In Feasibility Study	Waste Sites
300-FF-1 site with residual source mass causing uranium groundwater plume	316-1, 316-2, 316-5.
Site exceeds the quantitative risk evaluation (see Chapters 5, 6, and 7).	618-1, 618-2, 618-3.
Pre-ROD To-Go Sites	300-121, 300-123, 300-16, 300-16:1, 300-16:2, 300-16:3, 300-218, 300-219, 300-224, 300-24, 300-249, 300-25, 300-251, 300-258, 300-264, 300-268, 300-270, 300-273, 300-274, 300-276, 300-28, 300-40, 300-43, 300-46, 300-48, 300-6, 300-80, 307 RB, 313 ESSP, 333 WSTF, 3712 USSA, 600-117, 618-10/316-4, UPR-300-1, UPR-300-11, UPR-300-38, UPR-300-39, UPR-300-4, UPR-300-40, UPR-300-42, UPR-300-45, UPR-600-22.
Post-ROD To-Go Sites	300 RLWS, 300 RRLWS, 300-11, 300-15, 300-175, 300-2, 300-214, 300-22, 300-255, 300-257, 300-263, 300-265, 300-269, 300-277, 300-279, 300-280, 300-281, 300-282, 300-283, 300-284, 300-286, 300-287, 300-288, 300-289, 300-290, 300-291, 300-292, 300-293, 300-294, 300-295, 300-296, 300-32, 300-34, 300-39, 300-4, 300-5, 300-7, 300-9, 309-TW-1, 309-TW-2, 309-TW-3, 309-WS-1, 309-WS-2, 309-WS-3, 316-3, 323 TANK 1, 323 TANK 2, 323 TANK 3, 323 TANK 4, 325 WTF, 331 LSLT1, 331 LSLT2, 340 Complex, 400 PPSS, 400-37, 400-38, 600-290/600-290:2, 600-367, 600-63, 618-11, UPR-300-10, UPR-300-12, UPR-300-2, UPR-300-48, UPR-300-5.
Consolidated Sites	300-131, 300-132, 300-133, 300-134, 300-135, 300-136, 300-137, 300-138, 300-139, 300-140, 300-141, 300-142, 300-143, 300-144, 300-145, 300-146, 300-147, 300-148, 300-149, 300-150, 300-81, 300-82, 300-83, 300-84, 300-92, 333 ESHTSSA, 333 LHWSA, UPR-300-13, UPR-300-14, UPR-300-44, UPR-600-1, UPR-600-10, UPR-600-2, UPR-600-3, UPR-600-4, UPR-600-5, UPR-600-6, UPR-600-7, UPR-600-8, UPR-600-9.

Notes: The following sites are adjacent to long-term facilities and utilities (disposition expected scheduled after 2027): 300-4, 325 WTF, 331 LSLT1, 331 LSLT2, UPR-300-10, UPR-300-12, UPR-300-48.

8.3 Identification and Screening of Technology Types and Process Options

This section presents remedial technologies and process options that are subsets of the selected GRAs, and that may potentially meet RAOs for contaminated waste sites and groundwater at the 300 Area. The potential remedial technologies are evaluated or screened for implementability, effectiveness in eliminating, reducing, or controlling risks to HHE, and relative cost. The identified technologies are then combined into a range of remedial alternatives in Chapter 9.

The following text summarizes the technologies and process options considered as part of this evaluation. Although "no action" and institutional controls are not considered remedial technologies, they are important response actions to be considered as part of the remediation approach and are discussed herein.

Tables 8-8 and 8-9 present the identification and screening of technologies and remedial process options for the 300 Area in tabular form. Table 8-8 presents technologies for waste site treatment for uranium and other COCs. Table 8-9 present GRAs and process options for groundwater affected with uranium and other COCs.

8.3.1 Identification and Screening of Technologies for Waste Site Contamination

No Action. The no action response entails no further action to remove, remediate, monitor, or restrict access to contaminated sites. Source areas and residual soil contaminants in the waste sites would be left untreated and current monitoring activities would cease. The CERCLA RI/FS Guidance (EPA/540/G-89/004) and the NCP (40 CFR 300) require this response to remain in the FS process, where it serves as a baseline against which to compare all other alternatives. Although generally considered unacceptable as a remedial alternative, no action may be an appropriate alternative component where interim actions have been completed as dictated by the 300-FF-2 ROD (EPA/ROD/R10-01/119) (as presented in Tables 1-11, 1-12, and 1-13), and verification sampling data suggest the waste site does not present risks to HHE.

Institutional Controls. Institutional controls are non-engineered instruments such as administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use. They are generally to be used in conjunction with, rather than in lieu of, engineering measures such as waste treatment or containment and can be used during all stages of the cleanup process to accomplish various cleanup-related objectives. Institutional controls should be "layered" (i.e., use multiple ICs) or implemented in a series to provide overlapping assurances of protection from contamination. These administrative controls imposed on land use to prevent or reduce exposure to hazardous wastes or hazardous constituents and/or to protect the integrity of a remedy. Section 8.4.1.1 and Table 8-10 describe institutional controls for the Hanford Site.

The need for ICs is evaluated in the FS and recorded in CERCLA decision documents. The decision document is part of the administrative record for the selection of remedial actions. ICs will be identified for each waste site following completion of the remedial action if the contamination left in place is greater than levels protective of unrestricted use. As the sites are identified, DOE will apply and implement institutional controls in an integrated manner such that mechanisms in place will ensure controls are effective, implemented as planned, properly maintained, inventoried, periodically re-evaluated, and modified as necessary to reflect changes in conditions, needs, or technological advancements. DOE will maintain the ICs as long as necessary to perform their intended protective purposes and seek sufficient funds (*Use of Institutional Controls* [DOE P 454.1]).

The Sitewide IC Plan (DOE/RL-2001-41) describes how DOE-RL will implement and maintain OU-specific institutional controls specified in CERCLA decision documents. The Sitewide IC Plan

(DOE/RL-2001-41) is updated based on final CERCLA decision documents within 180 days after issuance of the final decision document. The Sitewide IC Plan (DOE/RL-2001-41) addresses the elements of *Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups* (EPA 540-F-00-005). In addition, institutional controls are reviewed during the CERCLA Five-Year review process.

Removal. Removal technologies include excavation of contaminated materials. Excavation of sites with contaminated soil follows the observational approach, allowing waste characterization and treatment to occur as excavation proceeds. Excavation must be coupled with analytical assessment, dust control, efficient transportation, treatment as required, and disposal. Excavated soil is segregated (either by an automated or laboratory-based approach) to determine disposal or treatment requirements.

Excavation can use conventional equipment and methods, including excavators, bulldozers, and wheeled loaders. Earthmoving equipment removes clean overburden, which can be staged for later use in backfilling, and contaminated media to stage for appropriate waste management activities. Contaminated media typically are removed in lifts (layers of uniform thickness) to allow screening for contamination. Field screening supports waste designation and helps determine achievement of remedial goals.

Process options under the removal GRA include standard (shallow) and deep excavation (greater than 6 m [20 ft] depths). The determination of 6 m (20 ft) for deep excavation is based on engineering considerations. At excavations exceeding 6 m (20 ft) below ground surface, implementation requires technologies that are more complex, such as large layback for open-pit type excavation or use of shoring. Given the increased complexity, deep excavations have an increased cost compared to shallow.

None of the contamination in the 300 Area is expected to be in high enough concentrations that the excavation efforts are considered nuclear activities. Consequently, standard excavation and personal protection practices are acceptable.

Ex Situ Treatment and Processing. Following excavation, soil can be treated with ex situ methods to reduce contaminant concentrations or toxicity, remove contaminants (transfer to different media), or reduce volume, and allow for less costly disposal. Treatment can be achieved by applying physical, chemical, biological, or thermal techniques.

For this effort, ex situ treatment does not include treatment performed for ultimate disposal, such as at ERDF. Treatment performed as required to meet disposal restrictions is included in the disposal process option, and assumed part of the "disposal to onsite/offsite landfill" process options. This ex situ treatment process option only covers technologies that could be used to treat the soil so that part or all of the soil volume could be backfilled at the location from which it was removed.

Ex situ treatment process options include the following:

- Ex situ solidification/stabilization
- Soil washing
- Ex situ vitrification
- Ex situ thermal desorption

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
No Action	No Action	No Action	All	Shallow/ Deep/PRZ	No further actions to address contamination. Source areas and residual contaminants in vadose zone are left untreated.	Low	High	Low	Low	Little impacts	Retained	Retained per the NCP (40 CFR 300).
						No remedial actions are taken.	No administrative or technical implementability challenges are associated with implementation of this option, since no actions are required.	No associated cost.	No associated cost.			
						No additional remedial actions are taken; however, effectiveness could be high if risk is previously mitigated, or COCs do not exceed cleanup criteria.	Applicable to sites where prior cleanup activities have been preformed, but insufficient data are currently available to close out the waste site. Low implementability on sites where sampling and analysis shows concentrations above cleanup criteria.		No associated cost.			
Removal	Excavation	Standard Excavation	All	Shallow	Shallow soil is removed using conventional construction equipment. Excavation limited to approximately 6 m [20 ft] bgs. Excavated soil is segregated (automated or laboratory based) to determine disposal or treatment requirements.	High	High	Moderate/High	Low	Waste generation if excavated soil is disposed of, greenhouse gas (GHG) and energy for excavation equipment.	Retained	
						Shallow sources removed.	Shallow excavation is typically straightforward. A permit is required for excavation in the 100, 200, and 300 Areas and the Hanford Reach National Monument.		No associated cost.			
		Deep Excavation	All	Shallow/ Deep/PRZ	Soil is removed to deeper depths. Deep excavation would require implementation of more complex technologies, for example, large laybacks for open-pit type excavation or alternatively use of shoring. Excavated soil is segregated (automated or laboratory based) to determine disposal or treatment requirements.	High	Moderate	High	Low	Waste generation if excavated soil is disposed of, GHG and energy for excavation equipment.	Retained	
						Locations of the deep sources will be difficult to identify, meaning large areas would have to be excavated to depth to ensure that the deep sources were removed.	Has been performed at the Hanford Site using laybacks. Shoring may be difficult with cobbles and boulders. Increased safety issues with very deep excavations. A permit is required for excavation in the 100, 200, and 300 Areas and the Hanford Reach National Monument.		No associated cost.			

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
Ex Situ Treatment and Processing	Ex Situ Treatment and Processing[d]	Solidification/Stabilization	Uranium, Mobile to Semimobile contaminants	Depends on excavation method.	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Agents include soluble phosphates, pozzolan/portland cement, silicates, bitumen, and acrylic polymers. The stabilized mass is returned to its original location, capped to shed water and prevent weathering, and the location is engineered to withstand seismic activity.	Low/Moderate Effective at immobilizing contaminants in excavated material. However, the stabilized mass must be protected from weathering and seismic activity for long-term durability.	Moderate Well established technology. Site-specific studies need to be completed to evaluate equipment required and appropriate solidification/stabilizing agents. Mechanically intense process - additional handling of the excavated soil could increase the potential for contaminant exposure, which could pose risk to workers.	High	Low	GHG and energy for production and delivery of reagent used, and for transport and mixing.	Not Retained*	Screened out in favor of the safer alternative of disposal in the ERDF, a centralized facility engineered to protect against weathering and seismic activity.
		Soil Washing	Possibly Uranium	Depends on excavation method.	Consists of: (1) size separation of highly contaminated soil fractions (fines) from minimally contaminated soil fractions (coarse), followed by (2) mechanical abrasion or washing to remove surface contamination. Final contaminated fraction is typically treated by technologies such as solidification/stabilization prior to onsite or offsite disposal.	Low/Moderate Effectiveness is driven by the binding processes that exist between the contaminants and the soil particles (adsorbed or precipitated). Pilot testing at Hanford suggests many contaminants strongly sorb to all sizes of soil. Pilot test is necessary to determine effective means to control chemistry (carbonate balance) for removing uranium.	Moderate Mechanically intense. Conventional aggregate washing and screening technology is used to separate soil particles by size fraction. Contaminated soils and water are disposed of, or further treated. Soils that meet cleanup criteria (remediated coarse soil) can be returned to the site. Rinseate will need to be treated prior to disposal.	Moderate/High	Low No associated cost.	Additional resource impact (water used in process), GHG and energy for process, and additional treatment of contaminated fines and water.	Not Retained*	Mechanically intense. Not proven for conditions similar to the Hanford Site.
		Ex situ Vitrification	All	Depends on excavation method.	Thermal treatment process that converts excavated soil and other materials into stable crystalline substances. The thermal treatment process is typically performed inside a chamber using plasma torches or electric arc furnaces to melt the soil. Organic contaminants are typically destroyed during the process by pyrolysis, while metals and radionuclides are retained in the molten soil.	High Heavy metals and radionuclides are incorporated into the glass structure which is generally resistant to leaching	Low High complexity of equipment required. Ex situ joule heating vitrification uses furnaces that have evolved from the glass industry.	High	Low No associated cost.	GHG and energy for heat generation. High energy requirements to sustain required heat.	Not Retained*	Complex technology, safety concerns with implementation.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
Ex Situ Treatment and Processing (cont.)	Ex Situ Treatment and Processing[d] (cont.)	Ex Situ Thermal Desorption	Organics	Depends on excavation method.	Direct application of heat to soil piles to increase the temperature of soil and destroy or volatilize organic compounds. A vapor cover and vacuum system is needed to transport volatilized water and organics to the gas treatment system. Also completed using mechanical systems (e.g., rotary drum).	High Technology can achieve rapid removal/destruction of a mix of volatile and semi-volatile organics at low residual levels.	Low Equipment readily available and commonly used, but can be mechanically complex	High	Low No associated cost.	GHG and energy for production of heat vapor treatment.	Not Retained*	Complex and challenging to implement.
Disposal	Disposal	Backfill Treated Soil	All	Shallow/ Deep/PRZ	Excavation and ex situ treatment followed by onsite disposal (backfill).	High Contaminated material has been treated by ex situ technologies.	High Excavated and treated soil will need to be compared to cleanup criteria to verify backfill is appropriate.	Low/Moderate	Low No associated cost.	GHG and energy for backfill.	Not Retained	No Ex Situ treatment technologies are retained.
		Disposal to ERDF	All	Shallow/ Deep/PRZ	Disposal of excavated soil at onsite landfill (ERDF). Treatment performed at the facility as required to meet land disposal restrictions.	High	High Implementability limited by COC concentrations and onsite landfill requirements.	Low/Moderate	Low No associated cost.	GHG and energy for transport.	Retained	
		Offsite Landfill	All	Shallow/ Deep/PRZ	Disposal of excavated soil at offsite landfill. Required for wastes that ERDF cannot accept.	High	High Implementability limited by COC concentrations and offsite landfill requirements.	Moderate	Low No associated cost.	GHG and energy for transport.	Retained	
		Offsite Repository (Waste Isolation Pilot Plant [WIPP])	Transuranic Waste	Shallow/ Deep/PRZ	TRU waste is soil and debris containing alpha-emitting TRU radionuclides having half-lives greater than 20 years at concentrations greater than or equal to 100 nCi/g at the time of assay. Transuranic radionuclides include elements with atomic numbers greater than 92 such as neptunium, plutonium, americium, and curium. TRU waste must be packaged and shipped to the WIPP in Carlsbad, New Mexico.	High	Moderate Implementable, but it is an offsite activity so both substantive and administrative requirements apply. Work must be coordinated through the Hanford Transuranic Waste Certification Program.	High	Low No associated cost.	GHG and energy for transport.	Retained	

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology		Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment	In Situ Treatment via Reagent	Reagent Approach	Physical/ Chemical/ Biological	Solidification	Mobile COCs to Semimobile Radionuclides, Other Metals, and Organics	Shallow/ Deep/PRZ	Contaminants are physically bound or enclosed within a stabilized mass. Agents include pozzolan/portland cement and chemical grouts (polyethylene extrusion, etc.). With organics, typically only used for free phase to reduce mobility.	Moderate/High Effectiveness relies on close-spaced grout injection, but may still be limited by soil heterogeneity. There is debate about the long-term durability of the monolith and if it is, in fact, permanent. Potential for direct exposure still exists if waste is shallow.	Moderate Depends on delivery method and scale of application.	High Depends on delivery method and scale of application.	Low Assuming monolith is permanent.	GHG and energy for production and delivery of substrate/reagent.	Not Retained*	
				Stabilization/ Sequestration	Uranium, Sr-90	Shallow/ Deep/PRZ	Chemical reactions are induced between the stabilizing agent and contaminant to reduce mobility (e.g., the formation of autunite from uranium). Agents include soluble phosphates and polyphosphates.	Moderate/High Chemistry of autunite sequestration of uranium using phosphates has been demonstrated at the 300 Area in groundwater. Potential for direct exposure still exists if waste is shallow.	Moderate Depends on delivery method.	Moderate Depends on delivery method.	Low Assuming stabilized mass is permanent.	GHG and energy for production and delivery of substrate/reagent.	Retained	
				Chemical Reduction	Uranium	Shallow/ Deep/ PRZ	Chemical reductant (e.g., calcium polysulfide, dithionite, hydrogen sulfide gas, ferrous sulfate, zero valent iron, etc.) is applied to the subsurface to treat contaminants within vadose zone. Chemical can be combined with solidification/stabilization or other treatment mechanisms.	Low Chemical reductants are instantly reactive, which requires overloading to maintain reactive strength at depth. Reduction of uranium is potentially reversible.	Low/Moderate Depends on delivery method. Localized temporary generation of secondary byproducts may occur when using reductants. May temporarily mobilize COCs toward groundwater. Handling chemical reductants is an H&S concern.	Low/Moderate Depends on delivery method.	Moderate/High	GHG and energy for production and delivery of chemical agent.	Not Retained*	
				In Situ Chemical Oxidation (ISCO)	Organics	Shallow/ Deep/PRZ	Subsurface delivery of chemical oxidant (e.g., hydrogen peroxide, ozone, permanganate, persulfate, percarbonate) to degrade organic COCs. Oxidants cause chemical destruction of toxic organic chemicals. Petroleum hydrocarbons and PAHs can be treated with a variety of oxidants (including peroxide, percarbonate, persulfate, and ozone); however, there are limited case studies demonstrating the successful treatment of PCBs with ISCO. Ozone is the most likely oxidant.	Moderate Effectiveness is a function of oxidant distribution and contact. Injection of ozone a possible alternative, but more complex than soil vapor extraction or bioventing alone. Multiple applications may be required to achieve complete treatment.	Low/Moderate Chemical oxidants can be delivered using soil mixing, horizontal injections wells, or vertical injection wells.	Moderate	Low/High O&M costs would be low assuming complete treatment can be achieved with a single application, or high if multiple applications are required to achieve treatment.	GHG and energy for production and delivery of substrate/reagent.	Not Retained*	Not retained in favor of excavation.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology		Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment via Reagent (cont.)	Reagent Approach (cont.)	Physical/ Chemical/ Biological (cont.)	Surface Bioremediation (Land Farming)	Organics	Shallow	Surface Bioremediation involves tilling the soil and adding moisture and an amendment to stimulate natural degradation at shallow depths (0 to 1.2 m [0 to 4 ft] bgs). Organic compounds are degraded by indigenous or inoculated microorganisms.	Moderate/High Surface bioremediation is effective for remediating low-level residual petroleum hydrocarbons in conjunction with source removal. PAHs and PCBs are more difficult to degrade. Effectiveness can be hindered by non-uniform amendment distribution, lack of appropriate microorganisms, or non-optimal moisture and temperature.	Moderate Tilling equipment limits achievable treatment depth. Implementation is challenging in gravelly/cobbly lithologies. Maintaining appropriate temperature and moisture conditions is more challenging for surface treatment.	Low	Low	GHG and energy for production and delivery of substrate/reagent.	Not Retained*	Not retained in favor of excavation.
				Biological Reduction	Uranium	Shallow/ Deep/PRZ	Biological carbon source (e.g., molasses, sodium lactate, emulsified oil, butane, etc.) is applied to the subsurface to treat contaminants within vadose zone.	Low Carbon source follows source release pathways. Biological reductants are activated by microbial activity, so reactive strength is maintained over relatively longer distances. Reduction of uranium is potentially reversible.	Low/Moderate Depends on delivery method. Localized temporary generation of secondary byproducts may occur. May temporarily mobilize COCs toward groundwater.	Low/Moderate	Moderate	GHG and energy for production and delivery of substrate. Depends on which substrate is used.	Not Retained*	
				Gaseous Ammonia Injection	Mobile COCs	Shallow/ Deep/PRZ	One of a number of possible gaseous reagents that are being investigated (along with ISGR below). It involves the injection of ammonia gas to increase pH to dissolve silica. The pH naturally decreases to ambient conditions over time and aluminosilicate minerals precipitate and possibly coat and immobilize various contaminants.	Unknown Effectiveness is being studied as part of a laboratory-scale investigation.	Unknown Implementation is unknown at a full-scale level. Containment of injected gases in the shallow vadose zone may be an issue.	Unknown Technology evaluation has been limited to laboratory tests.	Unknown Technology evaluation has been limited to laboratory tests.	GHG emissions from injection activities.	Not Retained*	Evaluation of results from the on-going treatability study is needed prior to making a decision regarding its full-scale use at the Hanford Site. This technology could be evaluated as a remedial alternative later.
				Soil Vapor Extraction (SVE)	Volatile Organics	Shallow/ Deep/PRZ	Soil vapor is extracted through vertical or horizontal extraction wells to induce contaminant mass transfer from soil to soil vapor, and remove contaminant mass from soil vapor. Vapor is treated separately (GAC, thermal oxidizer, etc.) or directly discharge to atmosphere if appropriate.	Moderate/High Technology is proven for remediating soils contaminated by volatile organics.	Moderate/High Applied using horizontal or vertical wells. Implementability depends on depth of application.	Moderate	Low	GHG and energy for installation of delivery mechanism and delivery of air; waste generation from soil cuttings.	Not Retained*	Not retained in favor of excavation.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology		Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment via Reagent (cont.)	Reagent Approach (cont.)	Physical/ Chemical/ Biological (cont.)	Bioventing	Organics	Shallow/ Deep/PRZ	Process that stimulates the natural biodegradation of aerobically degradable compounds in soil by providing oxygen to existing soil microorganisms. Bioventing uses low airflow rates to provide only enough oxygen to sustain microbial activity.	Moderate/High Technology is proven for remediating soils contaminated by petroleum hydrocarbons, but is less effective for PAHs and not effective for PCBs. Effectiveness can be limited by extremely low soil moisture content that would limit biodegradation.	Moderate/High Applied using horizontal or vertical wells. Implementability depends on depth of application.	Moderate	Low	GHG and energy for installation of delivery mechanism and delivery of air; waste generation from soil cuttings.	Not Retained*	Not retained in favor of excavation.
				Reductive Dechlorination Using Zero-Valent Metals and Bioremediation	PCBs	Shallow/ Deep/PRZ	Zero valent metals have the potential to reductively dechlorinate PCBs. Metals include iron, palladium, and other combinations. The contaminated soil and the metals are mixed in some fashion to allow the reactions to occur. Bioremediation, via the addition of an organic substrate is a very similar process and can be combined with zero-valent metal addition.	Unknown Very little published testing results are available.	Moderate Could be implemented by soil mixing with conventional excavation equipment if the contamination is shallow.	High	Low No associated cost.		Not Retained*	Several laboratory and field-scale demonstrations have been conducted to evaluate the performance of using NZVI for PCB dechlorination. The effectiveness of these treatment technologies is considered to be poorly known, given the limited availability of published testing results, and/or conflicting technology demonstration data. Reductive dechlorination using zero-valent metals and bioremediation are not proven technologies and were not retained for further consideration. More field studies must be conducted to test methods of bioaugmentation and biostimulation for PCB-dechlorinators.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology		Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment via Reagent (cont.)	Reagent Approach (cont.)	Physical/ Chemical/ Biological (cont.)	In Situ Gaseous Reduction with Chemical Reductant or Biological Substrate	Uranium	Shallow/ Deep/PRZ	A gaseous mixture of chemical reductants (e.g., hydrogen sulfide) or biological substrate (e.g., butane) is injected into and drawn through the vadose zone to reduce uranium. Research is underway to evaluate other reagents to immobilize contaminants.	Low Soil heterogeneity will result in preferential flow and limit treatment effectiveness of lower permeability soil. Reduction of uranium is potentially reversible.	Unknown Vapor extraction wells are installed around injection well at a radial spacing of approximately 4.6 m (15 ft). Large numbers of wells are required. Due to H&S risks, monitoring and emergency response plan are required for transporting, storing, and handling.	Unknown	Unknown	GHG emissions from injection activities.	Not Retained*	Evaluation of results from the on-going treatability study is needed prior to making a decision regarding its full-scale use at the Hanford Site. This technology could be evaluated as a remedial alternative later.
				In Situ Leaching (Solution Mining)	Uranium	PRZ	In situ leaching consists of injecting a leaching solution (lixiviant) using vertical injection wells, dissolving uranium, and pumping out the uranium-bearing solution for ex situ treatment and processing. Application assumes that uranium resides in a saturated zone where the lixiviant can thoroughly contact the sediment and hydrogeologic flow conditions allow controlled recovery of dissolved uranium.	Unknown There are no known applications of this technology to remedy uranium contamination. Treatment effectiveness would be a function of the ability of the lixiviant to contact sorbed uranium on sediments in the PRZ. The heterogeneity and temporal variations of the water table in the 300 Area make effective contact problematic.	Low Would be difficult to permit. Lixivants may include ammonium or sodium carbonate/bicarbonate with oxygen or hydrogen peroxide, or acid solutions such as sulfuric acid. Introduction of the caustic or acid solutions severely affects the surface mineralogy and water quality of the sediment and degrades the aquifer. Mobilized uranium must be controlled and collected.	Unknown	Unknown	GHG emissions from injection and ex situ treatment activities.	Not Retained*	
		Delivery Method	Mixing with Conventional Excavation Equipment	Mixing with Conventional Excavation Equipment	Dependent on type of reagent used	Shallow	Use of conventional excavation equipment (backhoes, excavators, front-end loaders, etc.) to mix amendments into the soil.	High Agents are uniformly mixed with soil column, providing good contact and reaction between COC and chemical.	Moderate Simple technology. Dust mitigation techniques will need to be implemented to control/prevent mechanical dispersion of contaminants.	Low/Moderate	Low No associated cost.	GHG emissions from machinery.	Retained	Retained for near-surface shallow applications, or to target soils at the bottom of existing excavations.
			Deep Soil Mixing	Deep Soil Mixing (Vertical/ Horizontal)	Dependent on type of reagent used	Shallow/ Deep/PRZ	Large mixing augers (1.5 to 3 m [5 to 10 ft] in diameter) or horizontally rotating heads are used to blend and homogenize reactants with soil. The reactants may be chemical reductants, biological substrate, or solidification/stabilization agents.	High Chemical agents are uniformly mixed with soil column, providing good contact and reaction between COC and chemical. Cement or clay can also be mixed with the chemical slurry to reduce the hydraulic conductivity and leachability of the soil.	Low Implementation will be more challenging in gravelly/cobbly lithologies. Although deep soil mixing has been performed to depths of 30 m (100 ft) bgs, most field applications have been limited to approximately 15 m (50 ft) bgs.	High	Low No associated cost.	GHG emissions from machinery.	Not Retained*	Deep soil mixing implementability will be limited by site conditions and required depth of treatment.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology		Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment via Reagent (cont.)	Delivery Method (cont.)	Foam Delivery of Reagents	Foam Delivery of Reagents	Dependent on type of reagent used	Shallow/ Deep/PRZ	Injection of foam into vadose zone. The foam is a mixture of a surfactant solution to create the foam, and a reagent, such as polyphosphate or calcium polysulfide. The foam increases the horizontal migration of the reagent away from the injection well.	Unknown Technology evaluation has been limited to laboratory scale tests. The stability of the foam, which will dictate the well spacing, is unknown – radius of influence may be limited to approximately 1.5m (5 ft). Reagent would comprise a small percentage of foam, requiring higher volumes of injection.	Unknown Technology evaluation has been limited to laboratory scale tests.	Unknown Technology evaluation has been limited to laboratory scale tests.	Unknown Technology evaluation has been limited to laboratory scale tests.	Waste generation from soil cuttings for well installation.	Not Retained*	Not retained in favor of injection using shear-thinning fluids. Evaluation of results from the on-going treatability study is needed prior to making a decision regarding its full-scale use at the Hanford Site. This technology could be evaluated as a remedial alternative later.
			Gas Delivery of Reagents	Gas Delivery of Reagents	Dependent on type of reagent used	Shallow/ Deep/PRZ	A gaseous mixture of chemical reagent is injected into and drawn through the vadose zone to reduce or stabilize mobile COCs.	Unknown Soil heterogeneity will result in preferential flow and limit treatment effectiveness of lower permeability soil.	Unknown Vapor extraction wells are installed around injection well at a radial spacing of approximately 4.6 m (15 ft). Large numbers of wells are required. Due to H&S risks, monitoring and emergency response plan are required for transporting, storing, and handling.	Unknown	Unknown	GHG emissions from injection activities. Waste generation from soil cuttings for well installation.	Not Retained*	Evaluation of results from the on-going treatability study is needed prior to making a decision regarding its full-scale use at the Hanford Site. This technology could be evaluated as a remedial alternative later.
			Injection Wells (Horizontal)	Injection Wells (Horizontal)	Dependent on type of reagent used	Shallow/ Deep/PRZ	Delivery of amendments using horizontal wells. Wells are installed using horizontal drilling techniques.	Low/Moderate Effectiveness can be hindered by non-uniform amendment distribution. Soil heterogeneity will result in preferential flow and limit treatment effectiveness of lower permeability soil. Multiple injections could be required.	Low Implementation is challenging in gravelly/ cobbly lithologies. Lithology would also pose issues with maintaining target depth and alignment with horizontal drilling. A pilot test of this technology encountered signification implementation challenges.	Moderate/High	Low	GHG emissions from well installation, development, and injection activities; waste generation from soil cuttings.	Not Retained*	Testing at the Hanford Site has not been successful.
			Injection Wells (Vertical)	Injection Wells (Vertical)	Dependent on type of reagent used	Shallow/ Deep/PRZ	Delivery of amendments using conventional vertical wells.	Moderate Effectiveness can be hindered by non-uniform amendment distribution. Distribution of liquid amendments is highly ineffective because of gravelly/cobbly lithology. Distribution in deeper vadose zone can be enhanced with the use of shear-thinning fluids, particularly within the periodically rewetted zone during periods of high groundwater table.	Low/Moderate Radius of influence likely to be low, requiring large number of injection wells. Injection radius of influence can be increased (on the order of 15 m) in deeper vadose zone during periods of high groundwater table with the use of shear-thinning fluids.	Moderate/High	Low	GHG emissions from well installation, development, and injection activities; waste generation from soil cuttings.	Retained	Retained for vadose zone soils with the addition of shear-thinning liquids.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology		Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment via Reagent (cont.)	Delivery Method (cont.)	Jet Grouting	Jet Grouting	Dependent on type of reagent used	Shallow/ Deep/PRZ	High-pressure injection of reactive slurry into soil to hydraulically mix the soil with the slurry. Fluidization of the soil is preferred. Jet grouting can also be completed using super permeating molten wax by (1) heating the soil, and (2) injecting the wax, resulting in an impermeable material.	Low/Moderate While jet grouting is capable of reaching the required treatment depth, jet grouting is not likely to achieve uniform distribution or a radius of influence greater than an order of 1.5 m (5 ft). Jet grouting of apatite and phosphate was pilot tested at 100-N for shallower and more limited application. Altered/ decreased permeability of soil resulted from amendment precipitation and/or liquefaction of fine-grained sediment fractures.	Low Implementation will be more challenging in gravelly/cobbly lithologies. Jet grouting has been performed to depths of up to 91 m (300 ft). Many closely spaced injection points (approximately 5-ft spacing) will be required.	High Limited radius of influence would make jet grouting cost-prohibitive over a large area.	Low	GHG emissions from injection activities.	Not Retained*	
			Surface Infiltration	Surface Infiltration	Dependent on type of reagent used	Shallow/ Deep/PRZ	Reagent is applied to ground surface to treat contaminants within vadose zone. Surface infiltration can be done through drip irrigation and shallow basin systems. Systems are generally designed to be 12-inches below the surface and covered to be protected. Can be applied to bottom of excavations to target deeper vadose zone and smear zone soils more effectively.	Moderate/High Amendments follow source release pathways. Distribution not likely to be uniform.	High Surface infiltration systems are simple to install and accessible for O&M.	Low/Moderate	Low/Moderate	Limited infrastructure. GHG emissions from production and delivery of substrate.	Retained	Retained for liquid substrates.
			Void Filling	Void Filling	Dependent on type of reagent used	NA (Pipelines)	Solidification of buried wastes using chemical extrusions or cement-based grout. Void filling is considered for filling large voids, specifically pipelines.	High Established and commonly used technology for removing voids in pipelines.	High Established and commonly used technology for removing voids in pipelines. Pipe branchlines/breaks need to be identified.	Moderate	Low No associated cost.	GHG and energy for production and delivery of reagentt used.	Retained	Retained for pipelines

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment Other	Physical/ Chemical/ Biological	Desiccation	All	Shallow/ Deep	Remediation by injecting hot dry air and withdrawing moist air from soil, immobilizing contaminants by preventing their aqueous-phase transport.	Unknown A treatability test for this technology will be conducted for waste sites in the Central Plateau contaminated with Tc-99. Theoretically, desiccation would reduce moisture content in the vadose zone. Reduction of COC migration would be effective until the soil is re-wetted – a likely occurrence with the changing River stages. The technology is also not effective in the long term without concurrent infiltration control.	Unknown Implementation requires installation of injection and extraction wells, which are proven technology. However, there is uncertainty related with the number of wells, well spacing, and well configuration details required for optimal field/full-scale implementation. Would also require implementation of infiltration control.	Unknown	Unknown	GHG and energy for air injection. Waste generation from soil cuttings for well installation.	Not Retained*	Evaluation of results from the on-going treatability study is needed prior to making a decision regarding its full-scale use at the Hanford Site. This technology could be evaluated as a remedial alternative later.
			In Situ Thermal Desorption	Organics	Shallow/ Deep/PRZ	Direct application of heat (e.g., using electrical heater elements, electrical resistive heating, injection of hot air, steam or hot water, radio frequency, etc.) to increase the temperature of soil and destroy or volatilize organic compounds. VOC capture required.	High Technology can achieve rapid removal/destruction of a mix of volatile and semi-volatile organics, and achieve low residual concentrations.	Low Technology is applied using vertical drilling methods, and requires a spacing of 1.5 to 3 m (5 to 10 ft). Recovery of COC vapors will require soil vapor extraction network and vapor barrier over entire treatment area.	High	Low No associated cost.	GHG and energy for production of heat and vapor recovery; waste generation from soil cuttings.	Not Retained*	Mechanically complex challenging to implement.
			In Situ Vitrification	All	Shallow Deep	Thermal treatment process that converts soil and other materials into stable crystalline substances. Contaminants are incorporated into the glass structure, which is generally strong, durable, and resistant to leaching.	High Heavy metals and radionuclides are retained within the treated soil, which is generally resistant to leaching.	Low High complexity of equipment required. Process uses an electric current to melt soil or other earthen materials at extremely high temperatures (1,600 to 2,000 °C [2,900 to 3,650 °F]). It is important to also account for safety considerations from exposure to high heat.	High	Low No associated cost.	GHG and energy for heat generation. High energy requirements to sustain required heat.	Not Retained*	Complex and challenging to implement.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option		COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
In Situ Treatment (cont.)	In Situ Treatment Other (cont.)	Physical/ Chemical/ Biological (cont.)	In Situ Flushing	Contaminants with high to moderate solubility (e.g., Uranium)	Shallow/ Deep/PRZ	Water or water with additives to enhance solubilization is applied to the ground surface or in infiltration trenches to flush contaminants out of the vadose zone to the water table, where it would be captured/treated.	Low Water follows source release pathways, but contaminants that remain in adsorbed phase will not be flushed and captured. Flushing or uranium was found to be slow and needing large volumes of water in laboratory studies. May create a larger groundwater problem if the groundwater capture is not effective.	Low/Moderate Drip irrigation system or trenches are simple to install and accessible for O&M. Requires installation and operation of new groundwater extraction system to capture contaminants mobilized to groundwater.	Moderate Cost increased due to need for groundwater extraction system.	Moderate/High Cost increased due to need for groundwater extraction system.	GHG and energy for installation.	Not Retained*	
			Phytoremediation	Bioavailable metals and Organics	Shallow	Phytoremediation uses plants and their associated rhizospheric microorganisms to remove, degrade, or contain contaminants.	Low Phytoremediation is only effective when plants are active, thus the technology is not effective during the winter. Phytoremediation only treats soils to the approximate depth of the plant roots, and is only appropriate for low concentrations of contaminants. It is a slow process that is applied over long periods of years or decades. Many metals and radionuclides are only taken up by the plants and not transformed to innocuous forms.	Moderate Involves large land requirements, and considerable work would be required to make a plot of land at the Hanford Site suitable for plant growth. If used to treat contaminants that are merely taken up and not transformed to innocuous forms, plants would need to be disposed of elsewhere to avoid ultimately returning the contaminants back to the soils they came from. Concerns about contaminants in the plants entering the food chain may need to be addressed.	Low	Moderate Depends on the need for to periodically harvest plants.	GHG and energy for installation, and potential disposal of harvested plants containing metals. Implementation of phytoremediation could lead to a GHG reduction credit.	Not Retained*	Phytoremediation would only be effective for low concentrations of contaminants in shallow soils over long periods, and many metals and radionuclides would accumulate in the plants and would not actually be treated, posing risks to ecological receptors.

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
Containment	Surface Barriers	Surface Barriers (e.g., Modified RCRA Subtitle C and/or D Barrier, Asphalt/ Concrete Cap, Vegetative Cap [Evapo-transpiration Cap], Hanford Barrier)	All	Shallow/ Deep	Surface barriers are generally designed to be impermeable to prevent surface water infiltration through the vadose zone and limit contaminant leaching to groundwater. Surface Barriers may also prevent direct contact to contaminants. Modified RCRA Subtitle C Barriers are designed for hazardous waste, category 3 and category 1 (mixed) LLW. Modified RCRA Subtitle D Barriers are designed for non-radiological and non-hazardous solid waste, or category 1 LLW where hazardous constituents are not present. Capillary barriers consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer designed to functionally increases the water-holding capacity. Asphalt/Concrete caps can be placed around structures to remain in place (e.g., reactors) in the short term (75 years) to promote drainage, prevent infiltration into possible sources below the reactors, and prevent exposure to contaminated soil. The Hanford Barrier design was developed for sites containing LLW greater than Class C, and/or significant inventories of transuranic constituents.	Moderate Leaching of near-surface source COCs will be controlled, but residual COCs in capillary fringe and deeper vadose zone pore water will continue to impact groundwater due to water table fluctuation. Prevention of direct contact will depend on specific design.	Moderate/High Implementability of the Hanford Barrier is moderate. No technical or administrative challenges are associated with implementing asphalt/concrete caps (high implementability). Modified RCRA Subtitle C and/or D Barrier and ET Caps are simple to install. For all surface barriers (except asphalt/concrete caps), biointrusion will need to be considered as part of the barrier/cap design.	Low/High Hanford Barrier (High); Modified RCRA Subtitle C and/or D Barrier (Moderate); Asphalt/Concrete Cap and ET Barrier (Low).	Low	GHG and energy for installation.	Not Retained*	Asphalt/Concrete caps may be retained as an interim measures for limiting exposure to shallow soil COCs at waste sites adjacent to long-term facilities (2027).

Table 8-8. Technologies for Uranium and Other COCs in the Waste Sites—300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[a]	Depth Range[b]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[c]	Retained/Not Retained	Screening Comment
Containment (cont.)	Horizontal Subsurface Barriers	Jet Grouting, Soil Freezing, or Wire Saw Barriers	All	Shallow/ Deep	Barriers placed beneath the contaminated zone to limit further migration. Jet grouting is as discussed above at one specific depth. Soil freezing involves placement of cooling media distribution systems into the subsurface to freeze a soil layer below the contamination. Wire saw barrier involves cutting a thin horizontal trench that is filled with grout using a diamond wire saw. The saw is placed in an excavation around the soil mass to be contained.	Low Significant uncertainty on the completeness of the barrier with all methods. Not applicable for treating residual COCs in capillary fringe and deeper vadose zone.	Low Would be difficult or impossible to implement at Hanford due to presence of gravels and cobbles, and/or the depth of application.	High	Low	Large amount of wastes generated, GHG released, and energy used during installation.	Not Retained*	

Source: "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300).

* Additional details on technologies not retained are provided in Appendix J.

a. Indicates the contaminants that can be addressed by a technology based on geochemical properties. A COC Applicability of "All" indicates implementation of a technology is not dependent on the nature of a chemical.

b. Depth range is based on practical limitations of implementing the given technology

c. Sustainability includes potential impacts to the environment that could arise from implementing this technology (e.g., GHG emissions, waste generation, water use and resource impacts, energy use). Alternative design will dictate how sustainable an approach is.

d. Ex situ treatment does not include treatment done for ultimate disposal at the ERDF. Treatment performed at the ERDF or the site as required to meet disposal restrictions is assumed part of the "disposal to onsite landfill" process option.

bgs = below ground surface
H&S = health and safety
MNA = monitored natural attenuation
NCP = National Contingency Plan
O&M = operations and maintenance
RAO = Remedial Action Objective

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions		Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
No Action		No Action	No Action	All	No remedial actions taken.	Low No remedial actions are taken.	High	Low	Low	Little impacts	Retained	Retained per the NCP (40 CFR 300).
Monitored Natural Attenuation (MNA)		MNA	MNA	Radionuclides with Reasonable Half-Lives, Nitrate	Relies on natural attenuation processes such as radioactive decay, biological and chemical reduction, adsorption, dilution, and dispersion to manage the contamination on site. Monitor groundwater plume to track natural attenuation processes until RAOs are achieved. Contingency measures are developed if attenuation is not adequate to control the risks. Typically combined with other technologies that manage the source areas and mitigate exposure.	Moderate/High Effective for tritium. MNA alone is not likely to achieve uranium standards within a period that is acceptable in high concentration areas. MNA may be used in conjunction with active remediation measures for other COCs as part of a treatment train.	High	Low	Low	Little impacts	Retained	Retained as potential component of remedy.
Removal	Aquifer Removal	Aquifer Excavation	Aquifer Excavation	All	Saturated aquifer soil is dewatered and soil is excavated using conventional equipment (backhoes, bulldozers, etc.). After draining water, management of excavated soil would be the same as for vadose zone soil.	Moderate/High Proven technology. Combination of dewatering and aquifer soil excavation removes dissolved and sorbed-phase COCs. Effectiveness may be limited by ability to locate bulk COC mass and remove saturated sediment over a large area.	Low Vadose zone soil requires excavation to access aquifer with conventional equipment. Depth of excavation will require large setbacks and/or extensive shoring. Volume of groundwater extracted during dewatering will be high and require treatment.	High	Low	GHG emissions from machinery.	Not Retained[a]	
		Aquifer Dredging	Mechanical Dredging	All	Saturated aquifer soil is removed from below the groundwater table using mechanical dredging equipment (clamshells, draglines, etc.). After draining water, management of excavated soil would be the same as for vadose zone soil.	Moderate/High Proven technology. Removes both dissolved and sorbed-phase COCs. Effectiveness may be limited by ability to locate bulk COC mass and remove saturated sediment over a large area.	Low Vadose zone soil requires excavation to access aquifer with dredging equipment. Depth of excavation will require large setbacks and/or extensive shoring.	High	Low	GHG emissions from machinery.	Not Retained[a]	
	Pump-and-Treat	Extraction	Extraction System	All Dissolved	Installation of groundwater extraction network (extraction wells or trenches) to capture COC mass. Groundwater is treated ex situ prior to disposal/re-injection into aquifer.	Low 300 Area aquifer conditions preclude effective mass reduction even at high pumping rates. Continuous pumping from water supply well has not appreciably reduced uranium concentrations. Furthermore, this technology would only affect about 1 percent of the total uranium mass at the 300 Area (fraction residing in the dissolved phase groundwater).	High Proven and implemented technology at the Hanford Site. Pump-and-treat systems have been installed and are operating at other River Corridor areas.	High	Moderate/ High	Energy consumption and GHG emissions from pumping systems.	Not Retained[a]	

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions		Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
Removal (cont.)	Ex Situ Treatment	Chemical	Ion-Exchange	Uranium, Nitrate	Ions from the aqueous phase are removed by exchange with innocuous ions on the exchange medium.	Moderate/High Effectiveness is variable, depending on COC. Effective for low concentrations of uranium.	High Proven technology. Currently used at the Hanford Site for removal of Cr(VI) from extracted groundwater. Vendors and equipment readily available.	Low/Moderate	Moderate/ High	Waste generation from IX regeneration disposal or re-generation. Energy consumption from process equipment.	Not Retained[a]	Not required because pump and treat extraction systems are not retained.
			Chemical Reduction and Precipitation	Uranium	Dissolved radionuclides and metals are transformed into an insoluble solid, which is removed by flocculation, sedimentation, and filtration. COCs are removed with the sludge.	Low/Moderate Could be effective based on the process chemistry, but site specific testing would be required. Likely effective only for high concentrations of uranium in secondary waste streams.	Moderate/High Vendors and equipment readily available, but no experience with the technology at the Hanford Site. Large volume of sludge would be produced.	Moderate/High	Moderate	Waste generation from chemical precipitation. Energy consumption from process equipment.	Not Retained[a]	
			Electrocoagulation	Possibly Uranium	Relies on electrochemical generation of ferrous iron. The ferrous iron reduces metals that are susceptible to reduction and converts them to insoluble solids, which are removed by sedimentation and filtration.	Low/Moderate Proof of concept testing would be required.	Low/Moderate Additional development and testing would be required. Potential negative impacts on re-injection of water.	Moderate/High	Moderate/ High	Waste generation from chemical precipitation. Energy consumption from process equipment.	Not Retained[a]	
		Biological	Wetlands	Nitrate	Extracted groundwater is pumped to a constructed wetland where contaminants are biologically reduced, or taken up by plants and algae.	Moderate Effective for nitrate, but additional research/pilot testing is required	Low/Moderate May require large surface area for extended period.	Moderate Depends on land requirements.	Low	Little impacts, except for land required	Not Retained[a]	
			Subgrade Bioreactors	Nitrate, Possibly Uranium	Extracted groundwater is pumped into a lined excavated that has been backfilled with organic media (e.g., wood mulch with zero valent iron). Nitrate and uranium are biologically reduced as it passes through the media. A second stage aeration/filtration stage could be provided to remove any biological byproducts (e.g., iron), petroleum, and solids prior to infiltrating or injecting back to groundwater.	Moderate/High Effective for nitrate, but treatability testing is required to verify effectiveness for uranium. Spent media will require treatment (e.g., stabilization or solidification) and disposal at ERDF, since the reduction of uranium is reversible.	Moderate Excavation and backfilling is easy to implement. Piping can be incorporated into the design to facilitate future delivery of liquid carbon sources (e.g., vegetable oil). Treatability testing required to verify implementability. Very large excavation and media volume will be needed for high flow rates.	Low/Moderate Depends on land requirements.	Low/Moderate	Impacts include spent media disposal land required.	Not Retained[a]	Not retained in favor of ion-exchange.
			Ex Situ Bioreactors	Nitrate, Possibly Uranium	Groundwater is amended with electron donor (carbon source) and passes through a matrix (fixed bed, fluidized bed, or membranes) with microbial films, where contaminants are biologically reduced. Effluent is oxygenated, filtered, and amended prior to recharge back into the ground.	Moderate Bioreactors commonly used for nitrate removal, but less commonly for other COCs.	Low/Moderate Vendors and equipment readily available, but no current experience with the technology at the Hanford Site.	High	Moderate	Waste generation from biological sludge. Energy consumption from process equipment.	Not Retained[a]	Considering large and complex system requirements for nitrate removal, and since ion exchange treatment can be used, ex situ bioreactors have not been retained.

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions		Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
Removal (cont.)	Ex Situ Treatment (cont.)	Biological (cont.)	Phytoremediation	Nitrate, Possibly Uranium	Use of plants and their associated rhizospheric microorganisms to remove, reduce/degrade, or contain chemical contaminants in soil or groundwater. Contaminants in groundwater can also be removed by applying it as irrigating water for plants.	Low/Moderate Commonly used for nitrate removal, but additional research/pilot testing is required to verify effectiveness for uranium. Could be used as a barrier approach, but there would be challenges with the depth to the water table even close to the river. Plants used for remediating radionuclides would require harvesting.	Low Requires large surface area for plants. Potential cultural issues with implementation near river, where depth to water is most shallow.	Low	Low	Impacts include land required and potential disposal of harvested plants containing radionuclides.	Not Retained[a]	Would only be effective for low concentrations of contaminants where groundwater is shallow over long periods, or when applied as irrigation water. Radionuclides would accumulate in the plants and not actually be treated, posing risks to ecological receptors.
		Physical	Membrane-Based Separation (Reverse Osmosis, Coupled Transport, Electrodialysis)	All	Contaminant molecules are separated from water through a selective membrane using either water pressure (RO), strip solution (coupled transport), or electrical field (electrodialysis). Clean effluent stream is collected from the "permeate" side of the membrane, and water containing the concentrated contaminants is disposed of.	Low/Moderate/High With the appropriate design, RO can be effective for almost any compound, and electrodialysis can be effective for removing ionic species. RO is effective for low concentrations of uranium. Couple transport is still in development, and its effectiveness is unproven.	Low/Moderate RO vendors and equipment readily available, although additional site specific testing would be required. Coupled transport technology is still in development. Electrodialysis equipment is prone to fouling. Pretreatment likely necessary, and a large volume of brine would be produced that would need to be treated and handled.	High	High	Waste generation in form of brine and high energy use from process equipment.	Not Retained[a]	
			Electrolysis	Radionuclides	Metal ions are electrochemically reduced to their elemental form at a cathode. Commercial applications of electrolytic recovery are typically used to remove metal ions from concentrated solutions (e.g., metal plating and etching solutions).	Moderate Can be effective if design and operations account for low metals concentrations in groundwater.	Low Treatment of low metal concentrations using conventional methods is not practical due to high power requirements.	High	High	Energy consumption from process equipment.	Not Retained[a]	
			Evaporation/ Distillation	All	Energy is applied to a solution to physically separate liquid from a dissolved or suspended solid. Evaporation results in a more concentrated condensate waste effluent.	Low Condensate waste effluent will likely required further treatment.	Low/Moderate Evaporation/distillation process can be accomplished using heaters, condensers, and evaporation ponds. The latter is not preferred due to the large land requirements.	High	High	Energy consumption from process equipment.	Not Retained[a]	

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions		Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
Removal (cont.)	Ex Situ Treatment (cont.)	Onsite Discharge	Groundwater Injection Wells	All	Treated groundwater is injected into onsite wells.	High Can enhance contaminant flushing, hydraulic control and capture of plume.	High Proven technology, currently used in existing pump-and-treat system at the 100 Area. The wells may be subject to clogging due to the buildup of chemical precipitates or microbial biofouling.	Moderate Injections wells will need to be installed.	Low/Moderate	GHG and energy for installation. Waste generation from soil cuttings for well installation.	Retained	
			Surface Infiltration	All	Treated groundwater is infiltrated into onsite trenches, located outside of zones of known waste sites.	High Effective means of disposal and may enhance contaminant flushing, hydraulic control and capture of plume if they can be located appropriately.	Moderate/High Infiltration would be easy to engineer and implement.	Low Trenches are lower cost than wells.	Low/Moderate	Little impacts	Retained	
		Offsite Discharge	Surface Water Discharge (NPDES)	All	Discharge of treated groundwater directly to the river at a permitted outfall.	High Effective means of treated water disposal.	Moderate Surface water discharge is commonly practiced for treated wastewater. A new NPDES permit would be required, and outfalls would need to be constructed outside of areas designated as Hanford Reach National Monument land.	Low	Low Little or no maintenance required.	Little impacts	Retained	Retained as potential remedy component, for discharge of treated process water.
			Beneficial Reuse of Treated Water	All	Use of treated water for a beneficial use such as irrigation, cooling water, dust control, or research.	High Effective means of treated water disposal, although it may affect the in situ removal mechanisms.	Moderate No nearby facility that could use large quantities of water. May be simple to implement for dust control for nearby earthwork (other Hanford sites, city of Richland).	High	Low	Water needs to be transported for reuse.	Retained	May be useful if water can be used for dust control and similar uses.

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions		Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
In Situ Treatment	Reagent Approach	Chemical	In Situ Chemical Stabilization	Uranium	Subsurface delivery of chemical reagents in a regular pattern of wells in the aquifer to sequester the contaminants. Chemical reactions are induced between the stabilizing agent and contaminant to reduce mobility (e.g., the formation of autunite from uranium). Agents include soluble phosphates and polyphosphates.	Moderate/High Currently being implemented at 100-N in a barrier approach for Sr-90 with favorable results. Pilot tests conducted at 300-Area show promise in treating uranium (autunite sequestration), but technology is not yet fully developed. Achieving even distribution of reagents may be difficult.	Moderate May require large number of injection points.	Moderate/High Dependant on number and type of injection points.	Moderate Periodic re-injection may be required.	Waste from drilling and GHG and energy from chemical production and transport.	Retained	Retained for application in the PRZ during high-river stages
			In Situ Chemical Reduction	Uranium	Subsurface delivery of chemical reductants (such as calcium polysulfide or dithionite) within plume to stimulate reduction of contaminant.	Low Chemical reductants instantly reactive, thus strongest reduction achieved near injection well, requiring tighter spacing of injection wells. However, re-oxidation of uranium is possible. Long term-maintenance of reduced conditions would be required.	Moderate May require large number of injection points.	Moderate/High Dependant on number and type of injection points. Likely higher capital cost compared to in situ biological.	Moderate Likely higher O&M compared to in situ biological.	GHG and energy for production and delivery of chemicals.	Not Retained[a]	
		Biological	In Situ Biological Treatment (Anaerobic)	Nitrate	Subsurface delivery and recirculation of various organic substrates in a regular pattern of wells in the aquifer to create reducing conditions that reduce nitrate.	Moderate Reactive life of biological electron donors is longer than chemical reductants so that reactive strength is maintained over relatively longer distances compared to in situ chemical treatment.	Moderate May require large number of injection points.	Moderate/High Dependant on number and type of injection points.	Moderate Depends on frequency of re-injection.	GHG and energy for production and delivery of substrate. Depends on which substrate is used.	Not Retained[a]	Not retained in favor of MNA
		Physical	Water Flushing	Uranium, Nitrate	Clean/treated water is injected to flush out contaminated groundwater to expedite remediation of plumes. Would be component of a pump-and-treat system.	Low Performance will depend on residual contamination in lower permeability layers. There is performance uncertainty with uranium.	Moderate Standard wells or infiltration trenches may be used for delivery. Requires installation and operation of a groundwater extraction system to capture mobilized contaminants.	Moderate Cost increased due to need for groundwater extraction system.	Moderate Cost increased due to need for groundwater extraction system.	GHG and energy for installation. Waste generation from soil cuttings for well installation.	Not Retained[a]	
	Delivery Method	Surface Infiltration	Surface Infiltration	Dependent on Type of Reagent Used	Trenches, French drains, or drip irrigations systems are used to inject water or reagents. Can be applied to bottom of excavations to target smear zone and shallow groundwater more effectively.	High With appropriate design, installation and, maintenance they can be effective.	Moderate/High Would be more acceptable to stakeholders if known vadose zone impacts are close or in contact with the water table.	Low/Moderate	Low	Less GHG and energy for installation.	Retained	

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions		Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
In Situ Treatment (cont.)	Delivery Method (cont.)	Groundwater Circulation Wells (GCWs)	Groundwater Circulation Wells (GCWs)	Dependent on Type of Reagent Used	Installation of wells with two screened zones in a single borehole. Groundwater is typically pump out of the formation from lower screen zone, and injected back into the formation in the upper zone. A circulation patter is created in the formation. The groundwater can be stripped inside the well to remove VOCs, or the wells can be used to deliver reagents.	Low The establishment of a reasonable circulation pattern depends on the formation characteristics. The low permeability lenses present in some locations may be problematic. Very high permeability may result in a small radius of influence so more wells will be required.	Low/Moderate A large number of wells may be required.	Moderate Depends on the number of wells required.	Moderate	Waste generation from soil cuttings for well installation, and GHG released and energy used for operation.	Not Retained[a]	Asymmetrical groundwater flow and groundwater flow short-circuiting, may limit the effectiveness of GCWs.
		Vertical Wells	Vertical Wells	Dependent on Type of Reagent Used	Standard vertical wells are used to inject water or reagents. Vertical wells include recirculation between separate wells (e.g., dipole recirculation).	High With appropriate design, installation and, maintenance they can be effective.	High Use extensively at Hanford.	Moderate/High Wells at Hanford are generally expensive.	Moderate	Waste generation from soil cuttings for well installation, and GHG released and energy used for operation.	Retained	Retained as a possible component of alternatives.
		Horizontal Wells	Horizontal Wells	Dependent on Type of Reagent Used	Horizontally drilled wells are used to inject water or reagents.	Low/Moderate Effectiveness can be hindered by non-uniform amendment distribution. Soil heterogeneity will result in preferential flow and limit treatment effectiveness of lower permeability soil. Multiple injections could be required.	Low Pilot test was not successful.	Moderate/High Costs are high but fewer wells are required.	Moderate	Waste generation from soil cuttings for well installation, and GHG released and energy used for operation.	Not Retained[a]	Pilot test was not successful.
Containment		Physical	Containment Wall (e.g., Slurry Wall, Grout Wall)	All	Slurry or grout wall barriers consist of a vertical barrier perpendicular to the groundwater flow direction, partially filled with bentonite slurry, grout, or other low permeability material. The barrier is typically keyed into a lower-permeability zone. The slurry/grout could be jet injected, mixed with the soils using large augers, or excavated.	Moderate Effectiveness is dependent on the continuity of the wall and the ability to key into the Ringold upper mud, which will be difficult to achieve because of depth. Does not reduce toxicity or volume of contaminants by itself. This technology requires groundwater extraction to control groundwater pressures from building up behind the barrier and potentially damaging the barrier or causing groundwater to flow under, over, or around the barrier.	Low Installation of slurry wall through cobbles and boulders to key into the Ringold upper mud is very difficult and cost-prohibitive. Driven sheet piles near the river have been attempted but failed because of the presence of cobbles.	High	Low/Moderate	GHG and energy for installation	Not Retained[a]	

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment
Containment (cont.)	Chemical/ Biological	Reactive Chemical Barrier (Apatite, ZVI, Zeolite, etc.)	Uranium, Nitrate	Subsurface injection or trenching in of chemicals along cross-gradient rows transecting plume. Chemicals are retained in the aquifer matrix so that contaminates are passively removed through reduction, sorption, or immobilization as groundwater moves through the treatment zone barriers.	Low/Moderate Effective if barrier treatment zone conditions are maintained. High flows of highly aerobic groundwater and changing water levels are likely to necessitate more frequent amendments and/or reduce permeability of barrier (for ZVI). Not effective in treating the bulk of the plume. For reduction mechanisms, re-oxidation of uranium is possible. Long term-maintenance of reduced conditions would be required.	Moderate Can be implemented with injection wells or trenching. However, both may be very challenging due to the presence of cobbles/boulders.	High	Moderate	GHG and energy for installation	Not Retained[a]	
		Reactive Biological Barrier	Uranium, Nitrate	Subsurface delivery and recirculation of electron donors along cross-gradient rows transecting plume. Residual reducing byproducts and biomass are retained in the aquifer matrix so that contaminants are passively removed as groundwater moves through the treatment zone barriers.	Low/Moderate Effective if barrier treatment zone conditions are maintained. Given the aerobic groundwater, re-amendment of the barrier would need to be frequent. Not effective in treating the bulk of the plume. Re-oxidation of uranium is possible. Long term-maintenance of reduced conditions would be required.	Low/Moderate Can be implemented with injection wells or recirculation dipole wells—latter option reduces number of wells required and is more cost-effective. Broad zones of secondary byproduct generation within treatment area may occur—requires re-oxygenation of groundwater prior to discharge to the river.	Moderate/High Dependant on number and type of wells	Moderate	GHG and energy for installation	Not Retained[a]	
	Hydraulic Control	Hydraulic Containment via Extraction	All	Install extraction wells along downgradient edge of plumes to control migration of COCs to the river.	Low/Moderate 300 Area aquifer conditions would require high pumping rates to achieve localized hydraulic containment. Continued uranium mass recharge from PRZ and river bank sediments would limit the effectiveness of this technology for keeping uranium from entering the river.	High Proven and implemented technology at Hanford. Pump-and-treat systems have been installed and are operating at other River Corridor, and can be designed to work with other remedial technologies.	High	Moderate	GHG and energy for operations	Not Retained[a]	
		Hydraulic Containment via Injection	All	Injection of river water or groundwater parallel to the river. Manages hydraulic gradients to create conditions (e.g., an inward gradient) throughout the year that mimic natural conditions of low plume discharge encountered during periods of high river stage. Barrier comprising closely spaced injection wells, infiltration trenches, and/or horizontal wells. Source of water from existing permitted Columbia River supply and/or groundwater.	Low 300 Area aquifer conditions would require high injection rates to achieve localized containment. Some flushing and dilution of the contamination already close to the river may occur and may not be viewed favorably. Continued uranium mass recharge from PRZ and rive bank sediments would limit the effectiveness of this technology for keeping uranium from entering the river.	Moderate Can be accomplished using practically achievable injection rates. Infiltration trenches will be more cost-effective than injection/horizontal wells but could cause seepage faces to develop along river cliff faces.	Moderate	Moderate	GHG and energy for operations	Not Retained[a]	

Table 8-9 Technologies for Uranium and Other COCs in Groundwater— 300 Area

General Response Actions	Remedial Technology	Process Option	COC Applicability[c]	Description	Relative Effectiveness	Relative Implementability	Relative Capital Cost	Relative O&M Cost	Sustainability[b]	Retained/ Not Retained	Screening Comment

Source: "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300).

a. Additional details on technologies not retained are provided in Appendix J.

b. Sustainability includes potential impacts to the environment that could arise from implementing this technology (e.g. greenhouse gas emissions, waste generation, water use and resource impacts, energy use). Alternative design will dictate how sustainable an approach is.

c. Indicates the contaminants that can be addressed by a technology based on geochemical properties. A COC Applicability of "All" indicates implementation of a technology is not dependent on the nature of a chemical.

H&S = health and safety

MNA = monitored natural attenuation

NCP = National Contingency Plan

O&M = operations and maintenance

RAO = remedial action objective

Table 8-10. Categories and Types of Current Hanford Site Institutional Controls

DOE-RL Categories of Institutional Controls[a]	DOE-RL Categorical Description	Types of Current Hanford Institutional Controls	Examples of Institutional Controls
Active/Passive Controls	These controls have long been understood to apply to the long-term management of radioactive waste. Active controls require clear institutional and human responsibilities and the active performance of responsibilities such as controlling access to a disposal site by means such as guards, performing maintenance operations or remedial actions at a site, controlling or cleaning up releases from a site, or monitoring parameters related to disposal system performance. Passive controls are defined by their dependence on the design of controls and structures such as permanent markers placed at a disposal site; public records and archives; government ownership and regulations regarding land or resource use; and other methods of preserving knowledge about the location design and contents of a disposal system.	**Warning Notices:** Provide visual identification and warning of hazardous or sensitive areas. A mechanism of warning notices includes signs that provide visual identification and warning of hazardous or sensitive areas.	**Warning Notices** – Requirement for placement of permanent signs and/or markers at specific areas of the site. – Applies to all COCs. – *Effectiveness*: Good. Reduces or eliminates the potential for direct contact with radiological contamination for the duration of elevated risk period, and for preserving knowledge about a specific area or design. – *Implementability:* Very Good. Readily implemented, requires periodic surveillance and maintenance. – *Cost:* Low. *Retained*
Proprietary/Government Controls	This type of control is based on the legal authority of landowners to control the use of their land. Proprietary controls, such as easements, are based on the rights associated with ownership of an interest in land. Government controls rely on the powers of governments to protect the public health and safety through zoning, legislation, land ownership, or permit programs.	**Land Use Management:** Ensures that use of the land is compatible with any hazards that exist. As presented in the Sitewide IC Plan (DOE/RL-2001-41), "DOE will restrict the use of land on waste sites and prohibit activities that would interfere with the remedial activity in accordance with the institutional controls requirements of the CERCLA decision documents and as described in applicable work plans." Implementation of land use management controls can ensure that any changes in use of the land are assessed before being allowed, and that institutional controls are maintained beyond change of ownership, as appropriate. Mechanisms include land-use and real property controls (e.g., proprietary controls including easements and covenants) and excavation permits. Land-use and real property controls ensure that the use of land is in accordance with Hanford Site plans and CERCLA decision documents. Site evaluations are required prior to any land disturbance activity, and excavation permits are required for excavations on the Hanford Site to prevent unplanned disturbance or infiltration as prohibited by CERCLA decision documents. **Groundwater Use Management:** Ensures proper use of groundwater through groundwater controls. As described in Sitewide IC Plan (DOE/RL-2001-41), groundwater use on the Hanford Site is generally restricted, except for limited research purposes and for monitoring and treatment, as approved by EPA or Ecology, or as authorized in EPA- or Ecology-approved documents. Excavation permits and the land use process also control groundwater use. Section 8.3.1.2 provides additional groundwater use management discussion.	**Land-Use Management** – Land use and real property controls (e.g., proprietary controls including easements and covenants). – Applies to all COCs. – *Effectiveness:* Good. Reduces or eliminates the potential for direct contact with contaminated groundwater when well implemented and maintained for the duration of elevated risk period. Ensures compatible land use. – *Implementability:* Very Good. Readily implemented, must identify and comply with all necessary legal requirements. – *Cost:* Low. *Retained* **Groundwater Use Management** – Groundwater controls. – Applies to all COCs. – *Effectiveness:* Good. Ensures no improper use of groundwater. – *Implementability:* Very Good. Readily implemented, but will likely require ongoing oversight and coordination with state water resource managers. – *Cost:* Low. *Retained*

Table 8-10. Categories and Types of Current Hanford Site Institutional Controls

DOE-RL Categories of Institutional Controls[a]	DOE-RL Categorical Description	Types of Current Hanford Institutional Controls	Examples of Institutional Controls
Structural/Nonstructural Controls	Structural controls include physical barriers (e.g., gates, fences, and natural barriers) to keep trespassers away from a site, signs to warn people of dangers, and engineered barriers (e.g., tanks) restricting or containing actual or potential contaminant migration. Nonstructural controls are all other limitations on the use of land that do not require physical means of exposure prevention.	**Entry Restrictions:** Prevent or limit the access of humans to particular hazardous or sensitive areas. They can also be used to avoid disturbance and exposure to remedies such as excavation areas, engineered barriers, or an effective vegetative soil layer, and serve to ensure adequate training for those who enter these areas. Procedural requirements for access, warning signs, and fencing can be implemented to provide entry restrictions.	**Entry Restrictions** – Procedural requirements for access Excavation/Drilling permits. – Applies to all COCs. – *Effectiveness*: Good. Reduces or eliminates the potential for direct contact with contaminated groundwater when well implemented and maintained for the duration of elevated risk period. Protects integrity of active remedies. – *Implementability:* Very Good. Readily implemented, requires periodic surveillance and maintenance. – *Cost:* Low. *Retained*
Informational Tools[b]	Provide information or notification about whether a remedy is operating as designed and/or that residual or contained contamination may remain onsite. Information devices include state registries, deed notices, and advisories.	**Waste Site Information Management:** This is an administrative mechanism implemented to maintain and provide access to information on the location and nature of contamination. The WIDS database identifies waste management units on the Hanford Site, their location, waste type, and status. Other descriptive information contained in WIDS includes size, extent, and appearance; testing or sampling efforts; regulatory information; bibliographic references; images; change history; and data validation. DOE-RL maintains the system in accordance with the WIDS change control system, which documents and traces additions, deletions, and/or other changes dealing with the status of waste management units.	**Waste Site Information Management** – Administrative – Applies to all COCs. – *Effectiveness:* Good. Ensures access to information on the location and nature of contamination. – *Implementability:* Very Good. Readily implemented, but requires maintenance of the information management system. – *Cost:* Low. *Retained*

a. *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41).

b. An "Informational Tool" is an EPA category of an institutional control that is used at the Hanford Site as discussed in *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41).

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Disposal. Following excavation, contaminated soil needs to be properly disposed, either at the onsite or offsite landfill, or by backfilling treated soil. Prior to implementation of a disposal option, waste acceptance criteria must be evaluated. Treatment required to meet ERDF waste acceptance criteria is evaluated under the disposal GRA under the onsite landfill disposal process option.

Backfilling treated soil involves excavation and ex situ treatment, followed by onsite disposal. Prior to implementation of this disposal option, treated soil will need to be compared to cleanup levels to verify backfilling is appropriate.

Disposal at the onsite landfill includes transport of excavated soil to EDRF. The waste acceptance criteria for ERDF are based on regulatory requirements (e.g., RCRA LDRs) and risk-based considerations for long-term protection of HHE. If waste cannot be accepted at ERDF, a suitable offsite disposal facility will be used. Part of this process option is treatment required to meet ERDF waste acceptance criteria. Therefore, an ex situ treatment process option does not need to be evaluated if excavation and disposal at ERDF are selected as remedial options.

In Situ Treatment. In situ treatment consists of actions that treat contamination in place using physical, chemical, or biological treatment techniques. Advantages of in situ treatment include significantly reduced exposure to site workers relative to removal of contaminated media for disposal or ex situ treatment. For this evaluation, in situ process options were subdivided by technologies that require delivery of a reagent to the subsurface for treatment, and those that implement another technique. Within actions requiring delivery of a reagent, technologies can be further subdivided by the reagent approach (physical, chemical, or biological), and the method for delivering the reagent to the subsurface.

For treatment of contaminated soil in the 300 Area, the following in situ remedial technologies and process options were evaluated:

- Reagent Approach
  - In situ solidification
  - In situ stabilization/sequestration
  - Chemical reduction
  - In situ chemical oxidation (ISCO)
  - Surface bioremediation (land farming)
  - Biological reduction
  - Combined chemical/biological reduction
  - Gaseous ammonia injection
  - Soil vapor extraction (SVE)
  - Bioventing
  - Reductive dechlorination using zero-valent metals or bioremediation of PCBs
  - In situ gaseous reduction (ISGR) with chemical reductant or biological substrate
  - In situ leaching (Solution Mining)
- Delivery Method
  - Mixing with conventional excavation equipment
  - Deep soil mixing (vertical/horizontal)
  - Foam delivery of reagents
  - Gas delivery of reagents
  - Horizontal injection wells
  - Vertical injection wells