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Hanford Site 300 Area

Record of Decision for 300-FF-2 and 300-FF-5, and
Record of Decision Amendment for 300-FF-1

U.S. Environmental Protection Agency, Region 10
U.S. Department of Energy, Richland Operations Office

November 2013

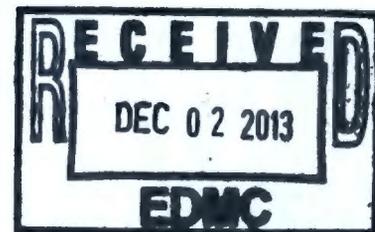


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ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
CUL	Cleanup Level
DCE	cis-1,2-dichloroethene
DOE	US Department of Energy
DWS	Drinking Water Standard (see also MCL)
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ft	feet
g	gram
IC	Institutional Control
L	liter
MCL	Maximum Contaminant Level (see also DWS)
mg	milligram
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
NCP	National Contingency Plan
NPL	National Priority List
O&M	Operations and Maintenance
OU	Operable Unit
pCi	Picocurie
PRZ	Periodically Rewetted Zone
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD/RAWP	Remedial Design/Remedial Action Work Plan
RI RI/FS	Remedial Investigation, Remedial Investigation/Feasibility Study
ROD	Record of Decision
RTD	Remove, Treat, Dispose
STOMP	Subsurface Transport Over Multiple Phases
TCE	Trichloroethene
TSD	Treatment, Storage and Disposal
VOC	Volatile Organic Chemical
WAC	Washington Administrative Code

DECLARATION OF THE RECORD OF DECISION

1.0 SITE NAME AND LOCATION

USDOE Hanford 300 Area
EPA# WA2890090077
300-FF-1, 300-FF-2 and 300-FF-5 Operable Units
Hanford Site
Benton County, Washington

2.0 STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedies for the 300-FF-2 and 300-FF-5 Operable Units (OUs) and amends the selected remedy for the 300-FF-1 OU for the U.S. Department of Energy (DOE) Hanford 300 Area, Hanford Site, Benton County, Washington. This remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). These decisions are based on the Administrative Record files for the 300-FF-1, 300-FF-2 and 300-FF-5 OUs. The State of Washington concurs with the selected remedies and ROD amendment.

3.0 ASSESSMENT OF THE SITE

The response actions selected in this Record of Decision (ROD) are necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants or contaminants which may present an imminent and substantial endangerment to public health or welfare or the environment.

4.0 DESCRIPTION OF THE SELECTED REMEDIES AND ROD AMENDMENT

The overall site cleanup strategy is to select a remedy for the waste sites in 300-FF-2, select a remedy for the groundwater in 300-FF-5 and amend the remedy for three 300-FF-1 waste sites. The interim action remedy for 300-FF-5 selected in 1996 and the interim action remedy for 300-FF-2 that was selected in 2001 are replaced with this final action remedy. The remedy for 300-FF-1 selected in 1996 is amended for additional remedial action of uranium from three sites. Contaminated buildings are being removed in accord with CERCLA Action Memoranda and are not part of the OUs addressed by this ROD.

The major components of the selected remedy for the 300-FF-2 OU are:

- Remove, Treat and Dispose (RTD) at waste sites
- Temporary surface barriers and pipeline void filling

- Enhanced attenuation of uranium using sequestration in the vadose zone, Periodically Rewetted Zone (PRZ) and top of the aquifer, and
- Institutional Controls (ICs), including the requirement that DOE prevent the development and use of property that does not meet residential CULs at the 300 Area Industrial Complex and 618-11 for other than industrial uses, including use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds.

The major components of the selected remedy for the 300-FF-5 OU are:

- Monitored Natural Attenuation (MNA)
- Groundwater monitoring
- Enhanced attenuation of uranium at the top of aquifer, and
- ICs.

The major component of the amended remedy for 300-FF-1 is:

- Enhanced attenuation of uranium using sequestration in the Vadose Zone, PRZ and top of the aquifer

RTD is used to remove contaminated soil, structures which includes pipelines and debris from waste sites via excavation; treat as necessary to meet disposal facility requirements, protect workers and prevent unacceptable environmental releases; and dispose of the waste. Uranium sequestration is used in the deep vadose zone, PRZ and top of the aquifer to reduce the mobility of uranium that is the primary source of contamination in groundwater. The enhanced attenuation of residual uranium will occur in an approximately 1 hectare (3 acres) area that is the highest contributing area to the persistent uranium groundwater plume. This action provides enhanced attenuation of uranium to restore the aquifer. MNA is used for nitrate, tritium, trichloroethene (TCE) and cis-1,2-Dichloroethylene (DCE) in groundwater. Uranium and other contaminants of concern (COCs) in the groundwater are monitored until Cleanup Levels (CULs) are met.

Due to ongoing use of some buildings and supporting in-ground infrastructure like utility lines, some of the waste sites will not be available for RTD for an extended period. Temporary surface barriers such as asphalt and void filling in pipelines will be used to reduce mobility of contaminants until the RTD activity can be performed.

The sequence and timing of the remedial action to be conducted at the operable units will be specified in a work plan written by DOE to be submitted to the U.S. Environmental Protection Agency (EPA) within 6 months after ROD approval. In-progress interim action remediation for 300-FF-2 and 300-FF-5 shall use the CULs selected in this ROD immediately upon issuance of this ROD. All other aspects of the interim actions for 300-FF-2 and 300-FF-5 shall continue to be performed in accordance with the existing RD/RAWP. When the new RD/RAWP for the remedies selected by this ROD is approved, that document will direct future remedial action and will replace all interim action RD/RAWP requirements. The estimated time to achieve CULs for waste sites is 19 years. This is based on Pacific Northwest National Laboratory use of 300 Area long-term facilities until 2027, followed by RTD at waste sites adjacent to the long-term

facilities within five years following 2027. The estimated time to achieve CULs in groundwater is 22-28 years for uranium and 18 years for tritium.

The selected remedies identify CULs that must be met to: restore groundwater to drinking water levels, protect groundwater and the Columbia River and protect industrial use in all areas. In addition, DOE and EPA have agreed to residential CULs which must be met outside the industrial complex and 618-11.

Performance standards are established for 300-FF-5 groundwater and 300-FF-2 soil, structures and debris. Performance standards for groundwater are CULs that are based on the drinking water standards (DWS) for uranium, tritium, nitrate and gross alpha; and risk-based standards that are more stringent than respective DWS for TCE and DCE. Performance standards selected for 300-FF-2 soil, structures and debris within the top 4.6 m (15 ft) below ground surface (bgs) are protective of industrial uses of the 300 Area Industrial Complex and the 618-11 burial ground, and residential use for the remaining areas. Soil, structures and debris performance standards for industrial use CULs protect an adult worker but not residents or children. The DOE will prevent the development and use of property that does not meet residential CULs at the 300 Area Industrial Complex and 618-11 for other than industrial uses, including use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds. The CULs for 300-FF-2 soil at all depths are also based on protection of groundwater and surface water.

Principal threat wastes exist in three waste sites in 300-FF-2. Soil in waste site 300-296 below the 324 building, vertical pipe units at the 618-10 and 618-11 burial ground waste sites and caissons at 618-11 contain principal threat waste. Under the selected remedy for 300-FF-2, all principal threat waste will be treated where practicable to reduce the toxicity, mobility, contamination or radiation exposure, including some that will be treated in-situ prior to removing the waste for disposal. Treatment will be with grout or an alternative method approved by EPA during remedial design. The selected remedy for 300-FF-2 requires all waste that is removed for disposal to be treated as necessary to meet the waste acceptance criteria of the disposal facility. Such treatment also reduces the toxicity and mobility of radionuclides and chemical hazardous substances.

ICs are used to control access to contamination in soil and groundwater above CULs for unlimited use and unrestricted exposure until such CULs are met. DOE shall be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

Table 1 summarizes how the 130 waste sites in 300-FF-1 and 300-FF-2 will be addressed.

5.0 STATUTORY DETERMINATIONS

The selected remedies attain the mandates of CERCLA §121, and, to the extent practicable, the NCP. The selected remedies are protective of human health and the environment, comply with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, are cost-effective and utilize permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable.

The remedies satisfy the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility or volume of hazardous substances, pollutants or contaminants as a principal element through treatment).

Because the selected and amended remedies will result in hazardous substances, pollutants or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedies are, or will be, protective of human health and the environment. Five-year reviews will be conducted after the initiation of remedial action and continue until hazardous substances no longer remain present above levels that allow for unlimited use and unrestricted exposure.

The preamble to the NCP states 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 § 104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit. The 300 Area sites addressed by this ROD and the Hanford Environmental Restoration Disposal Facility (ERDF) are reasonably close to one another, and the wastes are compatible for the selected disposal approach. Therefore, the sites are considered to be a single site for response purposes.

Table 1. 130 Waste Sites included in this ROD	
Technology/Approach	Waste Site
No additional action needed to meet selected remedy requirements for 300-FF-2 – 38 waste sites	300 VTS, 300-1, 300-10, 300-109, 300-110, 300-18, 300-253, 300-256, 300-259, 300-260, 300-262, 300-275, 300-29, 300-33, 300-41, 300-45, 300-53, 300-8, 303-M SA, 303-M UOF, 311 MT1, 311 MT2, 313 MT, 331 LSLDF, 333 ESHWSA, 600-22, 600-243, 600-259, 600-46, 600-47, 618-13, 618-5, 618-7, 618-8, 618-9, UPR-300-17, UPR-300-41, UPR-300-46
RTD to industrial cleanup levels - 74 waste sites in 300 Area Industrial Complex and 618-11	300 RLWS, 300 RRLWS, 300-11, 300-121, 300-123, 300-15, 300-16, 300-175, 300-2, 300-214, 300-218, 300-219, 300-22, 300-224, 300-24, 300-249, 300-251, 300-255, 300-257, 300-258, 300-263, 300-265, 300-268, 300-269, 300-270, 300-273, 300-274, 300-276, 300-277, 300-279, 300-28, 300-280, 300-281, 300-283, 300-284, 300-286, 300-289, 300-291, 300-293, 300-294, 300-296, 300-32, 300-34, 300-4, 300-40, 300-43, 300-46, 300-48, 300-5, 300-6, 300-7, 300-80, 300-9, 313 ESSP, 316-3, 331 LSLT1, 331 LSLT2, 333 WSTF, 340 COMPLEX, 3712 USSA, 618-11, UPR-300-1, UPR-300-10, UPR-300-11, UPR-300-12, UPR-300-2, UPR-300-38, UPR-300-39, UPR-300-4, UPR-300-40, UPR-300-42, UPR-300-45, UPR-300-48 UPR-300-5
RTD to residential cleanup levels - 12 waste sites	300-287, 300-288, 300-290, 316-4, 400 PPSS, 400-37, 400-38, 600-290, 600-367, 600-63, 618-10, UPR-600-22
Enhanced Attenuation – 7 waste sites ^a	Part of the deep vadose zone, PRZ and top of the aquifer most contaminated by uranium from sites 316-1 ^b , 316-2 ^b , 316-3, 316-5 ^b , 618-1, 618-2, 618-3

Total waste sites = 130. As of September 2013 all but about 34 of these sites have been remediated.

a – Seven sites are historically and currently the main contributors to groundwater uranium contamination. Those contributions are additive in the groundwater. Uranium sequestration will be used in the deep vadose zone, PRZ and top of the aquifer to reduce the mobility of uranium that is the primary source of contamination in groundwater. The enhanced attenuation of residual uranium will occur in an approximately 1 hectare (3 acres) area that is the highest contributing area to the persistent uranium groundwater plume. This action provides enhanced attenuation of uranium to help restore the aquifer.

b – Three waste sites included in 300-FF-1.

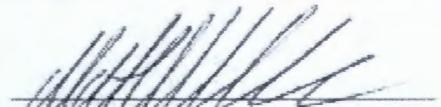
6.0 DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary of this ROD. Additional information can be found in the OU Administrative Record files which contain the documents which form the basis for the ROD operable unit remedial action selections.

- (a) **COCs and their respective concentrations.**
Soil COCs for 300-FF-2 are presented in table 2. Groundwater COCs for 300-FF-5 are presented in table 3. Concentrations are discussed in section 5. COCs for 300-FF-1 are not being revised by the ROD amendment.
- (b) **Baseline risk represented by the COCs.**
Baseline risk assessment for both human health and the environment is summarized in section 7.
- (c) **Cleanup levels established for COCs and the basis for the levels.**
CULs for soil are presented in table 4. CULs for groundwater are presented in table 5. The basis for CULs is included in sections 8.1 and 8.2, and tables 4 and 5.
- (d) **How source materials constituting principal threats are addressed.**
All principal threat waste will be treated to the maximum extent practicable as presented in section 11 and 12.2.1.
- (e) **Current and reasonably anticipated future land and current and potential future beneficial uses of groundwater used in the qualitative risk assessment and ROD.**
See section 6.
- (f) **Potential land and groundwater use that will be available at the site as a result of the selected remedy.** Potential land and groundwater use that will be available is identified in the Remedial Action Objectives (RAOs) (section 8) and in the selected remedy section (section 12). Industrial land use areas are shown in figure 10.
- (g) **Estimated capital, annual operation and maintenance (O&M) and total present value costs; discount rate; and the number of years over which the remedy cost estimates are projected.** Cost information is provided in section 10.7 for all the alternatives, and for the selected and amended remedies in the selected remedy section 12.3 table 8.
- (h) **Key factor(s) that led to selecting the remedy.** The selected and amended remedies are protective, satisfy cleanup requirements and provide the best balance of tradeoffs with respect to the balancing and modifying criteria used to select a remedy. See section 12.1.

7.0 AUTHORIZING SIGNATURES

USDOE Signature for the Record of Decision Amendment for the 300-FF-1 Operable Unit, and Record of Decision for the 300-FF-2 and 300-FF-5 Operable Units at the USDOE Hanford 300 Area Site as selected by the U.S. Department of Energy and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.


Matthew S. McCormick
Manager, Richland Operations Office
US Department of Energy

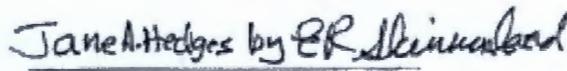
11/25/13
Date

USEPA Signature for the Record of Decision Amendment for the 300-FF-1 Operable Unit, and Record of Decision for the 300-FF-2 and 300-FF-5 Operable Units at the USDOE Hanford 300 Area Site as selected by the U.S. Department of Energy and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.


Richard Albright
Director, Office of Environmental Cleanup
US Environmental Protection Agency, Region 10

11/26/13
Date

State Signature for the Record of Decision Amendment for the 300-FF-1 Operable Unit, and Record of Decision for the 300-FF-2 and 300-FF-5 Operable Units at the USDOE Hanford 300 Area Site as selected by the U.S. Department of Energy and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.


Jane A. Hedges
Program Manager, Nuclear Waste Program
Washington State Department of Ecology

11/26/13
Date

DECISION SUMMARY

1.0 SITE NAME, LOCATION AND BRIEF DESCRIPTION

The Hanford site is federally-owned property located in south central Washington State, which is managed by the DOE. Hanford currently contains three National Priority List (NPL) sites. One of the NPL sites is the 300 Area (EPA ID# WA2890090077) in the southeast portion of Hanford in Benton County. The 300 Area includes three operable units called 300-FF-1 and 300-FF-2 (see figure 1), and 300-FF-5 (see figure 2). The 300-FF-5 OU encompasses groundwater contamination from 300 Area sources and does not include groundwater contamination from sources other than the 300 Area. Buildings are not part of the operable units. Contaminated buildings are being removed in accord with CERCLA Action Memoranda. This ROD addresses all three operable units. DOE is the lead agency responsible to perform the remedial actions, and the EPA is the lead regulatory agency.

The 300 Area NPL site is a semi-arid region adjacent to the Columbia River. Operations in the 300 Area Industrial Complex (figure 1) began in 1943. The complex includes buildings, facilities and process units where uranium nuclear fuel production plus research and development activities took place. Chemical and radioactive waste from these activities was disposed in liquid waste disposal sites and solid waste disposal sites. There have also been unplanned releases at other locations. Contamination has spread resulting in additional soil contamination and groundwater contamination. Nuclear fuel production ended in the late 1980s which ended the mission for many of the buildings. Currently there are several research and development laboratory buildings operating, and supporting utility infrastructure. Much of the 300 Area NPL site has been or is in the process of being cleaned up in accord with prior CERCLA RODs and Action Memoranda which are discussed in the Scope and Role section 4.

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Activities that have led to the Current Problems

The 300 Area is located in the southeastern portion of the Hanford Site. It includes distinct subareas: the 300 Area Industrial Complex (major liquid waste disposal sites, burial grounds and industrial facilities); the 400 Area; and waste sites within the 600 Area (including the 618-11 Burial Ground and the 618-10/316-4 Burial Ground).

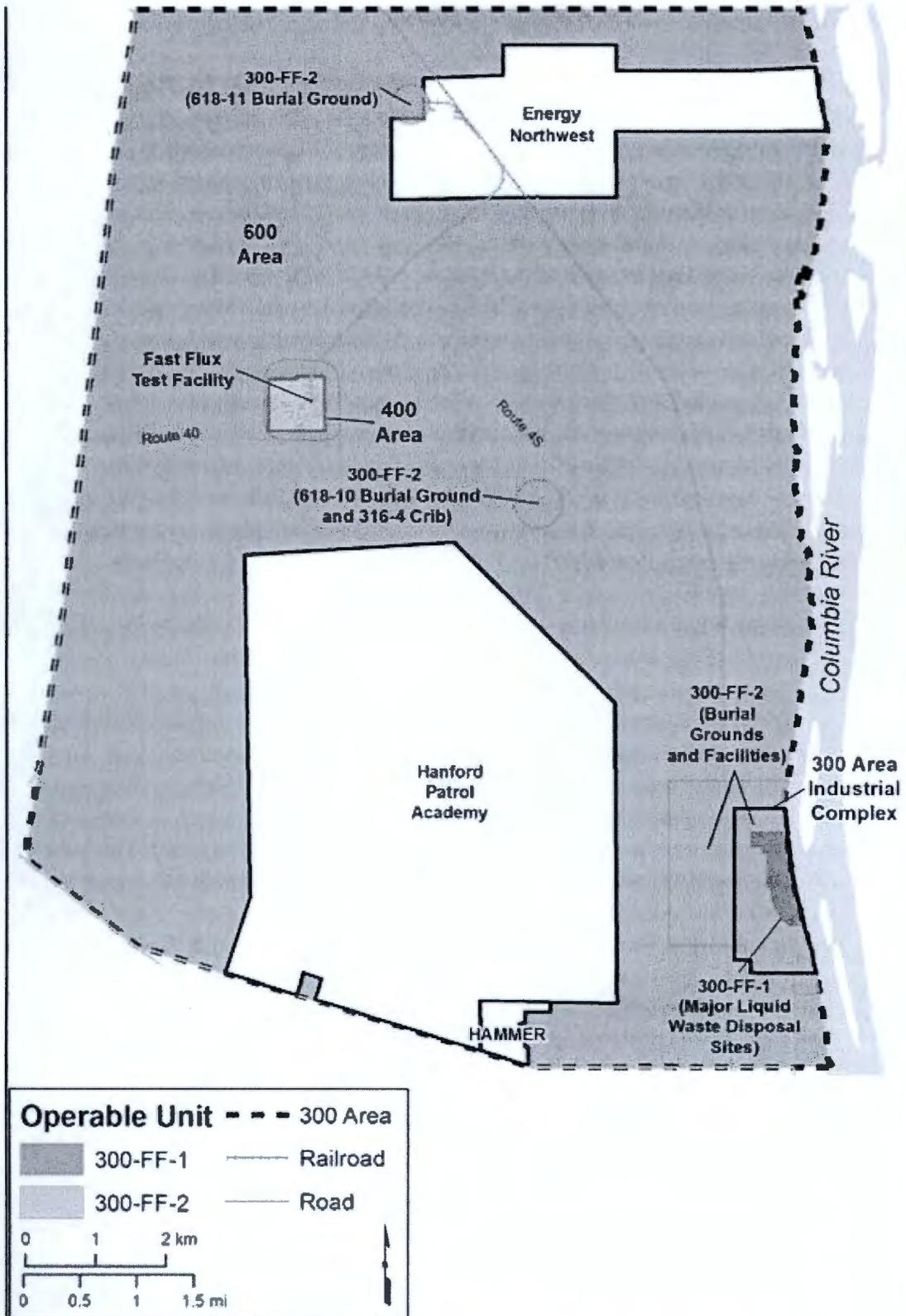


Figure 1. 300-FF-1 and 300-FF-2 Operable Units

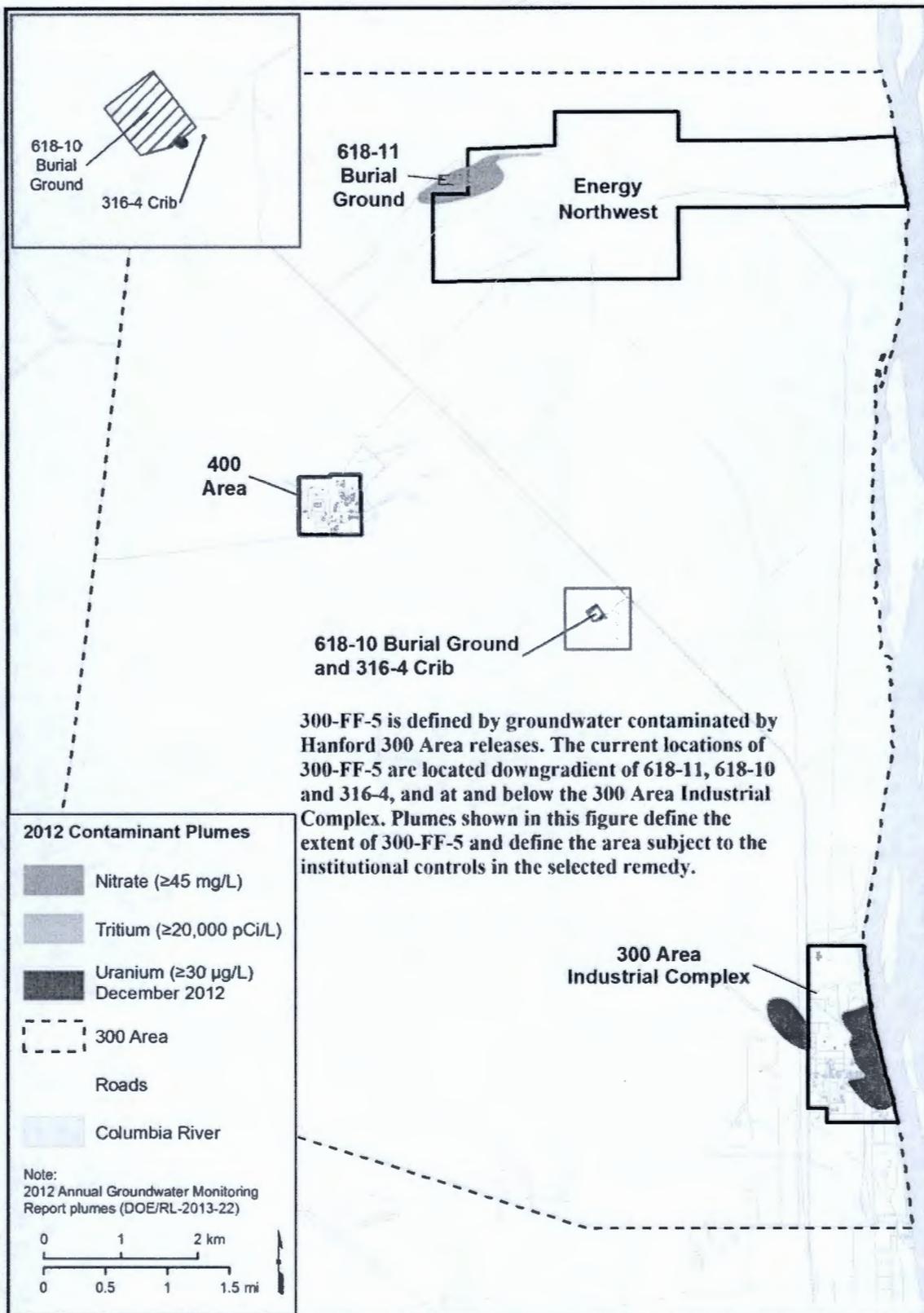


Figure 2. 300-FF-5 Operable Unit

The 300 Area Industrial Complex facilities began operations in 1943 and included fuel fabrication buildings, raw material storage, waste storage, finished product storage, technical support, service support and research and development (R&D) related to fuel fabrication and other Hanford Site processes. The complex includes the buildings, facilities and process units where the majority of uranium fuel production and research and development activities took place. Some of the facilities are still in use by the Pacific Northwest National Lab which will preclude access to some areas of contamination until approximately 2027. The 300 Area Industrial Complex is bounded by the following NAD83 North American Datum Washington State Plane South coordinate pairs, starting from the northeast corner at the river shore: 594317, 117476; follow river's edge to 594763, 115174; 593832, 115176; 593832, 115359; 593591, 115359; 593591, 117476; back to start.

The 400 Area contains four waste sites resulting from the Fast Flux Test Facility Reactor with relatively little contamination that are part of 300-FF-2. The Fast Flux Test Facility Reactor, which is not part of 300-FF-2, operated from 1980 until 1992. It is located approximately 5 mi northwest of the 300 Area Industrial Complex and about 4 mi west of the Columbia River.

Liquid wastes consisting of sanitary wastes and various radiochemical and radio-metallurgical process wastes were discharged via the Process Sewer System (300-15) to open ponds and trenches during most of the 300 Area operational history. The process sewer system consists of 50 km (31 mi) of underground piping. Liquid wastes were conveyed by the process sewer system to the South and North Process Ponds (316-1 and 316-2, respectively) between 1943 and 1975. Both ponds received from 1.5 to 11.4 million L/day (0.4 to 3 million gal/day) until they were phased out of service in 1974 and 1975. The 300 Area Process Trenches (316-5) replaced the ponds in 1975 and were used for disposal until 1994.

The primary waste stream disposed to these ponds and trenches was process waste from nuclear fuel fabrication; these sites also received radioactive liquid waste, sewage, laboratory waste and coal power plant waste. The waste from nuclear fuel fabrication included basic sodium aluminate solutions and acidic copper/uranyl nitrate solutions. Primary chemical contaminants disposed to the South and North Process Ponds included uranium (33,565 to 58,967 kg), copper (241,311 kg), fluoride (117,026 kg), aluminum (113,398 kg), nitrate (2,060,670 kg) and large volumes of nitric acid (HNO₃) and sodium hydroxide base (NaOH). Disposal of these waste streams resulted in both soil and groundwater contamination.

Solid wastes were disposed in burial grounds and shallow landfills from 1943 through the 1950s. In later years, highly radioactive wastes, including wastes with transuranic contaminants, were disposed of in 600 Area burial grounds. The burial grounds are 300-7, 300-9, 300-10, 618-1, 618-2, 618-3, 618-4, 618-5, 618-7, 618-8, 618-9, 618-10, 618-11, 618-12 and 618-13.

Contaminant releases identified at waste sites resulted in several groundwater contaminant plumes that lie within the 300-FF-5 groundwater OU. In addition, groundwater contaminated from operations in the 200 East Area (200-PO-1 OU) also extends beneath the 300 Area.

Contamination that originates from the 200 Area is not part of 300-FF-5 and will be addressed via a future CERCLA decision for 200-PO-1. In addition, nitrate from off-Hanford sources that enters the southern part of the 300 Area groundwater is not part of 300-FF-5. This ROD addresses 300 Area Hanford origin contaminants in groundwater.

2.2 Investigations, Cleanup Actions and Violations

For investigation and cleanup purposes, three OUs were established in the 300 Area, the 300-FF-1 and 300-FF-2 source OUs and the 300-FF-5 groundwater OU. 300-FF-1 contains contaminant sources associated with facilities and waste sites mainly represented by the former North Process Pond (316-1), South Process Pond (316-2) and 300 Area Process Trenches (316-5), where large volumes of liquid waste containing uranium were discharged. 300-FF-2 contains contaminant source areas associated with facilities and waste sites within the 300 Area Industrial Complex not included in 300-FF-1, the 400 Area and the 600 Area including the 618-10 and 618-11 Burial Grounds. It does not include buildings within those areas. Buildings are being addressed under CERCLA removal authority. Contaminant releases from these 300-FF-1 and 300-FF-2 waste sites resulted in several groundwater contaminant plumes that lie within 300-FF-5 groundwater.

DOE performed Remedial Investigations (RIs) and Limited Field Investigations starting in the early 1990s for 300-FF-1, 300-FF-2 and 300-FF-5 to characterize the nature and extent of contamination in the vadose zone and groundwater. DOE also completed a focused Remedial Investigation/Feasibility Study (RI/FS) for 300-FF-5 to provide characterization of the uranium contamination and conducted laboratory scale and field scale pilot testing to evaluate uranium sequestration with phosphate as a remedial alternative for uranium in groundwater. These investigations provided information on the nature and extent of contaminants in soil and groundwater, and the threat the contaminants pose to human health and the environment.

DOE has undertaken laboratory and field scale treatability studies at the 300 Area Industrial Complex to evaluate the use of phosphate to sequester (immobilize) uranium as a remedial technology. The purpose of the studies was to evaluate direct sequestration of dissolved uranium in groundwater by injecting phosphate into the aquifer, and to demonstrate surface infiltration of phosphate to immobilize uranium in the vadose zone to mitigate further uranium leaching to the aquifer.

One of the treatability studies was conducted to optimize phosphate formulations in the laboratory, and to evaluate the effectiveness of phosphate in sequestering uranium in the aquifer by two methods: direct formation of the insoluble uranium mineral autunite ($\text{Ca}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot n\text{H}_2\text{O}$) by introducing an orthophosphate/polyphosphate mixture in the aquifer, and secondly the formation of the mineral apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{OH})$), onto which uranium sorbs, by adding calcium citrate sodium phosphate in the aquifer. The results of the treatability study demonstrated that direct injection of phosphate can achieve treatment of uranium through the direct formation of autunite. The test showed that via this first method, uranium concentrations within 23 m (75 ft) of the pilot study injection well decreased below the

DWS from autunite formation. The treatability study showed that the second method, apatite formation in the aquifer, is less certain and is highly susceptible to groundwater flow and geochemical conditions.

Another treatability test was conducted at a very small area to test surface infiltration. The results of the infiltration testing indicated that at that site soil characteristics limited the infiltration such that phosphate treatment from the surface would not be effective. Based on historical water discharges to waste sites, application of dust suppression water during interim action cleanups and other water discharges such as water line breaks and flushing of fire system lines, most areas are expected to support a high infiltration. Infiltration rates around the former process ponds are expected to be high, as demonstrated during past liquid waste discharges.

Treatability testing helped identify uncertainties, limitations and the viability of treating uranium with phosphate. Based on the treatability testing, formation of apatite is not considered viable for the 300 Area. Use of phosphate to sequester uranium as autunite is considered a viable remedial technology. Direct injection of phosphate to the aquifer, PRZ and deep vadose zone to sequester uranium as autunite is considered viable. Phosphate infiltration from the surface is considered not viable in areas with poor infiltration. Based on historical water releases to ground surfaces, phosphate infiltration from the surface is considered viable in most of the 300 Area.

2.3 Previous Cleanup Actions

The Tri Party agencies conducted two removal actions in 1991 to mitigate the threat to human health and the environment from contaminant migration, primarily uranium, in the 300 Area which involved: (1) removal of soil from the 300 Area Process Trenches (316-5) in 300-FF-1 and (2) removal and disposal of drums containing uranium contaminated methyl isobutyl ketone (hexone) from the 618-9 Burial Ground in 300-FF-2.

In 1996, a final action ROD was issued for 300-FF-1, with remedies selected for 15 waste sites. The 15 waste sites included liquid waste disposal sites (e.g., South Process Pond [316-1], North Process Pond [316-2] and 300 Area Process Trenches [316-5]) and other solid waste disposal sites (e.g., 618-4 Burial Ground and 628-4 Landfill). Following implementation of these remedial actions, the Tri Party agencies determined that remediation, other than implementation of ICs, was complete for these 15 waste sites.

The 1996 ROD also included the selection of an interim remedial action for 300-FF-5 (EPA/ROD/R10-96/143). The interim remedy selected was natural attenuation with ICs to prevent human exposure to groundwater. The ROD required continued groundwater monitoring to verify modeled predictions of contamination attenuation and to evaluate the need for active remedial measures. ICs were required to prevent groundwater use while contaminant plumes were still present above DWSs. The groundwater aquifer is a potential future source of drinking water and natural attenuation was selected to restore groundwater to DWSs in a reasonable time frame. The RAOs in the ROD (EPA/ROD/R10-96/143) were to protect human and ecological receptors from exposure to contaminants in the groundwater and to protect the Columbia River

such that contaminants in the groundwater do not result in an impact to the Columbia River that could exceed the Washington State Surface Water Quality Standards. The remedial action implemented for uranium contamination in the groundwater, as specified in the 1996 interim action ROD for 300-FF-5, was (1) "continued groundwater monitoring" to verify modeled predictions of contaminant attenuation and (2) ICs to restrict groundwater use to prevent unacceptable exposures. The groundwater monitoring has shown that contamination attenuation did not occur as expected and the groundwater aquifer has not been restored to the DWSs within the 5- to 10-year timeframe identified in the interim action ROD. The persistence of uranium contamination in groundwater is attributed to the continuing source of uranium contamination in the PRZ.

In 2001, an interim action ROD was issued for 300-FF-2, with remedies selected for 56 waste sites. Active field remediation has been underway since and additional waste sites have been discovered and added to the scope of the interim action.

2.4 CERCLA Regulatory and Enforcement Activities

In 1989, the Hanford Site 300 Area was placed on the NPL (40 Code of Federal Regulations [CFR] 300, Appendix B). Also in 1989, DOE entered into the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement), which governs cleanup of the Hanford Site. The Tri Party agencies divided the overall cleanup into discrete OUs. The 300 Area includes three operable units called 300-FF-1, 300-FF-2 and 300-FF-5 (see figures 1 and 2). 300-FF-1 and 300-FF-2 address contaminated soils, non-building structures such as pipeline, debris and burial grounds. 300-FF-5 addresses the groundwater beneath the 300 Area from 300 Area sources. Buildings are not part of the OUs. Contaminated buildings are being removed in accord with CERCLA Action Memoranda.

3.0 COMMUNITY PARTICIPATION

The Tri-Parties developed a Community Relations Plan in April 1990 as part of the overall Hanford Site restoration process. It was designed to promote public awareness of the investigations and public involvement in the decision-making process.

A single RI/FS Report and single Proposed Plan for amending the 300-FF-1 final ROD and for final remedial action decisions for 300-FF-2 and 300-FF-5 were made available to the public on July 15, 2013. They were placed in the Administrative Record files for the three OUs and the information repositories listed below. The notice of the public comment period and availability of these two documents and the administrative records was published in the Tri-City Herald on July 15, 2013. Electronic listserv messages were sent to about 1,200 addresses, and about 2,000 US Postal Service letters were sent with a notice of the public comment period and availability of the documents. This information was included in Hanford's public involvement calendar available on the internet. A public comment period was originally scheduled to run from July 15 to August 16, 2013. An extension to the public comment period was requested. As a result, it was extended to September 16, 2013. Hanford's public involvement calendar available on the

internet was revised to list the extension and an electronic listserve message was sent on July 25, 2013. Public meetings were held on July 30, 2013 in Richland, WA; July 31, 2013 in Seattle, WA; and August 8, 2013 in Hood River, Oregon. Public meetings were held to present the Proposed Plan to a broader community audience than those that had already been involved at the site. At this meeting, representatives from DOE and EPA answered questions about problems at the operable units and the remedial alternatives. DOE and EPA also used this meeting to solicit a wider cross-section of community input, including on the 300 Area reasonably anticipated future land use and potential beneficial ground-water uses. DOE's and EPA's response to significant comments received during the comment period is included in the responsiveness summary, which is appendix B of this ROD. Public and tribal comments that were submitted are located in the administrative record <http://pdw.hanford.gov/arpir/pdf.cfm?accession=0087260> file. The administrative records are available at <http://pdw.hanford.gov/arpir/> under "predefined searches", "select by operable unit."

Hanford Public Information Repository Locations

Portland
Portland State University
Branford P. Millar Library
1875 SW Park Avenue
Portland, OR
(503) 725-4542

Seattle
University of Washington
Suzallo Library, Government Publications Department
P.O. Box 352900
Seattle, WA 98195
(206) 543-5597

Richland
Washington State University, Tri Cities
Consolidated Information Center
Room 101 L
2770 University Drive,
Richland, WA
(509) 375-3308

Spokane
Gonzaga University Foley Center Library
East 502 Boone Ave.,
Spokane, WA 99258
(509) 313-6110

4.0 SCOPE AND ROLE OF OPERABLE UNITS OR RESPONSE ACTION

The process for characterization and remediation of waste sites at the Hanford Site is addressed by the Tri-Party Agreement. The River Corridor and the Central Plateau are the two main geographic areas of cleanup work on the Hanford Site. The River Corridor includes the former fuel fabrication and reactor operations areas adjacent to the Columbia River. The Central Plateau includes the former fuel processing facilities and numerous waste disposal facilities. The objective of the cleanup strategy is to ensure cleanup actions address all threats to human health and the environment.

The Hanford cleanup strategy includes (1) removing contamination that is close to the Columbia River to support reasonably anticipated future uses, protect the environment, restore groundwater to beneficial use and ensure the aquatic life in the Columbia River is protected; and (2) moving the contaminated material to the Central Plateau or other EPA-approved disposal facility in accordance with CERCLA remedy requirements. This involves restoration of groundwater beneath the Hanford Site to DWSs and ensuring that aquatic life in the Columbia River is protected by achieving Ambient Water Quality Standards in areas where groundwater discharges to surface water. Long-term industrial activities are expected to continue in the 300 Area Industrial Complex.

Contaminated groundwater that migrates into the 300 Area from other areas, including from off site and contamination from the 200 Area are not part of 300-FF-5 and are not being addressed under this ROD. The groundwater contamination from the 200 Area will be addressed under a separate ROD for 200-PO-1. The Fast Flux Test Facility Reactor and associated facilities are not included in 300-FF-2 and are not addressed by this ROD.

This ROD addresses the risk from releases and potential releases in the following OUs:

- 300-FF-1 waste sites (limited to three waste sites with uranium in the deep vadose zone as a risk to groundwater)
- 300-FF-2 waste sites
- 300-FF-5 groundwater

Portions of the 300 Area shown in figure 1 not included in these OUs are the following:

- Hanford Patrol Training Academy including the firing ranges (active facility)
- Fast Flux Test Facility reactor and associated structures (now inactive)
- Energy Northwest and Bonneville Power Administration facilities (active facility)
- Volpentest HAMMER Training and Education Facility (active facility)
- Groundwater contamination emanating from the 200 Area (addressed in 200-PO-1) and nitrate from other than 300 Area sources
- Buildings

There have been several CERCLA and Resource Conservation and Recovery Act of 1976 (RCRA) decisions made for the 300 Area, as listed below. Interim actions were initiated in the 300 Area in 1996 for contaminated groundwater in 300-FF-5 and in 2001 for contaminated waste sites in 300-FF-2. The following are the RODs and associated Explanations of Significant Differences for these operable units:

- 1996 Record of Decision for 300-FF-1 and 300-FF-5 Operable Units (EPA/ROD/R10-96/143) (final action for the 300-FF-1 OU and interim action for the 300-FF-5 OU)
- 2000 Explanation of Significant Difference for 300-FF-5 Operable Unit Record of Decision (EPA/ESD/R10-00/524)
- 2001 Record of Decision for 300-FF-2 Operable Unit (EPA/ROD/R10-01/119) (interim action for the 300-FF-2 OU)
- 2004 Explanation of Significant Difference for 300-FF-2 Operable Unit Record of Decision
- 2009 Explanation of Significant Difference for 300-FF-2 Operable Unit Record of Decision
- 2011 Explanation of Significant Difference for 300-FF-2 Operable Unit Record of Decision

A final action ROD was issued for 300-FF-1. In 2000 an Explanation of Significant Differences was issued for the 300-FF-1 ROD. The remediation activities specified in the 300-FF-1 ROD are complete except for ongoing land use ICs. Data and information have been evaluated that identifies the need for an amendment to address risk to groundwater due to remaining uranium contamination.

Five action memoranda that apply to building deactivation, decommission, decontamination and demolition in the 300 Area:

- Action Memorandum for the 331 A Virology Laboratory Building
- Action Memorandum #1 for the 300 Area Facilities
- Action Memorandum #2 for the 300 Area Facilities
- Action Memorandum #3 for the 300 Area Facilities
- Action Memorandum for General Hanford Site Decommissioning Activities

Two removal actions for waste sites were approved in 1991 to mitigate the threat to human health and the environment from contaminant migration in the 300 Area (removal of soil from the 300 Area Process Trenches in 300-FF-1 and removal and disposal of drums containing uranium contaminated hexone from the 618-9 Burial Ground in 300-FF-2).

Three five-year review reports have been issued. CERCLA and the NCP (40 CFR 300) require that remedial actions that result in hazardous substances, pollutants or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed at least every 5 years after initiation of the selected remedial action to ensure that human health and the

environment are being protected by the remedial action being implemented. Three five-year reviews have been completed for the Hanford Site:

- 2001 – Hanford Site First CERCLA Five Year Review Report
- 2006 – Hanford Site Second CERCLA Five Year Review Report (DOE/RL-2006-20)
- 2012 – Hanford Site Third CERCLA Five Year Review Report (DOE/RL-2011-56)

Two RCRA Treatment, Storage and Disposal (TSD) units are currently permitted to operate in the 300 Area: the 325 Hazardous Waste Treatment Units (325 HWTU) and the 400 Area Waste Management Unit (400 40). Closure of these TSD units will occur in accordance with the Hanford Facility Dangerous Waste Permit.

Fourteen RCRA TSD Units in the 300 Area Industrial Complex have been certified by DOE as clean closed between 1995 and 2011: 300 Area Solvent Evaporator; 304 Concretion Facility; Thermal Treatment Test Facilities; Physical and Chemical Treatment Test Facilities; Biological Treatment Test Facilities; 332 Storage Facility; 324 Pilot Plant; 3718 F Alkali Metal Treatment & Storage Area; 311 Tanks Capacity; 303 K Storage Facility; 300 Area Waste Acid Treatment System; 303 M Oxide Facility; 305 B Storage Facility; and 331 C Storage Unit.

The Radiochemical Engineering Cells, High-Level Vault, Low-Level Vault and associated areas within the 324 Building are planned to be closed under DOE/RL-96-73 Closure Plan and coordinated with CERCLA Action Memorandum #2 for the 324 Building.

Three RCRA TSD Units in the 400 Area have been certified by DOE as clean closed between 1997 and 2003, namely the 4843 Alkali Metal Storage Facility, 437 Maintenance and Storage Facility and Sodium Storage Facility & Sodium Reaction Facility.

One RCRA TSD Unit in the 600 Area has been certified by DOE as clean closed in 1995, namely the Hanford Patrol Academy Demolition Sites. There was no residual radionuclide contamination following the RCRA closure, and no subsequent waste site was identified.

The 300 Area Process Trenches in 300-FF-1 were also a RCRA TSD unit that consisted of two parallel, unlined infiltration trenches. Closure activities have been certified by DOE as completed. Postclosure groundwater monitoring required by RCRA is conducted in accordance with DOE/RL-93-73, 300 Area Process Trenches Modified Closure/Postclosure Plan, which is incorporated into WA7890008967, Hanford Facility RCRA Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage and Disposal of Dangerous Waste. The CERCLA remedial program used the data and information from the RCRA monitoring in the evaluation that identified the need for an amendment to address risk to groundwater due to remaining uranium contamination.

5.0 SITE CHARACTERISTICS

The following subsection presents information on the operable units' surface features, current land and groundwater uses, extent and nature of contamination, including groundwater plumes and the conceptual model on contaminant migration and the potential contaminant receptors.

5.1 Site Features and Land and Groundwater

Major facilities exist in the 300 Area. Demolition of 300 Area Industrial Complex facilities is ongoing. Some of the facilities and utilities in support of the continuing mission of the Pacific Northwest National Laboratory in the 300 Area are expected to be retained through at least 2027 (figure 3). In addition, industrial activities continue in the 300 Area that are not part of the OUs being addressed by this ROD, including those associated with electrical power generation (Energy Northwest), training (HAMMER) and security (Hanford Patrol Academy). Deactivation activities were completed at the Fast Flux Test Facility Reactor (400 Area), which was placed in a long-term, low-cost surveillance and maintenance condition in 2009.

Within the 300 Area, groundwater is withdrawn from three water supply wells by Energy Northwest for drinking water and fire protection; and from three water supply wells in the 400 Area for drinking water. Groundwater samples from these water supply wells are monitored. In addition, groundwater contaminated with uranium is withdrawn from one well by Pacific Northwest National Laboratory for use in back-flushing filters used for fisheries research in the 331 Life Sciences Laboratory. Groundwater withdrawn from outside of 300-FF-5 is used to supply water for dust suppression during CERCLA remediation activities. The City of Richland provides potable water to the 300 Area Industrial Complex facilities.

Many communities downstream of the 300 Area and overall Hanford site draw water from the Columbia River for all or part of their domestic water supply. The City of Richland's water uptake from the Columbia River approximately 4 km (2.5 miles) downstream from the 300 Area is the closest municipal water intake to the Hanford Site. No alternate water sources have been required for the City of Richland because of contamination resulting from Hanford operations.



Figure 3. Long-term Retained Facilities in the 300 Area Industrial Complex

5.1.1 Physical Features Affecting Remedy Selection

The ground surface in the 300 Area Industrial Complex is flat except for a steep slope on the eastern edge down to the Columbia River which is the only surface water feature in the area. For the rest of the 300 Area, surface elevations change from approximately 137 m (449 ft) above mean sea level at the inland 618-11 Burial Ground to approximately 115 m (377 ft) at the 300 Area Industrial Complex.

The vadose zone is comprised of backfill materials and unconsolidated gravels and sand of the Hanford formation. In the 300 Area Industrial Complex, the average thickness of the vadose zone in the area of the waste sites is 10 m (33 ft); the thickness of the vadose zone at the 618-10 Burial Ground, the 618-11 Burial Ground and the 400 Area is 21 m (68 ft), 19 m (63 ft) and 31 m (125 ft), respectively.

As the river water height goes up and down on a seasonal cycle, so too does the groundwater level throughout the 300 Area Industrial Complex that abuts the river. Rising groundwater saturates what usually is the deep layer of the vadose zone. In some years, the river water height is much higher and remains high for much longer than in most years, and resulting elevated groundwater saturates deep vadose zone layers that may not have been wet for years. This fluctuating groundwater elevation creates the PRZ (figure 4).

The unconfined aquifer occurs in the highly permeable gravel-dominated Hanford formation and in the underlying, less permeable sands and gravels of the Ringold Formation (figure 5). The Ringold Formation lower mud unit is a confining layer, the aquitard at the base of the unconfined aquifer, and is characterized by very low permeability fine-grained sediment. This hydrologic unit prevents further downward movement of groundwater contamination to the deeper aquifers. The thickness of the unconfined aquifer along the Columbia River shoreline is about 25 m (80 ft).

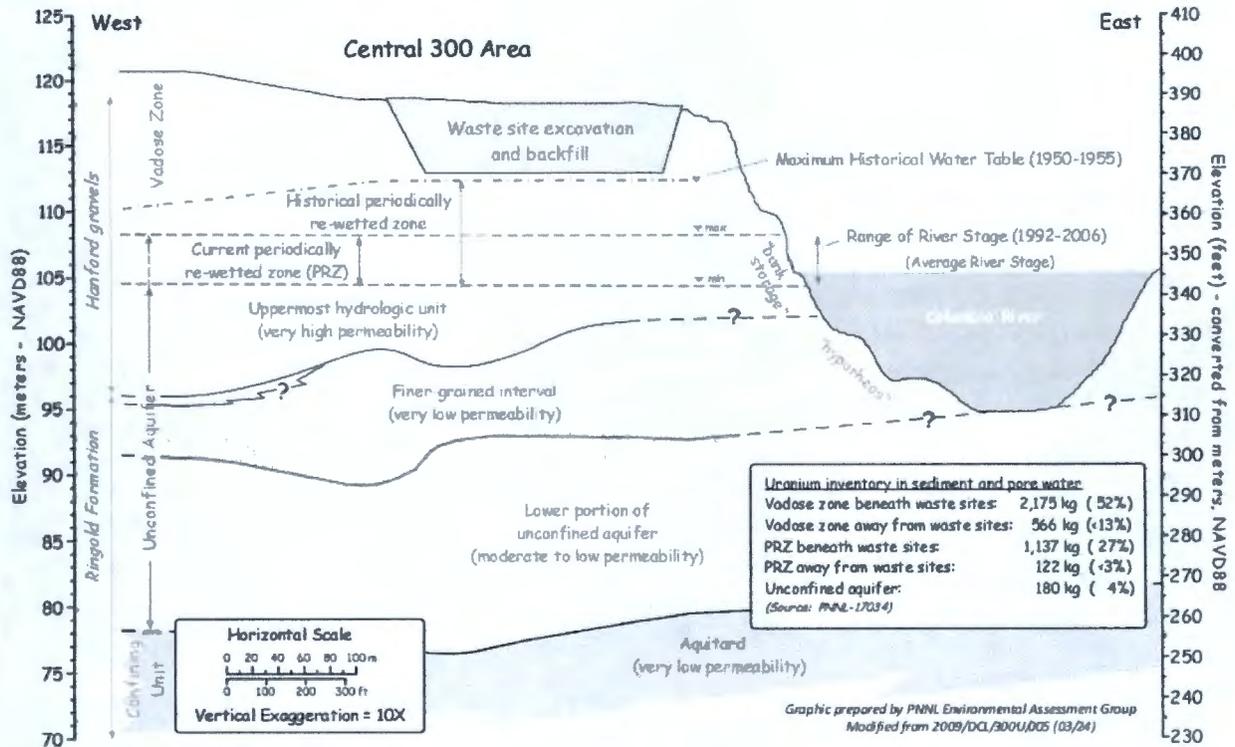


Figure 4. Principal Subsurface Features with PRZ and Uranium Inventory Estimates

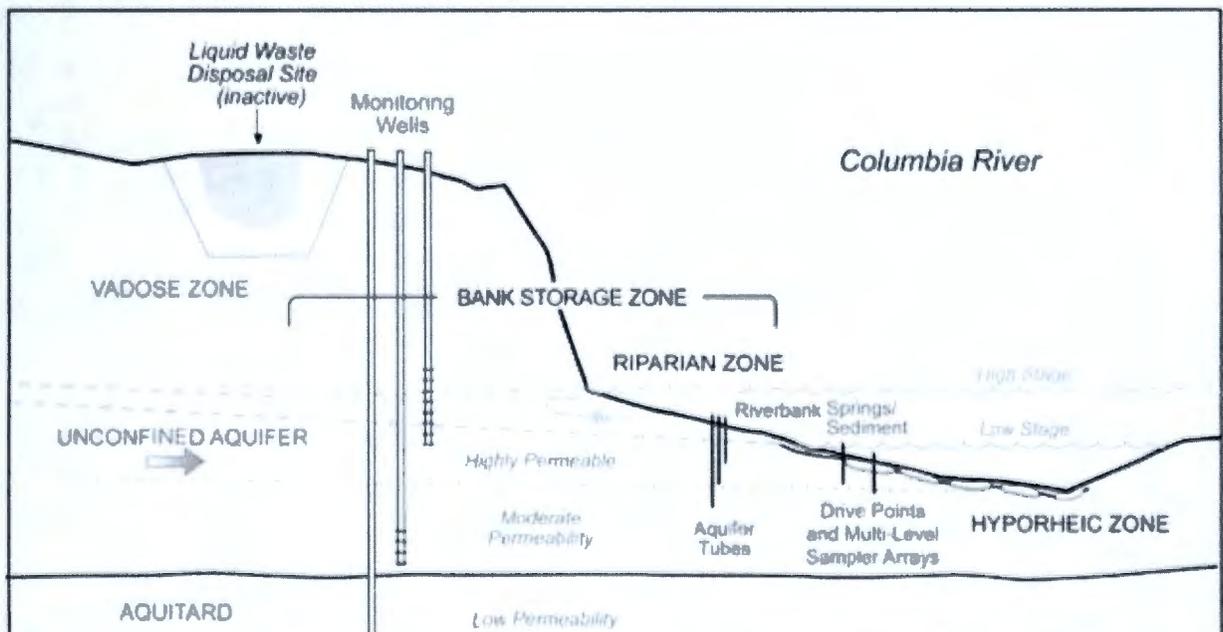


Figure 5. Conceptual Site Model of River and Groundwater Mixing Zone

Groundwater in the unconfined aquifer discharges to the Columbia River via upwelling through the riverbed and riverbank springs and seeps. The flux from the Hanford Site aquifer is very low, compared to the flow of the river. Because the river stage regularly fluctuates up and down, flow beneath the shoreline is back and forth, with river water intruding into the unconfined aquifer and mixing with groundwater at times. When the river stage drops quickly to a low elevation, riverbank seeps appear.

Groundwater flow velocities beneath the 300 Area in the Hanford formation portion of the aquifer are rapid, with rates up to 18 m/d (59 ft/d) having been observed. However, the hydraulic gradients change direction in response to river stage, which fluctuates on seasonal and multiyear cycles. Consequently, groundwater flow is not always directed toward the river.

In general, regional groundwater flow converges from the northwest, west and southwest, inducing an east-southeast flow direction in the 300 Area. During periods of extended high river stage (March through June), water flows from the river into the groundwater. The rise and fall of the river stage creates a dynamic zone of interaction between groundwater and river water (figure 4), affecting groundwater flow patterns, contaminant transport rates (e.g., uranium in groundwater), groundwater geochemistry, contaminant concentrations and attenuation rates.

Key geohydrologic factors considered in the remedy selection for deep uranium are the interaction between the groundwater and the Columbia River, the relatively high permeability of the sands and gravels in the vadose zone and unconfined aquifer and the lateral extent of the PRZ. When groundwater rises into the PRZ, it mobilizes residual mobile uranium contamination. Some of the mobilized residual uranium moves vertically to groundwater, some moves laterally to the nearby PRZ and some is redeposited back near the original location. In addition to river water fluctuations, small amounts of precipitation periodically percolate down toward the groundwater, which can further move uranium contamination to the PRZ and groundwater. The result is the deep uranium contamination spreads vertically and laterally with each high water event. This periodic input of mobile uranium to the groundwater results in a persistent uranium plume and continued discharge of relatively low uranium concentrations to the river until the source of uranium is depleted.

The development of alternatives in the RI/FS, which also are presented here, considered the extent of contamination, rates of attenuation and the benefits and problems with technologies available to address mobile uranium in the deep vadose zone and PRZ. The lateral extent of the PRZ limits the effectiveness of several technologies, including deep excavation, as a remedy to remove contamination that has migrated vertically to the PRZ and laterally away from the footprint of the waste site sources.

5.1.2 Waste Site Contamination

300-FF-1 waste sites in this ROD Amendment received liquid waste containing nitrate, uranium and other metals, organics and radionuclides. 300-FF-2 waste sites were likewise contaminated with liquid waste and/or solid waste. Most of the mobile contaminants, such as nitrate, have migrated through the vadose zone to groundwater. Primary contaminants in solid waste disposed

in burial grounds were uranium and other metals, plutonium (primarily in the 618-2 Burial Ground, 618-10 Burial Ground and the 618-11 Burial Ground), tritium and other fission products and nitrate. The solid wastes were buried up to 8 m (25 ft) below ground.

Many of the 300-FF-2 waste sites resulted from chemical and radionuclide releases under and around 300 Area buildings. Buildings are or will be addressed by CERCLA Action Memoranda, but waste sites resulting from building releases are in 300-FF-2. Many 300 Area buildings contained structural materials such as asbestos, mercury, lead and PCBs that are in waste sites. Most of the contamination resulted from facility processes, primarily laboratory waste and uranium fuel rod production.

Most of the uranium disposed in the 300 Area has been exhumed and disposed in ERDF. Residual uranium in the deep vadose zone is associated with the South Process Pond (316-1), North Process Pond (316-2) and 300 Area Process Trenches (316-5) in 300-FF-1 and 618-1, 618-2 and 618-3 burial grounds and 307 Process Trenches (316-3) in 300-FF-2. The PRZ contaminated by releases from these waste sites serves as the primary contributor of uranium to groundwater. Measurements were made to characterize the uranium inventories in the 300 Area Industrial Complex. A summary of the residual uranium inventories is presented in figure 6.

Soil sampling in the southwestern portion of the North Process Pond (316-2) near the former effluent inlet, and in the southern portion of the 300 Area Process Trenches (316-5) identified elevated uranium concentrations in the vadose zone and PRZ. Uranium concentrations increase in groundwater at these locations when the water table rises during high river stage, indicating that these locations constitute significant sources of ongoing groundwater contamination. Soil sampling at the 307 Process Trenches (316-3) identified uranium concentrations in the vadose zone under the central and eastern portions of the 307 Process Trenches.

In addition to the seven sites listed above, the following burial grounds have contributed to uranium in groundwater:

- At the 618-7 Burial Ground, a new area of uranium contamination in groundwater developed in 2008 as a result of infiltration of dust-control water during implementation of the interim remedial action. Uranium concentrations at nearby down gradient wells subsequently decreased. However, during the unusually high water table conditions in 2011, the uranium concentration temporarily increased because of the presence of mobile uranium in the lower portion of the vadose zone at this location. The 618-7 Burial Ground received solid waste containing uranium from fuel fabrication processes.
- The 618-10 Burial Ground and adjacent 316-4 Crib are the sources of uranium detected in groundwater at the 618-10 Burial Ground site. Uranium concentrations in nearby down gradient wells increased in 2004 and again in 2012 following application of dust-control water during implementation of the interim remedial action. The 316-4 Crib received liquid waste containing uranium.

The 618-10 and the 618-11 Burial Grounds contain a broad spectrum of low-level radioactive waste including fission products and byproduct waste (thorium and uranium), as well as waste with transuranic constituents. The 618-11 Burial Ground was the source of nitrate and of the tritium gas that interacted with vadose zone moisture and eventually entered groundwater.

Investigation of the soils beneath the 324 Building indicates that cesium-137 contamination extends at least 1.5 m (5 ft) below the building floor (4.0 m [13 ft] below grade) and strontium-90 contamination extends at least 9.1 m (30 ft) below grade, which is approximately 7.6 m (25 ft) above average groundwater levels. The contamination was discovered during deactivation, decommission, decontamination and demolition activities at the building in 2009, but likely resulted from a 1986 unplanned release of liquid within the B-Cell. A portion of the spill is believed to have left the cell through a leak in the floor, creating waste site 300-296.

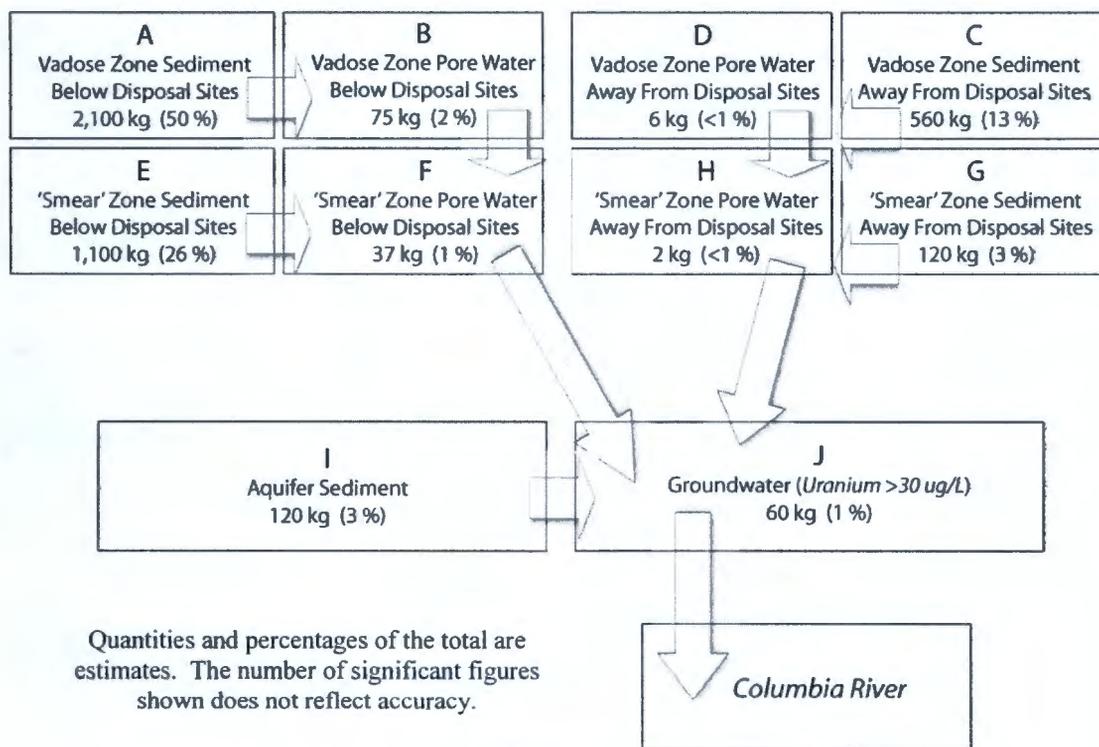


Figure 6. Estimated Residual Uranium Inventory and Exchange Paths Among Subsurface Compartments

5.1.3 Groundwater Contamination

Groundwater contaminants that are at levels that exceed Federal or State DWS in 300-FF-5 are uranium, gross alpha, tritium, nitrate, TCE and DCE. Groundwater contaminants do not exceed Federal or State ecological protection standards or risk-based thresholds near the river or where groundwater discharges into the river.

The contamination observed currently in the subsurface has resulted from activities that occurred in the past; especially during the peak nuclear fuels and plutonium production years of the 1950s and 1960s. High volume waste effluents resulting from fabrication of nuclear fuel assemblies were sent to ponds and trenches for infiltration into the soil column. Effluents were typically acidic, which promoted movement through environmental pathways, and contained significant quantities of uranium and other metals such as copper. Volatile organic chemicals (VOCs) such as TCE were used extensively and included in the effluent.

Other chemicals and radionuclides resulting from fuels processing research were also disposed to ponds and trenches, but in lesser volumes. Solid wastes from 300 Area activities were buried at locations within the 300 Area, or sent to outlying burial grounds when radiation levels of the waste were too high for densely occupied areas.

Contaminants retained on sediment at many of the disposal facilities including solid waste burial grounds has been removed by RTD interim remedial actions. Contamination currently observed in the soils and groundwater beneath the 300 Area is residual amounts that persist for a variety of reasons. Attenuation of these contaminants, to a greater and lesser degree, is dependent on contaminant properties and continues to occur by natural processes along environmental pathways away from the source locations. Contamination that has entered the groundwater pathway ultimately discharges to the Columbia River via upwelling through the riverbed sediment and occasionally through riverbank seeps. Groundwater contamination today is residual and will attenuate more slowly than when higher levels were present during operations.

Discharge of liquid waste during operations formed groundwater mounds beneath the disposal waste sites. Mobile contaminants, including volatile organic solvents such as tetrachloroethene, migrated with the flow of liquid, while less mobile contaminants such as uranium migrated at slower rates. The mounds dissipated after discharge ceased, with a portion of the contaminants dispersed inland. Groundwater is no longer contaminated with detectable concentrations of tetrachloroethene.

Contaminants can remain in the vadose zone following active liquid waste discharge as dissolved fractions within pore water or sorbed to soil until sufficient moisture is available for transport. Uranium is present in the lower vadose zone. The form uranium takes in solution is influenced by alkalinity which, in turn, affects uranium mobility. Uranium tends to sorb to aquifer matrix mineral surfaces and be less mobile when alkalinity in the aquifer is lowered. Columbia River water is low in alkalinity. At high river levels, river water infiltrates inland from the shore into the aquifer to some distance dependent on aquifer properties. Portions of the lower vadose zone become periodically rewetted (the PRZ) by a mix of groundwater and river water that is lower in alkalinity than pure groundwater. As a result, uranium in this zone of mixed river water/groundwater is sorbed to a large degree on the matrix mineral surfaces. The combination of uranium sorption and dilution results in diminished uranium concentrations in the river water/groundwater mixing zone during high river levels.

Further inland from the river water/groundwater mixing zone, the river stage creates an interruption of the natural groundwater gradient towards the river, causing groundwater levels to rise into the PRZ. In these inland areas, the relatively high-alkalinity groundwater comes in contact with uranium in the PRZ (in the form of both entrained vadose zone water and sorbed forms). Under these conditions, the uranium takes the form of a negative ion carbonate complex, which has less tendency to sorb. The overall effect is that in the inland areas, uranium concentrations rise in groundwater as the water table rises during high river stages (figure 5).

The uranium plume in groundwater that exceeds the 30 µg/L DWS covers approximately 0.5 km² (0.2 mi²) in the 300 Area Industrial Complex. There are much smaller uranium groundwater plumes down gradient of the 618-7 and 618-10 Burial Grounds. The volume of the main uranium plume is approximately 1,000,000 m³ (35 million ft³) with a dissolved uranium mass of approximately 60 kg (132 lbs). The extent of Columbia River shoreline where the uranium concentrations exceed the DWS during low river stage is approximately 1,200 m (3,400 ft). Figure 7 presents the groundwater uranium plumes for winter (low river stage) and summer (high river stage) seasons in 2011.

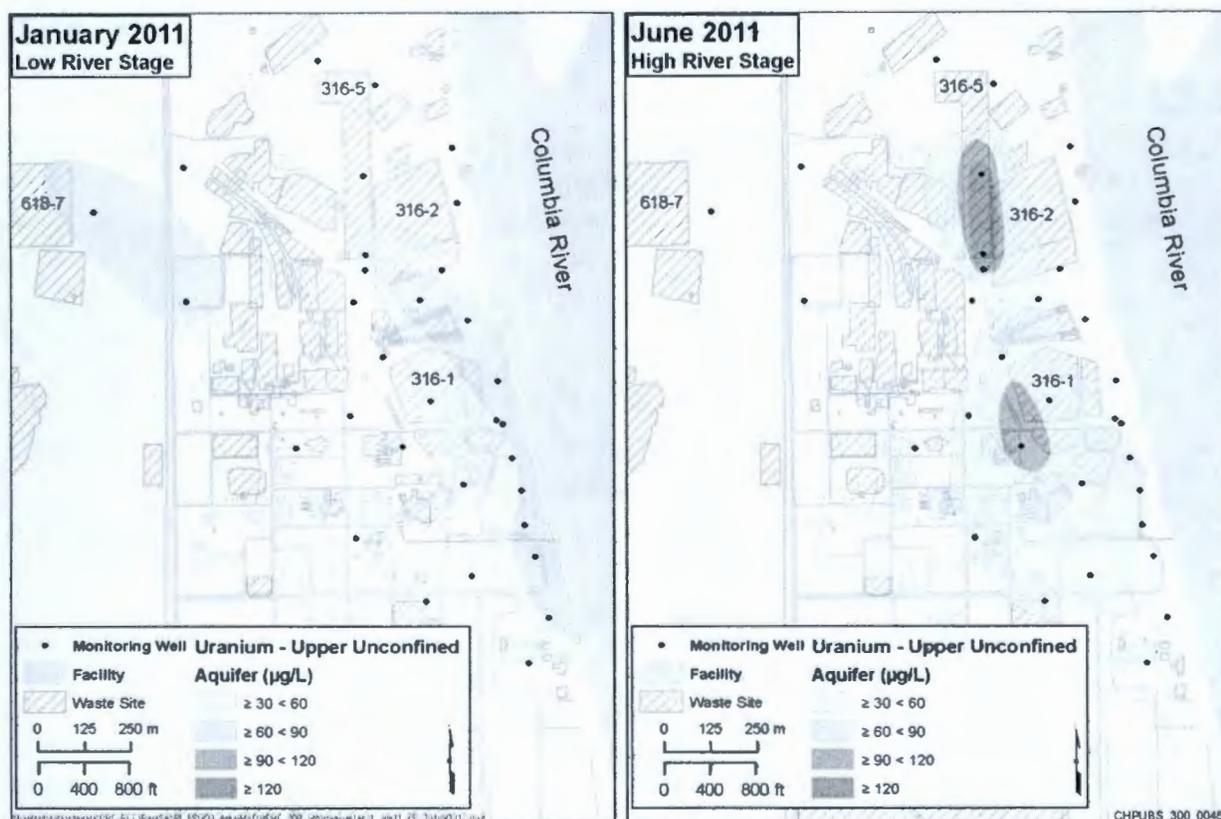


Figure 7. Uranium Plume in Groundwater, Winter and Summer 2011

Tritium in groundwater that exceeds the 20,000 picocurie per liter (pCi/L) DWS occurs in five wells down gradient from the 618-11 Burial Ground. Tritium concentrations from the 618-11 Burial Ground (figure 8) do not, and are not predicted to, affect the Columbia River above the DWS. Nitrate concentrations exceed the DWS at four wells down gradient from the 618-11 Burial Ground. The extent of the nitrate plume is similar to the extent of the tritium plume. Both contaminants disperse in the aquifer as groundwater slowly moves under the Energy Northwest reactor complex.

Nitrate in the 300 Area Industrial Complex exceeds the 45 mg/L DWS in areas where groundwater has been affected by off-site activities. Elevated nitrate concentrations are detected in the southern portion of the 300 Area and result from the migration onsite of nitrate-contaminated groundwater from sources to the southwest. Nitrate from off-site is not part of 300-FF-5.

VOCs that exceed the DWS in 300 Area groundwater are TCE and DCE. For wells that monitor the unconfined aquifer, only two samples were collected during the past five years that exceed the DWS of 5 µg/L for TCE. There have been no TCE detections for the samples collected from the wells that monitor the confined aquifer beneath the unconfined aquifer system.

DCE has been detected consistently at concentrations exceeding the DWS of 70 µg/L at a well located near the southern boundary of the former North Process Pond (316-2). The well monitors groundwater near the bottom of the unconfined aquifer in sandy gravel sediment of relatively low permeability. The origin for DCE is attributed to degradation of TCE disposed to the Process Trenches and/or North Process Pond. In 2011, DCE was also detected above the DWS at a new RI well located approximately 80 m (262 ft) further down gradient and screened at mid-depth in the unconfined aquifer.

TCE and DCE contamination exceeding DWSs is restricted to fine-grained sediment with negligible capacity to yield or transmit groundwater. The greatly restricted hydraulic flow has contained the VOCs in the fine-grained sediment since their disposal decades ago, and has minimized migration of VOCs into the more transmissive portions of the aquifer. Concentrations of these VOCs are not above DWSs in this more transmissive portion of the aquifer that discharges to the Columbia River. Natural attenuation through biodegradation is evident in historical monitoring results from well 399-1-16B, where TCE has degraded to DCE. Over the past 20 years, TCE concentrations from this well have decreased to below the DWS whereas DCE concentrations have remained fairly stable. DCE can then further degrade anaerobically to vinyl chloride, which then degrades either anaerobically or aerobically to CO₂. DCE can also degrade directly to CO₂ under aerobic conditions. The absence of vinyl chloride in down gradient wells indicates that these contaminants are degrading aerobically. The limited areal extent of VOCs in groundwater shows that these natural attenuation processes are working to prevent significant migration of VOCs.

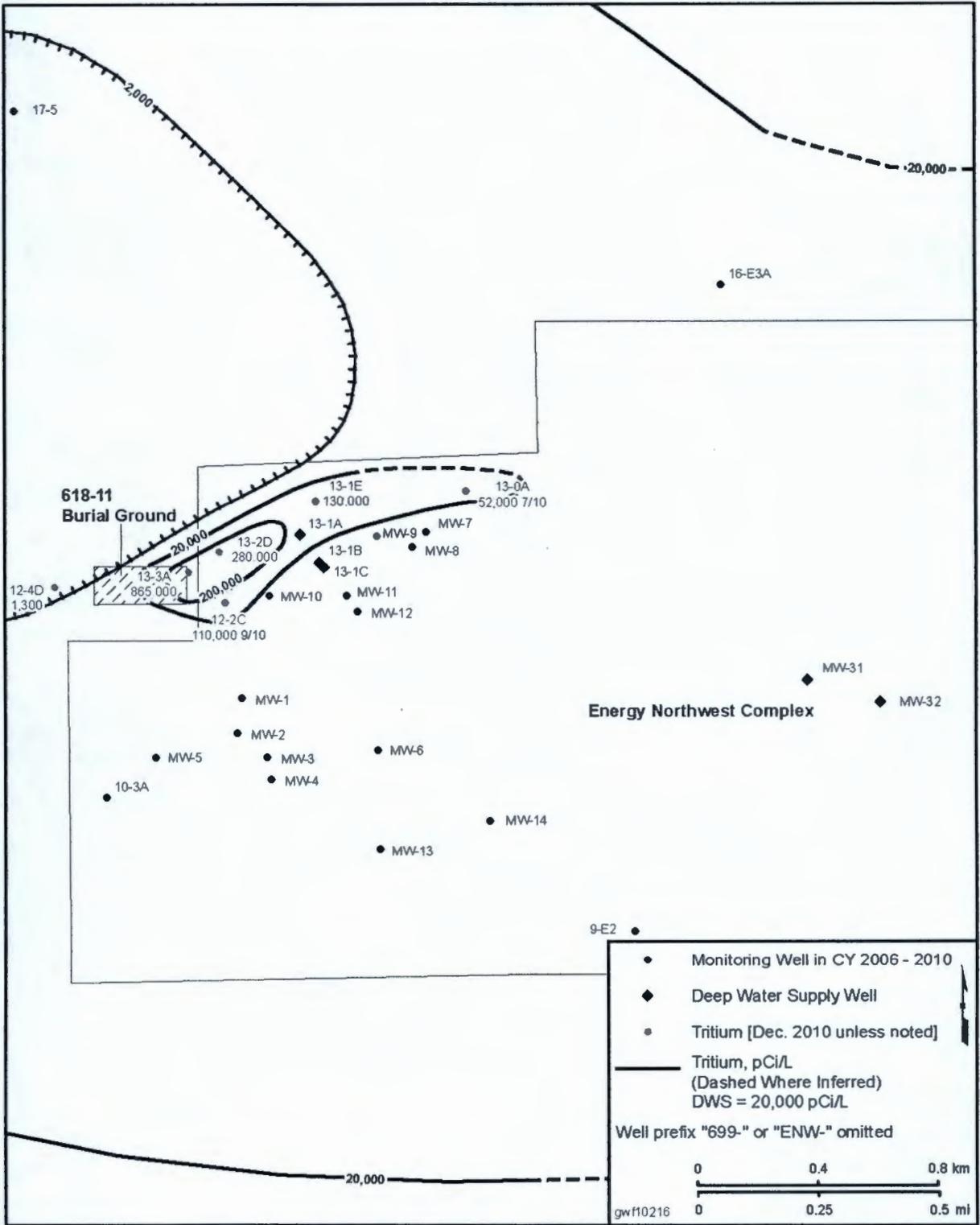


Figure 8. Tritium plume from 618-11 Burial Ground

6.0 CURRENT AND POTENTIAL FUTURE LAND AND WATER USES

6.1 Current On-site Land Uses

The 300-FF-1, 300-FF-2 and 300-FF-5 OU Areas are managed by the DOE and human access and use is restricted. The 300 Area OUs contains the following: (1) The 300 Area Industrial Complex (major liquid waste disposal sites, burial grounds and other waste sites); (2) The 400 Area waste sites contaminated by releases from the Fast Flux Test Reactor and support facilities; and (3) The 600 Area that includes the 618-11 and 618-10/316-4 Burial Grounds and undeveloped open land. Research and development activities within the 300 Area Industrial Complex are ongoing and projected to continue within designated facilities through at least 2027.

6.2 Current Adjacent/Surrounding Land Uses

Land adjacent to 300-FF-1 and 300-FF-2 waste site areas is shrub steppe habitat with several exceptions: Adjacent and east of 618-11 is an operating commercial nuclear power plant. Adjacent to and east of the 300 Area Industrial Complex is the Columbia River. The southern part of the 300 Area wraps around DOE's Hanford Patrol Academy and HAMMER training facilities. The land use further away, beyond the Hanford boundaries contains irrigated agriculture and to the south and east are the cities of Richland, West Richland and Pasco.

6.3 Reasonably Anticipated Future Land Uses, Expected Timeframes, and Basis for 300-FF-2

The 300 Area Industrial Complex has been an industrial site since the 1940s. This area contains laboratories operated by the Pacific Northwest National Laboratory that are expected to operate at least until 2027. The 618-11 burial ground is immediately adjacent to an operating commercial nuclear reactor. The reasonably anticipated future land use for the 300 Area Industrial Complex and 618-11 is industrial. DOE's reasonably anticipated future land use for the remaining portions of the 300 Area will be industrial whereas EPA believes other uses including residential are the reasonably anticipated future land use for the remaining areas. The expected timeframe for that land use is from the present into the foreseeable future. A portion of 300-FF-2 is mostly uncontaminated land with a small number of waste sites. The small number of waste sites are primarily away from the above active industrial areas and are surrounded by shrub steppe habitat. The 300 Area Industrial Complex and 618-11 have industrial based cleanup levels that will achieve a level of cleanup that allows industrial use. For the remaining portion of 300-FF-2, residential based cleanup levels are used, which also achieves a level of cleanup that allows for industrial use.

The expected timeframe for industrial use for the 300 Area Industrial Complex and 618-11 in 300-FF-2 is from the current time into the reasonably anticipated future. The basis for this is the

current industrial use which is anticipated to continue as discussed above. There are no current land use plans that will result in residential use for the other 300-FF-2 areas so the timeframe for future residential use to begin in those areas is unknown.

6.4 Current Groundwater Use and Designations

Some of the groundwater in 300-FF-5 is currently contaminated above standards, and withdrawal of this contaminated groundwater for uses other than remediation, research and monitoring is prohibited by ICs currently in place pursuant to the 1996 and 2001 RODs. Under current site use conditions and controls, the only complete human exposure pathway to groundwater in 300-FF-5 is the potential for limited exposure to groundwater from intermittent seeps along the Columbia River or during remediation, research and monitoring activities. 300-FF-5 groundwater is not being used for drinking water.

6.5 Potential Beneficial Groundwater Use

The NCP (40 CFR 300) establishes an expectation to “return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site” (“Remedial Investigation/Feasibility Study and Selection of Remedy” [40 CFR 300.430(a)(1)(iii)(F)]). Washington state regulations contain a similar expectation.

Given the nature of the groundwater in 300-FF-5, potential beneficial groundwater uses include drinking water, irrigation and industrial uses. Drinking water use includes other domestic uses such as bathing and cooking. The Tri-Party agencies’ goal for Hanford groundwater is consistent with the NCP.

6.6 Expected Timeframes for Beneficial Groundwater Use

Current and anticipated water use in the 300 Area Industrial Complex is municipal water from the city of Richland. There are no plans to start using 300-FF-5 groundwater as drinking water when standards are met. The expected timeframes to attain the DWSs in 300-FF-5 groundwater are 22-28 years for uranium, and 18 years for tritium. Nitrate above the DWS is from off-site sources and is not part of 300-FF-5 so an expected timeframe to attain the DWS has not been determined. The timeframe for organics TCE and DCE degradation to DWSs could not be estimated. Characterization data and trend data is limited due to the hydraulically tight formation that impedes sample collection.

6.7 Location of Anticipated Groundwater Use in Relation to Contamination

Groundwater monitoring for contamination is ongoing via many wells located throughout 300-FF-5 and that use is anticipated to continue in the future. Current and anticipated water use in the 300 Area Industrial Complex is municipal water from the city of Richland.

7.0 SUMMARY OF SITE RISKS

7.1 Summary of Human Health Risk Assessment

The baseline risk assessment estimates what risks the contamination at the 300 Area OUs poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment.

7.1.1 Human Health Identification of Chemicals of Concern

The human health risk assessment identified uranium, gross alpha, tritium, nitrate, TCE and DCE as COCs in 300-FF-5 groundwater based on a quantitative evaluation of groundwater data. Since most of the gross alpha is associated with total uranium, it will be addressed with the remediation of uranium. The COCs in the soil (table 2) are radionuclides, metals, asbestos, inorganic anions, semivolatile and volatile organics and polychlorinated biphenyls. The COCs in groundwater are listed in table 3. Contaminants of potential concern were initially identified by evaluating the history of operations in the 300 Area and analysis of soil and groundwater samples over time. The initial contaminants of potential concern were refined to COCs during site characterization and risk assessment.

7.1.2 Human Health Exposure Assessment

The current human exposure scenario is industrial. Exposure to contamination in the 300 Area is currently controlled by DOE's site controls to prevent unacceptable exposure to humans. Risks to current workers are managed through use restrictions and health and safety programs.

For purposes of establishing a basis for action and developing CULs, DOE and EPA have agreed to base cleanup assumptions on industrial exposure scenarios in the 300 Area Industrial Complex and 618-11, and residential scenarios elsewhere in 300-FF-2. Residential and industrial human exposure scenarios were evaluated in the River Corridor Baseline Risk Assessment, the Columbia River Component risk assessment and the baseline human health risk assessment in the 300 Area RI/FS Report. The residential, industrial and groundwater scenarios are described in this ROD because they are the basis for action and for the CULs. In addition to these residential and industrial exposure scenarios, the 300 Area RI/FS Report also includes human health risk estimates based on a National Monument worker, casual recreational user and Tribal exposure scenarios.

For assessing risk to chemicals in soil at areas outside the 300 Area Industrial Complex and 618-11, the State Model Toxics Control Act (MTCA) Standard Method B (Washington Administrative Code [WAC] 173-340-740, "Unrestricted Land Use Soil Cleanup Standards", 2007) levels were used. MTCA provides chemical-specific standards that define acceptable risk levels based on reasonable maximum exposure scenarios. For direct contact, these MTCA-based CULs are based on a six-year exposure of a child through incidental soil ingestion but does not

include consumption of site-derived food. For the inhalation pathway, the MTCA (WAC 173-340) Standard Method B air CULs are based on exposure of adults and children from inhalation of vapors and dust in ambient air. The scenario assumes exposure to the top 4.6 m (15 ft) of soil.

Table 2. Selected COCs for 300-FF-2

Exposure Medium: Soil in 300-FF-2.		
Radionuclides	Metals	Volatile Organics
Americium-241	Antimony	1,1,1-Trichloroethane
Cesium-137	Arsenic	1,2-Dichloroethene (total)
Cobalt-60	Barium	Methyl ethyl ketone (2-Butanone)
Europium-152	Beryllium	Methyl isobutyl ketone (hexone) (4-Methyl-2-pentanone)
Europium-154	Cadmium	Benzene
Europium-155	Chromium (total)	Carbon tetrachloride
Iodine-129	Chromium (hexavalent)	Chloroform
Plutonium-238	Cobalt	Cis-1,2-Dichloroethene (DCE)
Plutonium-239/240	Copper	Ethyl acetate
Plutonium-241	Lead	Ethylene glycol
Strontium-90	Lithium	Hexachlorobutadiene
Technetium-99	Manganese	Hexachloroethane
Tritium	Mercury	Tetrachloroethene
Uranium-233/234	Nickel	Toluene
Uranium-235	Selenium	Trichloroethene
Uranium-238	Silver	Vinyl chloride
Nonvolatile Organics	Strontium	Xylene
Total Petroleum Hydrocarbons	Thallium	Semivolatile Organics
Normal paraffin hydrocarbon (kerosene)	Tin	Benzo(a)pyrene
PCB Aroclor 1016	Uranium (total)	Chrysene
PCB Aroclor 1221	Vanadium	Phenanthrene
PCB Aroclor 1232	Zinc	Tributyl phosphate
PCB Aroclor 1242	Other	Inorganic Anions
PCB Aroclor 1248	Asbestos	Cyanide
PCB Aroclor 1254		Fluoride
PCB Aroclor 1260		Nitrate
COC = Contaminant of Concern		
PCB = Polychlorinated Biphenyl		

Table 3. Selected COCs for 300-FF-5		
Exposure Medium: Groundwater in 300-FF-5		
Uranium (as a metal)	Tritium	Cis-1,2-Dichloroethene (DCE)
Gross Alpha	Nitrate	Trichloroethene (TCE)
COC = contaminant of concern		
COCs were detected at concentrations in groundwater higher than DWSs or risk thresholds.		

For assessing residential risk from radionuclides in soil, the residential scenario assumes that exposure to soil within the top 4.6 m (15 ft) occurs over a 30-year period. A residence is established on the waste site and the resident receives exposure from direct contact with the soil from the waste site and through the food chain. This includes potential exposure through external radiation, incidental soil ingestion and inhalation of ambient dust particulates. The food chain pathway includes exposure from consumption of fruits and vegetables grown in a backyard garden and consumption of meat (beef and poultry) and milk from livestock raised in a pasture. Uptake of contamination into crops and livestock is assumed to occur from contamination present in soil. Contaminants in soil are transported through the soil column, into the underlying groundwater, and to a hypothetical down gradient well located at the waste site boundary that is used for drinking water consumption, irrigation of crops and watering livestock and consumption of fish raised in a pond of water from the down gradient well. An additional evaluation was performed for groundwater if the only exposure was through use of groundwater as a drinking water source (which includes other domestic uses such as bathing and cooking).

The exposure pathways and duration in the MTCA unrestricted scenario used to evaluate risk and develop CULs for chemical soil contaminants are less conservative than the default residential scenario in EPA guidance. However EPA guidance allows use of site-specific scenarios for assessing risk and setting CULs. The MTCA unrestricted scenario is single pathway, the lower of the ingestion or inhalation. The EPA default residential scenario uses multiple pathways, which is the sum of ingestion, inhalation and dermal pathways. The MTCA duration is six years for ingestion and is thirty years for inhalation. The EPA duration is thirty years for all pathways. The cancer risk limit for soil individual chemical CULs were set at the 1×10^{-6} limit in MTCA. Soil chemical CULs must also meet the multi-contaminant total cancer risk limit in MTCA of 1×10^{-5} . Although MTCA is less conservative on the risk scenarios, the acceptable MTCA risk limits are at the conservative end of the NCP cancer risk range, which is 1×10^{-4} to 1×10^{-6} . MTCA uses the same hazard index of one limit as EPA for non-cancer toxic effects.

The cancer risk limit for soil radionuclide CULs were set at 1×10^{-4} risk limit or 15 mrem/year for isotopes where that is more conservative. Soil radionuclide CULs must also meet the multi-contaminant total cancer risk limit of 1×10^{-4} . These soil risk limits were applied to both the industrial and residential scenarios.

For assessing the industrial scenario risks from chemicals in soil, the MTCA Standard Method C (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties", 2007) calculated levels were used. MTCA provides chemical-specific standards that define acceptable risk levels based

on reasonable maximum exposure scenarios. For direct contact, these MTCA-based CULs are based on exposure of an adult from incidental soil ingestion and inhalation. The MTCA-based industrial exposure for chemicals includes incidental soil consumption of 50 mg/day, and an exposure duration of 250 days/year for 20 years. The MTCA industrial scenario is single pathway, the lower of the ingestion or inhalation. The EPA guidance default industrial scenario is a multi-pathway approach, which is the sum of ingestion, inhalation and dermal pathways. The MTCA duration is 20 years for ingestion and inhalation. The EPA duration is 25 years for all pathways. Key exposure parameters in the MTCA industrial scenario used for assessing risk and developing soil chemical CULs are less conservative than in the EPA guidance. In contrast, the total cancer acceptable risk limit for chemicals in soil is set at the 1×10^{-5} limit in MTCA. In addition, the chemicals in soil multi-contaminant total cancer risk limit in MTCA is 1×10^{-5} . MTCA uses the same hazard index of one limit as EPA for non-cancer toxic effects.

Human health risk from exposure to groundwater was evaluated through risk calculations and comparison to federal and state drinking water or cleanup standards. For assessing human health risks from radionuclides and chemicals in groundwater, the methodology identified in EPA's tap water scenario was used (residential drinking water source in EPA's "Regional Screening Levels for Chemical Contaminants at Superfund Sites"). The approach used assumes that the groundwater is used as a tap water source for a 30 year period. Potential routes of exposure include ingestion, dermal contact and inhalation of volatiles during household activities. Groundwater concentrations were also compared to existing federal and state drinking water or cleanup standards.

Contaminant fate and transport modeling was performed to simulate and predict the movement of uranium from the vadose zone sediments, through the PRZ, and into the saturated zone, as well as the migration of uranium already present in the PRZ and saturated zone. The model predictions indicate a long-term declining trend in the dissolved uranium concentrations in groundwater for uranium transported from vadose zone sediments, with seasonal increases and decreases in concentrations as the water table rises and falls with river stage fluctuations. With no remedial actions, the dissolved uranium concentration is predicted to take approximately 28 years (starting in 2012) to drop below the DWS of 30 $\mu\text{g/L}$. The estimates of the time for the uranium concentration to decline below the DWS for each remedial alternative were based on the longer time of either the 90th percentile, or the 95 percent upper confidence limit on the mean of the uranium concentration in the most contaminated monitoring well. These fate and transport simulations assume that the current hydrologic and chemical conditions remain unchanged. This two-dimensional model was developed specifically for this evaluation, incorporating data collected since the original modeling was performed that supported the 1996 ROD, and includes more physically-based treatment of uranium sorption and desorption processes based on information about uranium transport in this environment learned from research at DOE's Integrated Field Research Center test site located in the former South Process Pond (316-1).

Transport modeling was performed for tritium, TCE and DCE, groundwater contaminants that are locally present in the aquifer. A fate and transport model was constructed for the tritium in the groundwater that exceeds the federal DWS beneath the 618-11 Burial Ground. This analysis

determined that the tritium concentrations would decline to below the DWS by 2031 under all alternatives, assuming no additional tritium input to groundwater. Analysis of chemical degradation and transport modeling of organics disposed of in the former 300 Area Process Trenches explain the TCE and DCE concentrations currently observed in groundwater.

7.1.3 Human Health Toxicity and Risk Characterization, Including Uncertainty Analysis

A total of 70 previously remediated waste sites with closeout verification data from the shallow vadose zone from 0 to 4.6 m (0 to 15 ft) bgs were evaluated in the RI risk assessment. Four of these previously remediated waste sites (316-1, 316-2, 316-5 and 618-3) contained residual uranium contamination that resulted in excess lifetime cancer risks greater than 1×10^{-4} based on the residential exposure scenario. However, these four waste sites are located within the 300 Area Industrial Complex and result in an excess lifetime cancer risk of less than 1×10^{-4} based on the industrial exposure scenario. All other previously remediated waste sites report a total excess lifetime cancer risk less than the MTCA ("Human Health Risk Assessment Procedures" [WAC 173-340-708(5)]) total risk threshold of 1×10^{-5} and a hazard index less than one for both the residential and industrial exposure scenarios. These scenarios and risk limits were used in setting PRGs in the risk assessment.

For waste sites that had not been previously remediated, process knowledge for these sites, and contamination and risk information for analogous waste in remediated sites was used to establish a basis for action and support remedy selection. Some of the sites not previously remediated had sample data which was used in the risk analysis.

Both the residential and industrial risk assessment scenarios considered direct exposure to contamination within the vadose zone upper 4.6 m (0 to 15 ft) bgs. In the risk assessment, closeout verification data from the only four sites excavated into the deep vadose zone were evaluated to identify where exposure to residual contamination could present a potential risk from an inadvertent exposure through deep excavation activities. Residential PRGs were used to identify where unacceptable risk could occur under unrestricted exposure. Two of the four previously remediated waste sites (618-1 and 618-2) contained residual radioisotope concentrations that resulted in an excess lifetime cancer risk greater than 1×10^{-4} based on the residential exposure scenario. Radionuclides associated with historical waste disposal contribute to the majority of the risk and will decay to concentrations less than the residential PRGs within 60 years.

The 70 previously remediated waste sites with closeout verification data were also evaluated as potential sources for groundwater and surface water contamination. Five of these waste sites had residual uranium contamination that exceeds soil PRGs for protection of groundwater. The five waste sites are the North Process Pond (316-2), the 300 Area Process Trenches (316-5) and the 618-1, 618-2 and 618-3 Burial Grounds. No other soil contaminants were identified that exceeded chemical or radionuclide soil PRGs which would cause an unacceptable risk to groundwater or the Columbia River.

Groundwater was evaluated as a potential drinking water source through a comparison of the exposure point concentration for each contaminant against the lowest applicable standard or risk-based concentration, including federal and state DWSs and MTCA-based groundwater CULs. To facilitate evaluation, groundwater within the 300-FF-5 groundwater OU was evaluated at two geographic locations: groundwater beneath the 300 Area Industrial Complex and groundwater beneath the 600 Area subregion.

A total of 54 monitoring wells completed in the unconfined aquifer within the 300 Area Industrial Complex were evaluated in the risk assessment. Of these, 15 wells were specifically sampled during the remedial investigation to address uncertainties. The groundwater beneath the 300 Area Industrial Complex contains uranium that is greater than the DWS of 30 µg/L.

Groundwater below the 300 Area Industrial Complex contains nitrate below the DWS of 45,000 µg/L due to 300 Area activities. Nitrate above the DWS of 45,000 µg/L is due to off-Hanford sources and is not part of 300-FF-5 and this ROD.

Two VOCs (TCE and DCE) have also been detected in the groundwater below the 300 Area Industrial Complex at concentrations that exceed both the risk-based concentration (based on the 2007 MTCA B groundwater CULs) and the federal and state DWS. Historically, TCE has exceeded the risk-based MTCA CUL (4 µg/L) and the DWS (5 µg/L) in a single well (399-4-14). Concentrations from this well ranged between less than 1 to 14 µg/L from 2007 through 2011. During the final sample event for the RI/FS, TCE was also measured above the risk-based level in well 399-4-1 at a concentration of 4.1 µg/L.

Similarly, DCE has been present above the risk-based MTCA CUL (16 µg/L) and the DWS (70 µg/L) in two wells (399-1-16B and 399-1-57) in the 300 Area Industrial Complex. Well 399-1-16B was completed in a relatively low-permeability interval that is difficult to monitor because of low recharge rates in this formation. Historical DCE concentrations from this well ranged between 97 to 230 µg/L from 2007 through 2011. During the final sample event for the RI/FS, DCE was also measured above the MTCA risk-based level and DWS in well 399-1-57 at a concentration of 110 µg/L.

A total of 17 monitoring wells are completed in the unconfined aquifer within the 600 Area subregion and were evaluated in the risk assessment. All of these wells were specifically sampled during the remedial investigation. Groundwater beneath the 600 Area subregion received releases from the 618-7, 618-10 and 618-11 Burial Grounds and the 316-4 Crib. Tritium and nitrate concentrations down gradient from the 618-11 Burial Ground are greater than the federal and state DWSs. Tritium concentrations are predicted to decline below the DWS by 2031 based on the results of fate and transport modeling. Down gradient of the 618-7 Burial Ground, total chromium concentrations in a single well and uranium concentrations in two wells have exceeded the federal and state DWSs. This groundwater contamination is attributed to the use of dust suppression water during remediation of the 618-7 Burial Ground. Since remediation of this waste site has been completed, the groundwater concentrations have declined below the DWSs. Similarly, uranium concentrations down gradient from the 618-10 Burial Ground have exceeded

federal and state DWSs. These elevated concentrations also are attributed to the use of dust suppression water during remediation of the 316-4 Crib and 618-10 Burial Ground.

Contaminant concentrations in the 300-FF-5 groundwater were also compared to DWSs and aquatic risk-based thresholds where groundwater discharges to the Columbia River. There are no State surface water quality standards for fresh water or Federal ambient water quality criteria for 300-FF-5 groundwater COCs.

The risk assessment included evaluation of groundwater contamination using the EPA tap water scenario. Both hazard and cancer risk were calculated for ingestion, dermal contact and inhalation risk of volatile contaminants during household activities. Based on the results of the groundwater risk evaluation, concentrations of uranium, TCE and DCE in the 300 Area Industrial Complex; uranium down gradient of 618-10; and tritium and nitrate in the 600 Area subregion exceeded risk thresholds and are identified as COCs. Gross alpha has no toxicity information, but was identified as a groundwater COC because it exceeded the DWS. Nitrate in groundwater south and southwest of the 300 Area Industrial Complex that exceeds the DWS is from off-site sources and is not part of 300-FF-5.

Uncertainties in the risk assessment arise due to multiple factors. Uncertainty reflects limitations in knowledge, and simplifying assumptions must be made to quantify health risks. Uncertainties are associated with sampling and analysis, sampling design, calculated exposure point concentrations, actual exposure verses exposure scenarios, toxicity assumptions and risk characterization.

A significant uncertainty in the risk assessment is related to backfill. The risk assessment for 300-FF-2 sites that had completed interim remediation did not consider the risk reduction resulting from backfill placed over residual contamination. Post excavation confirmatory sample data collected from the bottom and sides of the excavation hole to depths as great as 4.6 m (15 ft) was used in the risk assessment as if ground surface contained contamination at that concentration. Clean backfill reduces actual risk.

For many waste sites, characterization data has been collected using both random samples as well as samples that have been taken in areas anticipated to be the most contaminated. When both random and focused samples exist for an analyte at a waste site, risk could be overestimated due to sample bias. Focused samples tend to have higher contamination than random samples. During interim action remediation, random samples were used in a statistical comparison to CULs, and for some sites focused samples were collected and compared with CULs. These uncertainties apply to both the human health and the ecological risk assessments.

7.2 Summary of Ecological Risk Assessment

The RCBRA and the 300 Area RI/FS Report evaluated ecological risks at 300 Area interim remediated waste sites with upland habitats for potential ecological risks. The 300 Area RI/FS used information from the RCBRA and from other sources to evaluate the risk to populations

and communities of ecological receptors, and concluded that there was no ecological risk at remediated waste sites within 300-FF-2. The ecological risk evaluations have identified that 300-FF-2 interim remedial actions that achieved interim action ROD CULs to protect human health were also protective of ecological receptors. The risk conclusion considered the size of waste sites relative to ecological receptor home ranges. For 300-FF-2 waste sites that have not been interim remediated, once human health CULs are achieved, residual contamination would not be sufficient to adversely impact populations and communities of ecological receptors as demonstrated by the interim remediated sites.

The risk assessments for interim remediated waste sites, riparian, near-shore and river areas used both site-specific biological sampling and bioassays for plants and animals. In addition published literature on effects and effect thresholds for a vast variety of species was considered. Ecological risk contaminants of potential concern in the RCBRA for 300-FF-2 waste sites were cobalt-60, cesium-137, lead, strontium-90, plutonium-239/240, uranium-233/234, uranium-235, uranium-238 and total uranium. Ecological risk contaminants of potential concern in the RCBRA from 300-FF-5 groundwater were uranium, tributyl phosphate, strontium-90, technetium-99, tritium, DCE, tetrachloroethene and TCE.

The RCBRA, Columbia River Component risk assessment and 300 Area RI/FS Report evaluated ecological risks present in the riparian, near-shore and river areas adjacent to the 300 Area. The 300 Area RI/FS used information from these risk assessments and from other sources to evaluate risk to populations and communities of ecological receptors from 300 Area contamination. The risk assessments evaluated contaminants present in these environments, including risk from contamination that is not from 300 Area sources as part of assessing total risk. Pathways where Hanford operations may have released contaminants to the riparian, near shore and river environments were evaluated. A principal focus of the risk assessments were releases or potential releases of uranium, TCE and DCE into the river from groundwater. The RI/FS concluded that there were no contaminants of ecological concern or ecological risk to populations and communities due to the 300-FF-2 and 300-FF-5 OUs in riparian, near shore and river environments.

The Hanford Reach contains three species listed as threatened or endangered under the Federal Endangered Species Act. Two species are federally listed as endangered fish including the Upper Columbia River spring-run Chinook salmon and the steelhead. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is listed as a threatened species, but is not considered a resident species and is rarely observed in the Hanford Reach. 300-FF-5 contains six groundwater contaminants of concern which are uranium, gross alpha, tritium, nitrate, TCE and DCE. The Columbia River rapidly dilutes groundwater contaminants to relatively low concentrations, so the primary concern for ecological risk to aquatic biota is from exposure to pore water. Concentrations of these contaminants in the river bottom pore water are below screening levels and no observable effect concentrations for these fish species.

7.3 Basis for Action

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants or contaminants into the environment. Such a release or the threat of release may present an imminent and substantial endangerment to public health, welfare or the environment.

A total of 70 previously remediated waste sites with closeout verification data were evaluated in the 300 Area RI/FS. Four of these waste sites reported risks greater than 1×10^{-4} based on the residential exposure scenario, but reported risks less than 1×10^{-4} based on the industrial exposure scenario. However, these four waste sites are located within the 300 Area Industrial Complex and are the South Process Pond (316-1), North Process Pond (316-2), the 300 Area Process Trenches (316-5) and the 618-3 Burial Ground.

Five of the previously remediated waste sites reported uranium concentrations that exceed the soil CULs for protection of groundwater for use as drinking water. These five waste sites are located within the 300 Area Industrial Complex and are the North Process Pond (316-2), the 300 Area Process Trenches (316-5) and the 618-1, 618-2 and 618-3 Burial Grounds. The South Process Pond (316-1) had a large disposal inventory of uranium, and due to its proximity to the higher groundwater contamination is considered a contributor to the unacceptable uranium risk in groundwater. From site characterization and groundwater monitoring it is clear that the uranium plume in groundwater is replenished by the release of mobile uranium remaining in the PRZ, primarily near the south end of the 300 Area Process Trenches (316-5). There is a less important but widespread distribution of uranium in the deep vadose zone and PRZ resulting from the mounding of contaminated groundwater during active disposal periods. These residual sources will attenuate as the yearly groundwater rise/fall cycle removes a portion of the mobile uranium. It is not anticipated that uranium in the PRZ will be replenished as fast as the uranium is being removed and will remain above acceptable risk levels for approximately 28 years. The attenuation timeframe can be shortened by reducing the mass of mobile uranium in the PRZ within the most contaminated area by reducing the mobility of the uranium with the addition of phosphates. The most contaminated area is located near the south end of the process trenches where subsurface characterization data and the highest groundwater concentrations indicate the highest portion of residual uranium occurs.

Waste sites that have not been remediated were evaluated based on process history, sample data when available and analogous experience from sites already interim remediated. These waste sites were determined to pose an unacceptable risk to human health and the environment from direct exposure and some are potential sources for groundwater contamination, providing the basis for remedial action. COCs for these sites are presented in table 2.

Based on the results of the groundwater risk evaluation, concentrations of uranium, TCE and DCE in the 300 Area Industrial Complex, uranium down gradient of 618-10 and tritium and nitrate down gradient of 618-11, are present at levels in the groundwater that provide a basis for remedial action. Gross alpha is also a groundwater COC based on comparison to DWS.

8.0 REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

RAOs provide a general description of cleanup goals. These goals typically provide the basis for development of the remedial alternatives, provide a basis for evaluating the cleanup options, and provide an understanding of how the identified risks will be addressed by the response action. RAOs also facilitate the five-year review determination of protectiveness.

8.1 Remedial Action Objectives

RAOs describe what a proposed remedial action is expected to accomplish. Typically, RAOs include information on the media, receptors and contaminants, taking into account the current and reasonably anticipated future land use. RAOs for 300-FF-2 are based on industrial use exposure within the 300 Area Industrial Complex and 618-11, and the RAOs are based on residential use exposure for the rest of 300-FF-2. RAOs for 300-FF-5 reflect the potential use of 300 Area groundwater as a drinking water source. Drinking water use includes inhalation of vapors such as during showering. RAOs for the 300-FF-1 ROD amendment address uranium contamination in vadose zone and PRZ that provides the greatest contribution of contamination to the uranium groundwater plume and also reflect the potential use of 300-FF-5 groundwater as a drinking water source. The RAOs for the 300-FF-2 ROD are RAOs 2 through 6 below. The RAOs for the 300-FF-5 ROD are RAOs 1 and 7. The RAOs for the 300-FF-1 ROD Amendment are RAO 2 and RAO 7.

- RAO 1. Prevent human exposure to groundwater containing COC concentrations above CULs.
- RAO 2. Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above CULs for protection of groundwater, and of surface water concentrations above CULs for the protection of surface water at locations where groundwater discharges to surface water.
- RAO 3. Prevent human exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above residential scenario-based CULs in areas outside both the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- RAO 4. Prevent human exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above CULs for industrial use in the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- RAO 5: Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to human health and the environment.
- RAO 6. Prevent ecological receptors from direct exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above CULs.
- RAO 7. Restore groundwater impacted by Hanford Site releases to CULs which include DWSs, within a timeframe that is reasonable given the particular circumstances of the site.

These RAOs address the risks identified in the risk assessment, are protective of human health and the environment and are compatible with the RAOs in the previous RODs for these OUs.

8.2 Cleanup Levels

CULs are the specific endpoint contaminant concentrations that have been developed for each media and/or exposure pathway, that provide protection of human health and the environment and comply with Applicable or Relevant and Appropriate Requirements (ARARs).

Soil CULs for 300-FF-2 were developed based on direct human contact as well as groundwater and surface water protection (table 4). These CULs apply to soil, structures which includes pipelines and debris. CULs do not apply to chemicals that are an integral part of manufactured structures (for example zinc in galvanized metal). The chemicals that are an integral part of manufactured structures are not considered contamination. The concentration of contamination in structures and debris includes the surface contamination, contamination that has penetrated the material and the material. The need for remedial action is based on contamination. The direct contact CULs for radionuclides were set at the lower of the risk-based level of 1×10^{-4} cancer risk or 15 mrem/year radiation dose which was used in the 300-FF-2 interim action. Direct contact CULs for non-radionuclides are based on current state standards (2007 MTCA standards at WAC 173-340).

Soil CULs for the protection of groundwater and surface water are based on site-specific data for the 300 Area, current federal DWSs and risk-based concentrations that are more stringent than DWS for TCE and DCE using a MTCA calculation method plus EPA-approved toxicity information (table 4). Soil CULs for the protection of groundwater and surface water were calculated based on site-specific data and specific parameters using the STOMP code (Subsurface Transport Over Multiple Phases) with a one-dimensional model for all contaminants except uranium. For uranium, the STOMP code was used with a two-dimensional model that includes the effects of uranium's more complex sorption behavior. For highly mobile contaminants (retardation coefficient < 2), the model assumes the entire vadose zone from ground surface to groundwater is contaminated. For less mobile contaminants (retardation coefficient ≥ 2), the model assumes the top 70 percent is contaminated and the bottom 30 percent is not contaminated. For the 300 Area Industrial Complex and 618-11 Burial Ground, a groundwater recharge rate of 25 mm per year was used for the long term, representing a permanently disturbed soil with cheatgrass vegetative cover. For areas outside the 300 Area Industrial Complex and 618-11 where CULs are based on a residential scenario, a groundwater recharge rate of approximately 72 mm per year was used representing an irrigated condition. Based on this model for some contaminants, no soil CUL for groundwater or river protection is calculated because the contaminant is calculated to not reach the groundwater within 1,000 years at levels that contaminate groundwater above the values in table 5.

Soil residential CULs were calculated using the MTCA (WAC 173-340-740) chemical standards for unrestricted use for all COCs except the radionuclides using a hazard index of one and a

cancer risk of 1×10^{-6} . Soil residential CULs were calculated for radionuclides based on a cancer risk of 1×10^{-4} or 15 mrem/year when that is more conservative than the risk-based number.

Soil industrial CULs were calculated using the MTCA (WAC 173-340-745) chemical standards for industrial use for all COCs except the radionuclides using a hazard index of one and a cancer risk of 1×10^{-5} . Soil industrial CULs were calculated for radionuclides based on a cancer risk of 1×10^{-4} or 15 mrem/year when that is more conservative than the risk-based number.

A soil CUL for groundwater and river protection was calculated for total uranium but not for isotopic uranium because a DWS is not available for the different uranium isotopes. When total uranium analytical results (mg/kg) were available, exposure point concentrations were compared to the total uranium CUL. When only isotopic uranium results (pCi/g) were available, uranium was addressed by converting the isotopic uranium from activity based (pCi/g) to mass based (mg/kg) and summing to provide a mass based total uranium exposure point concentration.

During the FS process, PRGs were used to assess the feasibility of the remedial alternatives. For 300-FF-2, residential scenario-based CULs were developed for waste sites outside the 300 Area Industrial Complex and the 618-11 Burial Ground, and industrial CULs were developed for waste sites inside the 300 Area Industrial Complex and the 618-11 Burial Ground. Waste sites are listed in table 1. CULs developed for 300-FF-5 groundwater are presented in table 5.

Table 4: Cleanup Levels for 300-FF-2 COCs – Soil, Structures and Debris

Media: Soil, Structures and Debris							
Site Area: 300-FF-2							
Controls to Ensure Restricted Use: Yes.							
Contaminant	Units	Residential Cleanup Areas Outside both the 300 Area Industrial Complex and 618-11			Industrial Cleanup Areas within the 300 Area Industrial Complex and 618-11		
		Shallow Zone <= 15 ft bgs Direct Exposure Human Health		Soil CUL for GW & River Prot.	Shallow Zone <= 15 ft bgs Direct Exposure Human Health		Soil CUL for GW & River Prot.
		CUL	Basis for CUL	Surface to GW	CUL	Basis for CUL	Surface to GW
Americium-241	pCi/g	32	RA	--	210	RA	--
Cesium-137	pCi/g	4.4	RA	--	18	RA	--
Cobalt-60	pCi/g	1.4	RA	--	5.2	RA	--
Europium-152	pCi/g	3.3	RA	--	12	RA	--
Europium-154	pCi/g	3.0	RA	--	11	RA	--
Europium-155	pCi/g	125	RA	--	518	RA	--
Iodine-129	pCi/g	0.076	RA	12.8	1,940	RA	37.1
Plutonium-238	pCi/g	39	RA	--	155	RA	--
Plutonium-239/240	pCi/g	35	RA	--	245	RA	--
Plutonium-241	pCi/g	854	RA	--	12,900	RA	--
Technetium-99	pCi/g	1.5	RA	272	166,000	RA	420
Total beta radiostromtium (Strontium-90)	pCi/g	2.3	RA	227,000	1,970	RA	--
Tritium	pCi/g	459	RA	9,180	1,980	RA	12,200
Uranium-233/234	pCi/g	27.2	RA	--	167	RA	--
Uranium-235	pCi/g	2.7	RA	--	16	RA	--
Uranium-238	pCi/g	26.2	RA	--	167	RA	--
Uranium isotopes total	pCi/g	56.1	RA	--	350	RA	--
Antimony	mg/kg	32	MTCA-B	252	1,400	MTCA-C	760
Arsenic	mg/kg	20	MTCA-B	20	20	MTCA-C	--
Barium	mg/kg	16,000	MTCA-B	--	700,000	MTCA-C	--
Beryllium	mg/kg	160	MTCA-B	--	7,000	MTCA-C	--
Cadmium	mg/kg	80	MTCA-B	176	3,500	MTCA-C	--
Chromium (Total)	mg/kg	120,000	MTCA-B	--	>1,000,000	MTCA-C	--
Chromium (VI)	mg/kg	2.1	CWA	2.0	10,500	CWA	2.0
Cobalt	mg/kg	24	MTCA-B	--	1,050	MTCA-C	--
Copper	mg/kg	3,200	MTCA-B	3,400	140,000	MTCA-C	--

Lead	mg/kg	250	MTCA-A	1,480	1,000	MTCA-C	--
Lithium	mg/kg	160	MTCA-B	--	7,000	MTCA-C	--
Manganese	mg/kg	11,200	MTCA-B	--	490,000	MTCA-C	--
Mercury	mg/kg	24	MTCA-B	8.5	1,050	MTCA-C	--
Nickel	mg/kg	1,600	MTCA-B	--	70,000	MTCA-C	--
Selenium	mg/kg	400	MTCA-B	302	17,500	MTCA-C	912
Silver	mg/kg	400	MTCA-B	--	17,500	MTCA-C	--
Strontium	mg/kg	48,000	MTCA-B	--	>1,000,000	MTCA-C	--
Tin	mg/kg	48,000	MTCA-B	--	>1,000,000	MTCA-C	--
Uranium	mg/kg	81	MTCA-B	102	505	MTCA-C	157
Vanadium	mg/kg	400	MTCA-B	--	17,500	MTCA-C	--
Zinc	mg/kg	24,000	MTCA-B	64,100	>1,000,000	MTCA-C	--
Cyanide	mg/kg	48	MTCA-B	636	42	MTCA-C	1,960
Fluoride	mg/kg	4,800	MTCA-B	--	210,000	MTCA-C	--
Nitrate	mg/kg	568,000	MTCA-B	13,600	>1,000,000	MTCA-C	21,000
Aroclor 1016	mg/kg	5.6	MTCA-B	--	245	MTCA-C	--
Aroclor 1221	mg/kg	0.50	MTCA-B	0.017	66	MTCA-C	0.026
Aroclor 1232	mg/kg	0.50	MTCA-B	0.017	66	MTCA-C	0.026
Aroclor 1242	mg/kg	0.50	MTCA-B	0.14	66	MTCA-C	--
Aroclor 1248	mg/kg	0.50	MTCA-B	0.13	66	MTCA-C	--
Aroclor 1254	mg/kg	0.50	MTCA-B	--	66	MTCA-C	--
Aroclor 1260	mg/kg	0.50	MTCA-B	--	66	MTCA-C	--
Cis-1,2-Dichloroethylene (DCE)	mg/kg	160	MTCA-B	11	7,000	MTCA-C	18
Carbon tetrachloride	mg/kg	0.61	MTCA-B	0.44	6.1	MTCA-C	0.86
Chloroform	mg/kg	0.24	MTCA-B	1.3	2.4	MTCA-C	2.1
1,1,1-Trichloroethane	mg/kg	3,660	MTCA-B	361	8,000	MTCA-C	686
1,2-Dichloroethene (total)	mg/kg	720	MTCA-B	55	31,500	MTCA-C	89
Methyl ethyl ketone (2-Butanone)	mg/kg	28,400	MTCA-B	1,670	62,200	MTCA-C	2,590
Methyl isobutyl ketone (hexone) (4-Methyl-2-pentanone)	mg/kg	6,400	MTCA-B	285	28,700	MTCA-C	445
Benzene	mg/kg	0.57	MTCA-B	0.82	5.7	MTCA-C	1.4
Ethyl acetate	mg/kg	72,000	MTCA-B	--	>1,000,000	MTCA-C	--
Ethylene glycol	mg/kg	160,000	MTCA-B	5,030	>1,000,000	MTCA-C	7,770
Hexachlorobutadiene	mg/kg	13	MTCA-B	--	1,680	MTCA-C	--
Hexachloroethane	mg/kg	2.5	MTCA-B	23	25	MTCA-C	72

Tetrachloroethene	mg/kg	20	MTCA-B	2.4	82	MTCA-C	6.0
Toluene	mg/kg	4,770	MTCA-B	1,150	10,400	MTCA-C	2,190
Vinyl chloride	mg/kg	0.53	MTCA-B	0.013	5.2	MTCA-C	0.021
Xylenes (total)	mg/kg	103	MTCA-B	4,700	227	MTCA-C	11,090
Benzo(a)pyrene	mg/kg	0.14	MTCA-B	--	18	MTCA-C	--
Chrysene	mg/kg	14	MTCA-B	--	1,800	MTCA-C	--
Tributyl phosphate	mg/kg	111	MTCA-B	217	14,600	MTCA-C	658
Trichloroethene (TCE)	mg/kg	1.1	MTCA-B	1.3	3.5	MTCA-C	2.4
Normal paraffin hydrocarbon (Kerosene)	mg/kg	2,000	MTCA-A	2,000	2,000	MTCA-C	2,000
Total Petroleum Hydrocarbons – diesel	mg/kg	2,000	MTCA-A	2,000	2,000	MTCA-C	2,000
Total Petroleum Hydrocarbons – motor oil	mg/kg	2,000	MTCA-A	2,000	2,000	MTCA-C	2,000

bgs = below ground surface

CUL = cleanup level

GW = groundwater

CWA = Clean Water Act

Prot. = protection

RA = risk assessment

MTCA = Washington State's Model Toxics Control Act. MTCA-B is unrestricted, MTCA-C is industrial.

CULs basis for radionuclides is a cancer risk of 1×10^{-4} or 15 mrem/year dose whichever is more conservative. For uranium, 15 mrem/year is more conservative so that is the basis for the uranium isotopes total CUL. That total is divided among the individual uranium isotopes using the natural ratio of isotopes.

No uranium isotopes CUL is selected for groundwater and river protection because the DWS is used which is based on uranium metal.

CULs basis for chemicals is the more conservative of a hazard index of one or the cancer risk. The cancer risk is 1×10^{-6} for residential cleanup and 1×10^{-5} for industrial cleanup based on MTCA.

Basis for soil CUL for groundwater and river protection is the soil leach model in the RI.

Table 5: Cleanup Levels for 300-FF-5 COCs – Groundwater

Media: Groundwater			
Site Area: 300-FF-5			
Available Use: Drinking water and all other uses			
Controls to Ensure Restricted Use: Yes			
Contaminant of Concern	CUL	Units	Basis for CUL
Uranium	30	ug/L	DWS
Tritium	20,000	pCi/L	DWS
Nitrate (as NO ₃)	45,000	ug/L	DWS
Trichloroethene (TCE)	4	ug/L	Risk assessment for drinking water
Cis-1,2-Dichloroethene (DCE)	16	ug/L	Risk assessment for drinking water
Gross Alpha	15	pCi/L	DWS
CUL for total uranium metal of 30 ug/L is also protective of the uranium isotopes U-233/234, U-235 and U-238.			
Basis for these CULs are risk limits and DWS ARARs to protect drinking water uses which also are protective of the river.			

9.0 DESCRIPTION OF ALTERNATIVES

This section provides a brief description of the remedial alternatives developed and evaluated for 300-FF-1, 300-FF-2 and 300-FF-5. The following subsections provide general descriptions and expected outcomes of each of the alternatives evaluated in the FS.

9.1 Description of Remedy Components

9.1.1 Alternative 1: No Action

Estimated Capital Cost: \$0

Estimated Annual O&M Cost: \$0

Estimated Present Value (Discounted): \$0

Estimated Time to Achieve CULs for Uranium in Groundwater: 28 years

Estimated Time to Achieve CULs for Tritium in Groundwater: 18 years

Estimated Time to Achieve CULs by RTD for Waste Sites: Would not be met.

Consideration of a No Action alternative is a requirement of the NCP (40 CFR 300.430(e)(6), "Remedial Investigation/Feasibility Study and Selection of Remedy"). The No Action alternative is included to provide a baseline for comparison against the other alternatives. Under the No Action alternative, no active remedial action would be taken to address potential threats to human health and the environment posed by the contamination. All ongoing actions would cease, including ICs and groundwater monitoring. The No Action alternative would not remediate the waste sites and as a result, these waste sites would have contamination that is not protective of human health and the environment. Groundwater restoration would only occur through natural processes.

9.1.2 Alternative 2: RTD and ICs for 300-FF-2; and MNA, ICs and Groundwater Monitoring for 300-FF-5

Estimated Capital Cost: \$245 million
Estimated Annual O&M Cost: \$40 million
Estimated Present Value (Discounted): \$223 million
Estimated Time to Achieve CULs for Uranium in Groundwater: 28 years
Estimated Time to Achieve CULs for Tritium in Groundwater: 18 years
Estimated Time to Achieve CULs by RTD for Waste Sites: 19 years

Alternative 2 involves RTD and ICs at waste sites in 300-FF-2; for 300-FF-5 it includes MNA for nitrate, tritium, TCE and DCE in groundwater; monitoring for uranium and gross alpha in groundwater; and ICs. Remedial technologies for Alternative 2 are discussed in the Common Elements section. It is estimated that it will take approximately 28 years (by 2041) for the uranium concentrations in groundwater to decrease below the CUL if Alternative 2 is implemented. Alternative 2 does not modify the remedy previously selected for 300-FF-1 in the applicable ROD. No further remedial action will be performed for the residual uranium contamination associated with the 300-FF-1 waste sites.

There is significant uncertainty in the estimated time to achieve the uranium CUL described in the modeling section of the 300 Area RI/FS report (Chapter 5 and Appendix F of DOE/RL-2010-99). The estimated times to achieve the uranium CUL in groundwater for all of the alternatives depends primarily on the magnitude of the river stage fluctuations, which may differ from the magnitudes assumed in the model. The uncertainty in the estimated time to achieve the uranium CUL in the groundwater is highest for Alternative 2, which depends primarily on the magnitude of future river stage fluctuations and does not benefit from any remedial actions to reduce the amount of uranium in the deep vadose zone and PRZ.

9.1.3 Alternative 3: Phased Enhanced Attenuation of Uranium from Select Waste Sites, RTD and ICs for 300-FF-2; A ROD Amendment for Phased Enhanced Attenuation of Uranium from Select Waste Sites for 300-FF-1; and MNA, Groundwater Monitoring and ICs for 300-FF-5

Estimated Capital Cost: \$280 million
Estimated Annual O&M Cost: \$118 million
Estimated Present Value (Discounted): \$357 million
Estimated Time to Achieve CULs for uranium in groundwater: 22 years
Estimated Time to Achieve CULs for Tritium in Groundwater: 18 years
Estimated Time to Achieve CULs by RTD for Waste Sites: 19 years

Alternative 3 uses a combination of RTD and ICs at waste sites in 300-FF-2; and a phased approach for implementation of uranium sequestration in the vadose zone, PRZ and top of the aquifer at the treatment zone. For 300-FF-1, Alternative 3 calls for a ROD amendment for the same phased uranium sequestration approach at three 300-FF-1 waste site locations where there

are high uranium concentrations. Finally, for 300-FF-5 Alternative 3 uses a combination of MNA for nitrate, tritium, TCE and DCE in groundwater; enhanced attenuation with monitoring for uranium and monitoring for gross alpha in groundwater; and ICs. Compared to the no action alternative, this alternative is expected to reduce the time to restore the uranium-contaminated groundwater to the CUL in the 300 Area Industrial Complex because it addresses the continuing source of uranium.

Alternative 3 involves uranium sequestration in the vadose zone, PRZ and top of the aquifer at the treatment zone in addition to the remedial components identified in the Common Elements section. In this alternative, phosphate solution is added to the vadose zone, PRZ and top of the aquifer at the treatment zone to sequester, or bind, residual uranium to form a stable and insoluble mineral called autunite. This is anticipated to result in a reduction of soluble uranium entering the groundwater and is anticipated to reduce the restoration timeframe for uranium in the groundwater.

The application of phosphate to sequester residual uranium would be done in the areas of highest contribution of uranium to groundwater from the deep vadose zone and PRZ in 300-FF-1 and 300-FF-2. Previous tests performed in the laboratory and groundwater demonstrated the uranium sequestration technology is viable. Under this alternative, a phased approach would be used to collect the necessary design information (Phase I) that would be used for full-scale remedy implementation (Phase II), if conditions specified below are met.

Phase I will apply phosphate to the highest uranium concentration areas of the vadose zone and PRZ using a combination of surface infiltration, PRZ injection and groundwater injection techniques. Phase I will be applied over an area of approximately 1 hectare (3 acres). Prior to phosphate application in the vadose zone and PRZ, phosphate will be injected into the upper portion of the groundwater to attempt to sequester uranium potentially mobilized by the surface infiltration and PRZ injection. Following phosphate additions, vadose zone core samples will be collected to assess changes in uranium mobility, and groundwater monitoring will be conducted to assess changes in uranium concentrations. Design details of the application approach will be further defined in the RD/RAWP.

Implementation of Phase II requires that the following conditions are met at the conclusion of Phase I:

- Vadose zone core sample data and the groundwater response from Phase I testing will need to demonstrate the efficacy of the treatment approach to deliver treatment solutions to the PRZ.
- Laboratory tests of pretreatment cores will need to show an excess of 50 years of high water cycles that allow water to rise and fall in the PRZ are required to achieve DWSs.
- Laboratory testing of post-treatment vadose zone core samples and the groundwater response from Phase I testing will need to demonstrate that the technology provides adequate treatment to significantly improve the time to achieve DWSs within 50 years.

If all three of the conditions above are met, Phase II would be initiated. Phase II is an expansion of Phase I to approximately 18 hectares (45 acres) over and around 316-2, 316-1, 316-3, 618-1, 618-2, 618-3 and the southern half of 316-5. Phase I and Phase II of the remedial action are estimated to take approximately six years to complete. This time period is based on one year to complete the RD/RAWP, three years to implement and evaluate Phase I sequestration and if required an additional two years to implement Phase II sequestration. Following completion of these remedial actions, the model predicts that the CUL for uranium would be achieved in 16 years. Therefore, the overall time for Alternative 3 to achieve the uranium CUL is approximately 22 years.

There is significant uncertainty in the estimated time to achieve the uranium CUL in Alternative 3. This uncertainty is due to the complex interactions of the contamination in the vadose zone, PRZ and groundwater with the dynamic groundwater levels controlled by seasonal changes in the elevation of the river water. In addition to these inherent uncertainties, the model predictions do not include uranium mobilized from the vadose zone and PRZ during remedial activities (either through sequestration or RTD), which can influence the time necessary to achieve the CUL. Alternative 3 minimizes these impacts by providing partial treatment to protect the groundwater by sequestering uranium mobilized through the application of phosphate to the overlying vadose zone and PRZ. The estimated time to achieve the uranium CUL is also influenced by when the phosphate application can occur. Phosphate application will be performed when groundwater velocities are slow (i.e. rising and high river stage) and the groundwater conditions are favorable, so the limited window of opportunity for these favorable conditions may delay the schedule if the favorable conditions are missed. Although Alternative 3 is estimated to achieve the uranium CUL within 22 years, this timeframe is highly uncertain due to the factors described above.

9.1.4 Alternative 3a – Selected Alternative: Enhanced Attenuation of Uranium from Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Enhanced Attenuation of Uranium at Select Waste Sites for 300-FF-1; and MNA, Groundwater Monitoring and ICs for 300-FF-5.

Estimated Capital Cost: \$254 million

Estimated Annual O&M Cost: \$44 million

Estimated Present Value (Discounted): \$259 million

Estimated Time to Achieve CULs for uranium in groundwater: 22 to 28 years

Estimated Time to Achieve CULs for Tritium in Groundwater: 18 years

Estimated Time to Achieve CULs by RTD for Waste Sites: 19 years

Alternative 3a uses a combination of RTD and ICs at waste sites in 300-FF-2; and enhanced attenuation by applying reagents to a portion of the deep uranium contamination to enhance natural attenuation in the vadose zone and PRZ. For 300-FF-1, Alternative 3a calls for a ROD amendment for enhanced uranium attenuation at three 300-FF-1 waste site locations where there are high uranium concentrations. Finally, for 300-FF-5 Alternative 3a uses a combination of MNA for nitrate, tritium, TCE and DCE in groundwater; enhanced attenuation with monitoring

for uranium and monitoring for gross alpha in groundwater. Uranium is an alpha emitting radionuclide, so uranium attenuation will result in gross alpha attenuation. ICs are used to control access to residual contaminants in soil and groundwater as long as they exceed the CULs. This alternative is anticipated to reduce the time, as compared to the no action alternative, to restore the uranium-contaminated groundwater in the 300 Area Industrial Complex to the CUL because like Alternative 3 it would address the highest continuing source of uranium in the PRZ.

Alternative 3a uses enhanced attenuation for uranium in addition to the remedial components identified in the Common Elements section. Phosphate solution is added to the vadose zone, PRZ and top of the aquifer at the treatment zone to sequester, or bind, residual uranium to form a stable and insoluble mineral called autunite. This is anticipated to result in a reduction of soluble uranium entering the groundwater, and is anticipated to reduce the restoration timeframe for uranium in the groundwater. The unique characteristics of Alternative 3a include the following:

- Groundwater monitoring would be conducted for uranium from waste sites in 300-FF-1 and 300-FF-2 with uranium contamination above CULs deeper than 4.6 m (15 ft) bgs (former liquid waste sites 316-1, 316-2, 316-3 and 316-5 and former solid waste sites 618-2 and 618-3) and 618-1 because of the large waste disposal inventory and the proximity of 618-1 to higher uranium groundwater concentrations.
- The enhanced attenuation of residual uranium in the deep vadose zone and PRZ will occur in an approximately 1 hectare (3 acre) area that is the highest contributing area to the persistent uranium groundwater contamination. This treatment area is in the vicinity of former waste sites 316-5 and 316-2 (figure 9). This location is where the highest uranium contamination consistently occurs in groundwater.

This alternative will apply phosphate to the highest uranium concentration areas of the vadose zone and PRZ using a combination of surface infiltration, PRZ injection and groundwater injection techniques. Prior to phosphate application in the vadose zone and PRZ, phosphate will be injected into the upper portion of the groundwater below and to the east and south of the vadose zone and PRZ treatment area. This is done to sequester uranium potentially mobilized by the surface infiltration and PRZ injection. During implementation, tests will be conducted on post treatment vadose zone core samples to refine the groundwater model, and groundwater monitoring will be conducted to assess changes in uranium concentrations and the lateral spread of phosphate.

The use of sequestration as an enhancement to immobilize the deep residual uranium that is providing the highest uranium concentrations to the groundwater is expected to accelerate the natural attenuation of uranium contamination in the vadose zone, PRZ and aquifer.

Uranium sequestration in alternative 3a is estimated to take approximately four years to complete. This time period is based on one year to complete the RD/RAWP and three years to implement the enhanced attenuation. This alternative addresses the deep uranium contamination contributing to the persistent groundwater contamination. The estimated time to achieve the

groundwater CUL for uranium is expected to range between Alternative 3 (22 years) and Alternative 2 (28 years).

There is significant uncertainty in the estimated time to achieve the uranium CUL in Alternative 3a. This uncertainty is due to complex interactions of the contamination in the vadose zone, PRZ and groundwater with the dynamic groundwater levels controlled by seasonal changes in the elevation of the river water. In addition to these inherent uncertainties, the model predictions do not include uranium mobilized from the vadose zone and PRZ during remedial activities (either through sequestration or RTD), which can influence the time necessary to achieve the CUL. Alternative 3a minimizes these impacts by providing partial treatment of the groundwater to sequester uranium mobilized through the application of phosphate to the overlying vadose zone and PRZ. The estimated time to achieve the uranium CUL is also influenced by when the phosphate application can occur. Phosphate application will be performed when groundwater velocities are slow (i.e. rising and high river stage) and the groundwater conditions are favorable, so the limited window of opportunity for these favorable conditions may delay the schedule if the favorable conditions are missed. Although Alternative 3a is estimated to achieve the uranium CUL in 22 to 28 years, this timeframe is uncertain due to the factors described above.

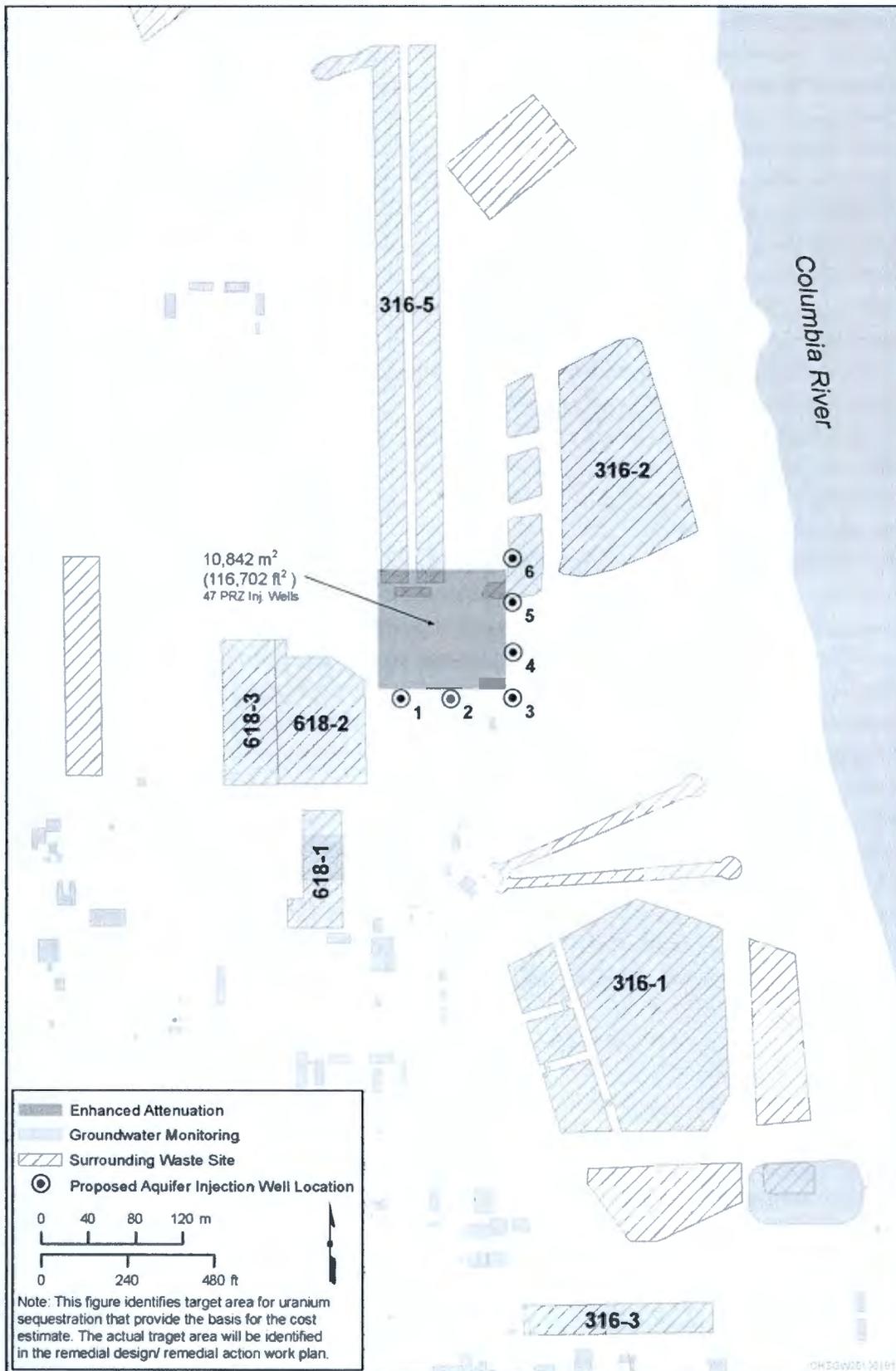


Figure 9. Alternative 3a Enhanced Attenuation Target Treatment Area

9.1.5 Alternative 4: Enhanced Attenuation and Focused Deep RTD of Uranium at Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Enhanced Attenuation and Focused Deep RTD of Uranium at Select Waste Sites for 300-FF-1; and MNA, ICs and Groundwater Monitoring for 300-FF-5

Estimated Capital Cost: \$488 million

Estimated Annual O&M Cost: \$110 million

Estimated Present Value (Discounted): \$537 million

Estimated Time to Achieve CULs for uranium in groundwater: 19 years

Estimated Time to Achieve CULs for Tritium in Groundwater: 18 years

Estimated Time to Achieve CULs by RTD for Waste Sites: 19 years

For 300-FF-2 Alternative 4 uses a combination of RTD at waste sites and focused deep RTD and uranium sequestration for deep uranium contamination in the vadose zone, PRZ and top of the aquifer at the treatment zone and ICs. Alternative 4 also includes an amendment of the existing 300-FF-1 ROD to require focused deep RTD and uranium sequestration for deep uranium contamination in the vadose zone, PRZ and top of the aquifer at the treatment zone in area of three waste site with the highest concentrations of uranium contamination. Finally for 300-FF-5 Alternative 4 calls for MNA for nitrate, tritium, TCE and DCE in groundwater; enhanced attenuation and monitoring for uranium, monitoring for gross alpha in groundwater; and ICs. Uranium is an alpha emitting radionuclide, so uranium attenuation will result in gross alpha attenuation. This alternative reduces the time, as compared to the no action alternative, required to restore the uranium-contaminated groundwater in the 300 Area Industrial Complex to the CUL because it addresses the continuing source of uranium in the PRZ.

With the exceptions of uranium sequestration and focused deep RTD, the remedial technologies for Alternative 4 are discussed in the Common Elements section. The specific design details would be provided in the RD/RAWP. The focused deep RTD and the application of the uranium sequestration technology, which are unique to Alternative 4, include the following:

- Focused deep RTD will target the areas of highest contribution of residual uranium to groundwater from the deep vadose zone. Standard excavation methods will be used because they are well established techniques and have been employed successfully at the Hanford Site for deep excavations
- Uranium sequestration in the vadose zone and PRZ using a combination of surface infiltration and deep injection techniques in areas of lower residual uranium concentration deeper than 4.6 m (15 ft) bgs that poses a risk to groundwater
- Uranium sequestration at the top of the aquifer at the treatment zone using injection wells at and down gradient of the waste sites. The primary purpose of injecting phosphate at the top of the aquifer at the treatment zone will be to sequester any untreated uranium that may be mobilized from the vadose zone during surface infiltration and injection into the PRZ.

Alternative 4 is estimated to take seven years to complete focused deep RTD and uranium sequestration. This time period is based on one year to complete the RD/RAWP, one year to

complete the waste site RTD remediation prior to starting the deep RTD remediation, two years to complete the deep RTD of the 0.76 million m³ (1.0 million yd³) of uranium-contaminated soil, one year to backfill and grade the excavation to provide access to the areas for sequestration application and drilling and two years to implement the uranium sequestration for the remaining deep uranium contamination. Following completion of these remedial actions, the model predicted 12 years to achieve the groundwater CUL for uranium. Therefore, the estimated time to achieve the groundwater CUL for uranium under Alternative 4 is 19 years.

The estimate of 12 years to achieve the CUL for uranium in the groundwater following completion of the remedial actions assumes a 100 percent reduction in the amount of uranium in the focused deep RTD areas and a 50 percent reduction in the amount of mobile uranium in the vadose zone as a result of sequestration. The estimated time to achieve the CUL does not include the impacts of additional uranium being driven from the vadose zone and PRZ to the aquifer by the application of dust suppression water during deep excavation.

9.1.6 Alternative 5: Expanded Deep RTD of Uranium at Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Expanded Deep RTD of Uranium at Select Sites for 300-FF-1; and MNA, ICs and Groundwater Monitoring for 300-FF-5

Estimated Capital Cost: \$1,309 million

Estimated Annual O&M Cost: \$38 million

Estimated Present Value (Discounted): \$1,341 million

Estimated Time to Achieve CULs for uranium in groundwater: 17 years

Estimated Time to Achieve CULs for Tritium in Groundwater: 18 years

Estimated Time to Achieve CULs by RTD for Waste Sites: 19 years

For 300-FF-2 Alternative 5 uses a combination of RTD at waste sites in 300-FF-2; extensive deep RTD for uranium contamination in the vadose zone and PRZ contributing to the uranium groundwater plume and ICs. Alternative 5 also includes an amendment of the 300-FF-1 ROD to require deep RTD for uranium contamination in the vadose zone, PRZ and top of the aquifer at the treatment zone in area of three waste site where there is high concentrations of uranium contamination. Finally for 300-FF-5 Alternative 5 calls for MNA for nitrate, tritium, TCE and DCE in groundwater; monitoring for uranium and gross alpha in groundwater and ICs. This alternative reduces the time, as compared to the no action alternative, to restore the uranium-contaminated groundwater in the 300 Area Industrial Complex to the CUL because it addresses the continuing source of uranium in the PRZ.

With the exception of extensive deep RTD, the remedial technologies for Alternative 5 are discussed in the Common Elements section. The extensive deep RTD technology, which is unique to Alternative 5, includes RTD to groundwater for the waste sites that contain the highest concentration of residual uranium in the deep vadose zone and PRZ. Standard excavation methods would be used because they are well established techniques and have been employed successfully at the Hanford Site for deep excavations. It is estimated that extensive deep RTD

would remove 3.3 million cubic meters (4.3 million cubic yards) of soil. Three new Super Cells would need to be constructed at the ERDF to dispose of the excavated soil.

Alternative 5 is estimated to take seven years to complete the deep RTD component of this alternative. This time period is based on one year to complete the RD/RAWP, one year to complete other RTD in the same area prior to starting the deep RTD remediation and five years to complete the deep RTD of the 3.3 million m³ (4.3 million yd³) of uranium-contaminated soil. Following completion of the remedial action, the model predicted 10 years to achieve the groundwater CUL for uranium. Note that the backfill and grading of the excavation are not included in the timeframe to achieve the uranium CUL in groundwater because the model prediction is based on removal of the contamination. Therefore, the estimated time to achieve the groundwater CUL for uranium under Alternative 5 is 17 years.

The estimate of 10 years to achieve the CUL for uranium following completion of the remedial action assumes a 100 percent reduction in the amount of uranium in the extensive deep RTD areas. The estimated time to achieve the CUL does not include the impacts of additional uranium being driven from the vadose zone and PRZ to the aquifer by the application of dust suppression water during deep excavation.

9.2 Common Elements and Distinguishing Features of Alternatives

Remedial action alternatives developed for 300-FF-2 and 300-FF-5 and for a 300-FF-5 ROD amendment have some components in common:

Institutional Controls. For 300-FF-2 and 300-FF-5, Alternatives 2, 3, 3a, 4 and 5 require ICs before, during and after the active phase of remedial action implementation where ICs are required to protect human health and the environment. ICs are used to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure. DOE will be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity. In the event that land is transferred out of federal ownership, appropriate provisions will be included in transfer terms or conveyance documents to maintain effective ICs (such as easements and covenants). ICs to support achievement of the RAOs are the following:

- Signage and access control to waste sites
- Maintenance and operation of an excavation permit program for protection of environmental and cultural resources and site workers
- Administrative controls limiting groundwater access and use where groundwater is above CULs
- In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners

- Control excavation in areas where contamination is left deeper than 4.6 m (15 ft) bgs that exceed levels protective of human health and the environment
- Prevent enhanced recharge over or near waste sites with potential to pose an unacceptable groundwater risk from irrigation
- Prevent bare gravel or bare sand covers over waste sites in the 300 Area Industrial Complex in areas where contamination exceeds residential groundwater and river protection CULs
- Prevent enhanced recharge from the discharge of water (such as drainage from paved parking lots or buildings) in areas where contamination exceeds residential groundwater and river protection CULs. Prevent irrigation in areas where contamination exceeds residential groundwater and river protection CULs.
- Land use controls to prohibit the development and use of property for residential housing, elementary and secondary schools, child care facilities and playgrounds in areas remediated to industrial rather than residential CULs.

RTD at Waste Sites. RTD of 300-FF2 waste sites in Alternatives 2, 3, 3a, 4 and 5 would achieve RAOs and CULs through (a) RTD the soil with COCs exceeding CULs identified in table 4 as deep as 4.6 m (15 ft) bgs to protect human health and ecological receptors from direct exposure to contaminants, (b) remove the engineered structures which includes pipelines with contamination exceeding CULs (e.g., burial ground trenches, drums, caissons and vertical pipe units), (c) RTD the soil and engineered structures below 4.6 m (15 ft) bgs with COCs other than uranium that exceeds CULs in table 4 for groundwater and river protection and (d) backfill and revegetate the excavated waste sites.

RTD applies to contaminated soil, structures which includes pipelines and debris with concentrations above the CULs. The contaminated waste would be removed from the waste sites, treated as necessary to meet disposal facility requirements such as grout treatment to meet Land Disposal Restrictions or to reduce air release potential, and sent to ERDF for disposal which is considered onsite or another disposal facility approved by EPA. Treatment would also be conducted in advance of removal as needed (e.g., for highly radioactive materials, including principal threat waste) to control worker exposure and minimize airborne releases. Treatment will be with grout or an alternative method approved by EPA during remedial design.

Soil from waste site 300-296 below the 324 Building B hot cell would be removed as part of the 300-FF-2 OU remediation. The highly contaminated soil would be treated as needed to control worker exposure and placed into other 324 Building hot cells, which provide additional shielding to workers from radioactive contaminants. Removal of the 324 Building, and the hot cells that would contain this 300-296 waste, will be performed under the CERCLA Action Memorandum #2 for the 300 Area Facilities. In addition, closure of the TSD units in the 324 Building will be performed under the RCRA Closure Plan.

RTD will treat the highly radioactive waste posing the principal threat and mix them with grout as appropriate to reduce the dose rate and to stabilize the waste materials. This treatment reduces the toxicity and mobility of the waste. The stabilized materials will be removed to the extent

necessary to ensure protection of human health and the environment and disposed at an appropriate disposal facility. Waste determined to be transuranic will be transported offsite for deep geologic disposal at the Waste Isolation Pilot Plant in New Mexico.

Temporary Surface Barriers and Pipeline Void Filling. For waste sites that exceed CULs in table 4 that are adjacent to the 300 Area facilities and utilities that will remain in operation through at least 2027 (long-term facilities), temporary surface barriers will be installed and maintained in areas specified in the RD/RAWP to reduce infiltration and contaminant flux to groundwater. The design of the barriers will be described in the RD/RAWP. Surface barriers will be constructed of asphalt or alternative materials approved by EPA in the RD/RAWP to decrease permeability. In addition, pipelines with uranium and/or mercury contamination that exceeds CULs in table 4 for groundwater and river protection that are inaccessible for the RTD remedy because of their close proximity to long-term facilities will be void filled to the maximum extent practicable as defined in the RD/RAWP to immobilize radionuclides (and elemental mercury in waste site 300 RRLWS) in the pipelines for groundwater protection. When the long-term facilities are no longer in use and are removed, the waste sites and pipelines will be remediated as described above in the RTD discussion. The long-term retained facilities are shown on figure 3.

MNA for Groundwater in 300-FF-5 OU. The MNA component is a remedial strategy that monitors natural attenuation processes until CULs are met. Natural attenuation relies on natural processes within the aquifer to achieve reductions in the toxicity, mobility, volume, concentration and/or bioavailability of contaminants. These natural processes include physical, chemical and biological transformations that occur without human intervention. Contaminants in groundwater that will be addressed through MNA are tritium and nitrate down gradient from the 618-11 Burial Ground and TCE and DCE in groundwater below the 300 Area Industrial Complex.

Natural attenuation of tritium from the 618-11 Burial Ground will occur through a combination of natural radiological decay and dispersion during transport. Natural attenuation of nitrate from the 618-11 Burial Ground will occur via diffusion and dispersion during transport and biodegradation. Computer modeling predicts that the tritium concentrations will decrease to below the CUL by 2031. The waste within the 618-11 Burial Ground that released the tritium will be removed by RTD.

MNA is used for the TCE and DCE in groundwater below the 300 Area Industrial Complex. Natural attenuation will occur primarily through physical attenuation (diffusion and dispersion) and biodegradation.

300-FF-5 Groundwater Monitoring. In addition to and as part of the MNA, groundwater monitoring will be performed to evaluate the effectiveness of MNA, and actions taken to address uranium. The monitoring will be for groundwater COCs (uranium, gross alpha, nitrate, TCE and DCE below the 300 Area Industrial Complex; uranium and gross alpha down gradient

from the 618-7 Burial Ground; and tritium and nitrate down gradient from the 618-11 Burial Ground).

300-FF-2 RTD and 300-FF-5 Monitoring Transition from Interim to Final Action. In-progress 300-FF-2 interim action RTD shall achieve the CULs in this ROD. All other aspects of the interim actions shall continue to be performed in accord with the existing RD/RAWP. DOE shall develop, and submit for EPA approval, a new RD/RAWP prepared in accordance with the Tri Party Agreement. When the new RD/RAWP is approved, that document will direct future remedial actions and the 300-FF-2 and 300-FF-5 interim remedial actions will be terminated.

9.3 Expected Outcomes of Each Alternative

The available uses of land at 300-FF-2 upon achieving CULs are the same for alternatives 2, 3, 3a, 4 and 5. The time frame is also the same. Land use in the 300 Area Industrial Complex and 618-11 is industrial, with associated ICs. The remainder of 300-FF-2 is being cleaned up to achieve residential cleanup standards. Soil CULs for these alternatives will be achieved in 19 years.

Available uses of 300-FF-5 groundwater will be unrestricted use upon achieving CULs. Groundwater impacted by tritium from the 618-11 burial ground will be available for all uses in approximately 18 years under all alternatives. Groundwater with uranium in excess of the uranium CUL will be available for all uses in approximately 17 to 28 years as shown in table 6. Groundwater in the southern portion of the 300 Area which is not part of 300-FF-5 exceeds the DWS for nitrate due to off-Hanford sources. The alternatives do not address that nitrate contamination or the off-site sources.

Within the 300 Area Industrial Complex there are areas away from waste sites that were not contaminated in excess of residential CULs for direct exposure, groundwater protection or both. Many of the waste sites in the 300 Area Industrial Complex at completion of interim remediation meet residential direct exposure and/or groundwater protection CULs in this ROD. Some interim remediated waste sites were cleaned up to industrial use standards and backfilled with at least 4.6 m (15 ft) of soil and backfill material that meets residential direct exposure and/or groundwater protection CULs. It is anticipated that some 300-FF-2 waste sites in the 300 Area Industrial Complex that undergo RTD under alternatives 2,3, 3a, 4 and 5 will attain residential direct exposure and/or groundwater protection CULs.

10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

Table 6. Comparative Evaluation of Remedial Alternatives

CERCLA Criteria	Remedial Alternatives					
	1	2	3	3a	4	5
Threshold Criteria						
Protection of human health/environment	No	Yes	Yes	Yes	Yes	Yes
Compliance with ARARs	No	Yes	Yes	Yes	Yes	Yes
Balancing Criteria						
Long-term effectiveness and permanence	Not Evaluated	★★★☆☆	★★★☆☆	★★★☆☆	★★★☆☆	★★★★★
Reduction of toxicity, mobility or volume through treatment	Not Evaluated	★★☆☆☆	★★★★★	★★★★★	★★★☆☆	★★☆☆☆
Short-term effectiveness and time to achieve CULs ^h	Not Evaluated	★★☆☆☆	★★★★★	★★★★★	★★★☆☆	★★☆☆☆
Implementability	Not Evaluated	★★★★★	★★★☆☆	★★★★★	★★★☆☆	★★★☆☆
Estimated Time to Achieve CUL for Uranium in Groundwater (years) ^a		28	22	22 to 28 ^b	19	17
Estimated Time to Achieve CUL for Tritium in Groundwater (years) ^c		18	18	18	18	18
Estimated Time to Achieve CULs by RTD for Waste Sites (years) ^d		19	19	19	19	19
Cost (million) ^e						
Waste Sites ^{f,g}	\$0	\$230	\$355	\$247	\$526	\$1,341
Groundwater	\$0	\$3.3	\$11.5	\$11.5	\$11.4	\$2.5
Total Cost (million) ^e	\$0	\$233	\$367	\$259	\$537	\$1,344
Modifying Criteria						
State acceptance	See Section 10.8					
Community acceptance	See Section 10.9					

Note: Although the remedial alternatives developed for evaluation do not have specific provisions for sustainable elements, those values can be incorporated during the remedial design phase.

★★☆☆☆ = Expected to perform less well with more disadvantages or uncertainty when Compared to the other alternatives.

★★★☆☆ = Expected to perform moderately well some disadvantages or uncertainties when compared to the other alternatives

★★★★★ = Expected to perform best with fewer disadvantages or uncertainties when compared to the other alternatives.

Table 6. Comparative Evaluation of Remedial Alternatives

CERCLA Criteria	Remedial Alternatives					
	1	2	3	3a	4	5
a.	The estimated time to achieve CULs for uranium in groundwater is based on the 90 th percentile, or the 95 percent upper confidence limit on the mean, of the annual dissolved concentration (whichever is longest) for the well with the highest uranium concentration to achieve the CUL.					
b.	The estimated time to achieve CULs for uranium in groundwater for Alternative 3a is expected to range between 22 years (timeframe for Alternative 3) and 28 years (timeframe for Alternative 2). Since enhanced attenuation targets the area contributing to highest groundwater contamination, the estimated time to achieve the CUL is expected to be similar to Alternative 3.					
c.	The tritium concentration is estimated to be below the CUL by 2031. The estimate of 18 years to achieve the CUL is based on a starting date of 2013.					
d.	The estimated time to achieve CULs for waste sites is 2032 based on Pacific Northwest National Laboratory use of 300 Area long-term facilities until 2027, followed by completion of RTD at waste sites adjacent to the long-term facilities within five years of closure of those facilities.					
e.	These cost estimates represent the total present value (discounted), prepared to meet a -30 to +50 percent range of accuracy.					
f.	Alternative 5 includes \$81.3 million for construction of three ERDF super cells for waste disposal.					
g.	Does not include costs for waste sites that have begun remediation under the interim action ROD by January 2013.					
h.	The evaluation of short-term effectiveness emphasizes consideration of any adverse impacts on human health and the environment associated with implementation of the remedial action. Time to achieve CULs is provided for each of the remedy elements.					
	Alternative 1— No Action					
	Alternative 2— RTD and ICs for 300-FF-2; and MNA, ICs and Groundwater Monitoring for 300-FF-5					
	Alternative 3— Phased Enhanced Attenuation of Uranium from Select Waste Sites, RTD, and ICs for 300-FF-2; A ROD Amendment for Phased Enhanced Attenuation of Uranium from Select Waste Sites for 300-FF-1; and MNA, Groundwater Monitoring and ICs for 300-FF-5					
	Alternative 3a— Enhanced Attenuation of Uranium from Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Enhanced Attenuation of Uranium at Select Waste Sites for 300-FF-1; and MNA, Groundwater Monitoring, and ICs for 300-FF-5.					
	Alternative 4— Enhanced Attenuation and Focused Deep RTD of Uranium at Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Enhanced Attenuation and Focused Deep RTD of Uranium at Select Waste Sites for 300-FF-1; and MNA, ICs and Groundwater Monitoring for 300-FF-5					
	Alternative 5— Expanded Deep RTD of Uranium at Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Expanded Deep RTD of Uranium at Select Sites for 300-FF-1; and MNA, ICs and Groundwater Monitoring for 300-FF-5					

Alternative 1 (No Action) proposes no remediation of waste sites (interim actions would end) in 300-FF-2 or 300-FF-5 groundwater, and the ICs under the interim action RODs would not be maintained. In addition the 300-FF-1 final ROD would not be amended to further address uranium contamination. Alternatives 2, 3, 3a, 4 and 5 include the same elements for remediation of all soil contaminants in 300-FF-2 other than residual uranium in the deep vadose zone and PRZ: RTD at the waste sites; Alternatives 2, 3, 3a, 4 and 5 include the same elements for remediation of 300-FF-5 groundwater: MNA for nitrate, tritium, TCE and DCE; groundwater monitoring for uranium and gross alpha; and ICs.

The six remedial alternatives provide different approaches for remediating the residual uranium contamination in the deep vadose zone and PRZ:

- Alternative 1 proposes no remediation;
- Alternative 2 proposes groundwater monitoring for the deep uranium contamination;
- Alternative 3 proposes a phased approach for in situ immobilization of deep uranium contamination through phosphate injection at approximately 18 hectares (45 acres);
- Alternative 3a proposes enhanced attenuation of deep uranium contamination through phosphate injection in the approximately 1 hectare (3 acre) area contributing to the persistent groundwater contamination near waste sites 316-5 and 316-2.
- Alternative 4 proposes removing the greatest mass of deep uranium contamination by excavating to groundwater, followed by in situ immobilization for the lesser mass of deep uranium contamination through phosphate injection;
- Alternative 5 proposes removing the deep uranium contamination by excavating to groundwater where the uranium exceeds groundwater protection CULs.

Alternative 1 does not meet the threshold criterion for protection of human health and the environment and, therefore, it was not evaluated further. Alternatives 2, 3, 3a, 4 and 5 would meet the threshold criterion for protection of human health and the environment and comply with ARARs; therefore, they are evaluated further.

10.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced or controlled, through treatment, engineering controls and/or ICs.

Alternatives 2, 3, 3a, 4 and 5 would meet the threshold criterion for protection of human health and the environment. Protectiveness is achieved by eliminating, reducing or controlling risks through different combinations of excavation and treatment of soil, structures and debris waste; temporary surface barriers and pipeline void filling; MNA; enhanced attenuation and ICs.

Alternatives 2, 3, 3a, 4 and 5 include the same elements for remediation of all 300-FF-2 soil contaminants other than residual uranium in the deep vadose zone and PRZ: RTD at waste sites. Alternatives 2, 3, 3a, 4 and 5 include the same elements for remediation of 300-FF-5 groundwater: MNA for nitrate, tritium, TCE and DCE; groundwater monitoring for gross alpha and nitrate; and ICs. Alternatives 2, 3, 3a, 4 and 5 include groundwater monitoring for uranium, but they differ regarding uranium because alternatives 3, 3a and 4 also apply phosphate to the top of the aquifer as part of uranium sequestration.

10.2 Compliance with Applicable or Relevant and Appropriate Requirements

CERCLA § 121(d) and the NCP § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA § 121(d)(4). Compliance with ARARs addresses whether an alternative will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provides a basis for invoking a waiver. Alternatives 2, 3, 3a, 4 and 5 will comply with ARARs and therefore would meet this threshold criterion. The selected remedy will be designed to meet location- and action-specific ARARs. There are no waivers from ARARs established in this ROD. ARARs for the selected remedy are listed and briefly described in appendix A. Key ARARs are portions of the state MTCA and DWSs.

10.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

Upon completion of in-field remedial elements of alternatives 2, 3, 3a, 4 and 5 no high risk contamination will remain. Alternatives 2, 3, 3a, 4 and 5 include ICs to manage risk in the interim period (several decades), and relatively limited ICs for residual (post active cleanup) risk in the long term. These ICs are expected to be reliably maintained.

Uranium is the principal contaminant that distinguishes the long-term effectiveness of the alternatives. Alternatives 4 and 5 are expected to provide the most long-term effectiveness and permanence in the 300 Area with respect to uranium as they provide for the removal of the greatest mass of deep uranium contamination through excavation; however, these alternatives do not remove the uranium contamination that has migrated laterally in the PRZ or aquifer. Alternatives 3 and 3a are expected to achieve long-term effectiveness and permanence for uranium contamination by using uranium sequestration in the treated area through direct formation of autunite, a stable uranium mineral that has low solubility. Alternatives 3 and 3a also have the potential to remediate more deep uranium contamination than Alternatives 4 and 5 in a manner that provides long-term effectiveness because the phosphate solutions can migrate laterally within the deep vadose zone, PRZ and aquifer to provide additional uranium

sequestration. However, there is some uncertainty associated with Alternatives 3 and 3a because uranium sequestration has not been implemented full-scale at the Hanford Site. Alternative 2 is expected to achieve long-term effectiveness and permanence, but relies on longer term natural processes to remove the residual uranium contamination in the deep vadose zone. As a result, uranium in the deep vadose zone may migrate to the groundwater in the interim due to the variable river stage.

Alternatives 2, 3, 3a, 4 and 5 will achieve long-term effectiveness and permanence, with Alternative 5 expected to perform best for this criterion.

10.4 Reduction of Toxicity, Mobility or Volume through Treatment

Reduction of toxicity, mobility or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternatives 2, 3, 3a, 4 and 5 are the same regarding treating principal threat waste and waste resulting from RTD with the exception of uranium contamination from seven sites and the top of the aquifer beneath the uranium soil treatment areas. As part of the RTD element, contaminated waste is treated as necessary to meet disposal facility requirements such as grout treatment to meet Land Disposal Requirements or reduce air release potential. Treatment would also be conducted in advance of removal as needed (e.g., for highly radioactive materials, including principal threat waste) to control worker exposure and minimize airborne releases.

Alternatives 3, 3a and 4 require in-situ treatment to reduce mobility of uranium in the vadose zone, PRZ and top of the groundwater aquifer.

Soil from waste site 300-296 below the 324 Building B Cell is part of 300-FF-2 remediation. Under alternatives 2, 3, 3a, 4 and 5 the highly contaminated soil will be retrieved and placed into other non leaking 324 Building hot cells. These cells provide additional shielding to workers from radioactive contaminants. Removal of the 324 Building, and the hot cells that would contain this 300-296 waste, will be performed under the CERCLA Action Memorandum #2 for the 300 Area Facilities. In addition, closure of the TSD units in the 324 Building Radiochemical Engineering Cells will be performed under the RCRA Closure Plan.

Under alternatives 2, 3, 3a, 4 and 5 principal threat waste from the 300-296 waste site, vertical pipe units at 618-10 and 618-11 and caissons at 618-11 will be treated to the maximum extent practicable to reduce the toxicity, mobility, contamination or radiation exposure. Treatment may be in-situ or during excavation as needed to control worker exposure. Treatment will be with grout or an alternative method approved by EPA during remedial design.

The area with the highest concentration of uranium in the vadose zone, PRZ and top of the aquifer is treated in-situ under alternatives 3 and 3a, but not under alternative 4. Alternative 3a in-situ treatment is equal to alternative 3 Phase 1. Alternative 3 includes a Phase 2 that if implemented treats an additional much larger area of uranium contamination. Alternative 4

addresses the same additional area as alternative 3 Phase 2 except under alternative 4 some of the additional area is exhumed under the RTD element rather than addressed through in-situ treatment. Therefore the most in-situ uranium treatment is achieved under alternative 3 with Phase 1 and 2, followed by alternative 3 with just Phase 1 and alternative 3a, which are equal. Alternative 4 provides for less treatment because the areas with the highest concentrations of uranium in the vadose zone and PRZ are exhumed via focused deep RTD rather than in-situ treatment. Except for principal threat waste which is treated, treatment of other RTD waste is limited to that needed to meet disposal facility requirements or to control worker exposure and minimize airborne releases.

Alternatives 2, 3, 3a, 4 and 5 provide reduction of toxicity, mobility and volume through treatment to different levels with Alternatives 3 and 3a providing the most toxicity, mobility and volume reduction followed by Alternative 4.

10.5 Short-term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any potential adverse impacts to workers, the community and the environment during construction and operation of the remedy until CULs are achieved.

Factors that are considered include (1) the speed with which the remedy can be implemented and (2) any adverse impacts on human health and the environment during the construction and implementation phase of the remedial action.

For Alternatives 2, 3, 3a, 4 and 5, the estimated time to achieve CULs for the waste sites is the same because several of the waste sites are collocated with long-term facilities. Remediation of these waste sites is assumed to occur within 19 years (by 2032), which is five years after the long-term facilities are no longer in use.

From the standpoint of uranium cleanup in the aquifer, it is expected to take 28 years to achieve the uranium CUL under Alternative 2. In addition, the estimated time for Alternative 2 to achieve the CULs for uranium in groundwater has the most uncertainty because it is the most dependent on the frequency of very high river fluctuations in the future.

For Alternatives 3, 3a, 4 and 5, the estimated times to achieve CULs for uranium in groundwater are identified in table 6. The following schedule assumptions are made:

- Alternative 2 does not include remediation of the residual uranium in the deep vadose zone and PRZ contributing to groundwater. The estimated time to achieve groundwater CUL for uranium begins in 2013 and takes 28 years, by year 2041. The uncertainty in the estimated time to achieve the uranium CUL in the groundwater is highest for Alternative 2, which depends on the frequency of very high river fluctuations in the future and does not benefit from any remedial actions in the deep vadose zone and PRZ.

- Alternative 3 is estimated to take six years to complete the uranium sequestration. Following those six years, the model predicted 16 years to achieve the groundwater CUL for uranium. Therefore, the estimated time to achieve groundwater CUL for uranium under Alternative 3 is 22 years, by year 2035. Alternative 3 has less uncertainty than Alternative 2 in this regard, but also is dependent on the frequency of very high river fluctuations in the future which controls the annual rate of uranium attenuation in the PRZ that is outside the area of uranium treatment.
- Alternative 3a is estimated to take four years to complete the uranium sequestration. This alternative addresses the deep uranium contamination contributing to the persistent groundwater contamination hot spot. The estimated time to achieve the groundwater CUL for uranium is expected to range between Alternative 3 (22 years, by year 2035) and Alternative 2 (28 years, by year 2041). Alternative 3a has more uncertainty in this regard than Alternative 3 that includes Phase 2 which uses uranium sequestration in a larger area. Alternative 3a has less uncertainty than Alternative 2 which is solely dependent on the frequency of very high river fluctuations in the future to attenuate uranium.
- Alternative 4 is estimated to take seven years to complete the focused deep RTD and uranium sequestration. Following those seven years, the model predicted 12 years to achieve the groundwater CUL for uranium. Therefore, the estimated time to achieve the groundwater CUL for uranium under Alternative 4 is 19 years, by year 2032. Alternative 4 has similar uncertainty to Alternative 3 and 3a because Alternative 4 is dependent on the frequency of very high river fluctuations in the future which controls the annual rate of uranium attenuation in the PRZ that is outside the area of the RTD actions.
- Alternative 5 is estimated to take seven years to complete the extensive deep excavation. Following those seven years, the model predicted 10 years to achieve the groundwater CUL for uranium. Therefore, the estimated time to achieve the groundwater CUL for uranium under Alternative 5 is 17 years, by year 2030. Alternative 5 has similar uncertainty to Alternative 4 because Alternative 5 is dependent on the frequency of very high river fluctuations in the future which controls the annual rate of uranium attenuation in the PRZ that is outside the area of the RTD actions.

Alternatives 4 and 5 both include deep RTD of residual uranium contamination. Handling the large volume of soil requires significant funding for building infrastructure (such as building new ERDF Super Cells and haul roads).

Although the deep excavation components of Alternatives 4 and 5 might appear to have higher short-term effectiveness because the uranium CUL is achieved more quickly than with other alternatives, deep RTD entails a number of adverse impacts during implementation. The deep excavation of soil to groundwater for the uranium-contaminated waste sites includes the minimum, standard safe-practice lay-back of 1.5 m (5 ft) for each vertical 1 m (3.3 ft) of excavation depth. This deep excavation will create a very large disturbed area and generate approximately 0.76 million m³ (1.0 million yd³) of soil in Alternative 4 and 3.3 million m³ (4.3 million yd³) of soil in Alternative 5 for handling and disposal. Given that large volumes of contaminated soil that will be generated, three new Super Cells will need to be constructed at the ERDF to dispose of the excavated deep contaminated soil for Alternative 5. The subsequent

backfill of the excavated areas will require loading, transportation and handling of a comparable volume of clean soil from a different location. For Alternative 4, the excavation and backfill of a combined 1.5 million m³ (2.0 million yd³) of soil are estimated to require approximately 6.3 million km (3.9 million mi) of truck haulage. The trucks would burn 10 million L (2.6 million gal) of diesel fuel and generate 31,000 metric tons (34,000 tons) of carbon dioxide and 250 metric tons (276 tons) of mono-nitrogen oxides. For Alternative 5, the excavation and backfill of a combined 6.6 million m³ (8.6 million yd³) of soil are estimated to require approximately 27 million km (17 million mi) of truck haulage. The trucks would burn 43 million L (11 million gal) of diesel fuel and generate 133,000 metric tons (147,000 tons) of carbon dioxide and 1,100 metric tons (1,200 tons) of mono-nitrogen oxides. These represent significant short-term implementation impacts to the environment.

Excavation technologies require dust control for worker safety and for airborne contamination control to protect on-site and off-site receptors. Application of dust control water during excavation of the vadose zone soils and partially saturated soils in the PRZ will release residual uranium contamination to the groundwater, as evidenced by the uranium plume that was produced by the excavation of vadose zone soil at the 618-7 and 618-10 Burial Grounds. As a result, the deep RTD in Alternatives 4 and 5 is likely to release more uranium to the groundwater, and to the river, than the other alternatives in the short term. The magnitude of this impact could not be quantified with sufficient certainty for inclusion in this evaluation. The impact from this mobilized uranium was not included in the time to achieve CULs presented in table 6.

Potential impacts to the site workers from implementing any of the alternatives onsite would be controlled and mitigated through health and safety procedures, the use of adequate worker personal protective equipment and a perimeter dust/air monitoring program that would provide timely and adequate data to mitigate any potential off-site effects in a timely manner. Because Alternatives 4 and 5 include excavation to depths greater than 4.6 m (15 ft) bgs, there would be an increase in safety challenges to workers compared to implementing a less invasive approach like uranium sequestration.

Alternatives 3 and 3a do not cause the extent of adverse short-term effects associated with deep excavation. Uranium sequestration proposed in Alternatives 3 and 3a would be effective in reducing the flux of the greatest mass of uranium to groundwater once the phosphate reagent contacts the uranium contaminant for a sufficient time to produce a stable uranium mineral. The deep RTD proposed in Alternative 4 and Alternative 5 to remove the greatest mass of uranium cannot be implemented without generating the unintended consequences of adverse effects on human health and the environment because of the large excavation footprint, large consumption of fuel resources and resulting air pollution and high potential for mobilizing uranium to the groundwater and to the river. Alternatives 3 and 3a were ranked as having the highest short-term effectiveness because (1) they do not extend the remediation timeframe beyond the time required for the waste sites and (2) they minimize adverse effects on human health and the environment.

10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility and coordination with other governmental entities are also considered.

Alternatives 2, 3, 3a, 4 and 5 include RTD, MNA and IC remedies that are technically and administratively feasible and are readily implementable. Alternative 5 is considered less implementable than Alternatives 3, 3a and 4 because of the need to conduct deep excavations, construct new ERDF Super Cells, identify a suitable borrow pit for obtaining backfill material and to build and maintain haul roads. Removal of residual uranium detected in the deep vadose zone or PRZ in the sidewalls of the planned excavation footprint will require additional excavation from the ground surface. Excavation of the PRZ is limited to periods when the river stage is low and the PRZ is available for excavation. The focused deep RTD in Alternative 4 has similar implementation issues, though of a lesser extent than alternative 5.

Alternatives 3, 3a and 4 have technical uncertainties associated with delivering the phosphate solutions effectively to the uranium contamination in the deep vadose zone and PRZ. To address these uncertainties, Alternatives 3, 3a and 4 apply phosphate at the surface, in the vadose zone and in the aquifer. Alternative 3 also uses a phased approach that provides an opportunity to optimize the delivery processes.

Alternatives 3, 3a and 4 use wells to deliver the phosphate solutions to the PRZ and top of the aquifer at the treatment zone. Alternative 3 which requires 311 wells, and Alternative 4 which requires 134 wells, are considered to pose more of an implementation challenge than Alternative 3a which requires 47 wells.

10.7 Cost

Estimated design, construction, O&M and decommissioning costs were developed for each alternative. Costs were not included for waste sites that have begun remediation under the interim action ROD by January 2013. Costs for O&M were based on the alternative-specific remedial timeframes, which range from 19 to 28 years. The total present value costs are \$233 million for Alternative 2, \$259 million for Alternative 3a, \$367 million for Alternative 3, \$537 million for Alternative 4 and \$1.344 billion for Alternative 5. The costs for remediation of waste sites and groundwater are presented for each alternative in table 4. The costs are lowest for Alternative 2 and highest for Alternative 5.

Total present value (discounted) costs were estimated using the real discount rate published in Appendix C of the Office of Management and Budget (OMB) Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, effective through January 2013*. Based on this guidance and the durations of the remedial alternative components, the real discount rates ranged from 0.7 percent to 2.0 percent.

Table 7. Summary of Costs for Remedial Alternatives

Remedial Alternative	Capital Cost	Annual Operations and Maintenance Cost	Total Present Value
1	\$ 0	\$ 0	\$ 0
2	\$ 245,412,000	\$ 40,096,000	\$ 233,011,000
3	\$ 279,567,000	\$ 144,113,000	\$ 366,839,000
3a	\$ 254,277,000	\$ 43,708,000	\$ 259,094,000
4	\$ 487,584,000	\$ 109,988,000	\$ 537,001,000
5	\$ 1,390,753,000	\$ 38,315,000	\$ 1,344,227,000

Alternative 1— No Action

Alternative 2— RTD and ICs for 300-FF-2; and MNA, ICs and Groundwater Monitoring for 300-FF-5

Alternative 3— Phased Enhanced Attenuation of Uranium from Select Waste Sites, RTD, and ICs for 300-FF-2; A ROD Amendment for Phased Enhanced Attenuation of Uranium from Select Waste Sites for 300-FF-1; and MNA, Groundwater Monitoring and ICs for 300-FF-5

Alternative 3a— Enhanced Attenuation of Uranium from Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Enhanced Attenuation of Uranium at Select Waste Sites for 300-FF-1; and MNA, Groundwater Monitoring, and ICs for 300-FF-5.

Alternative 4— Enhanced Attenuation and Focused Deep RTD of Uranium at Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Enhanced Attenuation and Focused Deep RTD of Uranium at Select Waste Sites for 300-FF-1; and MNA, ICs and Groundwater Monitoring for 300-FF-5

Alternative 5— Expanded Deep RTD of Uranium at Select Waste Sites, RTD and ICs for 300-FF-2; a ROD Amendment for Expanded Deep RTD of Uranium at Select Sites for 300-FF-1; and MNA, ICs and Groundwater Monitoring for 300-FF-5

10.8 State Acceptance

The State of Washington Department of Ecology (Ecology) provided the following state acceptance statement for inclusion in this ROD:

Ecology is the supporting regulatory agency for the 300-FF-1, 300-FF-2 and 300-FF-5 OU final remedy. Ecology concurs with the selected remedy.

Ecology notes that nitrate contamination of groundwater that exceeds drinking water is present in the south part of the 300 Area. This ROD addresses three OUs: 300-FF-1, 300-FF-2, and 300-FF-5 within the 300 Area NPL site. This ROD excludes the afore-mentioned nitrate contamination from the 300-FF-5 OU, and Ecology understands that EPA and DOE believe it comes from an upgradient source. Further, this ROD does not select CERCLA response actions for the afore-mentioned nitrate contamination. Therefore, consistent with CERCLA Section 120(a)(4), Ecology asserts that state laws concerning remedial and removal actions shall apply to removal and remedial actions for the afore-mentioned nitrate contamination in groundwater, specifically the Model Toxics Control Act

(MTCA) and its implementing regulations WAC 173-340 shall apply to the afore-mentioned nitrate contamination of groundwater.

10.9 Community Acceptance

The assessment of community acceptance includes determining which components of the alternatives community members support, have reservations about or oppose. Comments received and responses from DOE and EPA are provided in Appendix B Responsiveness Summary. Significant comments were submitted on the following topics:

- Industrial land use cleanup and associated ICs
- Risk from contamination entering the Columbia River
- Uranium cleanup level and Washington State cleanup standards
- Preference for excavation of the residual uranium
- Efficacy of uranium sequestration via addition of phosphates
- Monitored natural attenuation
- Long-term protectiveness
- Contingent remedy for uranium sequestration
- Performance requirement for uranium sequestration
- Viability of ICs
- Protect treaty rights, provide environmental justice
- Tribal treaties as ARARs
- Endangered Species Act consultation
- Cost of RTD in Alternatives 4 and 5 are too high
- Traditional Cultural Properties
- Colloidal Transport of Treated Uranium
- Tri-Party Agreement Milestones
- Modeling
- Dust Suppression Alternatives
- River Shoreline
- Phosphate as a Pollutant
- Contaminant Inventory
- Use Other More Stringent Standards
- 200-PO-1
- Risk assessment from multiple sites
- Ecological risk assessment

Generally the public comments supported the RTD element in the preferred alternative and using state cleanup standards as required CULs. Comments generally were not supportive of uranium sequestration or of using an industrial land use determination for parts of 300-FF-2 as a basis for CULs and ICs that do not provide for residential /unrestricted use.

11.0 PRINCIPAL THREATS

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable (40 CFR 300.430(a)(1)(iii)(A)). Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

Principal threat waste is present in 300-FF-2, but not in 300-FF-5. Contaminated groundwater is generally not considered to be a source material. Principal threat wastes in 300-FF-2 are the following:

- Vertical pipe unit waste in the 618-10 and 618-11 burial grounds. These are 4.6 m (15 ft) long pipes up to 0.6 m (22 inch) diameter with open pipe ends which were installed vertically in the ground. Highly radioactive containers of waste was transported in shielded containers and disposed into these in-ground vertical pipes. At the end of disposal, clean cover was placed over the vertical pipe units. RTD of this waste will require treatment to reduce the potential for airborne releases and reduce worker dose during retrieval. Such treatment will reduce the waste toxicity and mobility. Treatment will be with grout or other stabilizing material approved by EPA during remedial design.
- Caisson waste in the 618-11 burial ground. These are 3 m (10 ft) long pipes 2.4 m (8 ft) in diameter with an open bottom which were installed vertically in the ground with the top of the caisson about 4.6 m (15 ft) bgs. A 1 m (3 ft) diameter angled chute extended to the ground surface. Highly radioactive containers of waste were transported in shielded containers and disposed into these caissons. RTD of this waste will require treatment to reduce the potential for airborne releases and reduce worker dose during retrieval. Such treatment will reduce the toxicity and mobility. Treatment will be with grout or other stabilizing material approved by EPA during remedial design.
- Soil from waste site 300-296 below the 324 Building B hot cell. Based on in-situ radiation measurements and sample data this soil is extremely radioactive. Direct exposure to the contaminated soil for just a fraction of a second would exceed the CERCLA 1×10^{-4} cancer risk limit. The Cesium-137 at 8 billion pCi/g and Strontium-90 at 400 million pCi/g are the primary isotopes causing the high radiation dose and risk. The high risk soil requires remote excavation methods and is considered principal threat waste.

12.0 SELECTED REMEDIES AND ROD AMENDMENT

The selected remedies for both 300-FF-2 and 300-FF-5 are alternative 3a and as further described in this section. Alternative 3a also includes an amendment of the ROD for 300-FF-1.

12.1 Rationale for the Selected Remedies and ROD Amendment

The selected remedies are protective of human health and the environment and achieve substantial risk reduction through RTD of waste sites in 300-FF-2; treatment of the highest

uranium concentration location in the vadose zone and PRZ for groundwater protection; treatment of principal threat wastes; and by providing for the safe management of residual contamination through ICs.

Alternatives 2, 3, 3a, 4 and 5 include the same approach to remediation of soil contamination in 300-FF-2, other than residual uranium in the deep vadose zone and PRZ. The alternatives also include the same requirements for remediation of 300-FF-5 groundwater, except that the top of the aquifer is treated for uranium in alternatives 3, 3a and 4. Therefore, the comparison of alternatives focused on differences in how the alternatives addressed residual uranium in the deep vadose zone, PRZ and top of the aquifer. Alternative 3a performs comparably to Alternative 3 with just Phase 1 in that uranium treatment is focused on the area shown to be the most significant continuing source of uranium to groundwater. Alternative 3a estimates for achieving uranium CUL range from 22-28 years as compared to the 22 year estimate for Alternative 3. All alternatives rely on attenuation of uranium in the broadly distributed distal uranium source area created by the disposal operations. Alternatives 4 and 5 are expected to achieve uranium CULs in 19 and 17 years respectively, but require additional extensive excavation, and are expected to adversely impact the aquifer in the short term by mobilizing uranium through dust control water that leaches additional uranium into the groundwater. Large-scale excavation (Alternative 5) requires a large consumption of resources and associated air pollution emissions as described in section 10.5. Alternatives 3, 3a and 4 provide more treatment than alternatives 2 and 5 due to in-situ treatment of uranium. Alternative 3a treats the area with the highest concentration of uranium in the vadose zone, PRZ and top of the aquifer. Alternative 3 treats that same area plus addition areas if Phase 2 is implemented. The areas in alternative 3 including Phase 2 that would be treated for uranium mobility via injection of phosphate are excavated via deep RTD under alternative 5.

Alternatives 3 and 3a perform best regarding short-term effectiveness. The cost for the alternatives from lowest to highest are 2, 3a, 3, 4 and 5. For implementability alternative 2 performs best, followed by alternative 3a. Alternative 5 performs best for long-term effectiveness.

Alternative 5 performs best followed by alternative 4 regarding community acceptance given the preference for uranium RTD rather sequestration rather expressed by many of the commenters. Alternatives 2, 3, and 3a are equal in this regard because they utilize RTD equally. The state of Washington Department of Ecology concurs with selection of Alternative 3a.

The selected remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The selected remedy satisfies CERCLA § 121(b) to: (1) be protective of human health and the environment; (2) comply with ARARs (or justify a waiver); (3) be cost-effective; (4) use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (5) satisfy the preference for treatment as a principal element.

12.2 Description of Selected Remedies for 300-FF-2 and 300-FF-5

The remedies and ROD amendment selected may change somewhat as a result of the remedial design and construction process. Any changes to the remedies and ROD amendment described in the ROD will be documented using a technical memorandum in the administrative record, an Explanation of Significant Differences, or a ROD amendment, as appropriate.

12.2.1 RTD at Waste Sites for 300-FF-2

RTD of waste sites to achieve RAOs and CULs through (a) RTD the soil with COCs exceeding CULs identified in table 4 above as deep as 4.6 m (15 ft) bgs to protect human health and ecological receptors from direct exposure to contaminants, (b) remove the engineered structures which includes pipelines with contamination exceeding CULs (e.g., burial ground trenches, drums, caissons and vertical pipe units), (c) RTD the soil and engineered structures below 4.6 m (15 ft) bgs with COCs other than uranium that exceeds CULs in table 4 for groundwater and river protection and (d) backfill and revegetate the excavated waste sites. Except as specified in section 12.2.6 and 12.2.7 below, uranium that is identified during remedial activities to exceed CULs below 4.6m will be addressed either by RTD and/or sequestration with phosphate as approved by EPA.

Contaminated soil, structures and debris with concentrations above the CULs will be removed from the waste sites, treated as necessary to meet disposal facility requirements and sent to ERDF, which is considered onsite, or another facility approved by EPA. CULs apply to soil, structures which includes pipelines and debris. CULs do not apply to chemicals that are an integral part of manufactured structures (for example zinc in galvanized metal). The chemicals that are an integral part of manufactured structures are not considered contamination. The need for remedial action is based on contamination. In addition, treatment will be conducted as necessary in advance of removal to control worker exposure and minimize airborne releases (e.g., for highly radioactive materials, including principal threat waste).

Soil from waste site 300-296 below the 324 Building B Cell is part of 300-FF-2 and is addressed in the selected remedy. The highly contaminated soil that requires remote excavation methods will be retrieved and placed into other non-leaking 324 Building hot cells. These cells provide additional shielding to workers from radioactive contaminants. Removal of the 324 Building, and the hot cells that would contain this 300-296 waste, will be performed under the CERCLA Action Memorandum #2 for the 300 Area Facilities. In addition, closure of the TSD units in the 324 Building Radiochemical Engineering Cells will be performed under the RCRA Closure Plan.

Principal threat waste from the 300-296 waste site, vertical pipe units at 618-10 and 618-11 and caissons at 618-11 will be treated to the maximum extent practicable to reduce the toxicity, mobility, contamination or radiation exposure. Treatment may be in-situ or during excavation as needed to control worker exposure. Treatment will be with grout or an alternative method approved by EPA during remedial design.

12.2.2 Temporary Surface Barriers and Pipeline Void Filling for 300-FF-2

For waste sites that exceed CULs in table 4 that are adjacent to the 300 Area facilities and utilities that will remain in operation through at least 2027 (long-term facilities), temporary surface barriers will be installed and maintained in areas specified in the RD/RAWP to reduce infiltration and contaminant flux to groundwater. The design of the barriers will be described in the RD/RAWP. Surface barriers will be constructed of asphalt or alternative materials approved by EPA in the RD/RAWP to decrease permeability. In addition, pipelines with uranium and/or mercury contamination that exceed CULs in table 4 for groundwater and river protection that are inaccessible for the RTD remedy because of their close proximity to long-term facilities will be void filled to the maximum extent practicable as defined in the RD/RAWP to immobilize radionuclides (and elemental mercury in waste site 300 RRLWS) in the pipelines for groundwater protection. When the long-term facilities are no longer in use and are removed, the waste sites and pipelines will be remediated as described above in the RTD discussion. The long-term retained facilities are shown on figure 3.

12.2.3 Institutional Controls Common Elements for 300-FF-2 and 300-FF-5

ICs are required before, during and after the active phase of remedial action implementation where ICs are needed to protect human health and the environment. ICs are used to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure. DOE shall be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity and ICs. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

The current implementation, maintenance and periodic inspection requirements for ICs at the Hanford Site are described in approved work plans and in the Sitewide Institutional Controls Plan (DOE/RL-2001-41) that was prepared by DOE and approved by EPA and the State in 2002. No later than 180 days after the ROD is signed, DOE shall update the Sitewide Institutional Controls Plan to include the ICs required by this ROD and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised Sitewide Institutional Controls Plan shall be submitted to EPA and the Washington State Department of Ecology (Ecology) for review and approval as a Tri-Party Agreement primary document. The DOE shall comply with the Sitewide Institutional Controls Plan as updated and approved by EPA and Ecology.

The following institutional control performance objectives are required to be met as part of this remedial action. Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.
- In the event of any unauthorized access (e.g. trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.
- Activities that would disrupt or lessen the performance of any component of the remedies are prohibited.
- The DOE shall report on the effectiveness of ICs for 300-FF-2 and 300-FF-5 in an annual report, or on an alternative reporting frequency specified by the lead regulatory agency. Such reporting may be for 300-FF-2 and 300-FF-5 alone or may be part of the Hanford Sitewide ICs report.

Measures that are necessary to ensure continuation of ICs shall be taken before any lease or transfer of any land subject to ICs. DOE will provide notice to Ecology and EPA at least 6 months before any transfer or sale of land subject to ICs so that the lead regulatory agency can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for DOE to notify Ecology and EPA at least 6 months before any transfer or sale, DOE will notify Ecology and EPA as soon as possible, but no later than 60 days before the transfer or sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of the executed deed or transfer assembly to Ecology and EPA. DOE shall notify EPA and Ecology immediately upon discovery of any activity inconsistent with the specific ICs.

12.2.4 Institutional Controls Unique Elements for 300-FF-2

The following institutional control performance objectives are required to be met as part of this remedial action for 300-FF-2. Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- Exposure to contamination deeper than 4.6 m (15 ft) bgs is not anticipated. Where contamination at depth exceeds the residential or industrial use CULs, ICs are required to ensure future activities do not bring this contamination to the surface or otherwise result in exposure to contaminant concentrations that exceed the CULs.
- The DOE will prevent the development and use of property that does not meet residential CULs at the 300 Area Industrial Complex and 618-11 (figure 10) for other than industrial uses, including use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds.
- Signage and access control to waste sites with contamination above CULs will be provided.

- DOE shall employ and maintain an excavation permit program for protection of human health against unacceptable exposure, and protection of environmental and cultural resources.
- Prevent enhanced recharge in the 300 Area Industrial Complex and 618-11 over or near waste sites with soil concentration at any depth that exceed residential (irrigation-based) groundwater and surface water protection CULs until the CULs are achieved. Enhanced recharge controls are no irrigation or landscape watering, control drainage from low permeability areas including paved parking lots or buildings, and prevent bare gravel or bare sand covers.

12.2.5 Institutional Controls Unique Elements for 300-FF-5

The following institutional control performance objectives are required to be met as part of this remedial action for 300-FF-5. Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs are the following:

- Administrative controls limiting 300-FF-5 groundwater access and use in a manner that is protective of human health where groundwater is above CULs (see figure 2).



Figure 10. 300-FF-2 Industrial Use Areas Subject to Industrial Use ICs

12.2.6 Enhanced Attenuation of Uranium Common Elements for 300-FF-1 and 300-FF-2

Enhanced attenuation of uranium is to be achieved via sequestration treatment with phosphate. Phosphate will be applied near the ground surface; within the lower vadose zone, PRZ and top of the aquifer via injection wells; and within the top of the aquifer toward the east and south of the vadose treatment area.

Uranium sequestration by phosphate application will be implemented to enhance the natural attenuation of the uranium source mass in the vadose zone, PRZ and top of the aquifer in the area of highest uranium contamination (figure 9). The groundwater plume in this area results from three 300-FF-1 sites (316-1, 316-2 and 316-5) and four 300-FF-2 waste sites (316-3, 618-1, 618-2 and 618-3.) The treatment area is approximately 1 hectare (3 acres) and includes injection of phosphate at the top of the aquifer to address uranium that may be mobilized during the treatment process. The specific target area will be identified in the RD/RAWP. Uranium concentration and leachability characterization will be conducted on vadose zone and PRZ core samples collected before and after phosphate treatment to quantify the vadose zone and PRZ treatment effectiveness, and to refine the groundwater model. Groundwater monitoring will be conducted to assess changes in uranium concentrations and the lateral spread of phosphate.

Wells will be used for injection of phosphate to a zone that is located just above and/or within the aquifer to mitigate potential impacts to the aquifer from uranium that may be carried downward by the water used to inject the phosphate. This treatment zone will be in place during water and reagent application in the vadose zone and maintained for a short period afterwards to react with any uranium that leaches into groundwater as a result of the phosphate solution applied to the vadose zone and PRZ. Phosphate injections will be performed when groundwater conditions are favorable (e.g., when groundwater flows in from the river during rising and high river stages).

The specific reagent blends of phosphate will be designed to optimize desired treatment characteristics, depending on the delivery method and target media. For instance, a slower release formulation that contains polyphosphate is desirable for infiltration and PRZ injection applications, where the slower delivery rate and less certain reagent distribution pattern would benefit from a slower reaction time to allow the reagent to migrate further into the unsaturated soil. In contrast, a faster-reacting formulation containing 100 percent orthophosphate is beneficial when targeting groundwater at the top of the aquifer during transient high-water stages. The feasibility study was based a reagent blend of 20 percent polyphosphate and 80 percent orthophosphate for infiltration and PRZ injections, and a 100 percent orthophosphate reagent was assumed for aquifer injections. The reagent blend will be determined during remedial design.

Near surface treatment will use the following general approach, with details to be developed in remedial design and established in the RD/RAWP:

- Surface infiltration with phosphate reagent-amended water

- Reagent mixing facility, pipelines, injection wells, pumps, valves
- Reagent delivery system for surface application
- Monitoring and verification sampling, including soil borings and monitoring wells to monitor effectiveness and potential impacts to groundwater
- Estimated system flow rate ranging from 190 to 1,135 L/min (50 to 300 gal/min) per acre

Phosphate reagent will be injected into the lower vadose zone and PRZ through wells selectively screened or packed to apply reagent into a focused treatment interval. Treatment will use the following general approach, with details to be developed in remedial design and established in the RD/RAWP:

- Well injection with phosphate reagent-amended water
- Reagent mixing facility, pipelines, injection wells, pumps, valves
- Phosphate reagent injection wells will be spaced approximately 15 m (50 ft) apart. Wells will be screened across the lower vadose zone and PRZ within the footprint of and adjacent to (along the river side) of the 1 hectare (3 acre) target area. Preliminary design includes 47 injection wells.
- Monitoring and verification sampling including soil borings and monitoring wells to monitor effectiveness and potential impacts to groundwater
- Injection rates ranging from approximately 380 to 760 L/min (100 to 200 gal/min) for each well.

The timing of the application in the PRZ would be scheduled to maximize contact with the smear zone during the seasonal high groundwater elevation. Properly deployed, lateral reagent injection will be capable of contacting lower vadose zone and PRZ sediment at distances approximately 15 m (50 ft) from each injection well.

12.2.7 Enhanced Attenuation of Uranium for 300-FF-5

Uranium sequestration phosphate solutions will be delivered to the top of the aquifer through injection wells to limit the lateral mobility of untreated uranium that may be mobilized from the vadose zone during surface infiltration and injection into the PRZ. Treatment will use the following general approach, with details to be developed in remedial design and established in the RD/RAWP:

- Well injection of phosphate reagent-amended water
- Reagent mixing facility, pipelines, injection wells, pumps, valves
- Phosphate reagent injection wells spaced approximately 60 to 120 m (200 to 400 ft) apart adjacent to (along the river side) the approximately 1 hectare (3 acre) target area. Preliminary design includes six injection wells
- Injection rates ranging from approximately 380 to 760 L/min (100 to 200 gal/min) for each well.

12.2.8 MNA of Groundwater for 300-FF-5

Monitored natural attenuation is a remedial strategy that monitors natural attenuation processes until CULs are met, provided they are met within a reasonable timeframe. Natural attenuation relies on natural processes within the aquifer to achieve reductions in the toxicity, mobility, volume, concentration and/or bioavailability of contaminants. These natural processes include physical, chemical and biological transformations that occur without human intervention. Contaminants in groundwater in 300-FF-5 that will be managed through MNA are nitrate and tritium down gradient from the 618-11 Burial Ground and TCE and DCE at the 300 Area Industrial Complex.

Natural attenuation of nitrate and tritium from the 618-11 Burial Ground will occur through a combination of dispersion during transport and natural radiological decay for tritium. Computer modeling predicts that the tritium concentrations will decrease to below the CUL by 2031. The waste within the 618-11 Burial Ground that released the nitrate and tritium will be removed by RTD.

MNA is used for the TCE and DCE in groundwater from the 300 Area Industrial Complex. Natural attenuation will occur primarily through physical attenuation (diffusion and dispersion) and biodegradation.

MNA includes monitoring to ensure the effectiveness of natural attenuation to meet CULs. Monitoring as a component of MNA as well as the remaining monitoring requirements for 300-FF-5 will be integrated into the sampling and analysis portion of the RD/RAWP. This integrated sampling is described in section 12.2.9 below.

12.2.9 Groundwater Monitoring for 300-FF-5

Groundwater monitoring, including as required as a component of MNA, will be integrated into the sampling and analysis portion of the RD/RAWP. Sampling will be sufficient to document changes in contaminant plumes for all groundwater COCs. As part of monitoring the lateral extent of plumes, groundwater will be monitored in the near vicinity of the Columbia River throughout the 300 Area Industrial Complex and both north and south of that area to ensure lateral extent of the plumes are defined. Because several of the 300-FF-5 groundwater COCs are also contaminants in 200-PO-1 that move through the 300 Area, monitoring of 300-FF-5 COC plumes will include lateral extent sufficient to distinguish contamination that is part of 300-FF-5 versus 200-PO-1. Monitoring will continue until COCs have attained the CULs and are expected to continue to meet CULs and EPA approves termination of the monitoring. Considered in the evaluation will be processes that can affect concentrations such as river fluctuations, waste site activities and land use activities. Groundwater monitoring will be performed to evaluate the effectiveness of the selected 300-FF-5 remedy to achieve CULs. The monitoring will be for groundwater COCs (uranium, gross alpha, nitrate, TCE and DCE at the 300 Area Industrial Complex; uranium and gross alpha down gradient from the 618-7 Burial Ground; and tritium and nitrate down gradient from the 618-11 Burial Ground).

12.2.10 Transition from Interim to Final Action for 300-FF-2 and 300-FF-5

In-progress interim action shall use the CULs in this ROD immediately upon issuance of this ROD. All other aspects of the interim actions shall continue to be performed in accord with the existing RD/RAWP. DOE shall develop, and submit for EPA approval, a new RD/RAWP prepared in accordance with the Tri Party Agreement. When the new RD/RAWP is approved, that document will direct future remedial actions and will replace all interim action ROD work plan requirements.

12.3 Description of the Amended Remedy for 300-FF-1

The ROD for 300-FF-1 is amended to require enhanced attenuation with sequestration for uranium using phosphate at 300-FF-1 waste sites as described above in section 12.2.6. Phosphate will be applied to the vadose zone and PRZ using a combination of surface infiltration and injection into the deep vadose zone and PRZ near the southern portion of waste site 316-5 as described above. Uranium sequestration will be conducted at the top of the aquifer below the vadose treatment zone to limit the mobility of any uranium mobilized from the vadose zone during surface infiltration and injection into the vadose zone and PRZ.

12.4 Summary of the Estimated Remedy Costs

Total present value (discounted) costs were estimated using the real discount rate published in Appendix C of "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" (OMB Circular No. A-94, 2012). Based on this guidance and the durations of the remedial action elements, the real discount rates ranged from 0.7 percent to 2.0 percent. The costs for maintaining programmatic ICs and 5-year reviews are included with the cost estimates. Programmatic ICs costs were allocated between CERCLA and non-CERCLA site activities. At the time of the cost estimate there were 22 CERCLA RODs, so each ROD was allocated an equal portion of the CERCLA programmatic ICs costs. The total non-discounted cost for the ICs for 150 years is estimated to be \$26,000,000 for each ROD. The total discounted cost for the ICs at Hanford, based on a discount rate of 2.0 percent, is estimated at \$10,000,000 for each ROD. The total non-discounted cost for the 5-year reviews for 150 years is estimated to be \$630,000 per ROD. The total discounted cost for the 5-year reviews for 150 years is estimated to be \$190,000 per ROD. Costs estimates are within +50 to -30 percent accuracy expectation.

Waste Site Remediation	Capital	\$250,733,000
	Annual O&M	\$36,466,000
	Periodic	\$11,954,000
	Nondiscounted	\$299,152,000
	Net Present Value	\$247,614,000
Groundwater	Capital	\$3,544,000
	Annual O&M	\$7,242,000
	Periodic	\$1,941,000
	Nondiscounted	\$12,727,000
	Net Present Value	\$11,480,000
Total	Capital	\$254,277,000
	Annual O&M	\$43,708,000
	Periodic	\$13,895,000
	Nondiscounted	\$311,879,000
	Net Present Value	\$259,094,000
<p>O&M = Operations and Maintenance Costs for ICs are included in the costs for waste site remediation. Period costs include additional O&M and/or construction activities, including costs to replace an installed remedy or component of an installed remedy, and services that are not included in initial capital costs or annual O&M costs. Period costs may be one-time costs or costs that occur at intervals over the life of the remedy.</p>		

12.5 Expected Outcome of the Selected Remedies and ROD Amendment

Final CULs and the basis for the CULs are provided above in table 4. Waste site cleanup in the 300 Area Industrial Complex and 618-11 burial ground when completed will support industrial land use, and cleanup outside those two areas will support industrial as well as residential land use. In all areas, if contamination below 4.6 m (15 ft) bgs exceeds the direct contact surface CUL for that area, land use will be limited to prevent direct exposure to the deep contamination in accord with the ICs. Water infiltration ICs will apply to the industrial use areas that do not meet residential groundwater and river protection CULs. Groundwater use will be restricted where contamination is above CULs to prevent use as drinking water. Drinking water use includes other domestic uses such as bathing and cooking. Waste site cleanup is expected to be completed by 2032 based on the Pacific Northwest National Laboratory vacating facilities by 2027. The groundwater tritium plume is expected to meet the CULs in 19 years, and the uranium plume in 22-28 years. Groundwater contaminated with nitrate in the southern 300 Area originating offsite is not part of 300-FF-5, is not addressed by this ROD and is expected to remain contaminated for the foreseeable future. Remediated waste sites will not pose an unacceptable ecological risk.

13.0 STATUTORY DETERMINATIONS

Under CERCLA § 121 and the NCP, EPA must select a remedy that is protective of human health and the environment, complies with or appropriately waives ARARs, is cost effective and utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that include treatment that permanently and significantly reduces the volume, toxicity or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

The preamble to the NCP states 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 §104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit. 300-FF-1, 300-FF-2 and 300-FF-5 (addressed by this ROD) and ERDF are reasonably close to one another and the wastes are compatible for the selected disposal approach. Therefore, these OUs and ERDF are considered to be a single site for response purposes.

13.1 Protection of Human Health and Environment

The selected remedies and ROD amendment, alternative 3a, will protect human health and the environment through removal of waste, in-situ treatment, MNA to achieve CULs and ICs. CULs are set at levels that reduce risk to the acceptable risk range and comply with ARARs. Some waste to be removed will be treated in-situ prior to removal where necessary to protect workers or to manage airborne emissions. All waste that is removed will be treated as necessary to meet waste acceptance criteria for disposal. Uranium in soil that is not part of the RTD remedy that poses a risk to groundwater is expected to attenuate such that groundwater CULs will be attained, and attenuation will be enhanced with in-situ treatment with phosphate. Other groundwater contamination from Hanford activities will achieve CULs via MNA and waste site remedial action. ICs apply to prevent exposure to contamination in the soil and groundwater that exceeds levels protective of human health and the environment.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

ARARs are determined based on analysis of which requirements are applicable or relevant and appropriate to the distinctive set of circumstances and actions at a specific site. The NCP requires that ARARs be attained or appropriately waived during the implementation and at completion of the remedial action. No ARAR waivers are authorized as part of this ROD for 300-FF-2 and 300-FF-5 and ROD amendment for 300-FF-1. A summary of federal and state ARARs is attached as Appendix A. The selected remedies and ROD amendment addresses the chemical-, location- and action-specific ARARs described in Appendix A through adherence of those ARARs during implementation of the remedial action.

13.3 Cost-Effectiveness

The Selected Remedy is cost-effective. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (NCP §300.430(f)(1)(ii)(D)). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money to be spent.

The estimated present worth cost of the Selected Remedies and ROD Amendment is \$259 million. Although Alternative 2 is \$26 million less expensive, attenuation of the uranium groundwater plume is not enhanced. The additional cost for attenuation of the groundwater plume provides a significant increase in protection of human health and the environment and is cost-effective. The Selected Remedy's focused use of in-situ treatment for uranium will provide an overall level of protection comparable to Alternatives 3, 4 and 5 at a significantly lower cost (\$108 million, \$278 million and \$1,004 million respectively).

Often, more than one cleanup alternative is cost effective, but Superfund does not mandate the selection of the most cost-effective cleanup alternative. This is because the most cost-effective remedy does not always provide the best balance of tradeoffs with respect to remedy selection criteria. In addition, the most cost-effective cleanup alternative is not necessarily the least-costly alternative that is both protective of human health and the environment and ARAR-compliant.

13.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

This determination looks at whether the selected remedy provides the best balance of trade-offs among the alternatives with respect to the balancing criteria set forth in NCP §300.430(f)(1)(i)(B), such that it represents the maximum extent to which permanence and treatment can be practicably utilized. NCP §300.430(f)(1)(ii)(E) provides that the balancing shall emphasize the factors of "long-term effectiveness" and "reduction of toxicity, mobility or volume through treatment," and shall consider the preference for treatment and bias against offsite disposal or untreated waste. The modifying criteria were also considered in making this determination.

Principal threat waste from the 300-296 waste site, vertical pipe units at 618-10 and 618-11 and caissons at 618-11 will be treated to reduce the toxicity, mobility, contamination and radiation exposure. Non-principal threat waste resulting from RTD will be treated to reduce toxicity and mobility when necessary to (a) protect workers and prevent unacceptable environmental releases

during the remedial action and after disposal; and/or (b) meet the waste acceptance criteria of the disposal facility. Treatment may be in-situ or during excavation as needed to control worker exposure. RTD is a permanent solution that includes treatment for some of the waste.

Uranium in the vadose zone, PRZ and top of the aquifer will be treated with phosphate in the approximately 1 hectare (3 acre) target treatment zone to permanently reduce its mobility.

DOE and EPA have determined that the selected remedies and ROD amendment represent the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. Of those alternatives that are protective of human health and the environment and comply with ARARs, DOE and EPA have determined that the selected remedies and ROD amendment provide the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering State and community acceptance.

13.5 Preference for Treatment as a Principal Element

By utilizing treatment as a significant portion of the remedy, the statutory and NCP preference for remedies that employ treatment as a principal element is satisfied. The NCP §300.430(f)(1)(ii)(E) includes a “preference for treatment as a principal element and the bias against off-site land disposal of untreated waste.” The selected remedies and ROD amendment include treatment of the principal threat waste and the remedy for 300-FF-2 requires treatment of RTD waste as necessary to meet the waste acceptance criteria of the disposal facility and as necessary to reduce air releases and worker exposure during excavation and waste management. The selected remedy for 300-FF-2 and the ROD amendment for 300-FF-1 require in-situ treatment of uranium in the vadose zone and PRZ over an area of approximately 1 hectare (3 acres). The selected remedy for 300-FF-5 requires in-situ treatment of uranium in the top of the aquifer below and along the east and south edge of the soil treatment zone. In the selected remedy for 300-FF-2, most of the excavated waste will be disposed on-site in the ERDF. Much smaller quantities of waste such as transuranic waste will require off-site disposal in the national geological repository Waste Isolation Pilot Plant in New Mexico.

13.6 Five-Year Review Requirements

Because the selected remedies for 300-FF-2 and 300-FF-5 result in contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted pursuant to CERCLA §121(c) and NCP §300.430(f)(5)(iii)(c). DOE shall conduct a review of remedial actions at least every five years after the initiation of the remedial action to assure that the remedy is, or will be, protective of human health and the environment. The five-year reviews will include any additional information related to human health or ecological risk that is developed during the period covered by the review. The 300-FF-1 remedy as amended remains subject to the five-year review requirement established in the 1996 ROD.

14.0 DOCUMENTATION OF SIGNIFICANT CHANGES

DOE and EPA reviewed all written and verbal comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the proposed plan, were necessary. Although not significant, there are three changes in the remedy selected in this ROD that are different from the preferred alternative described in the proposed plan:

- The proposed plan identified groundwater nitrate in the southern end of the 300 Area that originates from off-site, flows through the 300 Area and discharges in the Columbia River as covered by the preferred alternative. However, 300-FF-5 as it is defined in this ROD does not include nitrate in the groundwater in the southern end of the 300 Area that originates from off-site. Therefore, the selected remedy for 300-FF-5 does not include a selected remedy for that plume. That contamination is not the result of Hanford activities. Other nitrate groundwater contamination from Hanford 300 Area activities is part of 300-FF-5 and is addressed by the selected remedy.
- The proposed plan identified industrial land use with corresponding CULs and ICs for both the 300 Area Industrial Complex and the 618-11 burial ground. That is unchanged in the selected remedy. There are portions of the 300 Area Industrial Complex that are not waste sites, have previously been remediated to residential direct exposure and/or groundwater and river protection CULs, or may in the future meet residential CULs while performing cleanup required to meet industrial CULs. The selected remedy includes the clarification that any areas identified as industrial use that meet the residential CULs for direct exposure and/or groundwater and river protection do not require the corresponding industrial use ICs for direct exposure and/or groundwater and river protection.
- An additional component was added to the selected remedy that was not identified as part of the preferred alternative. The selected remedy for 300-FF-2 also requires that during RTD or other activities that identify uranium that exceeds CULs below 4.6 m (15 ft), the uranium contamination will be addressed either by RTD and/or sequestration with phosphate as approved by EPA.

APPENDIX A. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Only the substantive requirements of listed ARARs are the ARARs. This ROD Amendment for 300-FF-1 does not remove any of the ARARs established in the 300-FF-1 ROD, but ARARs have been added where specified in the application column of the table below. New 300-FF-1 ARARs only apply to the limited part of the 300-FF-1 ROD that is amended which is the addition of a requirement to conduct uranium sequestration treatment with phosphate. The application column of the table identifies if the ARARs apply to the selected remedy for 300-FF-2, 300-FF-5 and/or the ROD amendment for 300-FF-1.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Maximum Contaminant Levels for Organic Contaminants" (40 CFR 141.50(b) and 141.61)	Establishes MCLs and non-zero MCLGs for drinking water. The standards are designed to protect human health from adverse effects of organic contaminants in drinking water.	These levels regulate the concentrations of contaminants in public drinking water supplies and are considered relevant and appropriate for groundwater and for surface water used potentially for drinking water. Although 300-FF-5 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.	300-FF-5. To be met through MNA and source control measures.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Maximum Contaminant Levels for Inorganic Contaminants"(40 CFR 141.51(b) and 141.62)	Establishes MCLs and non-zero MCLGs for drinking water. The standards are designed to protect human health from adverse effects of inorganic contaminants in drinking water.	These levels regulate the concentrations of contaminants in public drinking water supplies and are considered relevant and appropriate for groundwater and for surface water used potentially for drinking water. Although 300-FF-5 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.	300-FF-5. To be met through enhanced attenuation, MNA and source control measures.
"Maximum Contaminant Levels for Radionuclides" (40 CFR 141.66)	Establishes MCLs for drinking water. The standards are designed to protect human health from adverse effects of radionuclide contaminants in drinking water.	These levels regulate the concentrations of contaminants in public drinking water supplies and are considered relevant and appropriate for groundwater and for surface water used potentially for drinking water. Although 300-FF-5 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.	300-FF-5. To be met through enhanced attenuation, MNA and source control measures.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
“UIC Well Classification Including Allowed and Prohibited Wells”(WAC 173-218-040)	Establishes criteria and standards for an underground injection control program.	Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate.	300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies and ROD amendment will comply for injection wells and borings used for enhanced attenuation,
“Decommissioning of UIC Well” (WAC 173-218-120)	Identifies requirements for decommissioning of UIC wells.	Wells and borings are used for injection of phosphate.	300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies and ROD amendment will comply for UIC wells used for enhanced attenuation.
“Potable Groundwater Defined” (WAC 173-340-720(2)) “Groundwater Cleanup Standards” (WAC 173-340-720(4)(b)(i-iii)) (A)&(B) “Adjustments to Cleanup Levels” (WAC 173-340-720(7)) “Points of Compliance” (WAC 173-340-720(8)) “Compliance Monitoring” (WAC 173-340-720(9)(b-f))	Groundwater shall be classified as potable unless exclusion criteria are met. These groundwater cleanup requirements are ARARs where they are more stringent than federal MCL ARARs. Adjustments to CULs are made in accordance with WAC 173-340-720(7). Points of compliance are established throughout 300-FF-5. Groundwater sample analysis shall be conducted on unfiltered samples unless a filtered sample is shown to be more representative.	Groundwater in 300-FF-5 contains contaminants that require remediation. It is not currently used for drinking water but is a potential drinking water source. Groundwater discharges into the Columbia River, which is used for drinking water.	300-FF-5. The groundwater CULs for chemicals are calculated using Method B equations (720-1 and 720-2) for non-carcinogens and carcinogens, respectively. The selected remedy will comply with the standards using MNA and source control measures, with the 300-FF-5 points of compliance being throughout the 300-FF-5 aquifer.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"How Shall Each Water Well Be Planned and Constructed?"(WAC 173-160-161)	Water wells must not be a conduit for contamination and be constructed to yield the necessary quantity of water.	Water wells may be used to obtain water for remedial actions such as dust suppression. Monitoring wells in WAC 173-160-410(7) for 300-FF-5 are not water wells.	300-FF-2. The selected remedies will comply by constructing water wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.
"What Are the Requirements for the Location of the Well Site and Access to the Well?" (WAC 173-160-171)	Identifies the requirements for locating a well to protect groundwater from contamination and to provide for future well access.	Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate.	300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by siting and building wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?”(WAC 173-160-181)</p>	<p>Identifies requirements so that water wells do not provide a pathway for vertical movement of water and contamination within and between aquifers.</p>	<p>Water wells may be used to obtain samples and water for remedial actions such as dust suppression.</p>	<p>300-FF-2. The selected remedy will comply by building water wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.</p>
<p>“What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?” (WAC 173-160-400)</p>	<p>Identifies the minimum standards for resource protection wells and geotechnical soil borings.</p>	<p>Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate.</p>	<p>300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by building wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“What Are the General Construction Requirements for Resource Protection Wells?”(WAC 173-160-420)</p>	<p>Identifies the general construction requirements for resource protection wells.</p>	<p>Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate.</p>	<p>300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by building wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.</p>
<p>“What Are the Minimum Casing Standards?” (WAC 173-160-430)</p>	<p>Identifies the minimum casing standards.</p>	<p>Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate. Water wells may be used to obtain water for remedial actions such as dust suppression.</p>	<p>300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by building wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"What Are the Equipment Cleaning Standards?" (WAC 173-160-440)	Identifies the equipment cleaning standards for construction and maintenance of wells.	Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate. Water wells may be used to obtain water for remedial actions such as dust suppression.	300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by building, using and managing wells that meet these standards.
"What Are the Well Sealing Requirements?" (WAC 173-160-450)	Identifies the well sealing requirements for resource protection wells.	Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate.	300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by building, wells that meet these standards. Wells utilized for delivery of phosphate solutions shall be located, designed and constructed to optimize the delivery of such fluids to the vadose zone, periodically rewetted zone and groundwater; design to be approved in the RD/RAWP.
"What Is the Decommissioning Process for Resource Protection Wells and borings?"(WAC 173-160-460)	Identifies the decommissioning process for resource protection wells and borings.	Wells and borings are used to monitor groundwater; characterize the vadose zone, PRZ and groundwater; and for injection of phosphate.	300-FF-1, 300-FF-2 and 300-FF-5. The selected remedies will comply by decommissioning wells and borings to meet these standards.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Toxics Criteria for Those States Not Complying with Clean Water Act” (40 CFR 131.36(b)(1) as applied to Washington, 40 CFR 131.36(d)(14))</p>	<p>Establishes numeric water quality criteria for priority toxic pollutants for the protection of human health and aquatic organisms which supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.</p>	<p>Groundwater from 300-FF-5 that discharges into the Columbia River contains priority toxic pollutants that require remediation to meet toxics criteria standards.</p>	<p>300-FF-5. These standards apply where groundwater discharges to the river. The selected remedy will comply through MNA, infiltration control and source control measures.</p>
<p>“Toxic Substances”(WAC 173-201A-240(6))</p>	<p>Establishes water quality standards for surface waters of the State of Washington. Risk-based criteria for carcinogenic substances shall be selected such that the upper-bound excess cancer risk is less than 1×10^{-6} for individual contaminants.</p>	<p>Contaminated groundwater that requires remediation to protect drinking water uses discharges to the Columbia River. Surface water is not contaminated by 300-FF-5 discharges in excess of this standard.</p>	<p>300-FF-5. Columbia River surface waters of the State currently comply with this standard for discharges from 300-FF-5. The selected remedy will further reduce 300-FF-5 discharges and comply with this standard.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Unrestricted Land Use Soil Cleanup Standards” (WAC 173-340-740(3))</p> <p>“Unrestricted Land Use Soil Cleanup Standards, Adjustment to Cleanup Levels” (WAC 173-340-740(5))</p> <p>“Unrestricted Land Use Soil Cleanup Standards, Point of Compliance” (WAC 173-340-740(6))</p> <p>“Unrestricted Land Use Soil Cleanup Standards, Compliance Monitoring” (WAC 173-340-740(7))</p>	<p>Requires that soil CULs result in no significant adverse effects on terrestrial ecological receptors.</p> <p>Requires human health protection from both groundwater contaminated due to leaching and direct soil contact. Total excess cancer risk may not exceed 1×10^{-5} or a non-cancer hazard index of 1 for chemical contaminants. Soil points of compliance are throughout the site.</p> <p>Soil CULs apply to the less than 2mm size fraction of dry samples, or also larger size fractions if they could be crushed.</p>	<p>Soil contains contaminants in areas other than those identified as industrial use areas that require remediation.</p>	<p>300-FF-2. The selected remedy will comply through RTD of contaminants that exceed the standards, or application of phosphate to enhance attenuation of uranium. Table 4 includes soil CULs to protect direct exposure that meet the risk and hazard requirements plus groundwater and surface water protection due to leaching from soil contamination.</p>
<p>“Soil Cleanup Standards for Industrial Properties” (WAC 173-340-745(5))</p> <p>“Soil Cleanup Standards for Industrial Properties, Adjustments” (WAC 173-340-745(6))</p>	<p>Rules set standards for degree of cleanup required by a remedial action where industrial land use represents the reasonable maximum exposure under both current and future site use conditions. Total excess cancer risk may not exceed 1×10^{-5} or a non-cancer hazard index of 1 for chemical contaminants.</p>	<p>Soil contains contaminants in industrial use areas that require remediation.</p>	<p>300-FF-2. The selected remedy will comply through RTD of contaminants that exceed the standards</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Institutional Controls. Restrictive Covenants” (WAC 173-340-440(9))</p>	<p>Limit or prohibit activities that may interfere with the integrity of an interim action or cleanup action or that may result in exposure to hazardous substances at a site</p>	<p>ICs are required for soil and groundwater that does not meet requirements for unlimited use and unrestricted exposure.</p>	<p>300-FF-2 and 300-FF-5. The selected remedies include ICs that will meet the standard.</p>
<p>“General Standards for Maximum Emissions” (WAC 173-400-040)</p>	<p>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 reasonably available control technology. 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.</p>	<p>Soil remedial action at 300-FF-2 provides the potential for emissions subject to these standards because hazardous contaminants include regulated hazardous air pollutants.</p>	<p>300-FF-2. Remedial actions that have the potential to release hazardous air emissions will meet standards.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Emission Standards for Sources Emitting Hazardous Air Pollutants"(WAC 173-400-075(1, 3, 6)	Establishes emission standards, testing, monitoring and analytical methods for hazardous air pollutants.	300-FF-2 waste sites contain hazardous contaminants that can become airborne.	300-FF-2. Actions performed at 300-FF-2 that have the potential to emit visible, particulate, fugitive and hazardous air emissions and odors will meet standards.
"New sources in attainment or unclassifiable areas" (WAC 173-400-113)	New sources or modifications will comply with identified standards.	Remediation of 300-FF-2 waste sites may involve a new source or modification to an existing source.	300-FF-2. Remedial actions will be designed and performed in compliance with the standard.
"Emission Standards for Sources Emitting Hazardous Air Pollutants"(WAC 173-400-075)	Establishes national emission standards for hazardous air pollutants.	Soil hazardous contaminants detected at 300-FF-2 include regulated hazardous air pollutants.	300-FF-2. Remedial actions at 300-FF-2 will be designed and performed in compliance with the standard.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>Controls for New Sources of Toxic Air Pollutants. “Control Technology Requirements” (WAC 173-460-060)</p> <p>“Ambient Impact Requirement” (WAC 173-460-070)</p> <p>“Table of ASIL, SQER and de Minimis Emission Values”(WAC 173-460-150)</p>	<p>Shall not establish, operate or cause to be established or operated any new or modified toxic air pollutant source which is likely to increase TAP emissions without installing and operating BACT. Non-process fugitive emissions activities are exempt for the requirement to apply BACT. Requires compliance with the limits air pollutants include carcinogens and noncarcinogens listed in “Table of ASIL, SQER and de Minimis Emission Values” (WAC 173-460-150).</p>	<p>Hazardous contaminants detected in soil and/or 300-FF-5 groundwater include constituents that would constitute toxic air pollutants if released to the air.</p>	<p>300-FF-2. Remediation activities with the potential to emit hazardous air emissions identified in this standard will comply.</p>
<p>“Ambient Standard”(WAC 173-480-040)</p>	<p>Requires that emissions of radionuclides in the air shall not cause a maximum effective dose equivalent of more than 10 mrem/year to the whole body to any member of the public. Per “Applicability” (WAC 173-480-020), the ambient standard applies to the entire state. Measurements may be made at all points up to property lines of point, area and fugitive emission sources.</p>	<p>300-FF-2 contains radioactive soil, structures and debris that could be emitted to ambient air.</p>	<p>300-FF-2. Investigative and remediation activities (e.g., RTD, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels will be controlled to meet standards.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“General Standards for Maximum Permissible Emissions”(WAC 173-480-050(1))</p>	<p>At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas ALARA. Control equipment of facilities operating under ALARA shall be defined as reasonably available control technology and as low as reasonably achievable control technology.</p>	<p>The potential for fugitive and diffuse emissions because of excavation and related activities will require efforts to minimize those emissions.</p>	<p>300-FF-2. Investigative and remediation activities (e.g., excavation, RTD, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides to residential areas will meet standards.</p>
<p>“Emission Monitoring and Compliance Procedures” (WAC 173-480-070(2))</p>	<p>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.</p>	<p>Hazardous contaminants detected in soil, structures and debris in 300-FF-2 include radionuclides that could be emitted to unrestricted areas during remedial actions.</p>	<p>300-FF-2. Investigative and remediation activities (e.g., RTD, demolition, ventilation and vacuuming/exhaust) that have the potential to emit radionuclides to unrestricted areas will meet standards.</p>
<p>“Emission Standards for New and Modified Emission Units”(WAC 173-480-060)</p>	<p>Requires that construction, installation or establishment of new air emission control units use best available radionuclide control technology.</p>	<p>Hazardous contaminants detected in soil, structures and debris in 300-FF-2 include radionuclides that could be emitted from air emission control units during remedial actions.</p>	<p>300-FF-2. Investigative and remediation activities (e.g., 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 will meet standards.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“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”])</p>	<p>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.</p>	<p>Investigation and remedial actions in 300-FF-2 have the potential to emit hazardous air pollutants.</p>	<p>300-FF-2. Investigation and remedial actions that require air pollution control measures and/or equipment and have the potential to emit radionuclides to the ambient air will meet this standard.</p>
<p>“National Standards Adopted by Reference for Sources of Radionuclide Emissions” (WAC 246-247-035(1)(a)(i) and (ii)</p> <p>Adopts by reference “General Provisions” 40 CFR 61 Subpart A, “Radionuclides other than Radon” 40 CFR 61 Subpart H,</p>	<p>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.</p>	<p>Investigation and remedial actions in 300-FF-2 have the potential to emit hazardous air pollutants.</p>	<p>300-FF-2. 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 will be maintained and operated and compliance determined to meet this standard.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Radiation Protection, Air Emissions. General Standards"(WAC 246-247-040(3) and (4))	Requires that ALARA-based control technology Best Available Controls be used to control emissions depending on whether there is new construction or there is an existing emission unit, and whether there is a significant modification of an emission unit.	Hazardous contaminants that would be subject to radionuclide air emission standards and resultant requirements have the potential to be detected in and emitted from, structures, debris, soil and remediation equipment during remedial actions.	300-FF-2. Investigative and remedial actions will use BARCT or ALARACT to meet this standard.
"Monitoring, Testing and Quality Assurance" (WAC 246-247-075)	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.	Hazardous contaminants that would be subject to radionuclide air emission standards and resultant requirements have the potential to be detected in and emitted from, structures, debris, soil and remediation equipment during remedial actions.	300-FF-2. Monitoring, testing and quality assurance requirements will be defined and followed to meet this standard.
"National Emission Standards for Hazardous Air Pollutants" 40 CFR 61 Subparts A,C,E,H,I,M,Q,V	Emission standards and activity requirements for hazardous air pollutants including emission control requirements.	Hazardous contaminants are in the soil, structures and debris to be remediated, which could be released to the air. In particular, air exhaust units, vacuums and guzzlers, other remediation equipment and open air excavation have relatively high potential for air releases.	300-FF-2. Investigative and remedial activities will be conducted to meet standards.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
40 CFR 61.140, "Applicability" 40 CFR 61.14, "Standard for Demolition and Renovation"	Defines regulated ACM and regulated removal and handling requirements. Specifies requirements for demolition of regulated sources having the potential to emit asbestos, including the requirement that no visible emissions are allowed during demolition, handling, packaging and transport of ACM.	Encountering ACM on pipelines or buried asbestos within the 300-FF-2 Area is possible during the remediation activities.	300-FF-2. Site investigation, remediation activities and associated handling, packaging, transportation and disposal of ACM will meet standards.
"Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation and Spraying Operations" 40 CFR 61.150,	Identifies requirements for the removal and disposal of asbestos from demolition and renovation activities.	Pipelines, other debris and soil contain ACM.	300-FF-2. Site investigation, remediation activities and associated handling, packaging, transportation and disposal of ACM will meet standards. Disposal will meet standards for the disposal facility.
"Toxic Substances Control Act", as amended; 15 USC 2605, et seq.); "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (40 CFR Part 761)	Establishes prohibitions of, and requirements for, the manufacturing, processing, distribution in commerce, use, disposal, storage and marking of PCBs and PCB items.	Remediation waste resulting from 300-FF-2 remedial actions will contain PCBs subject to the standards for disposal, storage and marking of PCBs and PCB items.	300-FF-2. Disposal, storage and marking of PCBs and PCB waste will meet standards.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Applicability" (40 CFR 761.50(b)1, 2, 3 and 7 and (c))	Identifies PCB disposal, storage and cleanup requirements for PCB remediation waste and PCB/radioactive wastes at concentrations greater than 50 ppm.	Remediation is expected to generate PCB and PCB/radioactive waste.	300-FF-2. Management and disposal of remediation waste with PCBs will meet standards.
"Disposal Requirements" (40 CFR 761.60(a), (b) and (c))	Establishes requirements applicable to the 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-FF-2 Area.	300-FF-2. Standards will be met for PCB liquids, articles and debris handling, storage and disposal.
"PCB Remediation Waste" (40 CFR 761.61)	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-FF-2 Area.	300-FF-2. Standards will be met for PCB remediation wastes
"Dangerous Waste Regulations. Identifying Solid Waste"(WAC 173-303-016)	Identifies those materials that are and are not solid wastes and identifies those materials that are and are not solid wastes when recycled	Solid wastes will be generated during 300-FF-2 remedial actions which will be subject to solid waste and dangerous waste designation requirements.	300-FF-2. Standards will be met for investigative and remediation activities.
"Dangerous Waste Regulations. Recycling Processes Involving Solid Waste" (WAC 173-303-017)			
"Designation of Dangerous Waste" (WAC 173-303-070)	Establishes the method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste will be generated during 300-FF-2 Area remedial actions.	300-FF-2. Standards will be met for investigative and remediation (including waste treatment) activities that generate wastes.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Requirements for Universal Waste” (WAC 173-303-077)</p>	<p>Identifies certain batteries, mercury-containing equipment and lamps as exempt from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9906 (excluding WAC 173-303-960). These wastes are subject to regulation under WAC 173-303-573, “Land Disposal Restrictions” (WAC 173-303-140) and WAC 173-303-170 through 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).</p>	<p>Waste sites in 300-FF-2 contain wastes listed in this section.</p>	<p>300-FF-2. Remediation activities will meet standards for universal wastes.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Recycled, Reclaimed, and Recovered Wastes” (WAC 173-303-120(3) and (5))</p>	<p>Defines the requirements for recycling materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze and lead acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.</p>	<p>Wastes that can be recycled, reclaimed or recovered have the potential to be generated during 300-FF-2 Area remedial actions.</p>	<p>300-FF-2. Recycling of wastes subject to these requirements will be done in a manner that satisfies standards.</p>
<p>“Land Disposal Restrictions”(WAC 173-303-140)</p>	<p>Establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates by reference the federal land disposal restrictions (40 CFR Part 268).</p>	<p>Remediation may generate waste subject to land disposal restrictions.</p>	<p>300-FF-2. Disposal of wastes subject to these requirements will be treated as required and disposed in a manner that satisfies standards.</p>
<p>“Requirements for Generators of Dangerous Waste” (WAC 173-303-170)</p>	<p>Establishes the requirements for dangerous waste generators which include the substantive provisions of “Accumulating Dangerous Waste On-Site” (WAC 173-303-200) by reference. .</p>	<p>300-FF-2 investigation and remedial actions may generate dangerous wastes.</p>	<p>300-FF-2. Investigation and remediation wastes (contaminated soil, personnel protective gear, treatment chemicals) may be dangerous waste, and will be managed in accord with these requirements.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"Requirements for Closure of Dangerous Waste Units" (WAC 173-303-610)	Establishes requirements for closing units that have treated, stored or disposed of dangerous waste.	The 300-FF-2 OU includes units or areas where materials were disposed that would designate as dangerous waste.	300-FF-2. Closure requirements will be satisfied in implementing the selected remedial action where they are applicable or both relevant and appropriate.
"Use and Management of Containers" (WAC 173-303-630)	Establishes requirements for dangerous waste facilities that store containers of dangerous waste.	Remedial actions may involve management of dangerous waste in containers that are subject to this standard.	300-FF-2. Investigation and remedial actions that produce or manage containers of dangerous waste will be managed to meet standards.
"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)	Establishes minimum functional performance standards for the proper handling and disposal of solid waste other than specified regulated dangerous waste, PCB waste and radioactive waste. Provides requirements for the proper handling of such 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.	Covered solid waste will be generated during implementation of remedial actions.	300-FF-2. Investigative and remedial actions that generate covered solid waste will meet standards.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Protection of Historic Properties” (36 CFR 800)</p>	<p>Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification and evaluation. Potential project adverse effects are to be avoided or mitigated. Need to take actions as necessary to minimize harm to any National Historic Landmarks</p>	<p>Cultural and historic sites have been identified within 300-FF-2.</p>	<p>300-FF-2. Historical and cultural reviews have been done to identify cultural and historic sites. Additional reviews will be done at investigation and remedial action areas where existing reviews aren’t sufficient. For any discoveries appropriate actions will be taken to meet standards.</p>
<p>“National Historic Landmarks Program”(36 CFR 65)</p>	<p>These regulations set forth the criteria for establishing national significance. Requires that federal agencies shall, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to landmarks.</p>	<p>Cultural and historic sites have been identified within 300-FF-2.</p>	<p>300-FF-2. Investigation and remedial actions shall comply with this standard.</p>
<p>“Native American Graves Protection and Repatriation Regulations” (43 CFR 10) (25 USC §§ 3001 et seq.)</p>	<p>Establishes federal agency responsibility for discovery, protection and appropriate disposition of human remains, associated and unassociated funerary objects, sacred objects and items of cultural patrimony.</p>	<p>Native American archaeological, cultural and historic sites have been identified within the 300-FF-2. Native American remains and associated objects have the potential to be present.</p>	<p>300-FF-2. Investigations and remedial activities will be conducted to identify, protect and provide for appropriate disposition of covered human remains, objects and items.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
"National Historic Preservation Act" (16 USC 470, et seq.)	Establishes a program for preservation of historic properties and other purposes.	Historical properties may be located in the vicinity of 300-FF-2 waste sites or the lands utilized during remediation of the waste sites.	300-FF-2. Investigations and remedial activities will include identification and preservation of historic properties in accord with this standard.
"Archeological and Historic Preservation Act" (16 USC 469a-1 through 469a-2(d))	Requires that Federal projects do not cause the loss of 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 300-FF-2.	300-FF-2. Investigation and remediation activities will prevent irreparable loss of significant scientific, prehistoric or archeological data, the data will be preserved.
"Endangered Species Act of 1973", as Amended 16 U.S.C. §§ 1531-1544, specifically Sections 7 and 9(a). 50 CFR Part 17 (listings, prohibitions) 50 CFR Part 402 ,50 CFR Parts 222-224 (endangered and threatened marine species), 50 CFR 226.212 (critical habitat for Northwest salmon and steelhead)	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. Also prohibits taking of any endangered species.	300-FF-5 groundwater discharges into the Hanford Reach of the Columbia River which contains the Upper Columbia River spring-run Chinook salmon and the steelhead which are endangered. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is listed as a threatened species but is not considered a resident species and is rarely observed in the Hanford Reach.	300-FF-5. Remediation actions and investigation activities will be managed to avoid jeopardy and/or adversely affect a listed species or critical habitat.

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
<p>“Migratory Bird Treaty Act of 1918” (16 USC 703-712) 50 CFR parts 10 & 21</p>	<p>Protects all migratory bird species and prevents “take” of protected migratory birds, their young or their eggs.”</p> <p>Federal agencies are required to avoid or minimize impacts to migratory bird resources, restore or enhance their habitat and prevent or abate its detrimental alteration.</p>	<p>Migratory Birds utilize 300-FF-2.</p>	<p>300-FF-2. Remedial actions will 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 in a manner that complies with requirements.</p>
<p>“Bald and Golden Eagle Protection Act” (16 USC § 668, 50 CFR Part 22)</p>	<p>Protects eagle habitat to maintain eagle populations so the species is not classified as threatened, endangered or sensitive in Washington State.</p>	<p>Bald eagles nest, feed and overwinter along the shores of the Columbia River.</p>	<p>300-FF-2. Remedial actions will be performed in a way to protect bald eagle habitat.</p>

Regulatory Citation	Description of Regulatory Requirement	Rationale for Including	Application
ACM	= asbestos-containing material		
ALARA	= as low as reasonably achievable		
ALARACT	= as low as reasonably achievable control technology		
BACT (BARCT)	= best available (radionuclide) control technology		
CFR	= Code of Federal Regulation		
HWMA	= Hazardous Waste Management Act of 1976		
IDW	= investigation-derived waste		
MCL	= maximum contaminant level (drinking water standard)		
MCLG	= maximum contaminant level goal		
MNA	= monitored natural attenuation		
NESHAP	= National Emission Standards for Hazardous Air Pollutants		
PCB	= polychlorinated biphenyl		
PRZ	= periodically rewetted zone		
ROD	= record of decision		
RTD	= remove, treat and dispose		
USC	= United States Code		
WAC	= Washington Administrative Code		

APPENDIX B. RESPONSIVENESS SUMMARY

Introduction

This responsiveness summary was prepared in accordance with the requirements of CERCLA § 117(b), as amended. The purpose of this responsiveness summary is to summarize and respond to significant public comments, criticisms and new information submitted during the public comment period on the Proposed Plan and supporting documents for remediation of the 300-FF-1, 300-FF-2 and 300-FF-5 operable units on the Hanford Site.

Community Involvement

A formal public comment period ran from July 15 through September 16, 2013. Individuals sent written comments through the mail or electronically. Written comments were also collected at three public meetings held in Richland, WA; Seattle, WA; and Hood River, OR. The public meetings, comment period and availability of the Proposed Plan and administrative records were publicized in the Tri-City Herald on July 15, 2013. A fact sheet was mailed to the Hanford mailing list and sent electronically on the Hanford Listserv on July 15, 2013.

Comments and Responses

Comments were received from both individuals and groups covering a wide range of topics and varying perspectives. Significant comments were received on the following topics:

- Industrial land use cleanup and associated ICs
- Risk from contamination entering the Columbia River
- Uranium cleanup level and Washington State cleanup standards
- Preference for excavation of the residual uranium
- Efficacy of uranium sequestration via addition of phosphates
- Monitored natural attenuation
- Long-term protectiveness
- Contingent remedy for uranium sequestration
- Performance requirement for uranium sequestration
- Viability of ICs
- Protect treaty rights, provide environmental justice
- Tribal treaties as ARARs
- Endangered Species Act consultation
- Cost of RTD in Alternatives 4 and 5 are too high
- Traditional Cultural Properties
- Colloidal Transport of Treated Uranium
- Tri-Party Agreement Milestones
- Modeling
- Dust Suppression Alternatives
- River Shoreline
- Phosphate as a Pollutant

- Contaminant Inventory
- Use Other More Stringent Standards
- 200-PO-1
- Risk assessment from multiple sites
- Ecological risk assessment

A summary of the significant comments received and DOE and EPA responses are provided below.

Comment 1. Industrial Land Use Cleanup and Associated ICs – A recurring comment received regards the proposed application of soil CULs derived from calculations designed to be protective for an industrial land use exposure. Comments on this subject reflect the commenters' concerns with maintaining an industrial use of the land for perpetuity. Such comments generally recommend CULs based on unrestricted land use scenarios.

Response: The ROD selects residential CULs for the majority of 300-FF-2 (more than 39 square miles) and industrial CULs for the 300 Area Industrial Complex and the 618-11 Burial Ground (approximately 0.5 square mile). For more than 70 years the 300 Area Industrial Complex has been used for nuclear industrial activities. The Pacific Northwest National Laboratory will continue to utilize selected key mission critical buildings at least until 2027. The 618-11 burial ground is next to an operating commercial nuclear power reactor. Therefore DOE and EPA have determined that industrial land is the reasonably anticipated future land use and industrial CULs are appropriate.

Land use-based soil CULs affect the amount of contaminant that can remain and be protective. ICs must include restrictions that are protective of current and reasonably anticipated future land use. ICs prevent uses that the selected CULs do not protect. ICs are used to prevent exposure to residual contamination in soil and groundwater above CULs for unlimited use and unrestricted exposure until such CULs are met. Under the remedies selected by this ROD, DOE shall be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

The ROD includes ICs that require DOE to prevent use and consumption of contaminated groundwater until CULs identified in the ROD that are protective of drinking water uses are met. Application of ICs is common in superfund and MTCA cleanup projects as part of a protective remedy.

Industrial CULs do not result in adverse impacts to the Columbia River. Current and projected future contaminant releases from 300-FF-1, 300-FF-2 and 300-FF-5 to the Columbia River do not and are not expected to result in conditions exceeding standards and/or risk levels for human

and ecological users of the river, the shoreline and the Hanford Reach National Monument. Hence, no ICs are required for use of the river and shoreline. Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unrestricted use and EPA authorizes the removal of restrictions. The DOE will prevent the development and use of property that does not meet residential CULs at the 300 Area Industrial Complex and 618-11 for other than industrial uses, including use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds.

With regard to the comments and concerns about the long term reliability of ICs, the effectiveness of ICs identified in the Hanford records of decision is evaluated yearly. In addition, CERCLA five-year reviews will evaluate the protectiveness of cleanup decisions, including the application and maintenance of ICs identified in the ROD.

Comment 2. Risk from Contamination Entering the Columbia River - Numerous comments on the 300 Area Proposed Plan express a concern that there is a risk to the environment and to humans using the Columbia River from 300 Area-derived contaminants, primarily uranium.

Response: Current and projected future contaminant releases from 300-FF-1, 300-FF-2 and 300-FF-5 to the Columbia River do not and are not expected to result in conditions exceeding standards and/or risk levels for human and ecological users of the river, the shoreline and the Hanford Reach National Monument. The cleanup actions in this decision will further reduce contamination entering the river.

The 300 Area uranium plume discharges to the Columbia River during periods of low water stage. The groundwater from Hanford that exceeds the uranium drinking water standard will be remediated to DWSs by the selected remedies. It should be noted that current and past measurements within the river where groundwater enters the river meet the drinking water standard. Current measurements within the river bottom (hyporheic zone) show uranium above DWSs, however that water is not currently used for drinking water. The first point of water withdrawal for municipal use is at the City of Richland. DWSs are met in the withdrawn water from the river. Risk limits are not exceeded for anyone downstream due to releases from the 300 Area.

If ambient water quality standards to protect aquatic biota existed for uranium, these standards would be applicable in the river environment. In the absence of ambient water quality standards, risk thresholds for aquatic biota protection were evaluated and were met.

The majority of 300-FF-2 is not contaminated and is well below the CULs based on the residential scenario. Only a few waste sites that have a completed interim action remediation in the 300 Area Industrial Complex do not meet these residential CULs in the top 15 feet of soil.

There are no identified risks from recreational use of the river due to 300 Area contamination. Fish in the Columbia River contain contaminants not associated with 300 Area releases. The

RI/FS presents information that shows that the majority of the risk associated with consumption of fish from the Columbia River is from non-Hanford contaminants.

The selected remedies have specific requirements to limit dust and airborne emissions of contaminants including radionuclides and monitoring is part of the requirements.

The Data Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington provides information on radionuclides found in sediments above Bonneville and McNary Dams. Overall, relatively low concentrations of radionuclides from Hanford were found in sediment cores. The Columbia River Component risk assessment (provides risk assessment information from the river, including concentrations found in fish and their potential effects on human health. Overall, few samples contained measurable concentrations of radionuclides, and risk to human health was overwhelmingly due to non-Hanford contaminants.

Uranium, tritium and nitrate from Hanford can be detected in the pore water of the river gravels near the 300 Area, but these Hanford releases cannot be detected in the surface water adjacent to the 300 Area at elevated levels compared to upstream. Hanford contaminants in the river gravel pore water and within the river coming from 300-FF-5 presently have no effect, and are not expected to have an effect in the future on human health and the environment adjacent to and below the 300 Area (see risk assessment summary in section 7). Groundwater is currently not used as a drinking water source.

300-FF-5 groundwater COCs are uranium, nitrate, TCE, DCE and tritium. The human health risk assessment looked at results of a large fish collection effort and determined that the 300 Area was not a contributor to potential risk to human health through the consumption of fish. Risk from consuming fish in the Columbia River is mostly from non-Hanford sources. PCBs, mercury and chlorinated pesticides from upriver sources are the primary risk drivers. Radionuclides were rarely found (<1% of samples) in fish samples, and most of those detections were identified as incorrect analyses because of data quality problems. See the Columbia River Component risk assessment, Volume 2 for more information

Comment 3. Uranium Cleanup Level and Washington State Cleanup Standards

A number of comments were received recommending a human health protection standard for uranium that is lower than the drinking water standard (30 ppb). Because soil contamination may leach to groundwater, commenters request a correspondingly more stringent soil cleanup level.

Response: Uranium is both a toxic metal and is radioactive. The toxicity-based drinking water standard is 30 ppb. The radioactivity dose-based standard for total alpha is 15 pCi/L. Uranium is an alpha emitter which contributes to the total alpha dose, contributing to cancer risks. The 30 ppb standard is more stringent than the dose limit for the 300 Area contamination.

The ROD identifies CULs derived from ARARs and CERCLA and MTCA risk-based limits for direct exposure to humans and the environment and for the protection of groundwater and

surface water. The remedial alternatives presented in the 300 Area Proposed Plan and in the remedies selected by this ROD meet these standards and risk levels, including ARARs from the MTCA.

Literature contains many suggested other reference doses, some lower and some higher. Since the DWSs were established, there has been additional research on uranium and its risk as a radionuclide. This has been published in the 2005 Bier VII Report "Health Risks From Exposure to Low Levels of Ionizing Radiation". The CERCLA program uses toxicity information in EPA's Integrated Risk Information System (IRIS). This is a peer-reviewed human health assessment program that evaluates information on health effects that may result from exposure to environmental contaminants. Through the IRIS Program, EPA provides the highest quality science-based human health assessments to support the Agency's regulatory activities. The IRIS database is prepared and maintained by the EPA's National Center for Environmental Assessment (NCEA) within the Office of Research and Development (ORD). EPA maintains Regional Screening Levels for contaminants including uranium (as soluble salts) which are based on the IRIS reference dose of 0.003 mg/kg-day. The protective Regional Screening Levels for uranium using EPA default exposure assumptions are 230 mg/kg for residential soil, 3,000 mg/kg for industrial soil and 47 mg/L for tap water. The CULs in this ROD (which may be driven by groundwater protection) are 81 mg/kg for residential CUL areas, 157 mg/kg for industrial CUL areas and 30 mg/L for groundwater.

Calculation of radionuclide CULs is consistent with CERCLA and Atomic Energy Act (AEA) guidance. EPA and DOE have agreed on the methodology to derive radionuclide CULs using exposure scenarios containing multiple pathways including site-grown food. EPA and DOE have also agreed to use the lower of risk-based and dose-based CULs. Overall the approach is adequately conservative. State of Washington methodology for chemicals uses single pathway scenarios, which is not as conservative as the EPA CERCLA guidance approach used for radionuclides that adds risk from multiple exposure pathways. The lower of dose-based at 15 mrem/yr and risk-based at 1 in 10,000 cancer risk is used for radionuclides.

Comment 4. Preference for Excavation of the Residual Uranium - Numerous comments endorsed the exhumation of uranium-contaminated soils via RTD and subsequent disposal in the 200 Area ERDF. The comments varied on the suggested amount of residual uranium that should be removed, ranging from focused hotspot removal to complete removal of the remaining uranium-contaminated soil.

Response: In-situ treatment is the best option for immobilization of the residual uranium. A significant portion of the residual mobile uranium will be chemically immobilized in a stable mineral form.

Previous cleanup actions have removed most of the uranium-contaminated soil from the seven sites contributing to the uranium plume. Those actions have removed approximately 170,000 metric tons of uranium-contaminated soil and debris from the liquid waste disposal facilities. Contaminated soils were removed to a depth where established CULs were reached. Residual

uranium in the deeper vadose zone and PRZ is what the alternatives in the proposed plan would address and the subject of the comments. What remains is a relatively small percentage of the original mass. Excavation in the PRZ is problematic as described in Section 10.5 of the ROD and may result in releasing more uranium than if no action is taken.

The proposed plan alternatives include removal of the residual uranium-contaminated soil. The proposed plan presents two alternatives within the range of uranium removal suggested by comments. Alternative 4 presents focused hotspot removal, combined with phosphate sequestration in adjacent less-contaminated areas. Alternative 5 presents the option for nearly complete uranium removal above the groundwater. All alternatives including the excavation alternatives require a 10-15 year post-remediation time period for the uranium already in groundwater or that might reach groundwater before the remedy is implemented to attenuate to DWSs. While selection of alternatives 4 or 5 would be expected to somewhat accelerate achievement of the uranium CUL, there are other issues and concerns with those alternatives that make the selected remedy the better choice. Excavation of uranium-contaminated soil requires dust suppression with water that results in excess water that percolates through the soil carrying some uranium with it to groundwater.

Although the deep excavation components of Alternatives 4 and 5 might appear to have higher short-term effectiveness because the uranium CUL is achieved more quickly than with other alternatives, deep RTD entails a number of adverse impacts during implementation. The deep excavation of soil to groundwater for the uranium-contaminated waste sites includes the minimum, standard safe-practice lay-back of 1.5 m (5 ft) for each vertical 1 m (3.3 ft) of excavation depth. This deep excavation will create a very large disturbed area and generate approximately 0.76 million m³ (1.0 million yd³) of soil in Alternative 4 and 3.3 million m³ (4.3 million yd³) of soil in Alternative 5 for handling and disposal. Given that large volumes of contaminated soil that will be generated, three new Super Cells will need to be constructed at the ERDF to dispose of the excavated deep contaminated soil for Alternative 5. The subsequent backfill of the excavated areas will require loading, transportation and handling of a comparable volume of clean soil from a different location. For Alternative 4, the excavation and backfill of a combined 1.5 million m³ (2.0 million yd³) of soil are estimated to require approximately 6.3 million km (3.9 million mi) of truck haulage. The trucks would use 10 million L (2.6 million gal) of diesel fuel and generate 31,000 metric tons (34,000 tons) of carbon dioxide and 250 metric tons (276 tons) of mono-nitrogen oxides. For Alternative 5, the excavation and backfill of a combined 6.6 million m³ (8.6 million yd³) of soil are estimated to require approximately 27 million km (17 million mi) of truck haulage. The trucks would use 43 million L (11 million gal) of diesel fuel and generate 133,000 metric tons (147,000 tons) of carbon dioxide and 1,100 metric tons (1,200 tons) of mono-nitrogen oxides. These represent significant short-term implementation impacts to the environment.

Comment 5. Efficacy of Uranium Sequestration via Addition of Phosphates – Numerous comments were received questioning the efficacy of the remedial technology identified in the preferred alternative in the proposed plan, sequestration of uranium in situ via application of phosphates. Comments suggest the technology is not fully tested, resulting in many uncertainties

in the deployment of the technology. Comments range from requesting further testing prior to making a decision, to rejection of the technology in favor of removal of the residual uranium.

Response: DOE and EPA recognize the challenges in the deployment of the technology and will be able to design and deploy the remedy successfully. Information from laboratory studies and field testing supports selecting uranium sequestration. Laboratory studies show that uranium bind with phosphate to form autunite under the geochemical conditions that exist in the 300 Area. In addition to the laboratory studies, a field demonstration in 300 Area groundwater has been performed. Field testing was performed to evaluate forming an apatite barrier and the formation of autunite. The results were that an apatite barrier was not successfully formed but autunite was formed successfully resulting in uranium removal from the groundwater to below drinking water standard. Autunite is a geologically stable mineral that is not expected to breakdown and release the uranium. The selected remedy is based on the formation of autunite and does not use apatite.

Comment 6. Monitored Natural Attenuation - Numerous comments questioned MNA as an appropriate element of the remedial alternatives. The concerns were largely based on a desire for a more active and expedited remedy in support of RTD. Many of the comments incorrectly identified MNA as a remedial approach for uranium.

Response: The preferred and selected remedies are “enhanced attenuation” for uranium, wherein the ongoing residual source of uranium occurring in a defined “hotspot” will be treated to reduce the mobility of the uranium which better protects groundwater.

MNA is selected for the short-lived tritium, nitrate and for the localized deep occurrence of organic chemicals that have been degrading naturally. Groundwater contaminants are discussed in section 5.1.3 of this ROD and MNA as a component of the alternatives is evaluated in sections 8.3.2 and section 9.2.2.5 of the RI/FS report. The CULs for these contaminants will be attained in a reasonable period of time for restoring groundwater considering site circumstances.

Comment 7. Long-term Protectiveness – Comments were received questioning the long-term protectiveness of the preferred alternative presented in the proposed plan, generally in support of excavation-based remediation over in situ treatment. Comments were based on a perception that RTD is more protective than in situ treatment in that RTD results in removing more uranium from the river corridor.

Response: RTD and uranium sequestration will both achieve CULs and are protective of human health and the environment. Previous RTD removed the majority of the mass of uranium from the river corridor into safe disposal in ERDF. Uranium sequestration chemically binds uranium into autunite that is a geologically stable and immobile mineral form and therefore provides long-term protectiveness. Other alternatives that use RTD for the same deep uranium contamination also provide long-term protectiveness but were rated more poorly in other CERCLA evaluation criteria. Evaluation of alternatives is presented in section 10 of the ROD.

Comment 8. Contingent Remedy for Uranium Sequestration – Comments were received expressing an interest in having a contingent remedy should uranium sequestration fail.

Response: DOE and EPA believe uranium sequestration will significantly accelerate restoration of the groundwater to meet the uranium CUL to support drinking water. During the FS identification, screening and nine criteria evaluation of alternatives, DOE and EPA determined that contingent remedy was not appropriate. The selected remedy includes requirements for deep vadose zone and PRZ uranium sampling before and after application of phosphate to determine the change in uranium mobility in the treatment area. Groundwater monitoring before, during and after phosphate treatment is included in the selected remedy. This information will be available for review in the CERCLA-required 5 year review of protectiveness.

Comment 9. Performance Requirement for Uranium Sequestration – Comments highlighted that sequestration alternatives did not have performance benchmarks and thus no way to determine of the remedy element was successful. These comments were often tied the contingent remedy comment discussed above, namely failure to attain the benchmark would trigger the contingent remedy.

Response: Comments are correct that the alternatives specify requirements for application of phosphate for sequestration but do not have a percent reduction-type performance standard. The ROD does select a CUL which is based on protection of drinking water uses. Pre- and post-treatment sampling is required that will be used to measure the changes in leachability of uranium. The FS identified and evaluated many technologies and DOE and EPA have determined that sequestration is the appropriate selected remedy to accelerate restoration of the aquifer to meet uranium DWSs.

Comment 10. Viability of ICs – Comments challenged the appropriateness of using ICs. Some challenged the appropriateness, implementability and viability of ICs for any period of time, while other comments focused on long-term use of ICs. The remedy should not rely on long-term stewardship.

Response: Alternatives 2, 3, 3a, 4 and 5 rely on ICs for long-term protectiveness in less than one square mile of the 40 square mile 300-FF-2. It takes considerable time to implement the active phase of the remedies and it would be unsafe to allow unrestricted access and exposure in the near term to contamination. Therefore more extensive ICs were an essential element of all viable alternatives for short-term protectiveness.

Soil CULs protective of residential use apply to most (about 39 of the 40 square miles) of the 300 Area. After remediation, waste sites in these areas do not require any long-term ICs. ICs that restrict land use within the 300 Area Industrial Complex and 618-11 are included in all the alternatives except no action. In the selected remedy those ICs only apply to the areas that do not meet the residential use CULs. Long-term stewardship of ICs as an element of the alternatives was evaluated in the nine criteria analysis. A Hanford site-wide program to implement ICs has been established in response to previous Hanford RODs and other DOE requirements for site

security. The ICs in this selected remedy will be implemented through that existing program. DOE will be held responsible for the contamination in the future, which is addressed in this document. The transition to DOE's long-term stewardship program is an administrative function within DOE that will not have any impacts on protectiveness or compliance with the requirements in this document.

Existing waste sites with contamination and groundwater plumes require ICs until the active part of the remedy can be implemented, and long-term ICs will apply to portions of the 300 Area Industrial Complex and 618-11 that do not meet the residential use CULs.

Comment 11: Protect Treaty Rights, Provide Environmental Justice – There is an obligation to protect treaty rights while meeting cleanup thresholds. The decision must be protective of the health of tribal members for all exposure scenarios and tribal uses, provide environmental justice and not cause disproportionate impacts. The proposed plan did not describe DOE's trust obligation to affected tribes.

Response: Cleanup thresholds (CULs) are established based on the risk assessment and ARARs. The risk assessment included two tribal-authored and one DOE-authored scenarios. In determining CULs DOE and EPA identified the reasonably anticipated future land use and the corresponding risk assessment and ARARs. For the 300 Area Industrial Complex and 618-11 the reasonably anticipated future land use is industrial and therefore industrial use scenarios and the state's industrial use CUL were primarily used to establish soil CULs. For the remainder of the 300 Area the CULs for chemical contaminants were derived primarily using the state's CUL for unrestricted use. Soil CULs for radionuclides primarily are based on a residential scenario in which the receptor lives off the land at a waste site. The receptor lives on the waste site, derives their food from the waste site and derives their water from groundwater below the waste site that is impacted by mobile contaminants that leach from the waste site into the groundwater as enhanced by irrigation. DOE and EPA believe the CULs are protective of reasonably anticipated future land uses. The information in the risk assessment is available to tribal nations and their members to review.

Comment 12: Tribal Treaties as ARARs – Tribal treaties, which reserves specific rights and resources should be acknowledged as an ARAR or a must comply standard for cleanup decisions.

Response: Under CERCLA, ARARs are applicable or relevant and appropriate requirements under federal environmental or state environmental or facility siting laws that address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. Treaties do not meet the definition of an ARAR: Treaty requirements cannot be waived as ARARs can under CERCLA. The Treaties reserve specific rights and resources in the unique legal relationship between the Federal Government and Indian tribal governments. While Treaties are not ARARs, there are several ARARs that provide protection for cultural and natural resources such as the "Protection of Historic Properties" (36 CFR 800); "National Historic Landmarks Program" (36 CFR 65); "Native American Graves Protection and

Repatriation Regulations” (43 CFR 10)(25 USC §§ 3001 et seq.); National Historic Preservation Act (16 USC 470, et seq.); and the “Archeological and Historic Preservation Act” (16 USC 469a 1 through 469a 2(d)).

Comment 13. Endangered Species Act Consultation – Comments were received that Endangered Species Act consultation with the resource agencies should be conducted.

Response: The Hanford Reach contains three species listed as threatened or endangered under the federal Endangered Species Act (ESA). Two species are federally listed as endangered fish including the upper Columbia River spring-run Chinook salmon and the steelhead. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is listed as a threatened species but is not considered a resident species and is rarely observed in the Hanford Reach.

The ESA, section 7, includes an administrative requirement that federal agencies consult with U.S. Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (NMFS) before taking any action that may affect an endangered or threatened species. Administrative requirements are not part of the ARAR. The preferred remedy identified in the 300 Area Proposed Plan and in the ROD for 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units includes the ESA as an ARAR. Therefore, substantive ESA requirements to protect endangered species must be met.

The selected remedy will not jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. This conclusion is based on two lines of evidence. First, the preferred remedy does not take an action in the Columbia River, so there will not be any direct physical effects on fish or their habitat. Secondly, there are no adverse effects of contaminants on listed species of fish before, during or after the remedial actions, as discussed below.

The 300 Area contains six groundwater COCs, including uranium, gross alpha, tritium, nitrate, trichloroethene and cis-1,2-dichloroethene, as determined in the 300 Area RI/FS. The ecological risk assessment did not identify risks to aquatic organisms from groundwater or groundwater upwelling, so all the groundwater COCs are based on human health. The Columbia River rapidly dilutes groundwater contaminants to relatively low concentrations, so the primary concern for ecological risk to aquatic biota is from exposure to pore water in sediments. Larval fish are exposed to pore water while they are living in the sediments, which is when they have the highest sensitivity to contaminants. These six COCs in groundwater are discussed below.

Uranium concentrations in pore water have been measured as high as 113 µg/L from 34 samples collected during the river upwelling studies (Section 4.5.2 of the RI/FS), and as high as 137 µg/L from 16 samples from the River Corridor Baseline Risk Assessment (RCBRA). No effect thresholds for fish are identified as 910 µg/L in the RCBRA. Given that existing levels of uranium detected are well below no effect thresholds and that the remedy will serve only to

reduce uranium levels in groundwater, uranium concentrations pre-remedy, and concentrations expected post-remedy, will have no effect on fish, including trout and salmon.

Gross alpha is primarily from uranium, and toxicity from radionuclides is rapidly attenuated by water. Effect thresholds for aquatic receptors are at much higher levels than human health thresholds, so gross alpha is not an ecological concern, and there are no effects on fish, including trout and salmon.

Tritium concentrations in pore water have been measured as high as 6,720 pCi/L (table 4-25 in the RI/FS). The Columbia River Component (CRC) identifies an effect threshold of 265,000,000 pCi/L for tritium exposure to riparian animals. Aquatic animals are less sensitive than riparian animals. Exposure concentrations of tritium will not adversely affect fish. Nitrate concentrations in pore water have been measured as high as 21,800 µg/L in river upwelling studies (table 4-25 in the RI/FS). Background concentrations in groundwater are 26,871 µg/L (table 4-25 in the RI/FS). The no effect screening level is 7,100 µg/L and the low effect screening level is 37,600 µg/L.

Nitrate in the 300 Area is largely from offsite sources, and concentrations in the river are similar to upstream reference sites. Nitrate from offsite sources is not part of the 300-FF-5 Operable Unit groundwater and is not being addressed by this ROD. Adverse effects for trout and salmon are not expected currently, and the remedy will not increase the potential for adverse effects.

In pore water, trichloroethene was detected once at 4 µg/L, and 1,2-dichloroethene was not detected (table 4-25 in the RI/FS). Screening levels for aquatic organisms (identified as secondary chronic values) are 47 µg/L for trichloroethene, and 910 µg/L for 1,2-dichloroethane (ORNL ES/ER/TM-96/R2, 1996, Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota). The lowest chronic values for fish are 11,100 µg/L for TCE and >2,800 µg/L for DCE. Trout and salmon are not affected by TCE and DCE in the 300 Area.

Comment 14. Cost of RTD in Alternatives 4 and 5 are too High – Comments expressed a belief that the costs for the deep large RTD excavations included in Alternatives 4 and 5 were too high.

Response. The 300 Area and 100 Area have undergone extensive RTD for about two decades. There is a large actual Hanford cost data record that was used to produce the cost estimates for these alternatives. The cost of the RTD option for the 300 Area is driven, in part, by the need to address the uranium residing deep in the soil that is periodically rewetted as the aquifer responds to increased river stage. Excavation must go to the elevation of the aquifer at low river conditions to address the primary active uranium source. Two alternatives considered in the Proposed Plan include such deep excavation; Alternative 4 includes excavation of the “hotspot” and Alternative 5 that includes an extensive deep and laterally-extensive excavation approach. The other cost driver is the massive quantities of contaminated soil that would be excavated and hauled to the ERDF for disposal and the equivalent quantity of backfill needed. The large deep

excavation waste sites in the 100 Area address relatively localized high-concentration chromium sources where much of the excavated material can be backfilled after the localized, but deep, chromium-contaminated soil is removed. This is different than the 300 Area.

Comment 15: Traditional Cultural Properties – Comments were received regarding the identification and evaluation of Native American traditional cultural properties to ensure that they are appropriately dealt with during remedial actions.

Response: Traditional Cultural Properties and other historic items and areas are addressed in ARARs in this ROD. The ARARs are “Protection of Historic Properties”, “National Historic Landmarks Program”, “Native American Graves Protection and Repatriation Regulations”, “National Historic Preservation Act”, and “Archeological and Historic Preservation Act.” These ARARs identify the substantive requirements for the selected remedial actions. Traditional Cultural Properties are addressed by these ARARs.

Comment 16: Colloidal Transport of Treated Uranium – Colloidal transport of uranium in groundwater following phosphate treatment was raised as a question if that was considered in the evaluation.

Response: Colloidal transport was considered. Based on the previous field test in the 300 Area groundwater, colloidal transport of uranium was not observed following treatment with phosphate.

Comment 17: Tri-Party Agreement Milestones – Comments noted that the schedule for some elements of the alternatives did not comply with milestones in the Tri Party Agreements.

Response: This ROD and the schedule in the resulting RD/RAWP will be used when modifying milestones within the Tri-Party Agreement.

Comment 18: Modeling – Simplifications and assumptions used in modeling were questioned giving rise to the conclusion that modeling results are inaccurate and have too much uncertainty.

Response: Modeling includes simplifications and assumptions, which was summarized in the proposed plan. Modeling was sufficient for the purposes presented in the RI/FS and proposed plan and to support the decisions in this document. Uncertainties are acknowledged and discussed in all the documents.

Comment 19: Dust Suppression Alternatives – Comments were submitted regarding Hanford and off-Hanford experience with dust suppression liquids, and alternatives that can be used. Commenters requested that other alternatives be evaluated.

Response: Dust suppression during the excavation of contaminated soil is required to ensure that contaminated dust is not inhaled or ingested by workers and to ensure that contamination is not spread during remediation and transport to the disposal facility. Numerous different additives have been used in dust suppression water based on site specific conditions and the relative merits of the additives. They all involve mixing fixatives in water which is sprayed on waste sites.

Fixatives interact with the soil and contaminants, which is what they are designed to do. As a result the water percolates more quickly and leaches and transports some contaminants such as uranium.

Comment 20: River Shoreline – The river shoreline was identified as critical habitat for human and the environment. It deserves unique attention. State law requires shoreline management plans. People access the shore from upland and the river making human access ICs not implementable.

Response: The points in the comment are correct. For the selected remedy in the ROD, EPA and DOE have explicitly defined that ICs only apply to the areas with contamination that exceeds acceptable residential direct exposure levels and groundwater that exceeds levels for drinking water protection. ICs specified in the selected remedy apply to the areas shown in figures 1 and 2. Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions.

Comment 21: Phosphate as a Pollutant – Phosphate used in the sequestration process is a pollutant itself. We should not be adding phosphate that can get into the Columbia River.

Response: Based on the previous phosphate injection test in the 300 Area, phosphate is not believed to travel very far. The treatment area in the selected remedy is not adjacent to the river but rather at the inland core area of the plume.

Comment 22: Contaminant Inventory – A comment was provided that questioned the basis for the contaminant inventory in the 300 Area.

Response: Considerable effort, as described in the 300 Area RI/FS, has been made to characterize the residual uranium and other COCs in the 300 Area. DOE and EPA believe there is adequate site characterization to describe the conceptual model, describe the nature and extent of contaminant distribution, assess risk, and evaluate remedial alternatives to select a remedy in the ROD. There will always be some level of uncertainty, which is acknowledged. However, there is sufficient knowledge to make this decision.

Comment 23: Use Other More Stringent Standards – More stringent CULs for water were requested. For 300-FF-5 COCs the requested CUL was 0.8 ug/L for TCE based on a California public health goal, and 2.6 ug/L for uranium based on a 1993 ecological screening value from EPA. More stringent water CULs were submitted for other chemicals.

Response: The CULs in this ROD are based in part on risk assessments done for the 300 Area and the Hanford river corridor. The risk assessments used a broad basis for toxicological information in accordance with EPA risk assessment guidance. The CULs in this ROD are also based on ARARs in accord with CERCLA and the NCP.

Comment 24: 200-PO-1 – Remediation of contaminants from the 200-PO-1 OU will be years in the future. Those contaminants contaminate the same aquifer. Those COCs should be included in

300-FF-5. If 200-PO-1 contamination exceeds standards then the 300-FF-5 remedy must include a remedy for those contaminants.

Response: The 200-PO-1 contaminants are not included in 300-FF-5. When a remedy is selected for 200-PO-1 it will address those contaminants. 300-FF-5 is groundwater contaminated by releases from 300 Area activities.

Comment 25: Risk Assessment From Multiple Sites – The approach and assumptions in the human health risk assessment need to adequately address cumulative risk from exposure at multiple sites.

Response: The residential and industrial risk assessment scenarios used for waste sites places the full exposure at a single site. A protective remedy for each site will also be protective of someone who spends time at multiple sites. When someone is being exposed at one site they are not being exposed at the other sites.

Comment 26: Ecological Risk Assessment – Biological populations were defined too broadly. Ecological risks were calculated by individual waste site as though they were isolated from any other site when considering exposure to biological organisms. The cumulative potential exposure from all waste sites within a species-specific use area needs to be considered.

Response: CERCLA ecological risks are calculated at the biological community/population level as recommended in CERCLA risk assessment guidance. 300-FF-2 waste sites do not have ESA-listed species for which risk assessment at the individual level rather than community/population level would be appropriate.

When receptors are at one waste site receiving exposure they are not at the other waste sites so it is not appropriate to add risk from multiple waste sites as if the receptor is at multiple sites concurrently. The details of the ecological risk assessment are presented in Chapter 7 of the RI/FS document.