4.0 Hazard-Specific Discussion

This chapter describes the specific hazards at the Hanford Site and is organized by the major areas at Hanford: 100 Areas, 200 Areas and 300 Area (including key waste sites located in the 600 Area). In September 1996, the 1100 Area of the Site was cleaned up and deleted from the NPL. This chapter also describes the potential exposure pathways (conceptual site models) for both the current baseline end state and the end state vision.

Hazards at the Hanford Site can be grouped in two broad categories:

- **Near-term (safety-related) hazards** – where hazards with potentially large consequences could result from the release of radionuclides and chemical contaminants in the current or remediation phase. The major exposure pathway to receptors is via the air. Near-term releases are characterized by a relatively low likelihood of occurrence but moderate-to-high consequences. These hazards affect directly involved workers, co-located workers, and potentially the public and ecosystem receptors. Examples of these hazards include the larger inventories of radionuclides such as the cesium and strontium capsules stored in the Central Plateau, the plutonium inventory at PFP, the transuranic waste drums at the Central Waste Complex and former safety issue tanks. Current systems and procedures are in place to safely manage the risk posed by these materials and to minimize the potential for accidents that could lead to adverse consequences.

- **Long-term (environmental and human health) hazards** – where harm results from transport of radionuclide and chemical contaminants through the groundwater to human and ecological receptors or directly to future site uses. Long-term risks are characterized by a relatively high likelihood of occurrence but releases occur over a long time. The time frame of concern is primarily post-closure (e.g., 100s or 1,000s of years in the future). Examples of these hazards include the past releases of contaminants to the soil column in both the 100 and 200 Areas and existing groundwater plumes that discharge to the Columbia River.

In considering hazards, it is also important to understand the additional hazards that can be caused during remediation activities to workers and to ecological receptors through physical disruption of natural habitats.

Since the beginning of the Environmental Management mission at the Hanford Site in 1989, the highest priority has been given to reducing and eliminating the near-term risk contributors. These hazards represent the dominant source terms for near-term, safety-oriented risk assessments at the Hanford Site. These hazards are reduced and eliminated through removal to the 200 Area away from the Columbia River and population sources, through stabilization to less

Risk and Hazard

Risk is generally described as the product of the consequences and the likelihood of a receptor being exposed to a hazard. To understand risk it is necessary to understand the hazard source (e.g., quantity, toxicity), the likelihood of its release, the potential transport pathways (e.g., air, soil groundwater), and the specific exposure mechanisms for potential receptors (e.g., inhalation, ingestion).

hazardous forms, and through shipment off site for final disposition. Some of the most significant reductions in near-term hazards that have been achieved to date include:

- The spent nuclear fuel stored in the K Basins has been removed and placed in safe, dry storage in the 200 Area.
- In February 2004, PFP plutonium stabilization activities were completed.
- As of the end of FY 2001, all tank safety issues were resolved including the flammable gas and high heat issues, the two most problematic issues.
- During 2001 through 2002, the largest radiological inventories in the 300 Area were removed including the 324 Facility B Cell cleanout, removal of 13 million curies of isotopic heat sources (the German logs), and removal of other spent nuclear fuel.
- Significant hazards were removed from PUREX and B Plant in 1997 and 1998, respectively, resulting in less costly surveillance and maintenance.

Substantial progress has also been made to lower the risk posed by long-term hazards by reducing the potential for further environmental releases and by reducing the driving forces for prior environmental releases. These hazards represent the dominant sources for current and potential environmental contamination that can pose a threat to ecological receptors and to future human receptors. These hazards are reduced or eliminated by implementing treatment systems, including some removal actions, and by reducing the mobility and potential driving forces for transport through the environment. Some of the most significant progress in eliminating long-term hazards has been made in the following areas:

- Early in 2004, interim stabilization of all 149 single-shell tanks was completed by removal of pumpable liquid.
- From 2002 to 2004, extensive interim actions were implemented to minimize natural and manmade infiltration (e.g., water line leaks) into the vadose zone within tank farms to halt potential remobilization of previously leaked contaminants.
- Groundwater remediation was initiated in the 100 Areas for chromium in 1997 and for strontium-90 in 1995 to reduce the potential impact on the Columbia River ecosystem.
- Vapor extraction for the carbon tetrachloride plume in the 200 Areas (200-ZP-1 Operable Unit) was initiated in 1996 and continues to remove contaminant mass from this plume.
- From 1990 to 1995, liquid discharges to the 200 Areas soil column were reduced by ~23 billion liters (6 billion gallons) per year, thus reducing new sources of contamination and eliminating a key driving force for previous vadose zone and groundwater contamination.

The following sections summarize the remaining hazards in the 100 Areas, 200 Areas, and 300 Area. The potential exposure pathways are also described for both the current baseline end state and the end state vision.

4.1 100 Areas

The 100 Areas are located on the Columbia River shoreline, where nine nuclear reactors operated from 1944 to 1987. The nine plutonium production reactors are ~48 kilometers (30 miles) from Richland in the northern portion of the Hanford Site along the south bank of the Columbia River. The reactor cores range from ~85 to 823 meters (~280 to 2,700 feet) from the river bank. They are located close to the river to support the large quantities of cooling water required for operation.

4.1.1 Summary of Existing Hazards in the 100 Areas

Table 4.1 summarizes the existing hazards in the 100 Areas. DOE manages the risks posed by these hazards in order to protect the workers and the public. Managing the hazard is done on a graded approach that depends on the severity of the hazard. Monitoring and access controls are the primary method to ensure protection of workers and the public. Integrated safety management systems are in place to ensure protection of the workers during cleanup activities. The top priority hazards in the 100 Areas are the following in descending order of their relative importance:

- **K Basin sludge**. The K Basin sludge poses the most significant risk to workers and the public. The N Reactor fuel that was once stored in the K Basin storage pools has recently been transferred to a safer dry storage configuration in the Central Plateau. Safety management systems and procedures are in place to manage the risk posed by this material and to minimize the potential for accidents that could lead to adverse consequences.

- **Existing groundwater plumes that release contaminants to the Columbia River**. Several areas have groundwater contaminated with hexavalent chromium plumes, resulting from previous liquid discharges that upwell into the Columbia River at levels that exceed ambient water quality criteria for the protection of aquatic species. In addition, there is a strontium-90 plume at 100-N Area that exceeds drinking water standards by a factor of ~1,000. Active pump-and-treat systems and passive treatment system are in place to shrink the size of groundwater plumes and reduce potential releases to the Columbia River. Controls are in place to prevent consumptive use of groundwater.

- **Former production reactors**. Nine former production reactors include de-fueled graphite cores with a significant inventory of radionuclides. Current activities include reducing the footprint of these facilities and placing the reactor cores in interim safe storage for up to 75 years to allow decay of radionuclides until final disposition. Reactors awaiting interim safe storage are in a surveillance and maintenance program to minimize the potential for accidents that could lead to adverse consequences.

- **Subsurface contamination**. Liquid waste disposal sites and burial grounds have contributed to subsurface contamination. Depth of contamination ranges from the surface to groundwater. These sites are being excavated as much as 4.6 meters (15 feet) below grade to maximize potential future surface uses. Contaminated soil is trucked to the Central Plateau for disposal. Sites awaiting excavation are under a surveillance and maintenance program to minimize the spread of contamination.

Table 4.1. Summary of Existing Hazards in the 100 Areas

Material Category	Current Hazard
Surface	
K Basin Sludge	• K Basin sludge and debris (200,000 curies). Approximately 50 m^3 (65.4 yd^3 require packaging for removal with less than 0.5 m^3 of fuel pieces contributing the majority of this source term. The basins are currently not known to be leaking but have leaked in the past.
Surplus Production Reactors	• Nine surplus production reactors. Radioactive inventory contained in the core includes tritium (~98,000 curies); carbon-14 (~37,000 curies); chlorine-36 (~270 curies); cobalt-60 (~74,000 curies); cesium-137 (~270 curies); and uranium-238 (about 0.01 curies). The dose to workers from cobalt-60 and cesium-137 is one of the main drivers leading to the decision to place the reactor cores into interim safe storage for 75 years. Radioactive inventory in the core is not leaking.
Ancillary Facilities	• Ancillary facilities supported operations and maintenance of reactors. There were a total of 250 ancillary facilities in the 100 Areas with the remaining facilities located primarily at 100-N (59), KE/KW. Hazards range from industrial to potential contamination with radiological constituents, i.e., fission and activation products, metals, inorganic, organic compounds both volatile and nonvolatile.
Subsurface	
Liquid Waste Sites	• As of 1978, the deactivated 100 Area liquid waste sites contained a total radioactive inventory of 4,400 curies. The principal radionuclides remaining in the waste sites were reported to be tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, europium 152, europium-154, europium-155, and plutonium-239/240. DOE (1994) reported a 1988 inventory of about 10,000 curies of radionuclides (cobalt-60, strontium-90, ruthenium 106, cesium-134, cesium-137, and plutonium-239) in the two main 100-N Area liquid waste sites. Additional non-radioactive contaminants, such as sodium dichromate, are also common in the liquid waste sites. Liquid waste sites are the main contributor to groundwater contamination in the 100 Area due to the high volumes of disposal (see groundwater discussion below).
Solid Waste Burial Grounds	• Forty-five sites are estimated to have over 1 million m^3 (1.3 million yd^3) of solid, low-level radioactive waste associated with reactor operations. Waste containing plutonium or any other alpha emitters, cobalt-60 in amounts greater than 1 millicurie/gram, or beryllium was packaged and shipped to the 200 Area for burial in designated trenches. The main radionuclides are tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, silver-108m, europium-152, europium-154, and europium-155. Because disposal records prior to the late 1960s were not detailed, the estimates of the radionuclide inventory are uncertain and largely drawn from evaluations of analogous sites. The predominant radionuclides anticipated in the 45 burial grounds (compiled) are: tritium ~19,000 curies; cobalt-60, ~3,000 curies; nickel-63 ~2,000 curies; strontium-90 <10 curies; cesium-137 <10 curies; and silver-108m ~60 curies. Of the 45 burial grounds, there is one potential contributor (118-K-1) to groundwater contamination (tritium). Pieces of nuclear fuel were found during excavation of two large burial grounds in the B/C Area, a discovery that emphasizes the uncertainty associated with burial ground contents.
Groundwater	
Groundwater	• The most prominent contaminants in 100 Areas groundwater are tritium, strontium-90, hexavalent chromium, and nitrate. These contaminants originated primarily from disposal cribs and trenches, condensate cribs. Other sources include leaks from the 100-K Area East fuel storage basin, leaks from the 183-H basin and leaking retention basins. Because these sites are close to the Columbia River, these contaminants have been detected in springs that discharge to the river. Hexavalent chromium and strontium-90 have been detected above the National Ambient Water Quality Standards at isolated points on the river bottom where the groundwater upwells into the river prior to being diluted by the river.

Figures 4.1a through 4.1f display maps of the hazards in each of the 100 Areas. Conceptual models were developed for this document to describe the pathways these hazards could come in contact with a receptor. Conceptual models for the current state, current baseline end state, and end state vision are discussed in Section 4.1.3.

4.1.2 Exposure Pathways and Potential Implications of the End State Vision

Table 4.2 summarizes the assumptions for land use, exposure scenarios and pathways for determining risk based cleanup levels, remediation goals, and institutional controls (including final barriers if any) for both the current baseline end state and the end state vision. Most of the current interim action RODs (ROD 1996a, 1999a, 1999b, 1999c) for waste sites in the 100 Areas preceded the issuance of the ROD (64 FR 61615) for the CLUP. These RODs established cleanup goals based on a surrogate "rural residential farmer" exposure scenario in order to allow for unrestricted future surface use. In addition, the RODs protected against future degradation of groundwater. Subsequently, the CLUP established land use for the 100 Areas as conservation/preservation. The CLUP land-use scenario and the Hanford Reach National Monument designation do not envision large scale residential land use or groundwater use (current or future). There could be future isolated residents that support the National Monument for fire fighting or a ranger. These residents would not be placed on top of former waste sites.

As described in Section 3.5, the interested public voiced their opinion during a 100 Area End State Workshop that there is great uncertainty with regards to future activities beyond 50 years or after the government relinquishes control of the land. If the 100 Areas ever moves away from government control, the possibilities for future activities increase greatly, including the possibility of residential communities and hotels. However, there was general consensus at the workshop that the conservation and preservation type activities were preferred in order to protect the unique shrub steppe habitat. For purposes of the end state vision, it is assumed that the 100 Areas will remain in federal control in perpetuity. The intent of the end state vision is to align the remediation goals with an exposure scenario that is consistent with the CLUP (DOE 1999a) land-use designation while incorporating stakeholder input where possible.

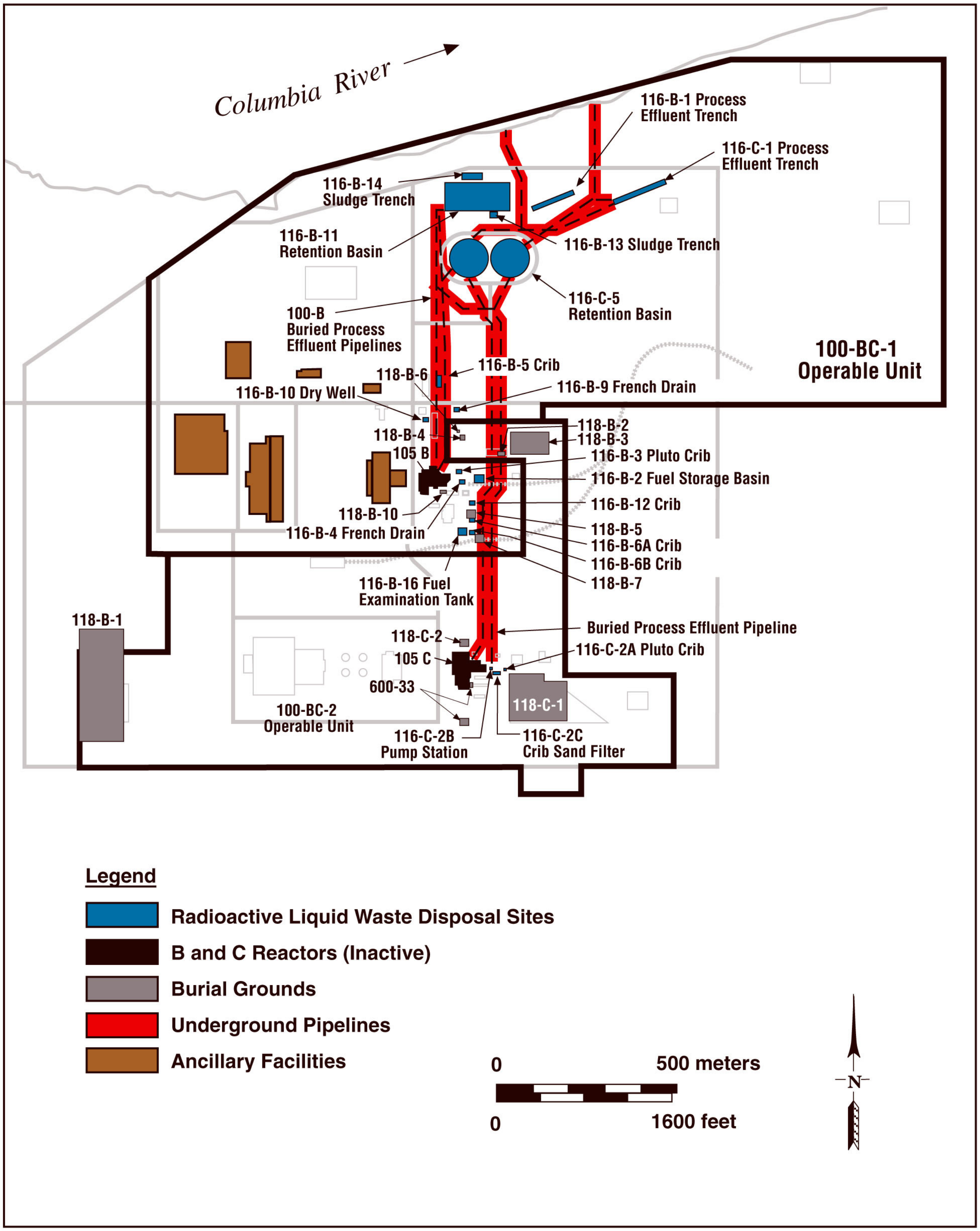

Figure 4.1a. 100-B/C Area Hazards

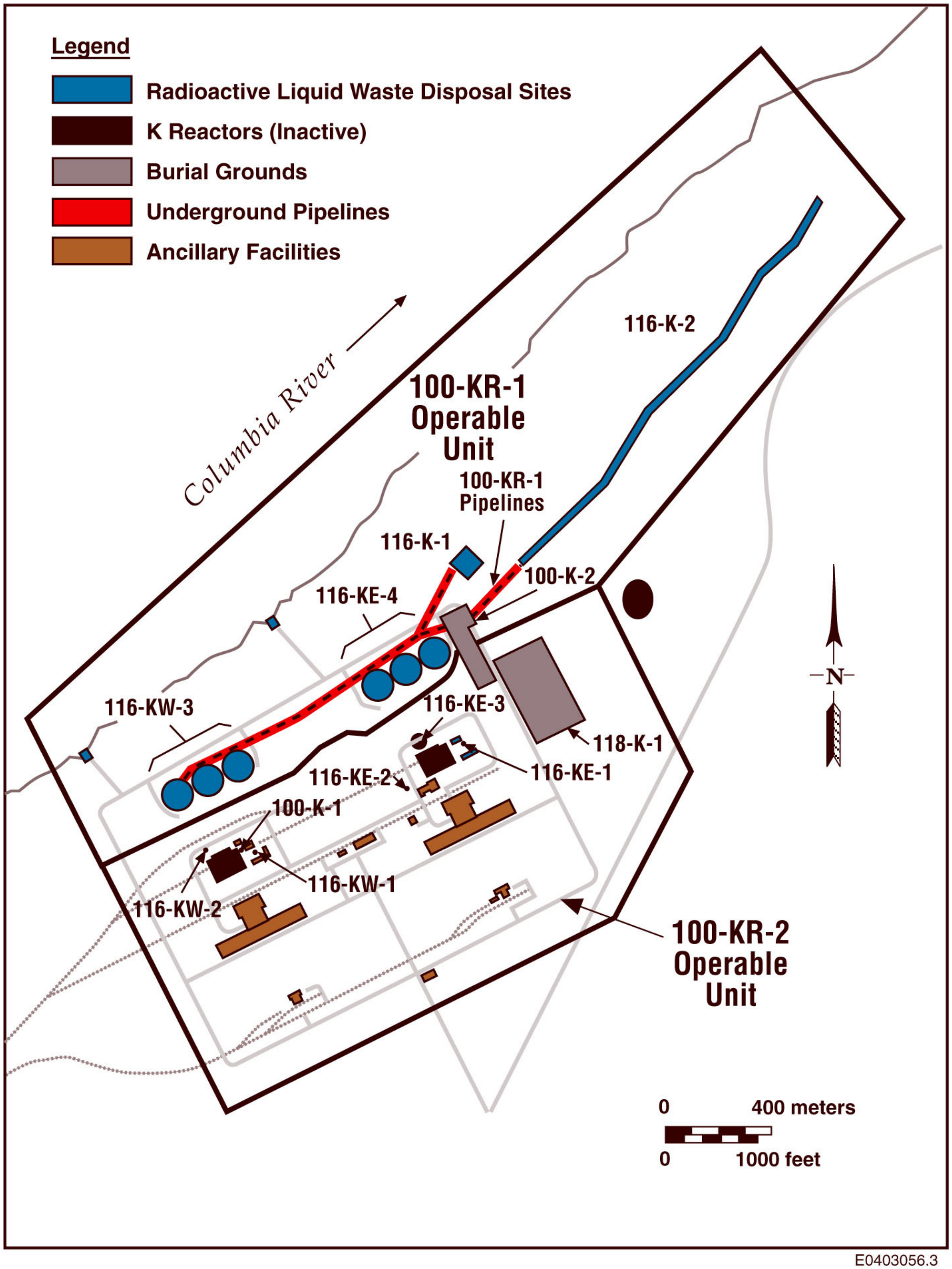

Figure 4.1b. 100-K Area Hazards

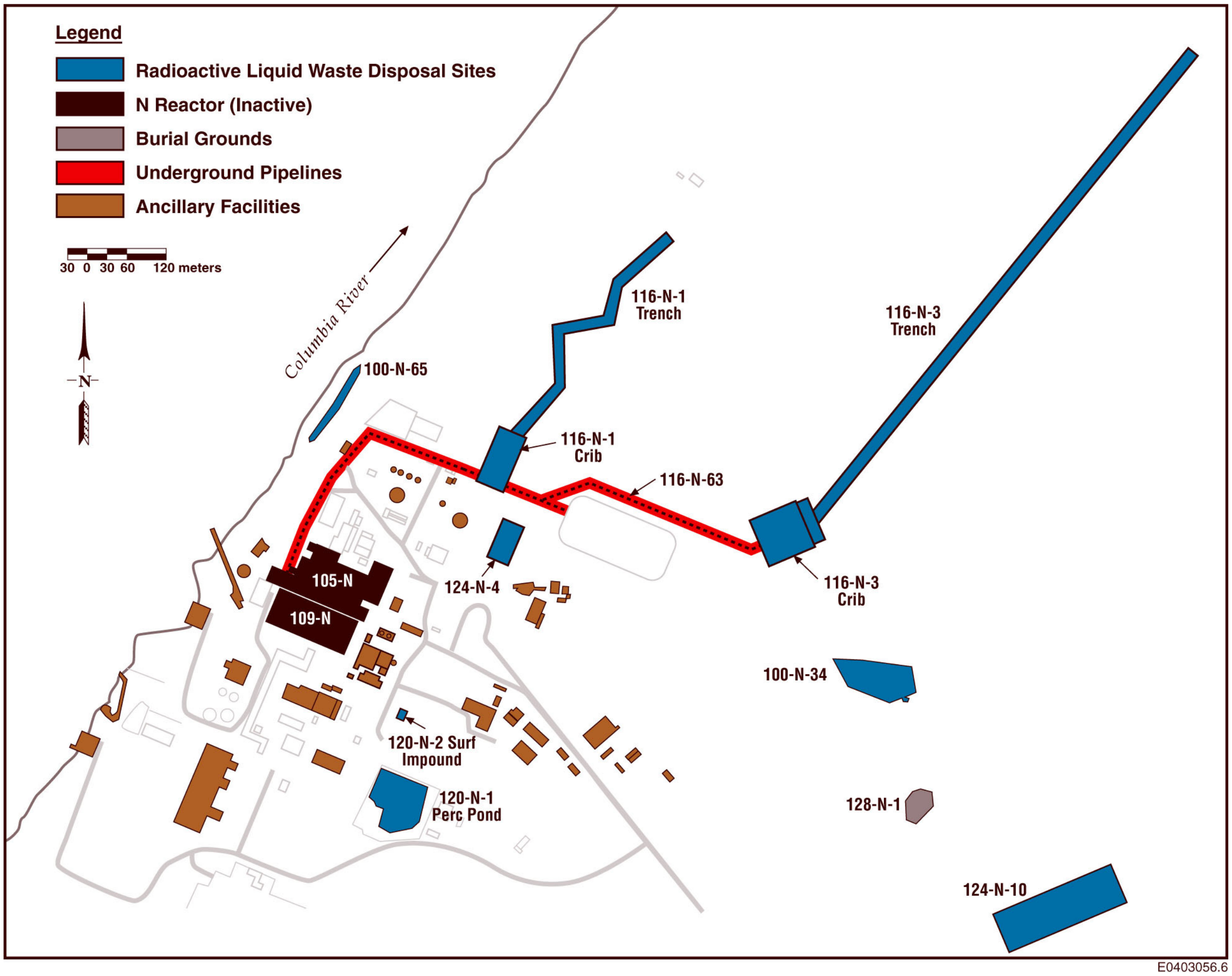

Figure 4.1c. 100-N Area Hazards

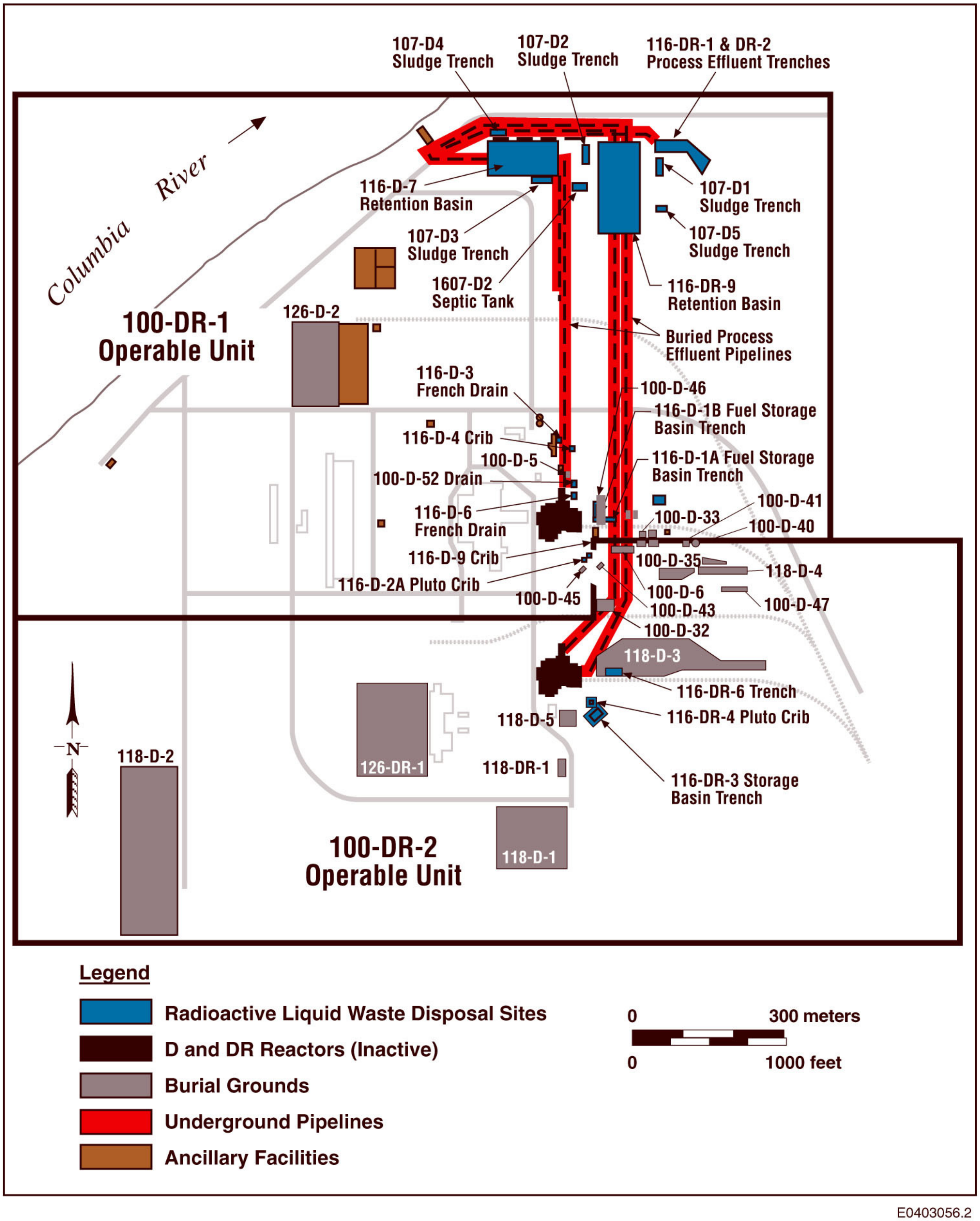

Figure 4.1d. 100-D Area Hazards

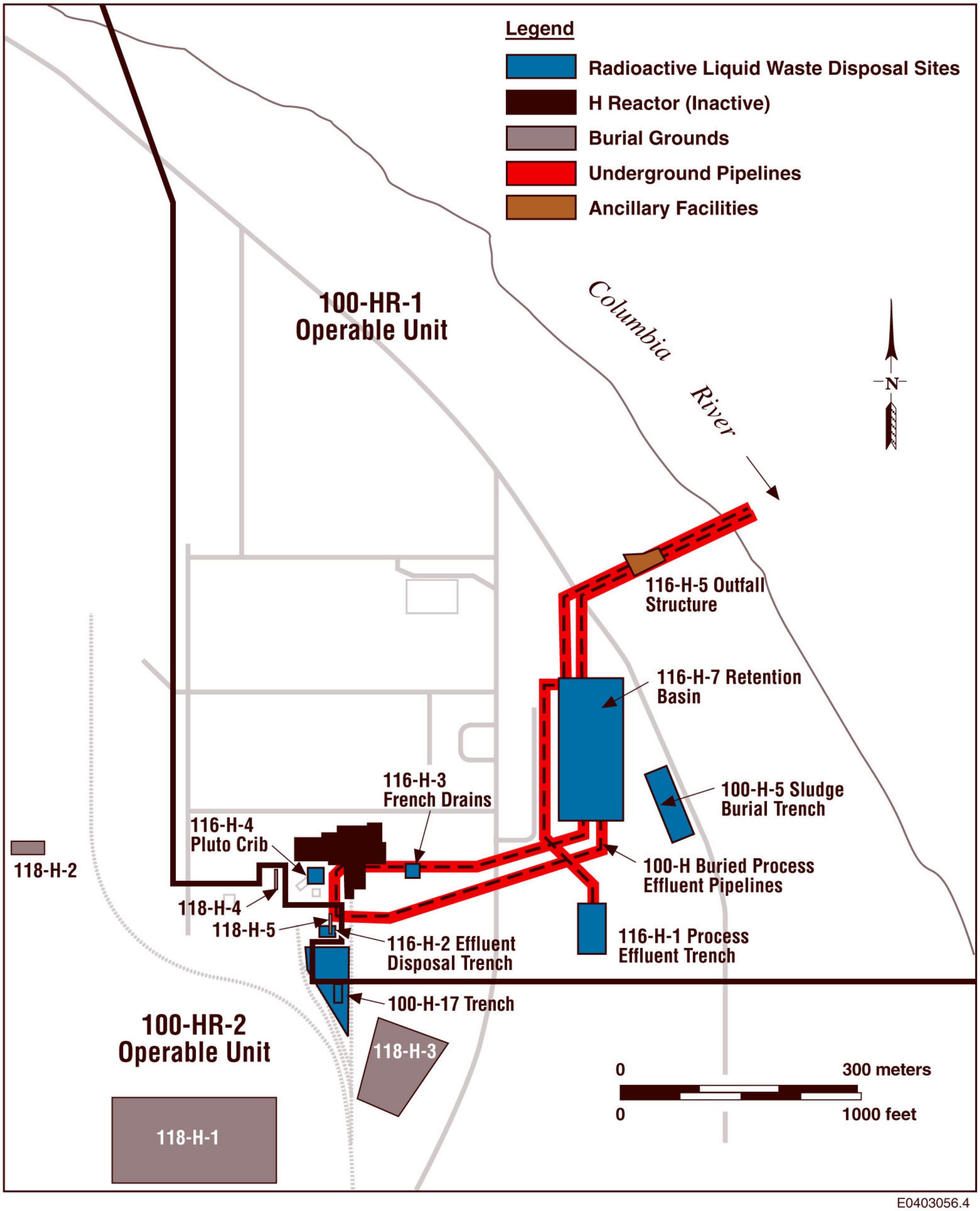

Figure 4.1e. 100-H Area Hazards

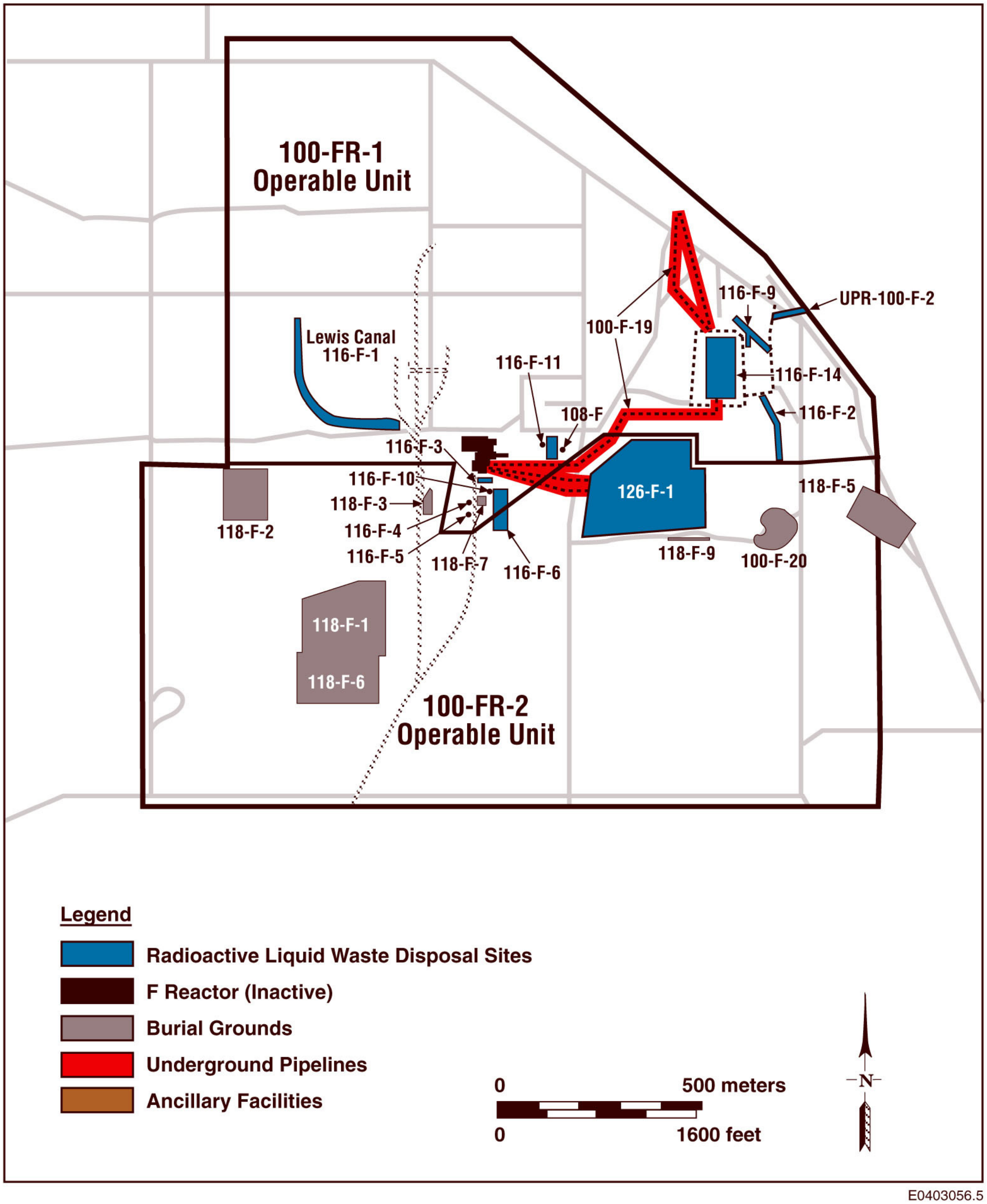

Figure 4.1f. 100-F Area Hazards

Table 4.2. 100 Areas – Overview and Comparison of Current and End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls

	Current Baseline End State	End State Vision[a]
Land Use and Key Assumptions	**Unrestricted surface use**	**Conservation Preservation** (consistent with CLUP and National Monument Designation) Restricted land use: with recreational activities, non-resident park ranger activities and tribal activities
Exposure Scenarios for Determining Cleanup Levels	**Rural residential farmer scenario**: • Exposure from soils due to direct contact, inhalation and external radiation to a depth of 4.6 m (15 ft) • Ingestion of vegetables, meat, and milk • Potential for soil excavation to 3.6 m (12 ft) for dwelling basement construction • 92.7 cm (36.5 in.) of annual irrigation and precipitation (used to evaluate mobilization of contaminants below 4.6 m (15 ft) and potential for degradation of groundwater). Future groundwater under the waste site is used as drinking water and irrigation for crops. • No decay of radionuclides	**Recreational Scenario** • Exposure from soils due to direct contact, inhalation, and external radiation from surface use • No food ingestion • No soil excavation, but possible animal intrusion • No groundwater use for drinking water or irrigation; incidental contact only • Decay of radionuclides **Non-Resident Park Ranger (TBD)** **Tribal Uses (proposed activities)**: • Hunting • Fishing • Gathering • Sweat lodge use • Materials and food use
Risk Protection Metrics/Goals	• 15 mrem/yr from radionuclides to restricted surface user (approximately $3x10^{-4}$ risk based on EPA guidance) • $1x10^{-6}$ risk from other contaminants • Source removal to promote restoration of groundwater to beneficial drinking water use, if practicable, based on 4 mrem/yr from MCL radionuclide concentrations • Excavation depth also protects deep rooting plant pathway and may provide adequate protection of other ecological resources	• CERCLA risk range $1x10^{-4}$ to $1x10^{-6}$ risk from other contaminants • Source containment or removal and treatment, if practicable, only where needed to promote restoration of groundwater to beneficial drinking water use, based on 4 mrem/yr from MCL radionuclide concentrations • Protection of ecological resources
Cleanup Actions		
Surface	• Remedial actions taken as needed to protect human health and ecological resources for this land-use scenario. • Human health based cleanup must be verified to be adequately protective of ecological resources.	• Remedial actions taken as needed to protect human health and ecological resources for this land-use scenario
Subsurface	• Waste sites excavated to depth of 4.6 m (15 ft)	• Cap-in-place or removal to achieve risk goals
Groundwater	• Remedial actions taken to prevent groundwater degradation, protect the River and return to beneficial drinking water use if practicable	• Same as Current Baseline End State
Institutional Controls	• Restrictions in place to preserve land uses and prevent use of groundwater. • Prevention of excavation below 4.6 m (15 ft). • Continued groundwater monitoring as required by CERCLA 5-year reviews.	• Restrictions to preserve land uses and prevent use of groundwater • Continued groundwater monitoring • Prevention of excavation into capped-in-place waste sites • Surveillance and maintenance of disposal sites and barriers

(a) Specific scenarios are still being developed and will be peer reviewed by EPA Region X.

4.1.3 100 Area Conceptual Site Model Description

Major hazards for the current state of the waste disposal sites in the 100 Area are noted in Table 4.1. One way to demonstrate how these hazards are managed is to build a conceptual site model to show the contaminants primary release mechanisms, transport pathways, exposure routes, and receptors (people or biota). The conceptual site models depict how potential receptors are protected by either blocking or breaking pathways that lead to exposure. The method used to block or break a pathway is how a hazard is managed in order to be protective of a receptor. Sometimes it is necessary to use more than one method to block a pathway. Pathways that are blocked have the potential to fail and still have an exposure. For example, a fence may block entry into a site but does not prevent a trespasser from climbing the fence. Pathways that are broken do not have the potential for exposure. For example, complete removal of a waste site breaks the transport pathway to a receptor from the waste site.

This section displays conceptual site models in Figures 4.1g through 4.1o for three types of hazards in the 100 Area: (1) liquid and solid disposal sites, (2) cocooned and not cocooned production reactors, and (3) ancillary facilities. Each type of hazard is evaluated for the current state, the current baseline end state, and the end state vision. Both the current baseline end state and end state vision are post cleanup scenarios.

4.1.3.1 100 Area Waste Disposal Sites – Current State

The liquid waste sites and burial grounds in the 100 Area are inactive and in a stabilized state. The location of the majority of remaining waste sites and burial grounds are shown in Figures 4.1a through 4.1f. Most of the larger sites have already been remediated in accordance with interim action RODs. Remediated sites are discussed in the current baseline end state. Waste sites that have yet to be remediated are discussed in this section. The principal radionuclides remaining in the waste sites were reported to be tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, europium 152, europium-154, europium-155, and plutonium-239/240. DOE (1994) reported a 1988 inventory of about 10,000 curies of radionuclides (cobalt-60, strontium-90, ruthenium 106, cesium-134, cesium-137, and plutonium-239) in the two main 100-N Area liquid waste sites. Additional non-radioactive contaminants, such as sodium dichromate, are also common in the liquid waste sites. Residual contamination from liquid waste sites can migrate through the vadose zone to groundwater. This transport pathway is shown in all of the figures depicting conceptual site models. Liquid waste sites are the main contributor to groundwater contamination in the 100 Area due to the high volumes of disposal.

The most prominent contaminants in 100 Area groundwater are tritium, strontium-90, hexavalent chromium, and nitrate. These contaminants originated primarily from disposal cribs and trenches, and condensate cribs. Other sources include leaks from the 100-K Area East fuel storage basin, leaks from the 183-H basin, and leaking retention basins. Because these sites are close to the Columbia River, these contaminants have been detected in springs that discharge to the river. Hexavalent chromium and strontium-90 have been detected above the National Ambient Water Quality Standards at isolated points on the river bottom where the groundwater upwells into the river prior to being diluted by the river. Active groundwater pump-and-treat systems and an in situ treatment wall is treating or slowing the migration of chromium (VI) to the river. There is also a pump-and-treat system in 100-N Area for the strontium-90 plume. This pump-and-treat system is generally not productive. The current state conceptual site model does not take credit for these treatment systems. The treatment systems are examined in the end state conceptual site models.

Burial grounds in the 100 Area contain solid and low-level radioactive waste associated with reactor operations. The main radionuclides are tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, silver-108m, europium-152, europium-154, and europium-155. Because disposal records prior to the late 1960s were not detailed, the estimates of the radionuclide inventory are uncertain and largely drawn from evaluations of analogous sites. Excavation of some burial grounds may reduce some of this uncertainty with the remainder of the burial grounds.

Figure 4.1g shows the conceptual site model for the current state for waste disposal sites that have yet to undergo any remediation (liquid and solid). The following represents the actions and control barriers DOE is taking now to either block or break the exposure transport pathway to the receptor and ensure protection to the workers, public and the environment.

4.1.3.2 Control Barriers for Waste Disposal Sites, Current State

Most major waste sites yet to be remediated have been stabilized with a layer of soil (overburden). A surveillance and maintenance program monitors the overburden to ensure there is no spread of contamination from wind or fire. As shown in Figure 4.1g, the overburden blocks the transport pathway from the near surface to air and protects the receptor that could potentially inhale contamination from the air transport pathway. The surveillance and maintenance program also applies an herbicide to the overburden to block the transport pathway of deep rooted plants potentially bringing up contamination to the surface and exposing the ecological receptors.

Institutional controls and safety procedures are applied to onsite workers and onsite public receptors. For example, to prevent accidental or inadvertent disturbances of the overburden on a waste site and to prevent direct exposures to contaminants in the waste site, institutional controls are applied (i.e., no consumptive use of groundwater, badge requirements, fences, barricades) and integrated safety management systems are in place (i.e., training, work controls, signs, onsite permit requirements for digging, etc.). These institutional control barriers are substantial and costly but necessary for blocking the exposure transport pathway to the onsite worker and onsite public from contamination that may be in the surface, near surface, subsurface, and groundwater (see Figure 4.1g). Though not shown in the figure, safety procedures also help protect the onsite workers during active remediation. Additional programs are in place to monitor groundwater, air releases, and the environment to ensure existing controls are working.

4.1.3.3 Control Barriers for Waste Disposal Sites, Current Baseline End State

The current baseline end state will have excavated the waste sites down to 4.6 meters (15 feet) to protect most surface users, including a hypothetical resident farmer. Excavations could go below 4.6 meters (15 feet) if needed to prevent future groundwater contamination above drinking water standards. Burial grounds will be excavated. The current baseline is in accordance with the current 100 Area Interim Action RODs. Figure 4.1h depicts excavation and backfill of the excavated waste sites as barrier #1. A yet to be completed final ROD(s) will require additional remedial actions and/or institutional controls if they are needed to meet remedial action objectives, including being protective of human health and the environment. Residual contamination in the deep vadose zone (below 4.6 meters [15 feet]) will be left behind for most of the liquid waste sites where contamination migrated through the vadose zone to groundwater. The principal radionuclides remaining in the deep vadose zone may be some combination

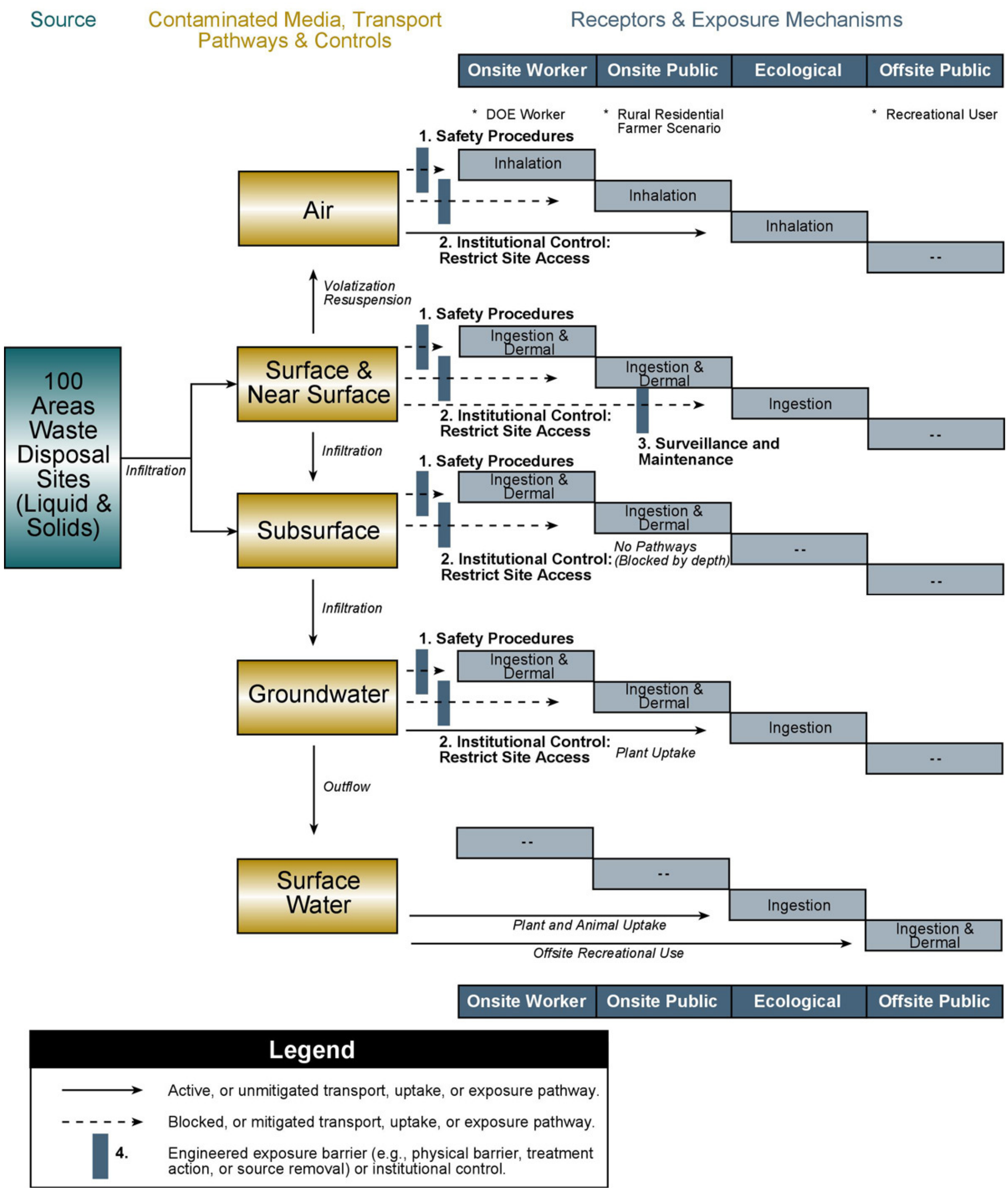

Figure 4.1g. 100 Area Waste Disposal Sites – Current State

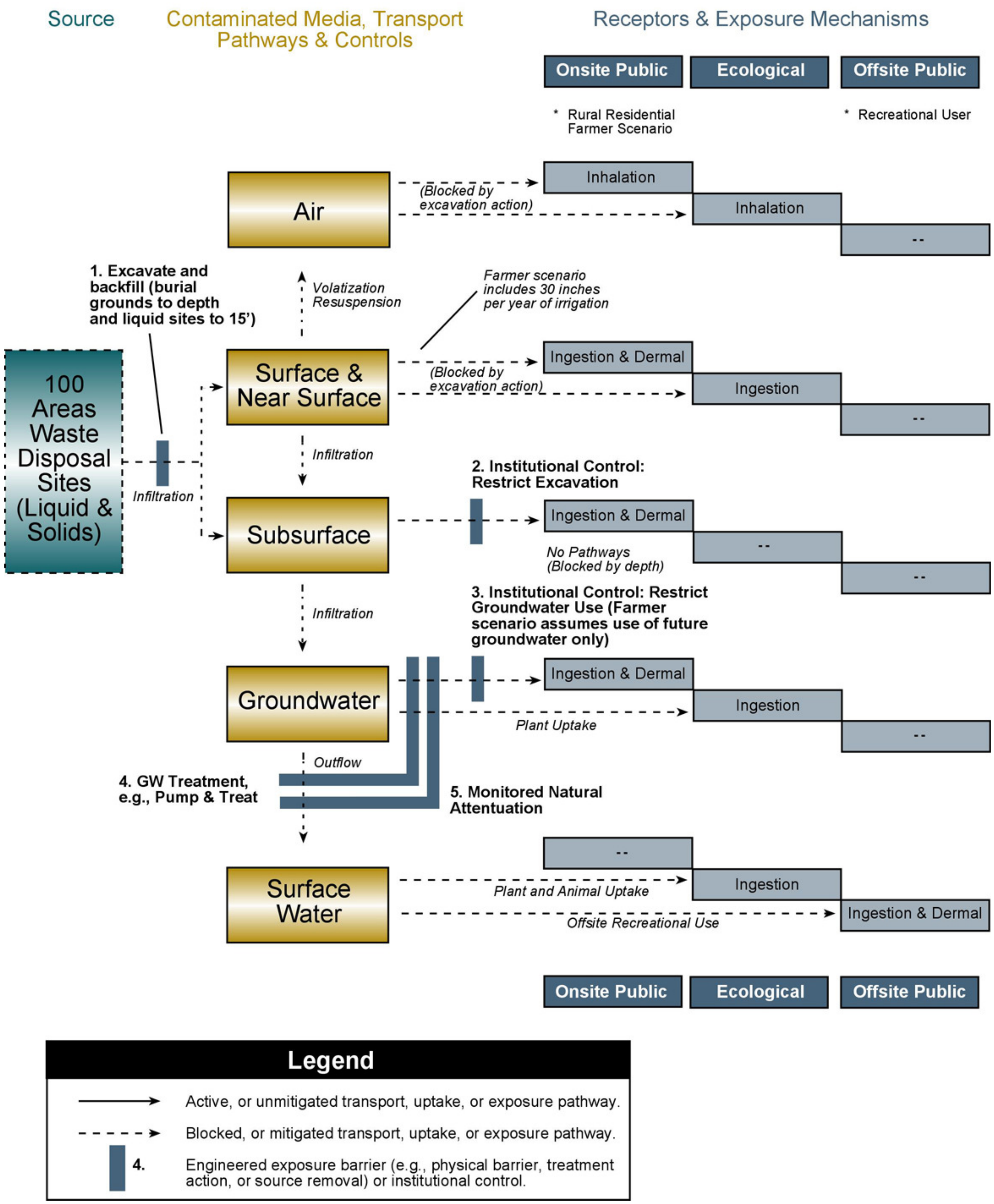

Figure 4.1h. 100 Area Waste Disposal Sites – Current Baseline End State

of tritium, carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, europium 152, europium-154, europium-155, and plutonium-239/240. The short-lived radionuclides will decay away over time. The major non-radionuclide contaminant is sodium dichromate. Barrier #2 in Figure 4.1h is an institutional control to prevent digging into the deep vadose zone (below 4.6 meters [15 feet]) to block the exposure transport pathway where contamination is present.

Groundwater pump-and-treat operations and an in situ treatment wall will be ongoing until chromium plumes meet remedial action objectives of a future CERCLA ROD. A strontium-90 plume will remain in groundwater and the deep vadose zone for up to 300 years, the amount of time needed for sufficient radioactive decay. There may also be an ongoing treatment system to minimize strontium-90 from reaching the Columbia River if one is found to be successful. Other plumes that are closer to meeting remedial action objectives or plumes that cannot be technically remediated may be monitored until the remediation objectives are met through natural attenuation of the contaminant. Groundwater institutional controls will continue to be needed to limit the use of groundwater until contamination levels are reduced to meet the remedial action objectives of a future CERCLA ROD. Decisions regarding final groundwater institutional controls and groundwater treatment or monitoring (barriers 3, 4, and 5 in Figure 4.1h) will be made via a CERCLA ROD.

A relatively small federal presence (compared to today's federal presence) will be required to implement the longer term actions required by DOE or future CERCLA RODs and to conduct 5-year post remediation CERCLA ROD reviews to ensure the remedies and controls are being adequately protective.

4.1.3.4 Control Barriers for Waste Disposal Sites, End State Vision

The end state vision would have excavation of waste sites (barrier #1 in Figure 4.1i) to be protective of surface uses and the environment. Protection of the environment may be the new driver for depth since surface use for the designated conservation/preservation land use would be less intrusive then a resident farmer. The exact depth required for excavation would need to be determined in a future CERCLA ROD based on what would meet the remedial action objects, including protection of human health and the environment. The majority of sites requiring excavation down to 4.6 meters (15 feet) have been completed. Burial grounds are the majority of sites left requiring deep excavation. Burial grounds, if excavated, are totally removed regardless of the depth.

An infiltration barrier over the large burial grounds cuts the transport pathway for exposure (barrier #2 in Figure 4.1i). There are 45 burial grounds in the 100 Area. Seven of these burial grounds are large, contain short-lived radionuclides, and are at least 15.2 meters (50 feet) above groundwater. It may be more economical to cap these seven burial grounds in place than to excavate them. There is process knowledge on these burial grounds; however they have not been fully characterized, leaving some uncertainty with regards of their content. Of the 16 large burial grounds, excavation has begun at two of them and both have contained pieces of spent nuclear fuel, which increases the uncertainty of what might be found in the remainder of the large burial grounds.

The remainder of the barriers (#3 through #6) depicted in Figure 4.1i are similar to the current baseline end state. Barrier #3, institutional controls, would also apply to any intrusion barriers constructed over burial grounds to ensure they remain functional. Similar to the current baseline end state, the institutional controls would be included in a future CERCLA ROD and 5 year CERCLA ROD reviews would be conducted to ensure remedies and controls are adequately protective.

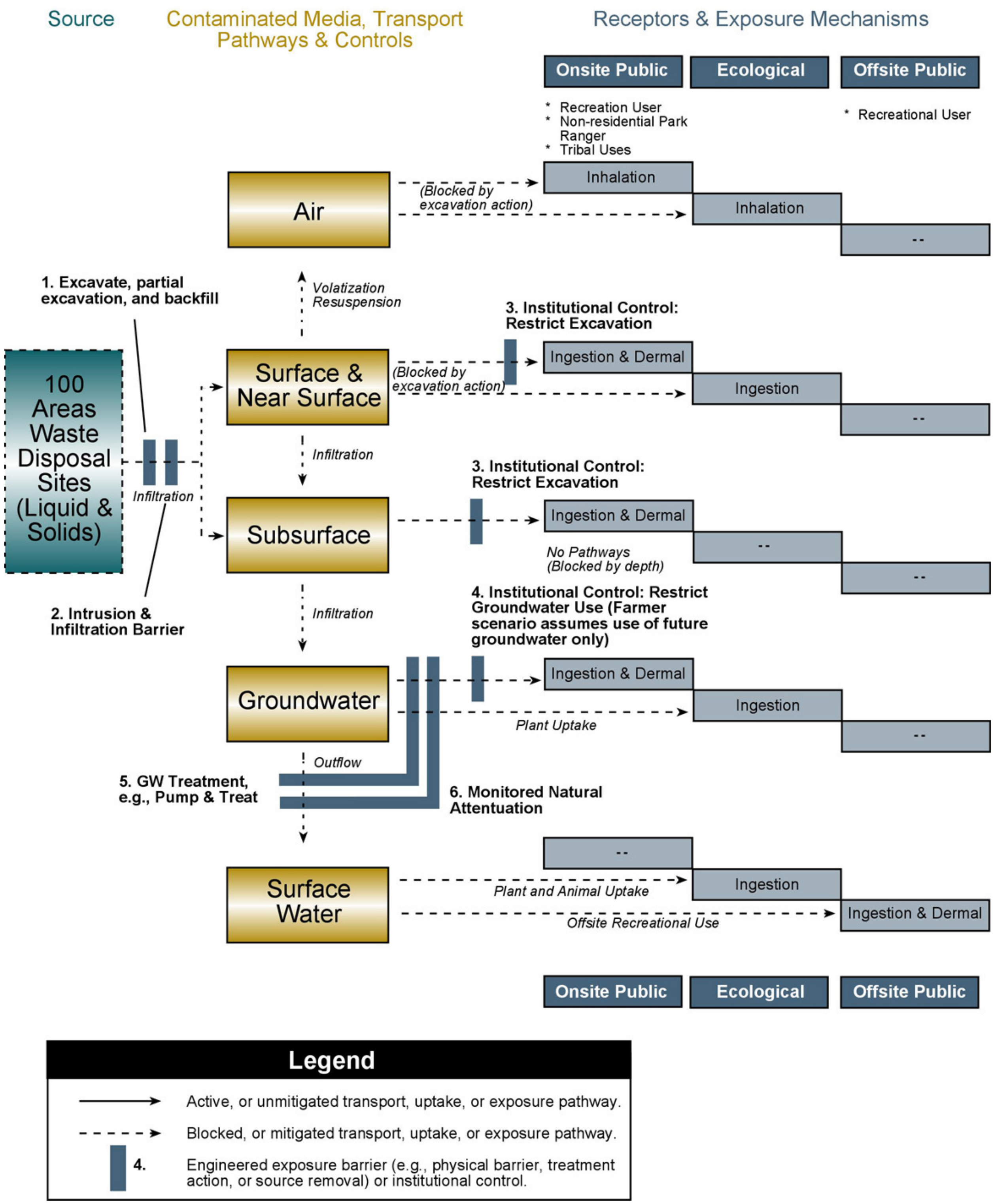

Figure 4.1i. 100 Area Waste Disposal Sites – End State Vision

4.1.3.5 Control Barriers for Former Production Reactors, Current State

The 100 Area have nine surplus production reactors located 85 to 823 meters (280 to 2,700 feet) from the banks of the Columbia River. Locations of each reactor core can be found in Figures 4.1a through 4.1f. Radioactive inventory contained in the reactor core includes tritium (~98,000 curies); carbon-14 (~37,000 curies); chlorine-36 (~270 curies); cobalt-60 (~74,000 curies); cesium-137 (~270 curies); and uranium-238 (~0.01 curies). The dose to workers from cobalt-60 and cesium-137 is one of the main drivers leading to the decision in the surplus reactor environmental impact statement (58 FR 4690) to place the reactor cores into interim safe storage for 75 years. Radioactive inventory in the core is not leaking. Five of the reactors have been or are nearly completed with the cocooning process for long-term storage to allow radioactive decay for up to 75 years prior to final disposition of the reactor cores. Figure 4.1j shows the cocooning process as barrier #1 to break the transport pathway for contamination. The cocooning process reduces the footprint of the reactor building by 80% down to the core and the shield walls. All openings are sealed and a 75-year slanted roof is installed over the building. Every 5 years the cocooned reactors are entered for monitoring purposes.

N, KE, KW, and B Reactors have yet to be cocooned. Fuel from N Reactor was stored in the KE and KW Reactor basins. The fuel from the K Basins has been removed and transported to the 200 Areas for dry storage. K Basin sludge and debris (200,000 curies) still requires removal prior to the cocooning of the KE and KW Reactors. Approximately 50 cubic meters (65.4 cubic yards) require packaging for removal with less than 0.5 cubic meters of fuel pieces contributing the majority of this source term. The K Basins are currently not known to be leaking but have leaked in the past. N Reactor has been deactivated and is awaiting the cocooning process. B Reactor has been proposed as a museum. There is good local support for the museum; however, a caretaker needs to be found. If no caretaker is found, B Reactor will also most likely be cocooned. Reactors that have not undergone cocooning require more extensive surveillance and maintenance to monitor and prevent the spread of contamination from the facility. Figure 4.1j shows surveillance and maintenance as barrier #2 to break the transport pathway for contaminants.

Safety procedures and institutional controls are applied to onsite workers and onsite public receptors. For example, to prevent people from accidentally walking into a radiological contamination zone within a building that may cause direct exposures to contaminants, institutional controls are applied (i.e., badge requirements, locked doors) and integrated safety management systems are in place (i.e., training, work controls, signs). These institutional control barriers and safety procedures are substantial and costly but necessary to ensure safety. Figure 4.1j depicts how safety procedures and institutional controls (barriers #3 and #4) block the transport pathway for contaminants. Though not shown in the figure, safety procedures also help protect the onsite workers during active remediation.

Additional programs are in place to monitor groundwater (barrier #6 in Figure 4.1j). Groundwater monitoring is not established for each reactor but there are groundwater wells in the general vicinity of each reactor.

4.1.3.6 Control Barriers for Former Production Reactors, Current Baseline End State

Eight or all nine reactors, depending on B Reactor museum support, will be cocooned (barrier #1 in Figure 4.1k) and awaiting removal to the Central Plateau for 75 years to allow for sufficient decay (barrier #2 in Figure 4.1k). N Reactor would need a decision document to transport its core to the Central

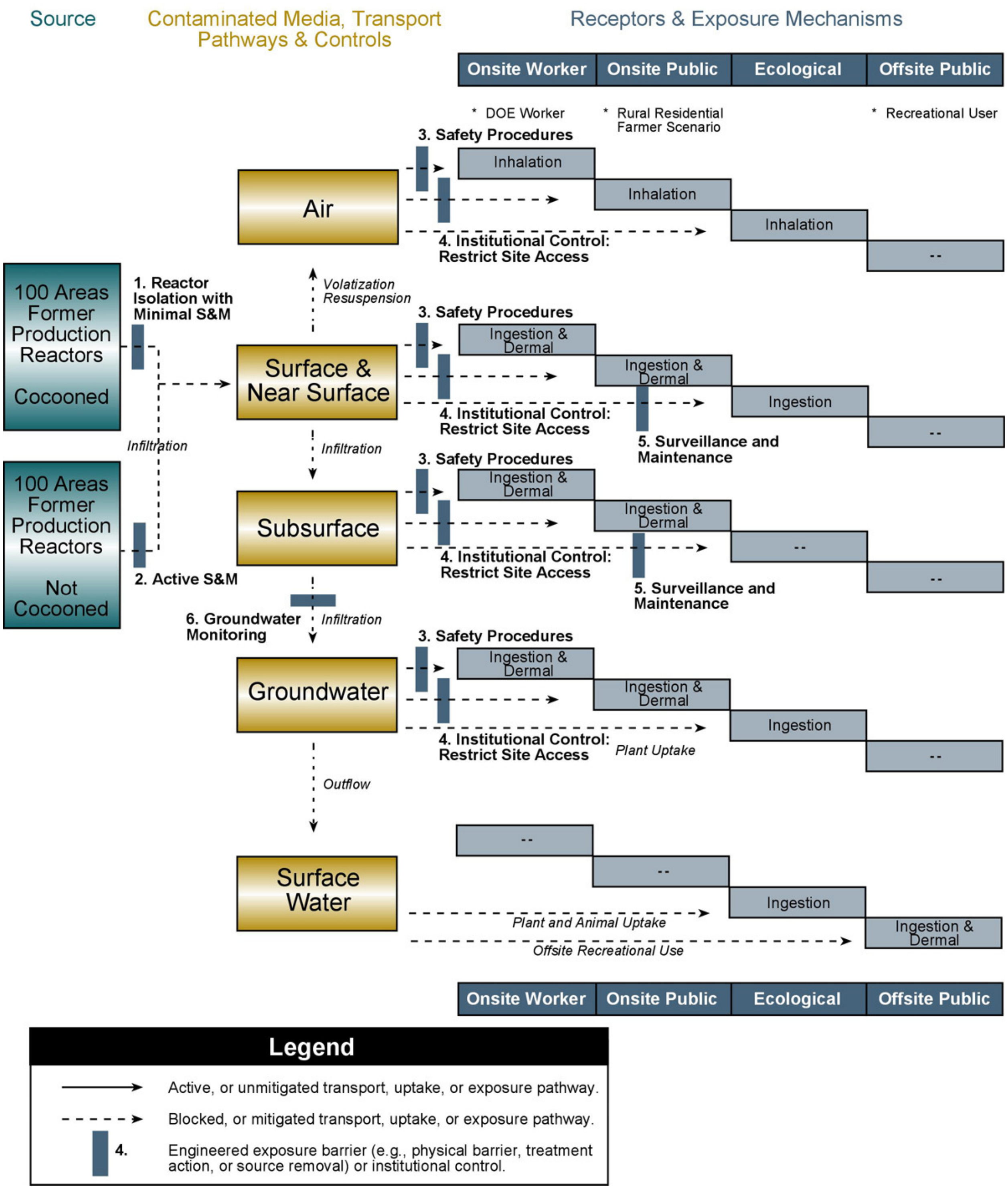

Figure 4.1j. 100 Areas Former Production Reactors – Current State

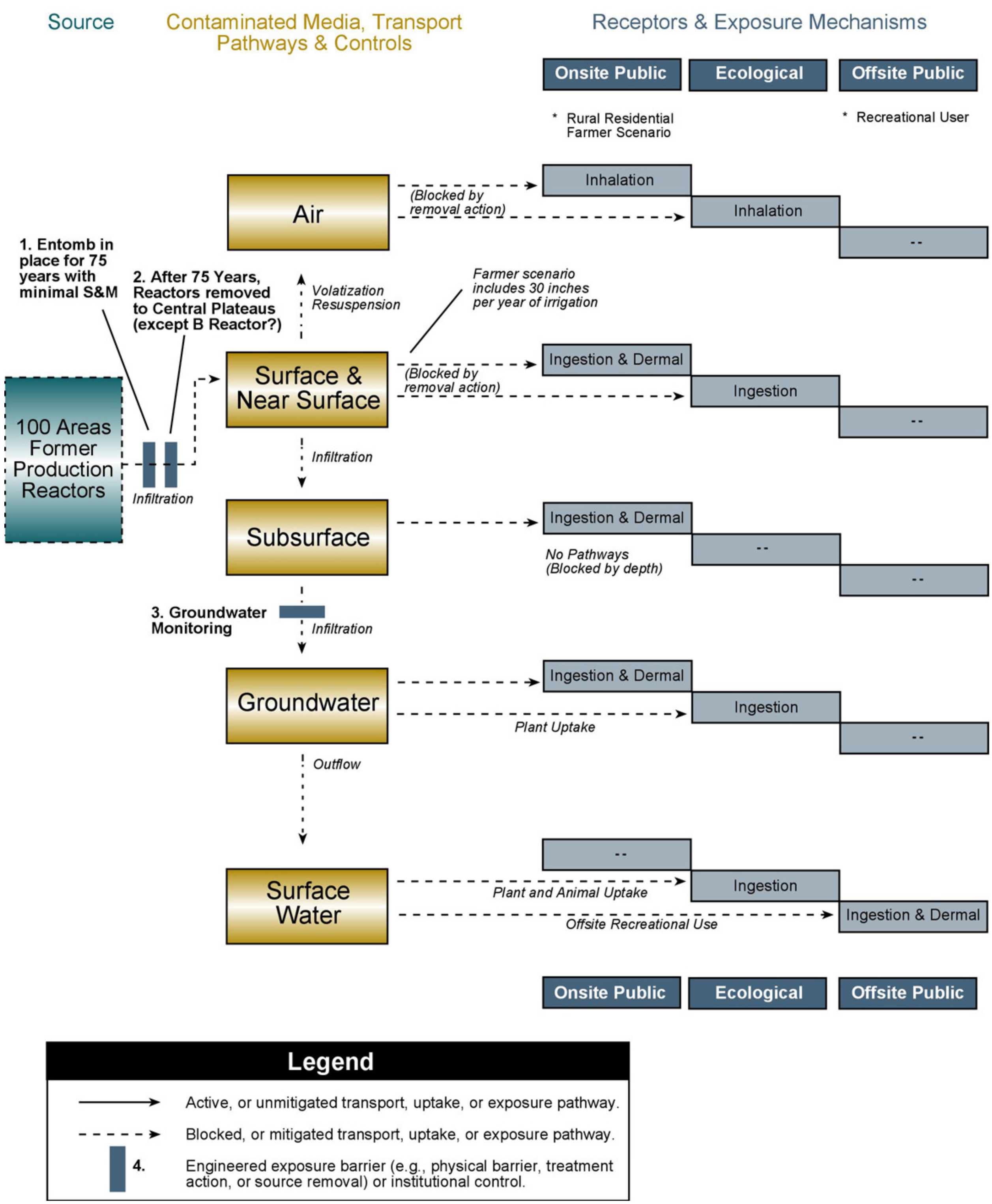

Figure 4.1k. 100 Areas Former Production Reactors – Current Baseline End State

Plateau. Each cocooned reactor would be entered periodically to be inspected. The time period between entries can be adjusted based on experience. Groundwater would be monitored (barrier #3 in Figure 4.1k) to ensure there is no spread of contamination through the vadose zone to groundwater.

4.1.3.7 Control Barriers for Former Production Reactors, End State Vision

The end state has the reactors staying in the 100 Area indefinitely. Barrier #1 in Figure 4.1l is the cocooning of the reactors and the indefinite surveillance and maintenance of the reactor blocks. The only additional activity required would be that every 75 years the roof needs replacing.

4.1.3.8 Control Barriers for 100 Areas Ancillary Facilities and Structures, Current State

Ancillary facilities supported operations and maintenance of reactors. There were a total of approximately 250 ancillary facilities in the 100 Areas with the remaining facilities located primarily at 100-N (59) and 100-K Areas. Locations of the majority of ancillary facilities can be found in Figures 4.1a through 4.1f. Hazards range from industrial to potential contamination with radiological constituents, i.e., fission and activation products, metals, inorganics, volatile organic compounds, and organic compounds.

The barriers blocking the transport pathways of contaminant reaching the receptors are very similar to those described with the reactor cores as shown in Figure 4.1m. Safety procedures, institutional controls, and surveillance and maintenance are the primary means of protecting the onsite worker and offsite public. Demolition and removal of the facilities is discussed in the end state sections below.

4.1.3.9 Control Barriers for 100 Areas Ancillary Facilities and Structures, Current Baseline End State

All ancillary facilities in the 100 Area will be demolished and removed as shown by barrier #1 in Figure 4.1n. Contamination may be left behind if it is determined not to impact groundwater. Barrier #2, groundwater monitoring, will ensure that residual contamination does not impact groundwater.

4.1.3.10 Control Barriers for 100 Areas Ancillary Facilities and Structures, End State Vision

The end state is identical to the current baseline end state; however, it may be determined that a few facilities may be able to be entombed or cocooned similar to the reactor cores. This is illustrated as barrier #2 in Figure 4.1o.

4.2 300 Area

The 300 Area is one of the four NPL areas at Hanford, encompasses ~1.35 square kilometers (~0.52 square mile), is adjacent to the Columbia River, and is ~1.6 kilometers (~1 mile) north of the Richland city limits.

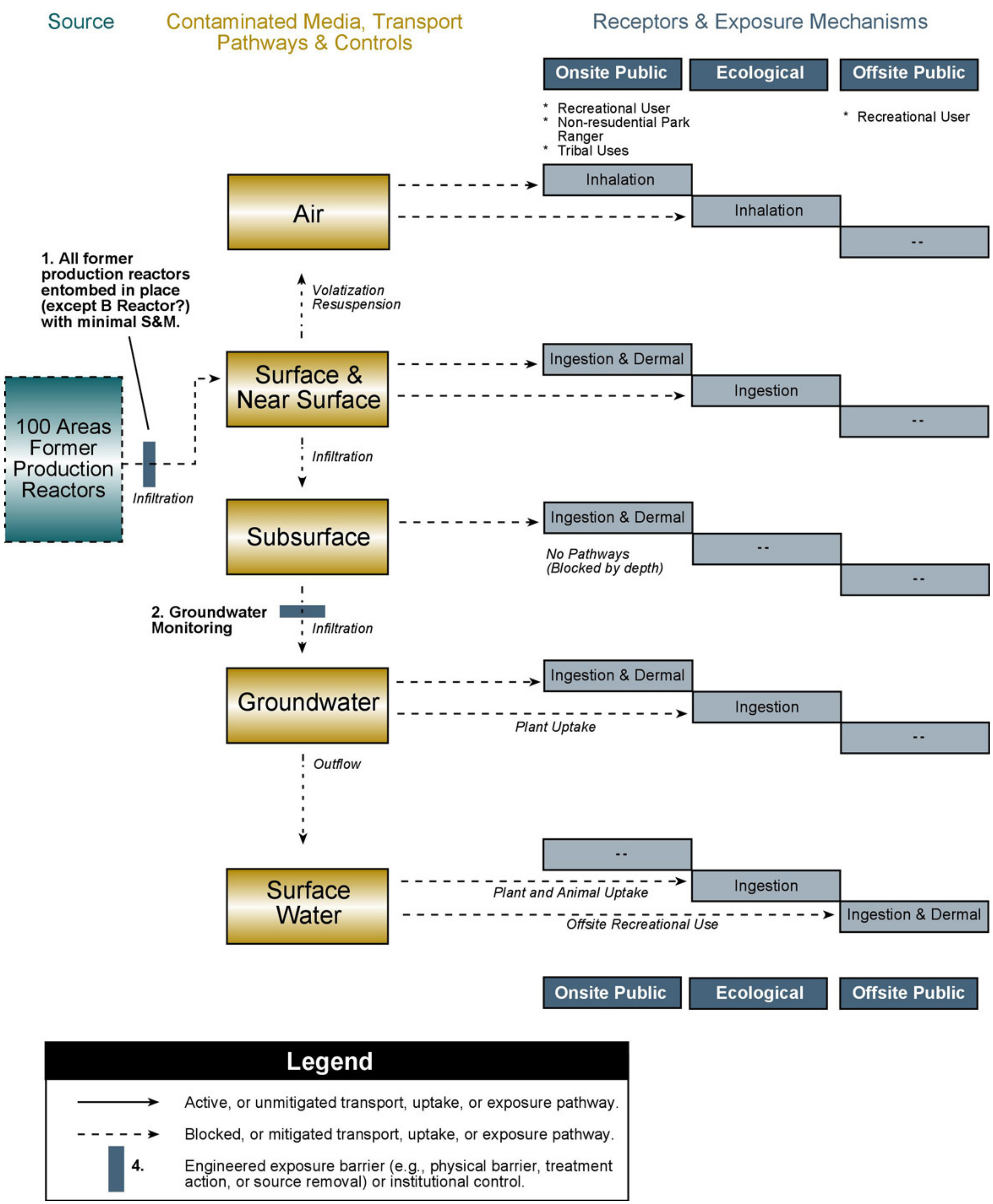

Figure 4.1l. 100 Areas Former Production Reactors – End State Vision

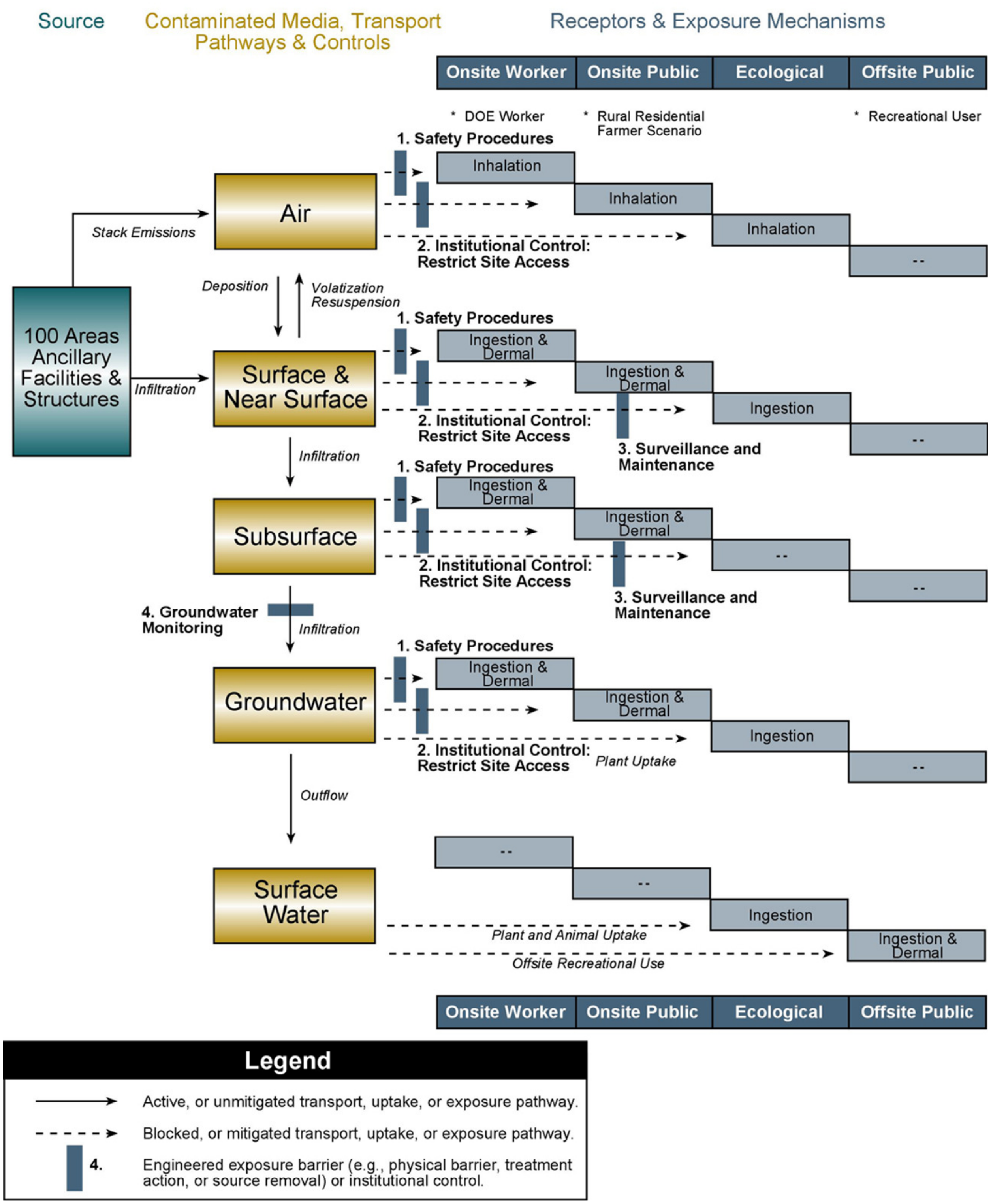

Figure 4.1m. 100 Areas Ancillary Facilities and Structures – Current State

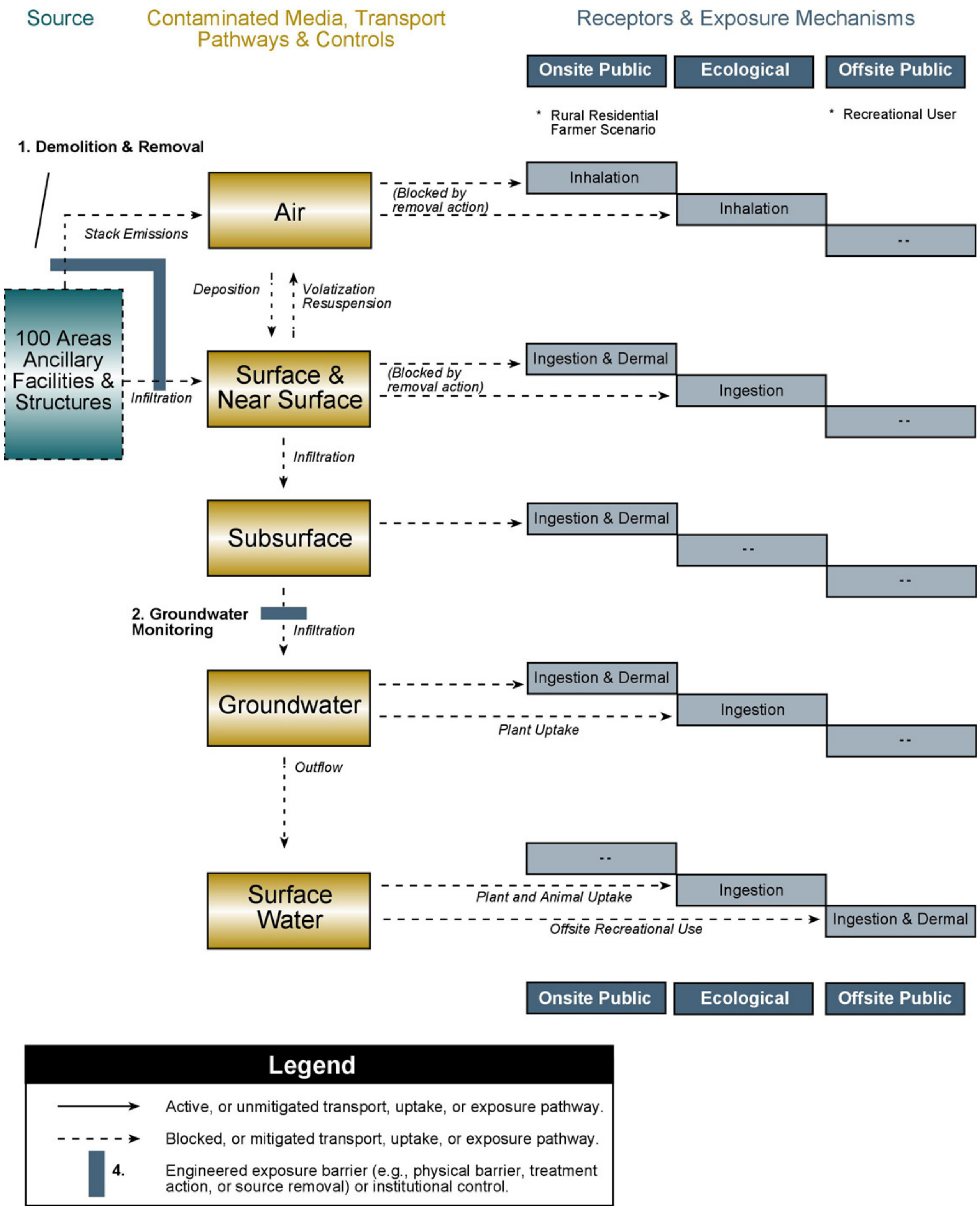

Figure 4.1n. 100 Areas Ancillary Facilities and Structures – Current Baseline End State

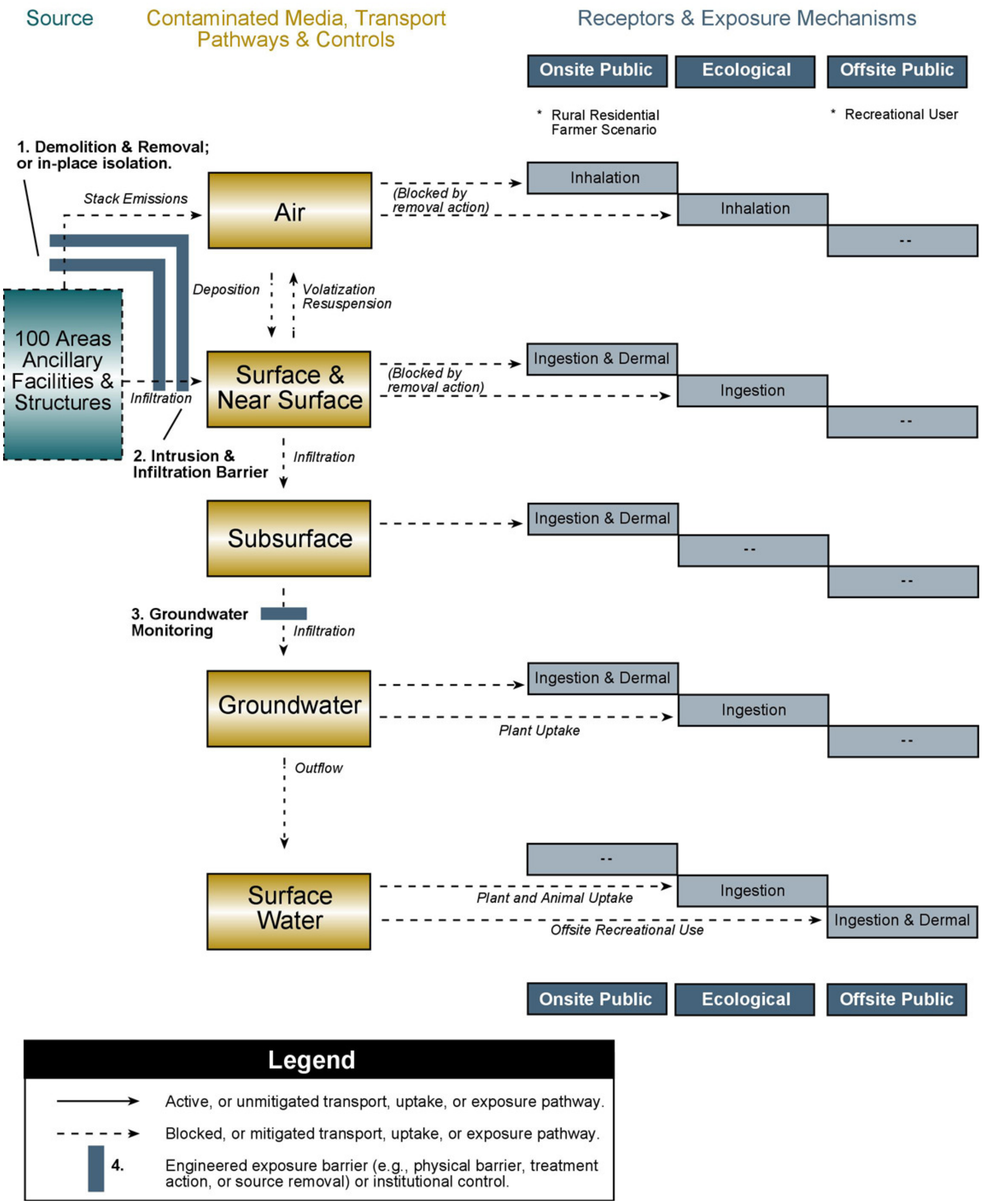

Figure 4.1o. 100 Areas Ancillary Facilities and Structures – End State Vision

4.2.1 Summary of Existing Hazards

Table 4.3 summarizes the existing hazards in the 300 Area. The top priority hazards in the 300 Area are the following:

- **324 and 327 facilities**. The current radiological inventory is estimated to be 65,000 and 1,500 curies, respectively.

- **Solid waste burial grounds**. 618-10 and 618-11 are large burial grounds with low- to high-activity waste including ~10,000 cubic meters (13,079 cubic yards) of suspect transuranic contaminated waste.

- **Existing groundwater plumes**. The most prominent contaminant in the groundwater underlying the 300 Area is uranium, which does intersect the Columbia River. In the vicinity of the 618-11 burial ground, tritium reached its highest concentration on the Hanford Site at 4 million pCi/L in 2002, but this plume does not reach the Columbia River.

- **Former liquid disposal sites**. The sites were original sources for groundwater contamination. Removing the hazard posed by groundwater contamination necessitates the elimination of any future sources of new contamination to the groundwater.

Figure 4.2a displays the hazard map for the 300 Areas.

4.2.2 Exposure Pathways and Potential Implications of the End State Vision

Table 4.4 summarizes the assumptions for land use, exposure scenarios and pathways, remediation goals, and institutional controls (including final barriers if any) for both the current baseline end state and the end state vision. The current ROD (ROD 1996b) uses the default *Model Toxics Control Act* (WAC 173-340) industrial scenario as the exposure scenario that assumes excavation to a depth of 4.6 meters (15 feet). Under the end state vision, a 300-Area-specific industrial exposure scenario (allowed by WAC 173-340) will be developed to determine what clean up levels are protective of human health. The intent of the end state vision is to align the remediation goals with an exposure scenario that is site-specific to the 300 Area. The implications to changing the exposure scenario may be that excavations, if needed, may be less the current 4.6 meters (15 feet). It is difficult to expand on the extent of differences until the site-specific industrial scenario is developed. Details of the current baseline end state and end state vision conceptual model exposure pathways are described below.

Table 4.3. Summary of Hazards in the 300 Area

Material Category	Current Hazard
Surface	
Facilities	• The 300 Area has 220 facilities that will be demolished. The hazards for the 300 Area are waste embedded in facilities in ductwork, concrete, piping, paint, equipment, insulation, cracks, crevices, and other places exist in multifaceted variety. Given the multitude of missions, processes, materials, isotopes, and other substances used in 300 Area facilities over the years, a comprehensive list is not possible in this venue. • The 324 Building is the former Waste Technology Engineering Laboratory. The building contains two major hot cell complexes for irradiated materials and cold side demonstrations of nuclear waste processes. Current fissile inventory has been reduced to only what is known to be held up as contamination in glove boxes, hot cells, and ventilation system ducting. The estimated inventory of radionuclides is 65,000 curies. • The 325 Building is the Radiochemical Processing Laboratory. This facility is an active radiochemical analytical laboratory. It contains an estimated in-process inventory of ~6,200 curies of tritium and ~440 curies of plutonium. An additional inventory of ~7,400 curies of plutonium-238 is contained in a non-dispersible form (mostly in solid ceramic radioisotope thermal generators built for use with NASA spacecraft). • The 327 Building is the former Post Irradiation Testing Laboratory. The building contains ten hot cells, a water fuel storage fuel basin, and a water transfer basin leading into A Cell. It also contains a dry storage carousel for holding samples from fuel and reactor material testing and examination programs. The facility is assumed to contain 1,500 curies of material including less than 200 grams of plutonium.
Subsurface	
Liquid Waste Sites	• There are 120 liquid waste disposal sites. Prior to 1994, liquid waste was discharged to a series of unlined ponds and process trenches just north of the 300 Area. The primary contaminant in the 300 Area is uranium from the fuel fabrication processes. However, numerous other potential contaminants exist for individual waste sites based on the history of their use and operation.
Solid Waste Burial Grounds	• There are eight burial grounds remaining in the 300 Area, including 618-10 and 618-11. • The 618-10 and 618-11 burial grounds contain three categories for waste disposal; <10 Ci/ft^3 (low activity), 10 to 1,000 Ci/ft^3 (moderate-activity), and above 1,000 Ci/ft^3 (high activity). The low activity waste was primarily disposed of in trenches, while moderate and high activity wastes were disposed in vertical pipe units and caissons and sometimes to trenches in concrete/lead-shielded drums. 618-11 is a known contributor of tritium in groundwater. These burial grounds include 10,000 m^3 (13,079 yd^3) of suspect transuranic contaminated waste. • The 618-7 burial ground includes hundreds of 113.5-L (30-gal) iron drums of Zircaloy chips stored in water to mitigate their pyrophoric attributes. • The general content burial grounds received a broad spectrum of chemical and radiological waste as well as solid waste and debris. None appear to be impacting groundwater. The 300 Area burial grounds have a greater amount of uncertainty with regard to their contents in comparison to the 100 Area burial grounds. For example the 618-4 burial ground unexpectedly encountered 1,500 drums of uranium chips in oil during excavation.
Groundwater	
Groundwater	• The most prominent contaminant in groundwater is uranium. • A plume of trichloroethene is attenuating naturally, and concentrations remain below MCLs. • Tritium in groundwater near 618-11 burial ground is the highest onsite (4 million pCi/L in 2002). Tritium has migrated from the 200 Area below MCLs into the 300 Area.

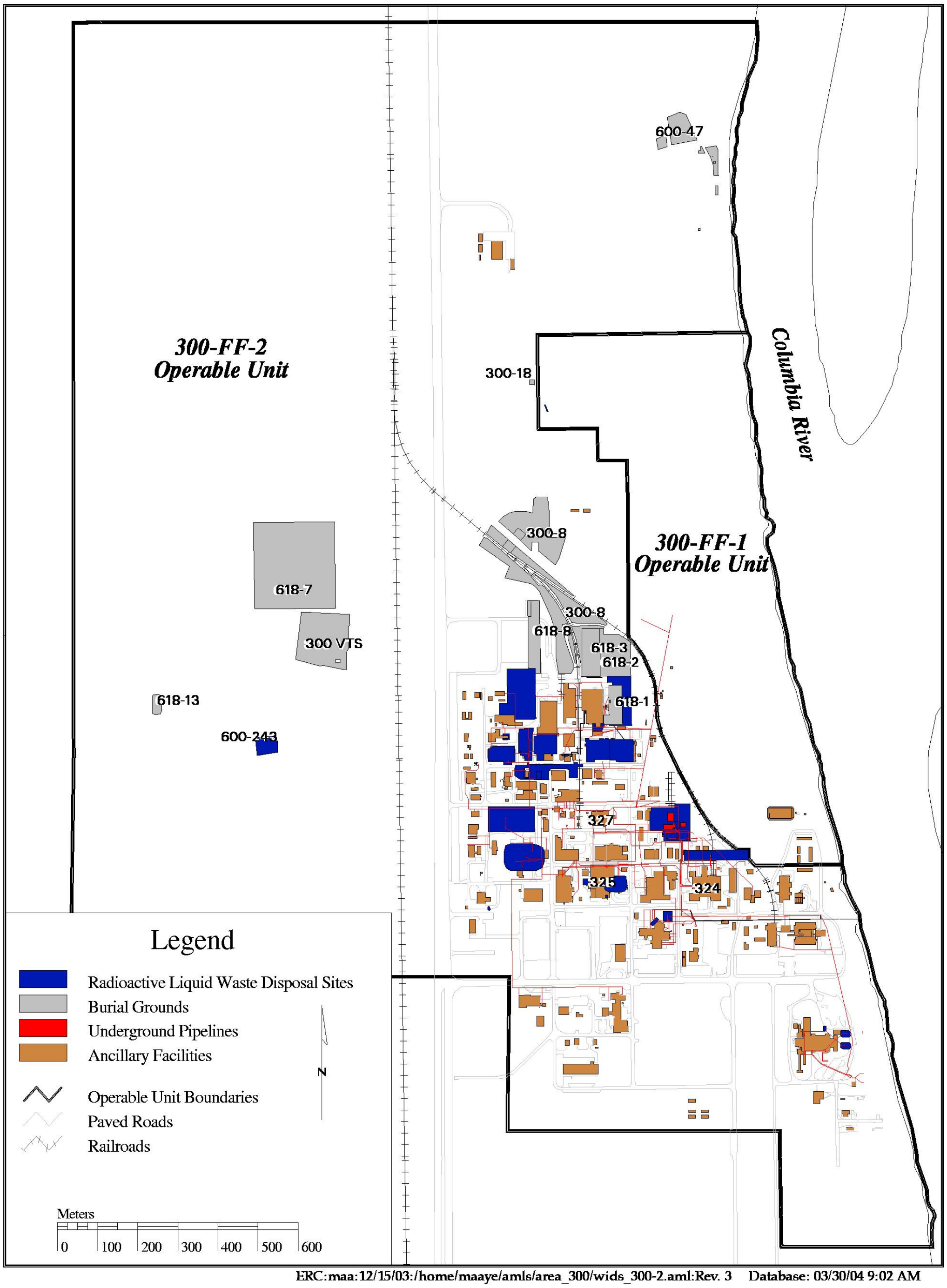

Figure 4.2a. Hazard Map for the 300 Areas

Table 4.4. 300 Areas – Overview and Comparison of Current and End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls

	Current Baseline End State	End State Vision
Land Use and Key Assumptions	Industrial use	Industrial use
Exposure Scenarios for Determining Cleanup Levels	MTCA default industrial scenario (4.6 m [15 ft] excavation) Human health based cleanup must be verified to be adequately protective of ecological resources.	Site-specific industrial scenario and ecological assessment as basis for final ROD
Risk Protection Metrics/Goals	• 15 mrem/yr. from radionuclides to industrial worker ($3x10^{-4}$ risk based on EPA guidance) • $1x10^{-6}$ risk from other contaminants • Source removal to promote restoration of groundwater to beneficial drinking water use, based on 4 mrem/yr from MCL radionuclide concentrations [dose limit for hypothetical drinking water pathway] • Excavation depth also protects deep rooting plant pathway and may provide adequate protection of other ecological resources.	• CERCLA risk range $1x10^{-4}$ to $1x10^{-6}$ risk from other contaminants • Source containment or removal and treatment if practicable only where needed to promote restoration of groundwater to beneficial drinking water use, based on 4 mrem/yr from MCL radionuclide concentrations • Protection of ecological resources
Cleanup Actions		
Surface	• Remedial actions taken as needed to protect human health and ecological resources for this land-use scenario.	• Same
Subsurface	• Waste sites excavated to depth of 4.6 m (15 ft)	• Install surface barrier or remove to achieve risk goals
Groundwater	• Remedial actions taken to prevent groundwater degradation, protect the River and return to beneficial drinking water use if practicable	• Same
Institutional Controls	• Restrictions in place to preserve land uses and prevent use of groundwater. • Prevention of excavation below 4.6 m (15 ft).	• Restrictions in place to preserve land uses and prevent use of groundwater. • Prevention of excavation into waste sites with surface barriers. • Surveillance and maintenance of disposal sites and surface barriers.

4.3 200 Areas

4.3.1 Summary of Hazards

Table 4.5 summarizes the existing hazards in the 200 Areas. Figures 4.3a and 4.3b show hazards in the 200 West and East Areas. The top priority hazards in the 200 Areas are the following in descending order of their relative importance:

- **Radioactive mixed waste tanks**. The 200 Area Core Zone contains 149 single- and 28 double-shell tanks distributed among 18 tanks farms (Figure 4.3c). The tanks contain about ~2.04E+008 liters (>53 million gallons) of liquid, sludge, and saltcake waste. These tanks contain 200 million curies of radioactivity.

- **Plutonium from the Plutonium Finishing Plant**. Approximately 17 metric tons (18.7 tons) of bulk plutonium-bearing material has been stabilized and repackaged into ~2,200 specification 3013 cans awaiting final disposition to Savannah River Site and ~2,400 pipe overpack containers that will be shipped to WIPP. The disposition of these materials to a consolidated storage location for long-term storage is not expected until after 2007.

- **Waste Materials stored in facilities at the Central Waste Complex**. In 2003, ~8000 cubic meters (10,000 cubic yards) of transuranic-mixed, mixed low-level waste, and low-level waste was stored at the Central Waste Complex pending stabilization, treatment, or shipment to a final disposal location. There is continual through-put which currently is rapidly decreasing the mixed low-level waste in storage and increasing the amount of transuranic-mixed waste in storage based on currently available treatment, disposal, and shipment capabilities.

- **Cesium and strontium capsules are currently stored in the Central Plateau**. Less than 2,000 cesium/strontium capsules are currently being stored in basins. These capsules contain ~130 million curies of cesium-137 and strontium-90 removed from concentrated tank waste to reduce heat generation in underground storage tanks. Efforts are underway to move these capsules from the water-filled basin to dry storage pending final disposition.

- **Spent nuclear fuel stored in the Canister Storage Building**. Approximately 75% of the spent nuclear fuel in the entire DOE complex is stored at Hanford. Most of this fuel, nearly 2,086 metric tons (2,300 tons) is stored in the Canister Storage Building. Other spent nuclear fuel from FFTF is also planned for storage within the 200 Areas pending shipment and final disposal at the Nuclear Waste Repository.

- **Former liquid disposal sites that were original sources for groundwater contamination**. Of the ~1,000 past-practice waste sites on the Central Plateau, there are over 400 liquid waste sites that received liquid from 200 Area operations. Current and potential impacts to groundwater are dominated by releases from waste sites that received liquid waste. These waste sites included ponds, ditches, cribs, trenches, and injection or reverse wells. The major radioactive hazards associated with these sites include plutonium, uranium, strontium-90, cesium-137, iodine-129, and technetium-99. The chemical hazards associated with these liquid waste sites include volatile organics such as carbon tetrachloride, concentrated acids including nitric acid, and other organic compounds.

Table 4.5. Summary of Hazards in the 200 Areas

Material Category	Current Hazard
Surface	
Nuclear Materials	• Storage facilities located within the Plutonium Finishing Plant (PFP) and Central Waste Complex (CWC) currently store ~17 metric tons (18.7 tons) of stabilized plutonium-bearing materials. The disposition of these materials to a consolidated location for long-term storage is not expected until after 2007 • Approximately 75% of the Spent Nuclear Fuel (SNF) in the entire DOE complex is stored at Hanford. Most of this SNF, nearly 2,086 metric tons (2,300 tons) will be stored in the Central Plateau. Other SNF from the Fast Flux Test Facility is also planned for storage within the 200 Areas pending shipment and final disposal at the Nuclear Waste Repository. • Less than 2,000 cesium/strontium capsules are currently being stored in the Central Plateau. These capsules contain ~130 million curies of cesium-137 and strontium-90 removed from concentrated tank waste to reduce heat generation in underground storage tanks. Efforts are underway to move these capsules from the water-filled storage to dry storage pending final disposition. • Approximately 8,000 m^3 (10,463 yd^3) of transuranic/mixed low-level waste (TRU/MLLW) stored at CWC pending stabilization, treatment, or offsite shipment.
Nuclear Production Facilities	• Five irradiated nuclear fuel reprocessing facilities were used to recover 64,000 kg (141,095 lb) of plutonium from SNF. These facilities are massive structures with thick concrete walls to shield the workers from the highly radioactive chemical processing operations and residual contamination. Currently, four of these five facilities, PUREX, Reduction-Oxidation (REDOX), B Plant, and U Plant are in long-term surveillance and maintenance while T Plant remains active as a storage and processing facility for remote-handled (RH) TRU/MLLW. Final disposition of these facilities is expected to include collapsing the upper levels and isolating the facility remnants from the environmental with earthen barriers. • The PFP facilities were used to purify, process, and produce various plutonium product materials. These facilities contain extensive plutonium contamination within glove boxes, ducting systems, piping and other process vessels. Current plans are to demolish the PFP to slab-on-grade pending a future decision on the final disposition.
Ancillary Facilities	• More than 900 ancillary facilities were constructed to support irradiated nuclear fuel processing operations. These support facilities were contaminated with a variety of hazardous and radioactive substances including acids, metals, other organic and inorganic chemicals and radioactive fission and activation products.
Subsurface	
Liquid Waste Sites	• Over 400 liquid waste sites received liquid from 200 Area operations. These waste sites included ponds, ditches, cribs, trenches, and injection or reverse wells. The composition of the waste streams disposed to these sites varied widely from lightly contaminated steam condensate and cooling water to highly concentrated process and tank waste. The major radioactive hazards associated with these sites include plutonium, uranium, strontium-90, cesium-137, iodine-129, and technetium-99. The chemical hazards associated with these liquid waste sites include volatile organics such as carbon tetrachloride, concentrated acids such as nitric acid, and other organic compounds.

Table 4.5. (contd)

Material Category	Current Hazard
Solid Waste Burial Grounds	• Nearly 100 landfills were constructed within the 200 Area to dispose of solid, low-level radioactive, and TRU waste. Approximately 15,000 m^3 (19,619 yd^3) of this waste is retrievably stored TRU waste that is scheduled to be exhumed and packaged for shipment to WIPP. Much of the low-level radioactive solid and hazardous waste was generated during reprocessing or from other DOE sites is to be isolated from the accessible environment using surface barriers.
Radioactive Mixed Waste Tanks	• Within the 200 Area Core Zone are 18 tank farms containing 149 single-shell tanks, 28 double-shell tanks, and ancillary facilities. The tanks are below ground and contain ~ 2.04E+008 L (>53 million gal) of liquid, sludge and saltcake waste. The tanks contain ~200 million curies of radioactivity and other hazardous metals and chemicals. Most of the tanks are beyond their design life and 67 have leaked or are assumed to have leaked ~ 3.8 million L (1 million gal). Some of this leaked waste has reached the groundwater that flows to the Columbia River. Additional leaks are likely to occur, presenting a hazard to the public and the environment as the contaminated groundwater moves away from the Core Zone. The long-term hazards are primarily via the groundwater pathway and by intruders digging into the waste after institutional control is lost. • Airborne releases are also a hazard. Currently, workers are exposed to chemical vapors that are occasionally emitted from the tanks. Radioactive airborne releases with potential to reach off site could occur if, as a result of a leak in a pressurized transfer line, waste was sprayed into the air.
Groundwater	
Groundwater	• 200 East Area. Plumes beneath the 200-PO-1 Operable Unit resulting from discharges from the PUREX Plant; principle contaminants include tritium, nitrate, and iodine-129. These plumes extend from 200 East Area to the shoreline of the Columbia River where this groundwater discharges into the river. • 200 East Area. Plumes beneath the 200-BP-5 Operable Unit resulting from discharges of highly contaminated tank and process waste to the soil; principle contaminants include the mobile contaminants technetium-99 and nitrate as well as strontium-90, cesium-137, and plutonium that are far less mobile. • 200 West Area. Plumes beneath the 200-UP-1 Operable Unit resulting from REDOX and U Plants liquid discharges; includes a plume containing tritium, nitrate, and iodine-129 located near the REDOX Plant and a second plume near U Plant containing elevated concentrations of uranium, technetium-99, and nitrate. • 200 West Area. Plumes beneath the 200-ZP-1 Operable Unit resulting from discharges from the PFP. Carbon tetrachloride has spread well beyond the area surrounding PFP and contaminated much of the groundwater beneath 200 West Area. • The primary receptors that are potentially at risk due to contaminated groundwater are biota in the Columbia River that reside in the areas of groundwater upwelling and plants in the riparian zone that have roots down to groundwater. The tritium and iodine-129 plumes from 200 East Area pose a hazard for an estimated 150 years, by which time the tritium will have decayed to below drinking water standards and the iodine-129 will have dispersed to below drinking water standards. Other contaminant plumes are expected to remain beneath the Core Zone through effective source control and groundwater remedial action.

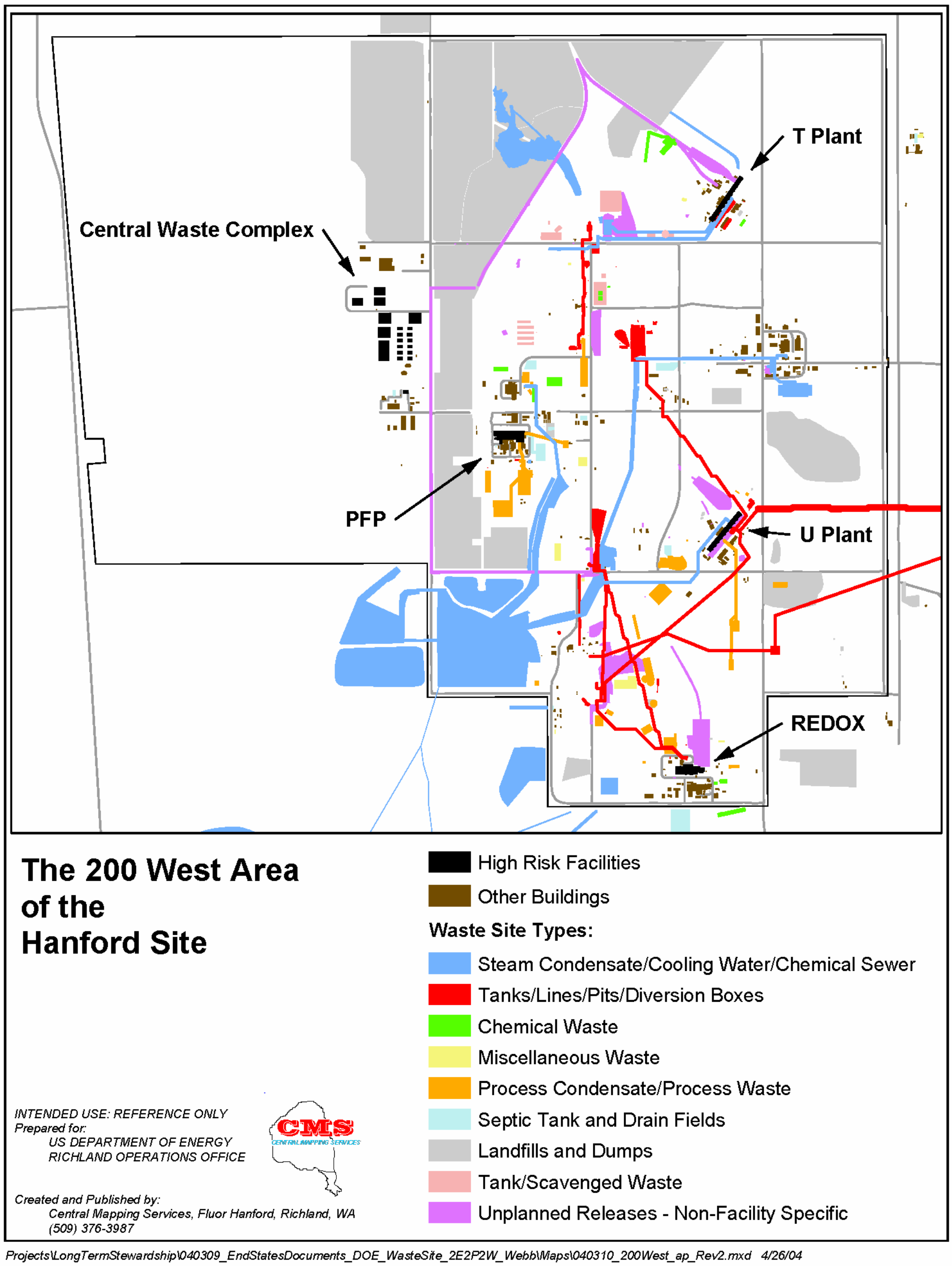

Figure 4.3a. 200 West Area Hazard Map

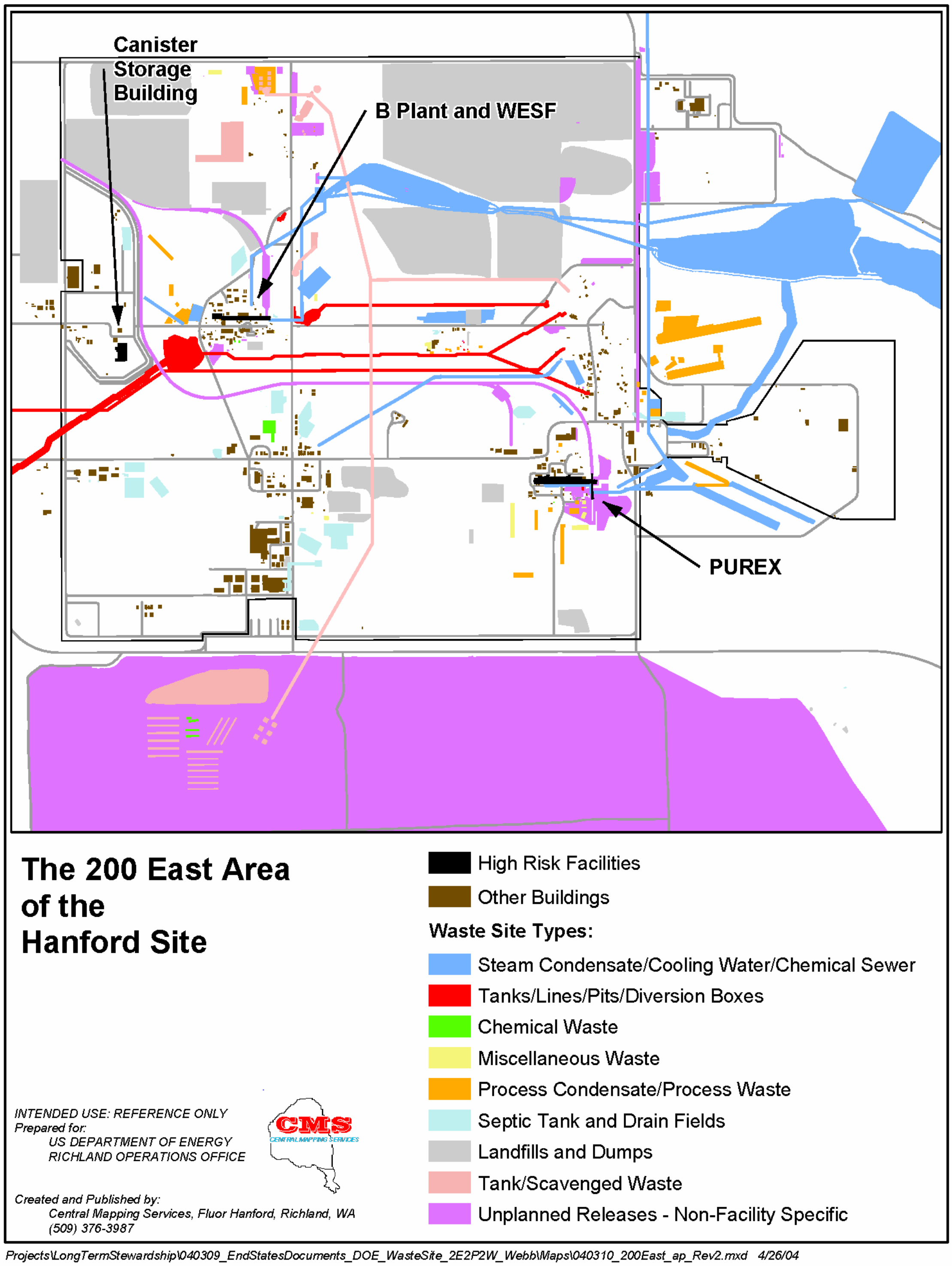

Figure 4.3b. 200 East Area Hazard Map

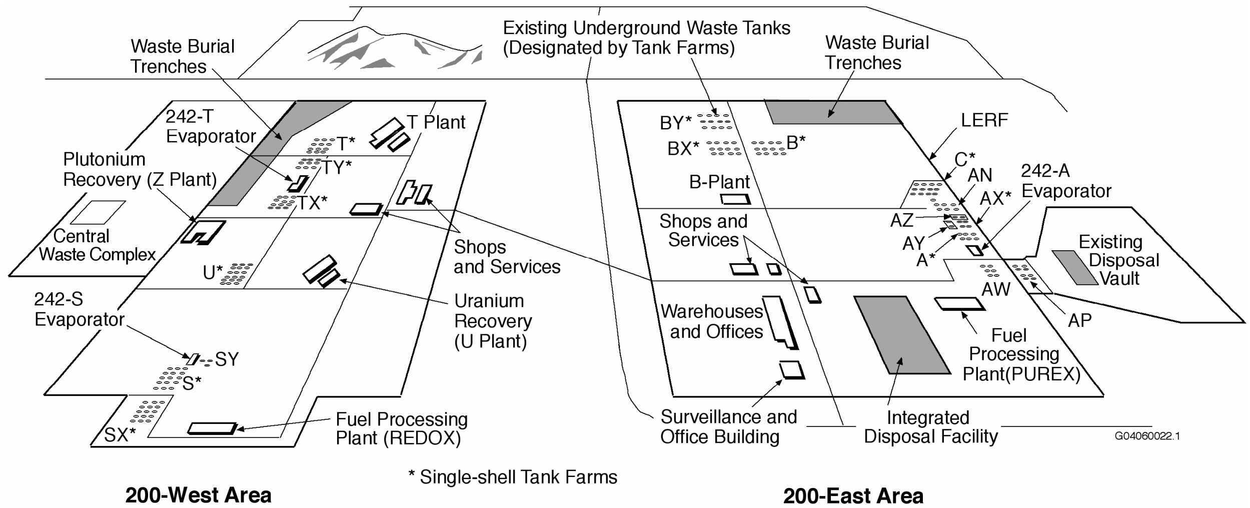

Figure 4.3c. Tank Farm Map

- **Solid waste burial grounds**. Nearly 100 landfills were constructed within the 200 Areas to dispose of solid, low-level radioactive, and transuranic waste. Approximately 15,000 cubic meters (19,619 cubic yards) of this waste is retrievably stored transuranic waste that is scheduled to be exhumed and packaged for shipment to WIPP. Much of the low-level radioactive solid and hazardous waste was generated during reprocessing or from other DOE sites is to be isolated from the accessible environment using surface barriers.

- **Former production facilities**. Nine hundred facilities, including five canyon facilities and PFP, were constructed to conduct irradiated nuclear fuel processing operations. These facilities are contaminated with a variety of hazardous and radioactive substances including acids, metals, other organic and inorganic chemicals, and radioactive fission and activation products.

- **Existing groundwater plumes with contaminants slowly moving toward the Columbia River**. There are four primary groundwater plumes (and operable units) underlying the 200 Areas. These plumes contain the following contaminants at levels that exceed drinking water standards: tritium, iodine-129, technetium-99, uranium, nitrate, and carbon tetrachloride. Far less mobile strontium-90, cesium-137, and plutonium are present in the soil, but are not a major threat to the groundwater.

4.3.2 Exposure Pathways and Potential Implications of the End State Vision

Within the 200 Areas, the exposure pathways will differ between areas inside the Core Zone and areas outside of the Core Zone. Table 4.6 summarizes the assumptions for land use, exposure scenarios and pathways, remediation goals, and institutional controls for both the current baseline end state and the end state vision for areas outside of the Core Zone. Table 4.7 provides this information for areas inside of the Core Zone.

Table 4.6. 200 Areas Waste Sites Overview and Comparison of Current and End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls – Outside Core Zone

	Current Baseline End State	End State Vision
Land Use and Key Assumptions	Conservation	Conservation/Preservation
Exposure Scenarios for Determining Cleanup Levels	**Recreational user** • Exposure from soils due to direct contact, inhalation, and external radiation • No soil excavation, but possible animal intrusion • Groundwater is not used for drinking water **Occasional Native American use scenario** • Exposure from soils and biota due to direct contact, inhalation, external radiation and ingestion • No soil excavation, but possible intrusion of plants and animals then consumed or used • No groundwater use assumed **Residential scenario** • Exposure from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 4.6 m (15 ft) for construction activities • Groundwater is not used for drinking water **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Exposure to 4.6 m (15 ft) • Exposure to contaminated biota	**Recreational user** • Exposure from soils due to direct contact, inhalation, and external radiation • No soil excavation, but possible animal intrusion • Groundwater is not used for drinking water **Occasional Native American use scenario** • Exposure from soils and biota due to direct contact, inhalation, external radiation and ingestion • No soil excavation, but possible intrusion of plants and animals then consumed or used • No groundwater use assumed **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Biologically active zone to 4.8 m (16 ft) • Exposure to contaminated biota
Risk Protection Metrics/Goals	• 10^{-4} to 10^{-6} risk range under CERCLA; 15 mrem/yr from radionuclide equates to 3 x 10^{-4} • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater	• 10^{-4} to 10^{-6} risk range under CERCLA • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater

Table 4.6. (contd)

	Current Baseline End State	End State Vision
Cleanup Actions		
Surface	• Remedial action taken as needed to protect human health and ecological resources for this land-use scenario • Includes surface barriers, removal, or use of existing soil cover with institutional controls and monitored natural attenuation	• Remedial action taken as needed to protect human health and ecological resources for this land-use scenario • Includes surface barriers, removal, or use of existing soil cover with institutional controls and monitored natural attenuation
Subsurface	• Remedial actions taken to prevent groundwater degradation and protect river • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal	• Remedial action taken as needed to protect groundwater degradation and protect the river; also protects human health and ecological resources • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal
Groundwater	• Remedial actions taken to prevent groundwater degradation and protect river • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal	• Remedial actions taken to prevent groundwater degradation and protect river • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal
Institutional Controls	• Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5-year reviews. • Prevention of excavation into waste sites with surface barriers. • Surveillance and maintenance of disposal sites and surface barriers.	• Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5-year reviews. • Prevention of excavation into waste sites with surface barriers. • Surveillance and maintenance of disposal sites and surface barriers.

Table 4.7. 200 Areas Waste Sites Overview and Comparison of Current and End State Assumptions for Land Use, Exposure Scenarios, Risk Protection Goals, and Potential Institutional Controls – Inside Core Zone

	Current Baseline End State	End State Vision
Land Use and Key Assumptions	Industrial Land Use	Exclusive Industrial Land Use
Exposure Scenarios for Determining Cleanup Levels	**Industrial worker** • Exposure from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 4.6 m (15 ft) for construction activities • Groundwater is not used for drinking water **Inadvertent intruder** • Exposure to soils due to direct contact, inhalation, and external radiation • Soils are taken from a borehole, spread on the surface in a 200 m^2 (239 y^2)garden, and used by a residential intruder; no groundwater consumption is assumed **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Exposure to 4.6 m (15 ft) • Exposure to contaminated biota	**Nuclear industrial worker** • Exposure <u><</u>5 rem/year whole body from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 4.6 m (15 ft) • No groundwater use assumed **Non-nuclear industrial worker** • Exposure <u><</u>100 mrem/year from soils due to direct contact, inhalation, and external radiation • Potential for soil excavation to 4.6 m (15 ft) • No groundwater use assumed **Inadvertent intruder** • Exposure to soils due to direct contact, inhalation, and external radiation • Soils are taken from a borehole, spread on the surface in a 200 m^2 (239 y^2)garden, and used by a residential intruder; no groundwater consumption is assumed **Biological receptor** • Exposure from soils due to direct contact, ingestion, inhalation, and external radiation • Biologically active zone to 4.8 m (16 ft) • Exposure to contaminated biota
Risk Protection Metrics/Goals	• 10^{-4} to 10^{-6} risk range under CERCLA; 15 mrem/yr from radionuclide equates to 3 x 10^{-4} • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater	• 10^{-4} to 10^{-6} risk range under CERCLA • Ecological screening per EPA 8-step process using WAC-173-340-900, Table 749-3 and BDAC BCGs as screening levels • Source containment or removal to protect human health, the environment, and the groundwater
Cleanup Actions		
Surface	• Remedial action taken as needed to protect human health and ecological resources for this land-use scenario • Includes surface barriers, removal, or use of existing soil cover with institutional controls and monitored natural attenuation	• Remedial action taken as needed to protect human health and ecological resources for this land-use scenario • Includes surface barriers, removal, or use of existing soil cover with institutional controls and monitored natural attenuation

Table 4.7. (contd)

	Current Baseline End State	End State Vision
Subsurface	• Remedial actions taken to prevent groundwater degradation and protect river • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal	• Remedial action taken as needed to prevent groundwater degradation and protect the river; also protects human health and ecological resources • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal
Groundwater	• Remedial actions taken to prevent groundwater degradation and protect river • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal	• Remedial actions taken to prevent groundwater degradation and protect river • Includes surface barriers with institutional controls or removal, treatment as needed, and disposal
Institutional Controls	• Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5-year reviews. • Prevention of excavation into waste sites with surface barriers. • Surveillance and maintenance of disposal sites and surface barriers.	• Restrictions in place to preserve land uses and prevent use of groundwater. • Continued groundwater monitoring as required by CERCLA 5-year reviews. • Prevention of excavation into waste sites with surface barriers. • Surveillance and maintenance of disposal sites and surface barriers.

Release and transport of contaminants from closed tank farms can result from two primary mechanisms: (1) the infiltration of water (natural recharge) into disposal systems leading to the slow release of residual contaminants from their final waste form, and (2) inadvertent intrusion into disposal sites if institutional controls were lost. The potential exposure routes for these mechanisms are shown in Figure 4.3d. For the infiltration mechanism, exposure could occur to a human receptor at the nearest point of groundwater use. For the direct human intrusion mechanism, there would be direct exposure to contaminants and potentially secondary exposure depending on the assumptions for an intruder scenario.

The principal difference in the remediation and control actions between the current baseline end state and the end state vision results from the assumption that the Core Zone remains industrial exclusive use and, therefore, there is no expected groundwater consumption adjacent to tank farm boundaries. The offsite public receptor is located outside of the Core Zone. Thus, there is one additional institutional control in the end state vision, #4 (see Chapter 5) – no onsite groundwater use. This assumption is consistent with all other cleanup actions within the Core Zone of the Central Plateau. The expected impact of this control is that the expected tank waste retrieval amount could be less than the current assumption of 99%.

There are no pathways shown for ecological receptors as the depth of disposal, including final barriers, is expected to be less than 4.6 meters (15 feet). Potential ecological pathways and additional exposure scenarios will be evaluated in 200 Area risk assessments.

4.4 400 Area

The Fast Flux Test Facility (FFTF) is a 400-megawatt (thermal) liquid-metal (sodium) cooled fast neutron flux nuclear test reactor. The facility is located in the 400 Area of the Hanford Site. In addition to the FFTF, the 400 Area also includes the Fuels and Materials Examination Facility and ~80 other facilities, ~10 remaining waste sites, underground structures, and contaminated pipelines.

4.4.1 400 Area Current Baseline End State

Risk to the public, workers, and environment will be reduced by removing contamination from the waste sites and disposing of the material in Environmental Restoration Disposal Facility. A disposition path for the sodium used to cool the FFTF during operation needs to be resolved. DOE-RL's current baseline assumes sodium hydroxide will be utilized by the Waste Treatment Plant. Facilities in the 400 Area will be deactivated, decontaminated, decommissioned, and demolished. The FFTF reactor will be placed into interim safe storage.

4.4.2 400 Area End State Vision

The end state vision for the 400 Area is the same as the current end state.

4.5 Overview of Hanford's Plans for Conducting Risk Assessments

Numerous risk assessments are currently underway and are planned for the Hanford Site. Collectively, these risk assessments will provide a quantitative assessment of end state alternatives. As these risk assessments are conducted, they will influence cleanup decisions and refine the end state vision for the Site.

A compilation of Hanford Site risk assessments is contained in DOE/RL-2005-37, Rev. 0 ("Status of Hanford Site Risk Assessment Integration, FY 2005"). More than fifty individual risk assessments were identified covering all areas of the Site and ranging in scale from individual waste site assessments to comprehensive ecological and human health assessments for the entire Site. Table 4.8 summarizes the major risk assessments that are underway or planned for the separate areas of the Site, and for the Site as a whole. This table describes the scope and the anticipated schedule, although theses schedules are subject to change.

Table 4.8. Summary of Hanford Site Risk Assessments (from DOE/RL-2005-37, Rev. 0)

Area Risk Assessment Title	Scope	Status/Schedule
Site-Wide		
Composite Analysis	Evaluates the potential long-term human health impact from combined radionuclide releases to groundwater, surface water and air from all sources following closure of the Hanford Site. Supports low-level waste disposal authorizations by ensuring that separate disposal and closure actions do not collectively exceed DOE standards. Examines several end state alternatives.	The CA is required to be updated every 5 years or more often when warranted by changes in plans. Next update: Summer 2006.
100 Area		
River Corridor Baseline Risk Assessment • 100 B/C Pilot • 100 Area Component • Columbia River Component	Evaluates impact to human health and the environment to support final decision making and completion of the CERCLA process for the 100 Area waste site operable units.	Elements of these risk assessments are underway. Completion is expected in FY ~2007 with the River Component expected somewhat later.
River Corridor Groundwater Risk Assessments	Evaluates impact to human health and the environment to support final decision making and completion of the CERCLA process for the 100 Area groundwater operable units.	Elements of these risk assessments are underway. Completion is expected in FY ~2009 – 2010.
200 Area		
Central Plateau Waste Site Risk Assessments	Assess the human health and ecological risk where a remedy will result in residual contamination at a site to support CERCLA decision making for Plateau waste sites. These assessments evaluate alternative remedies for waste sites.	Risk assessments have been completed for several Operable Units and are underway for most other Operable Units. Completion is expected in FY 2008.
Central Plateau Groundwater Risk Assessments	Assess the human health and ecological risk of existing groundwater contamination and evaluate the effectiveness and merits of alternative remedies to support CERCLA decision making.	Risk assessments for 200 West Area plumes are scheduled for 2006 – 2007. Risk assessments for 200 East Area plumes are scheduled for 2007 – 2008.
Canyon Facility Risk Assessments	Assess the human health and ecological risk where a remedy will result in residual contamination at a facility to support CERCLA decision making for the five Canyon Facilities on the Central Plateau.	Risk assessment for the U Plant Canyon was completed in FY 2005. Risk assessments for other canyons are TBD.
Integrated Disposal Facility Performance Assessment	Per DOE Order 435.1 develops and maintains a performance assessment of the IDF that includes disposal of ILAW, failed melters, LLW, and MLLW.	Initial draft performance assessment completed in FY 2005. Updates to be provided as necessary to support Disposal Authorization.
Single-Shell Tank Performance Assessment (and tank closure risk assessments)	Assesses the long-term environmental and human health effects of the planned closure of tank farm Waste Management Areas (WMAs) to support RCRA Closure Plans. Includes assessment of all potential final sources in each WMA: past leaks, ancillary equipment, tank residuals, retrieval leak loss, and adjacent waste sites.	Initial draft performance assessment to be completed and available for external review in early FY 2006. Updates to be provided as necessary to support WMA closure actions.
Tank Closure Environmental Impact Statement	Assesses the environmental and human health effects of a broad range of closure end states for tank farms including a "no action" alternative, landfill closure alternatives, and clean closure alternatives.	This EIS is currently underway. Expected completion is during FY 2006 – 2007.

Table 4.8. (contd)

Area Risk Assessment Title	Scope	Status/Schedule
300 Area		
River Corridor Baseline Risk Assessment – 300 Area Component	Evaluates impact to human health and the environment to support final decision making and completion of the CERCLA process for the 300 Area NPL waste sites.	Elements of this risk assessment are underway. Completion is expected in FY ~2007.
300 Area Groundwater Risk Assessment (300-FF-5)	Evaluates impact to human health and the environment to support final decision making and completion of the CERCLA process for the 300 Area NPL groundwater operable unit.	This risk assessment is planned to start in FY 2006 with completion expected during FY 2007.
400 Area		
FFTF Environmental Impact Statement	This EIS evaluates a broad range of final disposition end points for the FFTF complex.	This risk assessment is currently underway and is planned for completion during FY 2007.