5.2 FFTF DECOMMISSIONING ALTERNATIVES

This section describes the potential long-term environmental and human health impacts associated with implementation of alternatives considered to decommission FFTF and auxiliary facilities at Hanford; to manage waste from the decommissioning process, including waste designated as remote-handled special components (RH-SCs); and to manage the disposition of the Hanford inventory of radioactively contaminated bulk sodium from FFTF, as well as other onsite facilities. Three FFTF Decommissioning alternatives were considered and analyzed: (1) FFTF Decommissioning Alternative 1: No Action, in which only certain deactivation activities at FFTF would be conducted, consistent with previous DOE National Environmental Policy Act actions, and two action alternatives: (2) FFTF Decommissioning Alternative 2: Entombment, and (3) FFTF Decommissioning Alternative 3: Removal. FFTF Decommissioning Alternative 2 would involve removing all above-grade structures within the 400 Area Property Protected Area (PPA), with minimal removal of below-grade structures, equipment, and materials as necessary to comply with regulatory standards. The FFTF reactor vessel and other below-grade equipment would remain. FFTF Decommissioning Alternative 3 would consist of removing all above-grade structures within the 400 Area PPA, with additional removal of contaminated below-grade structures, including the FFTF reactor vessel, equipment, and materials. Associated construction, operations, deactivation, closure, and decommissioning activities are assessed, as applicable, for each alternative.

For each action alternative (i.e., FFTF Decommissioning Alternatives 2 and 3), two options (a Hanford and an Idaho option) were evaluated for disposition of RH-SCs and processing of bulk sodium. For RH-SCs, the Hanford Option would involve treating the waste in a new, onsite treatment facility, followed by disposal of the treated components and residuals along with other Hanford waste in the 200 Areas. Under the Idaho Option, RH-SCs would be shipped to the Remote Treatment Project (RTP) at the Idaho National Laboratory's (INL's) Idaho Nuclear Technology and Engineering Center (INTEC). Following treatment at the RTP, the FFTF components and residuals would be disposed of with other INL waste at an offsite facility or returned to Hanford for disposal. For processing of bulk sodium under the Hanford Reuse Option, the bulk sodium would be stored in its current locations until it is shipped to a new onsite facility for processing. The bulk sodium would be converted to a caustic sodium hydroxide solution, which would then be transferred to the WTP for reuse. Under the Idaho Reuse Option, the bulk sodium would be stored in its current locations until it is shipped to the INL Materials and Fuels Complex (MFC) for processing in the existing Sodium Processing Facility (SPF). Following processing, the caustic would be returned to Hanford for reuse in the WTP. These alternatives and options are described further in Chapter 2, Section 2.5.

5.2.1 Groundwater

The focus of this section is on the impacts of FFTF disposition (sodium processing and remote-handled treatment should not have a groundwater impact); the waste removed from FFTF or resulting from removal will be discussed under the Waste Management alternatives.

5.2.1.1 FFTF Decommissioning Alternative 1: No Action

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 1: No Action, including long-term groundwater impacts of contaminant sources within the FFTF barrier. Impacts of sources removed from within the FFTF barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.1.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 1, after a period of administrative control, no further actions would be taken to remove radionuclides or chemicals from within the FFTF barrier. Summaries of the

proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, two major periods were identified for FFTF Decommissioning Alternative 1, as follows:

- The administrative control period was assumed to start in CY 2008 and end in CY 2107 (100-year duration). It was assumed that during this administrative control period, corrective action or emergency response measures would preclude releases of contaminants from FFTF to the environment.

- The post–administrative control period was assumed to start in CY 2108 and continue through the 10,000-year period of analysis until CY 11,940. During this post–administrative control period, all remaining contaminants at FFTF would be available for release to the environment.

5.2.1.1.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 1. Complete results for all 40 COPCs are provided in Appendices M, N, and O, but this discussion of long-term impacts associated with FFTF Decommissioning Alternative 1 is focused on the following COPC drivers:

- Radiological risk drivers: tritium and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: total uranium

The COPC drivers for FFTF Decommissioning Alternative 1 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the FFTF barrier during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Total uranium becomes a contributor toward the end of the period of analysis. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially all of the radiological risk associated with FFTF Decommissioning Alternative 1. Even though there is no chemical risk predicted, there is a chemical hazard. Total uranium accounts for essentially all of the chemical hazard risk associated with FFTF Decommissioning Alternative 1.

The COPC drivers that are discussed in detail in this section fall into three categories. Technetium-99 is mobile (i.e., moves with groundwater) and long lived (relative to the 10,000-year period of analysis). It is essentially a conservative tracer. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Total uranium is long-lived, or stable, but not as mobile as the other COPC drivers. This constituent moves about seven times more slowly than groundwater.

The other COPCs that were analyzed do not significantly contribute to drinking water risk or hazard at the FFTF barrier during the period of analysis because of low inventories, low release rates, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.2.1.1.3 Analysis of Release and Mass Balance

This section presents the impacts of FFTF Decommissioning Alternative 1 in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies (see Figures 5–344 through 5–346). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude within the same series of figures.

Figure 5–344 shows the estimated release to the vadose zone of the radiological risk drivers. The total release to the vadose zone is controlled by the combination of decay at the source and available inventory (i.e., 100 percent of the inventory is either decayed at the source or released during the period of analysis). About 0.4 curies of tritium, about 27 curies of technetium-99, and about 37,000 kilograms of total uranium are released to the vadose zone over the period of analysis.

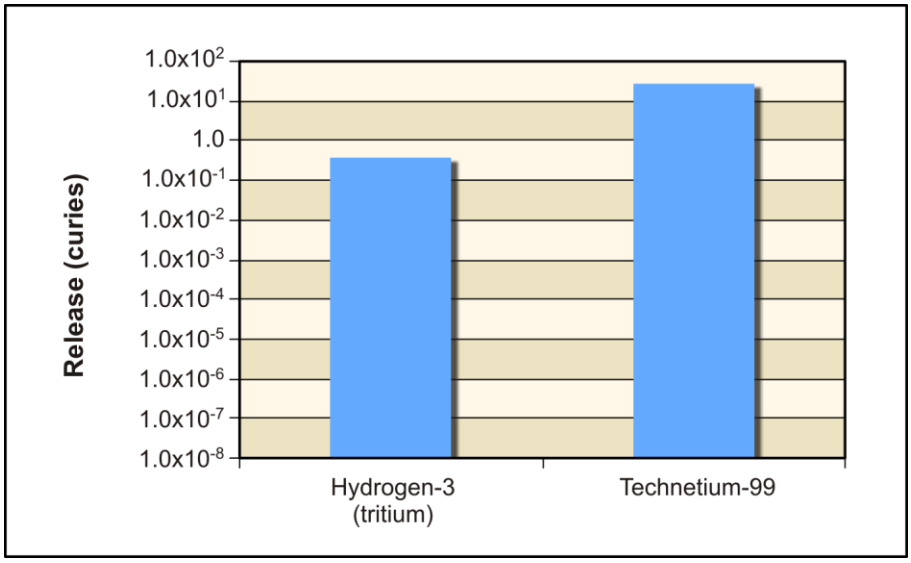


Figure 5–344. FFTF Decommissioning Alternative 1 Releases of Radioactive Constituents of Potential Concern to Vadose Zone from Sources Inside the Fast Flux Test Facility Barrier

Figure 5–345 shows the release to groundwater of the radiological risk drivers. In addition to the inventory considerations, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For technetium-99, the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, the amount released to groundwater is strongly attenuated by radioactive decay. Less than 1 percent of the tritium released in the analysis into the vadose zone reaches groundwater. For total uranium, the amount released to groundwater is less than that released to the vadose zone because of vadose zone retention. Only about 11 percent of the total uranium released in the analysis into the vadose zone reaches groundwater. This result suggests that total uranium is not a factor until the end of the 10,000-year period of analysis because of the long travel times for this COPC in the vadose zone.

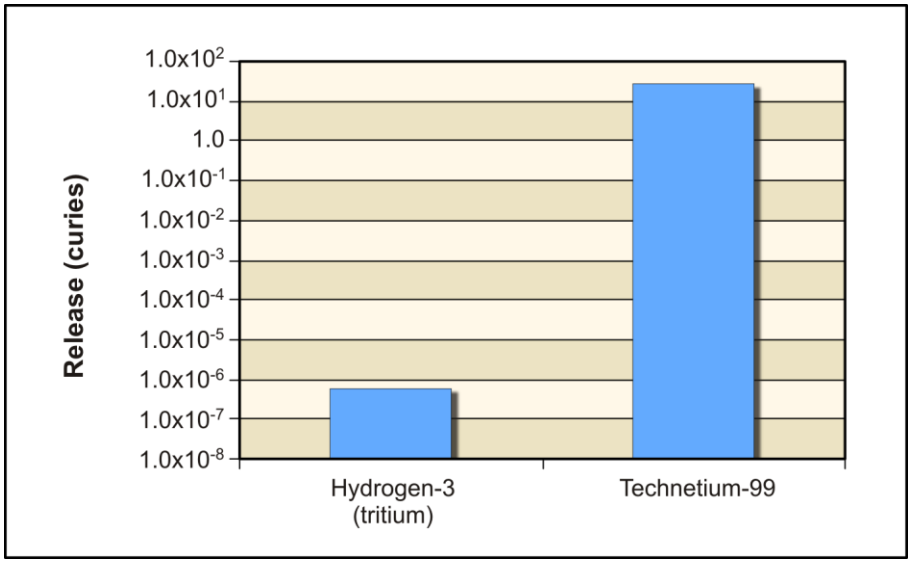


Figure 5–345. FFTF Decommissioning Alternative 1 Releases of Radioactive Constituents of Potential Concern to Groundwater from Sources Inside the Fast Flux Test Facility Barrier

Figure 5–346 shows the release to the Columbia River of the radiological risk drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is strongly attenuated by radioactive decay. Overall, only about 4 percent of the tritium released to groundwater reaches the Columbia River in the analysis. For total uranium, the amount released to the Columbia River is strongly attenuated by retardation; only about 63 percent of the total uranium released to groundwater reaches the Columbia River in the analysis.

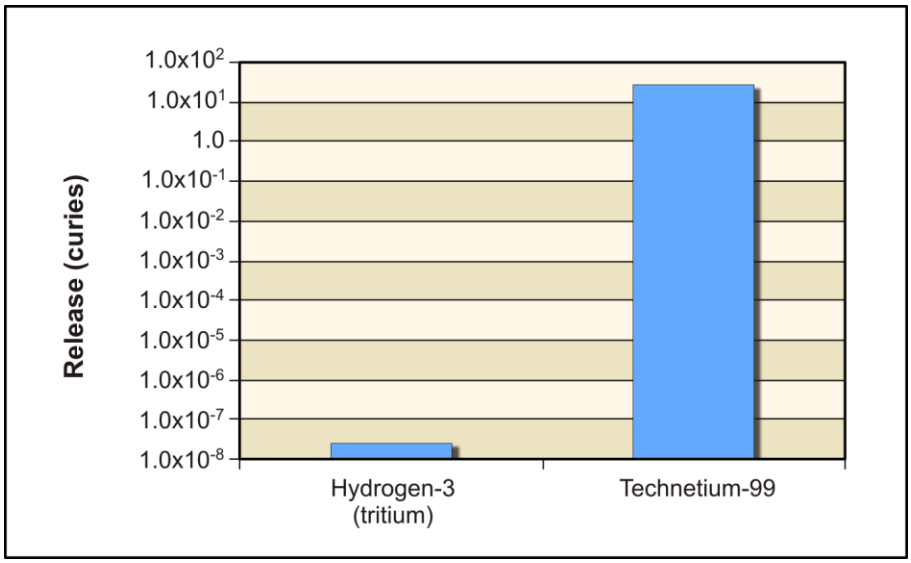


Figure 5–346. FFTF Decommissioning Alternative 1 Releases of Radioactive Constituents of Potential Concern to Columbia River from Sources Inside the Fast Flux Test Facility Barrier

5.2.1.1.4 Analysis of Concentration Versus Time

This section presents the analysis of FFTF Decommissioning Alternative 1 impacts in terms of groundwater concentration versus time at the FFTF barrier and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Table 5–82 and Figures 5–347 and 5–348). The benchmark concentration of each radionuclide is also shown (900 and 20,000 picocuries per liter for technetium-99 and tritium, respectively). Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over two orders of magnitude.

Figure 5–347 shows concentration versus time for technetium-99. The concentration of technetium-99 at the FFTF barrier peaks at about 45 percent of the benchmark around CY 2790. During this time, groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration. Technetium-99 is essentially not a factor at times later than CY 3890.

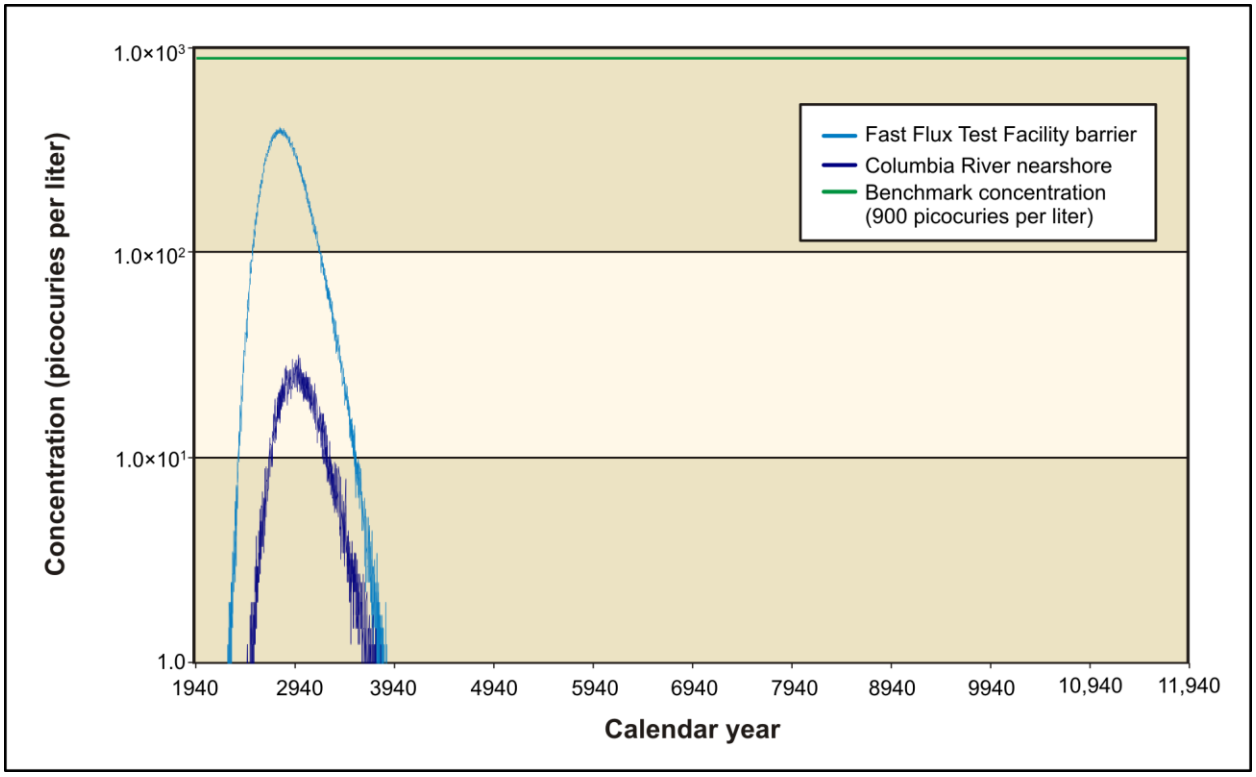


Figure 5–347. FFTF Decommissioning Alternative 1 Technetium-99 Concentration Versus Time

Figure 5–348 shows concentration versus time for tritium. Note that for visual clarity, the time period shown in this figure is from CYs 1940 through 2440 (500 years), rather than the full 10,000-year period of analysis. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor. Releases from FFTF do not cause groundwater concentrations to exceed the benchmark concentration throughout the period of analysis. The concentrations at the FFTF barrier peak at about 8 orders of magnitude below the benchmark concentration. During this time, groundwater concentrations at the Columbia River nearshore peak at about 11 orders of magnitude below the benchmark concentration.

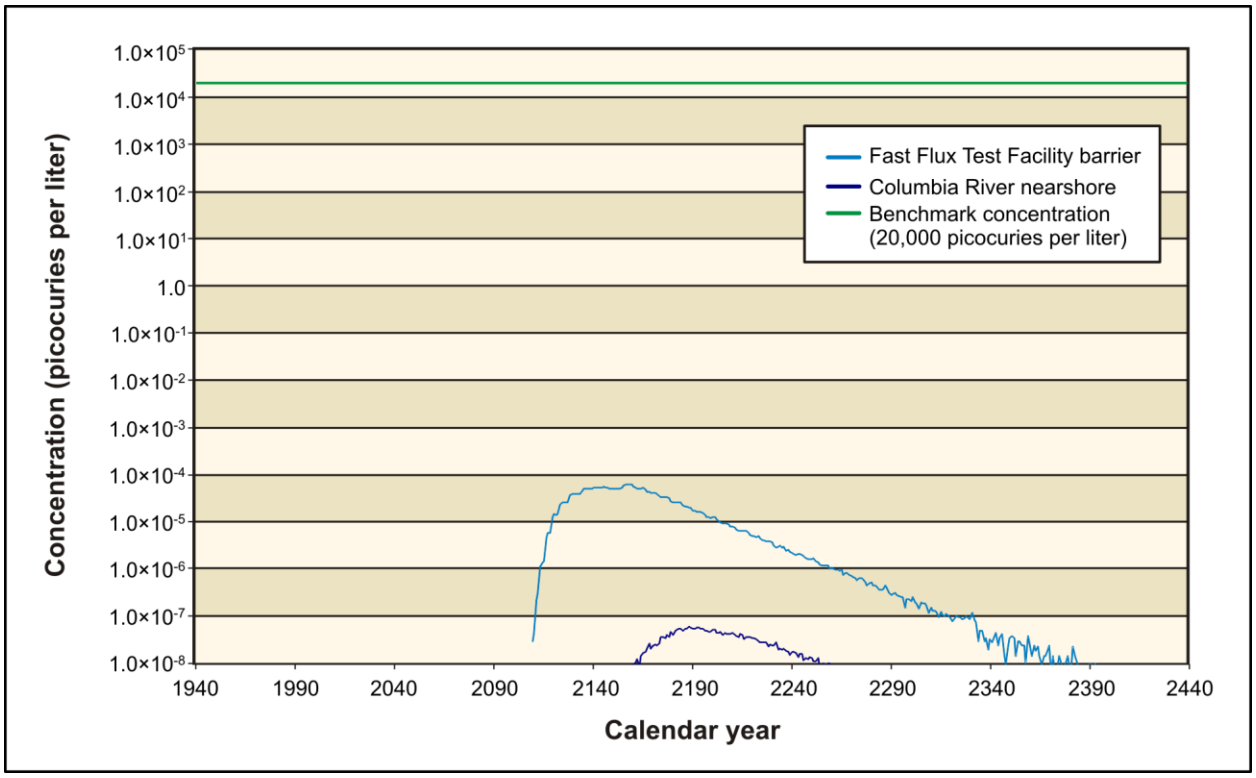


Figure 5–348. FFTF Decommissioning Alternative 1 Hydrogen-3 (Tritium) Concentration Versus Time

For total uranium, releases do not occur until well into the post–administrative control period, around CY 5000. The concentration of total uranium at the FFTF barrier peaks at about 66 percent of the benchmark concentration near the end of the analysis period, around CY 11,840. Groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration at this time.

Table 5–82 lists the estimated maximum concentrations of technetium-99 and total uranium in the peak year at the FFTF barrier and Columbia River nearshore. The COPC concentrations never exceed the respective benchmark concentrations at the FFTF barrier or Columbia River nearshore during the 10,000-year analysis period.

Table 5–82. FFTF Decommissioning Alternative 1 Maximum COPC Concentrations in the Peak Year at the FFTF Barrier and Columbia River Nearshore

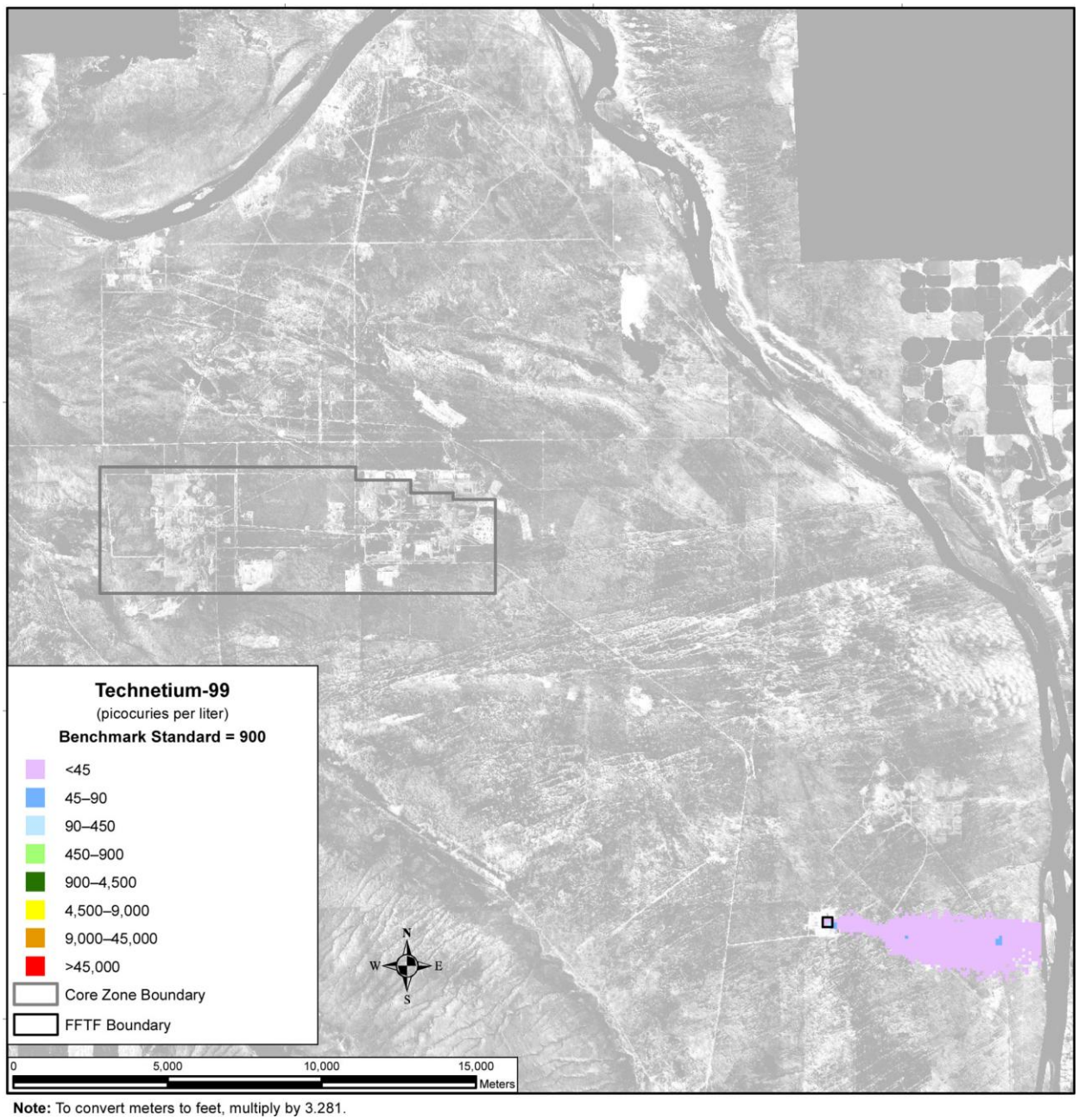
Contaminant	FFTF Barrier	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)			
Technetium-99	411 (2790)	32 (2978)	900
Chemical (micrograms per liter)			
Total uranium	20 (11,842)	1 (11,788)	30

Note: Corresponding calendar years shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

5.2.1.1.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of FFTF Decommissioning Alternative 1 in terms of the spatial distribution of COPC driver concentrations in groundwater at selected times. Concentrations of radionuclides are in picocuries per liter (see Figures 5–349 and 5–350). Concentrations of each radionuclide are indicated by a color scale that is relative to the benchmark concentration (900 and 20,000 picocuries per liter for technetium-99 and tritium, respectively). Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

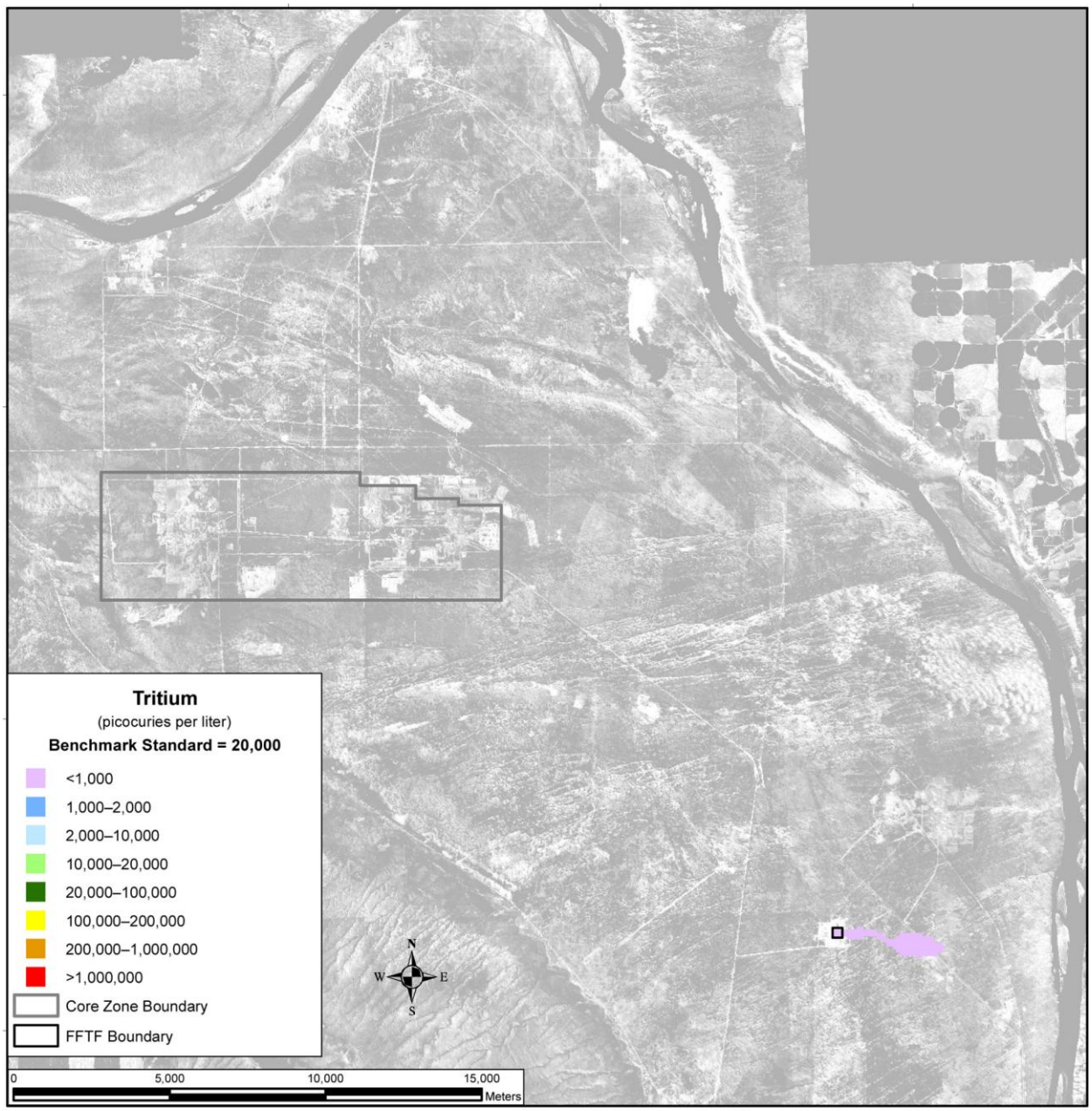
Figure 5–349 shows the spatial distribution of technetium-99 concentrations in groundwater in CY 2590, roughly the time of greatest development of the groundwater plume. For ease of presentation, the FFTF barrier is represented by a polygon surrounding FFTF. Releases from FFTF result in a groundwater concentration plume that extends east from the facility to the Columbia River nearshore. Peak concentrations in this plume are less than one-hundredth of the benchmark in CY 2590.



Note: To convert meters to feet, multiply by 3.281.

Figure 5–349. FFTF Decommissioning Alternative 1 Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2590

Figure 5–350 shows the spatial distribution of tritium concentrations in groundwater in CY 2135, roughly the time of greatest development of the groundwater plume. For ease of presentation, the FFTF barrier is represented by a polygon surrounding FFTF. Analysis releases from FFTF result in a groundwater concentration plume that extends from the facility east to the Columbia River nearshore. Peak concentrations in this plume are less than one-twentieth of the benchmark concentration in CY 2135.



Note: To convert meters to feet, multiply by 3.281.

Figure 5–350. FFTF Decommissioning Alternative 1 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2135

5.2.1.1.6 Summary of Impacts

Under FFTF Decommissioning Alternative 1, none of the COPCs exceed the benchmark concentrations at the FFTF barrier or the Columbia River nearshore during the 10,000-year period of analysis. Tritium concentrations are strongly attenuated by radioactive decay and are essentially negligible, peaking at about eight orders of magnitude below the benchmark standard at the FFTF barrier. Technetium-99 impacts are greatest around CY 2600 to 2800, when the associated groundwater plume is most developed and peak concentrations reach about 400 picocuries per liter at the FFTF barrier, about 45 percent of the benchmark. Total uranium is not a factor until near the end of the analysis, around CY 11,800, when peak concentrations reach about 20 micrograms per liter at the FFTF barrier, about 66 percent of the benchmark concentration.

5.2.1.2 FFTF Decommissioning Alternative 2: Entombment

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 2: Entombment, including long-term groundwater impacts of contaminant sources within the FFTF barrier. Impacts of sources removed from within the FFTF barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.2.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 2, all above-grade structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the Reactor Containment Building and any other remaining below-grade structures (including the reactor vessel). Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, two major periods were identified for FFTF Decommissioning Alternative 2, as follows:

- The entombment period was assumed to start in CY 2013, when decommissioning activities would begin, and end in CY 2121, following the completion of decommissioning and entombment activities and a 100-year postclosure period. It was assumed that there would be no releases from FFTF during this entombment period.

- The post-entombment period was assumed to start in CY 2122 and continue through the 10,000-year period of analysis until CY 11,940. During this post-entombment period, all remaining constituents at FFTF would be available for release to the environment, over time, as the barrier degrades and any remaining COPCs are released from the underground, grouted components.

5.2.1.2.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 2. Complete results for all 40 COPCs are provided in Appendices M, N, and O, but this discussion of long-term impacts associated with FFTF Decommissioning Alternative 2 is focused on the following COPC drivers:

- Radiological risk drivers: technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: none

The COPC driver for FFTF Decommissioning Alternative 2 was selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the FFTF barrier during the 10,000-year period of analysis and selecting the major contributor. This process is described in Appendix Q. The radiological risk driver accounts for essentially all of the radiological risk. No chemical risk is predicted. The peak chemical hazard to a drinking-water well user at the FFTF barrier is essentially negligible.

The COPC driver that is discussed in detail in this section is technetium-99. Technetium-99 is mobile (i.e., moves with groundwater) and long-lived (relative to the 10,000-year period of analysis). It is essentially a conservative tracer. The other COPCs that were analyzed do not significantly contribute to drinking water risk or hazard at the FFTF barrier during the period of analysis because of low inventories, low release rates, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.2.1.2.3 Analysis of Release and Mass Balance

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of the total amount of radioactive COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies (see Figures 5–351 through 5–353). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over seven orders of magnitude.

Figure 5–351 shows the estimated release of technetium-99 to the vadose zone, about 27 curies. This is the same inventory estimate for FFTF Decommissioning Alternative 1 because the source of the technetium-99 is not removed under this alternative. Figure 5–352 shows the technetium-99 release to groundwater, which is essentially the same as that released to the vadose zone. This is due to technetium-99's lack of retardation and long half-life. Figure 5–353 shows the technetium-99 release to the Columbia River, which also is about 27 curies.

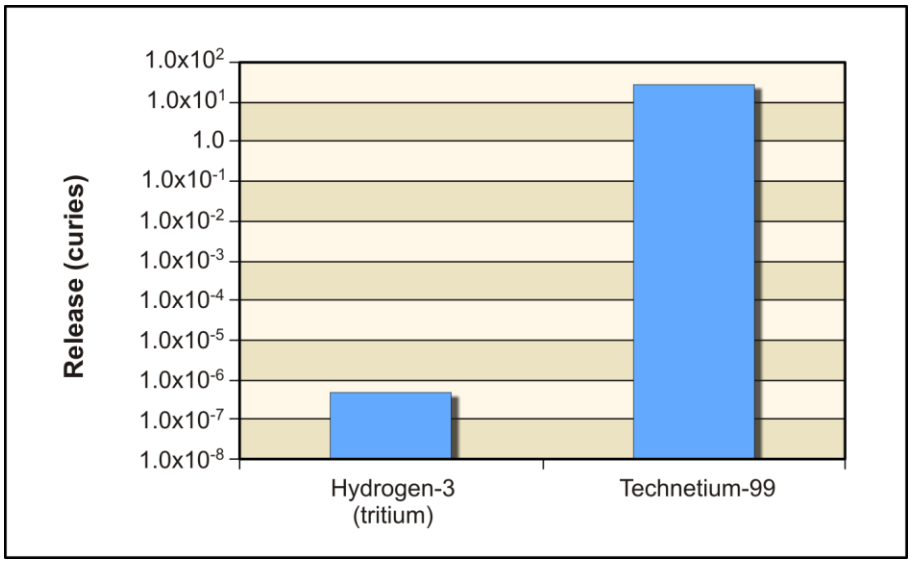


Figure 5–351. FFTF Decommissioning Alternative 2 Releases of Radioactive Constituents of Potential Concern to Vadose Zone from Sources Inside the Fast Flux Test Facility Barrier

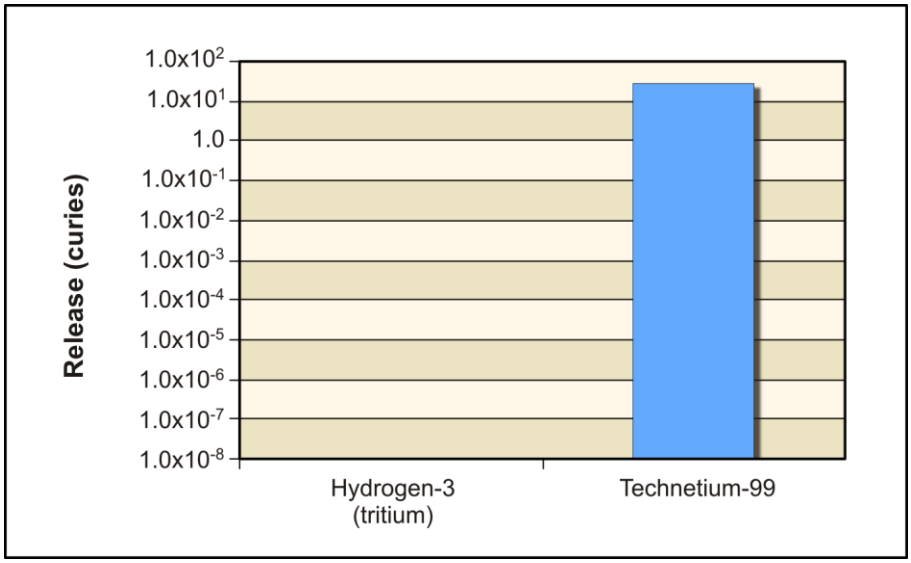


Figure 5–352. FFTF Decommissioning Alternative 2 Releases of Radioactive Constituents of Potential Concern to Groundwater from Sources Inside the Fast Flux Test Facility Barrier

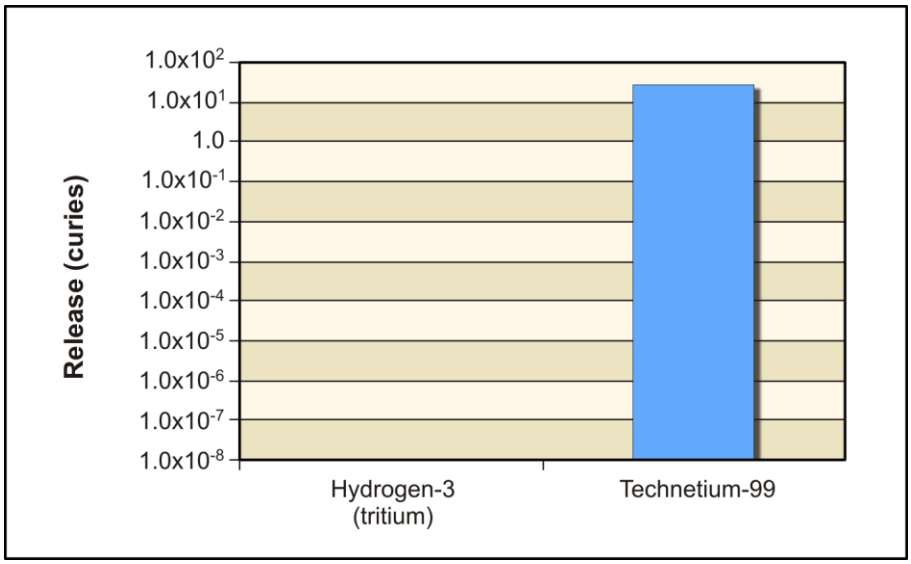


Figure 5–353. FFTF Decommissioning Alternative 2 Releases of Radioactive Constituents of Potential Concern to Columbia River from Sources Inside the Fast Flux Test Facility Barrier

5.2.1.2.4 Analysis of Concentration Versus Time

This section presents the analysis of FFTF Decommissioning Alternative 2 impacts in terms of groundwater concentration versus time at the FFTF barrier and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter (see Figure 5–354). The benchmark concentration of technetium-99 is also shown (900 picocuries per liter). Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over an order of magnitude.

Figure 5–354 shows concentration versus time for technetium-99. The concentration of technetium-99 at the FFTF barrier peaks at about 45 percent of the benchmark around CY 3100. During this time, groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration. Technetium-99 is essentially not a factor at times later than CY 4200.

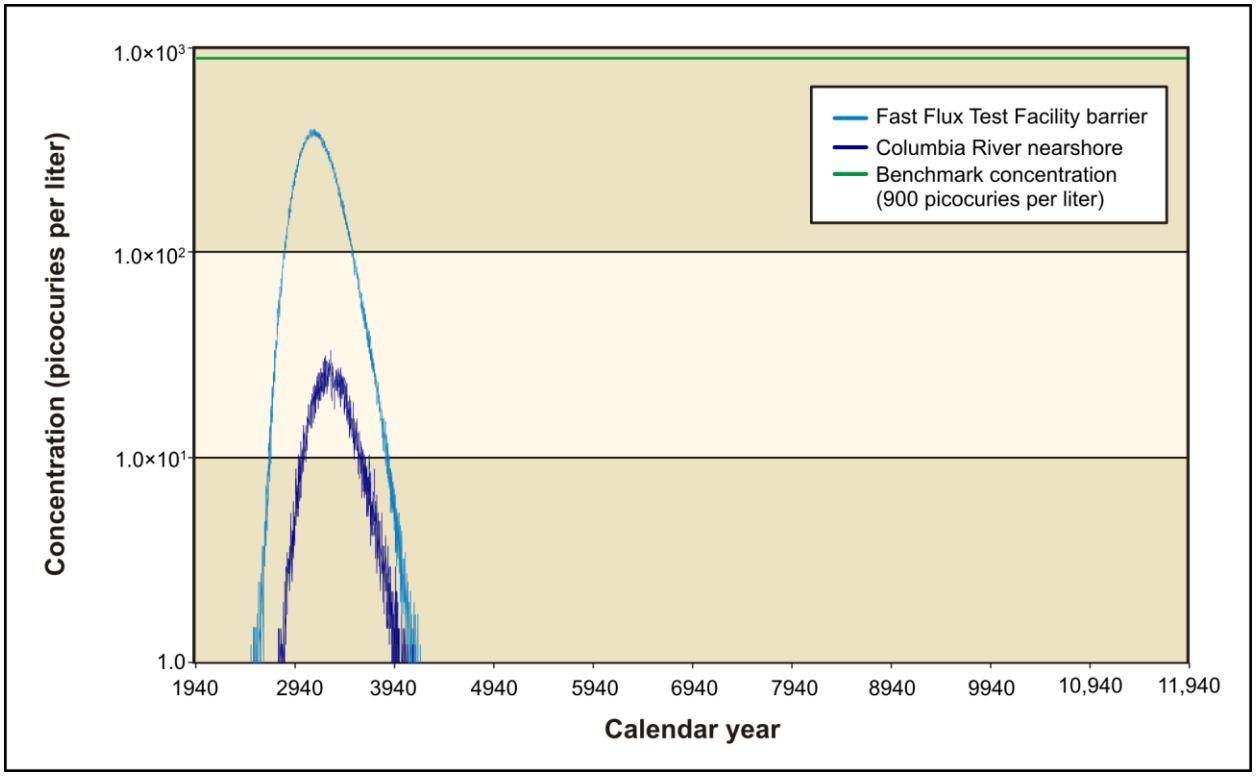


Figure 5–354. FFTF Decommissioning Alternative 2 Technetium-99 Concentration Versus Time

Table 5–83 lists the estimated maximum concentrations of technetium-99 in the peak year at the FFTF barrier and Columbia River nearshore. Technetium-99 concentrations never exceed the benchmark concentration at the FFTF barrier or the Columbia River nearshore during the 10,000-year analysis period.

Table 5–83. FFTF Decommissioning Alternative 2 Maximum COPC Concentrations in the Peak Year at the FFTF Barrier and Columbia River Nearshore

Contaminant	FFTF Barrier	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)			
Technetium-99	401 (3137)	34 (3307)	900

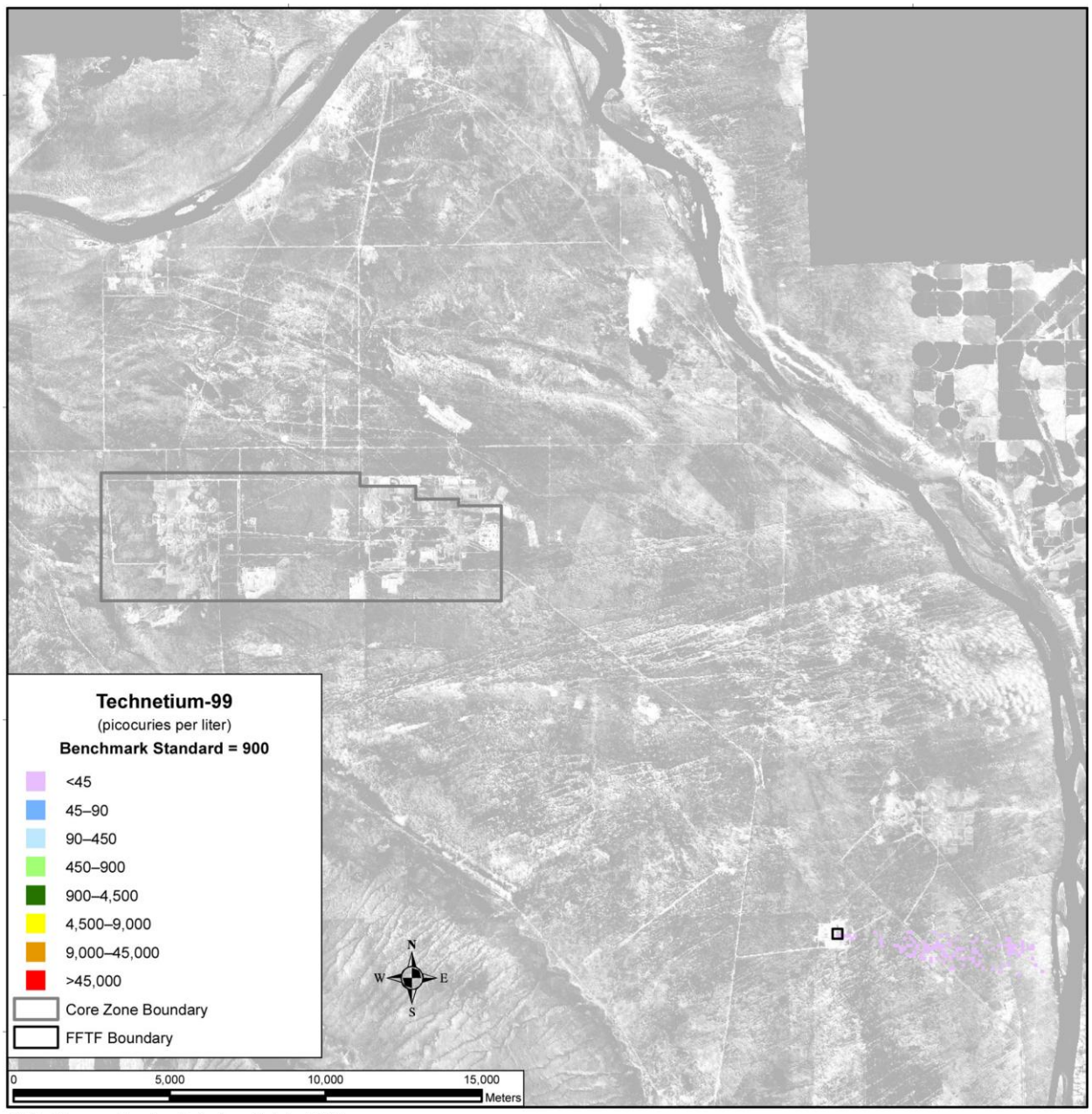
Note: Corresponding calendar years shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

5.2.1.2.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of the spatial distribution of the COPC driver concentrations in groundwater at selected times. Concentrations are in picocuries per liter (see Figure 5–355). Concentrations of technetium-99 are indicated by a color scale that is relative to the benchmark concentration (900 picocuries per liter). Concentrations greater than the

benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration.

Figure 5–355 shows the spatial distribution of the technetium-99 plume in CY 2590, before the time of greatest development of the groundwater plume. Analysis releases from FFTF result in a groundwater concentration plume that extends east from the facility to the Columbia River nearshore. Peak concentrations in this plume are less than one-twentieth of the benchmark in CY 2590.



Note: To convert meters to feet, multiply by 3.281.

Figure 5–355. FFTF Decommissioning Alternative 2 Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2590

5.2.1.2.6 Summary of Impacts

Under FFTF Decommissioning Alternative 2, the impacts of technetium-99 on groundwater are similar to those under FFTF Decommissioning Alternative 1. Technetium-99 concentrations do not exceed benchmark standards at the FFTF barrier or the Columbia River nearshore during the 10,000-year period of analysis. The impacts are greatest around CY 3200.

5.2.1.3 FFTF Decommissioning Alternative 3: Removal

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 3: Removal, including long-term groundwater impacts of contaminant sources within the FFTF barrier. Impacts of sources removed from within the FFTF barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.3.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 3, all above-grade structures within the 400 Area PPA would be removed; additionally, contaminated below-grade structures, equipment, and materials would be removed. Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, two major periods were identified for FFTF Decommissioning Alternative 3, as follows:

- The removal period was assumed to start in CY 2013, when decommissioning activities would begin, and end in CY 2121, following the completion of decommissioning and removal activities and a 100-year postclosure period. It was assumed that there would be no releases from FFTF during this removal period.

- The post-removal period was assumed to start in CY 2122 and continue through the 10,000-year period of analysis until CY 11,940. During this post-removal period, all remaining constituents at FFTF would be available for release to the environment.

5.2.1.3.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 3. These COPCs would become available for release to the environment at the end of the post-removal period in 2121. The total amount of each COPC released to the aquifer would be limited first by the inventory remaining after removal. The removal activities would limit the residual inventories to a much greater extent under FFTF Decommissioning Alternative 3 than under FFTF Decommissioning Alternatives 1 and 2. The maximum residual inventory calculated under FFTF Decommissioning Alternative 3 is for carbon-14, which is approximately 8×10^{-4} curies. The second factor that would limit release to the aquifer is attenuation by retardation and/or radioactive decay. Accounting for both factors, the calculated maximum total release to the aquifer of all COPCs is for technetium-99, which is 4×10^{-6} curies. For all COPCs, the calculated peak rate of release to the aquifer is less than 10^{-8} curies per year, the threshold for evaluating long-term groundwater impacts (see Appendix O). Thus, the analysis predicts no long-term groundwater impacts associated with FFTF Decommissioning Alternative 3 above *de minimis* values.

5.2.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer (i.e., radiological risk). For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects

due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as a Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radioactive and chemical constituents is provided in Appendix K, Section K.1. Screening analysis identified 14 radioactive and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more information on the screening analysis and on results of detailed analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternative.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radioactive and chemical constituents, dose from radioactive constituents, and Hazard Index from chemical constituents—were calculated for each year for 10,000 years for each receptor at three specific locations (i.e., the FFTF barrier, Columbia River nearshore, and Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts expressed as dose and the observation that peak risk and peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose. Also, to summarize time dependence of impacts, time series of lifetime risk are presented only for locations of likely maximum impact, that is, near field barriers and the Core Zone Boundary.

Impacts on human health over the long period following decommissioning of FFTF would be due primarily to the materials left in place following no action, entombment, or removal. Onsite analysis locations comprise the FFTF boundary and the Columbia River nearshore. Offsite analysis locations comprise access points to Columbia River surface water near the site and population centers downstream of the site. Estimates of constituent concentrations in Columbia River surface water are used to calculate the impacts for both offsite location points of analysis. The total population of downstream water users was assumed to be 5 million people for the entire 10,000-year period of analysis (DOE 1987). Four types of receptors are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses either groundwater or surface water for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce approximately 25 percent of average requirements for crops and animal products. The third type, an American Indian resident farmer, also uses either groundwater or surface water for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking water consumption and consumes both wild plant materials, which use groundwater, and game, which use surface water. Members of the offsite population are assumed to have the activity pattern of a residential farmer, using surface water to meet the total annual drinking water requirement and to irrigate a garden that provides approximately 25 percent of annual crop and animal product requirements. These receptors are also assumed to consume fish harvested from the river. Impacts on an individual of the offsite population are the same as those reported in tables in this chapter for the resident farmer at the Columbia River surface-water location.

The significance of dose impacts is evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 458.1, *Radiation Protection of the Public and the Environment*. The level of protection provided for the drinking water pathway is evaluated by comparison with the applicable drinking water standards presented in Section 5.2.1. Population doses are compared against total effective dose equivalent from natural background sources of 311 millirem per year for a member of the population of the United States

(NCRP 2009). The significance of noncarcinogenic chemical impacts is evaluated by comparison against a guideline value of unity for Hazard Index. Estimation of Hazard Index less than unity (1) indicates that observable effects would not occur.

5.2.2.1 FFTF Decommissioning Alternative 1: No Action

This section contains the results for FFTF Decommissioning Alternative 1: No Action. The section includes analysis of long-term human health impacts from sources within the FFTF barrier. Impacts from sources removed from the FFTF barrier and disposed of in an IDF are discussed in Section 5.3, which deals with waste management issues.

Under FFTF Decommissioning Alternative 1, only those actions consistent with previous DOE actions under the National Environmental Policy Act would be completed. Final decommissioning of FFTF would not occur. For analysis purposes, the remaining waste would be available for release to the environment after an institutional control period of 100 years.

Potential human health impacts of this alternative are detailed in Appendix Q and summarized in Tables 5–84 and 5–85. The key radioactive constituent contributor to human health risk would be technetium-99. The chemical risk and hazard drivers were essentially negligible. Neither the dose standards nor the Hazard Index guideline would be exceeded at any location. Population dose is estimated as 1.15×10^{-2} person-rem per year for the year of peak dose. This corresponds to 7.43×10^{-7} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the FFTF barrier is presented in Figure 5–356.

Table 5–84. FFTF Decommissioning Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	7.19×10^{-1}	1.91×10^{-1}	2.47×10^{-5}	0.00	2.47×10^{-5}	1.85	1.95×10^{-1}	8.14×10^{-5}	3.87×10^{-16}	8.14×10^{-5}
Columbia River nearshore	5.57×10^{-2}	7.99×10^{-3}	1.91×10^{-6}	0.00	1.91×10^{-6}	1.43×10^{-1}	8.14×10^{-3}	6.30×10^{-6}	0.00	6.30×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	2.31×10^{-6}	2.09×10^{-7}	1.01×10^{-10}	0.00	1.01×10^{-10}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–85. FFTF Decommissioning Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	3.79	2.03×10^{-1}	1.78×10^{-4}	1.77×10^{-11}	1.78×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	2.93×10^{-1}	8.50×10^{-3}	1.38×10^{-5}	0.00	1.38×10^{-5}	9.58×10^{-4}	3.72×10^{-4}	5.12×10^{-8}	0.00	5.12×10^{-8}
Off Site										
Columbia River	5.33×10^{-6}	2.90×10^{-7}	2.53×10^{-10}	0.00	2.53×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

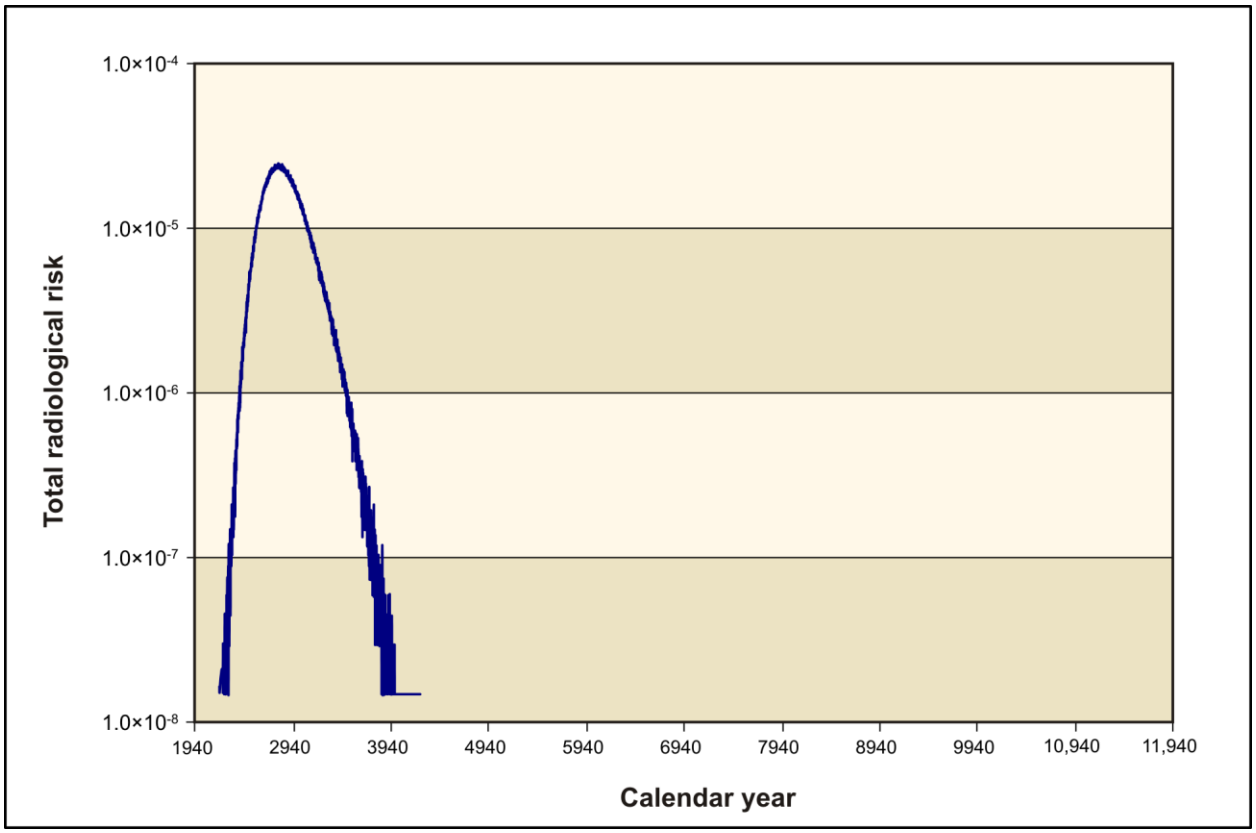


Figure 5–356. FFTF Decommissioning Alternative 1 Time Series of Radiological Risk for the Drinking-Water Well User at the Fast Flux Test Facility Barrier

5.2.2.2 FFTF Decommissioning Alternative 2: Entombment

Under FFTF Decommissioning Alternative 2: Entombment, all aboveground structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the Reactor Containment Building and any other remaining below-grade structures, including the reactor vessel. Impacts from sources removed from the FFTF barrier and disposed of in an IDF are discussed in Section 5.3, which discusses waste management issues.

Potential human health impacts of this alternative are summarized in Tables 5–86 and 5–87 and are detailed in Appendix Q. The key radioactive constituent contributor to human health risk would be technetium-99. The chemical risk and hazard drivers would be essentially negligible. Neither dose standards nor the Hazard Index guideline would be exceeded at any location. Population dose is estimated as 1.15×10^{-2} person-rem per year for the year of peak dose. This corresponds to 7.40×10^{-7} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the FFTF barrier is presented in Figure 5–357.

Table 5–86. FFTF Decommissioning Alternative 2 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	7.02×10^{-1}	0.00	2.42×10^{-5}	0.00	2.42×10^{-5}	1.81	0.00	7.94×10^{-5}	0.00	7.94×10^{-5}
Columbia River nearshore	5.86×10^{-2}	0.00	2.02×10^{-6}	0.00	2.02×10^{-6}	1.51×10^{-1}	0.00	6.63×10^{-6}	0.00	6.63×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	2.30×10^{-6}	0.00	1.01×10^{-10}	0.00	1.01×10^{-10}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–87. FFTF Decommissioning Alternative 2 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	3.70	0.00	1.74×10^{-4}	0.00	1.74×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.09×10^{-1}	0.00	1.45×10^{-5}	0.00	1.45×10^{-5}	1.01×10^{-3}	0.00	5.39×10^{-8}	0.00	5.39×10^{-8}
Off Site										
Columbia River	5.30×10^{-6}	0.00	2.52×10^{-10}	0.00	2.52×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

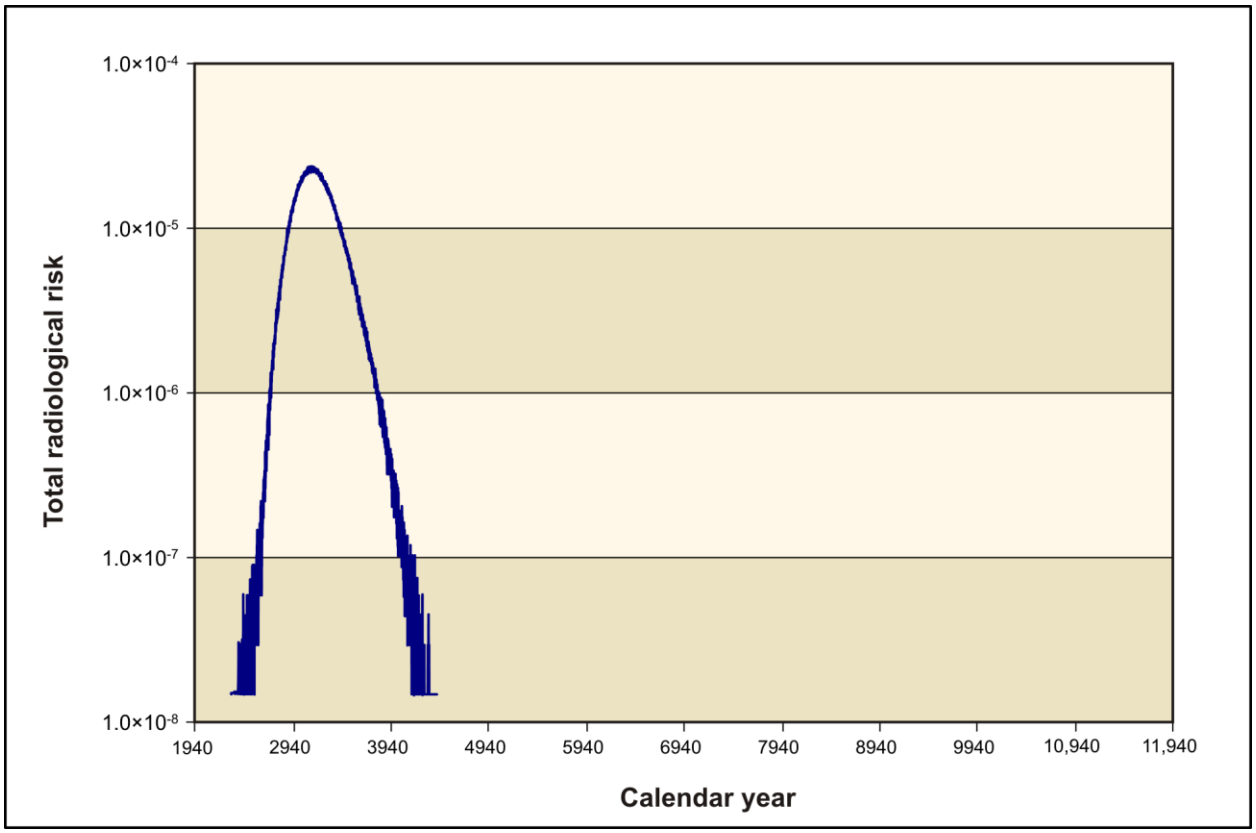


Figure 5–357. FFTF Decommissioning Alternative 2 Time Series of Radiological Risk for the Drinking-Water Well User at the Fast Flux Test Facility Barrier

5.2.2.3 FFTF Decommissioning Alternative 3: Removal

Under FFTF Decommissioning Alternative 3: Removal, nearly all aboveground structures, as well as contaminated below-grade structures, equipment, and materials, would be removed. As a result of the removal of contaminated material, negligible impacts on groundwater, surface water, and human health are predicted.

5.2.2.4 FFTF Decommissioning Intruder Scenario

Intruders are individuals who enter the FFTF area and engage in activity that could cause direct contact with residual contamination in the abandoned or stabilized structures. As in the case of Tank Closure alternatives, two types of receptors and two types of scenarios were considered. The receptor types were the American Indian resident farmer and the resident farmer, and the scenario types were home construction and well drilling. Because the majority of radionuclides in the FFTF area are in hardware at a depth greater than that of the foundation for a home, the home construction scenario was screened from the analysis. Also, sensitivity analysis determined that in all cases for residential agriculture, impacts on the American Indian resident farmer exceeded impacts on the resident farmer. Because inhalation and external exposure are the only exposure modes for the well-drilling worker, impacts on the worker involved in well drilling would be the same for the resident farmer and American Indian resident farmer. For the FFTF area, estimates of inventory indicate that the greatest hazard is due to quantities of the long-lived radionuclides carbon-14, technetium-99, and isotopes of uranium remaining at the site. Relatively small amounts of short-lived radionuclides are estimated to remain at the site. Consequently, impacts of intrusion in the FFTF area are represented by the well-drilling scenario, in which a worker inhales dust and receives external radiation while drilling the well and an American Indian resident

farmer contacts residual contamination brought to the surface during development of the well. The impacts under this intrusion scenario for the three FFTF Decommissioning alternatives are summarized in Table 5–88 for the drilling worker and American Indian resident farmer intruders. Resident farmer impacts are dominated by exposure to carbon-14, while for the worker, carbon-14, technetium-99, and uranium isotopes contribute to dose through the direct external and inhalation pathways. For both the resident farmer and drilling worker, impacts are presented as dose for the year of peak dose. Because radionuclides appearing due to decay and ingrowth did not have major contributions to dose, the year of peak dose occurs immediately after loss of institutional control. The DOE intruder dose guideline of 500 millirem is not exceeded under any alternative.

Table 5–88. Doses to a Well-Drilling Worker and an American Indian Engaged in Residential Agriculture Following Well Drilling at the FFTF Area

	Dose (rem per year)		
	FFTF Decommissioning Alternative		
Receptor	1	2	3
Worker	4.5×10^{-6}	4.5×10^{-6}	2.7×10^{-14}
Resident farmer	1.1×10^{-3}	1.1×10^{-3}	1.4×10^{-8}

Key: FFTF=Fast Flux Test Facility.

5.2.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under the FFTF Decommissioning alternatives. Risk indices—Hazard Quotient and Hazard Index—were calculated by comparing the predicted dose with the benchmark dose (see Appendix P). Risk indices could not be calculated for lizards, toads, or birds exposed to organic compound COPCs released under the FFTF Decommissioning alternatives because there are no toxicity reference values for such receptors for these COPCs. Risk indices for air emissions were calculated for FFTF Decommissioning Alternative 1 and for the Hanford Option and Hanford Reuse Option and the Idaho Option and Idaho Reuse Option (also referred to as "Hanford Option/Reuse Option" and "Idaho Option/Reuse Option") under FFTF Decommissioning Alternatives 2 and 3. Although the disposition of RH-SCs and bulk sodium could occur at either Hanford or INL under FFTF Decommissioning Alternatives 2 and 3 (e.g., Hanford Option and Idaho Reuse Option, Idaho Option and Hanford Reuse Option), risk indices were calculated only for the Hanford Option/Reuse Option, the scenario with the greatest impact on ecological resources from releases to air at Hanford, and for the Idaho Option/Reuse Option, the scenario with the least impact on ecological resources from releases to air at Hanford. Releases to air would still occur at Hanford under the Idaho Option/Reuse Option due to activities that would occur at FFTF regardless of where the RH-SCs or bulk sodium is sent for disposition. Separate risk indices for air emissions were not calculated for the three components of each alternative: disposition of facilities, RH-SCs, and bulk sodium. Calculated risk indices for the COPC with the highest Hazard Quotient or Hazard Index for each receptor are presented.

Releases to air are expected from leaving the deactivated FFTF and associated facilities and components in place under the No Action Alternative (FFTF Decommissioning Alternative 1) and facility disposition under FFTF Decommissioning Alternatives 2 and 3. Releases to air associated with the disposition of RH-SCs and bulk sodium are expected under FFTF Decommissioning Alternatives 2 and 3 at Hanford under the Hanford Option/Reuse Option and the Idaho Option/Reuse Option and under FFTF Decommissioning Alternatives 2 and 3 at INL under the Idaho Option/Reuse Option. The impacts on ecological resources were evaluated for the combined releases to air from the disposition of RH-SCs and bulk sodium. The estimated impacts are identical under FFTF Decommissioning Alternatives 2 and 3 because the options for RH-SC disposition and bulk sodium disposition are identical under the two

alternatives. Releases to groundwater are expected under all FFTF Decommissioning alternatives—No Action, Entombment, and Removal.

The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources due to releases to groundwater were evaluated at the Columbia River.

5.2.3.1 FFTF Decommissioning Alternative 1: No Action

The FFTF Decommissioning No Action Alternative is not expected to result in releases of radionuclides to air. Releases of chemicals to air are expected due to deactivation activities under FFTF Decommissioning Alternative 1 (see Section 5.2 and Chapter 2, Section 2.3). The calculated risks to plants, the Great Basin pocket mouse, and the coyote from air releases under FFTF Decommissioning Alternative 1 (and Alternative Combination 1) are the highest of all Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Predicted emissions of COPCs to air under FFTF Decommissioning Alternative 1 pose a small risk to plants (Hazard Quotient is 47) and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–89). The chemical COPCs released to air with the largest calculated Hazard Quotients for the Great Basin pocket mouse are xylene (2120), toluene (338), formaldehyde (79), and benzene (17) at the onsite maximum-exposure location. The coyote has the next-largest calculated Hazard Quotient for the chemical COPC xylene (269).

Table 5–89. FFTF Decommissioning Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

FFTF Decommissioning Alternative	Hazard Quotient of Worst-Case Chemical COPC by Receptor			
	Plants	Great Basin Pocket Mouse	Coyote	Mule Deer
	Toluene	Xylene	Xylene	Formaldehyde
1	4.68×10^{1}	**2.12×10^{3}**	2.69×10^{2}	4.79×10^{1}
2, Hanford Option/Reuse Option	1.64×10^{-1}	**7.63**	9.69×10^{-1}	6.13×10^{-1}
2, Idaho Option/Reuse Option	7.81×10^{-2}	**3.71**	4.71×10^{-1}	4.17×10^{-1}
3, Hanford Option/Reuse Option	1.65×10^{-1}	**7.68**	9.75×10^{-1}	5.84×10^{-1}
3, Idaho Option/Reuse Option	7.96×10^{-2}	**3.76**	4.78×10^{-1}	3.88×10^{-1}

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text. Results are not available for other terrestrial receptors: side-blotched lizard, mourning dove, western meadowlark, and burrowing owl.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

No risk to terrestrial, riparian, or aquatic ecological receptors from releases to air is predicted under FFTF Decommissioning Alternative 1 at the offsite maximum-exposure location (Columbia River). The only estimated Hazard Quotient exceeding 1 is xylene for the mouse (2.4).

Predicted emissions of chemical and radioactive COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (a Hazard Quotient of 0.029) for groundwater releases under FFTF Decommissioning Alternative 1 (see Table 5–90) is that calculated for exposure to uranium for mammals eating fish (the raccoon) at the Columbia River. This indicates no risk to ecological receptors from chemical or radioactive COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 1.

Table 5–90. FFTF Decommissioning Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Receptors at the Columbia River

FFTF Decommissioning Alternative	Hazard Quotient of Highest-Value COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Technetium-99	Uranium[a]					
1	2.20×10^{-7}	2.73×10^{-5}	1.30×10^{-2}	2.91×10^{-2}	1.28×10^{-3}	8.07×10^{-5}	5.46×10^{-3}
2	2.32×10^{-7}	0	0	0	0	0	0
3	8.78×10^{-14}	0	0	0	0	0	0

[a] Uranium as chemical.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; Rad.=radioactive.

5.2.3.2 FFTF Decommissioning Alternative 2: Entombment

Under FFTF Decommissioning Alternative 2, long-term impacts on ecological resources were evaluated for releases relative to air and groundwater at Hanford and releases to air at INL associated with the disposition of FFTF and associated facilities, RH-SCs, and bulk sodium.

Predicted emissions of COPCs in air at Hanford under FFTF Decommissioning Alternative 2 (Hanford Option/Reuse Option or Idaho Option/Reuse Option) do not pose a risk to ecological receptors. The chemical COPC with the largest calculated Hazard Quotient for air releases is xylene for the mouse (7.6) at the onsite maximum-exposure location under the Hanford Option/Reuse Option (see Table 5–89). Hazard Quotients calculated for chemical COPCs released to air under FFTF Decommissioning Alternative 2, Idaho Option/Reuse Option, are about half as large as those under the Hanford Option/Reuse Option. The largest Hazard Index (2.0×10^{-4}) for radioactive COPCs released to air under FFTF Decommissioning Alternative 2, Hanford Option/Reuse Option (see Appendix P, Table P–3), is predicted for the coyote at the onsite maximum-exposure location, with sodium-22 as the primary contributor. This Hazard Index, much smaller than 1, indicates no risk from radioactive COPCs released to air at Hanford under FFTF Decommissioning Alternative 2 for either the Hanford Option/Reuse Option or the Idaho Option/Reuse Option. Also, no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air is predicted under FFTF Decommissioning Alternative 2 at the offsite maximum-exposure location (Columbia River) under both the Hanford Option/Reuse Option and Idaho Option/Reuse Option.

Although risk indices were not calculated for ecological receptors at INL, the relative magnitude of emissions there suggests little to no risk. For the disposition of RH-SCs and bulk sodium under FFTF Decommissioning Alternative 2, Idaho Option/Reuse Option, the predicted peak annual emissions of tritium (5.72 curies per year), cesium-137 (3.3×10^{-4} curies per year), and uranium (9.5×10^{-8} curies per year) at INL are orders of magnitude smaller than the maximum emissions at Hanford under any *TC & WM EIS* alternative (1.22×10^{3} curies per year for tritium, 2.5×10^{2} curies per year for cesium-137, and 3.7×10^{-2} curies per year for uranium) (see Table 5–91). Because predicted emissions of COPCs do not pose a risk to ecological receptors at Hanford, the smaller rates at INL are unlikely to pose a risk to similar ecological receptors with similar exposure pathways.

Predicted emissions of chemical and radioactive COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (Hazard Index of 0.000007) for groundwater releases under FFTF Decommissioning Alternative 2 (see Table 5–90) is that calculated for total internal and external exposure to all radioactive COPCs for mammals eating fish (the least weasel) at the Columbia River. This indicates no risk to ecological receptors from chemical or radioactive COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 2.

5.2.3.3 FFTF Decommissioning Alternative 3: Removal

Under FFTF Decommissioning Alternative 3, long-term impacts on ecological resources were evaluated for releases relative to air and groundwater at Hanford and releases to air at INL associated with the disposition of FFTF and associated facilities, RH-SCs, and bulk sodium.

Predicted emissions of COPCs in air at Hanford under FFTF Decommissioning Alternative 3 (Hanford Option/Reuse Option or Idaho Option/Reuse Option) are similar to those under FFTF Decommissioning Alternative 2 and do not pose a risk to ecological receptors. The chemical COPC with the largest calculated Hazard Quotient (xylene, 7.68) is for the mouse at the onsite maximum-exposure location (see Table 5–89). Hazard Quotients calculated for chemical COPCs released to air under FFTF Decommissioning Alternative 3, Idaho Option/Reuse Option, are about half as large as those under the Hanford Option/Reuse Option. The largest Hazard Index (2.0×10^{-4}) for radioactive COPCs released to air under FFTF Decommissioning Alternative 3, Hanford Option/Reuse Option (see Appendix P,

Table P–3), is predicted for the coyote at the onsite maximum-exposure location, primarily from sodium-22. This indicates no risk from radioactive COPCs released to air at Hanford under FFTF Decommissioning Alternative 3, either Hanford Option/Reuse Option or Idaho Option/Reuse Option. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under FFTF Decommissioning Alternative 3 at the offsite maximum-exposure location (Columbia River).

Although risk indices were not calculated for ecological receptors at INL, the relative magnitude of emissions there suggests little to no risk. For the disposition of RH-SCs and bulk sodium under FFTF Decommissioning Alternatives 2 and 3, Idaho Option/Reuse Option, the predicted peak annual emissions of tritium (5.72 curies per year), cesium-137 (3.30×10^{-4} curies per year), and uranium (9.5×10^{-8} curies per year) at INL are orders of magnitude smaller than the maximum emissions at Hanford under any *TC & WM EIS* alternative (2.02×10^{3} curies per year for tritium, 2.50×10^{2} curies per year for cesium-137, and 3.7×10^{-2} curies per year for uranium). The emissions of COPCs at INL would be smaller than the maximum emissions at Hanford under the Tank Closure, FFTF Decommissioning, and Waste Management alternatives (see Table 5–91). Because predicted emissions of COPCs under FFTF Decommissioning Alternative 3 do not pose a risk to ecological receptors at Hanford, the smaller rates at INL are unlikely to pose a risk to similar ecological receptors with similar exposure pathways.

Table 5–91. Comparison of Peak Annual Emission Rates at INL Under FFTF Decommissioning Alternatives 2 and 3 and at Hanford Under Tank Closure, FFTF Decommissioning, and Waste Management Alternatives

Constituent of Potential Concern	INL	Hanford	Alternative
Radionuclide (curies per year)			
Hydrogen-3 (tritium)	5.72	2.02×10^{3}	Tank Closure 1 and 2A
Cesium-137	3.30×10^{-4}	2.50×10^{2}	Tank Closure 6B
Uranium (all isotopes)	9.51×10^{-8}	3.69×10^{-2}	Tank Closure 1 and 2A
Chemical (grams per year)			
Sulfur dioxide	1.19×10^{4}	2.23×10^{7}	Waste Management 2 (Disposal Groups 2 and 3)
Toluene	1.71×10^{4}	2.85×10^{7}	Waste Management 2 (Disposal Groups 2 and 3)
Xylene	4.87×10^{3}	8.45×10^{6}	Waste Management 2 (Disposal Groups 2 and 3)
1,3-Butadiene	1.55×10^{1}	1.07×10^{5}	Waste Management 2 (Disposal Groups 2 and 3)
Mercury	0	N/A	N/A
Formaldehyde	0	N/A	N/A

Note: To convert grams to ounces, multiply by 0.03527.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; N/A=not applicable because constituent not released at INL.

Predicted emissions of chemical and radioactive COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (a Hazard Index of 0.000000000002) for groundwater releases under FFTF Decommissioning Alternative 3 is that calculated for total internal and external exposure to all radioactive COPCs for mammals eating fish (the least weasel) at the Columbia River. This indicates no risk to ecological receptors from chemical or radioactive COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 3.

5.2.4 Environmental Justice

Sections 5.2.1 and 5.2.2 evaluate groundwater impacts and associated potential long-term human health effects under the FFTF Decommissioning alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a minority or low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. (See Appendix Q, Section Q.2.4.1, for assumed consumption levels for the different receptors.) The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from that of the American Indian resident farmer. The American Indian hunter gatherer would not cultivate crops, but rather would gather food from indigenous plants and harvest a larger amount of fish from the Columbia River, drink no milk, consume no eggs, and drink a larger amount of water (water that would be gathered from potentially contaminated surface-water sources); thus, the receptor was assumed to be exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Appendix Q, Section Q.2.2.

Long-term human health impacts of FFTF decommissioning actions would be greatest under FFTF Decommissioning Alternative 1. Under this alternative, none of the hypothetical receptors at any of the assessment boundaries would be exposed to radiation doses in excess of regulatory limits or to chemicals with a Hazard Index greater than 1. The greatest risk would be to the American Indian resident farmer at the FFTF boundary. During the year of peak dose, this receptor would receive a radiation dose of 3.8 millirem, compared with the regulatory limit of 100 millirem from all sources. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index less than 1. Therefore, none of the FFTF Decommissioning alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations.