APPENDIX U
SUPPORTING INFORMATION FOR THE LONG-TERM CUMULATIVE IMPACT ANALYSES

This appendix contains detailed information supporting the long-term cumulative impact analyses presented in Chapter 6. Long-term cumulative impacts would occur following the active project phase under each alternative. For this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*, long-term cumulative impacts were assessed out to approximately 10,000 years in the future.

Cumulative Impacts

Effects on the environment that result from the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (40 CFR 1508.7).

This section presents detailed information regarding long-term cumulative impacts on groundwater quality and human health. The methodology used to estimate cumulative impacts for this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* was divided into four phases: (1) selection of resource areas and appropriate regions of influence (ROIs), (2) selection of reasonably foreseeable future actions, (3) estimation of cumulative impacts, and (4) identification of monitoring and mitigation requirements. The general cumulative impacts methodology is described in Appendix R. A flowchart showing the four phases of cumulative impacts analysis is presented in Appendix R, Figure R–2. The information presented in this appendix reflects portions of Phases 2 and 3 and contains detailed information to support the long-term cumulative impacts analysis presented in Chapter 6.

The cumulative impact analyses of these resource areas were based largely on the results of the modeling performed for the cumulative groundwater quality analysis. Inventory development for the past, present, and reasonably foreseeable future action (non–*TC & WM EIS*) sources is described in Appendix S. Appendix S also describes the non–*TC & WM EIS* actions in the ROIs that were considered in the cumulative impact analyses of groundwater quality and human health.

U.1 GROUNDWATER QUALITY

This section discusses the methodology and results for the long-term groundwater impacts of non–*TC & WM EIS* actions. The methodology is described in Section U.1.1, and the results are discussed in Sections U.1.2 through U.1.4. The presentation of the results follows the format developed for the *TC & WM EIS* alternatives (see Appendix O and Chapter 5). This section does not present cumulative groundwater quality impacts (i.e., non–*TC & WM EIS* impacts added to the impacts of the *TC & WM EIS* alternative combinations). Cumulative groundwater quality impacts are presented in Chapter 6.

U.1.1 Methodology

The purpose of the long-term groundwater impacts analysis for non–*TC & WM EIS* sources is to provide a context for the comparison of the *TC & WM EIS* alternatives. Therefore, the methodology was designed to be fully consistent with the long-term groundwater alternatives analysis and the *Technical Guidance Document for Tank Closure Environmental Impact Statement, Vadose Zone and Groundwater Revised Analyses* (DOE 2005). This design consistency includes the models chosen to conduct the analysis, the parameter selection that affects the analysis, and the presentation and interpretation of the results.

The development of the inventory for the non–*TC & WM EIS* sources is described in Appendix S. The constituents of potential concern (COPCs) considered in this analysis include all the COPCs in the *TC & WM EIS* alternatives analysis, as well as several COPCs that originate from only non–*TC & WM EIS* sources. The inventory development relied on a search of available literature that provided estimates of the inventories for each source, estimates of uncertainties in the inventories, and a characterization of each source type and likely end state.

The approach to analyzing releases to the vadose zone for the non–*TC & WM EIS* sources was the same as that described in Appendix M for the *TC & WM EIS* alternatives. This analysis used site-specific parameters to estimate release rates from each of the sources to the vadose zone. The waste-form performance parameters, release models, and infiltration profiles in the release to vadose zone analysis are fully consistent with their counterparts in the *TC & WM EIS* alternatives analysis. The output from the analysis of the releases to the vadose zone was input into the vadose zone transport analysis.

The vadose zone transport analysis methodology for the non–*TC & WM EIS* sources was the same as that described in Appendix N for the *TC & WM EIS* alternatives. The vadose zone transport analysis used the STOMP [Subsurface Transport Over Multiple Phases] model to solve the nonlinear equations describing water and contaminant mass transport through the vadose zone. A fully three-dimensional model of the subsurface geology for each of the non–*TC & WM EIS* sources was developed using the same techniques that were used in the *TC & WM EIS* alternatives analysis. The material properties, infiltration profiles, and transport properties used in the vadose zone analysis are fully consistent with the *TC & WM EIS* alternatives analysis. The output from the vadose zone transport analysis was input into the groundwater transport analysis.

The methodology used for groundwater transport impacts analysis for non–*TC & WM EIS* sources was the same as that described in Appendices L and O for the *TC & WM EIS* alternatives. Appendix L discusses the development of the Base Case groundwater flow field, which describes the direction and rate of water movement in the aquifer. This Base Case flow field was used for both the *TC & WM EIS* alternatives analysis and the non–*TC & WM EIS* sources analysis. Appendix O discusses the use of the particle-tracking method to calculate a fully three-dimensional, regional-scale transient analysis of contaminant distribution in the aquifer. The flow field, transport properties, and concentration measurement parameters in the groundwater transport analysis are fully consistent with the *TC & WM EIS* alternatives analysis. The outputs from the groundwater transport analysis were analyzed in terms of overall mass balance, concentration versus time at selected locations, and concentration distributions at selected times, which is the same process used for the alternatives impact analysis. The level of protection provided for the drinking water pathway is evaluated by comparison against the maximum contaminant levels of the "National Primary Drinking Water Regulations" (40 CFR 141) and other benchmarks presented in Appendix O.

U.1.2 Release and Mass Balance

This section presents the results of the impacts analysis for non–*TC & WM EIS* sources in terms of total amount of COPCs released to the vadose zone, groundwater, and Columbia River. Releases of radionuclides are totaled in curies, and releases of chemicals are totaled in kilograms. Both are totaled over the 10,000-year period of analysis. Table U–1 lists the releases to the vadose zone, groundwater, and Columbia River for the COPCs that contribute the bulk of the risk.

Table U–1. Release to the Vadose Zone, Groundwater, and the Columbia River of the COPC Drivers from Non–*TC & WM EIS* Sources

	Radionuclide (curies)				Chemical (kilograms)		
Release to:	**H-3**	**I-129**	**Tc-99**	**U-238**	**Cr**	**NO_3**	**Utot**
Vadose zone	3.43×10^{6}	2.49×10^{1}	7.33×10^{2}	3.13×10^{3}	3.35×10^{5}	7.38×10^{7}	2.53×10^{5}
Groundwater	2.06×10^{6}	2.48×10^{1}	7.12×10^{2}	1.48×10^{2}	3.40×10^{5}	7.42×10^{7}	1.05×10^{5}
Columbia River	1.11×10^{5}	2.46×10^{1}	7.26×10^{2}	1.40×10^{2}	3.51×10^{5}	7.47×10^{7}	9.28×10^{4}

Note: Total amount released over the 10,000-year period of analysis.

Key: COPC = constituent of potential concern; Cr=chromium; H-3=hydrogen-3 (tritium); I=iodine; NO_3=nitrate; Tc=technetium; *TC & WM EIS = Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; U=uranium; Utot=total uranium.

U.1.3 Concentration Versus Time

This section presents the results of the impacts analysis for non–*TC & WM EIS* sources in terms of groundwater COPC concentrations versus time at the Core Zone Boundary and Columbia River. Table U–2 lists the maximum COPC concentrations at the Core Zone Boundary and the Columbia River nearshore for the peak year of the 10,000-year period of analysis. Figures U–1 through U–9 include concentration versus time plots for hydrogen-3 (tritium), iodine-129, strontium-90, technetium-99, uranium-238, carbon tetrachloride, chromium, nitrate, and total uranium, respectively. Because of the discrete nature of the concentrations carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentrations is included on several of these figures. This confidence interval was calculated to aid in interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when (1) the concentration had a considerable amount of noise, (2) the concentration trend was level, and (3) the concentration was near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude.

Table U–2. Maximum Peak Year Concentrations of the COPCs from Non–*TC & WM EIS* Sources at the Core Zone Boundary and the Columbia River Nearshore

Contaminant	Core Zone Boundary (peak year)	Columbia River Nearshore (peak year)	Benchmark Concentration[a]
Radionuclide (picocuries per liter)			
Hydrogen-3 (tritium)	104,000,000 (1996)	4,190,000 (1986)	20,000
Carbon-14	46,700 (1998)	196 (2013)	2,000
Strontium-90	181,000 (1998)	4,160,000 (1991)	8
Technetium-99	1,230 (3301)	2,830 (1999)	900
Iodine-129	50.9 (4043)	9.1 (4540)	1
Cesium-137	0[b] (1997)	1,310,000 (1985)	200
Uranium isotopes (includes U-233, -234, -235, -238)	2,200 (1991)	22,400 (1973)	15
Neptunium-237	114 (2066)	16 (2004)	15
Plutonium isotopes (includes Pu-239, -240)	2,660 (11,848)	4,250 (2983)	15

Table U–2. Maximum Peak Year Concentrations of the COPCs from Non–*TC & WM EIS* Sources at the Core Zone Boundary and the Columbia River Nearshore *(continued)*

Contaminant	Core Zone Boundary (peak year)	Columbia River Nearshore (peak year)	Benchmark Concentration[a]
Chemical (micrograms per liter)			
1-Butanol	17,200 (1998)	49 (11,243)	3,600
Carbon tetrachloride	3,350 (2270)	60.7 (2527)	5
Chromium[c]	2,540 (2216)	16,100 (1978)	100
Dichloromethane	0.7 (3286)	0.1 (4711)	5
Fluoride	90,200 (2003)	14,500 (1982)	4,000
Hydrazine/hydrazine sulfate	0.030 (3343)	0.088 (3627)	0.022
Lead	0[b] (2021)	9,080 (2374)	15
Manganese	392 (8610)	242 (2286)	1,600
Mercury	183 (2015)	25.5 (1997)	2
Nickel (soluble salts)	0[b] (11,871)	8,310 (3877)	700
Nitrate	1,020,000 (2269)	502,000 (1973)	45,000
Total uranium	3,290 (1991)	15,400 (1964)	30
Trichloroethylene (TCE)	0.1 (3404)	0.2 (3764)	5

[a] The sources of the benchmark concentrations are provided in Appendix O, Section O.3.
[b] Values that are less than 0.001 are reported as zero.
[c] It was assumed, for the purposes of analysis, that all chromium was hexavalent.
Note: Peak concentrations for some non–*TC & WM EIS* source constituents occur in the past. The relationship of past to future non–*TC & WM EIS* source constituent concentrations is presented in the concentration versus time plots in Figures U–1 through U–9.
Key: COPC=constituent of potential concern; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

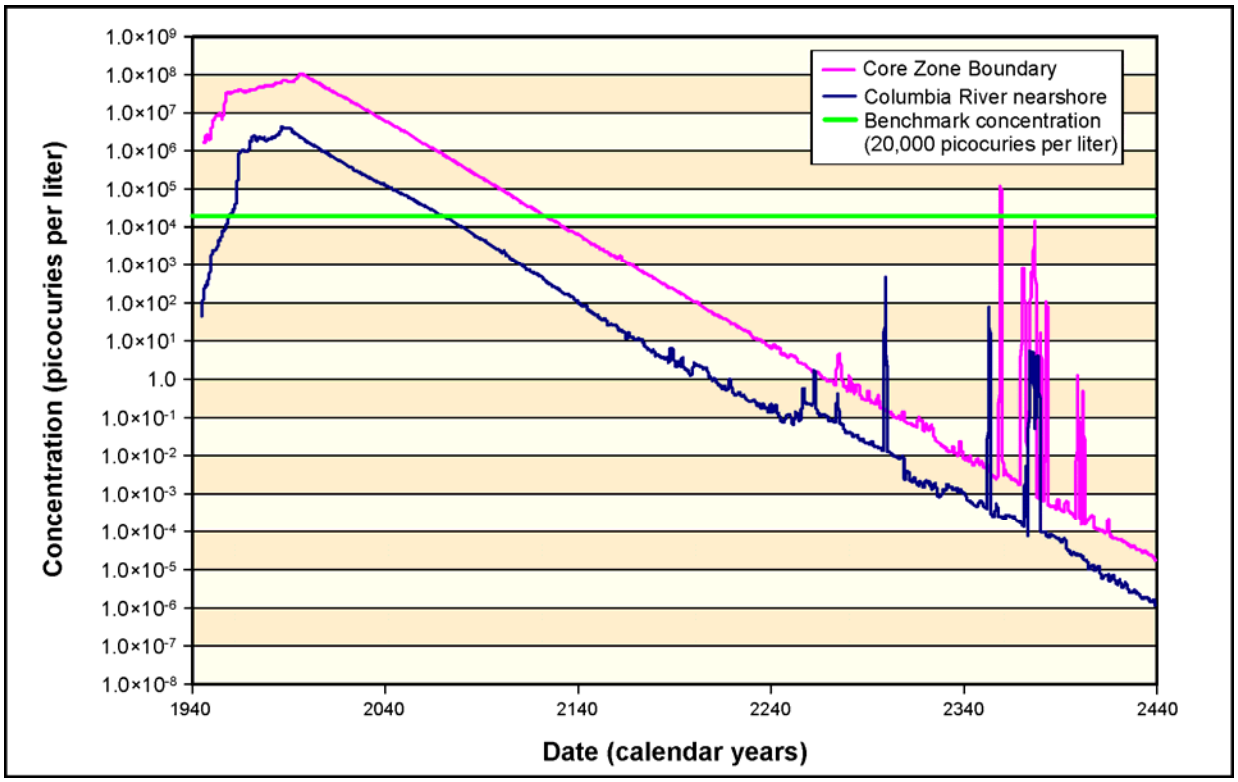


Figure U–1. Hydrogen-3 (Tritium) Concentration Versus Time (Non–*TC & WM EIS* Sources)

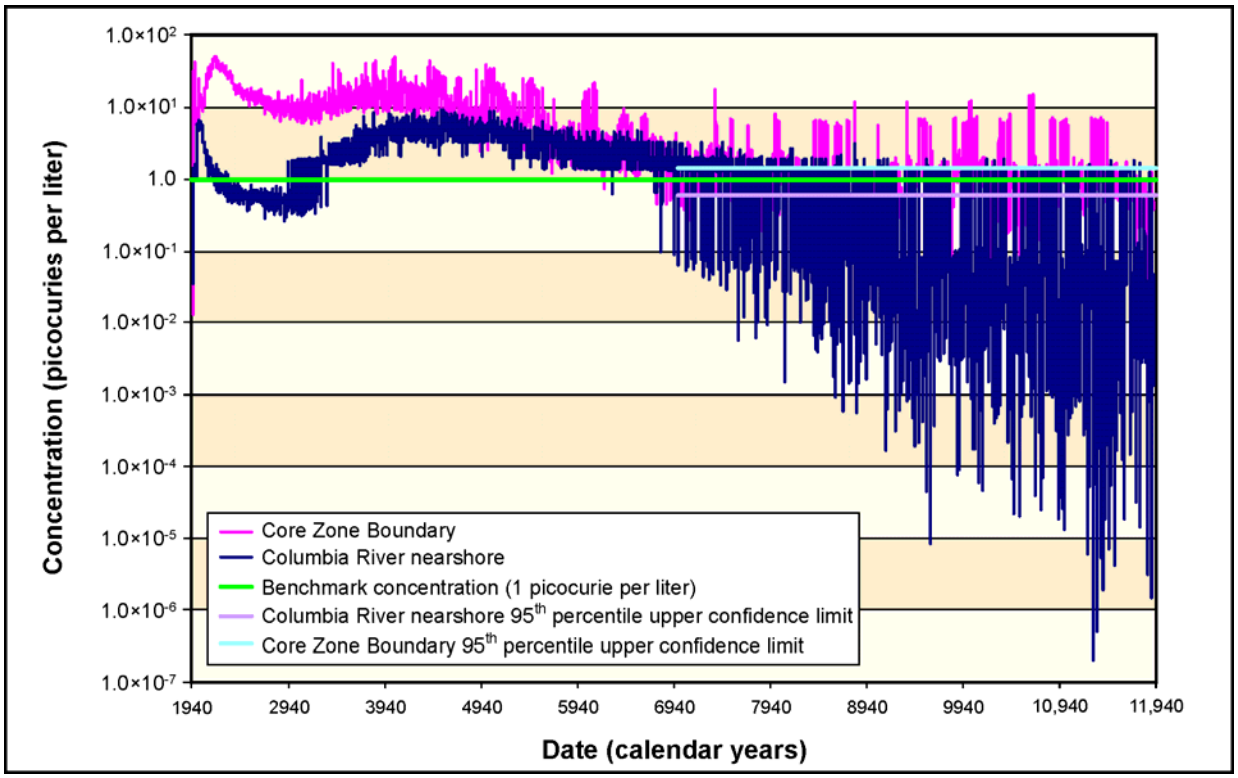


Figure U–2. Iodine-129 Concentration Versus Time (Non–*TC & WM EIS* Sources)

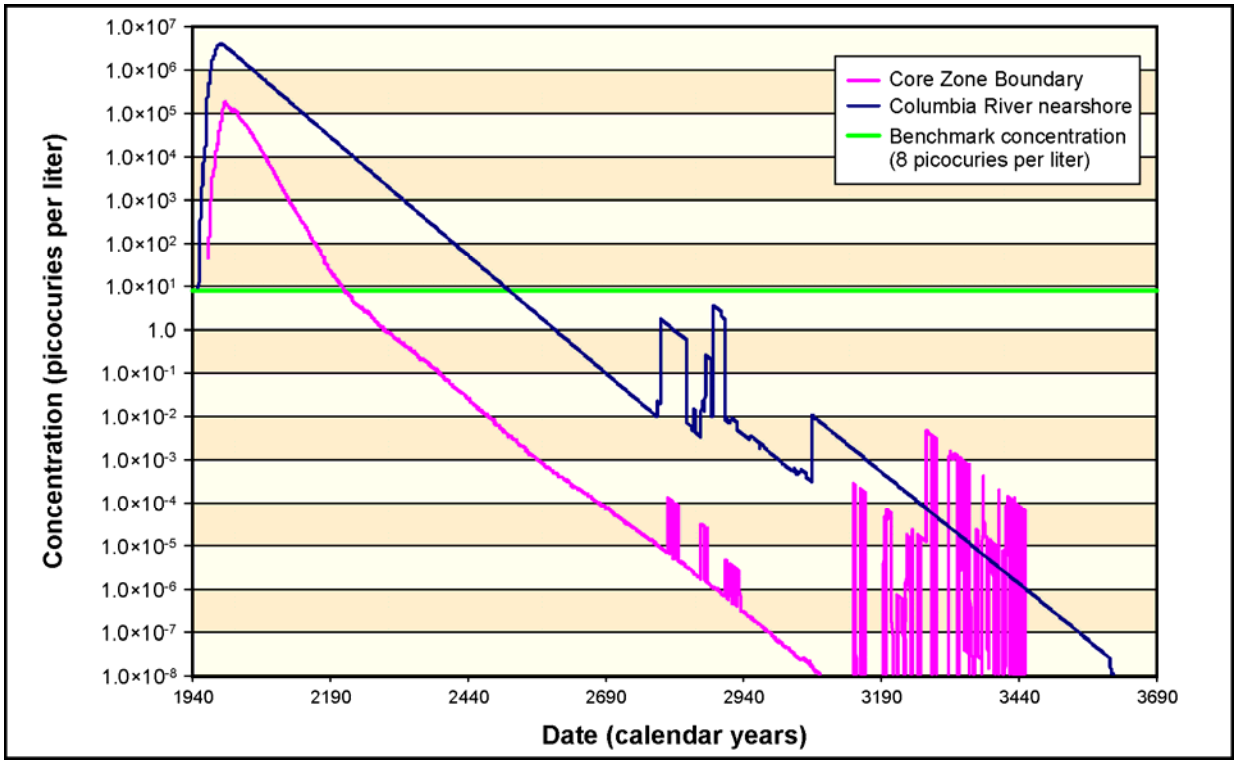


Figure U–3. Strontium-90 Concentration Versus Time (Non–*TC & WM EIS* Sources)

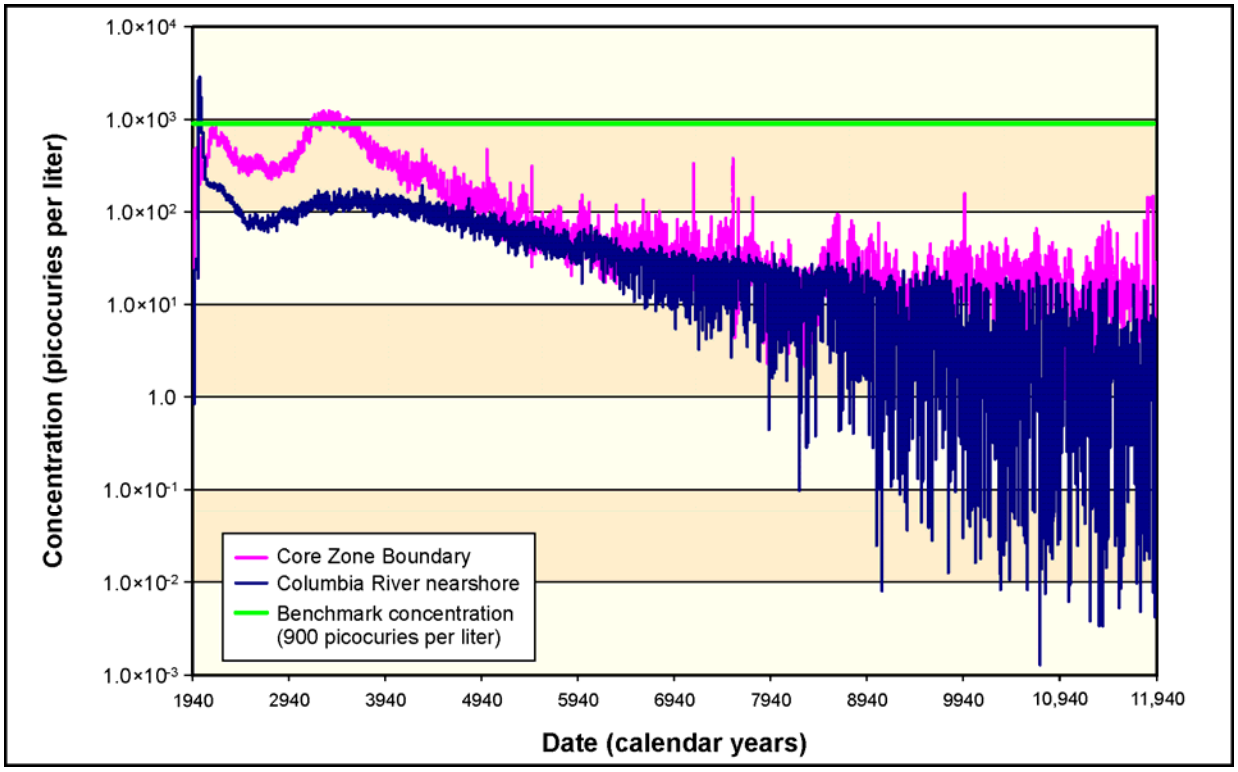


Figure U–4. Technetium-99 Concentration Versus Time (Non–*TC & WM EIS* Sources)

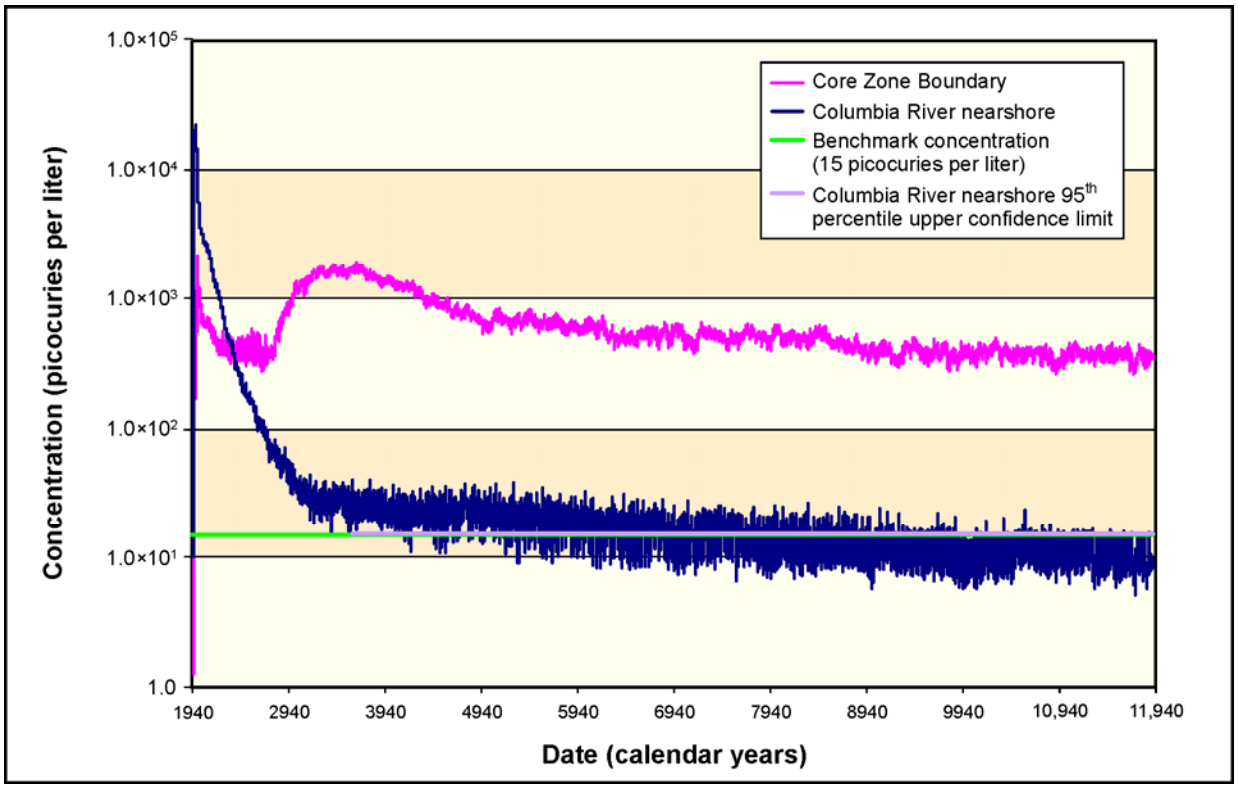


Figure U–5. Uranium-238 Concentration Versus Time (Non–*TC & WM EIS* Sources)

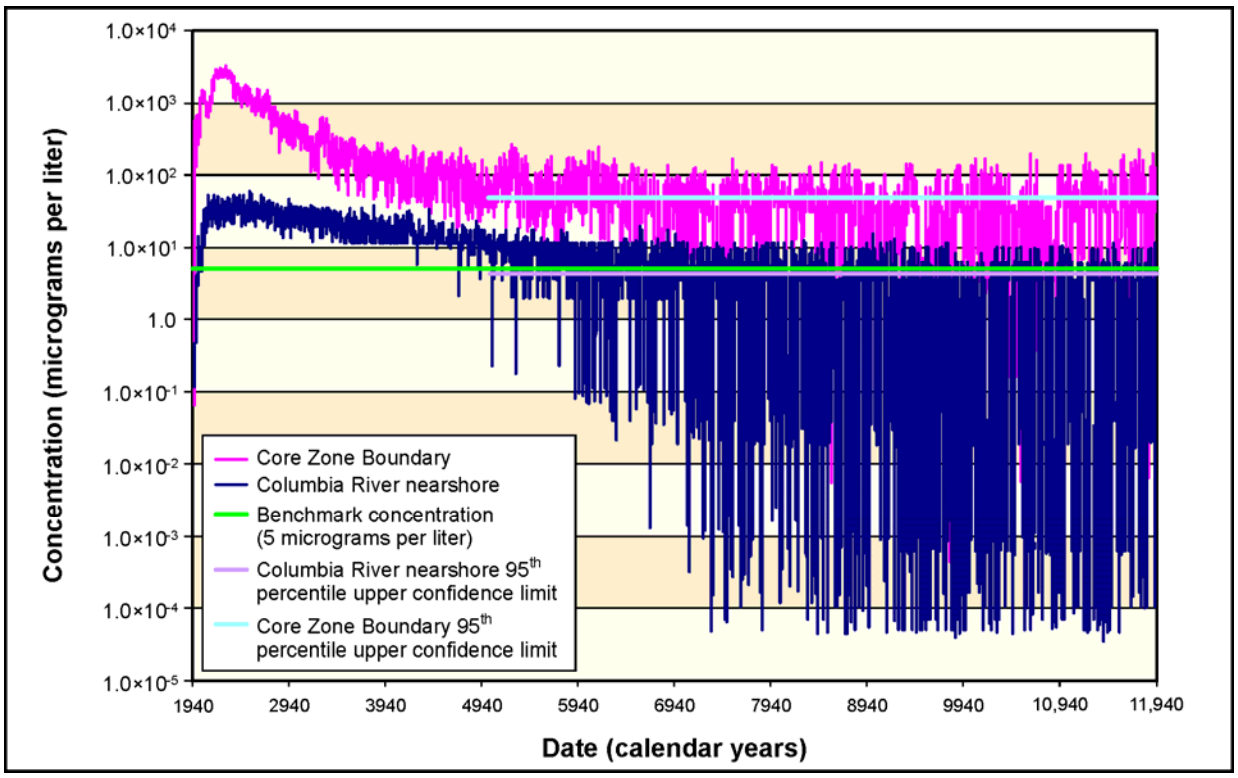


Figure U–6. Carbon Tetrachloride Concentration Versus Time (Non–*TC & WM EIS* Sources)

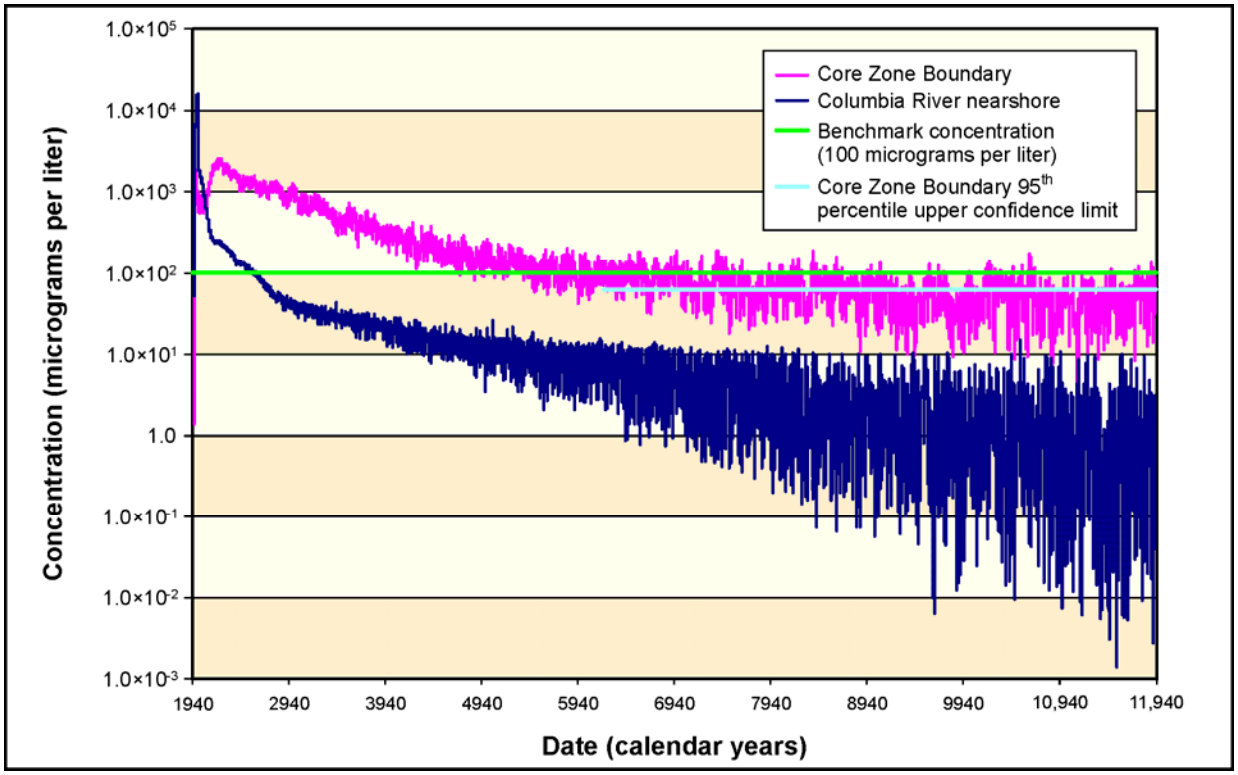


Figure U–7. Chromium Concentration Versus Time (Non–*TC & WM EIS* Sources)

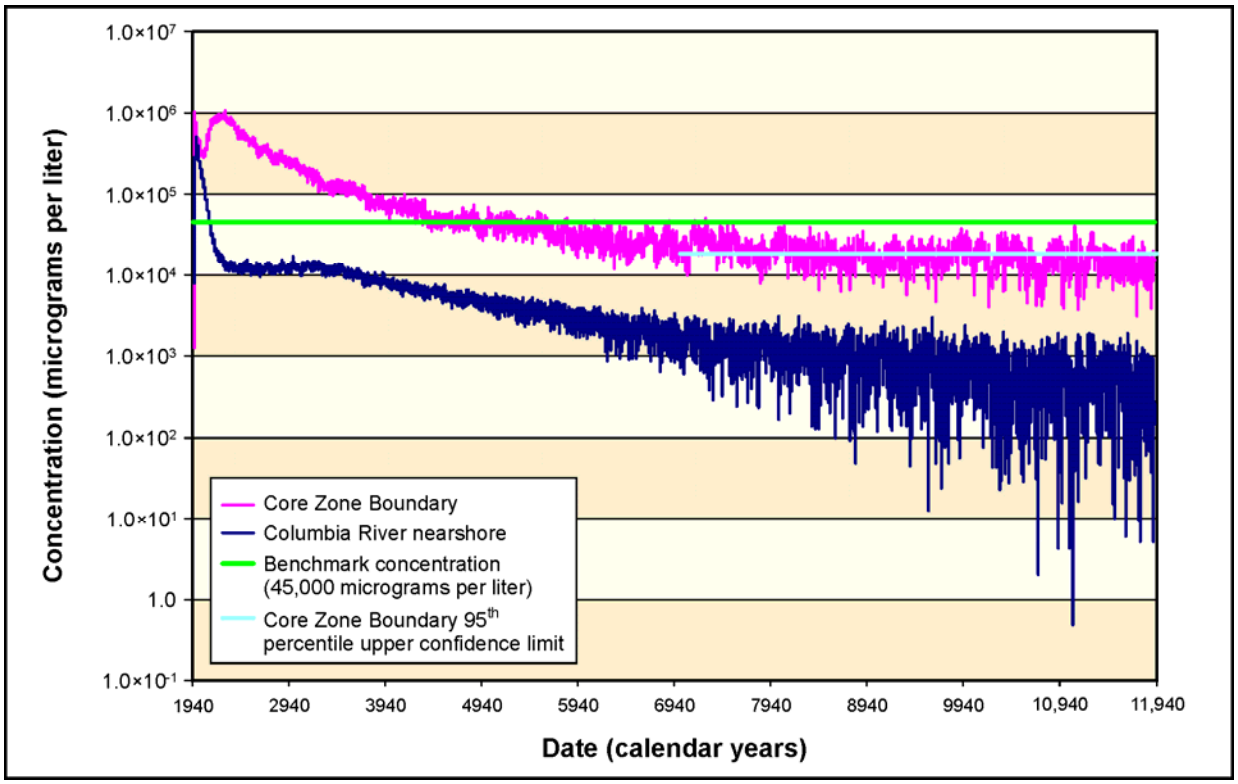


Figure U–8. Nitrate Concentration Versus Time (Non–*TC & WM EIS* Sources)

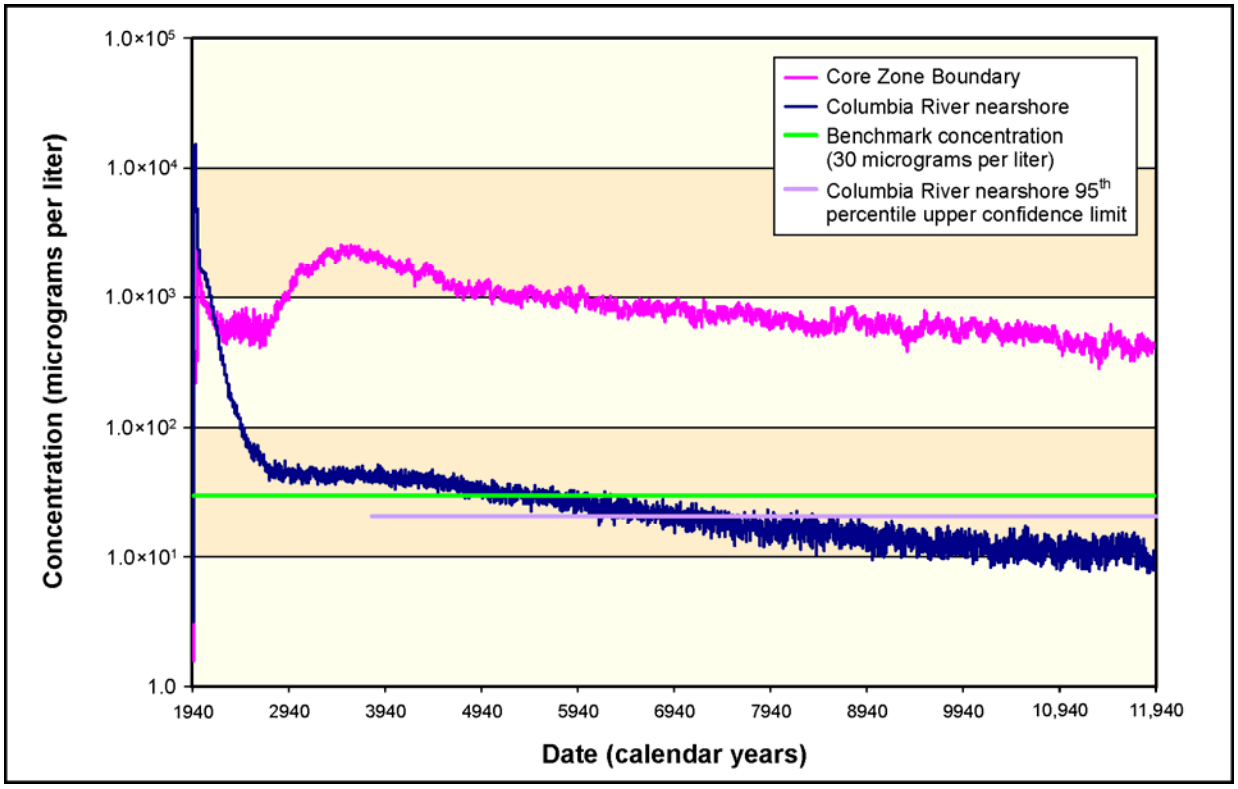


Figure U–9. Total Uranium Concentration Versus Time (Non–*TC & WM EIS* Sources)

U.1.4 Spatial Distribution of Concentration

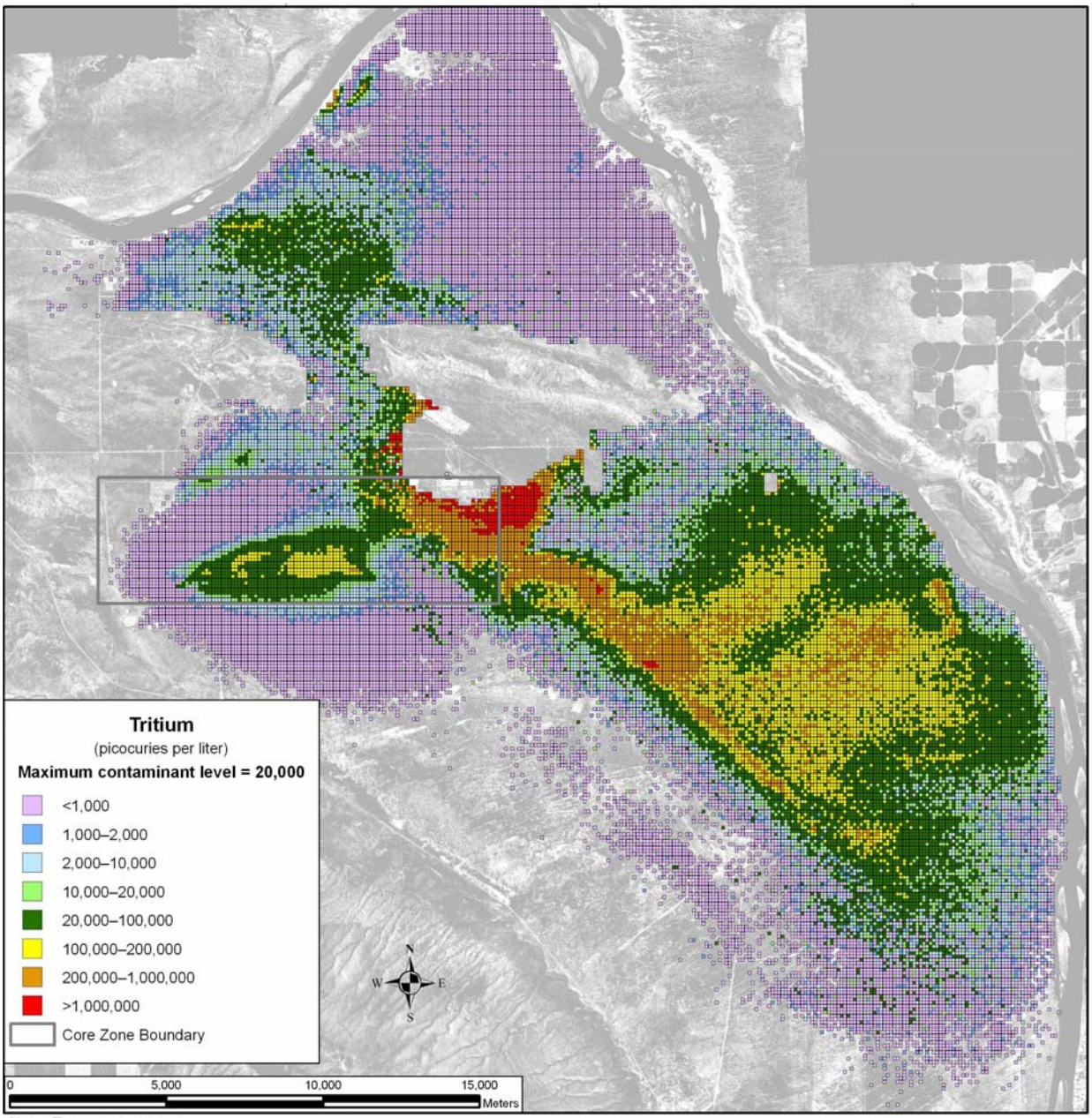
This section presents the results of the impacts analysis for non–*TC & WM EIS* sources in terms of the spatial distribution of COPC concentrations in the groundwater at selected times. Concentrations for each radionuclide and chemical are indicated by a color scale indicating the benchmark concentration. 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. Figures U–10 through U–48 include maps of the projected concentrations of contaminants in the groundwater for the following:

- Tritium in 2005 and 2135 (see Figures U–10 and U–11)
- Iodine-129 in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–12 through U–16)
- Strontium-90 in 2005 and 2135 (see Figures U–17 and U–18)
- Technetium-99 in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–19 through U–23)
- Uranium-238 in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–24 through U–28)
- Carbon tetrachloride in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–29 through U–33)
- Chromium in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–34 through U–38)
- Nitrate in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–39 through U–43)
- Total uranium in 2005, 2135, 3890, 7140, and 11,885 (see Figures U–44 through U–48)

In general, the simulations of groundwater transport in this *TC & WM EIS* replicate the values measured in the field to a close order of magnitude, particularly for discharges to cribs and trenches (ditches), where the historic measurements are most complete and show the strongest signature of past-practice operations. As shown in Appendices N and O, the agreement is good for both *TC & WM EIS* alternative sources and non–*TC & WM EIS* sources. There are two contaminant plumes for which the simulated plumes are in greater disagreement with observation. Both are non–*TC & WM EIS* sources: the carbon tetrachloride plume in the 200-West Area (see Figure U–29), and the uranium-238 plume (see Figure U–24) and total uranium plume (see Figure U–44) in the 200-East Area.

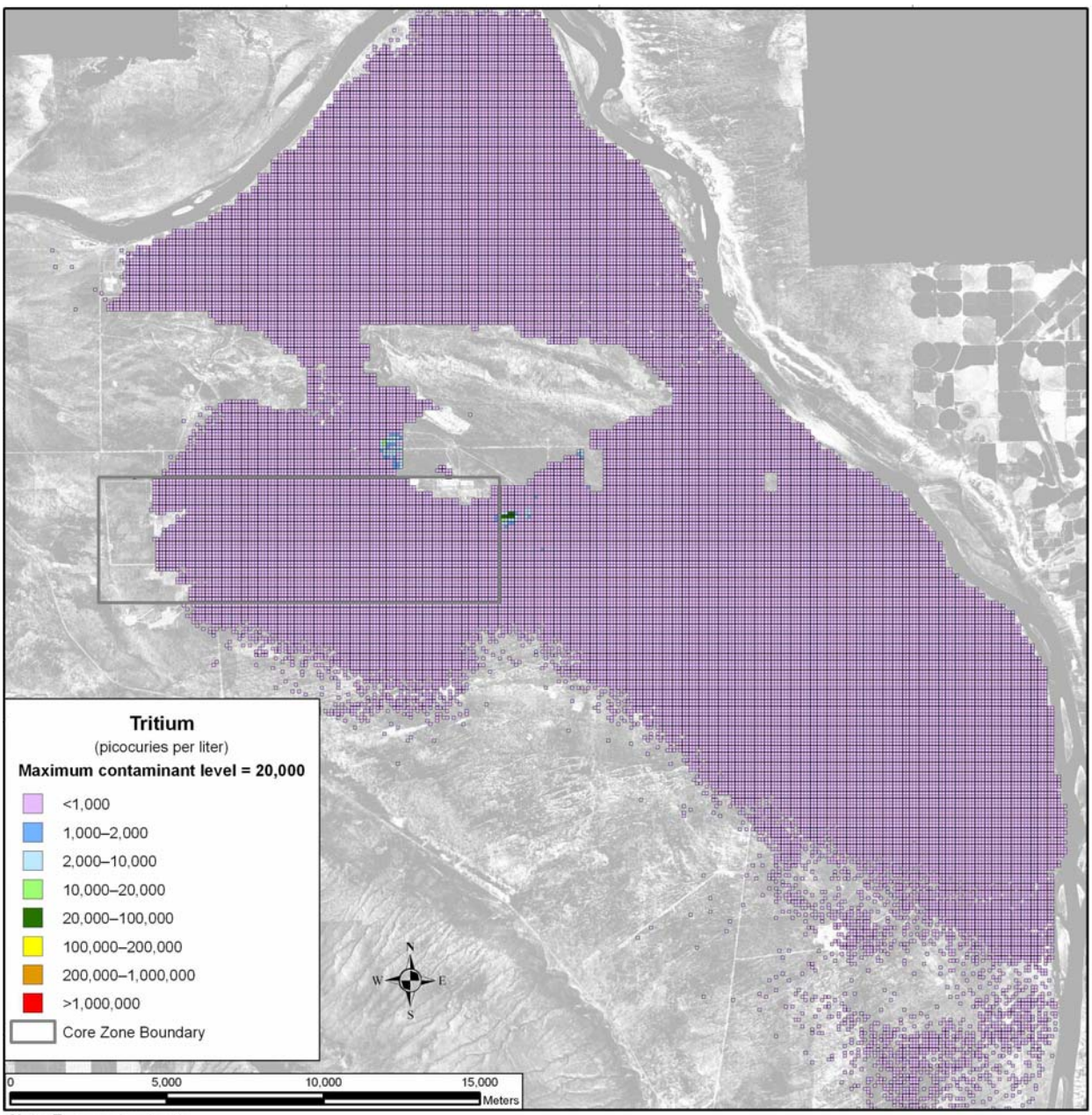
Carbon tetrachloride, when discharged in sufficient quantity, behaves as a dense, non-aqueous-phase liquid (DNAPL) rather than a dissolved solute. Simulation results for DNAPL flow and transport in the vadose zone exhibit sensitivities of more than several orders of magnitude to uncertainties in input parameters, which suggests that DNAPL contaminant behavior is not well understood or constrained. For the purposes of the *TC & WM EIS* long-term groundwater cumulative impacts analysis, these vadose zone uncertainties were recognized to result in variations in predicted groundwater impacts that are qualitatively greater than those for other COPCs in the analysis. Therefore, the *TC & WM EIS* analysis of the carbon tetrachloride plume started with a more-constrained initial condition, the 65,000 kilograms (143,000 pounds) of carbon tetrachloride estimated in the vadose zone in 2005 (Hartman and Webber 2008). This total inventory was assumed to be present in the unconfined aquifer starting in 2005, and the concentrations were modeled forward from this initial condition. In addition, because of the uncertainties in the design and implementation of the groundwater remediation system for Operable Unit 200-ZP-1, no credit was taken in the *TC &WM EIS* modeling for removal or containment of carbon tetrachloride. In light of these approximations, the predicted concentrations of carbon tetrachloride should be considered qualitatively more uncertain than other contaminants in the cumulative impacts analysis.

Uranium-238 and total uranium simulation results show higher impacts resulting from large discharge facilities in the 200-East Area (e.g., B Pond) than actually observed. The disagreement of these plumes with field measurements suggests that two possible areas of uncertainty may dominate the simulation of these impacts. The first is the uncertainty in the inventory of uranium-238 and total uranium in the large discharge ponds (see Appendix S), which is approximately 50 percent. The second, and probably more-important source of uncertainty, is the interaction of uranium-238 and total uranium with subsurface materials beneath these facilities. The *TC & WM EIS* analysis is based on a distribution coefficient for uranium of about 0.6 milliliters per gram (DOE 2005). This value, although appropriate for far-field conditions in the unconfined aquifer, is probably not representative of the conditions beneath the large discharge sources (e.g., B Ponds). Therefore, the prediction of the uranium-238 and total uranium contaminant plumes for large non–*TC & WM EIS* sources should be considered an overestimate of the actual impacts by about an order of magnitude.



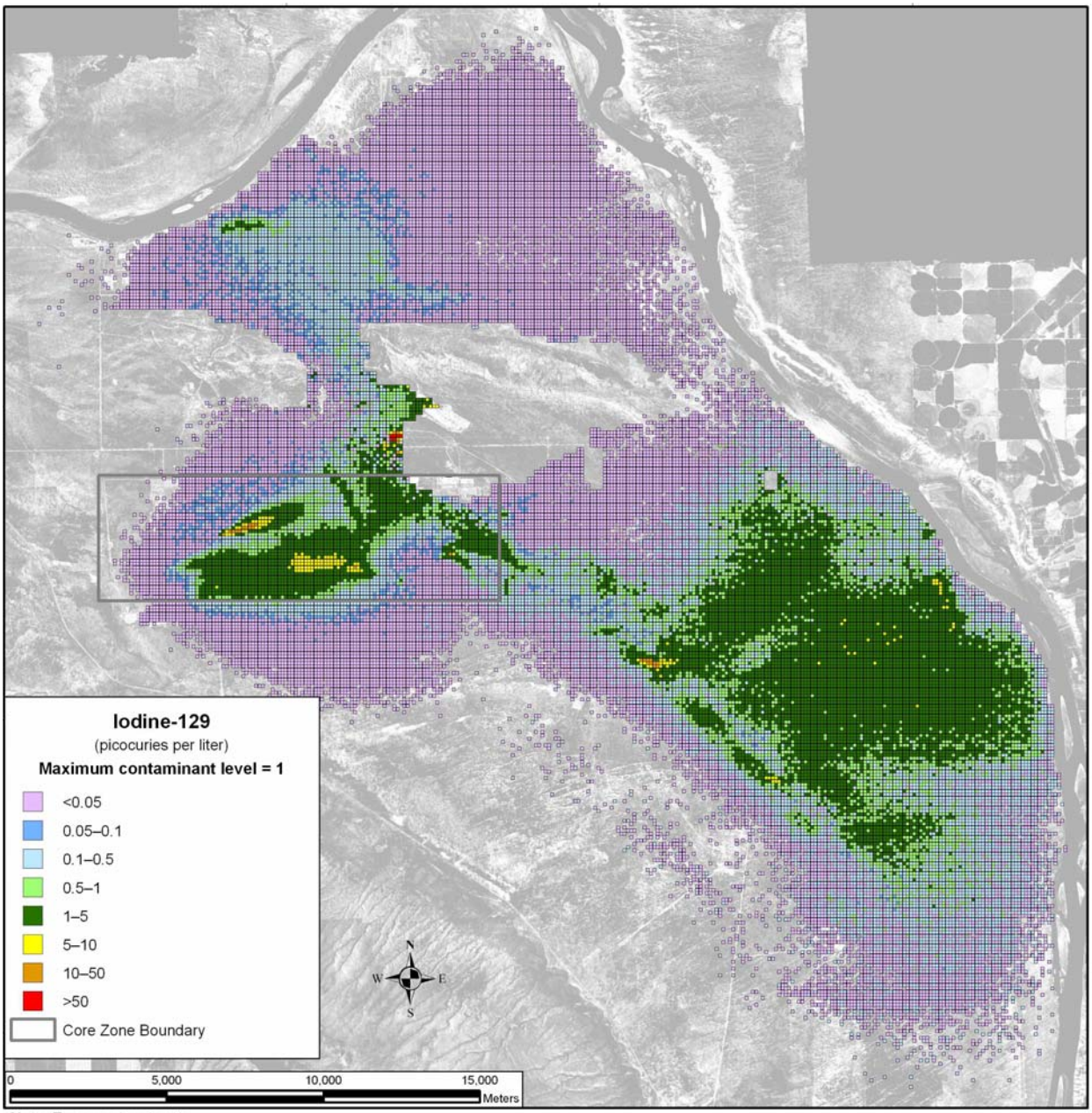
Note: To convert meters to feet, multiply by 3.281

Figure U–10. Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



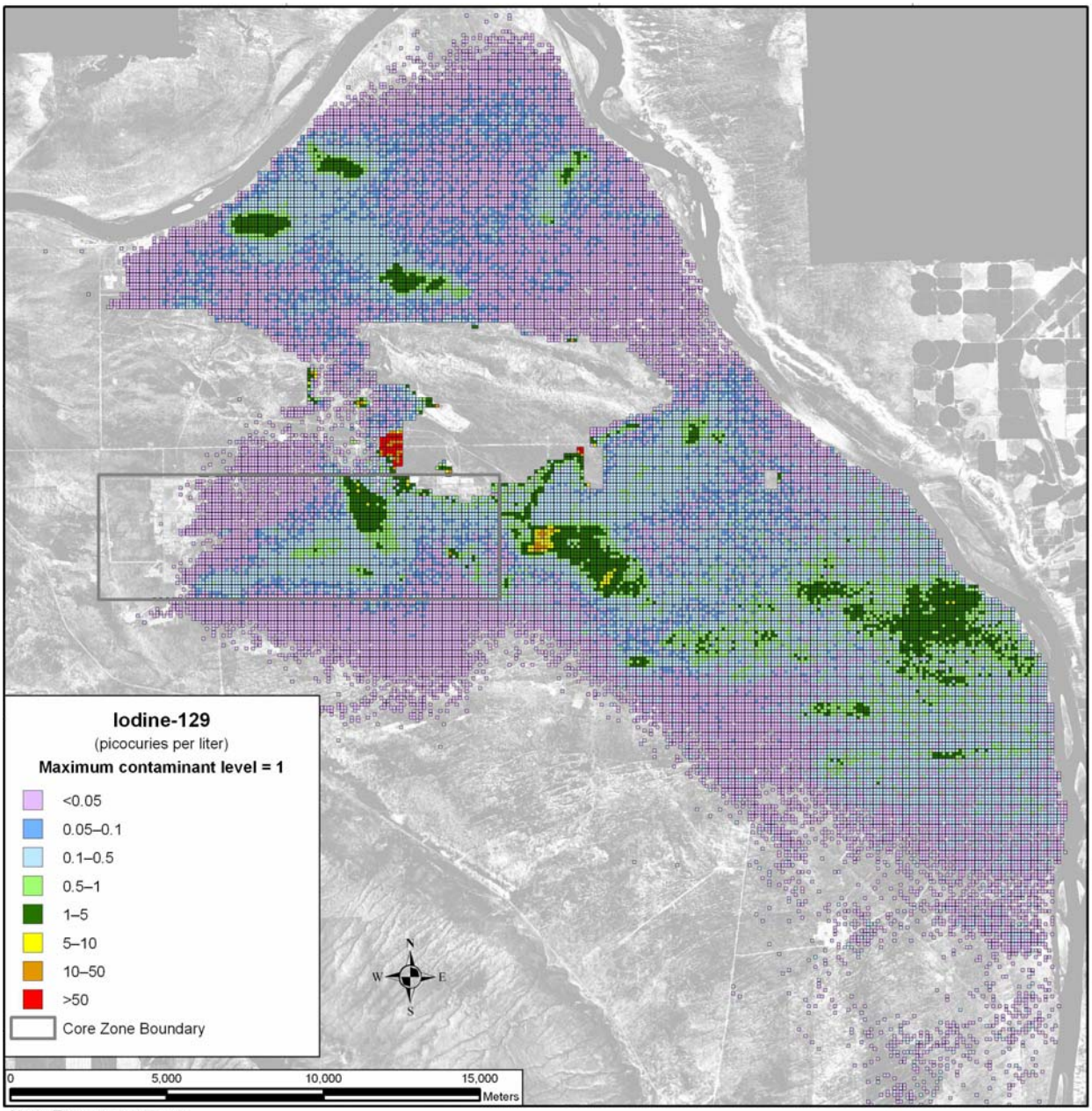
Note: To convert meters to feet, multiply by 3.281

Figure U–11. Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



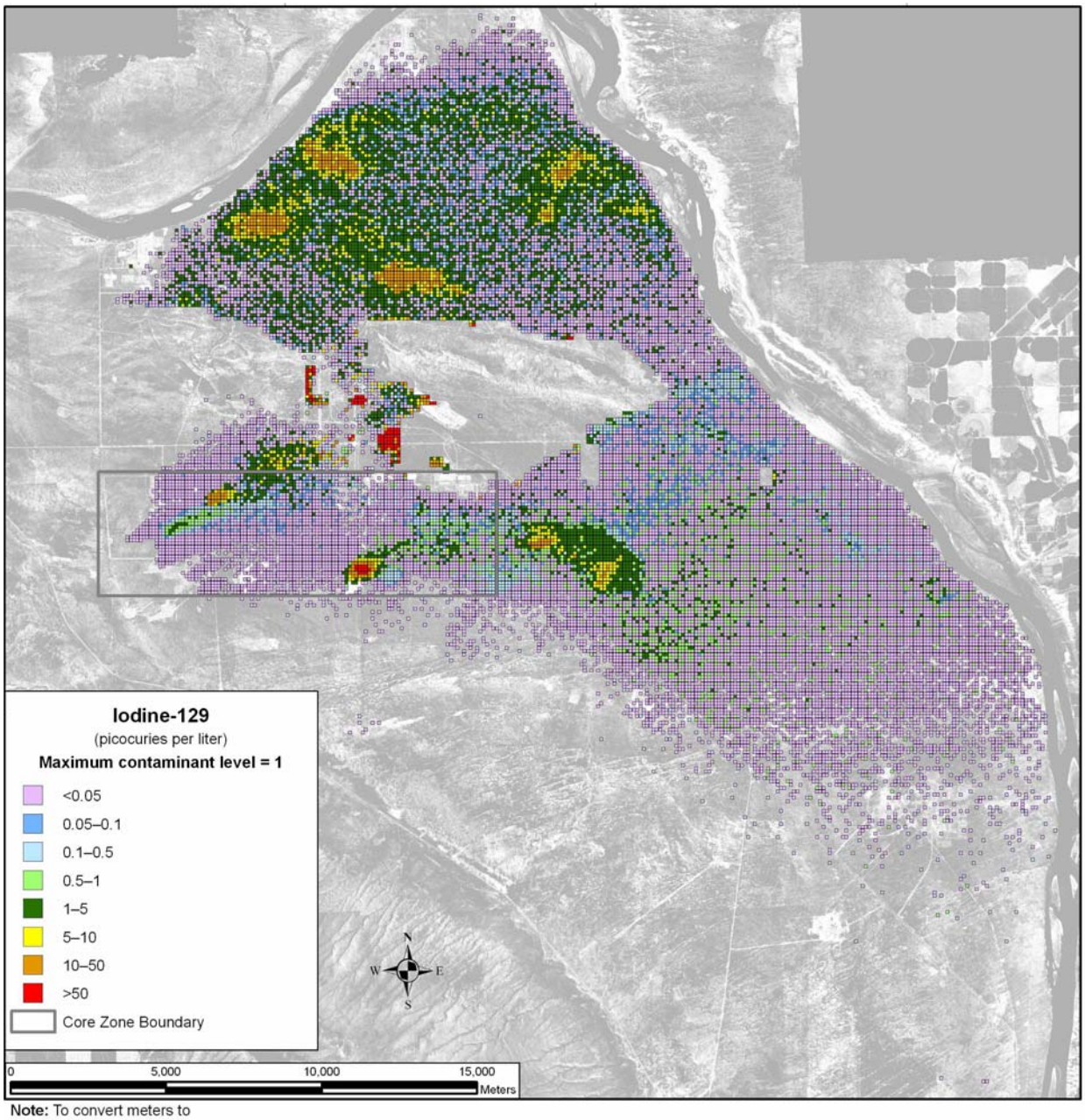
Note: To convert meters to feet, multiply by 3.281

Figure U–12. Spatial Distribution of Groundwater Iodine-129 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



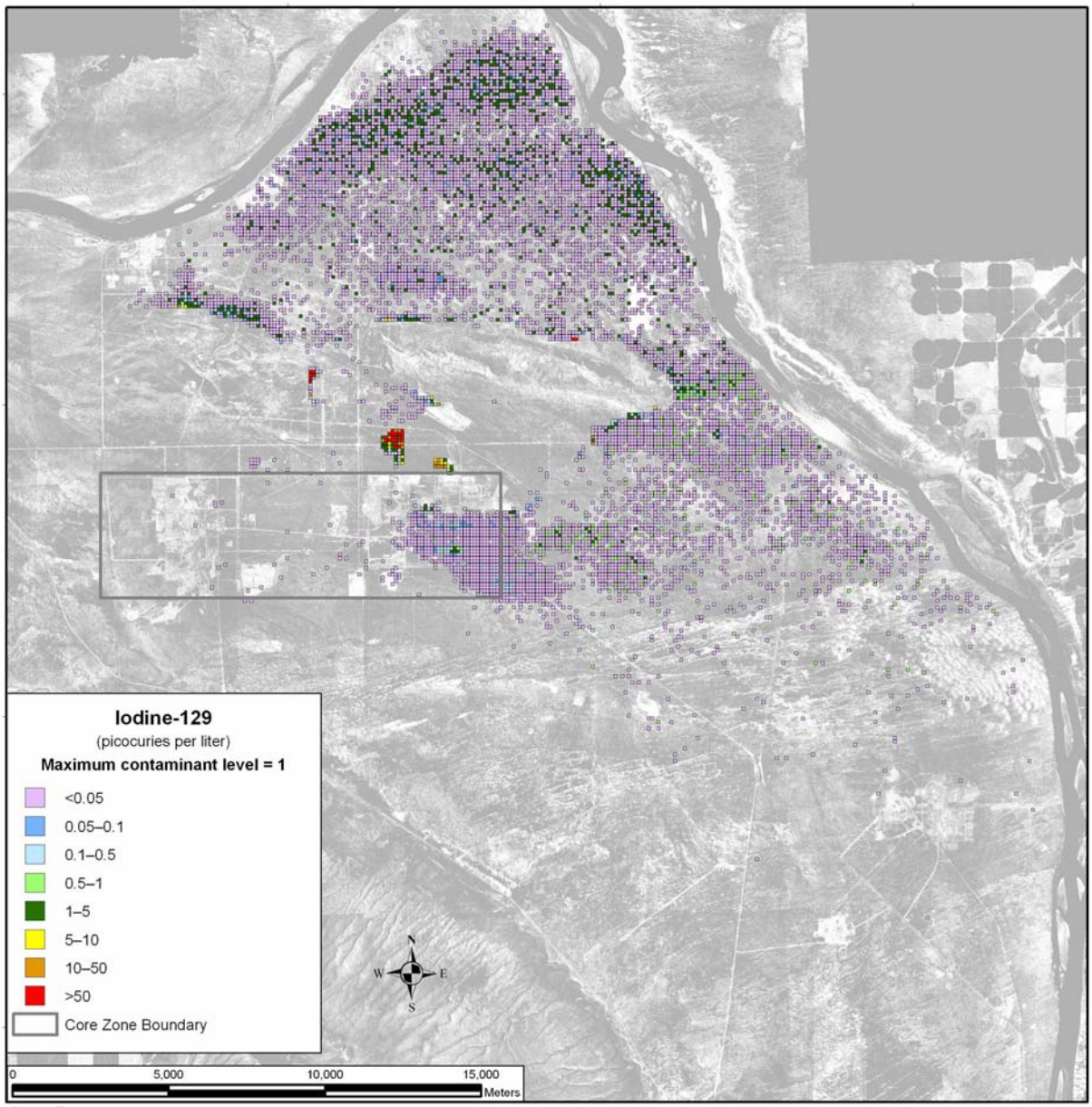
Note: To convert meters to feet, multiply by 3.281

Figure U–13. Spatial Distribution of Groundwater Iodine-129 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



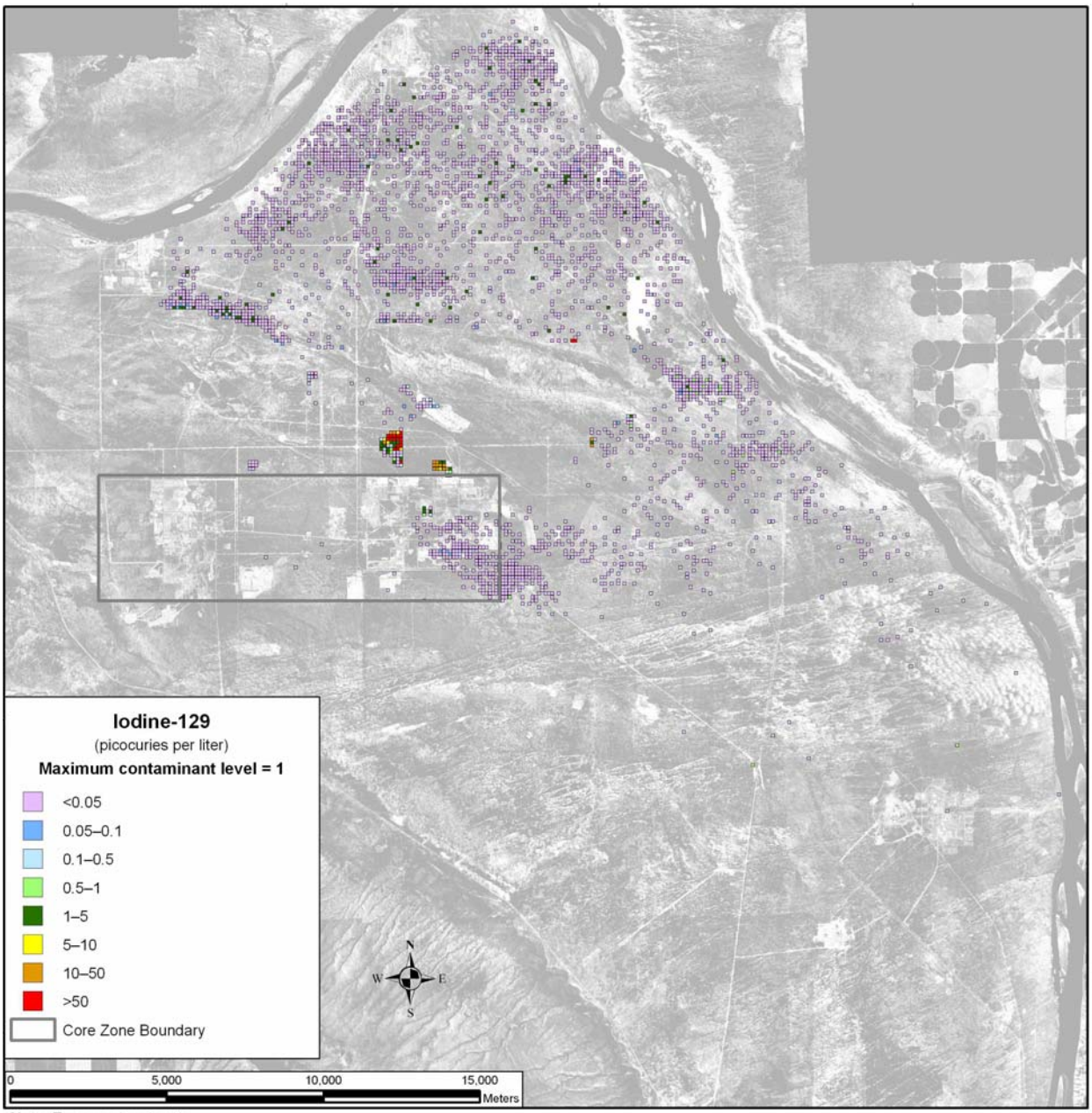
Note: To convert meters to feet, multiply by 3.281

Figure U–14. Spatial Distribution of Groundwater Iodine-129 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



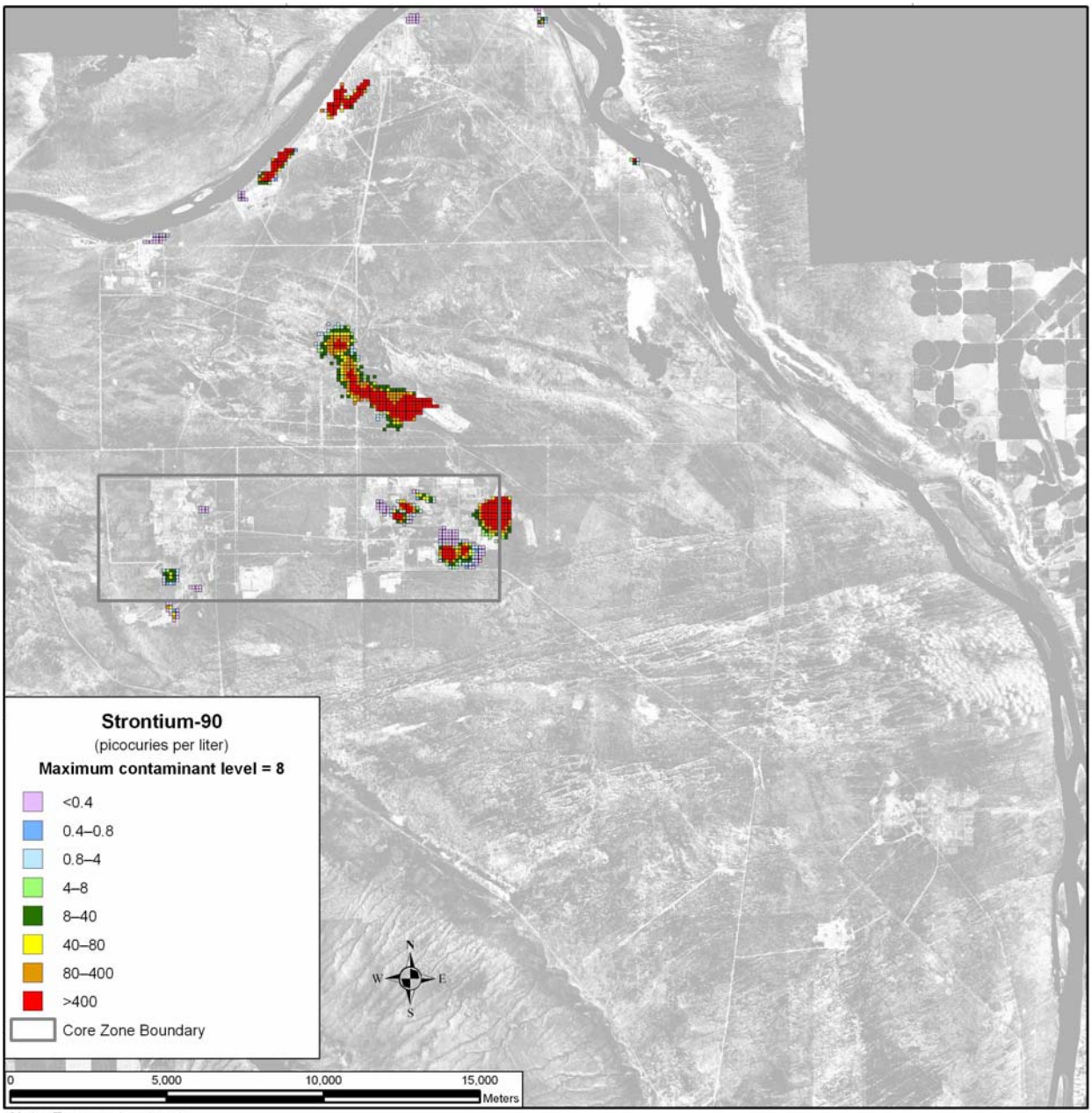
Note: To convert meters to feet, multiply by 3.281

Figure U–15. Spatial Distribution of Groundwater Iodine-129 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



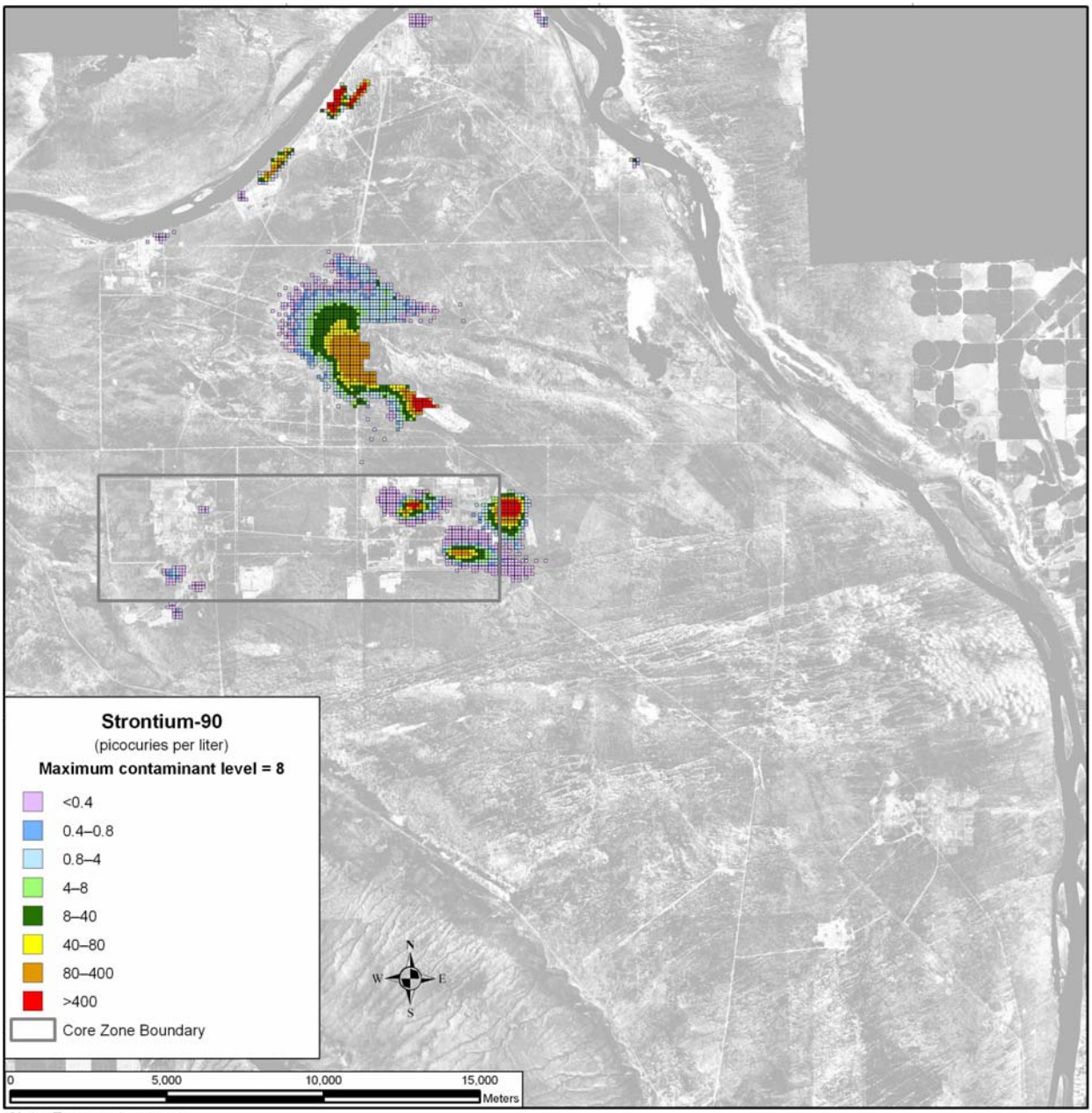
Note: To convert meters to feet, multiply by 3.281

Figure U–16. Spatial Distribution of Groundwater Iodine-129 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885



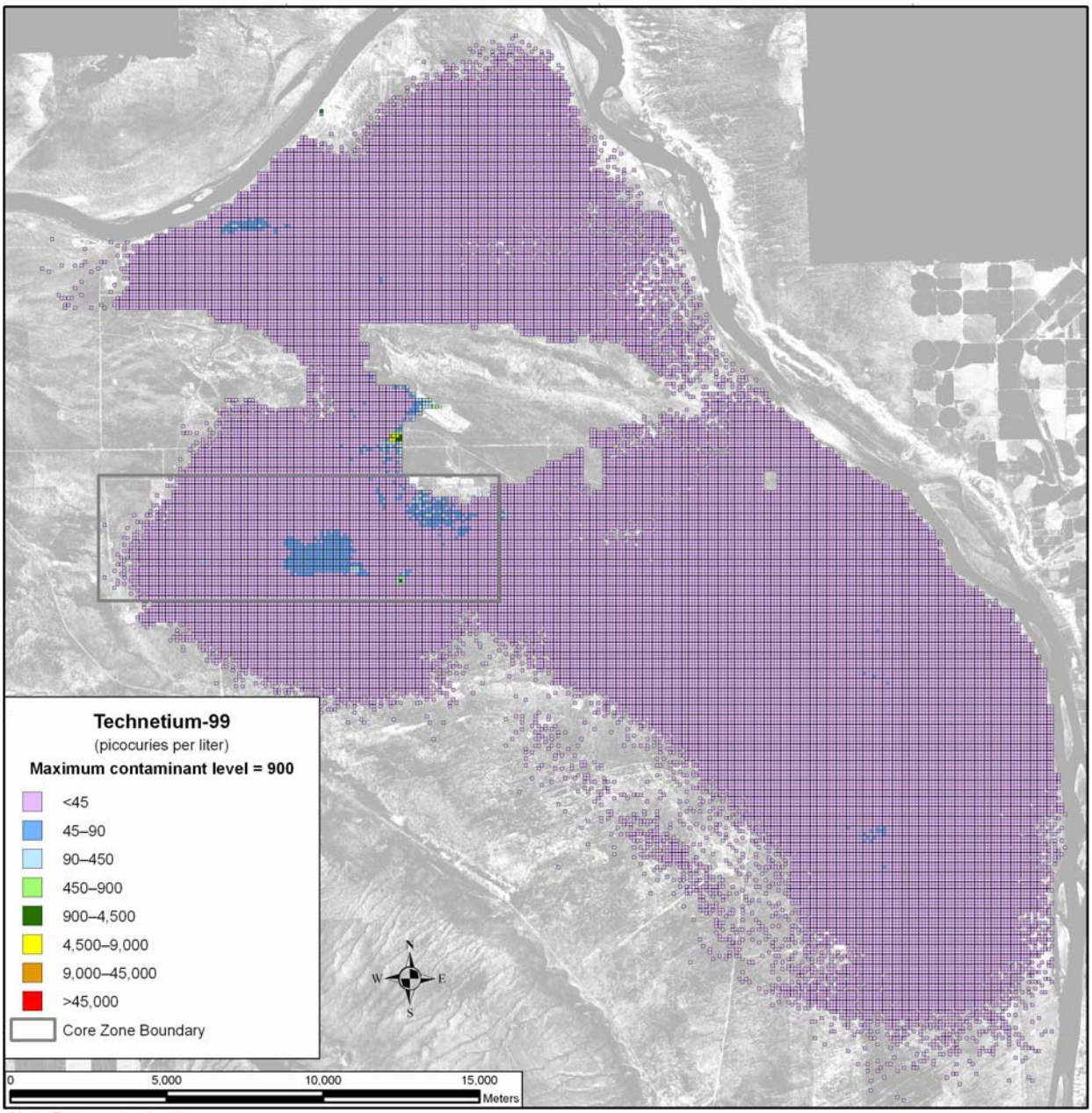
Note: To convert meters to feet, multiply by 3.281

Figure U–17. Spatial Distribution of Groundwater Strontium-90 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



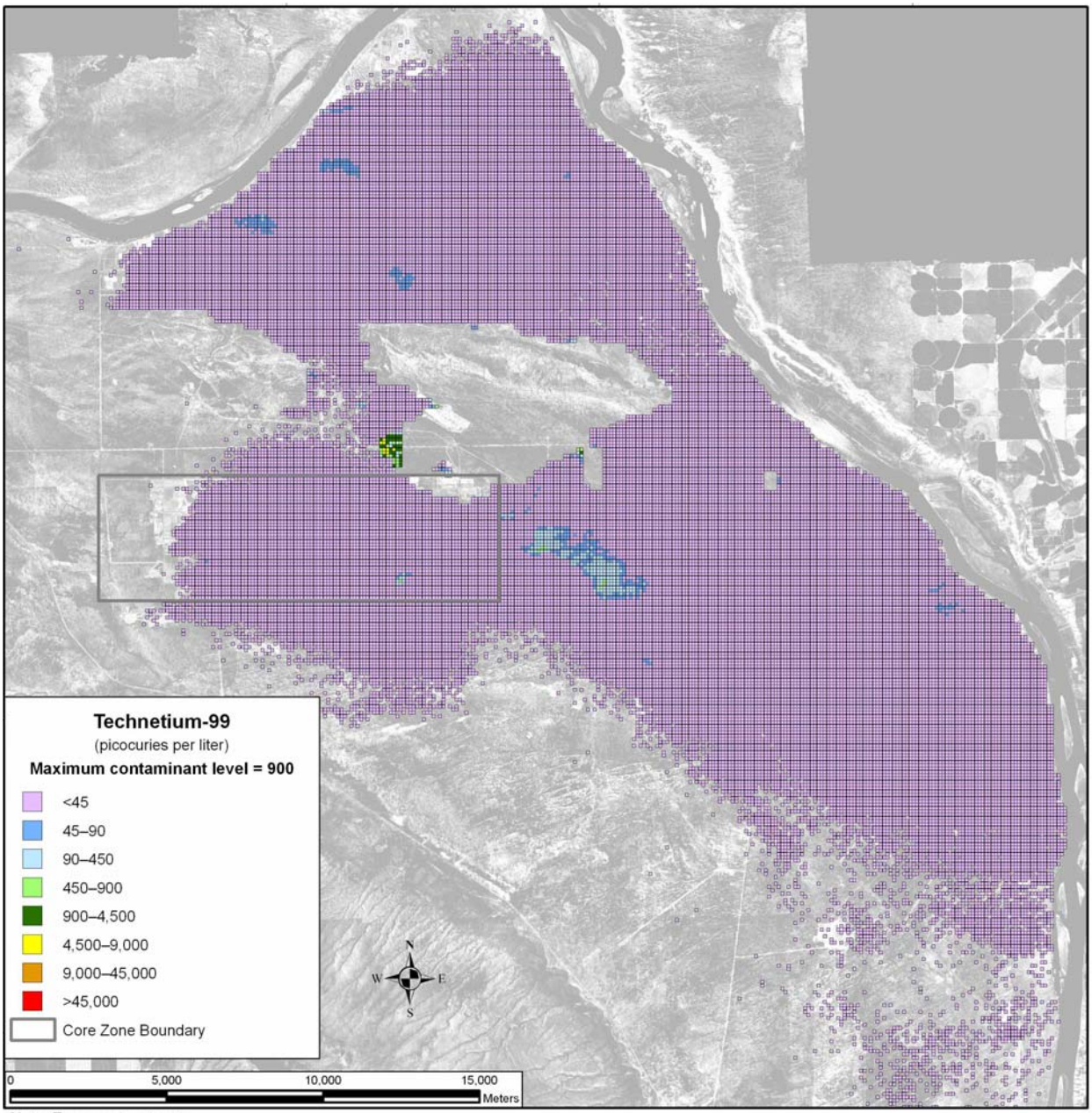
Note: To convert meters to feet, multiply by 3.281

Figure U–18. Spatial Distribution of Groundwater Strontium-90 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



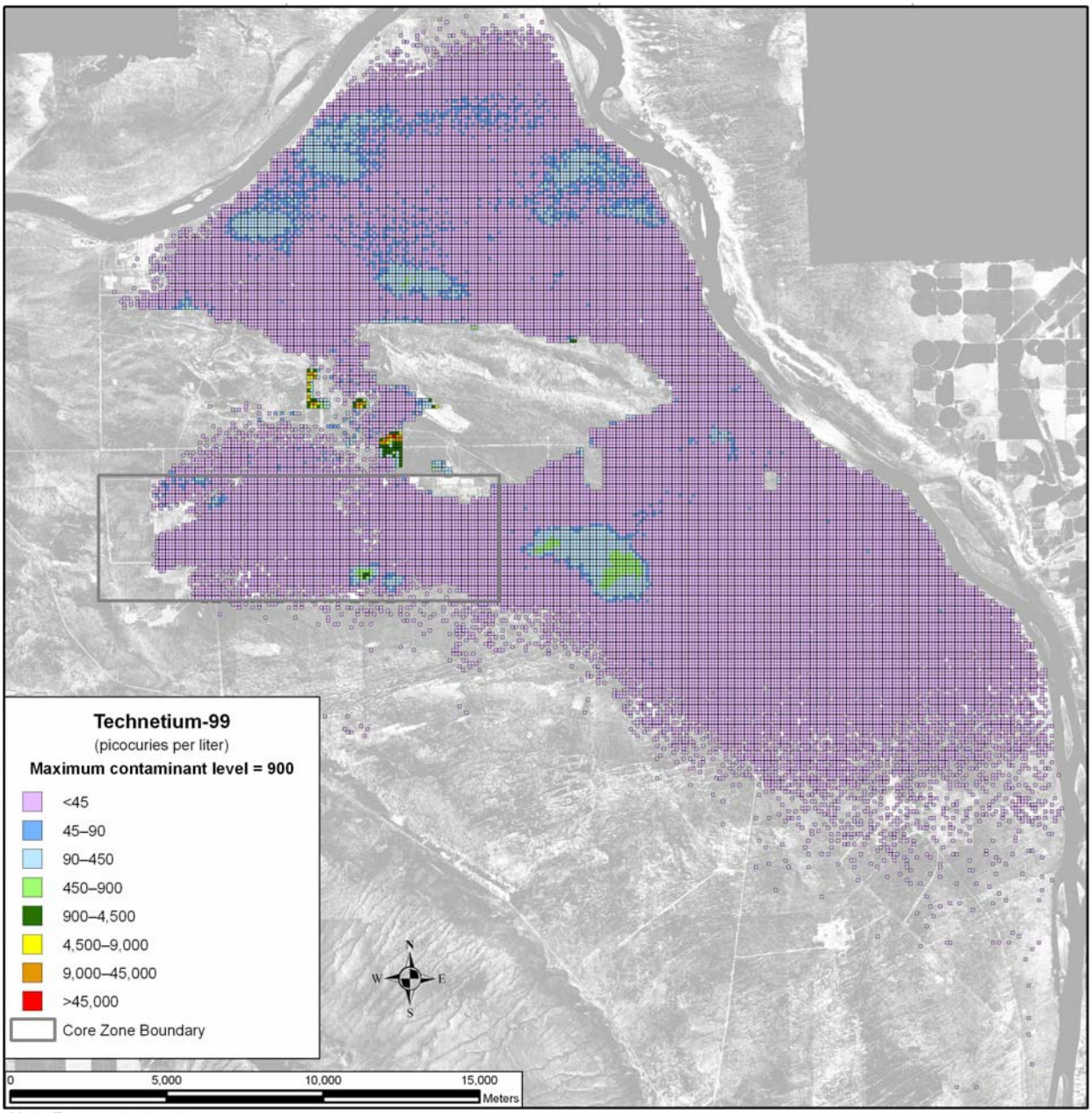
Note: To convert meters to feet, multiply by 3.281

Figure U–19. Spatial Distribution of Groundwater Technetium-99 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



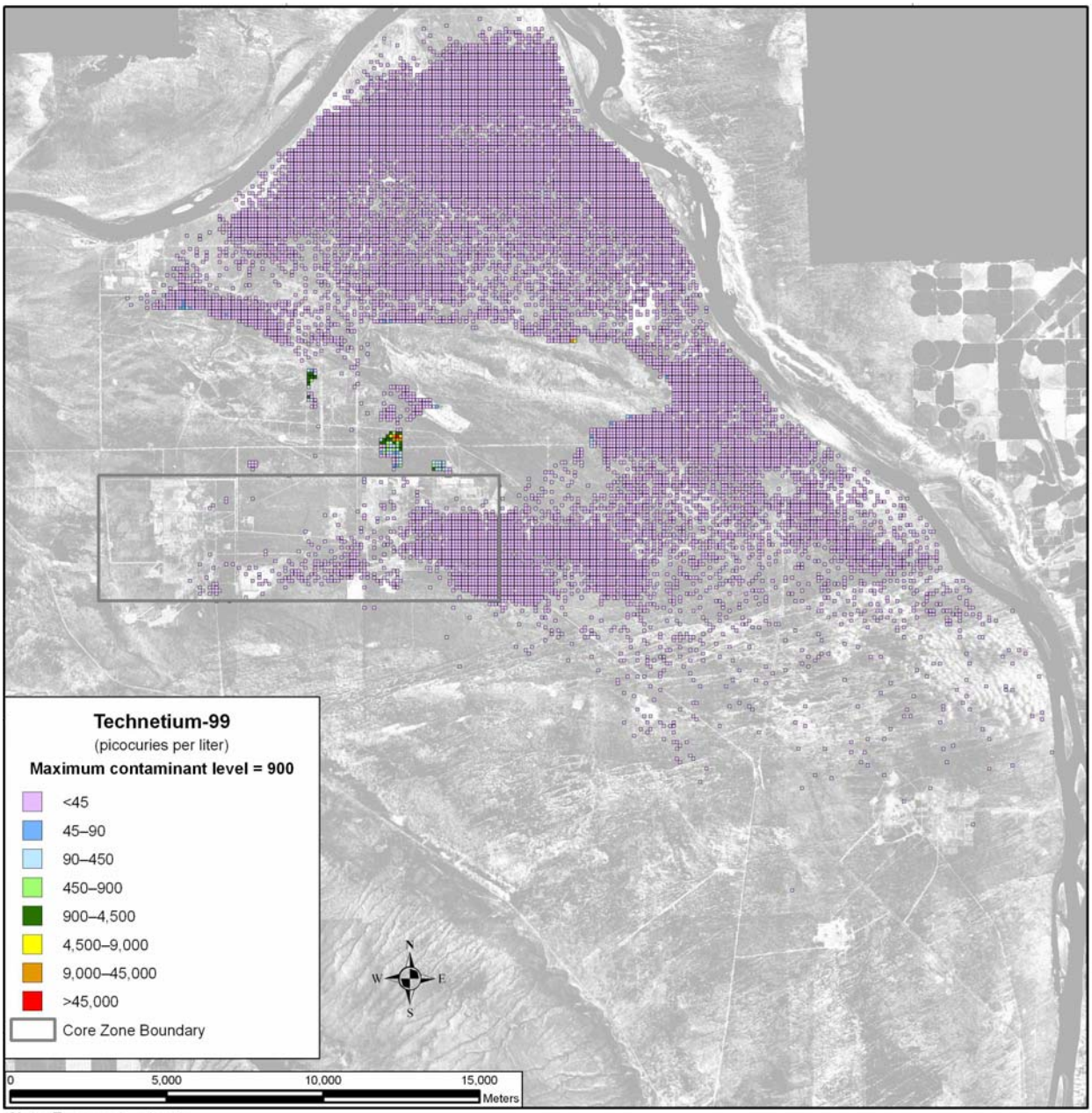
Note: To convert meters to feet, multiply by 3.281

Figure U–20. Spatial Distribution of Groundwater Technetium-99 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



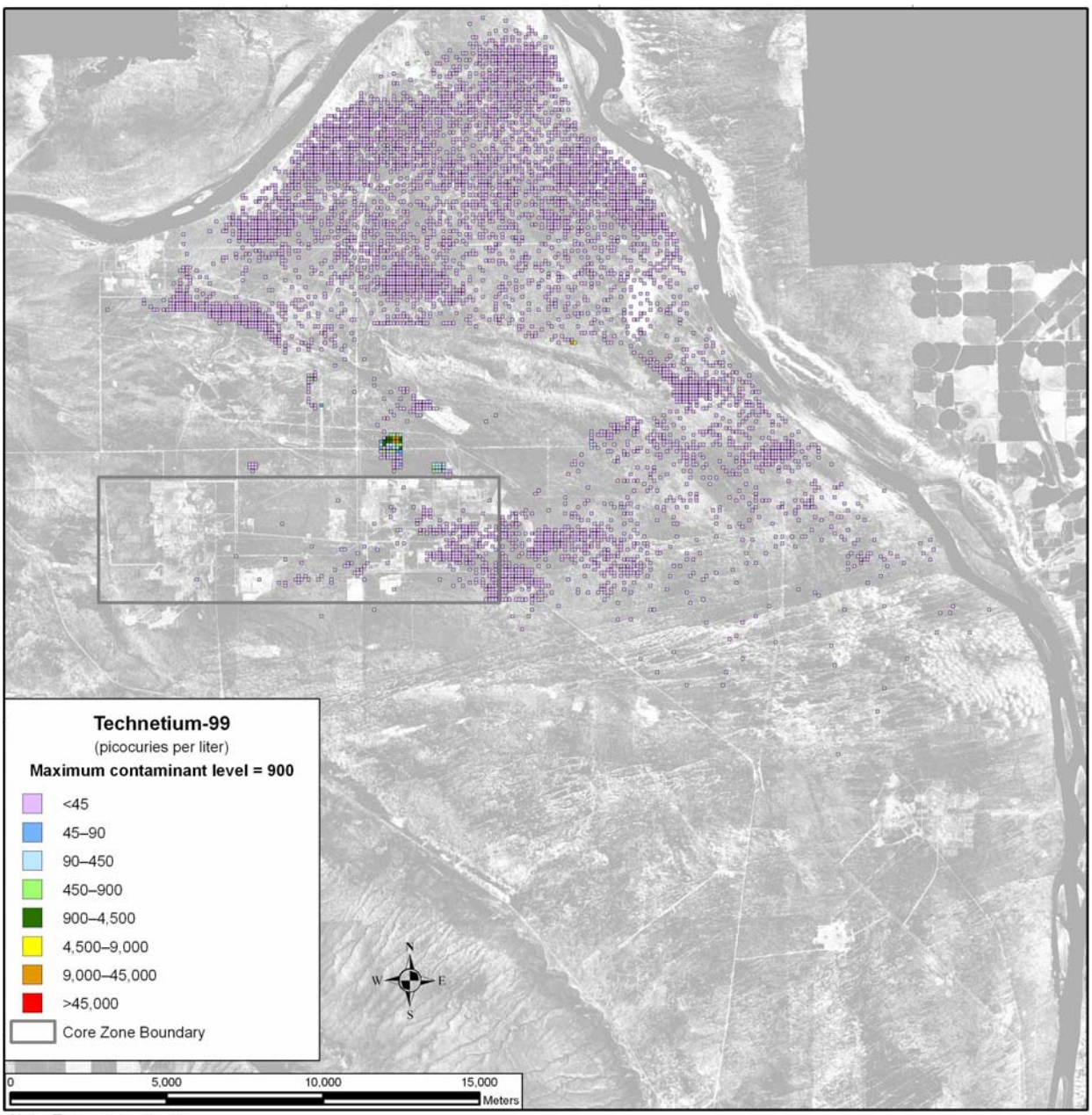
Note: To convert meters to feet, multiply by 3.281

Figure U–21. Spatial Distribution of Groundwater Technetium-99 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



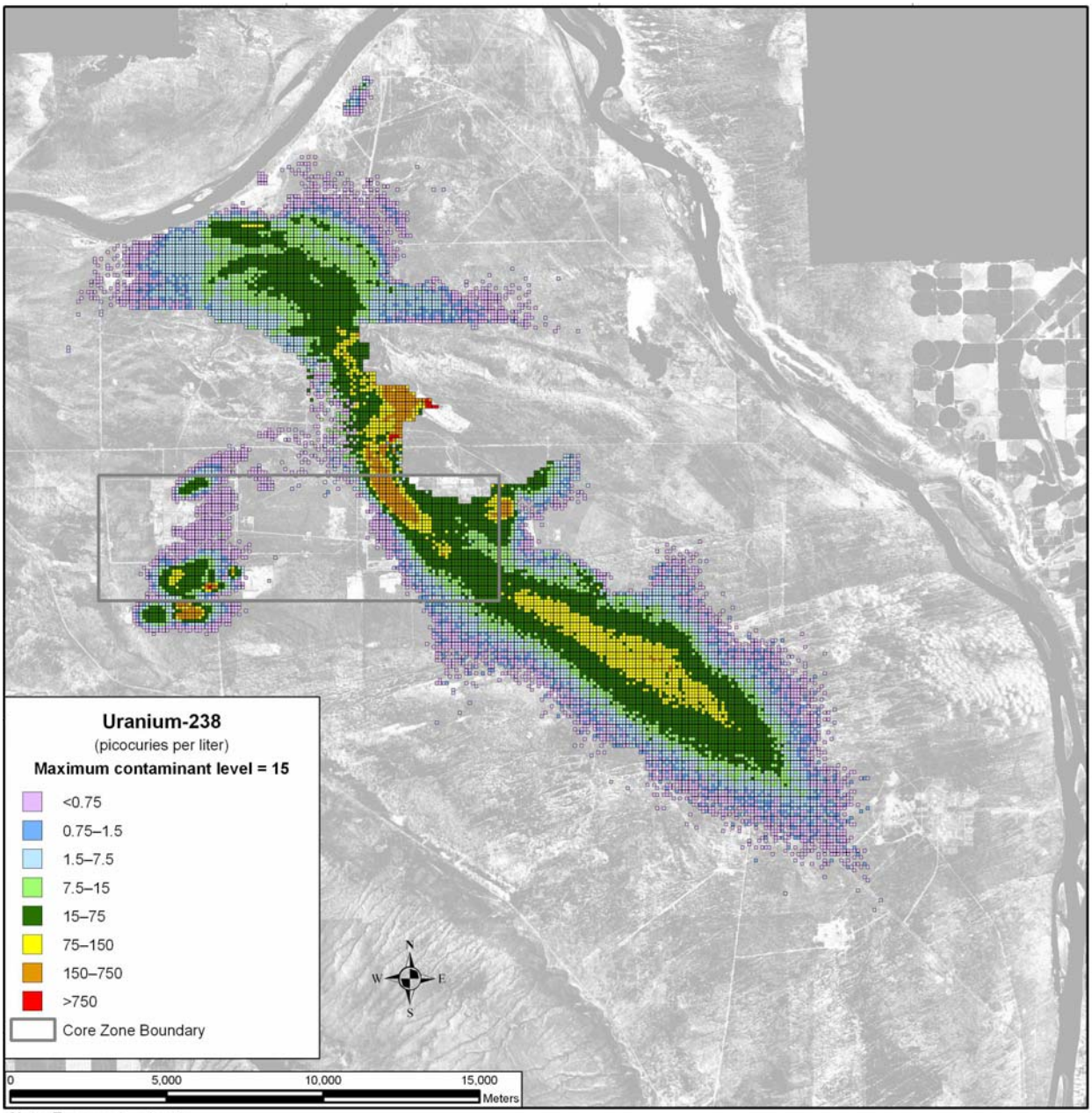
Note: To convert meters to feet, multiply by 3.281

Figure U–22. Spatial Distribution of Groundwater Technetium-99 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



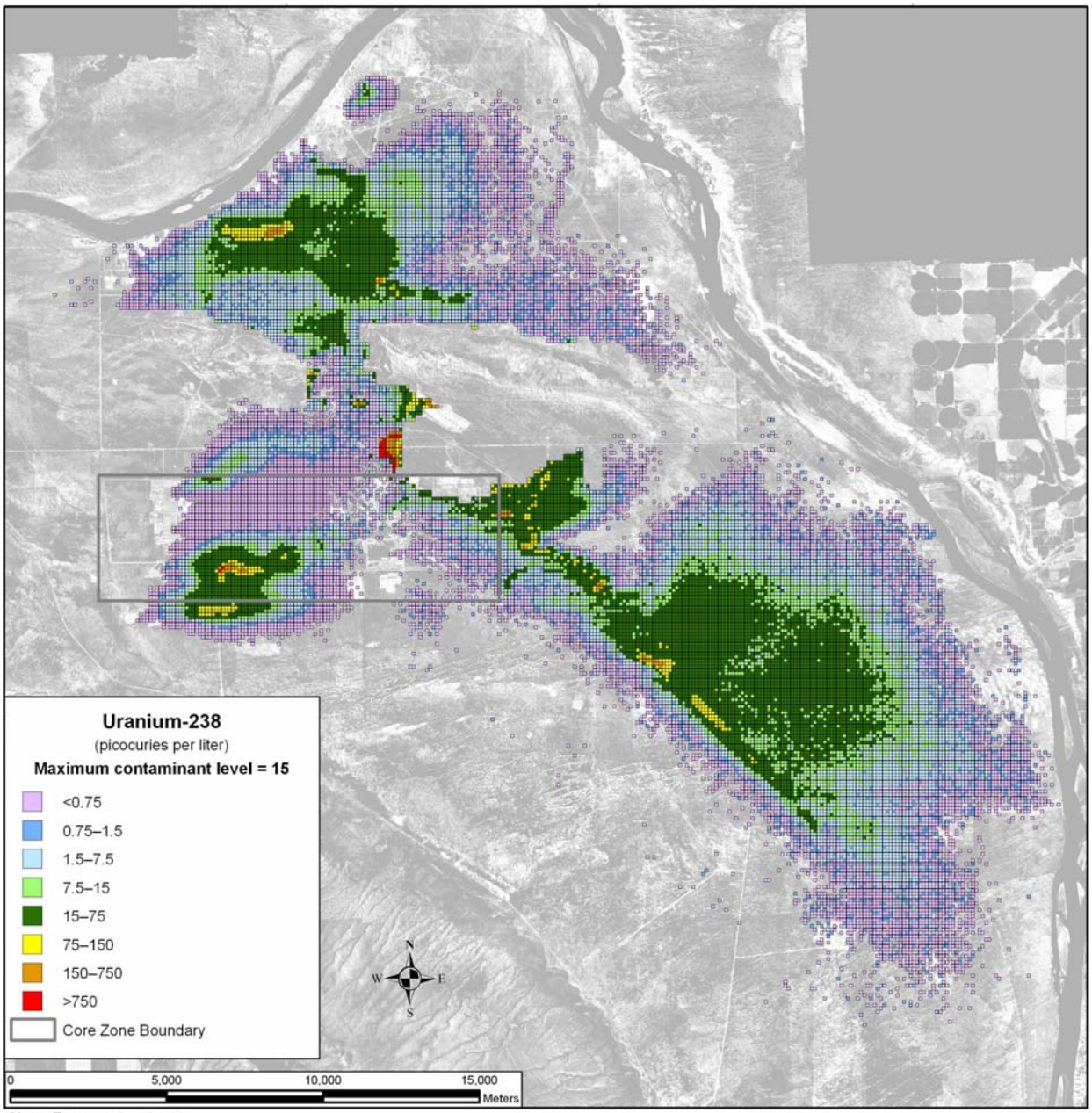
Note: To convert meters to feet, multiply by 3.281

Figure U–23. Spatial Distribution of Groundwater Technetium-99 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885



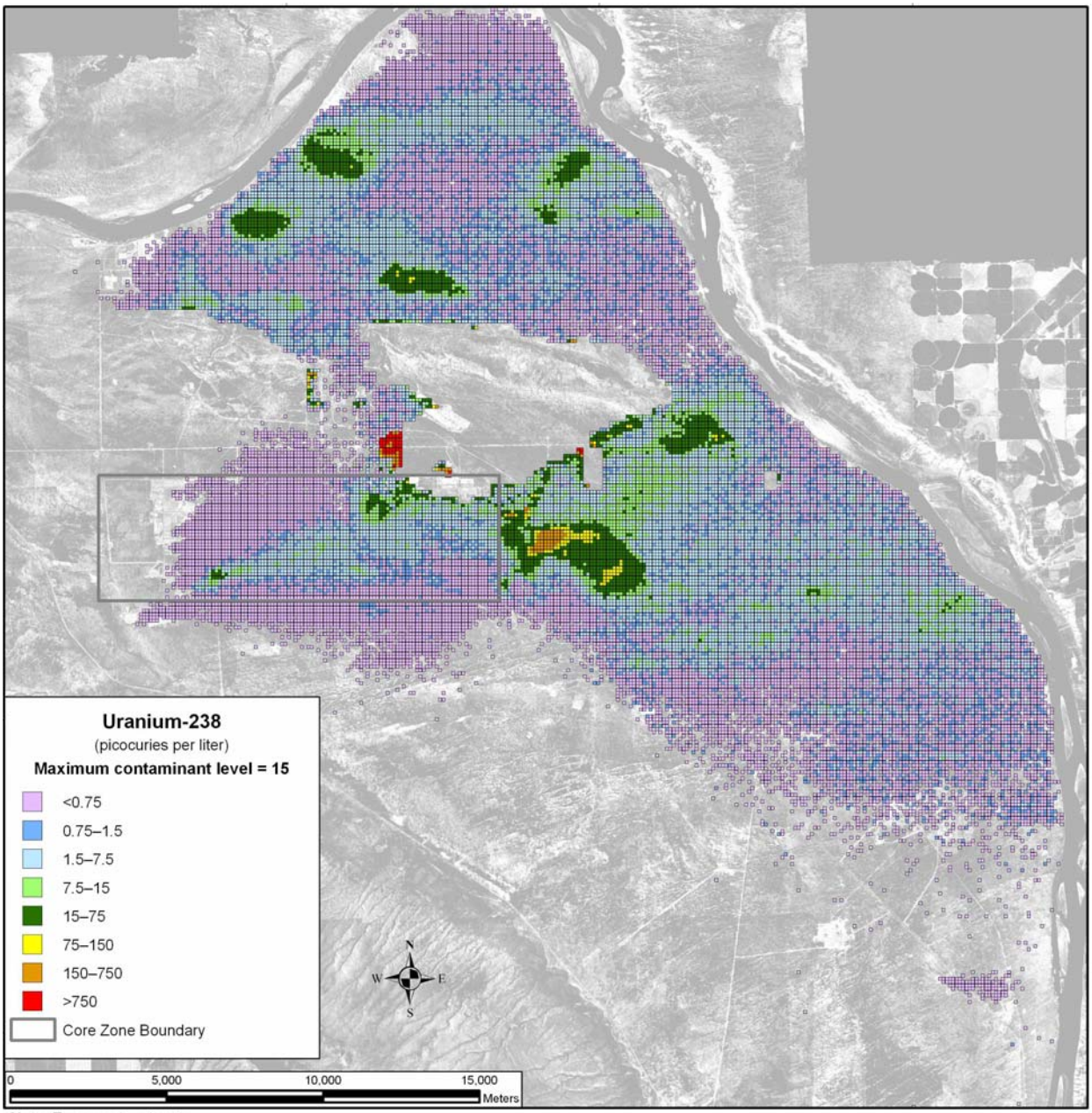
Note: To convert meters to feet, multiply by 3.281

Figure U–24. Spatial Distribution of Groundwater Uranium-238 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



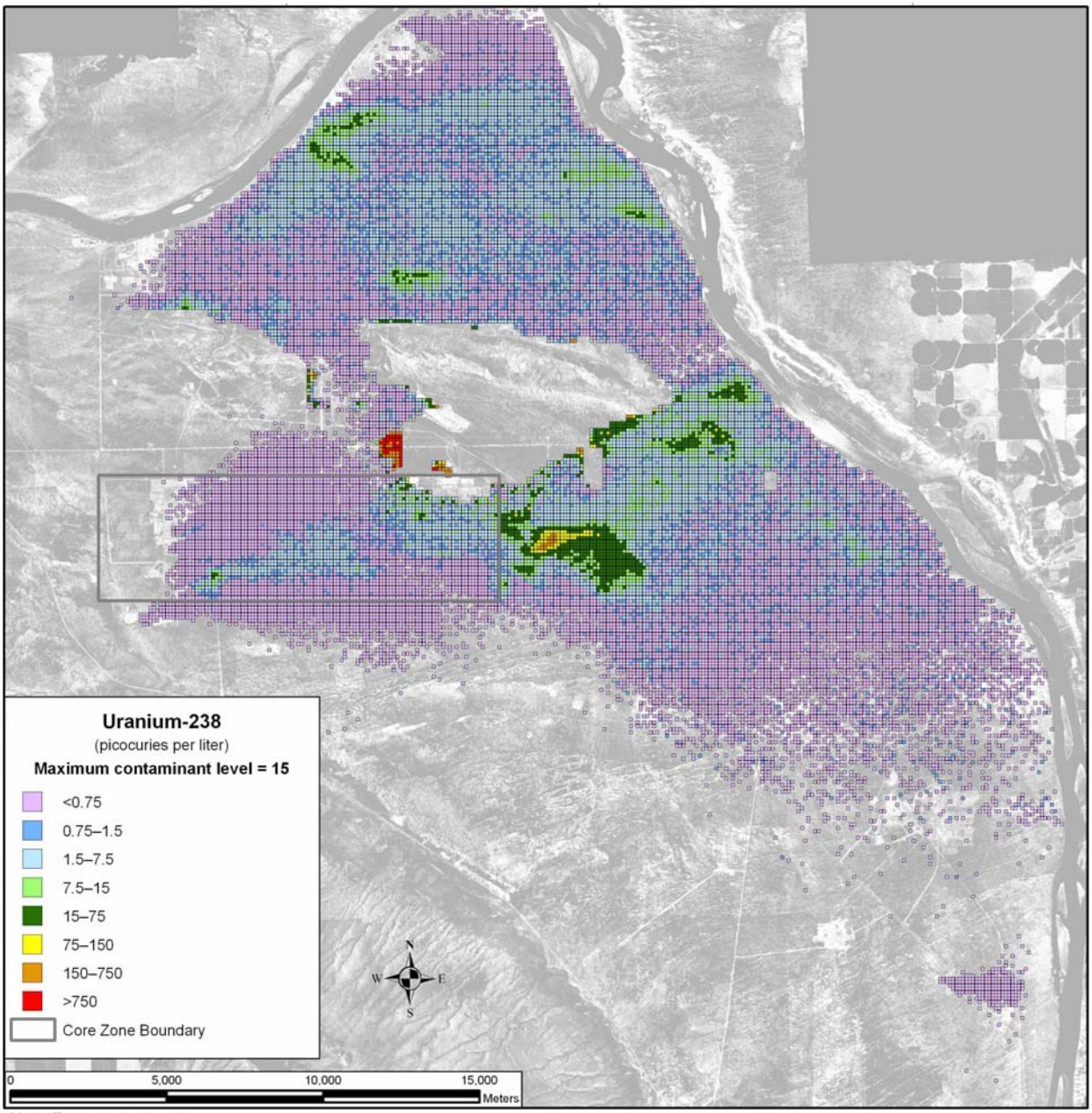
Note: To convert meters to feet, multiply by 3.281

Figure U–25. Spatial Distribution of Groundwater Uranium-238 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



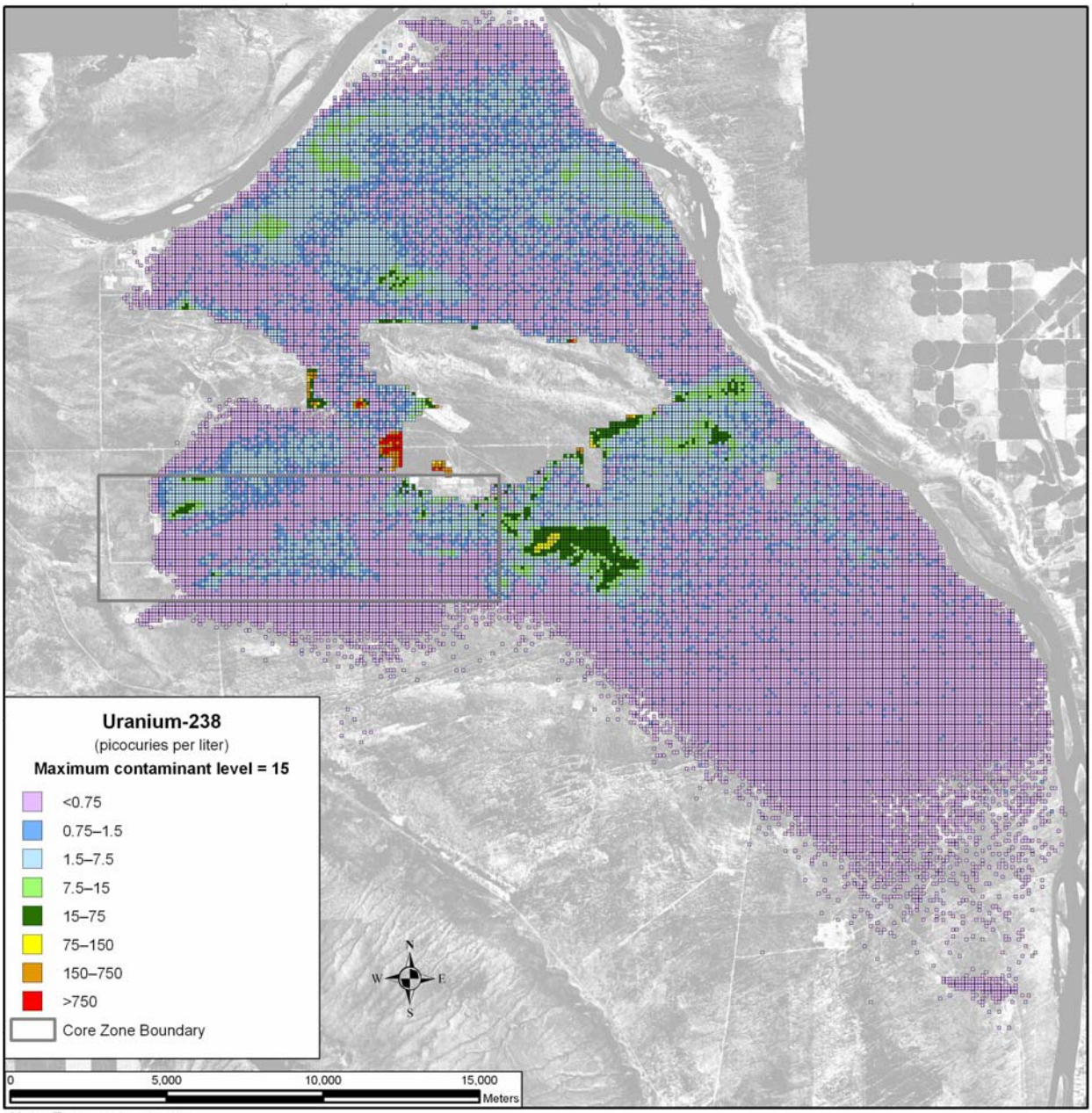
Note: To convert meters to feet, multiply by 3.281

Figure U–26. Spatial Distribution of Groundwater Uranium-238 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



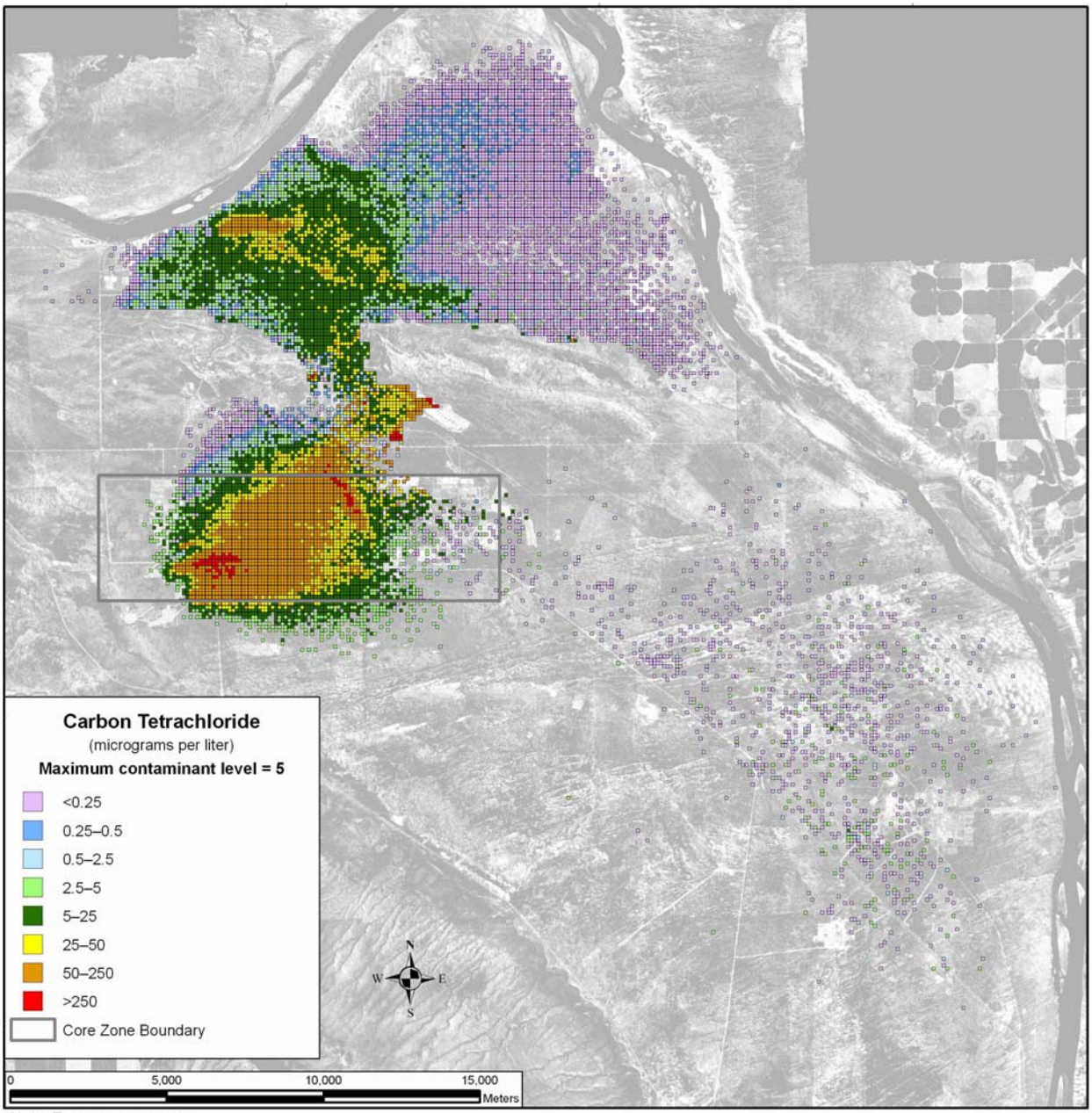
Note: To convert meters to feet, multiply by 3.281

Figure U–27. Spatial Distribution of Groundwater Uranium-238 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



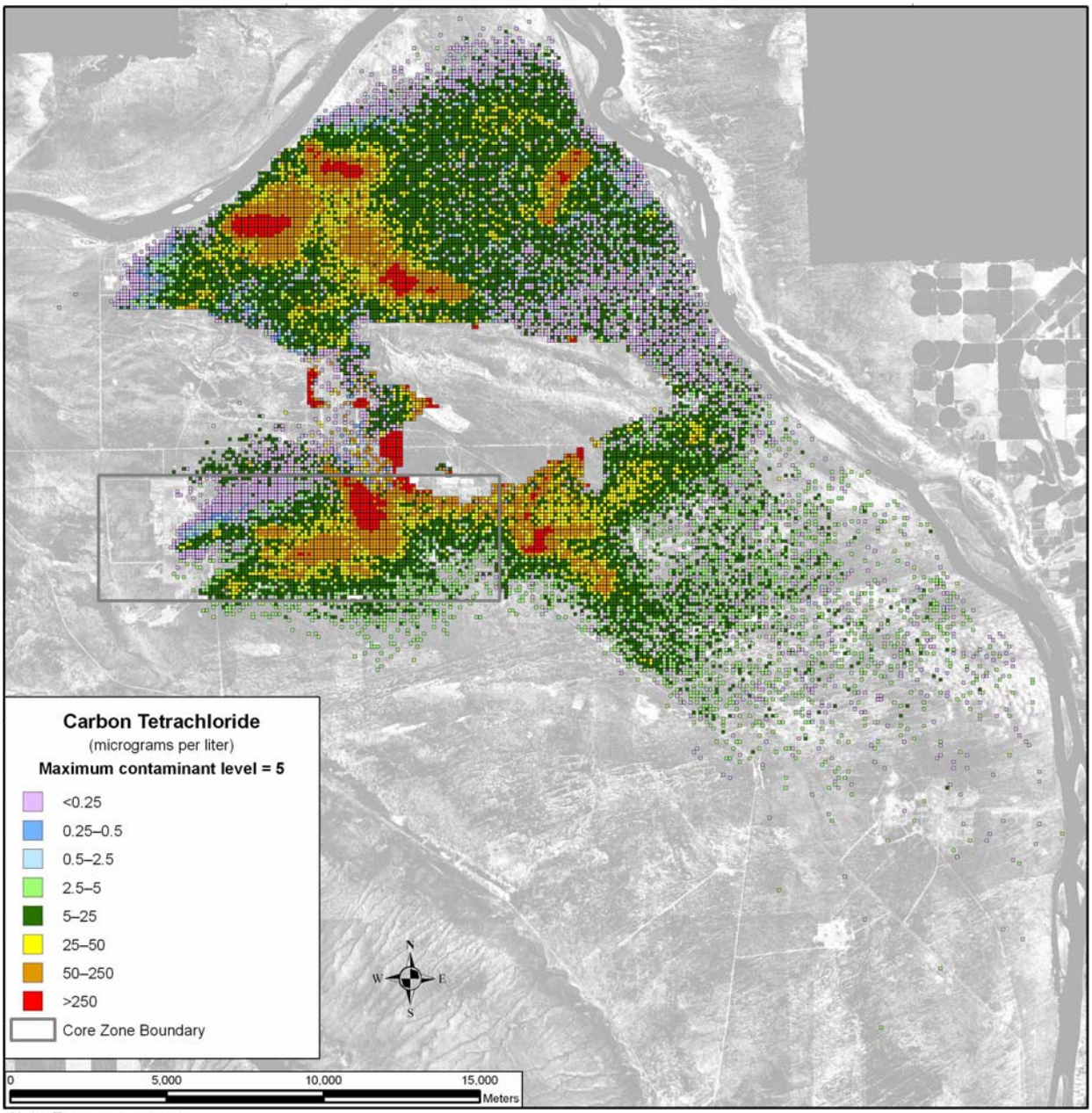
Note: To convert meters to feet, multiply by 3.281

Figure U–28. Spatial Distribution of Groundwater Uranium-238 Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885



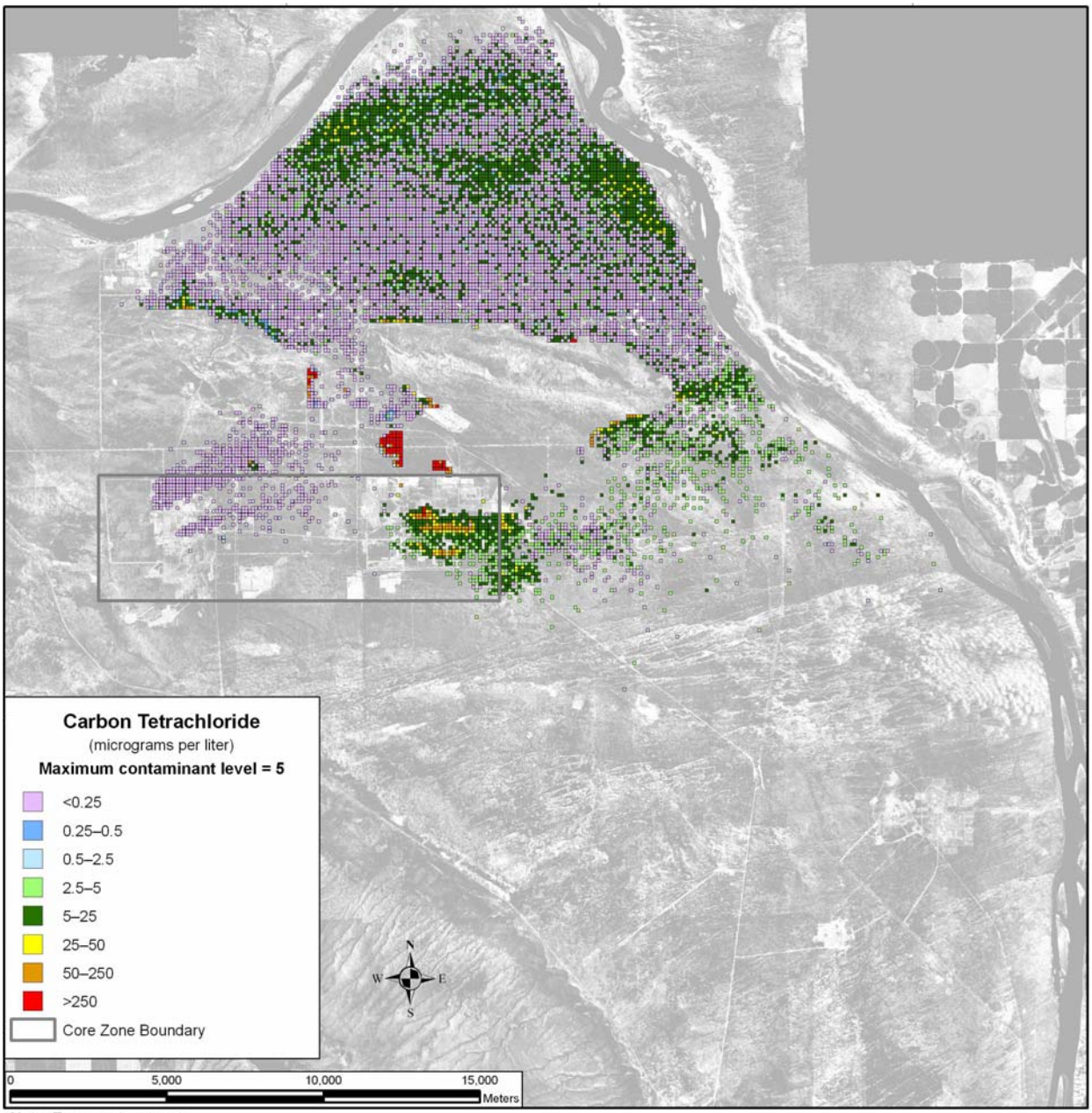
Note: To convert meters to feet, multiply by 3.281

Figure U–29. Spatial Distribution of Groundwater Carbon Tetrachloride Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



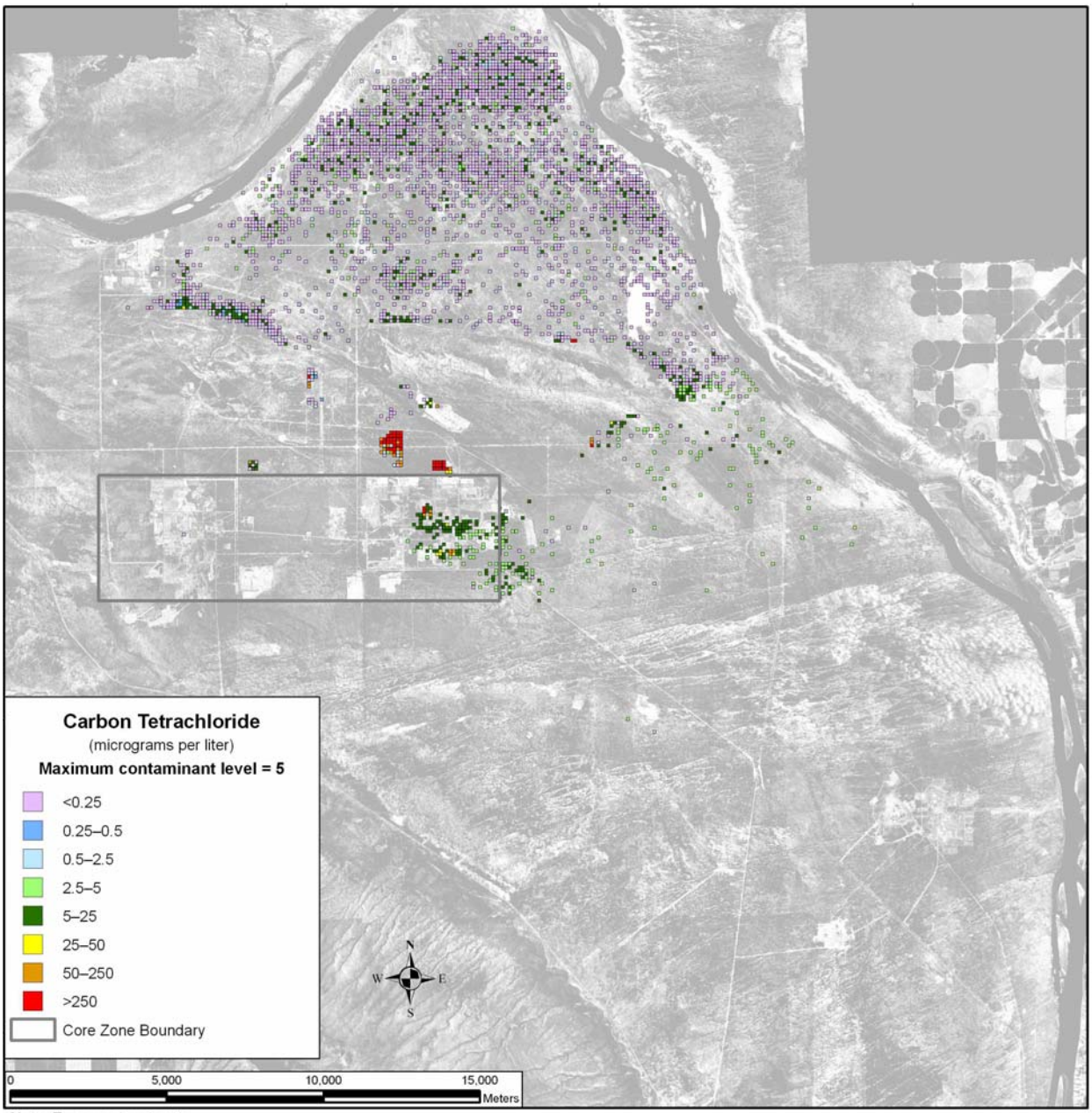
Note: To convert meters to feet, multiply by 3.281

Figure U–30. Spatial Distribution of Groundwater Carbon Tetrachloride Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



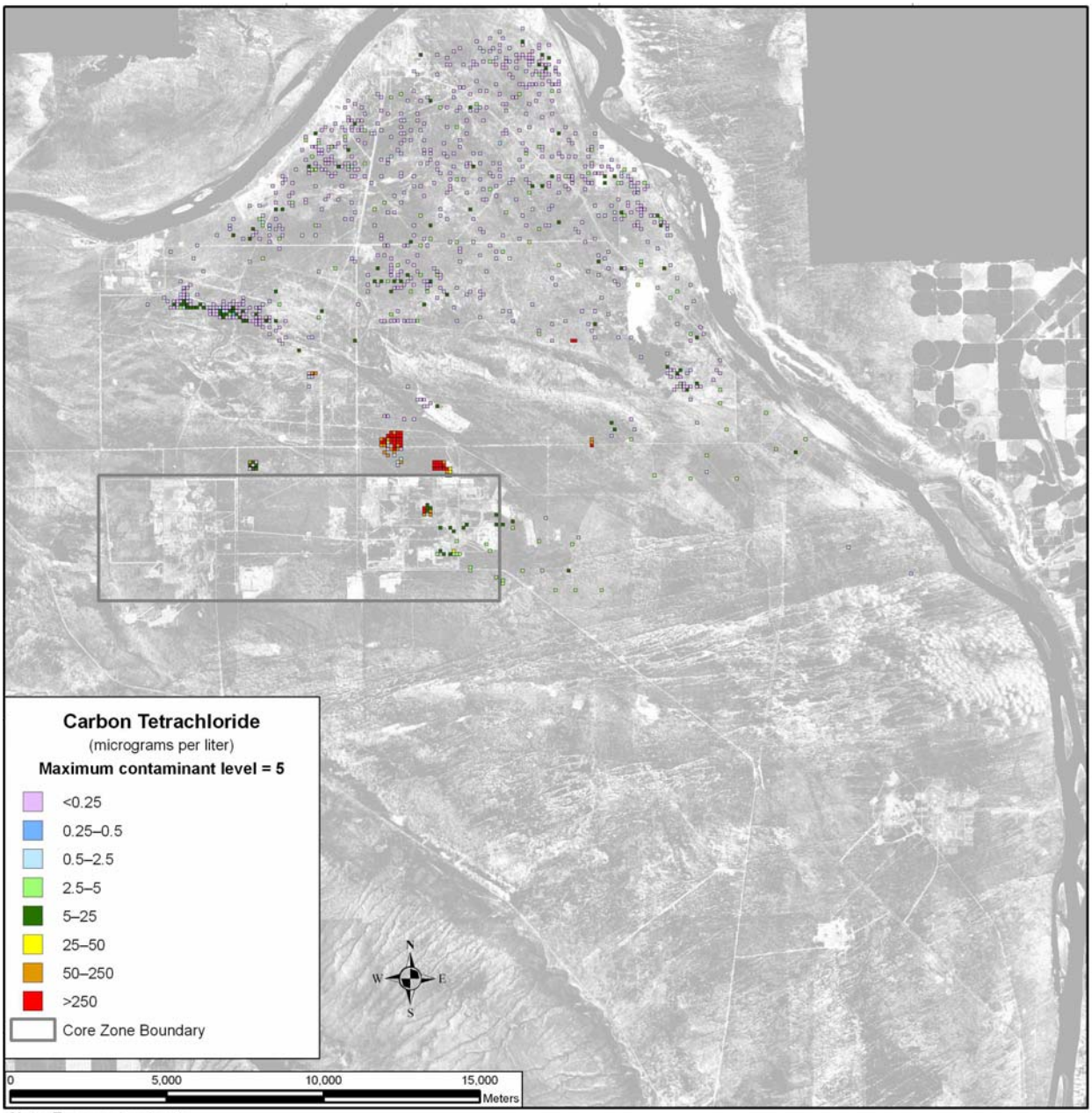
Note: To convert meters to feet, multiply by 3.281

Figure U–31. Spatial Distribution of Groundwater Carbon Tetrachloride Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



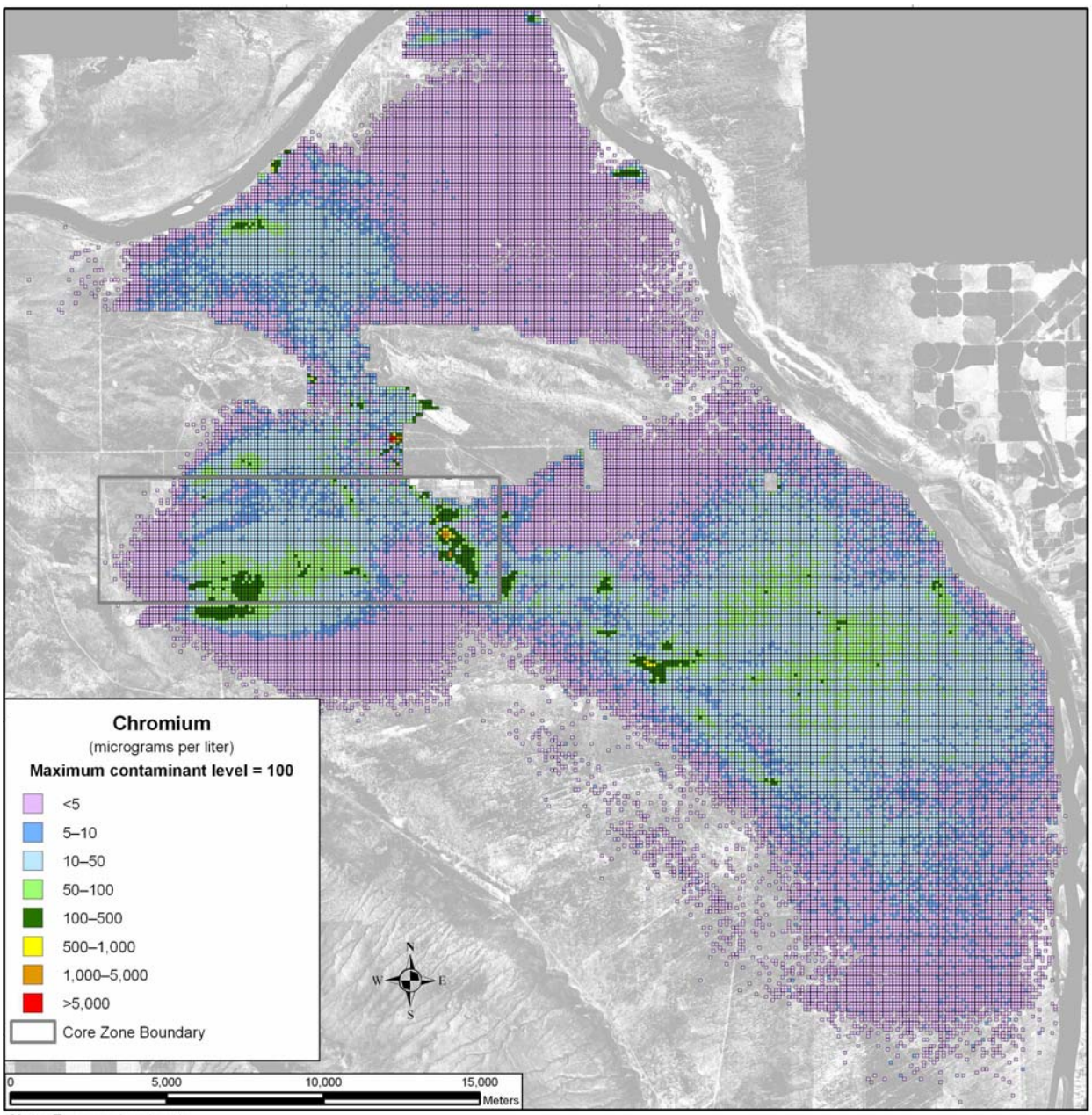
Note: To convert meters to feet, multiply by 3.281

Figure U–32. Spatial Distribution of Groundwater Carbon Tetrachloride Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



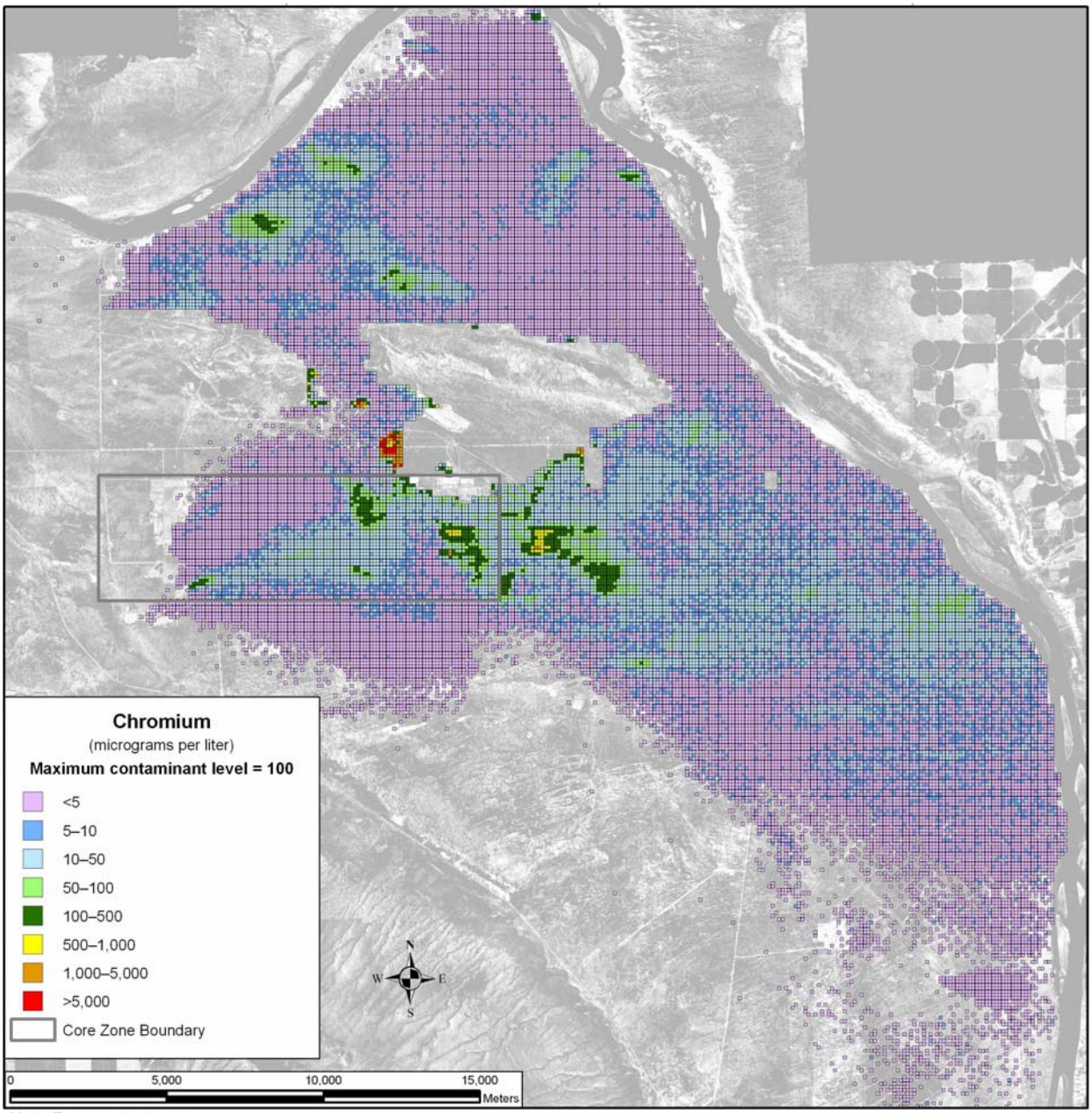
Note: To convert meters to feet, multiply by 3.281

Figure U–33. Spatial Distribution of Groundwater Carbon Tetrachloride Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885



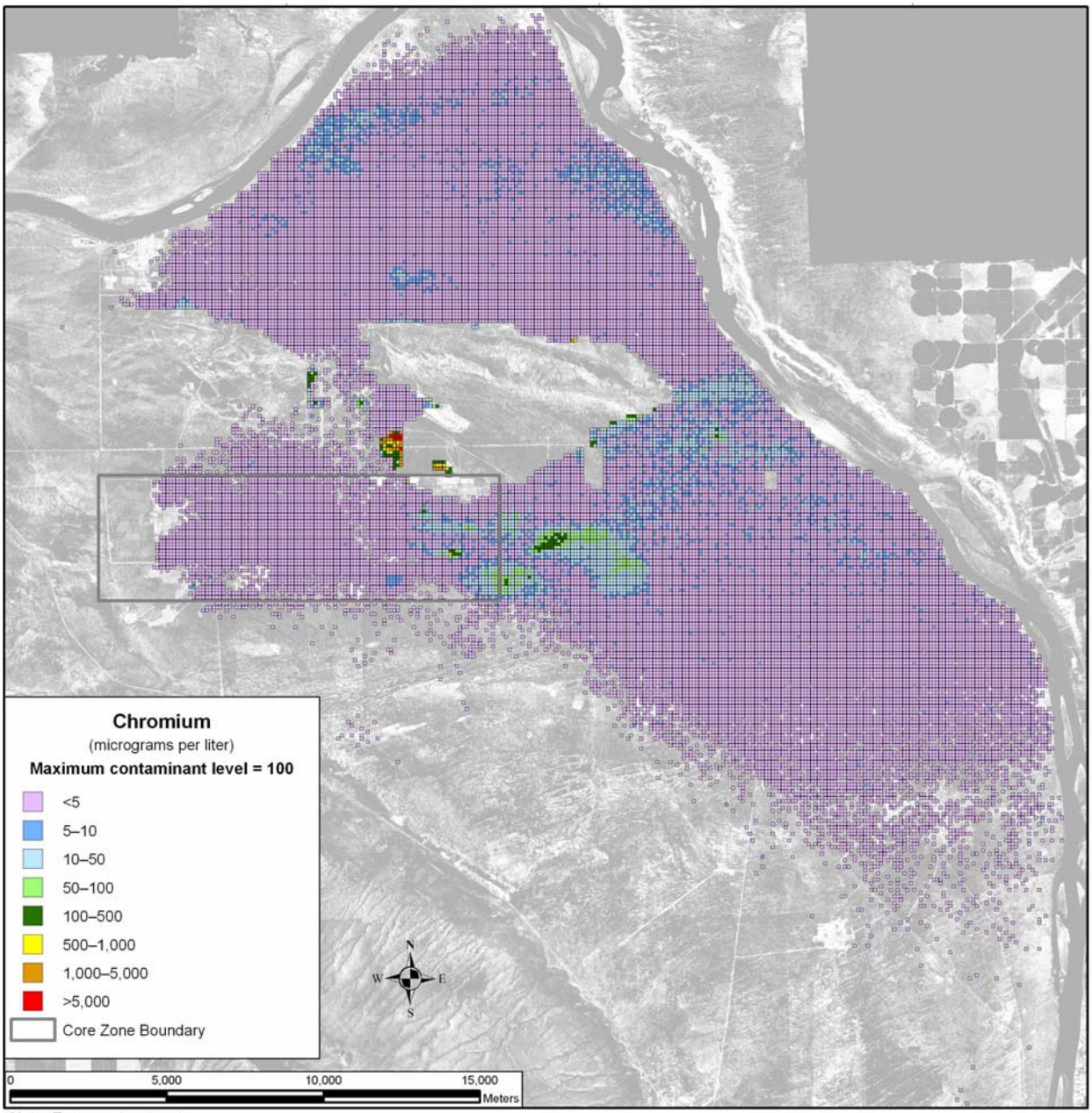
Note: To convert meters to feet, multiply by 3.281

Figure U–34. Spatial Distribution of Groundwater Chromium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



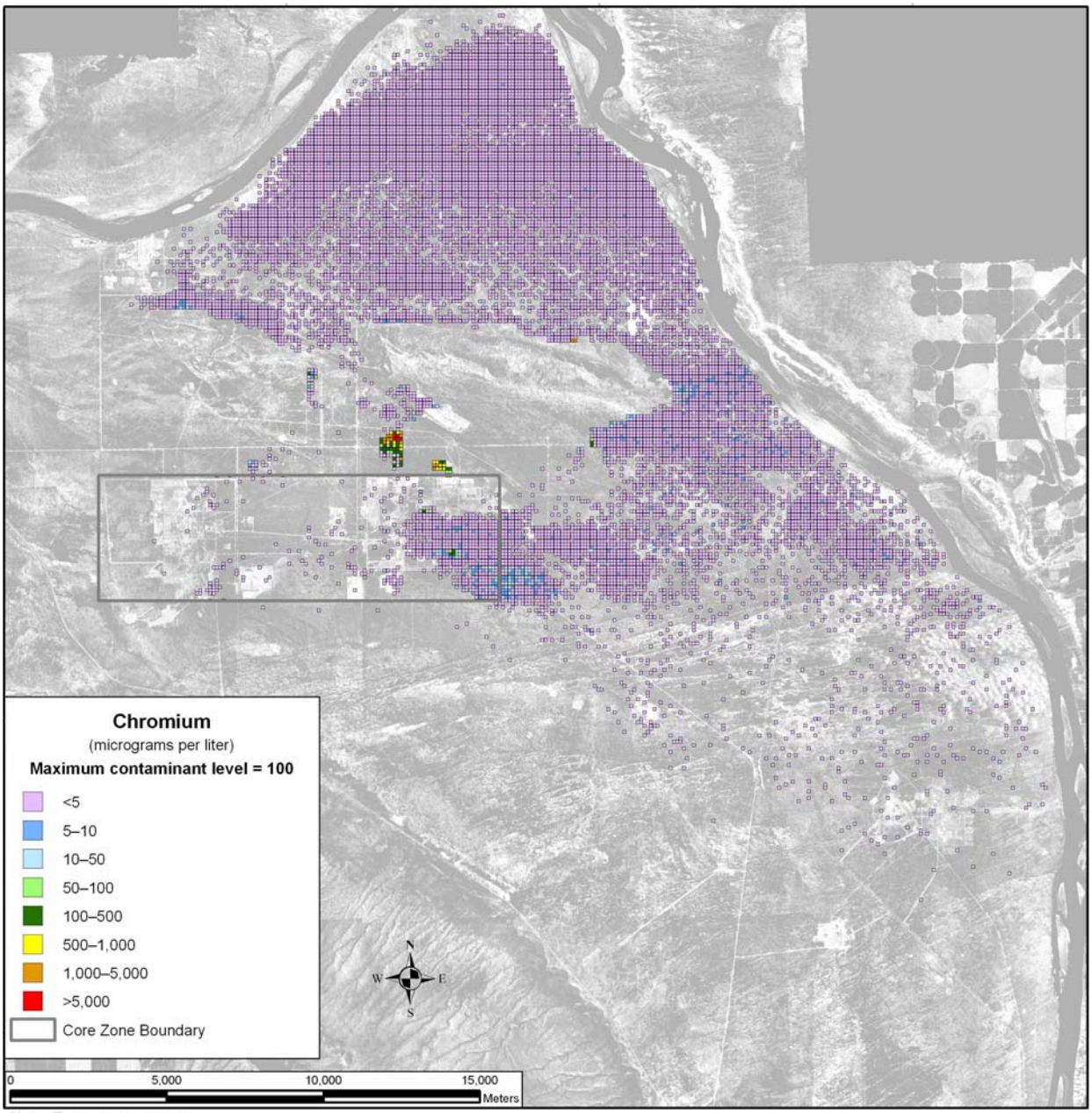
Note: To convert meters to feet, multiply by 3.281

Figure U–35. Spatial Distribution of Groundwater Chromium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



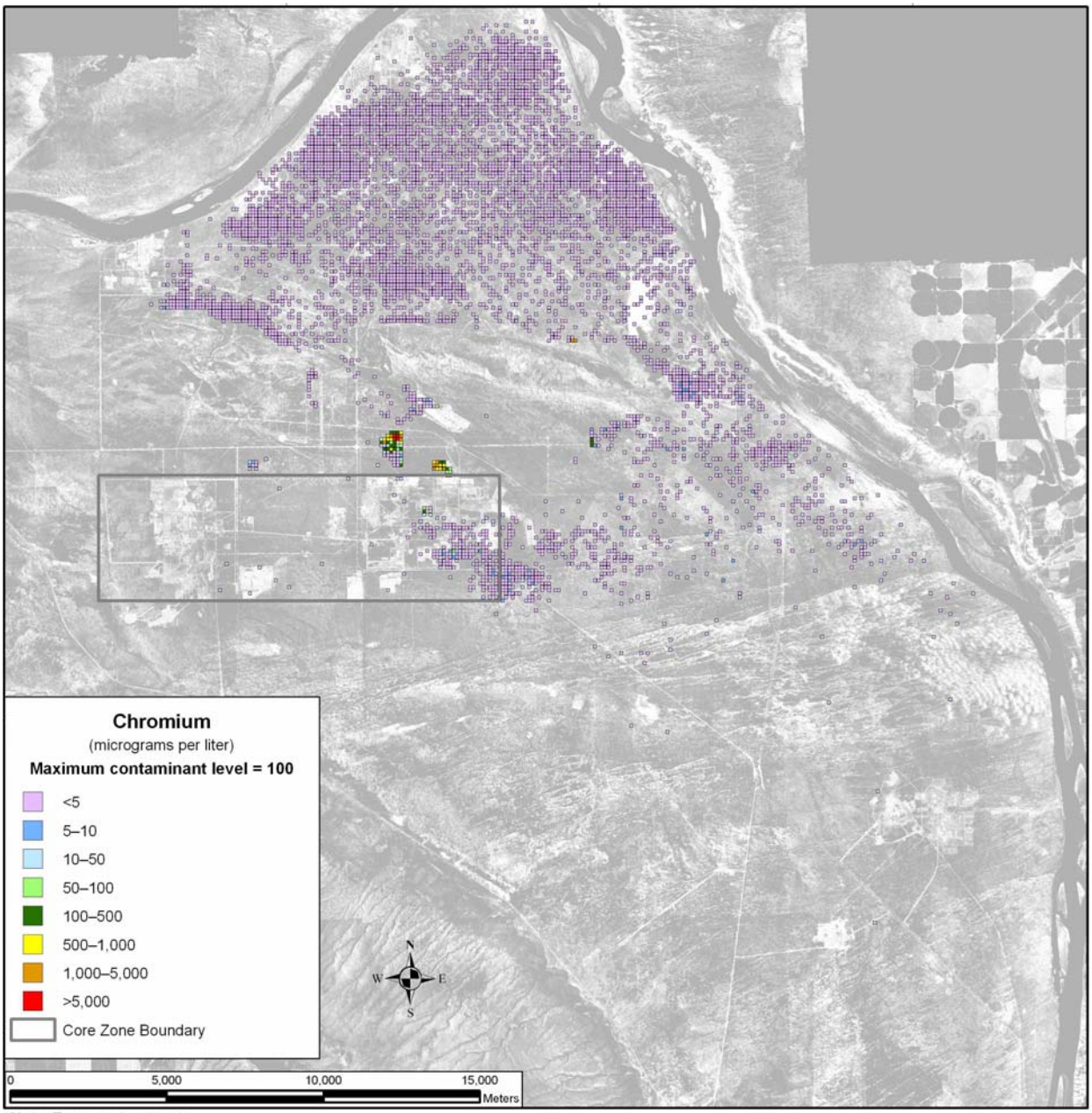
Note: To convert meters to feet, multiply by 3.281

Figure U–36. Spatial Distribution of Groundwater Chromium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



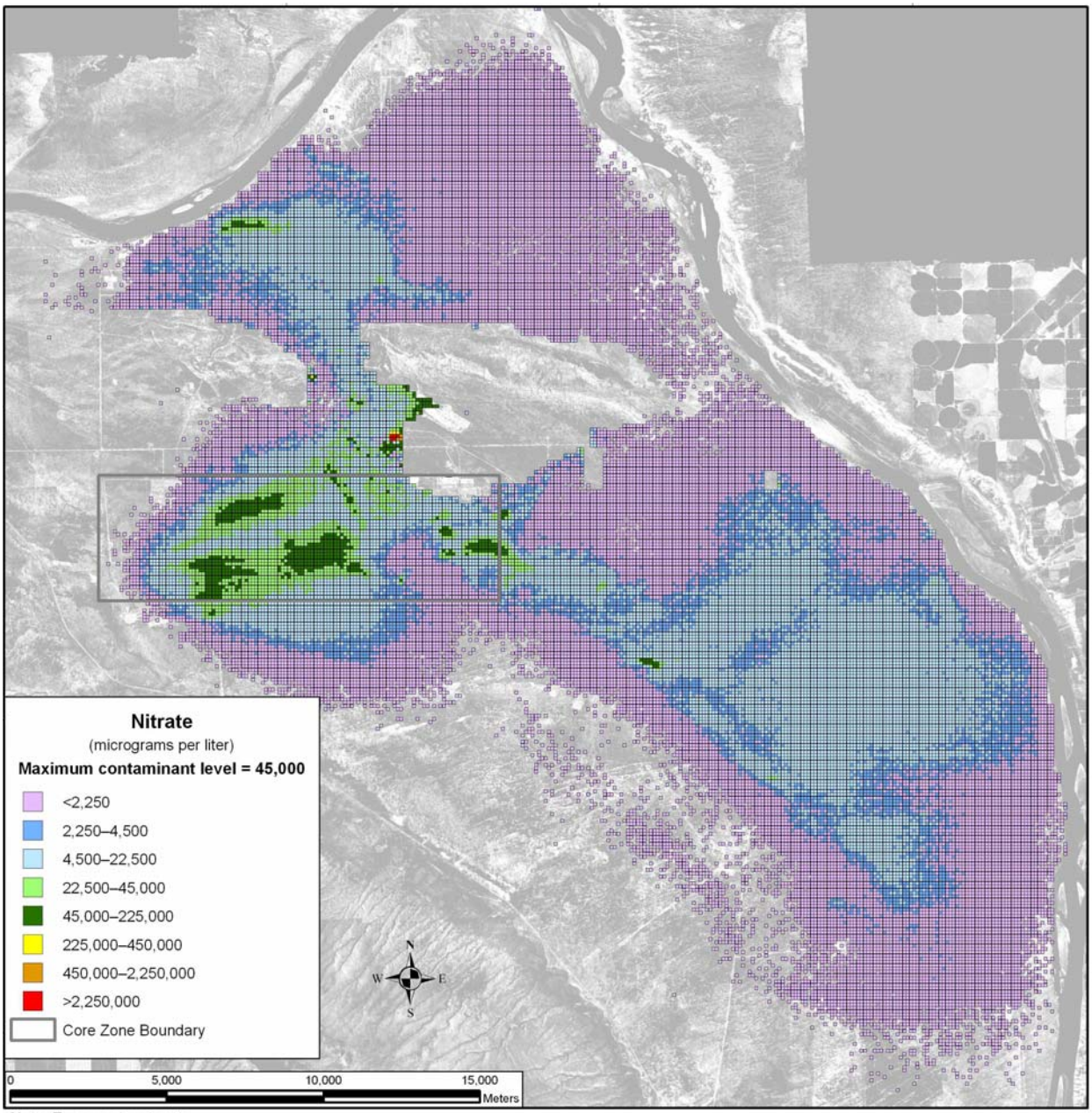
Note: To convert meters to feet, multiply by 3.281

Figure U–37. Spatial Distribution of Groundwater Chromium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



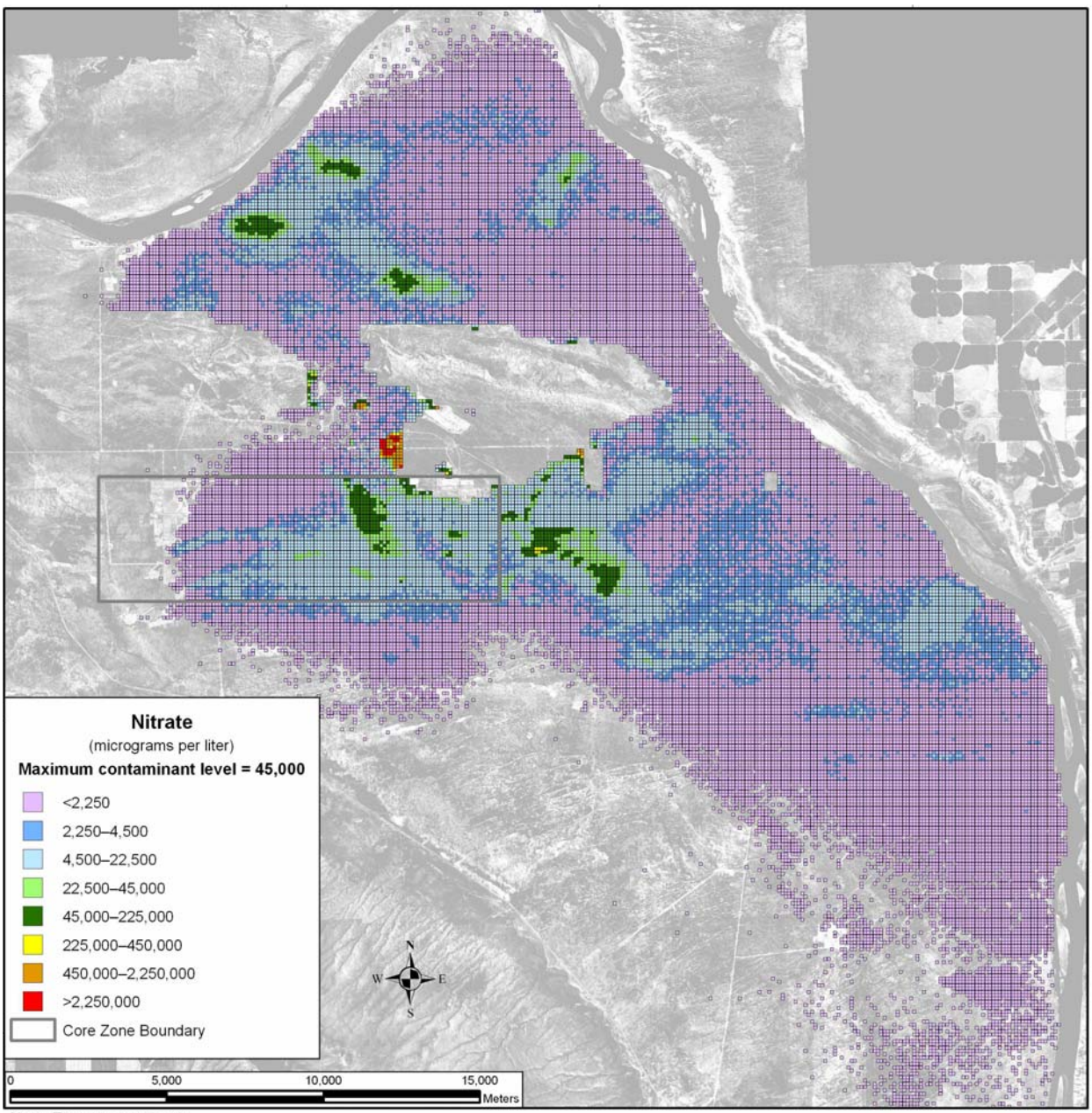
Note: To convert meters to feet, multiply by 3.281

Figure U–38. Spatial Distribution of Groundwater Chromium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885



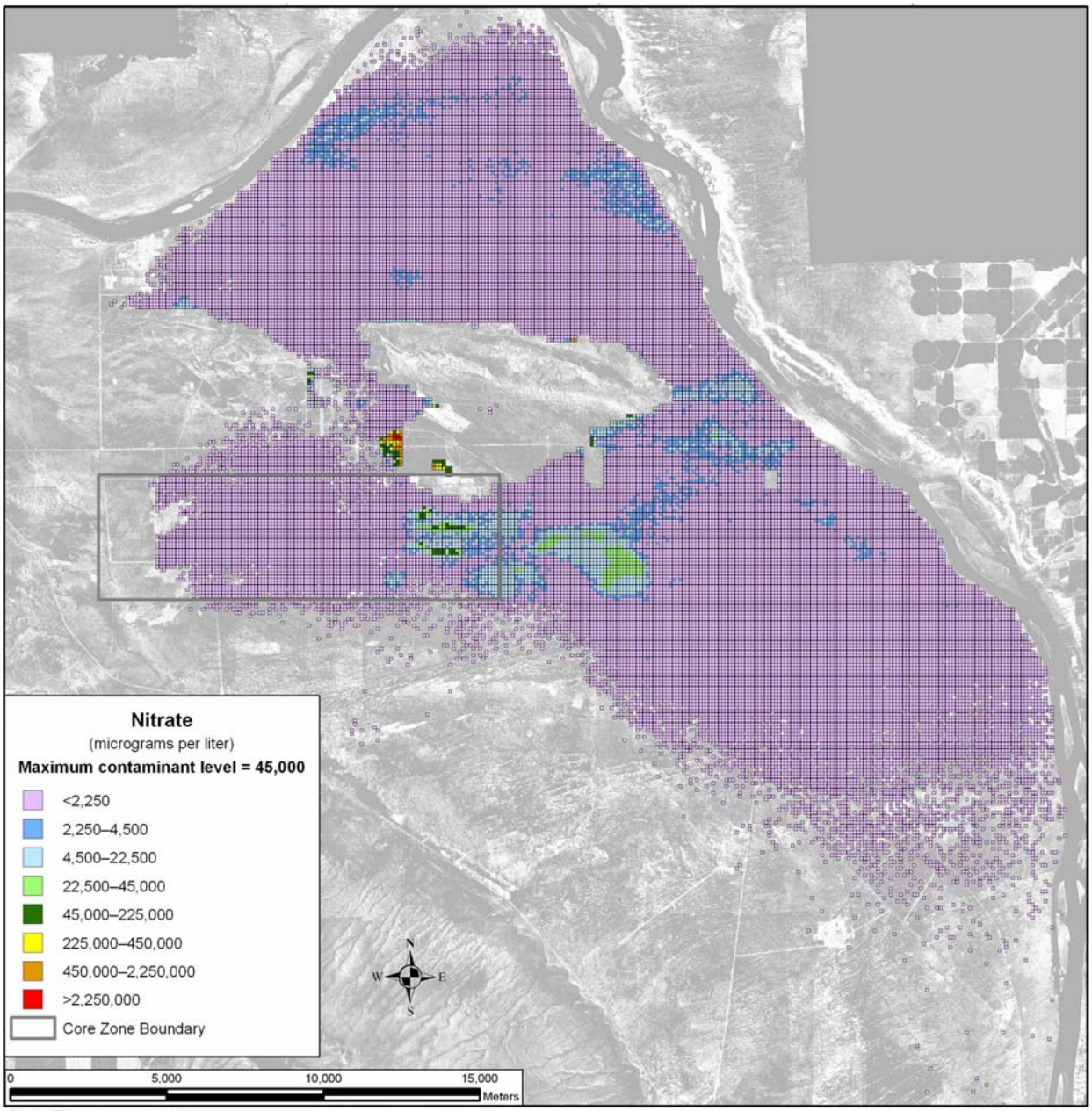
Note: To convert meters to feet, multiply by 3.281

Figure U–39. Spatial Distribution of Groundwater Nitrate Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



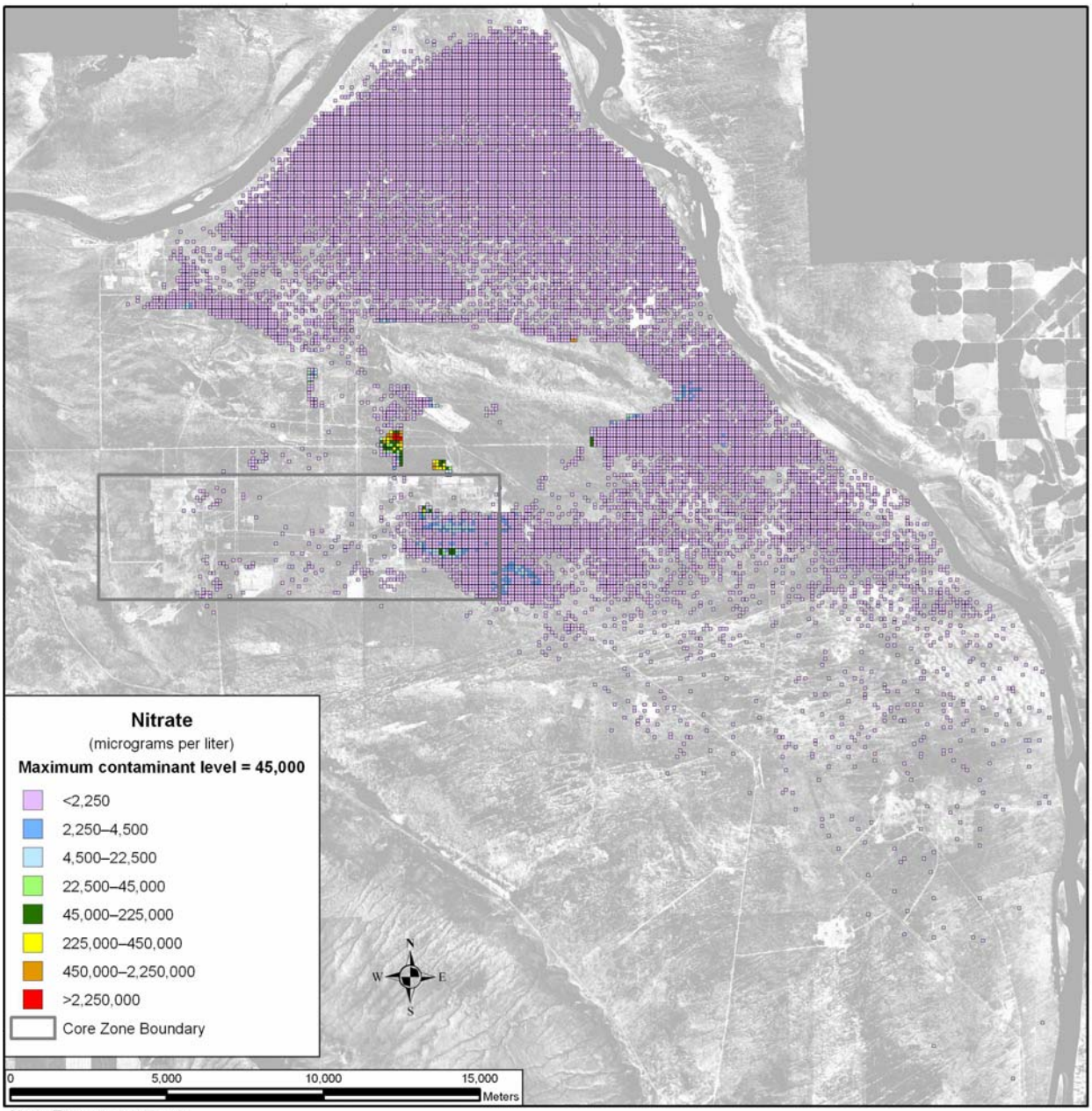
Note: To convert meters to feet, multiply by 3.281

Figure U–40. Spatial Distribution of Groundwater Nitrate Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



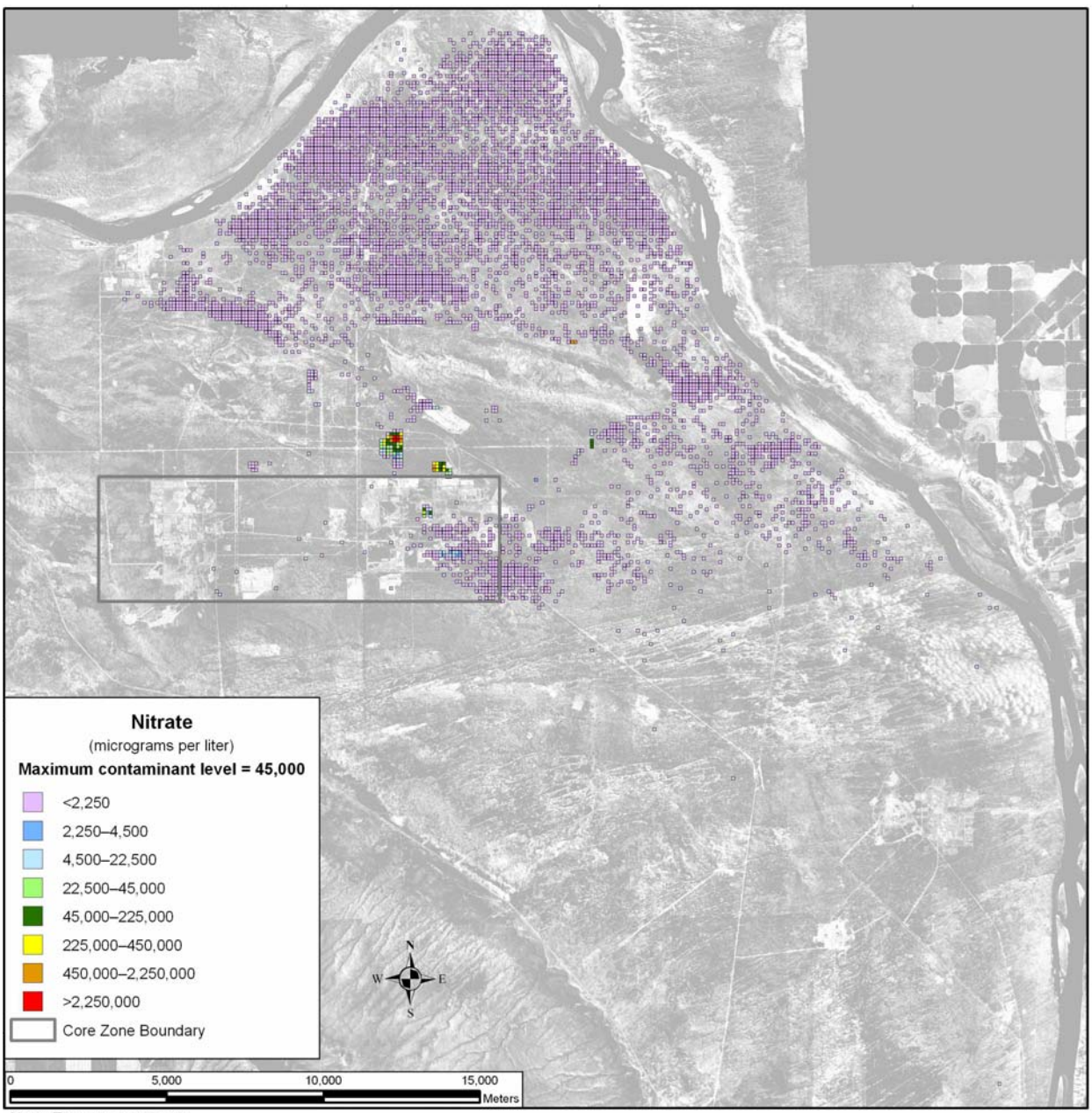
Note: To convert meters to feet, multiply by 3.281

Figure U–41. Spatial Distribution of Groundwater Nitrate Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



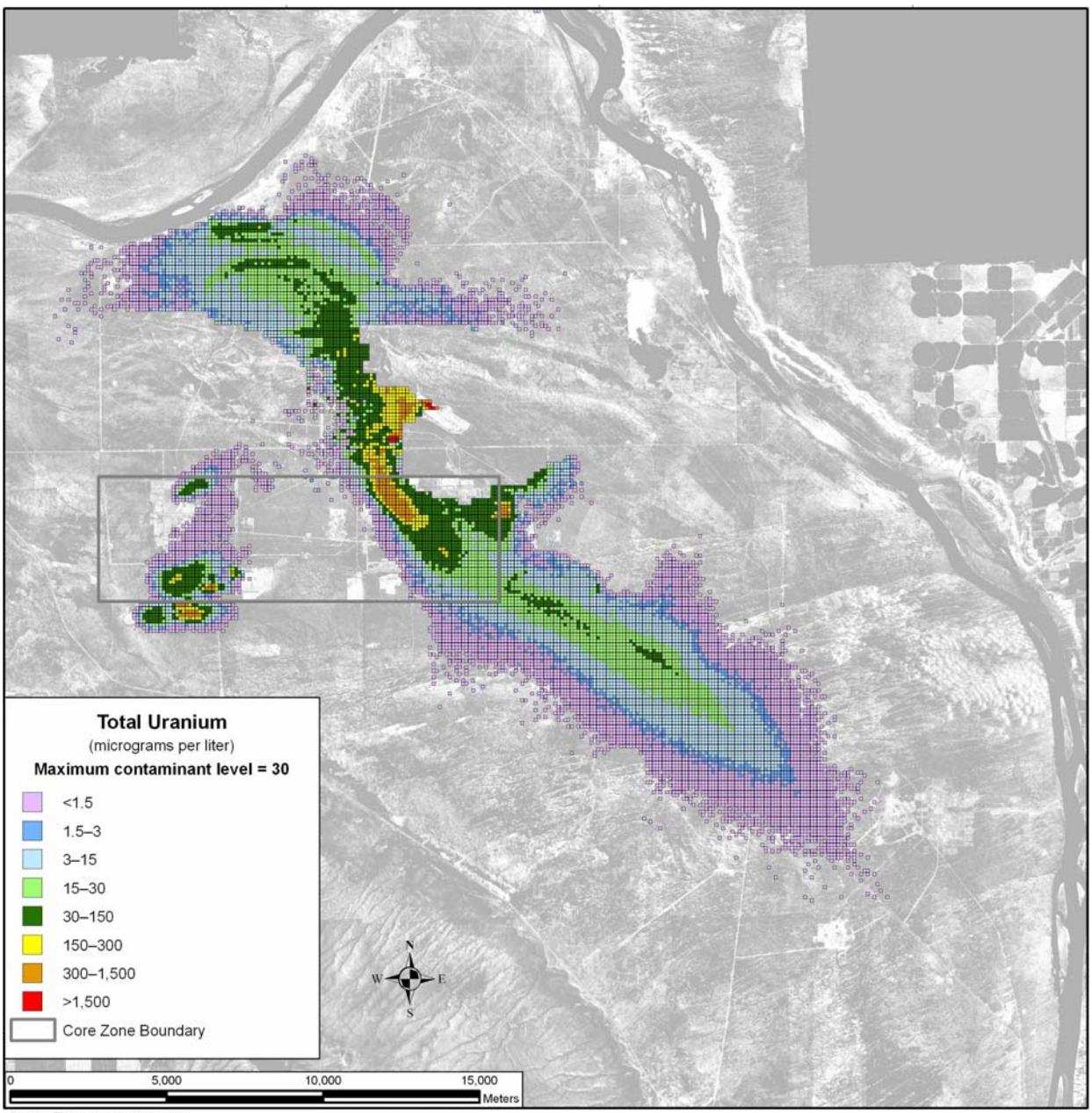
Note: To convert meters to feet, multiply by 3.281

Figure U–42. Spatial Distribution of Groundwater Nitrate Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



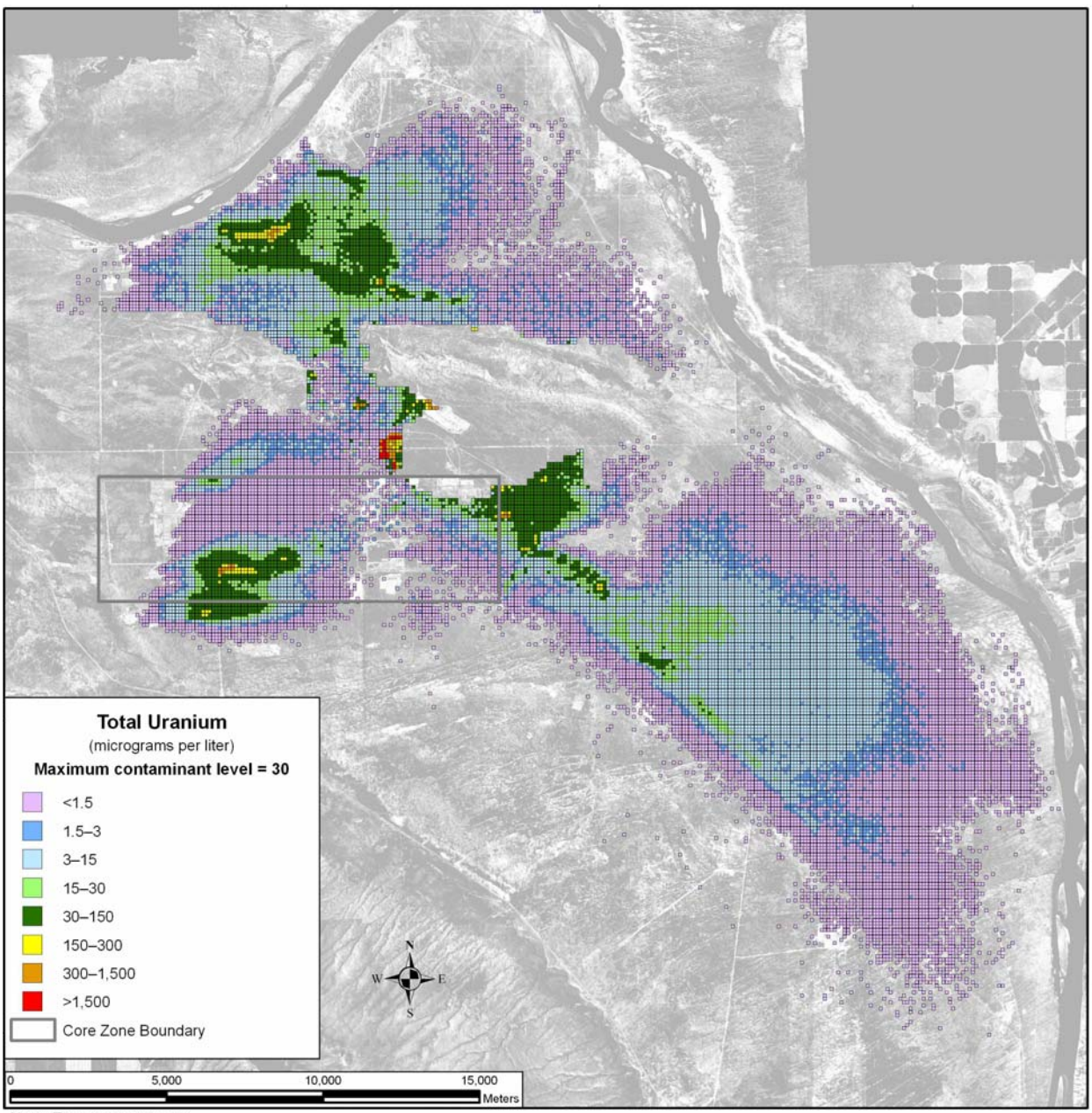
Note: To convert meters to feet, multiply by 3.281

Figure U–43. Spatial Distribution of Groundwater Nitrate Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885



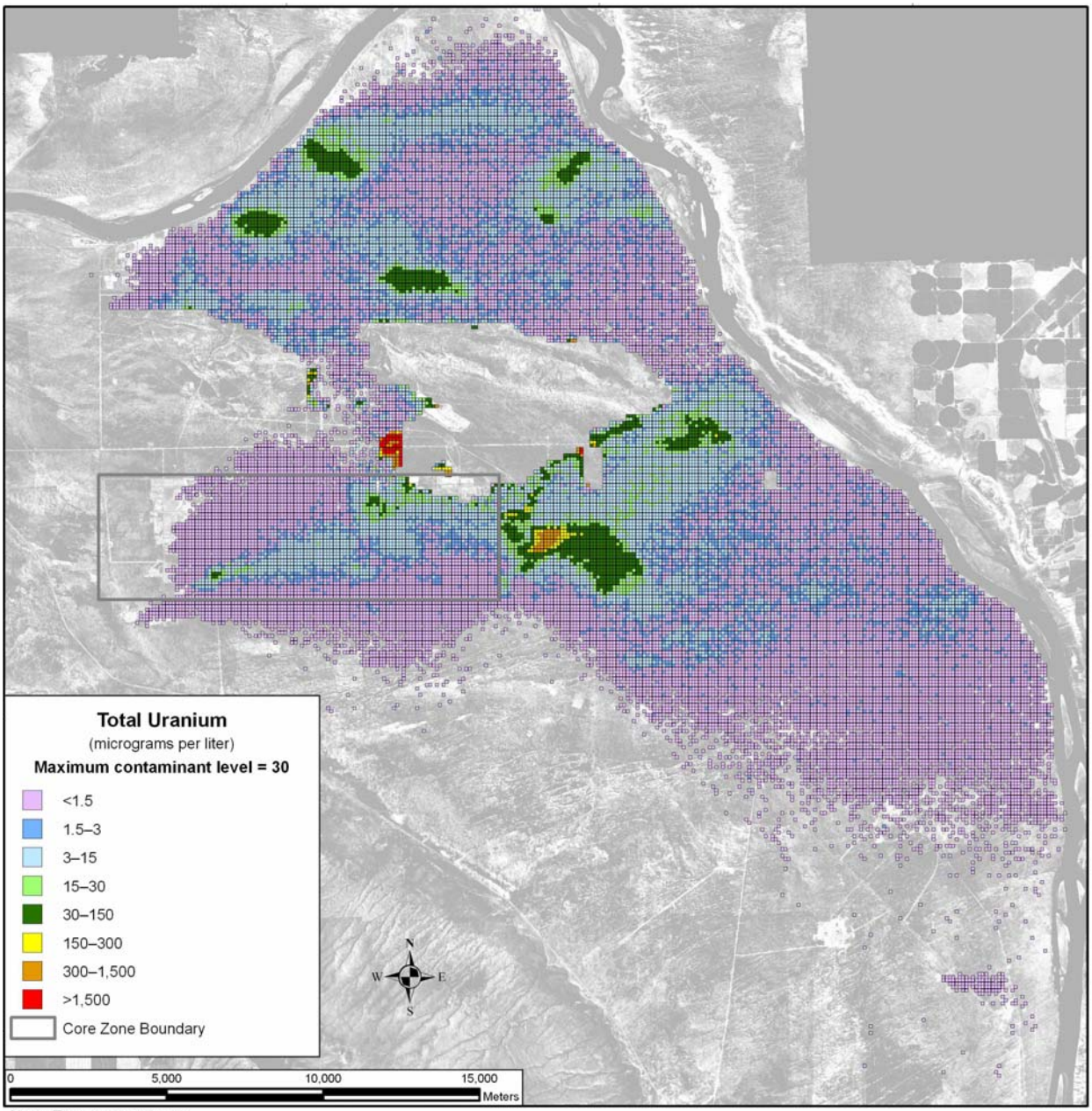
Note: To convert meters to feet, multiply by 3.281

Figure U–44. Spatial Distribution of Groundwater Total Uranium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2005



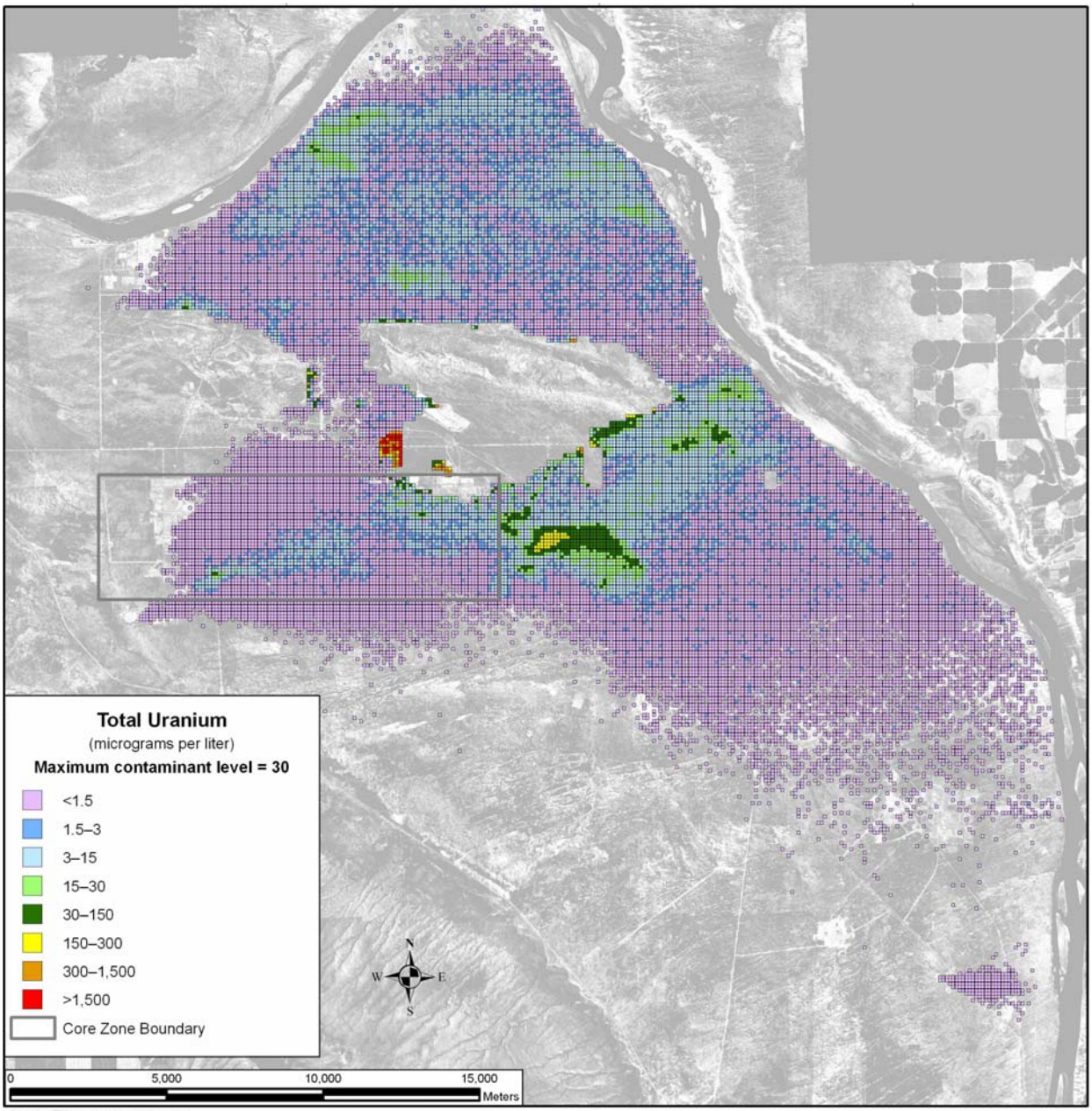
Note: To convert meters to feet, multiply by 3.281

Figure U–45. Spatial Distribution of Groundwater Total Uranium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 2135



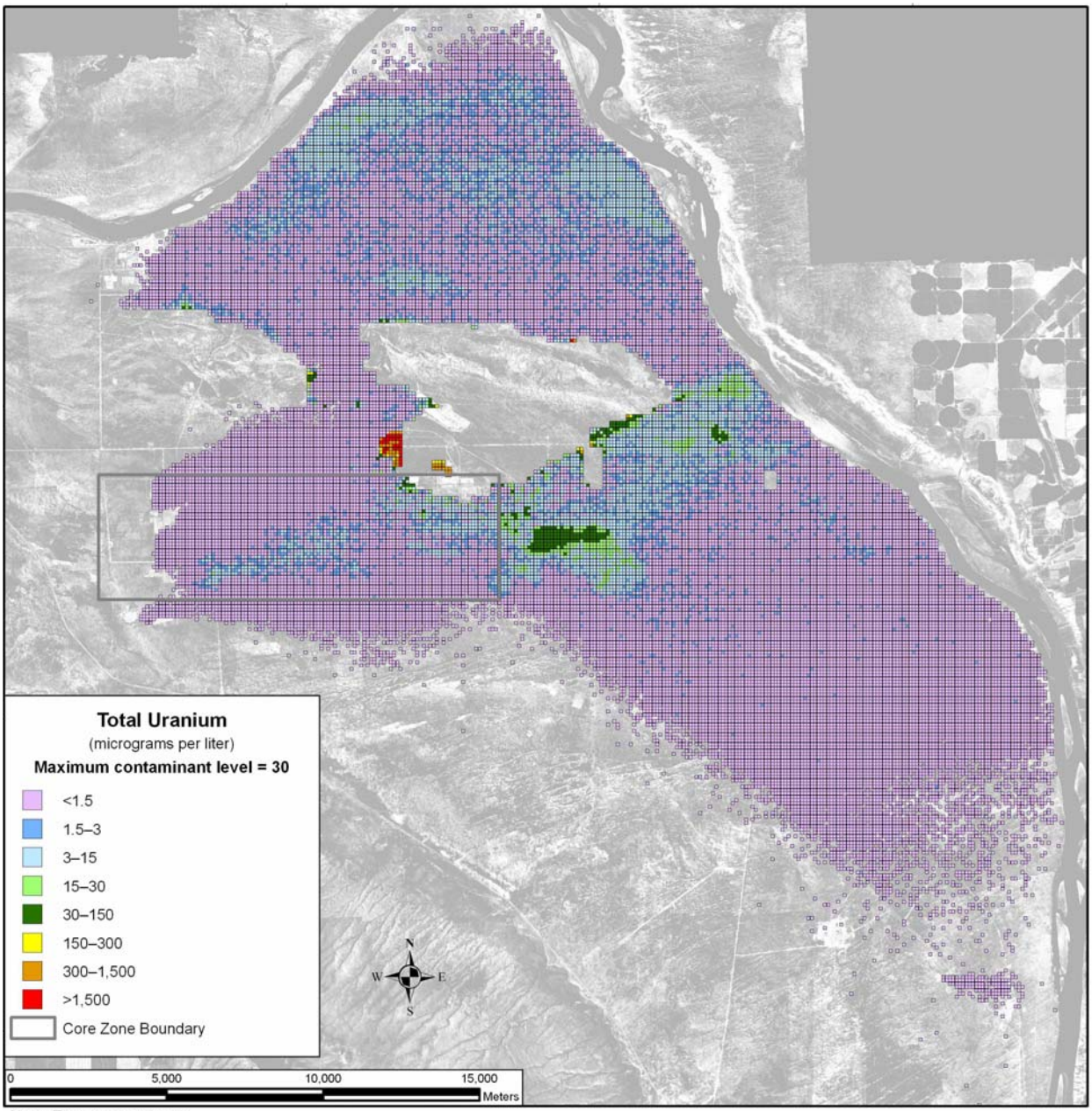
Note: To convert meters to feet, multiply by 3.281

Figure U–46. Spatial Distribution of Groundwater Total Uranium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure U–47. Spatial Distribution of Groundwater Total Uranium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure U–48. Spatial Distribution of Groundwater Total Uranium Concentration (Non–*TC & WM EIS* Sources), Calendar Year 11,885

U.2 HUMAN HEALTH

This section presents the results of the long-term cumulative impacts analysis for human health. The same methodology used for the alternatives analysis was used to analyze cumulative impacts. A description of this methodology is presented in Appendix Q.

The long-term human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer. Potential human health impacts 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 an individual chemical to the intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotient of a group of individual chemical constituents.

As with the individual alternatives, four measures of human health impacts are considered in this analysis—lifetime risk of developing cancer from radiological constituents, lifetime risk of developing cancer from chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures are calculated each year for 10,000 years for applicable receptors at three locations of analysis (i.e., Core Zone Boundary, 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 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.

The three onsite locations of analysis are the Core Zone Boundary, the Columbia River nearshore, and the Columbia River. The offsite location of analysis is for population centers downstream of the site. The total offsite population is assumed to be 5 million people.

Consistent with DOE guidance (DOE Guide 435.1-1), the potential consequences of loss of administrative or institutional control are considered by estimations of impacts on onsite receptors. Because DOE does not anticipate loss of control of the site, these onsite receptors are considered hypothetical and are used to develop estimates for past and future periods of time.

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 groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses groundwater 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 drinks surface water and consumes both wild plant materials, which use groundwater, and game animals, which use surface water.

The significance of dose impacts is evaluated by comparison against the 100-millirem-per-year all-pathway standard specified for protection of the public and the environment in DOE Order 5400.5. The level of protection provided for the drinking water pathway is evaluated by comparison against applicable drinking water standards presented in Chapter 5, Section 5.1.1. The significance of noncarcinogenic chemical health effects is evaluated by comparison against a Hazard Index guideline value of less than unity.

Potential human health impacts of the past, present, and reasonably foreseeable future actions (non–*TC & WM EIS* actions) are summarized in Tables U–3 through U–5. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butanol, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. As shown in Tables U–3 through U–5, the peak radiological dose and risk have already occurred for all locations and all receptors. For the peak Hazard Index and nonradiological risk, the peak has either already occurred or would occur between the years 2200 and 2500. For the period of time prior to calendar year 2000, lifetime radiological risks for the year of peak risk at the Core Zone Boundary and Columbia River locations were high, approaching unity. For the period after calendar year 2000, risks remain high, with values between 1×10^{-3} and 1×10^{-2}. The estimate of radiological dose for the years of peak dose for the offsite population is 215 person-rem per year, approximately 0.01 percent of the average background dose.

Table U–3. Human Health Impacts of Past, Present, and Reasonably Foreseeable Future Non–*TC & WM EIS* Actions at the Core Zone Boundary

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	1.04×10^{-1}	1.22×10^{4}	1.16×10^{-1}	1.04×10^{-1}	1.94×10^{4}	2.02×10^{-1}	1.04×10^{-1}	3.56×10^{4}	4.04×10^{-1}
Carbon-14	3.87×10^{-5}	6.21×10^{1}	1.31×10^{-3}	3.87×10^{-5}	1.25×10^{2}	2.95×10^{-3}	3.87×10^{-5}	4.10×10^{2}	1.04×10^{-2}
Strontium-90	1.79×10^{-4}	1.31×10^{4}	2.19×10^{-1}	1.79×10^{-4}	1.68×10^{4}	3.14×10^{-1}	1.79×10^{-4}	2.79×10^{4}	5.95×10^{-1}
Technetium-99	2.24×10^{-7}	3.92×10^{-1}	1.35×10^{-5}	2.24×10^{-7}	1.01	4.42×10^{-5}	2.24×10^{-7}	2.05	9.64×10^{-5}
Iodine-129	5.24×10^{-9}	1.49	1.70×10^{-5}	5.24×10^{-9}	1.73	2.29×10^{-5}	5.24×10^{-9}	2.14	3.30×10^{-5}
Cesium-137	2.47×10^{-13}	9.00×10^{-6}	1.64×10^{-10}	2.47×10^{-13}	7.78×10^{-4}	1.74×10^{-8}	2.47×10^{-13}	2.34×10^{-3}	5.25×10^{-8}
Uranium isotopes (includes U-233, -234, -235, -238)	1.47×10^{-6}	1.83×10^{2}	2.07×10^{-3}	1.47×10^{-6}	1.90×10^{2}	2.21×10^{-3}	1.47×10^{-6}	2.03×10^{2}	2.50×10^{-3}
Neptunium-237	4.64×10^{-8}	1.36×10^{1}	6.28×10^{-5}	4.64×10^{-8}	1.37×10^{1}	6.59×10^{-5}	4.64×10^{-8}	1.64×10^{1}	7.42×10^{-5}
Total	1.04×10^{-1}	2.55×10^{4}	3.38×10^{-1}	1.04×10^{-1}	3.65×10^{4}	5.22×10^{-1}	1.04×10^{-1}	6.42×10^{4}	1.00
Year of peak impact	1997	1997	1997	1997	1997	1997	1997	1997	1997
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	7.89×10^{-1}	2.25×10^{-1}	0.00	7.89×10^{-1}	4.09×10^{-1}	0.00	7.89×10^{-1}	1.14	0.00
Carbon tetrachloride	3.35	1.37×10^{2}	5.33×10^{-3}	3.35	8.59×10^{2}	3.35×10^{-2}	3.35	3.74×10^{3}	1.46×10^{-1}
Chromium	1.88	1.79×10^{1}	0.00	1.88	1.79×10^{1}	7.38×10^{-9}	1.88	2.62×10^{1}	3.38×10^{-4}
Fluoride	1.44×10^{1}	6.87	0.00	1.44×10^{1}	7.07	0.00	1.44×10^{1}	7.60	0.00
Manganese	6.96×10^{-7}	1.42×10^{-7}	0.00	6.96×10^{-7}	1.82×10^{-7}	0.00	6.96×10^{-7}	8.25×10^{-7}	0.00
Mercury	4.69×10^{-4}	4.47×10^{-2}	0.00	4.69×10^{-4}	5.91×10^{-2}	0.00	4.69×10^{-4}	8.80×10^{-2}	0.00
Nitrate	9.65×10^{2}	1.72×10^{1}	0.00	9.65×10^{2}	2.27×10^{1}	0.00	9.65×10^{2}	4.45×10^{1}	0.00
Total uranium	5.57×10^{-1}	5.31	0.00	5.57×10^{-1}	5.37	0.00	5.57×10^{-1}	5.56	0.00
Total	9.86×10^{2}	1.84×10^{2}	5.33×10^{-3}	9.86×10^{2}	9.13×10^{2}	3.35×10^{-2}	9.86×10^{2}	3.83×10^{3}	1.46×10^{-1}
Year of peak impact	2270	2270	2270	2270	2270	2270	2270	2270	2270

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Key: *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

Table U–4. Human Health Impacts of Past, Present, and Reasonably Foreseeable Future Non–*TC & WM EIS* Actions at the Columbia River Nearshore

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	3.76×10^{-3}	4.39×10^{2}	4.17×10^{-3}	2.90×10^{-3}	5.39×10^{2}	5.63×10^{-3}	2.90×10^{-3}	9.91×10^{2}	1.12×10^{-2}
Carbon-14	1.06×10^{-7}	1.70×10^{-1}	3.60×10^{-6}	8.53×10^{-8}	2.77×10^{-1}	6.51×10^{-6}	8.53×10^{-8}	9.03×10^{-1}	2.29×10^{-5}
Strontium-90	4.16×10^{-3}	3.04×10^{5}	1.00	3.88×10^{-3}	3.65×10^{5}	1.00	3.88×10^{-3}	6.05×10^{5}	1.00
Technetium-99	1.12×10^{-6}	1.96	6.74×10^{-5}	1.23×10^{-7}	5.53×10^{-1}	2.43×10^{-5}	1.23×10^{-7}	1.13	5.30×10^{-5}
Iodine-129	2.90×10^{-9}	8.27×10^{-1}	9.41×10^{-6}	1.68×10^{-9}	5.54×10^{-1}	7.33×10^{-6}	1.68×10^{-9}	6.84×10^{-1}	1.06×10^{-5}
Cesium-137	9.63×10^{-4}	3.51×10^{4}	6.41×10^{-1}	1.31×10^{-3}	4.14×10^{6}	1.00	1.31×10^{-3}	1.24×10^{7}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	7.36×10^{-6}	9.14×10^{2}	1.03×10^{-2}	9.38×10^{-6}	1.21×10^{3}	1.41×10^{-2}	9.38×10^{-6}	1.29×10^{3}	1.59×10^{-2}
Neptunium-237	1.04×10^{-8}	3.03	1.40×10^{-5}	1.03×10^{-8}	3.06	1.47×10^{-5}	1.03×10^{-8}	3.65	1.65×10^{-5}
Plutonium isotopes (includes Pu-239, -240)	2.94×10^{-6}	1.99×10^{3}	8.68×10^{-3}	3.33×10^{-6}	2.36×10^{3}	1.06×10^{-2}	3.33×10^{-6}	2.92×10^{3}	1.23×10^{-2}
Total	8.89×10^{-3}	3.42×10^{5}	1.00	8.10×10^{-3}	4.51×10^{6}	1.00	8.10×10^{-3}	1.31×10^{7}	1.00
Year of peak impact	1991	1991	1991	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Carbon tetrachloride	1.10×10^{-3}	4.49×10^{-2}	9.66×10^{-5}	1.10×10^{-3}	2.82×10^{-1}	6.07×10^{-4}	1.10×10^{-3}	1.23	4.79×10^{-5}
Chromium	1.61×10^{1}	1.53×10^{2}	0.00	1.61×10^{1}	1.54×10^{2}	4.27×10^{-10}	1.61×10^{1}	2.24×10^{2}	2.90×10^{-3}
Fluoride	1.35×10^{1}	6.44	0.00	1.35×10^{1}	6.63	0.00	1.35×10^{1}	7.13	0.00
Manganese	1.50×10^{-5}	3.07×10^{-6}	0.00	1.50×10^{-5}	3.93×10^{-6}	0.00	1.50×10^{-5}	1.78×10^{-5}	0.00
Mercury	1.76×10^{-2}	1.67	0.00	1.76×10^{-2}	2.22	0.00	1.76×10^{-2}	3.30	0.00
Nitrate	4.04×10^{2}	7.22	0.00	4.04×10^{2}	9.50	0.00	4.04×10^{2}	1.86×10^{1}	0.00
Total uranium	5.03	4.79×10^{1}	0.00	5.03	4.85×10^{1}	0.00	5.03	5.02×10^{1}	0.00
Total	4.39×10^{2}	2.17×10^{2}	9.66×10^{-5}	4.39×10^{2}	2.21×10^{2}	6.07×10^{-4}	4.39×10^{2}	3.05×10^{2}	2.95×10^{-3}
Year of peak impact	1978	1978	2527	1978	1978	2527	1978	1978	1978

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Key: *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

Table U–5. Human Health Impacts of Past, Present, and Reasonably Foreseeable Future Non–*TC & WM EIS* Actions at the Columbia River Surface Water

Radioactive Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	2.56×10^{-8}	4.75×10^{-3}	4.96×10^{-8}	2.56×10^{-8}	8.84×10^{-3}	1.00×10^{-7}	2.90×10^{-3}	9.15×10^{2}	1.12×10^{-2}
Carbon-14	2.35×10^{-14}	8.40×10^{-8}	2.01×10^{-12}	2.35×10^{-14}	6.65×10^{-5}	1.81×10^{-9}	8.53×10^{-8}	5.93×10^{-2}	1.62×10^{-6}
Strontium-90	3.35×10^{-10}	3.16×10^{-2}	5.89×10^{-7}	3.35×10^{-10}	4.82×10^{-1}	9.99×10^{-6}	3.88×10^{-3}	2.32×10^{5}	1.00
Technetium-99	1.56×10^{-12}	7.04×10^{-6}	3.09×10^{-10}	1.56×10^{-12}	1.63×10^{-5}	7.70×10^{-10}	1.23×10^{-7}	1.35×10^{-3}	7.40×10^{-8}
Iodine-129	6.94×10^{-14}	2.30×10^{-5}	3.05×10^{-10}	6.94×10^{-14}	3.75×10^{-4}	9.02×10^{-9}	1.68×10^{-9}	3.33×10^{-3}	8.16×10^{-8}
Cesium-137	1.64×10^{-12}	5.18×10^{-3}	1.16×10^{-7}	1.64×10^{-12}	2.54×10^{-2}	5.70×10^{-7}	1.31×10^{-3}	8.32×10^{6}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	1.06×10^{-11}	1.37×10^{-3}	1.59×10^{-8}	1.06×10^{-11}	3.77×10^{-3}	5.33×10^{-8}	9.38×10^{-6}	9.33×10^{1}	1.18×10^{-3}
Neptunium-237	4.31×10^{-15}	1.28×10^{-6}	6.12×10^{-12}	4.31×10^{-15}	1.25×10^{-5}	7.54×10^{-11}	1.03×10^{-8}	3.28×10^{-1}	1.67×10^{-6}
Plutonium isotopes (includes Pu-239, -240)	6.75×10^{-15}	4.87×10^{-6}	2.19×10^{-11}	6.75×10^{-15}	7.62×10^{-4}	4.27×10^{-9}	3.33×10^{-6}	3.63×10^{2}	1.32×10^{-3}
Total	2.59×10^{-8}	4.29×10^{-2}	7.71×10^{-7}	2.59×10^{-8}	5.22×10^{-1}	1.07×10^{-5}	8.10×10^{-3}	8.56×10^{6}	1.00
Year of peak impact	1985	1985	1985	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Resident Farmer**			**American Indian Resident Farmer**			**American Indian Hunter-Gatherer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	0.00	0.00	0.00	0.00	0.00	0.00	1.77×10^{-3}	2.05×10^{-3}	0.00
Boron and compounds	0.00	0.00	0.00	0.00	0.00	0.00	1.20×10^{-4}	1.19×10^{-6}	0.00
Carbon tetrachloride	5.25×10^{-7}	1.35×10^{-4}	3.41×10^{-8}	2.31×10^{-7}	2.67×10^{-4}	7.93×10^{-9}	6.07×10^{-2}	6.53×10^{1}	5.94×10^{-3}
Chromium	8.06×10^{-5}	7.68×10^{-4}	2.92×10^{-14}	7.88×10^{-5}	1.20×10^{-3}	1.01×10^{-10}	1.09×10^{-1}	2.40×10^{-1}	9.79×10^{-6}
Fluoride	3.70×10^{-5}	1.81×10^{-5}	0.00	2.92×10^{-5}	2.02×10^{-5}	0.00	2.15	3.15×10^{-1}	0.00
Hydrazine/hydrazine sulfate	0.00	0.00	0.00	0.00	0.00	6.09×10^{-7}	8.72×10^{-13}	3.18×10^{-210}	4.09×10^{-10}
Manganese	2.59×10^{-15}	6.78×10^{-16}	0.00	2.59×10^{-15}	1.05×10^{-14}	0.00	8.97×10^{-2}	5.67×10^{-2}	0.00

Table U–5. Human Health Impacts of Past, Present, and Reasonably Foreseeable Future Non–*TC & WM EIS* Actions at the Columbia River Surface Water *(continued)*

Chemical Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Mercury	2.92×10^{-12}	3.69×10^{-10}	0.00	1.95×10^{-14}	6.88×10^{-11}	0.00	5.62×10^{-6}	2.15×10^{-4}	0.00
Nickel (soluble salts)	0.00	0.00	0.00	0.00	0.00	0.00	3.94×10^{-1}	7.35×10^{-1}	0.00
Nitrate	1.97×10^{-3}	6.79×10^{-5}	0.00	2.68×10^{-3}	2.52×10^{-1}	0.00	1.08×10^{1}	4.39×10^{-1}	0.00
Total uranium	1.59×10^{-5}	1.53×10^{-4}	0.00	1.61×10^{-5}	2.14×10^{-4}	0.00	7.39×10^{-2}	3.28×10^{-2}	0.00
Trichloroethylene (TCE)	0.00	0.00	0.00	0.00	0.00	5.06×10^{-10}	1.87×10^{-12}	7.28×10^{-10}	3.74×10^{-14}
Total	2.10×10^{-3}	1.14×10^{-3}	3.41×10^{-8}	2.81×10^{-3}	2.54×10^{-1}	6.18×10^{-7}	2.05×10^{1}	6.71×10^{1}	5.95×10^{-3}
Year of peak impact	1965	1965	1990	1962	1962	3243	2527	2527	2527

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Key: *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*

Potential human health impacts of Alternative Combination 1, with the past, present, and reasonably foreseeable future (non–*TC & WM EIS*) actions discussed above, are summarized in Tables U–6 through U–8. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butanol, acetonitrile, boron and boron compounds, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. The impacts of Alternative Combination 1 are dominated by the impacts of non–*TC & WM EIS* sources. The estimate of radiological dose for the year of peak dose for the offsite population is 215 person-rem per year, approximately 0.01 percent of average background dose.

Table U–6. Alternative Combination 1 Cumulative Human Health Impacts at the Core Zone Boundary

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	1.04×10^{-1}	1.22×10^{4}	1.16×10^{-1}	1.04×10^{-1}	1.94×10^{4}	2.03×10^{-1}	1.04×10^{-1}	3.56×10^{4}	4.04×10^{-1}
Carbon-14	3.87×10^{-5}	6.21×10^{1}	1.31×10^{-3}	3.87×10^{-5}	1.25×10^{2}	2.95×10^{-3}	3.87×10^{-5}	4.10×10^{2}	1.04×10^{-2}
Strontium-90	1.79×10^{-4}	1.31×10^{4}	2.19×10^{-1}	1.79×10^{-4}	1.68×10^{4}	3.14×10^{-1}	1.79×10^{-4}	2.79×10^{4}	5.95×10^{-1}
Technetium-99	2.98×10^{-6}	5.22	1.79×10^{-4}	2.98×10^{-6}	1.34×10^{1}	5.88×10^{-4}	2.98×10^{-6}	2.73×10^{1}	1.28×10^{-3}
Iodine-129	7.65×10^{-9}	2.18	2.48×10^{-5}	7.65×10^{-9}	2.53	3.35×10^{-5}	7.65×10^{-9}	3.12	4.82×10^{-5}
Cesium-137	2.47×10^{-13}	9.00×10^{-6}	1.64×10^{-10}	2.47×10^{-13}	7.78×10^{-4}	1.74×10^{-8}	2.47×10^{-13}	2.34×10^{3}	5.25×10^{-8}
Uranium isotopes (includes U-233, -234, -235, -238)	1.47×10^{-6}	1.83×10^{2}	2.07×10^{-3}	1.47×10^{-5}	1.90×10^{2}	2.21×10^{-3}	1.47×10^{-6}	2.03×10^{2}	2.50×10^{-3}
Neptunium-237	4.64×10^{-8}	1.36×10^{1}	6.28×10^{-5}	4.64×10^{-8}	1.37×10^{1}	6.59×10^{-5}	4.64×10^{-8}	1.64×10^{1}	7.42×10^{-5}
Total	1.04×10^{-1}	2.55×10^{4}	3.38×10^{-1}	1.04×10^{-1}	3.66×10^{4}	5.22×10^{-1}	1.04×10^{-1}	6.42×10^{4}	1.00
Year of peak impact	1997	1997	1997	1997	1997	1997	1997	1997	1997
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	2.61×10^{-2}	7.47×10^{-3}	0.00	7.89×10^{-1}	4.09×10^{-1}	0.00	7.89×10^{-1}	1.14	0.00
Acetonitrile	0.00	0.00	0.00	1.61×10^{-2}	9.56×10^{-2}	0.00	1.61×10^{-2}	1.73×10^{-1}	0.00
Carbon tetrachloride	4.06×10^{-1}	1.66×10^{1}	5.33×10^{-3}	3.35	8.59×10^{2}	3.35×10^{-2}	3.35	3.74×10^{3}	1.46×10^{-1}
Chromium	2.94×10^{1}	2.80×10^{2}	0.00	3.19	3.04×10^{1}	1.25×10^{-8}	3.19	4.44×10^{1}	5.75×10^{-4}
Fluoride	2.59	1.23	0.00	1.44×10^{1}	7.07	0.00	1.44×10^{1}	7.60	0.00
Manganese	0.00	0.00	0.00	6.96×10^{-7}	1.82×10^{-7}	0.00	6.96×10^{-7}	8.25×10^{-7}	0.00
Mercury	0.00	0.00	0.00	4.69×10^{-4}	5.91×10^{-2}	0.00	4.69×10^{-4}	8.80×10^{-2}	0.00
Nitrate	1.36×10^{4}	2.43×10^{2}	0.00	1.35×10^{3}	3.17×10^{1}	0.00	1.35×10^{3}	6.21×10^{1}	0.00
Total uranium	1.28×10^{-1}	1.22	0.00	5.57×10^{-1}	5.37	0.00	5.57×10^{-1}	5.56	0.00
Total	1.36×10^{4}	5.42×10^{2}	5.33×10^{-3}	1.37×10^{3}	9.34×10^{2}	3.35×10^{-2}	1.37×10^{3}	3.86×10^{3}	1.47×10^{-1}
Year of peak impact	1956	1956	2270	2270	2270	2270	2270	2270	2270

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Table U–7. Alternative Combination 1 Cumulative Human Health Impacts at the Columbia River Nearshore

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	3.76×10^{-3}	4.39×10^{2}	4.17×10^{-3}	2.90×10^{-3}	5.39×10^{2}	5.63×10^{-3}	2.90×10^{-3}	9.91×10^{2}	1.12×10^{-2}
Carbon-14	1.06×10^{-7}	1.70×10^{-1}	3.60×10^{-6}	8.53×10^{-8}	2.77×10^{-1}	6.51×10^{-6}	8.53×10^{-8}	9.03×10^{-1}	2.29×10^{-5}
Strontium-90	4.16×10^{-3}	3.04×10^{5}	1.00	3.88×10^{-3}	3.65×10^{5}	1.00	3.88×10^{-3}	6.05×10^{5}	1.00
Technetium-99	1.15×10^{-6}	2.01	6.90×10^{-5}	1.36×10^{-7}	6.10×10^{-1}	2.68×10^{-5}	1.36×10^{-7}	1.24	5.84×10^{-5}
Iodine-129	2.93×10^{-9}	8.35×10^{-1}	9.50×10^{-6}	1.71×10^{-9}	5.65×10^{-1}	7.48×10^{-6}	1.71×10^{-9}	6.98×10^{-1}	1.08×10^{-5}
Cesium-137	9.63×10^{-4}	3.51×10^{4}	6.41×10^{-1}	1.31×10^{-3}	4.14×10^{6}	1.00	1.31×10^{-3}	1.24×10^{7}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	7.36×10^{-6}	9.14×10^{2}	1.03×10^{-2}	9.38×10^{-6}	1.21×10^{3}	1.41×10^{-2}	9.38×10^{-6}	1.29×10^{3}	1.59×10^{-2}
Neptunium-237	1.04×10^{-8}	3.03	1.40×10^{-5}	1.03×10^{-8}	3.06	1.47×10^{-5}	1.03×10^{-8}	3.65	1.65×10^{-5}
Plutonium isotopes (includes Pu-239, -240)	2.94×10^{-6}	1.99×10^{3}	8.68×10^{-3}	3.33×10^{-6}	2.36×10^{3}	1.06×10^{-2}	3.33×10^{-6}	2.92×10^{3}	1.23×10^{-2}
Total	8.89×10^{-3}	3.42×10^{5}	1.00	8.10×10^{-3}	4.51×10^{6}	1.00	8.10×10^{-3}	1.31×10^{7}	1.00
Year of peak impact	1991	1991	1991	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Carbon tetrachloride	1.10×10^{-3}	4.49×10^{-2}	9.66×10^{-5}	1.10×10^{-3}	2.82×10^{-1}	6.07×10^{-4}	1.10×10^{-3}	1.23	4.79×10^{-5}
Chromium	1.61×10^{1}	1.53×10^{2}	0.00	1.61×10^{1}	1.54×10^{2}	5.55×10^{-10}	1.61×10^{1}	2.24×10^{2}	2.90×10^{-3}
Fluoride	1.35×10^{1}	6.44	0.00	1.35×10^{1}	6.63	0.00	1.35×10^{1}	7.13	0.00
Manganese	1.50×10^{-5}	3.07×10^{-6}	0.00	1.50×10^{-5}	3.93×10^{-6}	0.00	1.50×10^{-5}	1.78×10^{-5}	0.00
Mercury	1.76×10^{-2}	1.67	0.00	1.76×10^{-2}	2.22	0.00	1.76×10^{-2}	3.30	0.00
Nitrate	4.08×10^{2}	7.29	0.00	4.08×10^{2}	9.59	0.00	4.08×10^{2}	1.88×10^{1}	0.00
Total uranium	5.03	4.79×10^{1}	0.00	5.03	4.85×10^{1}	0.00	5.03	5.02×10^{1}	0.00
Total	4.43×10^{2}	2.17×10^{2}	9.66×10^{-5}	4.43×10^{2}	2.21×10^{2}	6.07×10^{-4}	4.43×10^{2}	3.05×10^{2}	2.95×10^{-3}
Year of peak impact	1978	1978	2527	1978	1978	2527	1978	1978	1978

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Table U–8. Alternative Combination 1 Cumulative Human Health Impacts pat the Columbia River Surface Water

Radioactive Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	2.56×10^{-8}	4.76×10^{-3}	4.97×10^{-8}	2.56×10^{-8}	8.85×10^{-3}	1.00×10^{-7}	2.90×10^{-3}	9.15×10^{2}	1.12×10^{-2}
Carbon-14	2.35×10^{-14}	8.40×10^{-8}	2.01×10^{-12}	2.35×10^{-14}	6.65×10^{-5}	1.81×10^{-9}	8.53×10^{-8}	5.93×10^{-2}	1.62×10^{-6}
Strontium-90	3.35×10^{-10}	3.16×10^{-2}	5.89×10^{-7}	3.35×10^{-10}	4.82×10^{-1}	9.99×10^{-6}	3.88×10^{-3}	2.32×10^{5}	1.00
Technetium-99	8.15×10^{-12}	3.67×10^{-5}	1.61×10^{-9}	8.15×10^{-12}	8.47×10^{-5}	4.01×10^{-9}	1.36×10^{-7}	1.53×10^{-3}	8.34×10^{-8}
Iodine-129	7.79×10^{-14}	2.58×10^{-5}	3.42×10^{-10}	7.79×10^{-14}	4.21×10^{-4}	1.01×10^{-8}	1.71×10^{-9}	3.49×10^{-3}	8.54×10^{-8}
Cesium-137	1.64×10^{-12}	5.18×10^{-3}	1.16×10^{-7}	1.64×10^{-12}	2.54×10^{-2}	5.70×10^{-7}	1.31×10^{-3}	8.32×10^{6}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	1.06×10^{-11}	1.37×10^{-3}	1.59×10^{-8}	1.06×10^{-11}	3.77×10^{-3}	5.33×10^{-8}	9.38×10^{-6}	9.33×10^{1}	1.18×10^{-3}
Neptunium-237	4.31×10^{-15}	1.28×10^{-6}	6.12×10^{-12}	4.31×10^{-15}	1.25×10^{-5}	7.54×10^{-11}	1.03×10^{-8}	3.28×10^{-1}	1.67×10^{-6}
Plutonium isotopes (includes Pu-239, -240)	6.75×10^{-15}	4.87×10^{-6}	2.19×10^{-11}	6.75×10^{-15}	7.62×10^{-4}	4.27×10^{-9}	3.33×10^{-6}	3.63×10^{2}	1.32×10^{-3}
Total	2.60×10^{-8}	4.30×10^{-2}	7.73×10^{-7}	2.60×10^{-8}	5.22×10^{-1}	1.07×10^{-5}	8.10×10^{-3}	8.56×10^{6}	1.00
Year of peak impact	1985	1985	1985	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Resident Farmer**			**American Indian Resident Farmer**			**American Indian Hunter-Gatherer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	0.00	0.00	0.00	0.00	0.00	0.00	1.77×10^{-3}	2.05×10^{-3}	0.00
Acetonitrile	0.00	0.00	0.00	0.00	0.00	0.00	2.12×10^{-3}	1.26×10^{-2}	0.00
Boron and compounds	0.00	0.00	0.00	0.00	0.00	0.00	1.20×10^{-4}	1.19×10^{-6}	0.00
Carbon tetrachloride	3.25×10^{-6}	8.35×10^{-4}	3.41×10^{-8}	2.31×10^{-7}	2.67×10^{-4}	7.93×10^{-9}	6.07×10^{-2}	6.53×10^{1}	5.94×10^{-3}
Chromium	2.23×10^{-5}	2.12×10^{-4}	5.10×10^{-14}	8.32×10^{-5}	1.27×10^{-3}	5.05×10^{-10}	1.41×10^{-1}	3.12×10^{-1}	1.27×10^{-5}
Fluoride	4.63×10^{-5}	2.27×10^{-5}	0.00	2.92×10^{-5}	2.02×10^{-5}	0.00	2.15	3.15×10^{-1}	0.00
Hydrazine/hydrazine sulfate	0.00	0.00	0.00	0.00	0.00	6.09×10^{-7}	8.72×10^{-13}	3.18×10^{-210}	4.09×10^{-10}

Table U–8. Alternative Combination 1 Cumulative Human Health Impacts at the Columbia River Surface Water *(continued)*

Chemical Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Manganese	8.07×10^{-13}	2.11×10^{-13}	0.00	2.59×10^{-15}	1.05×10^{-14}	0.00	8.97×10^{-2}	5.67×10^{-2}	0.00
Mercury	1.30×10^{-9}	1.64×10^{-7}	0.00	1.95×10^{-14}	6.88×10^{-11}	0.00	5.62×10^{-6}	2.15×10^{-4}	0.00
Nickel (soluble salt)	7.20×10^{-19}	1.31×10^{-18}	0.00	0.00	0.00	0.00	3.94×10^{-1}	7.35×10^{-1}	0.00
Nitrate	3.46×10^{-3}	1.20×10^{-4}	0.00	4.90×10^{-3}	4.60×10^{-1}	0.00	2.03×10^{1}	8.10×10^{-1}	0.00
Total uranium	5.64×10^{-6}	5.43×10^{-5}	0.00	1.61×10^{-5}	2.14×10^{-4}	0.00	7.39×10^{-2}	3.28×10^{-2}	0.00
Trichloroethylene (TCE)	0.00	0.00	0.00	0.00	0.00	5.06×10^{-10}	1.87×10^{-12}	7.28×10^{-10}	3.74×10^{-14}
Total	3.54×10^{-3}	1.24×10^{-3}	3.41×10^{-8}	5.03×10^{-3}	4.62×10^{-1}	6.18×10^{-7}	3.01×10^{1}	6.76×10^{1}	5.95×10^{-3}
Year of peak impact	1984	1984	1990	1962	1962	3243	2527	2527	2527

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Potential human health impacts of Alternative Combination 2, with the past, present, and reasonably foreseeable future (non–*TC & WM EIS*) actions discussed above, are summarized in Tables U–9 through U–11. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butanol, boron compounds, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. The impacts of Alternative Combination 2 are dominated by the impacts of non–*TC & WM EIS* sources. The estimate of radiological dose for the year of peak dose for the offsite population is 215 person-rem per year, approximately 0.01 percent of the average background dose.

Table U–9. Alternative Combination 2 Cumulative Human Health Impacts at the Core Zone Boundary

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	1.04×10^{-1}	1.22×10^{4}	1.16×10^{-1}	1.04×10^{-1}	1.94×10^{4}	2.03×10^{-1}	1.04×10^{-1}	3.56×10^{4}	4.04×10^{-1}
Carbon-14	3.87×10^{-5}	6.21×10^{1}	1.31×10^{-3}	3.87×10^{-5}	1.25×10^{2}	2.95×10^{-3}	3.87×10^{-5}	4.10×10^{2}	1.04×10^{-2}
Strontium-90	1.79×10^{-4}	1.31×10^{4}	2.19×10^{-1}	1.79×10^{-4}	1.68×10^{4}	3.14×10^{-1}	1.79×10^{-4}	2.79×10^{4}	5.95×10^{-1}
Technetium-99	1.78×10^{-6}	3.11	1.07×10^{-4}	1.78×10^{-6}	7.99	3.51×10^{-4}	1.78×10^{-6}	1.63×10^{1}	7.66×10^{-4}
Iodine-129	8.79×10^{-9}	2.50	2.85×10^{-5}	8.79×10^{-9}	2.91	3.85×10^{-5}	8.79×10^{-9}	3.59	5.54×10^{-5}
Cesium-137	2.47×10^{-13}	9.00×10^{-6}	1.64×10^{-10}	2.47×10^{-13}	7.78×10^{-4}	1.74×10^{-8}	2.47×10^{-3}	2.34×10^{-3}	5.25×10^{-8}
Uranium isotopes (includes U-233, -234, -235, -238)	1.47×10^{-6}	1.83×10^{2}	2.07×10^{-3}	1.47×10^{-6}	1.90×10^{2}	2.21×10^{-3}	1.47×10^{-6}	2.03×10^{2}	2.50×10^{-3}
Neptunium-237	4.64×10^{-8}	1.36×10^{1}	6.28×10^{-5}	4.64×10^{-8}	1.37×10^{1}	6.59×10^{-5}	4.64×10^{-8}	1.64×10^{1}	7.42×10^{-5}
Total	1.04×10^{-1}	2.55×10^{4}	3.38×10^{-1}	1.04×10^{-1}	3.66×10^{4}	5.22×10^{-1}	1.04×10^{-1}	6.42×10^{4}	1.00
Year of peak impact	1997	1997	1997	1997	1997	1997	1997	1997	1997
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	2.61×10^{-2}	7.47×10^{-3}	0.00	7.89×10^{-1}	4.09×10^{-1}	0.00	7.89×10^{-1}	1.14	0.00
Carbon tetrachloride	4.06×10^{-1}	1.66×10^{1}	5.33×10^{-3}	3.35	8.59×10^{2}	3.35×10^{-2}	3.35	3.74×10^{3}	1.46×10^{-1}
Chromium	2.88×10^{1}	2.74×10^{2}	0.00	2.84	2.70×10^{1}	1.11×10^{-8}	2.84	3.95×10^{1}	5.11×10^{-4}
Fluoride	2.59	1.23	0.00	1.44×10^{1}	7.07	0.00	1.44×10^{1}	7.60	0.00
Manganese	0.00	0.00	0.00	6.96×10^{-7}	1.82×10^{-7}	0.00	6.96×10^{-7}	8.25×10^{-7}	0.00
Mercury	0.00	0.00	0.00	4.69×10^{-4}	5.91×10^{-2}	0.00	4.69×10^{-4}	8.80×10^{-2}	0.00
Nitrate	1.31×10^{4}	2.34×10^{2}	0.00	1.48×10^{3}	3.48×10^{1}	0.00	1.48×10^{3}	6.83×10^{1}	0.00
Total uranium	1.28×10^{-1}	1.22	0.00	5.57×10^{-1}	5.37	0.00	5.57×10^{-1}	5.56	0.00
Total	1.32×10^{4}	5.27×10^{2}	5.33×10^{-3}	1.50×10^{3}	9.34×10^{2}	3.35×10^{-2}	1.50×10^{3}	3.86×10^{3}	1.46×10^{-1}
Year of peak impact	1956	1956	2270	2270	2270	2270	2270	2270	2270

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Table U–10. Alternative Combination 2 Cumulative Human Health Impacts at the Columbia River Nearshore

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	3.76×10^{-3}	4.39×10^{2}	4.17×10^{-3}	2.90×10^{-3}	5.39×10^{2}	5.63×10^{-3}	2.90×10^{-3}	9.91×10^{2}	1.12×10^{-2}
Carbon-14	1.06×10^{-7}	1.70×10^{-1}	3.60×10^{-6}	8.53×10^{-8}	2.77×10^{-1}	6.51×10^{-6}	8.53×10^{-8}	9.03×10^{-1}	2.29×10^{-5}
Strontium-90	4.16×10^{-3}	3.04×10^{5}	1.00	3.88×10^{-3}	3.65×10^{5}	1.00	3.88×10^{-3}	6.05×10^{5}	1.00
Technetium-99	1.13×10^{-6}	1.98	6.82×10^{-5}	1.49×10^{-7}	6.71×10^{-1}	2.95×10^{-5}	1.49×10^{-7}	1.37	6.43×10^{-5}
Iodine-129	2.94×10^{-9}	8.38×10^{-1}	9.54×10^{-6}	1.70×10^{-9}	5.60×10^{-1}	7.42×10^{-6}	1.70×10^{-9}	6.92×10^{-1}	1.07×10^{-5}
Cesium-137	9.63×10^{-4}	3.51×10^{4}	6.41×10^{-1}	1.31×10^{-3}	4.14×10^{6}	1.00	1.31×10^{-3}	1.24×10^{7}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	7.36×10^{-6}	9.14×10^{2}	1.03×10^{-2}	9.38×10^{-6}	1.21×10^{3}	1.41×10^{-2}	9.38×10^{-6}	1.29×10^{3}	1.59×10^{-2}
Neptunium-237	1.04×10^{-8}	3.03	1.40×10^{-5}	1.03×10^{-8}	3.06	1.47×10^{-5}	1.03×10^{-8}	3.65	1.65×10^{-5}
Plutonium isotopes (includes Pu-239, -240)	2.94×10^{-6}	1.99×10^{3}	8.68×10^{-3}	3.33×10^{-6}	2.36×10^{3}	1.06×10^{-2}	3.33×10^{-6}	2.92×10^{3}	1.23×10^{-2}
Total	8.89×10^{-3}	3.42×10^{5}	1.00	8.10×10^{-3}	4.51×10^{6}	1.00	8.10×10^{-3}	1.31×10^{7}	1.00
Year of peak impact	1991	1991	1991	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Carbon tetrachloride	1.10×10^{-3}	4.49×10^{-2}	9.66×10^{-5}	1.10×10^{-3}	2.82×10^{-1}	6.07×10^{-4}	1.10×10^{-3}	1.23	4.79×10^{-5}
Chromium	1.61×10^{1}	1.53×10^{2}	0.00	1.61×10^{1}	1.54×10^{2}	5.13×10^{-10}	1.61×10^{1}	2.24×10^{2}	2.90×10^{-3}
Fluoride	1.35×10^{1}	6.44	0.00	1.35×10^{1}	6.63	0.00	1.35×10^{1}	7.13	0.00
Manganese	1.50×10^{-5}	3.07×10^{-6}	0.00	1.50×10^{-5}	3.93×10^{-6}	0.00	1.50×10^{-5}	1.78×10^{-5}	0.00
Mercury	1.76×10^{-2}	1.67	0.00	1.76×10^{-2}	2.22	0.00	1.76×10^{-2}	3.30	0.00

Table U-10. Alternative Combination 2 Cumulative Human Health Impacts at the Columbia River Nearshore *(continued)*

	Drinking-Water Well User			Resident Farmer		American Indian Resident Farmer			
Chemical Constituent	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Nitrate	4.08×10^{2}	7.28	0.00	4.08×10^{2}	9.59	0.00	4.08×10^{2}	1.88×10^{1}	0.00
Total uranium	5.03	4.79×10^{1}	0.00	5.03	4.85×10^{1}	0.00	5.03	5.02×10^{1}	0.00
Total	4.42×10^{2}	2.17×10^{2}	9.66×10^{-5}	4.42×10^{2}	2.21×10^{2}	6.07×10^{-4}	4.42×10^{2}	3.05×10^{2}	2.95×10^{-3}
Year of peak impact	1978	1978	2527	1978	1978	2527	1978	1978	1978

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Table U–11. Alternative Combination 2 Cumulative Human Health Impacts at the Columbia River Surface Water

Radioactive Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	2.56×10^{-8}	4.76×10^{-3}	4.98×10^{-8}	2.56×10^{-9}	8.86×10^{-3}	1.01×10^{-7}	2.90×10^{-3}	9.15×10^{2}	1.12×10^{-2}
Carbon-14	2.35×10^{-14}	8.40×10^{-8}	2.01×10^{-12}	2.35×10^{-14}	6.65×10^{-5}	1.81×10^{-9}	8.53×10^{-8}	5.93×10^{-2}	1.62×10^{-6}
Strontium-90	3.35×10^{-10}	3.16×10^{-2}	5.89×10^{-7}	3.35×10^{-10}	4.82×10^{-1}	9.99×10^{-6}	3.88×10^{-3}	2.32×10^{5}	1.00
Technetium-99	7.24×10^{-12}	3.26×10^{-5}	1.43×10^{-9}	7.24×10^{-12}	7.52×10^{-5}	3.56×10^{-9}	1.49×10^{-7}	1.67×10^{-3}	9.13×10^{-8}
Iodine-129	7.73×10^{-14}	2.56×10^{-5}	3.39×10^{-10}	7.73×10^{-14}	4.18×10^{-4}	1.00×10^{-8}	1.70×10^{-9}	3.46×10^{-3}	8.47×10^{-8}
Cesium-137	1.64×10^{-12}	5.18×10^{-3}	1.16×10^{-7}	1.64×10^{-12}	2.54×10^{-2}	5.70×10^{-7}	1.31×10^{-3}	8.32×10^{6}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	1.06×10^{-11}	1.37×10^{-3}	1.59×10^{-8}	1.06×10^{-11}	3.77×10^{-3}	5.33×10^{-8}	9.38×10^{-6}	9.33×10^{1}	1.18×10^{-3}
Neptunium-237	4.31×10^{-15}	1.28×10^{-6}	6.12×10^{-12}	4.31×10^{-15}	1.25×10^{-5}	7.54×10^{-11}	1.03×10^{-8}	3.28×10^{-1}	1.67×10^{-6}
Plutonium isotopes (includes Pu-239, -240)	6.75×10^{-15}	4.87×10^{-6}	2.19×10^{-11}	6.75×10^{-15}	7.62×10^{-4}	4.27×10^{-9}	3.33×10^{-6}	3.63×10^{2}	1.32×10^{-3}
Total	2.60×10^{-8}	4.30×10^{-2}	7.73×10^{-7}	2.60×10^{-8}	5.22×10^{-1}	1.07×10^{-5}	8.10×10^{-3}	8.56×10^{6}	1.00
Year of peak impact	1985	1985	1985	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Resident Farmer**			**American Indian Resident Farmer**			**American Indian Hunter-Gatherer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	0.00	0.00	0.00	0.00	0.00	0.00	1.77×10^{-3}	2.05×10^{-3}	0.00
Boron and compounds	0.00	0.00	0.00	0.00	0.00	0.00	1.20×10^{-4}	1.19×10^{-6}	0.00
Carbon tetrachloride	3.25×10^{-6}	8.35×10^{-4}	3.41×10^{-8}	2.31×10^{-7}	2.67×10^{-4}	7.93×10^{-9}	6.07×10^{-2}	6.53×10^{1}	5.94×10^{-3}
Chromium	2.26×10^{-5}	2.15×10^{-4}	5.16×10^{-14}	8.31×10^{-5}	1.27×10^{-3}	1.38×10^{-10}	1.31×10^{-1}	2.88×10^{-1}	1.18×10^{-5}
Fluoride	4.63×10^{-5}	2.27×10^{-5}	0.00	2.92×10^{-5}	2.02×10^{-5}	0.00	2.15	3.15×10^{-1}	0.00
Hydrazine/hydrazine sulfate	0.00	0.00	0.00	0.00	0.00	6.09×10^{-7}	8.72×10^{-13}	3.18×10^{-210}	4.09×10^{-10}
Manganese	8.07×10^{-13}	2.11×10^{-13}	0.00	2.59×10^{-5}	1.05×10^{-14}	0.00	8.97×10^{-2}	5.67×10^{-2}	0.00
Mercury	1.30×10^{-9}	1.64×10^{-7}	0.00	1.95×10^{-14}	6.88×10^{-11}	0.00	5.62×10^{-6}	2.15×10^{-4}	0.00

Table U–11. Alternative Combination 2 Cumulative Human Health Impacts at the Columbia River Surface Water *(continued)*

Chemical Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Nickel (soluble salts)	7.20×10^{-19}	1.31×10^{-18}	0.00	0.00	0.00	0.00	3.94×10^{-1}	7.35×10^{-1}	0.00
Nitrate	3.47×10^{-3}	1.20×10^{-4}	0.00	4.86×10^{-3}	4.57×10^{-1}	0.00	1.65×10^{1}	6.65×10^{-1}	0.00
Total uranium	5.64×10^{-6}	5.43×10^{-5}	0.00	1.61×10^{-5}	2.14×10^{-4}	0.00	7.39×10^{-2}	3.28×10^{-2}	0.00
Trichloroethylene (TCE)	0.00	0.00	0.00	0.00	0.00	5.06×10^{-10}	1.87×10^{-12}	7.28×10^{-10}	3.74×10^{-14}
Total	3.55×10^{-3}	1.25×10^{-3}	3.41×10^{-8}	4.99×10^{-3}	4.59×10^{-1}	6.18×10^{-7}	2.63×10^{1}	6.74×10^{1}	5.95×10^{-3}
Year of peak impact	1984	1984	1990	1962	1962	3243	2527	2527	2527

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Potential human health impacts of Alternative Combination 3, with the past, present, and reasonably foreseeable future (non–*TC & WM EIS*) actions discussed above, are summarized in Tables U–12 through U–14. The key radiological constituent contributors to human health risk are tritium, carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium isotopes, neptunium-237, and plutonium isotopes. The chemical risk and hazard drivers are 1-butanol, boron and boron compounds, carbon tetrachloride, chromium, fluoride, hydrazine/hydrazine sulfate, manganese, mercury, nickel (soluble salts), nitrate, total uranium, and trichloroethylene. The impacts of Alternative Combination 3 are dominated by the impacts of non–*TC & WM EIS* sources. The estimate of radiological dose for the year of peak dose for the offsite population is 215 person-rem per year, approximately 0.01 percent of the average background dose.

With the addition of the alternative combinations to the past, present, and reasonably foreseeable future (non–*TC & WM EIS*) actions, and comparing among the alternative combinations, the peaks for the dose, risk, and Hazard Index occur at similar times and concentrations. A more-detailed discussion of the results of the cumulative impact analyses is presented in Chapter 6.

Table U–12. Alternative Combination 3 Cumulative Human Health Impacts at the Core Zone Boundary

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	1.04×10^{-1}	1.22×10^{4}	1.16×10^{-1}	1.04×10^{-1}	1.94×10^{4}	2.03×10^{-1}	1.04×10^{-1}	3.56×10^{4}	4.04×10^{-1}
Carbon-14	3.87×10^{-5}	6.21×10^{1}	1.31×10^{-3}	3.87×10^{-5}	1.25×10^{2}	2.95×10^{-3}	3.87×10^{-5}	4.10×10^{2}	1.04×10^{-2}
Strontium-90	1.79×10^{-4}	1.31×10^{4}	2.19×10^{-1}	1.79×10^{-4}	1.68×10^{4}	3.14×10^{-1}	1.79×10^{-4}	2.79×10^{4}	5.95×10^{-1}
Technetium-99	1.85×10^{-6}	3.24	1.11×10^{-4}	1.85×10^{-6}	8.31	3.65×10^{-4}	1.85×10^{-6}	1.69×10^{1}	7.96×10^{-4}
Iodine-129	8.46×10^{-9}	2.41	2.74×10^{-5}	8.46×10^{-9}	2.80	3.70×10^{-5}	8.46×10^{-9}	3.45	5.33×10^{-5}
Cesium-137	2.47×10^{-13}	9.00×10^{-6}	1.64×10^{-10}	2.47×10^{-13}	7.78×10^{-4}	1.74×10^{-8}	2.47×10^{-13}	2.34×10^{-3}	5.25×10^{-8}
Uranium isotopes (includes U-233, -234, -235, -238)	1.47×10^{-6}	1.83×10^{2}	2.07×10^{-3}	1.47×10^{-6}	1.90×10^{2}	2.21×10^{-3}	1.47×10^{-6}	2.03×10^{2}	2.50×10^{-3}
Neptunium-237	4.64×10^{-8}	1.36×10^{1}	6.28×10^{-5}	4.64×10^{-8}	1.37×10^{1}	6.59×10^{-5}	4.64×10^{-8}	1.64×10^{1}	7.42×10^{-5}
Total	1.04×10^{-1}	2.55×10^{4}	3.38×10^{-1}	1.04×10^{-1}	3.66×10^{4}	5.22×10^{-1}	1.04×10^{-1}	6.42×10^{4}	1.00
Year of peak impact	1997	1997	1997	1997	1997	1997	1997	1997	1997
Chemical Constituent	**Drinking-Water Well User**			**Resident Farmer**			**American Indian Resident Farmer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	2.61×10^{-2}	7.47×10^{-3}	0.00	7.89×10^{-1}	4.09×10^{-1}	0.00	7.89×10^{-1}	1.14	0.00
Carbon tetrachloride	4.06×10^{-1}	1.66×10^{1}	5.33×10^{-3}	3.35	8.59×10^{2}	3.35×10^{-2}	3.35	3.74×10^{3}	1.46×10^{-1}
Chromium	2.88×10^{1}	2.74×10^{2}	0.00	2.77	2.64×10^{1}	1.09×10^{-8}	2.77	3.86×10^{1}	4.99×10^{-4}
Fluoride	2.59	1.23	0.00	1.44×10^{1}	7.07	0.00	1.44×10^{1}	7.60	0.00
Manganese	0.00	0.00	0.00	6.96×10^{-7}	1.82×10^{-7}	0.00	6.96×10^{-7}	8.25×10^{-7}	0.00
Mercury	0.00	0.00	0.00	4.69×10^{-4}	5.91×10^{-2}	0.00	4.69×10^{-4}	8.80×10^{-2}	0.00
Nitrate	1.31×10^{4}	2.34×10^{2}	0.00	1.48×10^{3}	3.47×10^{1}	0.00	1.48×10^{3}	6.81×10^{1}	0.00
Total uranium	1.28×10^{-1}	1.22	0.00	5.57×10^{-1}	5.37	0.00	5.57×10^{-1}	5.56	0.00
Total	1.32×10^{4}	5.27×10^{2}	5.33×10^{-3}	1.50×10^{3}	9.33×10^{2}	3.35×10^{-2}	1.50×10^{3}	3.86×10^{3}	1.46×10^{-1}
Year of peak impact	1956	1956	2270	2270	2270	2270	2270	2270	2270

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Table U–13. Alternative Combination 3 Cumulative Human Health Impacts at the Columbia River Nearshore

Radioactive Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	3.76×10^{-3}	4.39×10^{2}	4.17×10^{-3}	2.90×10^{-3}	5.39×10^{2}	5.63×10^{-3}	2.90×10^{-3}	9.91×10^{2}	1.12×10^{-2}
Carbon-14	1.06×10^{-7}	1.70×10^{-1}	3.60×10^{-6}	8.53×10^{-8}	2.77×10^{-1}	6.51×10^{-6}	8.53×10^{-8}	9.03×10^{-1}	2.29×10^{-5}
Strontium-90	4.16×10^{-3}	3.04×10^{5}	1.00	3.88×10^{-3}	3.65×10^{5}	1.00	3.88×10^{-3}	6.05×10^{5}	1.00
Technetium-99	1.13×10^{-6}	1.98	6.82×10^{-5}	1.49×10^{-7}	6.72×10^{-1}	2.95×10^{-5}	1.49×10^{-7}	1.37	6.44×10^{-5}
Iodine-129	2.94×10^{-9}	8.38×10^{-1}	9.54×10^{-6}	1.70×10^{-9}	5.61×10^{-1}	7.42×10^{-6}	1.70×10^{-9}	6.92×10^{-1}	1.07×10^{-5}
Cesium-137	9.63×10^{-4}	3.51×10^{4}	6.41×10^{-1}	1.31×10^{-3}	4.14×10^{6}	1.00	1.31×10^{-3}	1.24×10^{7}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	7.36×10^{-6}	9.14×10^{2}	1.03×10^{-2}	9.38×10^{-6}	1.21×10^{3}	1.41×10^{-2}	9.38×10^{-6}	1.29×10^{3}	1.59×10^{-2}
Neptunium-237	1.04×10^{-8}	3.03	1.40×10^{-5}	1.03×10^{-8}	3.06	1.47×10^{-5}	1.03×10^{-8}	3.65	1.65×10^{-5}
Plutonium isotopes (includes Pu-239, -240)	2.94×10^{-6}	1.99×10^{3}	8.68×10^{-3}	3.33×10^{-6}	2.36×10^{3}	1.06×10^{-2}	3.33×10^{-6}	2.92×10^{3}	1.23×10^{-2}
Total	8.89×10^{-3}	3.42×10^{5}	1.00	8.10×10^{-3}	4.51×10^{6}	1.00	8.10×10^{-3}	1.31×10^{7}	1.00
Year of peak impact	1991	1991	1991	1985	1985	1985	1985	1985	1985

Chemical Constituent	Drinking-Water Well User			Resident Farmer			American Indian Resident Farmer		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Carbon tetrachloride	1.10×10^{-3}	4.49×10^{-2}	9.66×10^{-5}	1.10×10^{-3}	2.82×10^{-1}	6.07×10^{-4}	1.10×10^{-3}	1.23	4.79×10^{-5}
Chromium	1.61×10^{1}	1.53×10^{2}	0.00	1.61×10^{1}	1.54×10^{2}	5.11×10^{-10}	1.61×10^{1}	2.24×10^{2}	2.90×10^{-3}
Fluoride	1.35×10^{1}	6.44	0.00	1.35×10^{1}	6.63	0.00	1.35×10^{1}	7.13	0.00
Manganese	1.50×10^{-5}	3.07×10^{-6}	0.00	1.50×10^{-5}	3.93×10^{-6}	0.00	1.50×10^{-5}	1.78×10^{-5}	0.00
Mercury	1.76×10^{-2}	1.67	0.00	1.76×10^{-2}	2.22	0.00	1.76×10^{-2}	3.30	0.00
Nitrate	4.08×10^{2}	7.28	0.00	4.08×10^{2}	9.59	0.00	4.08×10^{2}	1.88×10^{1}	0.00
Total uranium	5.03	4.79×10^{1}	0.00	5.03	4.85×10^{1}	0.00	5.03	5.02×10^{1}	0.00
Total	4.42×10^{2}	2.17×10^{2}	9.66×10^{-5}	4.42×10^{2}	2.21×10^{2}	6.07×10^{-4}	4.42×10^{2}	3.05×10^{2}	2.95×10^{-3}
Year of peak impact	1978	1978	2527	1978	1978	2527	1978	1978	1978

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

Table U–14. Alternative Combination 3 Cumulative Human Health Impacts at the Columbia River Surface Water

Radioactive Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Dose (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)	**Concentration at Year of Peak Dose** (curies per cubic meter)	**Dose at Year of Peak Dose** (millirem per year)	**Radiological Risk at Year of Peak Radiological Risk** (unitless)
Hydrogen-3 (tritium)	2.56×10^{-8}	4.76×10^{-3}	4.98×10^{-8}	2.56×10^{-8}	8.86×10^{-3}	1.01×10^{-7}	2.90×10^{-3}	9.15×10^{2}	1.12×10^{-2}
Carbon-14	2.35×10^{-14}	8.40×10^{-8}	2.01×10^{-12}	2.35×10^{-14}	6.65×10^{-5}	1.81×10^{-9}	8.53×10^{-8}	5.93×10^{-2}	1.62×10^{-6}
Strontium-90	3.35×10^{-10}	3.16×10^{-2}	5.89×10^{-7}	3.35×10^{-10}	4.82×10^{-1}	9.99×10^{-6}	3.88×10^{-3}	2.32×10^{5}	1.00
Technetium-99	7.24×10^{-12}	3.26×10^{-5}	1.43×10^{-9}	7.24×10^{-12}	7.52×10^{-5}	3.56×10^{-9}	1.49×10^{-7}	1.68×10^{-3}	9.14×10^{-8}
Iodine-129	7.73×10^{-14}	2.56×10^{-5}	3.39×10^{-10}	7.73×10^{-14}	4.18×10^{-4}	1.01×10^{-8}	1.70×10^{-9}	3.47×10^{-3}	8.48×10^{-8}
Cesium-137	1.64×10^{-12}	5.18×10^{-3}	1.16×10^{-7}	1.64×10^{-12}	2.54×10^{-2}	5.70×10^{-7}	1.31×10^{-3}	8.32×10^{6}	1.00
Uranium isotopes (includes U-233, -234, -235, -238)	1.06×10^{-11}	1.37×10^{-3}	1.59×10^{-8}	1.06×10^{-11}	3.77×10^{-3}	5.33×10^{-8}	9.38×10^{-6}	9.33×10^{1}	1.18×10^{-3}
Neptunium-237	4.31×10^{-15}	1.28×10^{-6}	6.12×10^{-12}	4.31×10^{-15}	1.25×10^{-5}	7.54×10^{-11}	1.03×10^{-8}	3.28×10^{-1}	1.67×10^{-6}
Plutonium isotopes (includes Pu-239, -240)	6.75×10^{-15}	4.87×10^{-6}	2.19×10^{-11}	6.75×10^{-15}	7.62×10^{-4}	4.27×10^{-9}	3.33×10^{-6}	3.63×10^{2}	1.32×10^{-3}
Total	2.60×10^{-8}	4.30×10^{-2}	7.73×10^{-7}	2.60×10^{-8}	5.22×10^{-1}	1.07×10^{-5}	8.10×10^{-3}	8.56×10^{6}	1.00
Year of peak impact	1985	1985	1985	1985	1985	1985	1985	1985	1985
Chemical Constituent	**Resident Farmer**			**American Indian Resident Farmer**			**American Indian Hunter-Gatherer**		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
1-Butanol	0.00	0.00	0.00	0.00	0.00	0.00	1.77×10^{-3}	2.05×10^{-3}	0.00
Boron and compounds	0.00	0.00	0.00	0.00	0.00	0.00	1.20×10^{-4}	1.19×10^{-6}	0.00
Carbon tetrachloride	3.25×10^{-6}	8.35×10^{-4}	3.41×10^{-8}	2.31×10^{-7}	2.67×10^{-4}	7.93×10^{-9}	6.07×10^{-2}	6.53×10^{1}	5.94×10^{-3}
Chromium	2.26×10^{-5}	2.15×10^{-4}	5.16×10^{-14}	8.31×10^{-5}	1.27×10^{-3}	1.32×10^{-10}	1.30×10^{-1}	2.87×10^{-1}	1.17×10^{-5}
Fluoride	4.63×10^{-5}	2.27×10^{-5}	0.00	2.92×10^{-5}	2.02×10^{-5}	0.00	2.15	3.15×10^{-1}	0.00
Hydrazine/hydrazine sulfate	0.00	0.00	0.00	0.00	0.00	6.09×10^{-7}	8.72×10^{-13}	3.18×10^{-210}	4.09×10^{-10}
Manganese	8.07×10^{-13}	2.11×10^{-13}	0.00	2.59×10^{-15}	1.05×10^{-14}	0.00	8.97×10^{-2}	5.67×10^{-2}	0.00

Table U–14. Alternative Combination 3 Cumulative Human Health Impacts at the Columbia River Surface Water *(continued)*

Chemical Constituent	Resident Farmer			American Indian Resident Farmer			American Indian Hunter-Gatherer		
	Concentration at Year of Peak Hazard Index (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)	**Concentration at Year of Peak Hazard Index** (grams per cubic meter)	**Hazard Index at Year of Peak Hazard Index** (unitless)	**Nonradiological Risk at Year of Peak Nonradiological Risk** (unitless)
Mercury	1.30×10^{-9}	1.64×10^{-7}	0.00	1.95×10^{-14}	6.88×10^{-11}	0.00	5.62×10^{-6}	2.15×10^{-4}	0.00
Nickel (soluble salts)	7.20×10^{-19}	1.31×10^{-18}	0.00	0.00	0.00	0.00	3.94×10^{-1}	7.35×10^{-1}	0.00
Nitrate	3.47×10^{-3}	1.20×10^{-4}	0.00	4.86×10^{-3}	4.57×10^{-1}	0.00	1.64×10^{1}	6.59×10^{-1}	0.00
Total uranium	5.64×10^{-6}	5.43×10^{-5}	0.00	1.61×10^{-5}	2.14×10^{-4}	0.00	7.39×10^{-2}	3.28×10^{-2}	0.00
Trichloroethylene (TCE)	0.00	0.00	0.00	0.00	0.00	5.06×10^{-10}	1.87×10^{-12}	7.28×10^{-10}	3.74×10^{-14}
Total	3.55×10^{-3}	1.25×10^{-3}	3.41×10^{-8}	4.99×10^{-3}	4.59×10^{-1}	6.18×10^{-7}	2.62×10^{1}	6.74×10^{1}	5.95×10^{-3}
Year of peak impact	1984	1984	1990	1962	1962	3243	2527	2527	2527

Note: Concentrations are those reported for groundwater at the specified location. Total concentrations, although reported, are not used in the analysis.

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