2.0 Contaminants for the Screening Assessment

To assess potential risk to humans and the environment, we first needed to determine what potential contaminants are in the Columbia River and which ones fit within the scope of the screening assessment. In this section we describe our initial review of contaminants and our selection of a limited set of contaminants for study. For the initial review, we compiled easily available information and used generalized human and ecological assessments. The data and parameters we used in selecting contaminants for study are NOT the ones we used in the remainder of the screening assessment because the data and parameters used for the risk assessment could only be determined once the contaminants were selected. The reader interested in details of how the contaminants for study were selected may refer to Appendix I-A.

To select the contaminants to be analyzed in the screening assessment, an abundance of historical data concerning contamination of the Columbia River was reviewed. The data that fit within the scope of the screening assessment were then subjected to a multi-stage screening process. A screen is a test used to identify potentially critical materials, such as contaminants.

The references used as sources of data for selecting the contaminants are annotated in Appendix I-A.1. These data sources were not always the same as the ones ultimately used for determining the contaminant concentrations in the screening assessment of potential risk. Contaminants were selected before the data sources were gathered for determining the contaminant concentrations in order to focus the data-gathering efforts on the specific contaminants to be screened in the assessment. The data sources used for determining the contaminant concentrations in the screening assessment of potential risk are described in Section 3.0.

Before any specific screens were applied to the data to select the contaminants for the screening assessment, the data were first reviewed to ensure they were within the scope of this effort. The scope for selecting the contaminants was slightly different from the scope of the screening assessment itself. The scope of the screening assessment is to evaluate the current conditions of the Columbia River (vicinity of Priest Rapids Dam to McNary Dam), groundwater (0.8 kilometer/0.5 mile in from the river), and adjacent riparian zone. The scope used for selecting the contaminants was the same except groundwater data were only reviewed if they were within 150 meters (500 feet) of the Columbia River or within one of the operating areas. This resulted in a spatial focus mostly on the Hanford 100, 300, and 1100 Areas and a limited focus in other areas with known groundwater contaminants.

A multi-stage screening process was developed to prioritize the contaminants in terms of potential risk to human health and to the ecosystem. The screens were for radionuclides, carcinogenic chemicals, toxic chemicals, ambient water quality criteria, aquatic biota threshold toxicity, aquatic biota LC_{50},[a] embryonic/juvenile fish toxicity, and radiation dose to fish. Each stage of the process identified contaminants of interest. The combined results of the total screening then composed the total list of contaminants to be evaluated in the screening assessment. Also addressed was the potential for radiation doses arising from discrete radioactive particles in the river sediment or from direct irradiation from near-river Hanford facilities.

(a) LC_{50} is the chemical concentration reported to be lethal to 50 percent of the exposed organisms after some period of exposure, usually a few hours to a few days.

Although the primary concern is the current status of the Columbia River, additional consideration was given to the potential for future impact by contaminants currently in the Hanford Site groundwater. Consideration was not given to the potential impact of contaminants that may be in soils or facilities away from the Columbia River, but that are not in the groundwater. Full details of the selection methods are presented in Appendix I-A, but the results of the selection are presented in this section.

The results of the screening process are discussed in Section 2.1. The discrete radioactive particles in the sediment of the Columbia River shoreline and islands are discussed in Section 2.2. Section 2.3 addresses special effects from Hanford facilities located adjacent to the river. Section 2.4 addresses existing and potential future contaminants from groundwater sources distant from the river. The overall conclusions, listed as the contaminants to be evaluated in the screening assessment, are given in Section 2.5. The references for this section are listed in Section 7.0 of Part I.

Supporting details for selecting the contaminants for the screening assessment are provided in Appendix I-A. The references used as data sources are annotated in Appendix I-A.1. A composite list of radionuclides and chemicals identified as being present in environmental samples is provided in Appendix I-A.2. Appendix I-A.3 presents the numerical approach to screening the several hundred analytes into those evaluated in the assessment. Appendix I-A.4 provides tables of data used (analytes evaluated, parameter values, and numerical results) in selecting contaminants for the screening assessment.

2.1 Screening Results

In this section (Tables 2.1-2.8), we list those contaminants that our screening process showed to be ones we needed to include in our study. Each table shows the contaminants by the particular medium in which the contaminants were found (Columbia River, groundwater, sediment, and soil) and indicates whether the contaminant affects humans or the environment.

Applying the equations and assumptions defined in the screening approach (Appendix I-A.3) to the maximum concentrations of contaminants resulted in a series of complementary, but not necessarily intercomparable, screening values for each contaminant. The varying numbers of assumptions and associated varying degrees of conservatism required each of the screenings to be evaluated separately. The results of the combined screenings, however, then defined the overall list of contaminants to be used in the screening assessment. The overall results and interpretation of the screening are given here. The radionuclides and chemicals are listed in the tables in the order of the screening results.

2.1.1 Columbia River Water Sample Screening

Using the approach described in Appendix I-A, the contaminants were identified that contribute over 99 percent of the risk directly in the water of the Columbia River. The individual screenings and the identified contaminants related to human risk are listed in Table 2.1, and those related to ecological risk are

Table 2.1. Contaminants of Potential Interest Related to Human Health Identified by Screening Columbia River Samples

Radionuclide Screening	Carcinogenic Chemical Screening	Toxic Chemical Screening
Cesium-137	Chromium	Nitrates
Iodine-129		Phosphates
Uranium-234		Copper[a]
Uranium-238		
(a) See later discussion in Section 2.1.5 on samples near limit of detection.		

listed in Table 2.2. Several contaminants are highlighted in Tables 2.1 and 2.2 with footnotes, indicating a potential problem with the screening result on the basis of source information. These difficulties are described in Section 2.1.5.

Table 2.2. Contaminants of Potential Interest Related to Ecological Risk Identified by Screening Columbia River Samples

Ambient Water Quality Criteria Screening	Aquatic Biota Threshold Toxicity Screening	Aquatic Biota LC_{50} Screening	Embryonic/ Juvenile Fish Toxicity Screening	Radiation Dose to Fish Screening
Chromium[a]	Nickel[a]	Copper[a]	Diesel[b]	Uranium-234
Copper[a]	Phosphate	Nitrate	Chromium[a]	Uranium-238
Nickel[a]		Zinc[a]		
Zinc[a]		Chromium[a]		
(a) See later discussion in Section 2.1.5 on samples near limit of detection. (b) Diesel as xylene. See discussion in Section 2.1.5 on suspect samples.				

2.1.2 Groundwater Sample Screening

A very large fraction of available Hanford-related environmental samples are of groundwater. Only those taken within about a kilometer (0.6 miles) of the river were used in compiling the database for the screening. Even so, many positive samples were noted. Most of the samples were derived from investigations of the Hanford operating areas (100, 300), but many were from wells located near the river but far from the reactor, fuel fabrication, and research sites. Contaminants identified for investigation include several metals and radionuclides. The screening level used accounted for over 99 percent of the risk for each result. The individual screenings and the identified contaminants related to human health are listed in Table 2.3, and those related to ecological risk are listed in Table 2.4.

Table 2.3. Contaminants of Potential Interest Related to Human Health Identified by Screening Groundwater Samples

Radionuclide Screening	Carcinogenic Chemical Screening	Toxic Chemical Screening
Strontium-90	Chromium	Nitrates
Carbon-14		Nitrites
Cobalt-60		
Tritium (Hydrogen-3)		

Table 2.4. Contaminants of Potential Interest Related to Ecological Risk Identified by Screening Groundwater Samples

Ambient Water Quality Criteria Screening	Aquatic Biota Threshold Toxicity Screening	Aquatic Biota LC_{50} Screening	Embryonic/ Juvenile Fish Toxicity Screening	Radiation Dose to Fish Screening
Mercury	Sulfates	Phosphates	Lead	Carbon-14
Lead	Lead	Copper	Ammonia	Strontium-90
Chromium	Nickel	Zinc	Chromium	
Zinc	Ammonia	Lead		
Copper	Fluorides	Mercury		
		Nitrate/nitrite		

2.1.3 Columbia River Sediment Sample Screening

Because the Hanford Reach is a relatively fast-flowing portion of the river, little accumulation of sediment actually occurs at Hanford. Accordingly, sediment samples represent a very small portion of the historical Hanford data. This is a clear area for future sampling work. Nevertheless, the sediment samples provided sufficient information to apply the screening technique. The individual screenings and the identified contaminants related to human risk are listed in Table 2.5, and those related to ecological risk are listed in Table 2.6.

Table 2.5. Contaminants of Potential Interest Related to Human Health Identified by Screening Columbia River Sediment Samples

Radionuclide Screening	Carcinogenic Chemical Screening	Toxic Chemical Screening
Neptunium-237 Strontium-90 Cesium-137 Cobalt-60	Chromium	Chromium

Table 2.6. Contaminants of Potential Interest Related to Ecological Risk Identified by Screening Columbia River Sediment Samples

Ambient Water Quality Criteria Screening	Aquatic Biota Threshold Toxicity Screening	Aquatic Biota LC_{50} Screening	Embryonic/ Juvenile Fish Toxicity Screening	Radiation Dose to Fish Screening
Chromium		Chromium	Diesel[a]	Strontium-90 Cesium-137
(a) Diesel as xylene.				

2.1.4 Near-River Soil Sample Screening

Contaminants measured in soil upland of the riparian corridor near the Columbia River are generally not an immediate hazard because they are currently in the soil and not subject to mass transport to the river and subsequent human and biotic exposure. However, their existence is the primary reason for continuing cleanup of the Hanford operating areas, and having a screening prioritization is useful. Also, directing future sampling efforts is useful for determining if any of the contaminants most likely to cause problems are beginning to reach the river. Because of the nature of the contamination (generally solids in or associated with soil) and the nature of the activities carried out at Hanford over its history, these contaminants differ somewhat from those actually found in more mobile media (river water, groundwater, and sediment). Even so, it is informative to note the similarities in the list generated via the soil screening with those lists generated for the other media. The individual screenings and the identified contaminants related to human and ecological risk are listed in Tables 2.7 and 2.8, respectively.

In Tables 2.2, 2.6, and 2.8, the contaminant diesel is identified. In the contaminants analyzed for and found, various components of diesel fuel are individually listed. However, in all cases, these components were found in the same sites—those associated with leaks of diesel fuel from underground storage tanks. Therefore, they have been grouped here as a single dominant contaminant.

Table 2.7. Contaminants of Potential Interest Related to Human Health Identified by Screening Near-River Soil Samples

Radionuclide Screening	Carcinogenic Chemical Screening	Toxic Chemicals Screening
Europium-152	Chromium	Copper
Cobalt-60	Arochlor 1248	Nitrates
Europium-154		Nitrites
Cesium-137		
Carbon-14		

Table 2.8. Contaminants of Potential Interest Related to Ecological Risk Identified by Screening Near-River Soil Samples

Ambient Water Quality Criteria Screening	Aquatic Biota Threshold Toxicity Screening	Aquatic Biota LC_{50} Screening	Embryonic/ Juvenile Fish Toxicity Screening	Radiation Dose to Fish Screening
Copper	Diesel[(a)]	Silver Chloride	Diesel[(a)]	Carbon-14
Cyanide		Copper		Cobalt-60
Chlordane		Cyanide		Cesium-137
(a) Variously as kerosene, benzene, xylene, and ethylbenzene.				

2.1.5 Use of Background and Suspect Measurements

During the screening process, a few radionuclides and chemicals were initially identified as of potential interest but were not evaluated further because measurements showed them to be within their naturally occurring background levels (DOE 1996a, 1992b). These radionuclides and chemicals and their background values are identified in Tables A.1, A.2, and A.3 on diskette in Appendix I-A. In addition, the screening process identified several chemicals to be those that EPA (1991, 1989) considers non-hazardous to humans under environmental conditions. These non-hazardous chemicals, which were removed from further consideration in the human risk screens,

During the screening process, a few contaminants survived the screening, but their measurements were the same or lower than measurements taken of the same material where no known polluting source was in the area. Such measurements are known as background levels. Those contaminants (eliminated because their measurements were within their naturally occurring background levels) are identified in Appendix I-A. Also, some of the results from the screens turned up suspect measurements. Suspect measurements are ones that appear to be measuring mistakes, such as the measurement being totally out of line with any other measurements for that contaminant. Although several measurements were suspect, we did not eliminate any of those, but did note which ones look suspect.

included aluminum, calcium, iron, magnesium, potassium, and sodium. These contaminants were still screened with the ecological risk screens.

The majority of the measurements taken over the past 15 years were collected according to modern quality assurance procedures (Dirkes et al. 1994). Because the data used in the screening process come from these measurements of the past 15 years, their quality is in accordance with modern quality assurance procedures. All data recorded in the referenced studies were used in the screening process and are traceable.

During the evaluations for this screening assessment, five potential constituents of concern with single, questionable, measured results were encountered with the potential to influence the selection criteria related to Columbia River water. One of those potential constituents of concern is xylene, which is labeled with a footnote in Table 2.2. This chemical was identified as coming from a single sample that is thought to have been contaminated during sampling or analysis because this and other chemicals identified in that one sample are common laboratory and industrial solvents (Dirkes et al. 1993, p. 4.1). This compound is unlikely to have elevated concentrations in river water as a result of releases from the Hanford Site because the suspect sample was paired with another suspect sample from upstream of the Hanford Site, which also indicated high concentrations of organic contaminants. ("Paired with" means that the two samples were analyzed at the same time using the same techniques.) However, in Tables 2.2, 2.6, and 2.8, xylene and other petroleum derivatives are again identified, associated with diesel fuel leaks. Therefore, the general category of diesel fuel is retained.

Four other chemicals labeled with a footnote in Tables 2.1 and 2.2 as being suspect are copper, chromium, nickel, and zinc. These four metals and several more identified in Table A.7 (on diskette) in Appendix I-A (see SW-LD notations in the general notes column) were very near the lower limits of detection in a series of samples at the Richland Pumphouse (Dirkes et al. 1993). This reference compared concentrations of 20 volatile organic chemicals, 19 metals, and 7 anions upstream from the Hanford Site at the Vernita Bridge and downstream from the Hanford Site at Richland. No volatile organic chemicals were routinely detected at either location. The concentrations of most metals were also very low. However, copper and nickel were each reported one time (out of nine sampling periods) as being slightly above the limit of detection. The limit of detection for copper for the Dirkes et al. (1993) study was 20 micrograms/liter. The single reported positive sample was 22 micrograms/liter. The limit of detection for nickel was 30 micrograms/liter. The single reported positive sample was 31 micrograms/liter. These values probably do not represent the actual level of river contamination. However, because these metals are identified as being of potential concern in other sources (for example, groundwater and/or sediment and/or soils), they are retained on the lists.

2.2 Discrete Radioactive Particles

Discrete radioactive particles are of concern because if you inhaled one of the most radioactive particles and it remained lodged in your nasal passage for up to 48 hours, the resulting dose to a small area of the skin in your nose would be about ten times the working limit. The working limit is 75 microcurie-hours, the limit established to prevent small radiation burns. This section relates that some discrete radioactive particles have been found and removed but assumes the possible existence of others.

Discrete particles of radioactive material, primarily cobalt-60, are included in the list of contaminants for further evaluation.

The presence of small, discrete particles of radioactive material was discovered by Sula during a shoreline survey in 1978-1979 (Sula 1980). In that survey, Sula reported finding 188 discrete particles of contaminated material. The majority of the discrete particles were found buried in rocky, flat areas with little or no vegetation. Sula recovered 14 particles for special study. Laboratory analysis identified the gamma radiation emitted from the particles to be entirely due to cobalt-60 with activities ranging from 1.7 to 24 microcuries. Sula (1980, p. 36) describes the particles as follows:

> *When isolated, the particles were barely visible to the naked eye, appearing as small, dark colored chips or flakes of roughly equal size. Microscopic examination of three particles showed them to be metallic appearing flakes with diameters of approximately 0.1 mm. The particles were found to vary in elemental composition, but all contained significant proportions of chromium, iron, and cobalt characteristic of the alloy stellite, used in valve and pump components in all of the production reactors.*

Sula declined to predict how many particles exist in the Columbia River but did note that “the number of particles found per square meter of ground surveyed decreases as one travels downstream from the reactor areas” (Sula 1980, p. 36).

The next attempt to measure these particles came in 1993 (Cooper and Woodruff 1993). Although the area surveyed was somewhat less than that surveyed by Sula, the 1993 survey also found eleven particles: ten on one island near the reactors and one farther downstream. Two particles were recovered for further analysis. The activities of these two particles were 1.7 and 16 microcuries of cobalt-60.

Most recently, cleanup efforts on the island closest to and downstream of the 100-D Area (the island noted in both the Sula and Cooper and Woodruff surveys as having the highest concentration of particles) have recovered 103 particles with activities ranging from 0.13 to 22 microcuries of cobalt-60 and minor amounts of other Hanford radionuclides (Wade and Wendling 1994).

Cooper and Woodruff (1993) evaluated the potential for radiation dose from inhalation or ingestion of a discrete particle and from external exposure. Their evaluation concluded that, although the possibility of inhalation is remote, the dose-limiting exposure pathway is the inhalation of a particle at the upper end of the range of activity that would remain lodged in the nasal passages for up to 48 hours, resulting in a dose about ten times the recommended limit for occupational exposure of this type (NCRP 1989).

2.3 Effects from Hanford Facilities

Some Hanford facilities near the river emit radiation that is detectable on the river shoreline. Others are physically located in the river.

2.3.1 Direct Irradiation

Direct irradiation is of concern because if you boat or fish near certain facilities, the radiation dose rate is higher than in other areas. This section discusses recent measurements of radiation exposure and notes that the dose rates have fallen significantly since the N Reactor was closed in 1988.

Elevated levels of direct irradiation are included as "contaminants" to be considered in further evaluations.

For the last several years, the highest direct radiation exposure rates from Hanford operations observed at locations where the public currently has access have been on the Columbia River along about a 2-kilometer (1.2-mile) stretch of the southern shoreline at the 100-N Area (for example, Thatcher 1995; Dirkes et al. 1994). External radiation measurements have been reported in the Hanford Site annual environmental reports for this location since 1990 (for example, Dirkes and Hanf 1995; Dirkes et al. 1994). The source of the elevated exposure rates is radiation from facilities located along the river in the 100-N Area. Although the public is not currently allowed access to the shoreline, the adjacent river is open to the public for recreational uses.

In 1988, EG&G Energy Measurements performed an aerial survey of direct exposure rates on the Hanford Site, including the Columbia River and adjacent facilities (EG&G 1990). A low-level, generalized increase in exposure rates is indicated for the shorelines of most of the river. The individual facilities are distinctly noticeable. The 100-N Area evidences the highest exposure rates of river locations.

Elevated radiation dose rates at the shoreline are reported in Dirkes et al. (1994, pp. 76, 168). The highest values were measured adjacent to the N Reactor itself and also near the 1301-N Liquid Waste Disposal Facility. Microroentgens measure the ability of radiation to ionize air. They are numerically roughly equivalent to microrads—the energy absorbed in tissue. The highest readings along the shoreline in 1994 ranged up to about 100 microroentgen/hour in an area with background exposure rates from 7-10 microroentgen/hour. Dirkes et al. (1994, p. 75) qualify this number to be a probable overestimate. The dose rates have fallen significantly since the closure of the N Reactor in 1988. Dose rates are also elevated near the 100-K Area because of radiologically contaminated materials such as internally contaminated ion-exchange modules used in maintaining water quality in the nearby 105-KE fuel storage basin. A third area of elevated exposure rates is adjacent to the 300 Area.

In 1993 measurements were also made by boat on the Columbia River adjacent to the N Reactor facilities about 75 meters (250 feet) from the Hanford shoreline (Cooper and Woodruff 1993, pp. 4.12-4.13). At this distance, the exposure rates along a 1500-meter (5000-foot) track parallel to the river shoreline near the facility ranged from essentially background levels (5 microroentgen/hour) to about 20 microroentgen/hour. Exposure rates on the north shore of the river across from N Reactor were all essentially background.

Washington State Department of Health staff performed a radiation survey along the 100-N Area shoreline in July 1994 and one along the opposite shoreline in February 1995 (Thatcher 1995). The goal of the surveys was to measure skyshine (caused by Compten scattering of gamma rays) as a result of sources of cobalt-60 and cesium-137 in the 100-N Area. Results indicated two areas of elevated exposure near the Emergency Dump Tank and the Liquid Waste Disposal Facilities. In both areas, the net maximum exposure rate is 19 microroentgen/hour, occurring along approximately 245 meters (800 feet) of shoreline. Analysis of the results for the opposite shoreline identified no significant increases over background.

2.3.2 Effluent Pipe System

Liquid effluent from the reactors was directly discharged to the main channel of the river primarily via large pipelines buried in the river bottom. At times, liquid effluent was also directly discharged via spillways on the river bank. Because of the potential for the pipelines to contain residual contamination, they were investigated in the summer of 1995. A robot was used to radiologically, chemically, and physically characterize the insides of the effluent pipelines at 100-B, 100-D, and 100-DR Areas (Dunks 1995). The inspections documented each pipe's interior condition by video recording the interior, taking radiation monitoring measurements, performing ultrasonic testing to determine the pipes' thickness, and collecting interior scale and sediment samples. Scale and sediment samples were collected with a remote-controlled arm on the robot.

Radiation monitoring in the 100-B pipeline showed no zones with greater than 1 milliroentgen/hour (lower instrument detection level). Equipment difficulties made radiation measurements in the 100-D and 100-DR pipelines unreliable. Samples were taken of scale and sediment and analyzed for carbon-14, potassium-40, cobalt-60, nickel-63, cesium-137, europium-152, europium-154, europium-155, plutonium-238, plutonium-239/240, tritium (hydrogen-3), and uranium. The concentrations of all radionuclides were lower than the maxima in soil and sediment presented in Table A.5. The samples were also analyzed for aluminum, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, vanadium, and zinc. Only iron at 100-B and 100-D Areas and chromium and mercury at 100-D Area were found in concentrations greater than soil/sediment samples shown in Table A.5.

Iron is to be expected in steel pipes. Chromium and mercury have been identified in Section 2.1 as contaminants requiring further evaluation. Thus, no additional contaminants were observed in the effluent pipelines that need to be added to the list evaluated in the screening assessment.

2.4 Groundwater Sources Distant from the Columbia River

To select the contaminants for the screening assessment, we are not using measurements of contaminants found in the groundwater farther than 500 feet from the Columbia River. However, we did pass those contaminants through the screens; the results are shown in Tables 2.9 and 2.10. Sample portraits of two contaminants, tritium (hydrogen-3) and nitrate, were prepared for the groundwater, as Figures 6 and 7 show in the "Site Characterization" section. While contaminants in groundwater farther than 500 feet from the Columbia River are not yet entering the river, they have the potential to do so within 10 to 200 years. In this section, we also discuss the actions being taken to impede the contaminants from reaching the river.

Certain contaminants now in soil or groundwater distant from the Columbia River at Hanford may some time in the future pose a source of contamination to the river. Some distant contaminants are essentially certain to reach the river, while other contaminants have only the potential to reach the river at this time, in part because planned remedial actions will either immobilize or remove them. The contaminants that are already in groundwater are quite likely to reach the Columbia River in the future. Contaminants contained in Hanford tank farms or burial grounds may or may not pose a future hazard. For the screening assessment, only those contaminants currently in the groundwater as defined in Section 2.4.1 are considered. Section 2.4.2 briefly refers to documentation of the potential sources of future groundwater contamination.

2.4.1 Existing Groundwater Plumes

More than 105 plumes, containing 20 contaminants, are readily observable in groundwater beneath the Hanford Site (DOE 1994b; Ford 1993). Table A.6 summarizes the nature of the existing groundwater contaminant plumes, their general locations, and maximum measured concentrations. Maps of these plumes are provided in Ford (1993), DOE (1994b), and Dirkes et al. (1994). Note that each author of these reports draws the outlines of the plumes somewhat differently, depending on the purpose of the reports. Examples of two of the most widely dispersed contaminants, tritium (hydrogen-3) and nitrate, are shown in Figures 6 and 7 of the "Site Characterization" section of this screening assessment.

Because contaminant plumes distant from the Columbia River are not in direct contact with the river, they do not yet constitute a source of contaminants in the river. The window for future concern varies depending both on the location of the plumes and the material in them. Groundwater travel times from the current location to discharge in the river vary by location. Travel times in the 100 Areas generally are less than 1 year. Travel times for groundwater carrying the plumes in the 200 East Area are generally from 20 to 200 years. Travel times for the contaminants in the 600 Area evolving from the Central Landfill Site are probably about 10 years. Travel times for plumes in the 200 West Area may be as long as 80 to 300 years (Freshley and Graham 1988). All of these estimated times depend on future groundwater conditions and influences such as quantity of water discharged from Hanford operating facilities.

Most of the contaminants listed in Table A.6 are relatively mobile in groundwater. However, cobalt-60, strontium-90, and cesium-137 interact chemically with the soil and move more slowly than the groundwater (Dirkes and Hanf 1995). The chemical interactions add to the delay that these materials will experience, particularly those in the distant 200 Areas, before the plumes begin to discharge to the Columbia River.

Because the half-lives of cobalt-60 (5.3 years), strontium-90 (28.8 years), and cesium-137 (30.2 years) are relatively short compared with the travel time from the 200 Areas to the Columbia River (including sorption effects), they are expected to decay before reaching the river. The strontium-90 in distant plumes in the 100 Areas will likely reach the river or continue to enter the river as is the case at the 100-N Area.

Applying the equations and assumptions defined in Section A.3.2 to the groundwater plumes resulted in a series of complementary, but not necessarily intercomparable, screening values for each contaminant. The overall screening results for existing groundwater plumes away from the river are given in Table 2.9 for those related to human health and Table 2.10 for those related to ecological risk.

Table 2.9. Contaminants of Potential Interest Related to Human Health Identified by Screening Existing Groundwater Plumes Away from the Columbia River

Radionuclide Screening	Carcinogenic Chemical Screening	Hazard Index Screening
Tritium (Hydrogen-3)	Carbon Tetrachloride	Nitrate
Cobalt-60	Chloroform	
Strontium-90	Trichloroethylene	
Technetium-99		
Iodine-129		
Cesium-137		
Uranium-234/238		
Plutonium-239/240		

Table 2.10. Contaminants of Potential Interest Related to Ecological Risk Identified by Screening Existing Groundwater Plumes Away from the Columbia River

Ambient Water Quality Criteria Screening	Aquatic Toxicant Threshold Screening	Aquatic Biota LC_{50} Screening	Embryonic/ Juvenile Fish LC_{50} Screening	Aquatic Biota Dose Screening
Chromium	Fluorides	Nitrates	Chromium	Cesium-137
Cyanide				Uranium-234
				Uranium-238

2.4.2 Potential Future Groundwater Sources

The scope of the screening assessment involves the current conditions of the Hanford Reach of the Columbia River. A very large number of radionuclides and chemicals are contained in Hanford facilities, waste management sites, or other contaminated areas. The radionuclides and chemicals are present in varying amounts and with varying potential for release to the environment. The following information is provided for readers interested in potential future releases. This information was not used directly to determine the list of contaminants evaluated in the screening assessment.

Remedial actions are planned or under way by DOE under the provisions of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) to bring the Hanford Site into compliance with the applicable requirements of CERCLA (42 USC 9601), the Resource Conservation and Recovery Act (RCRA) (42 USC 6901), and the Washington State Hazardous Waste Management Act (RCW 1985). The DOE program responsible for conducting remedial actions at the Hanford Site is referred to as the Richland Environmental Restoration Project. The scope of the Richland Environmental Restoration Project (DOE 1994h) encompasses the following groups of actions:

- radiation area remedial actions/underground storage tanks (UST)
- RCRA closures
- single-shell tank closures
- past-practice site operable unit (source and groundwater) remedial actions
- surplus facilities decontamination and decommissioning
- storage and disposal facilities

Radiation area remedial actions address the management and control of inactive waste sites to minimize the spread of surface soil contamination. The UST program addresses the management of state-regulated, non-radioactive USTs in accordance with Washington State regulations. RCRA closures address actions at certain waste management units classified under RCRA as treatment, storage, and disposal (TSD) units. (Hanford has over 50 groups of TSD units.) Units subject to regulation as TSD units must either receive a RCRA operating permit or be closed in accordance with the RCRA closure process.

Single-shell tank closures address the development and implementation of final disposal of the 149 single-shell tanks at Hanford. The environmental impact statement for the Tank Waste Remediation System addresses the management, treatment, storage, and disposal of waste in the single-shell tanks (DOE 1996b).

Remedial actions for past-practice operable units address the investigation and remediation of units where waste or other substances have been disposed (intentionally or unintentionally) and are not subject to regulation as TSDs. Over 1000 past-practice units have been identified at the Hanford Site (Ecology et al. 1994).

The Surplus Facilities Decontamination and Decommissioning Program addresses the safe management and final disposition of facilities, such as surplus production reactors and chemical processing buildings, that have been retired and declared surplus. Decontamination and decommissioning of the reactors along the Columbia River are addressed in the *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington (Final Environmental Impact Statement)* (DOE 1992c). Storage and disposal facilities address the planning, construction, and operation of facilities required for the success of the Richland Environmental Restoration Project (DOE 1994g). These facilities are being addressed individually through CERCLA (42 USC 9601 et seq.), RCRA (42 USC 6901 et seq.), and the National Environmental Policy Act (NEPA) (42 USC 4321 et seq.) requirements.

Descriptions of the various potential impacts and releases to the Columbia River from the Richland Environmental Restoration Project (DOE 1994g) are provided in the *Hanford Remedial Action Draft Environmental Impact Statement* (DOE 1996c). In addition to the Richland Environmental Restoration Project efforts (DOE 1994g), additional documentation on high-level waste and transuranic waste facilities is covered in the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (DOE 1987).

The future of the many existing waste sites is undergoing review. Very few will remain in their current condition. Predicting the future impact of these sites is nearly impossible until additional planning and activities occur. The reader is directed to the various references for further information on the potential contaminants and their potential future impact on the Columbia River.

2.5 Contaminants Selected for the Screening Assessment

In this section, we list the 23 contaminants (Table 2.11) that passed the screen and therefore were used in assessing potential risk to humans and the environment. When we initially applied the eight screens, we identified 31 contaminants to evaluate in the screening assessment. However, by applying the limited scope for the screening assessment defined by the CRCIA Team, 8 of the 31 contaminants appeared to be out of scope and therefore were eliminated.

More than 600 different radionuclides or chemicals have been sought in Hanford-related environmental samples. A large number of potential contaminants have never been detected in the Hanford/Columbia River environments. For the roughly 100 compounds that have been detected at some level, screening was performed on the basis of potential impact on human health or the health of Columbia River ecosystems. Eight different types of screens were used, each designed to support a screening assessment of the current state of the river. The screens were applied to account for over 99 percent of the potential risk for each endpoint (biological resource and their attributes of concern for this assessment) evaluated. (For a comprehensive assessment, other potential sources of contamination would also be evaluated, for example, waste tanks, other facilities, or vadose zone sources). The results of the screens were robust in that the same compounds were identified numerous times by the eight screens. Applying the screens for contaminants in the operating areas and other areas within 150 meters (500 feet) of the Columbia River yielded a list (derived from Tables 2.1-2.8) of potential contaminants for analysis in the screening assessment, plus direct irradiation and discrete radioactive particles.

Existing Hanford groundwater contamination outside the 100 and 300 Areas farther than 150 meters (500 feet) away from the Columbia River was also addressed. Some of the contaminants identified by this portion of the screening process (Tables 2.9 and 2.10) are not yet entering the Columbia River but have the potential to do so within 10 to 200 years (Freshley and Graham 1988). Some contaminants are common with those identified as being already in or near the river, and some are unique (for example, carbon tetrachloride and trichloroethylene). Of the 14 contaminants identified by the eight screens for the sources far from the river, 8 contaminants are duplicates of those identified from the near-river sources.

When the eight screens were applied to the data sources, 31 contaminants were identified for potential evaluation during the screening assessment. However, by applying the limited scope for the screening assessment defined by the CRCIA Team, 8 of the 31 contaminants appeared to be out of scope. The 8 contaminants identified in the contaminant screening process, but that are out of scope, are listed below with a rationale for their elimination. The contaminants eliminated from evaluation in the screening assessment may well be evaluated in a comprehensive impact assessment. See Part II of this report for a discussion of the requirements for a comprehensive assessment. The environmental behavior of the contaminants will be monitored by the Tri-Party agencies to determine their migration toward the Columbia River.

With the elimination of the eight contaminants, the remaining contaminants, shown in Table 2.11, are those to be evaluated in the screening assessment of potential risk.

Table 2.11. Contaminants Identified for Evaluation in the Screening Assessment[(a)]

Radionuclides	Carcinogenic Chemicals	Toxic Chemicals
Tritium (Hydrogen-3)	Benzene	Ammonia
Carbon-14	Chromium	Chromium
Cobalt-60		Copper
Strontium-90		Cyanide
Technetium-99		Diesel (constituents)
Iodine-129		Lead
Cesium-137		Mercury
Europium-152		Nickel
Europium-154		Nitrates/nitrites
Uranium-234/238		Phosphates
Neptunium-237		Sulfates
		Zinc
(a) Direct irradiation and discrete radioactive particles will also be evaluated.		

Arochlor 1248 - This polychlorinated biphenyl (PCB) and others like it have been identified in a number of contaminated soil sites associated with electrical transformers. The predominant risk to human health and the environment associated with these sites concerns users of upland areas, not risk to the groundwater or the Columbia River. PCBs have not been detected in samples from groundwater wells located in the screening assessment study area (0.8 kilometer/0.5 mile in from the river between Priest Rapids Dam and McNary Dam). Based on historical data from wells, which did not indicate the presence of PCBs, this constituent was not included in the suite of analyses for riverbank seepage samples collected as part of the limited field investigation for the 100 Areas (DOE 1992a). Cleanup of these sites will be driven by the need to protect upland species.

Carbon tetrachloride - The process to identify contaminants for the screening assessment included groundwater data from anywhere on site, regardless of distance from the Columbia River. By contrast, the calculations of risk for the screening assessment are limited to data associated with the river corridor. Because carbon tetrachloride is in the groundwater under the 200 Areas at substantial concentrations of up to 6.5 parts per million (Ford 1993), it was included in the contaminant screening process. However, carbon tetrachloride has not migrated away from the 200 Areas and is many years away from the river corridor (Dirkes and Hanf 1995). Hence, it is not evaluated in the screening assessment, which focuses on the current state of the river.

Chlordane - This pesticide has been identified as a soil contaminant. The predominant risk to human health and the environment associated with chlordane in soil is for users of upland areas, not risk to the groundwater or the Columbia River. Chlordane has not been detected in samples from groundwater wells located in the screening assessment study area. Based on historical data from wells, which did not indicate the presence of pesticides and herbicides, this constituent was not included in the suite of analyses for riverbank seepage samples collected as part of the limited field investigation for the 100 Areas (DOE 1992a).

Chloroform - This compound was identified as a potential hazard in groundwater away from the river. The much lower concentrations identified as being near the river were not identified as high priority pollutants by the screening process. With the focus of the screening assessment on contaminants of current potential risk and because the more elevated concentrations in the 200 Areas are as yet far from the river (Dirkes and Hanf 1995), this contaminant was eliminated from evaluation in the screening risk assessment.

Fluorides - This chemical compound was identified in groundwater both near and away from the river. Near the river, it was identified in concentrations only slightly elevated (less than three times) above background levels. Because the more elevated concentrations in the 200 Areas are as yet far from the river (Dirkes and Hanf 1995; Ford 1993), this contaminant was eliminated from current evaluation in the screening risk assessment.

Plutonium - This contaminant was identified as having very low concentrations in near-river groundwater and soils (undetectable in surface water, 0.03 picocuries/liter in groundwater, 0.071 picocuries/gram in sediment, and up to 230 picocuries/gram in soils—see Table A.4 in Appendix I-A). Higher concentrations in limited areas of the 200 Area groundwater (up to 69 picocuries/liter) were sufficient to cause the radionuclide to be identified by the screening process. With the focus of the initial phase on contaminants of current potential risk and because the more elevated concentrations in the 200 Areas are as yet far from the river (Dirkes and Hanf 1995; Ford 1993), this contaminant was eliminated from evaluation in the screening risk assessment.

Silver chloride - This contaminant was identified as extremely elevated in a single area of soil contamination in the 300 Area. This single area is over 100 times more contaminated with silver than any other area. The predominant risk to human health and the environment associated with silver in soil is for users of upland areas, not risk to the groundwater or the Columbia River. Cleanup of this site will be driven by the need to protect upland species. Silver has not been detected in samples from groundwater wells located in the screening assessment study area nor in samples of riverbank seepage and sediment associated with seepage, which were collected as part of the limited field investigation for the 100 Areas (DOE 1992a).

Trichloroethylene - This compound was identified as a potential hazard in groundwater away from the river. The roughly equivalent concentrations identified as being near the river were not identified as high priority pollutants by the screening process. This is an artifact produced because the screens cannot be directly compared. With the focus of the initial phase on contaminants of current potential risk and because the concentrations in the 200 Areas are essentially the same as those near the river, this contaminant was eliminated from evaluation in the screening risk assessment.