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Mr. Michael Goldstein
U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, D.C. 20460

Dear Mr. Goldstein:

UPDATED PAGES FOR THE DRAFT REPORT "SCREENING ASSESSMENT AND REQUIREMENTS FOR A COMPREHENSIVE ASSESSMENT: COLUMBIA RIVER COMPREHENSIVE IMPACT ASSESSMENT," DOE/RL-96-16, APRIL 1997

In April you were provided an early iteration of the Columbia River Comprehensive Impact Assessment (CRCIA) report. Since then a number of minor corrections have been made to the draft you received. These corrections were incorporated into the public draft of the CRCIA report that was distributed.

Because of the nature of these changes, it is more appropriate to send you the enclosed updated pages rather than the whole CRCIA report. Please exchange the outdated pages in your copy with the enclosed pages.

If you have any questions, please contact me at (509) 376-6192.

Sincerely,

Robert K. (Bob) Stewart

Robert K. Stewart, Project Manager
Groundwater Project

Enclosure

cc w/o encl:
L. E. Gadbois, EPA
D. J. Guzzetta, ICF-KH

Preface

The Columbia River is a critical resource for residents of the Pacific Northwest. It provides for basic needs and is interrelated with the life style and quality of life for Columbia Basin's many human and non-human residents. This resource was one of the key features that drew the Manhattan Project's planners to the site now called Hanford to produce nuclear weapon materials. Production of those materials has left behind a legacy of chemical and radioactive contaminants and materials that have affected and may be continuing to affect the Columbia River for the foreseeable future.

To evaluate the impact to the river from these Hanford-derived contaminants, the U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology (the Tri-Party agencies) initiated a study referred to as the Columbia River Comprehensive Impact Assessment (CRCIA). To address concerns about the scope and direction of CRCIA as well as enhance regulator, tribal, and public involvement, the CRCIA Management Team (CRCIA Team) was formed in August 1995. The CRCIA Team has met weekly to share information and provide input to decisions made by the Tri-Party agencies concerning CRCIA. Representatives from the Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Yakama Indian Nation, Hanford Advisory Board, Oregon State Department of Energy, Tri-Party agencies, and Hanford contractors are active participants on the team.

Purpose and Objectives of the Comprehensive Assessment

The purpose of the Columbia River Comprehensive Impact Assessment (CRCIA) is to assess the effects of Hanford-derived materials and contaminants on the Columbia River environment, river-dependent life, and users of river resources for as long as these contaminants remain intrinsically hazardous.

For CRCIA to be comprehensive, representatives of the major community groups (non-U.S. Department of Energy) on the CRCIA Team have agreed that the following objectives must be achieved if the results and conclusions are to be acceptable by all concerned:

- estimate, with useful certainty, river-related human health and ecological risks for the time period that Hanford materials and contaminants remain intrinsically hazardous
- evaluate the sustainability of the river ecosystem, the interrelated cultural quality of life, and the viability of socio-economic entities for the time period that Hanford materials and contaminants remain intrinsically hazardous
- provide results that are useful for decision making on Hanford waste management, environmental restoration, and remediation

Project Approach

To address CRCIA objectives, the CRCIA Team has agreed to conduct CRCIA using a phased approach. The initial phase, which is required and described in Tri-Party Agreement milestones M-15-80 and M-15-80-T01, includes two components: 1) a screening assessment to evaluate the potential impact to the river, resulting from current levels of Hanford-derived contaminants in order to support decisions on

Executive Summary

Introduction

The Columbia River is a critical resource for residents of the Pacific Northwest. It provides for basic needs and is interrelated with the life style and quality of life for the Columbia Basin's many human and non-human residents. This resource was one of the key features that drew the Manhattan Project's planners to the site now called Hanford to produce nuclear weapon materials. Production of those materials has left behind a legacy of chemical and radioactive contaminants and materials that have affected and may be continuing to affect the Columbia River for the foreseeable future.

We are conducting the Columbia River Comprehensive Impact Assessment in phases. The first phase is a screening assessment, the results of which are presented in Part I of this report. In the screening assessment, we evaluated the potential impact to the Columbia River resulting from current levels of Hanford-derived contaminants. The results of the screening assessment will be used to support decisions on Interim Remedial Measures. Part II of this report defines the requirements to conduct a comprehensive assessment of the Columbia River.

To evaluate the impact to the river from the Hanford-derived contaminants, the U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology (the Tri-Party agencies) initiated a study referred to as the Columbia River Comprehensive Impact Assessment (CRCIA). To address concerns about the scope and direction of CRCIA as well as enhance regulator, tribal, stakeholder, and public involvement, the CRCIA Management Team (CRCIA Team) was formed in August 1995. The CRCIA Team has met weekly to share information and provide input to decisions made by the Tri-Party agencies concerning CRCIA. Representatives from the Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, Yakama Indian Nation, Hanford Advisory Board, Oregon State Department of Energy, Tri-Party agencies, and Hanford contractors are active participants on the team.

The CRCIA Team has agreed to conduct CRCIA using a phased approach. The initial phase, which is required and described in Tri-Party Agreement milestones M-15-80 and M-15-80C-T01 (Ecology et al. 1994), includes two components: 1) a screening assessment to evaluate the potential impact to the river, resulting from current levels of Hanford-derived contaminants in order to support decisions on Interim Remedial Measures, and 2) a definition of the essential work remaining to provide an acceptable comprehensive river impact assessment. The screening assessment is described in Part I of this report. The essential work remaining is described in Part II of this report.

Additional phases of CRCIA will be identified and decisions made regarding the conduct of the remaining work based on submittal of information as required by Tri-Party Agreement milestones M-15-80A, M-15-80B, and M-15-80B-T01.

- Environmental media
  - Direct use: Columbia River water, riverbank seep water, river and seep sediment, external radiation
  - Indirect use: groundwater (surrogate for seep water), riparian soils, aquatic and riparian biota (used for model comparison, verification)

Technical Approach

A screening assessment by its very nature is a limited assessment. Such limited assessments are used to indicate whether the issues under study warrant further investigation. Screening assessments are often used to express risk in relative terms rather than absolute because of the number and type of assumptions required to drive risk models, the degree of uncertainty inherent in the input to the models, and the limitations in available environmental data. The assumptions, uncertainties, and limitations are applied consistently across the study area, resulting in useful information relative to risk.

While more detailed than typical screening level assessments, limitations to the CRCIA screening assessment have been identified. The CRCIA screening assessment was restricted to 1) current conditions, 2) the Columbia River and adjacent riparian zone between Priest Rapids Dam and McNary Dam, 3) a limited number of contaminants, 4) a limited amount of monitoring data, 5) a limited number of species, and 6) a limited number of scenarios. For the results of the assessment to be useful, these limitations and the process through which the study was conducted must be understood.

The screening assessment technical approach is summarized through the following activities:

- Determining study domain and spatial scale
- Identifying contaminants to be assessed (resulting in 26 contaminants, 28 when accounting for various constituents of those contaminants)
- Identifying a variety of species to evaluate ecological exposure to the contaminants (resulting in 52 species)
- Identifying a variety of exposure scenarios to evaluate human exposure to the contaminants (resulting in 12 scenarios)
- Identifying, collecting, and preparing monitoring data available for the contaminants
- Assessing risk to human health and the environment posed by exposure to the contaminants

To attempt to quantify the uncertainty, two calculation methods were used: deterministic and stochastic. For the deterministic method, the equations were calculated with single, high values of the parameters to identify potential worst case results. For the stochastic method, the equations were calculated with all possible combinations of parameter values, resulting in an output distribution rather than a single value.

For the human health assessment, both deterministic and stochastic calculations were performed for all contaminants, all scenarios, and all river segments. The contaminants assessed fall into one of three categories (carcinogenic chemicals, toxic chemicals, and radionuclides), each of which result in a different type of risk. Individual calculations for each of these contaminant/scenario/segment combinations are compared with toxicity or carcinogenicity indices as appropriate.

For the ecological risk analysis, deterministic calculations were performed for all species/contaminant/ segment combinations. However, stochastic calculations were only performed for those combinations that resulted in an Environmental Hazard Quotient (EHQ) greater than 1.0. Results of the stochastic calculations were compared with toxicological benchmarks, including the lowest observed effect level (LOEL) and the lethal concentration (LC_{50}).

A benefit of the use of stochastic calculations was that it enabled the results to be subjected to statistical comparisons. In these comparisons, the stochastic distribution of concentrations and resulting risk in each Hanford-influenced river segment could be compared to those in a background segment upstream and out of the influence of the Hanford Site. These comparisons provide insight into the nature and magnitude of the incremental risks posed by Hanford releases and identify areas of concern.

Supporting information relative to the respective sections and appendixes in Part I has been published on diskettes, which have been issued with limited distribution. In addition, because numerous changes have occurred in Volume II of the draft data report since its initial publication in June 1996, a revised Volume II is being issued, also with limited distribution. The CRCIA report with its diskettes and the updated version of Volume II of the June 1996 data report with its diskettes are available on the Internet at http://www.hanford.gov/crcia/crcia.htm. Both the diskettes and hard copies of Volume II are also available from S.D. Cannon (509-372-6210).

Results and Discussion

The results of the ecological and human health screening assessments are provided in Sections 4.2 and 5.2, respectively. As a result of Hanford Site operations as well as from other human activities upstream of the Hanford Site, environmental levels of some contaminants do appear to be elevated. Both the ecological modeling and human exposure simulations identify contaminants and locations for which risk to both the environment and humans is evident and for which further analyses or measurements would be worthwhile.

Figure S.1 is a high-level summary of the findings of the ecological risk and human health risk assessments. The contaminants and affected segments of the Columbia River that pose a potential risk according to the results of either the ecological or human risk assessments are identified. The overlapping benthic species or life stages. Contaminants contributing to their risk are chromium, copper, cyanide, lead, mercury, and zinc. The media contributing most to this risk are pore water and sediment, with pore water most significant.

The segments presenting the greatest potential ecological risk are Segment 2 (chromium and lead at the 100-B/C Area), Segment 4 (chromium, copper, mercury, and zinc at the 100-K Area), Segment 5 (chromium and lead), Segment 6 (cobalt-60 and mercury at the 100-N Area), Segment 7 (cesium-137, cobalt-60, lead, and zinc at the 100-D Area), Segment 8 (cobalt-60, mercury, and technetium-99), Segment 9 (chromium, cobalt 60, lead, and mercury), Segment 10 (cesium-137, chromium, mercury, and technetium-99 at the 100-H Area), Segment 12 (cesium-137, cobalt-60, and mercury), Segment 13 (cobalt-60, lead, and mercury at the 100-F Area), Segment 14 (mercury and technetium-99), Segment 16 (cobalt-60 and mercury), Segment 17 (lead, but results suspect and zinc), Segment 19 (lead and mercury), Segment 20 (cyanide, lead, mercury, technetium-99, and zinc at the 300 Area—all results suspect), and Segment 21 (cyanide and lead).

Segments with potential acute ecological risk are Segment 4 (chromium and zinc), Segment 5 (lead), Segment 8 (mercury), Segment 9 (chromium, lead, and mercury), Segments 10 and 14 (mercury), Segment 13 (lead and mercury), Segment 17 (lead), and Segment 20 (copper and zinc). Data were insufficient to assess ecological risk of any contaminant in Segments 11, 18, and 22-27. Risk from nitrite, sulfate, and phosphate was not evaluated because of the general lack of toxicity benchmarks. They present no risk from food-chain exposure, however, because they are readily metabolized. Risk from neptunium-237 and carbon-14 was not evaluated because of the lack of pore water data. Surface water data for europium-152 were absent in Segments 1-18, so risk from this isotope was not estimated in those segments. Risk from certain other contaminants was not evaluated in all segments because of missing pore water data (see Figure 4.19 in Section 4.2).

The human health analysis identified the categories of humans most likely to be affected. Humans in the region of the Hanford Site may have a wide variety of exposures, from low to high (see Figures 5.1-5.3 in Section 5.2.3.1). Generally speaking, the scenarios for the Fish Hatchery Worker, Industrial Worker, and Ranger have the lowest exposures and, therefore, are lowest in terms of health risk. As defined in Section 5.1, none of the people involved in these scenarios consume foods grown in the Columbia River riparian zone or drink seep water. Therefore, the exposures are mostly incidental external exposures and inhalation of resuspended materials, though the Fish Hatchery and Industrial workers also consume a moderate amount of Columbia River water. The risk to workers from these pathways is quite low in comparison to those projected for people potentially exposed in other ways. At the other extreme, people postulated to live along the Columbia River, to eat substantial quantities of foods grown in the riparian zone, to eat fish and wildlife from the river, and to drink seep water have much larger potential exposures and, thus, estimated health risk. This category encompasses nearly all of the remainder of the scenarios described in Section 5.1. From a risk assessment standpoint, very few differences appear between any of the Native American scenarios and recreational/residential scenarios.

The segments presenting the greatest potential human health risk for any given scenario are as follows (these are identified using the estimated hazard index greater then 1.0 and/or an estimated lifetime risk greater than 1E-4): Segment 2 (chromium), Segment 4 (chromium and copper), Segments 5 and 6 water. The primary route of exposure to humans is via consumption of seep water. The most extensive region where seep water contaminated with tritium enters the Columbia River is the vicinity of the old Hanford townsite.

Uranium-234/238. Although uranium is also ubiquitous in the environment, several areas have concentrations elevated above background levels. The media of interest include sediment and seep water near the 300 Area. A prominent pathway is the consumption of prey animals by animals farther up the food chain.

Zinc. The risk to biota is predominantly influenced by pore water and sediment. This metal provides the highest absolute contribution of risk to biota, but the median relative ratio to the upstream value is generally less than one for risk to humans. Zinc is one of the metals that may also be enhanced from upstream sources.

Screening Assessment Conclusions

By agreement with the Tri-Parties and the CRCIA Team, this screening assessment addressed the current potential for ecological and human risk, resulting from known levels of contaminants in the Columbia River or in its immediate vicinity.

The screening study posed the general questions:

- Do current levels of contaminants in Columbia River water, sediment, and riparian zone materials pose a potential risk to ecological resources?

- Do current levels of contaminants in Columbia River water, sediment, and riparian zone materials pose a potential risk to humans who might be exposed to them?

When taken in the context of the screening assessment, the answers to the two main assessment questions are yes. As a result of Hanford operations as well as from other human activities upstream of the Hanford Site, environmental levels of some contaminants do appear to be elevated. Both the ecological modeling and human exposure simulations identify further analyses or measurements would be worthwhile.

Through the use of multiple exposure scenarios, the possible activities of people who could come into contact with the contaminants were evaluated. In general, risk to people today is low because of restricted access to the Hanford Site. Casual visitors and even people working in jobs associated with the Columbia River are not at risk unless they frequent limited areas and consume seep or spring water in which high concentrations of contaminants are present. However, potentially increased risk is possible if people were to move onto the Hanford Site and derive large percentages of their daily food intake from crops and animals in the river's riparian zone. In most instances, this higher risk is limited in extent to a few regions of highest contamination. Although there are numerous cultural differences between the general population and Native Americans, the common pathways of food and water consumption could affect both groups. These common pathways are the ones by which most exposure would be received. The key differences come in the source of the water and food products.

1.0 Introduction

Current ecological and human risk from contaminants in the Columbia River have been evaluated in the screening assessment component of the Columbia River Comprehensive Impact Assessment (CRCIA) Project. The risk studied was that attributable to past and present activities at the Hanford Site. These activities resulted in radioactive and hazardous materials that can affect the environment and human health. As a result, ecological risk was evaluated relative to the health of the current river ecosystem. Human risk was evaluated for a range of river use options.

For the screening assessment, we attempted to answer the following questions:

- **What contaminants need to be studied?**
- **What information already exists about contamination to the river from activities at Hanford?**
- **What species should be studied to identify the possible effects of contamination on the environment?**
- **What exposures (Scenarios) do humans have to river contamination?**
- **What levels of contamination exist in the study area?**

1.1 Purpose and Objective

The purpose of the CRCIA screening assessment is to support decisions on Interim Remedial Measures and to focus a subsequent and more comprehensive risk assessment. The objective of the screening assessment was to identify areas where the greatest potential exists for adverse effects on humans or the environment. The Hanford Reach of the Columbia River was evaluated in the screening assessment in a way that will be useful in the CERCLA process but not necessarily in strict accordance with CERCLA procedures (for example, risk assessment methodology and remedial decision making).

The purpose of Part I of this report is to provide the results of the screening assessment conducted by the Pacific Northwest National Laboratory in consultation with the Columbia River Comprehensive Impact Assessment Management Team (CRCIA Team). The requirements for the remaining work to be done have been written by the CRCIA Team and are included as Part II of this report.

1.2 Scope of Work

The scope of the CRCIA screening assessment was to evaluate potential risk to the environment and human health resulting from current levels of Hanford-derived contaminants. The screening assessment has the primary components of:

- Determining study domain and spatial scale
- Identifying contaminants to be assessed
- Identifying a variety of species to evaluate ecological exposure to the contaminants
- Identifying a variety of exposure scenarios to evaluate human exposure to the contaminants
- Identifying, collecting, and preparing monitoring data available for the contaminants
- Assessing risk to human health and the environment posed by exposure to the contaminants

2.0 Contaminants for the Screening Assessment

To assess possible 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 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 the selection of 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 the results of the risk assessment and not the details of how the contaminants for study were selected may skip most of this section. However, the reader should review at least Section 2.8 to know which contaminants were selected for study.

To select the contaminants to be analyzed in the screening assessment, an abundance of historical data concerning contamination of the Columbia River were reviewed. The data that fit within the scope of the screening assessment were then subjected to a multi-stage screening process. The references used as data sources for selecting the contaminants are annotated in Section 2.1. These data sources were not always the same as the ones ultimately used for the source term of the screening assessment of potential risk. Contaminants were selected prior to gathering the source term data so as to focus the data gathering efforts on the specific contaminants to be screened in the assessment. The data sources used for the source term of 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 filtered to ensure they were within the scope. 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 human health potential risk and ecosystem potential risk. The screens were for radionuclides, carcinogenic chemicals, toxic chemicals, ambient water quality criteria, aquatic biota threshold toxicity, aquatic biota LC_{50}, 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. The potential was also addressed for radiation doses arising from discrete radioactive particles in the river sediment or from direct irradiation from near-river Hanford facilities. 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.

3.0 Data for the Screening Assessment

This section explains the process of gathering data and provides the data that were used in the ecological (Section 4.2) and human health (Section 5.2) screening assessments.

> **For the screening assessment, we needed to find information (monitoring data) about the**
>
> - **26 contaminants (28 when accounting for various constituents of those contaminants for which data were available) potentially in**
> - **4 media (groundwater, sediment, seeps, surface water) plus external radiation at**
> - **27 segments (areas) along the Hanford Reach of the Columbia River**

3.1 Scope

The Columbia River has been the focus of environmental monitoring programs for five decades. The scope of the data task is to compile data collected by the various monitoring programs for the contaminants of interest. Because the scope of the assessment is the current state of the river, January 1990 was selected as the earliest date for which data would be collected. Data after January 1990 reflect both current conditions and high quality monitoring methods.

The media for which data on contaminant concentrations were needed for the ecological and human health screening assessment calculations are groundwater, sediment, seeps, and surface water. In addition, external radiation data were needed for the human health assessment. Some of the data available but not complete enough for assessment purposes are contaminant concentrations in biota, cobalt-60 particles, drive point groundwater data for chromium, N Springs punch point water data, and pore water data for chromium. These data were used in limited calculations and model validation exercises.

3.2 Approach

All defining decisions for the collection and processing of the data were made with CRCIA Team concurrence. All team decisions relating to the efforts of the data task are presented in Table 3.1.

> **The data needed to be**
>
> - **Found, gathered, and identified according to the segment in which the data originated (see Section 3.3) and**
> - **Selected for use (See Section 3.4) in the screening assessment**
>
> **For each of these steps, we consulted and reached consensus with the CRCIA Team on how best to proceed.**

A Geographic Information System was used to assist in implementing the processing of the data for the screening assessment. The Geographic Information System is a computerized system designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. Many software packages exist that perform basic Geographic Information System functions. Arc/Info Rev. 7.0.2 was used for the data task (ESRI 1994).

4.1.2 Species Selection Approach

To identify the species that have a high potential for exposure to or effects from contaminants and that are culturally and ecologically important to the CRCIA Team, a two-tier screening approach was used (Table 4.1). Species groups considered in the screening process included fungi, algae, higher plants, and animals (fish, invertebrates, and terrestrial wildlife). Fungi were included after the master list of species (Table C.1 in Appendix C, Part I) was developed. Microbial populations in surface soil, surface water, and sediment were excluded from consideration in the master list of species. While microorganisms play a critical role in nutrient cycling and other energy processes in the Columbia River ecosystem, they are considered to be highly adaptable to environmental change. In addition, the microbial community structure may change in response to a toxicant without altering the overall functional status of that community because of the ubiquity of microbiota and the redundancy of their metabolic processes. This means that any localized effects of a toxicant are likely compensated in a relatively short time and that the potential for long-term effects to the Columbia River community are low. The steps used throughout this two-tier screen were developed with the approval of the CRCIA Team.

We used several screens to reduce an overwhelming number of species to a manageable number of species to be evaluated. An overview of the criteria for the screens and the selection process are in Table 4.1. One of the initial screens was developed by a panel of regional biologists. The other screens were developed after consulting and reaching agreement with the CRCIA Team. Each time we applied a screen the number of species was reduced. Several screens were used to arrive at the first tier, labeled the Tier I list of species. Several more screens were used to arrive at the second tier, labeled the Tier II list of species. The Tier II list shows the species evaluated in the screening assessment of potential risk to the environment. After each screening, the CRCIA Team reviewed the resulting list and reinstated any species they felt the screen had inappropriately filtered out. Key terms to be familiar with when reading about the approach used to select species are:

- **biotic media are living organisms and their products**
- **abiotic media are inorganic (not living) materials**
- **biomagnifying contaminants are those that occur in higher concentrations at higher levels in the food chain**
- **non-biomagnifying contaminants are those that remain at the same concentration or decrease in concentration at higher levels in the food chain.**

4.1.2.1 Tier I Species Screen

A list of Tier I species was identified using the following protocol. Each step of the protocol is elaborated on in the subsections.

This section describes the details of the various screens used to arrive at the species on the Tier I list.

1. A master list was developed that included plant and animal species known to occur in the riparian and aquatic ecosystems of the Columbia River between the vicinity of Priest Rapids Dam and the Columbia River estuary.

2. The master list was reduced to 368 species that occur within the study area.

The resulting ranks, which indicated the qualitative, relative exposure of species within taxonomic groups, were presented to the CRCIA Team. The CRCIA Team then identified 65 of these as tentative Tier II species based on their rank and cultural and ecological importance. These 65 were further reduced to 52 final Tier II species by excluding 1) those with a life style similar to that of another Tier II species, 2) those with low average summary scores, and 3) those that virtually never occur in the river or riparian zone. These 52 Tier II species are those for which contaminant exposures and effects will be analyzed in the screening assessment of ecological risk, the results of which are presented in Section 4.2).

4.1.2.2.1 Methods. In general, the magnitude of an individual's exposure to a contaminant is a function of the

- Concentration of the contaminant in the media (in other words, air, groundwater, prey, sediment, soil, and surface water) contacted by the individual
- Number of media contacted by the individual
- Number of pathways (in other words, dermal, ingestion, inhalation) by which contaminated media may enter the organism
- Duration of an individual's contact with the contaminated media

To arrive at a simplified conceptual exposure model, species were first grouped by life style as either fully aquatic, semi-aquatic, or primarily riparian. Within life styles, species were grouped primarily by major taxa; for example, amphibian, bird, fish, insect, mammal, plant, reptile. Within taxonomic groups, species were grouped largely by trophic level; for example, carnivore, herbivore, omnivore. The species in each taxonomic group and trophic level were evaluated to determine their potential exposure to contaminated abiotic media (air, groundwater, pore water, sediment, soil, and surface water) at source areas believed to have contaminant loads sufficient to pose a substantial hazard at one or more critical life stages using a general conceptual exposure model approved by the CRCIA Team. The contaminant source areas are shown in Table 4.4 and evaluated further in Section 4.1.2.2.8. Results are shown in Tables 4.5, 4.6, and 4.7 for aquatic, semi-aquatic, and terrestrial species, respectively. Exposure to biotic media such as prey is addressed in Section 4.1.2.2.2.

Of the 181 Tier I species, some were grouped based on similar life styles and trophic levels resulting in 121 species. The CRCIA Team added 5 species to the 121 for a total of 126 species. The 126 species were scored, using the conceptual exposure model described above, for their potential exposure to contaminated media. Scores were scaled to reflect the general magnitude of a species potential exposure to contaminants in each medium, the duration of exposure, and acute radiation sensitivity. These scores represent an index of the relative exposure of species within taxonomic groups. These scores do not represent real differences in exposure. Species were scored specifically on:

- Exposure to Biotic and Abiotic Media: Exposure to media occurs when a species 1) ingests prey, sediment/soil, pore water/groundwater, or surface water which are contaminated; 2) comes in dermal contact with those media; or 3) inhales air-borne contaminants. Scores were assigned to each species for each medium. For the ingestion of prey, scores were differentiated depending on whether the there was virtually no difference in the ranking of species within taxonomic groups based on composite scores and highest average summary scores (see point 8 above). Therefore, because the effect of the composite scores in the ranking of species is minimal, the highest average summary scores were considered to be more valuable than the composite scores for the purposes of this species screen.

4.1.2.2.12 Identification of Final Tier II Species. The CRCIA Team selected 65 of the ranked Tier I species (Table C.3, Appendix C, Part I, rows 28 and 35) as tentative Tier II species based on their rank and cultural and ecological importance. These were further reduced to 52 final Tier II species by excluding 1) those with a life style similar to that of another Tier II species, 2) those with low average summary scores, and 3) those that virtually never occur in the river or riparian zone.

Table 4.17 presents the results of ranking the Tier I species, based on highest average summary scores and composite scores, and identifies those selected as Tier II species with a (+) in the right hand column. The Tier II species are those evaluated in the screening assessment of ecological risk (Section 4.2). A high rank (a low numeric value) represents a high potential exposure to contaminated media. Footnote letters (c, d, and e) in the right-hand column indicate that a species was not selected for the final list of Tier II species for the reasons specified in the footnotes.

The number and percent of Tier I species retained during the Tier II screening process are shown in Table 4.18.

Table 4.17. (Cont'd)

Taxa/Species[a]	Rank Based on Highest Average Summary Scores	Rank Based on Composite Scores	Selected by CRCIA Team as Tentative Tier II Species	Final Tier II Species
American kestrel	27	14	*	+
Barn owl	27	14	*	(d)
Emergent Vegetation				
Tule	1	1	*	+
Fish				
Channel catfish	1	1	*	+
Largescale sucker	2	2	*	+
Mountain sucker	2	2	*	+
Piute sculpin	4	4	*	(c)
White sturgeon	6	6	*	+
Common carp	6	7	*	+
Mountain whitefish	6	7	*	+
Pacific lamprey	8	16	*	+
Small mouth bass	11	9	*	+
Trout (rainbow)	11	11	*	+
Trout (bull)	11	11	*	(c)
Northern squawfish	11	11	*	(d)
Salmon (all)	11	17	*	+
Steelhead trout	18	18	*	(c)
Fungi	1	1	*	+
Macrophytes				
Columbia yellow cress[f]	1	1	*	+
Water milfoil	1	1	*	+
Duckweed	4	4	*	(c)
Mammals				
Muskrat	1	1	*	+
Beaver	3	3	*	+
Coyote	3	3	*	+
Raccoon	3	3	*	+
Short-tailed and long-tailed weasel	3	3	*	+
Mule deer	3	10	*	+
Great Basin pocket mouse	4	11	*	(e)
Western harvest mouse	9	11	*	+

Table 4.18. Number of Tier I Species by Taxonomic Group Retained in the Tier II Species Screen

	Algae	Amphibians	Aquatic Invertebrates	Birds	Emergent Vegetation	Fish	Fungi	Macrophytes	Mammals	Reptiles	Terrestrial Invertebrates	Terrestrial Vegetation	Total
No. of Tier I Species	12	4	15	48	8	24	1	5	21	7	7	29	181
No. of Tier I Species Selected by the CRCIA Team as Tentative Tier II Species	2[(a)]	3	7	18	1	14	1	3	8	2	0	7	66
Percent of Tier I Species Selected by the CRCIA Team as Tentative Tier II Species	17%	75%	47%	38%	13%	60%	100%	60%	38%	29%	0%	24%	36%
No. of Tier I Species Selected as Final Tier II Species	2[(a)]	1	7	13	1	10	1	2	7	2	0	6	52
Percent of Tier I Species Selected as Final Tier II Species	17%	25%	47%	27%	13%	42%	100%	40%	33%	29%	0%	21%	29%

(a) Periphyton and phytoplankton, two broad taxa that include many algae species, were selected as tentative and final Tier II species (see Table 4.17).

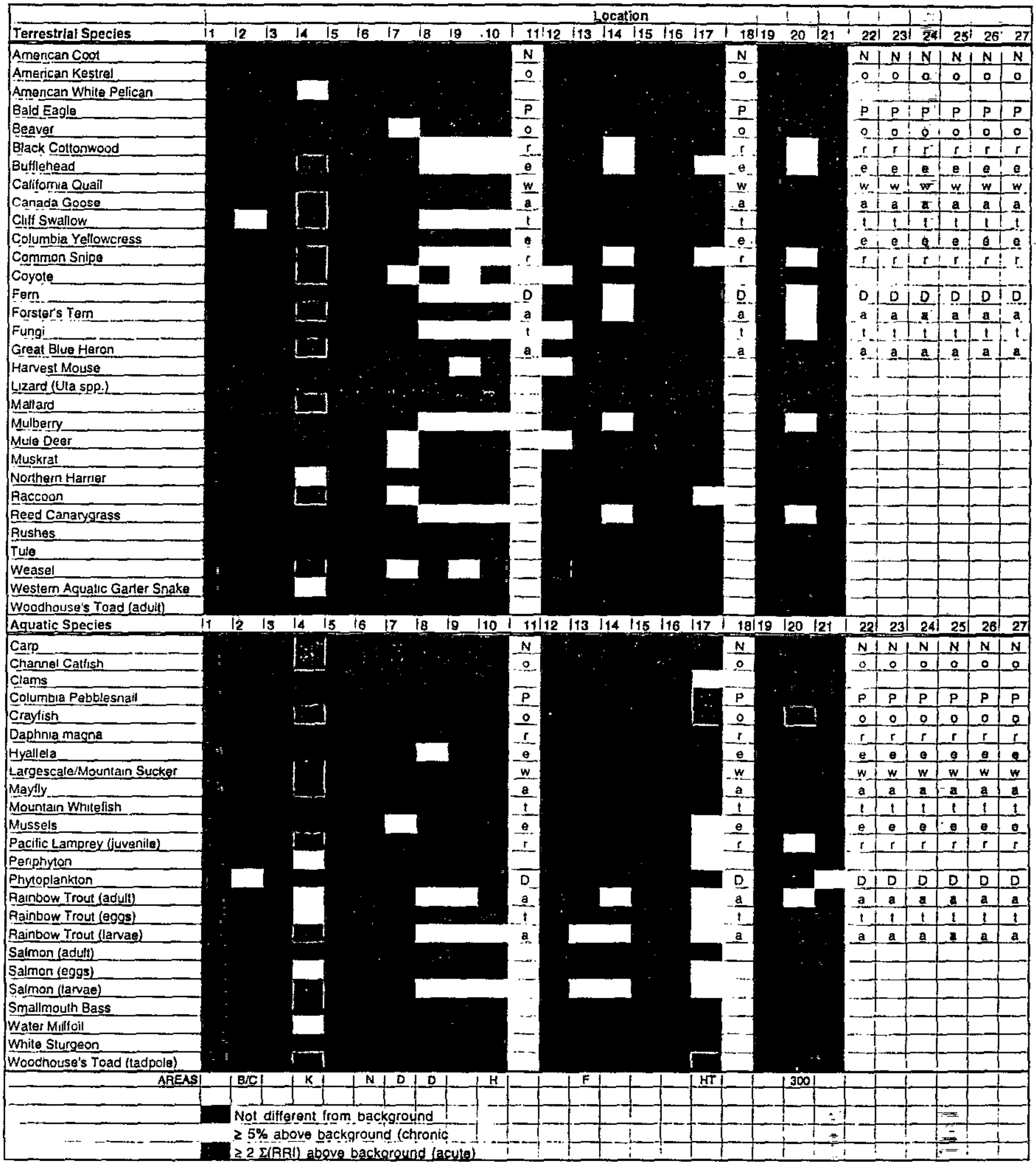

Figure 4.22. Levels of Ecological Risk above Background for Species in Study Area Segments for Terrestrial and Aquatic Organisms

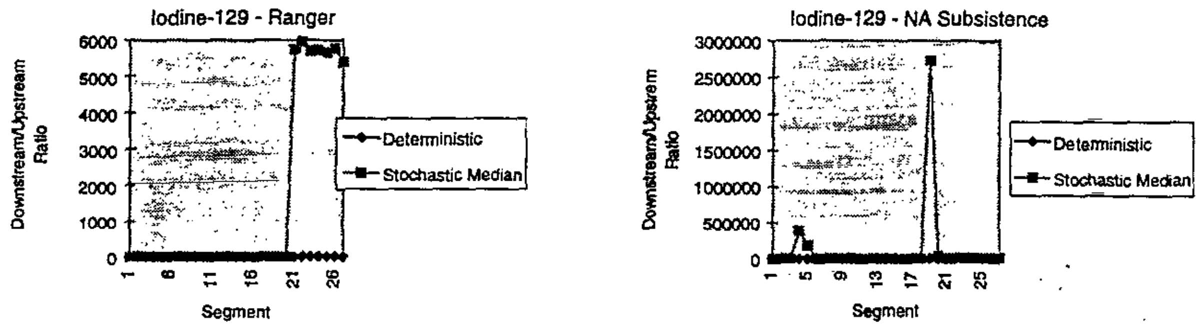

Figure 5.18. Absolute and Downstream/Upstream Ratios of Estimated Risk Results for Ranger and Native American Subsistence Resident Scenarios for Iodine-129

Iodine-129. The ratios of the risk estimated for iodine-129 using the Ranger and Native American Subsistence scenarios for each river segment compared to the risk estimated for Segment 1 are presented in Figure 5.18. For the Ranger Scenario, the risk is directly dependent on the concentration measured in surface water. Only two such measurements are available, in Segments 1 and 21. The maxima in these two segments are very similar; the median measured value in Segment 1 is much less than that in Segment 21. Both measured concentration values are very small. There is essentially no risk from external exposure to iodine-129, and so the Ranger Scenario is not a good measure of risk from this radionuclide because it postulates only external and dermal exposures. The Native American Subsistence Resident Scenario indicates much higher concentrations of iodine-129 in the seep water of Segments 4, 5, 10, and 19 (each of these were surrogated with seep water data). These segments correspond to the locations of groundwater monitoring wells that are sampled for iodine-129 (Dirkes and Hanf 1996, p. 205). The highest risk from iodine-129 via the Ranger Scenario is from surface water in Segment 22 with a lifetime risk of 6.9×10^{-15}. The highest risk via the Native American Subsistence Resident Scenario is from seep water in Segment 19 with a risk of 2.2×10^{-6}.

Kerosene. This potential contaminant was not detected in any of the media sampled during the time frame of the database. Therefore, it was not analysed in the screening assessment.

6.0 Synthesis of Results

The objective of the screening assessment was to identify areas where the greatest potential exists for adverse effects on humans or the environment under current conditions. This required determining what contaminants are elevated because of past or ongoing Hanford Site operations, and, if those contaminants are elevated, what is the measure of potential risk to both humans and the ecosystem.

With the above in mind, the following assessment questions were established:

- Do current levels of contaminants in Columbia River water, sediment, and riparian zone materials pose a potential risk to ecological resources?

- Do current levels of contaminants in Columbia River water, sediment, and riparian zone materials pose a potential risk to humans who might be exposed to them?

If the answers to either of these questions were yes, then answers for the following sub-set of questions were sought:

- What contaminants contribute to risk? (For answer, see Figure 6.1 and Table 6.1.)
- Where in the study area are these contaminants located? (For answer, see Figure 6.1 and Table 6.1.)
- In what media are these contaminants concentrated? (For answer, see Table 6.1.)
- Which organisms or groups of organisms have the greatest likelihood of being adversely affected? (For answer, see discussion below in Section 6.3 and Table 4.22 in Section 4.2.)
- Humans in which economic or cultural categories have the greatest likelihood of being adversely affected? (For answer, see discussion below in Section 6.3 and Figure 5.4 in Section 5.2.)

6.1 Assessment Context

By agreement with the Tri-Parties and the CRCIA Management Team, this screening assessment addressed the current potential for ecological and human risk, resulting from known levels of contaminants in the Columbia River or in its immediate vicinity. The screening assessment does not address inventories currently moving towards the river from distant locations or other inventories that may be left by future remediation activities at other Hanford Site locations.

The contaminants that could possibly be associated with past Hanford Site operations were evaluated. This contaminant identification process, described in Section 2.2, was based on a preliminary review of easily available records, environmental measurements, and process knowledge. The initial list contained nearly 100 possible environmental contaminants. Although a considerable effort was expended to compile this list, its use was to focus the remaining data gathering on only those contaminants of greatest interest. The data and parameters used in the selection of contaminants for study were not the ones 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.

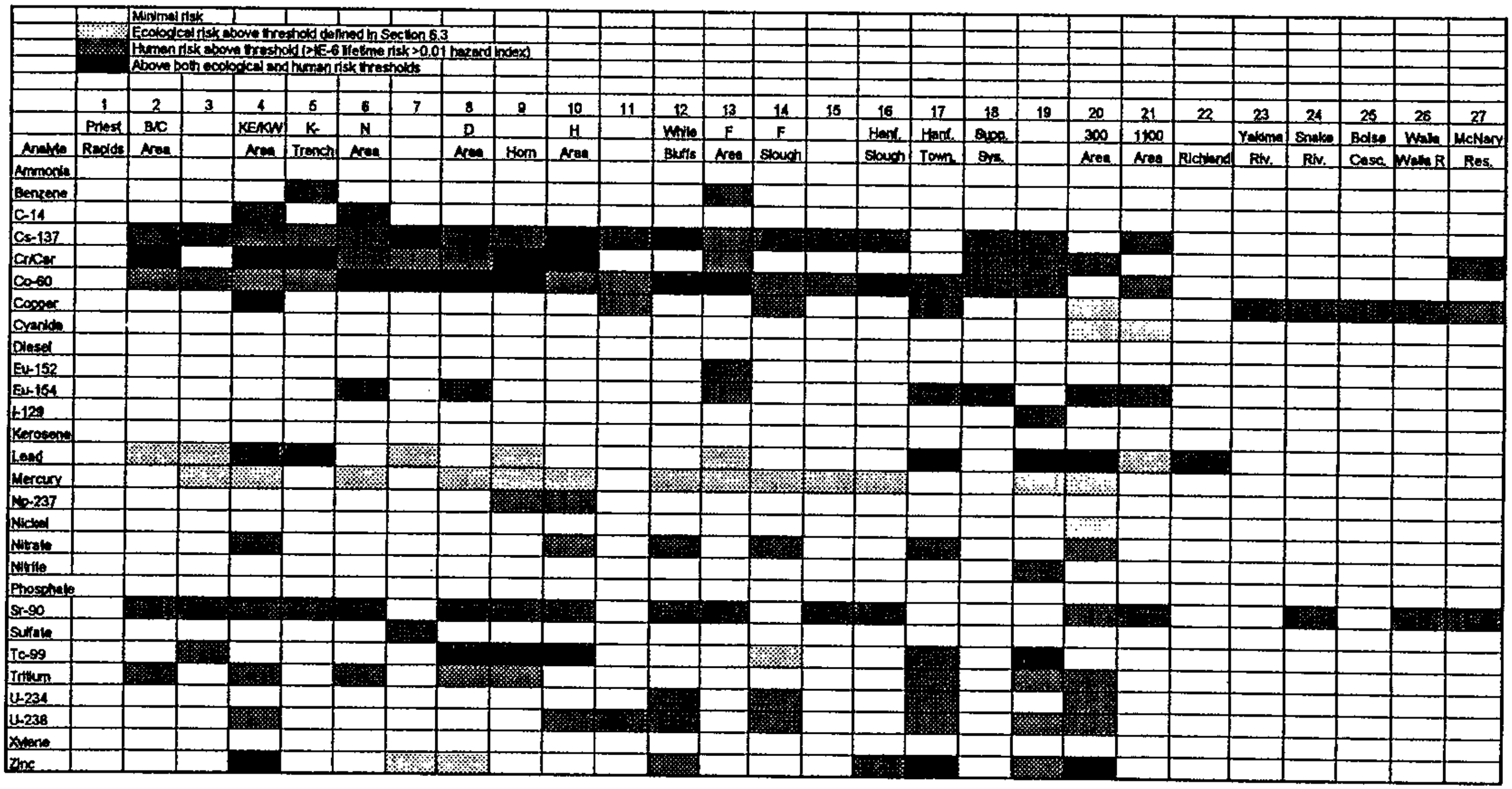

Figure 6.1. Summary of the Screening Assessment of Risk to the Ecosystem and Human Health (The reporting thresholds in this figure identify potentially hazardous contaminants, chronic and acute effects to all plants and animals, and toxic and carcinogenic impacts on human health for all scenarios considered in this report.)

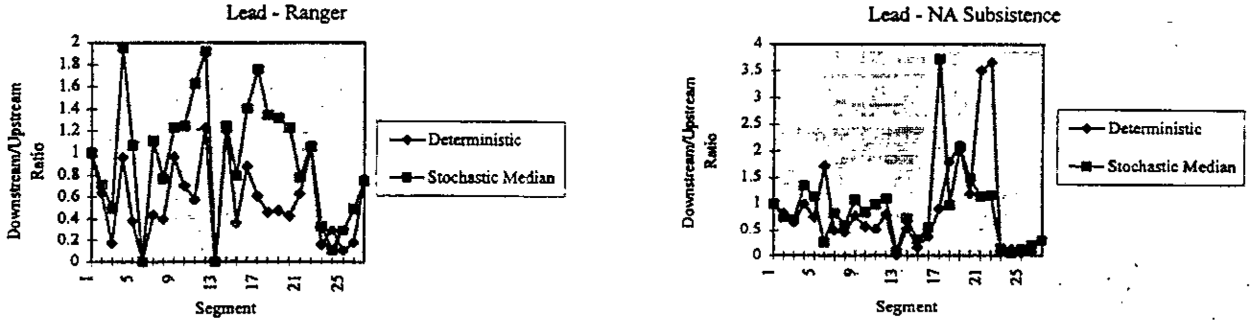

Figure 5.19. Downstream/Upstream Ratios of Estimated Risk Results for Ranger and Native American Subsistence Resident Scenarios for Lead

Lead. The ratios of the risk estimated for lead using the Ranger and Native American Subsistence Resident scenarios for each river segment compared to the risk estimated for Segment 1 are presented in Figure 5.19. The deterministic results for neither the Ranger nor Native American Subsistence Resident scenarios indicate deviations much above background, but the stochastic calculations indicate that Segments 4, 12, and 17 may be elevated. In these and the other segments, the controlling medium is sediment. In all cases, the concentrations of lead in sediment are within about a factor of 2 of the upstream value. The highest risk from lead via the Ranger Scenario is in Segment 4 with a hazard index of 2.0×10^{-3}. The highest risk via the Native American Subsistence Resident Scenario is from sediment and seep water together in Segment 17 with a risk of 1.2. Lead has the second highest hazard index calculated.

The segments presenting the greatest potential risk are Segment 2 (chromium and lead at the 100-B/C Area), Segment 4 (chromium, copper, mercury, and zinc at the 100-K Area), Segment 5 (chromium and lead), Segment 6 (cobalt-60 and mercury at the 100-N Area), Segment 7 (cesium-137, cobalt-60, lead, and zinc at the 100-D Area), Segment 8 (cobalt-60, mercury, and technetium-99), Segment 9 (chromium, cobalt 60, lead, and mercury), Segment 10 (cesium-137, chromium, mercury, and technetium-99 at the 100-H Area), Segment 12 (cesium-137, cobalt-60, and mercury), Segment 13 (cobalt-60, lead, and mercury at the 100-F Area), Segment 14 (mercury and technetium-99), Segment 16 (cobalt-60 and mercury), Segment 17 (lead but results suspect and zinc), Segment 19 (lead and mercury), 20 (cyanide, lead, mercury, technetium-99, and zinc at the 300 Area—all results suspect) and Segment 21 (cyanide and lead).

Segments with potential acute risk are Segment 4 (chromium and zinc), Segment 5 (lead), Segment 8 (mercury), Segment 9 (chromium, lead, and mercury), Segments 10 and 14 (mercury), Segment 13 (lead and mercury), Segment 17 (lead), and Segment 20 (copper and zinc). Data were insufficient to assess risk of any contaminant in Segments 11, 18, and 22-27. Risk from nitrite, sulfate, and phosphate was not evaluated because of the general lack of toxicity benchmarks. They present no risk from food-chain exposure, however, because they are readily metabolized. Risk from neptunium-237 and carbon-14 was not evaluated because of the lack of pore water data. Surface water data for europium-152 were absent in Segments 1-18, so risk from this isotope was not estimated in those segments. Risk from certain other contaminants was not evaluated in the central portion of the study area due to missing pore water data (see Figure 4.19).

4.2 Results: Ecological Risk Screening Assessment

To estimate the potential risk to the environment, we put the data described in Section 3.0, the species described in Section 4.1, and the parameters for those species described in this section into a computer model. The computer model consisted of a series of equations that estimated exposure to contaminants. In this section, we describe how the information from the three sources was used in the equations and what the results of the equations are. We used the exposure results to estimate the possible risk to the environment from contaminants in the Columbia River.

This section presents the analysis of the risk posed by contaminants for the Tier II species. Exposures are estimated using deterministic and stochastic models. Deterministic models use maximum source term and exposure data in a single run of the exposure model. Stochastic models use the same exposure model in a regime that uses the probability density functions for the input parameters. The deterministic models are run for all portions of the study area. The stochastic models are run for those portions of the study area where deterministic exposure exceeds a toxicological threshold. Model composition, toxicological benchmarks, and model results are described below.

This screening ecological risk assessment generally follows EPA guidance for conducting such assessments (EPA 1992a, 1996a), with specific guidance employed as deemed appropriate to the scope and requirements set by the CRCIA Team. The methodology used included defining conceptual exposure models, defining assessment endpoints, characterizing biotic exposure and effects, and characterizing risk to the assessment endpoints. However, this assessment has changed some of the terminology for easier understanding.

4.2.1 Endpoints for Ecological Species of Interest

Following EPA usage, we use the term "endpoint" to denote the biological resources and their attributes that are of concern for this assessment. "Assessment endpoints" denotes the attributes of interest for the species. "Measurement endpoint values" or "measurement endpoints" denotes the toxicological response used to represent the assessment endpoint. For radionuclides and carcinogenic chemicals, the measurement endpoints are the levels known to be lethal to 50 percent of an exposed population (expressed as LD_{50} or LC_{50}) and the lowest levels known to produce a toxic response in any member of a population (expressed as LOEL). We were not always able to find measurement endpoints for each species. In those cases, we used the measurement endpoint value of a similar species.

Assessment endpoints comprise those biological resources and attributes that are to be protected and maintained within the ecosystems potentially at risk (EPA 1992a). Consequently, these endpoints are defined by CRCIA Team concerns for the study area. The species evaluated as assessment endpoints under this risk assessment are described in Section 4.1. The CRCIA Team specified that the resource values to be protected center on the long-term survival and health of the populations of these species within the study area and throughout the Columbia River system. Consequently, the measurement endpoints (the measurable ecological characteristics related to the ecological values to be protected, EPA 1992a) selected for this assessment include the concentrations of contaminants that are known to be lethal to 50 percent of an exposed population (LD_{50} or LC_{50}), and the lowest concentrations that are known to produce clinically toxic responses in any member of a population (the lowest observed effective level or LOEL).

Table 4.17. (Cont'd)

Taxa/Species[a]	Rank Based on Highest Average Summary Scores	Rank Based on Composite Scores	Selected by CRCIA Team as Tentative Tier II Species	Final Tier II Species
Reptiles				
Western garter snake	1	1	*	+
Side-blotched lizard	3	6	*	+
Terrestrial Vegetation				
Black cottonwood	1	1	*	+
Dense sedge	1	1	*	+
Fern (all)	1	1	*	+
White mulberry	1	1	*	+
Reed canary grass	1	1	*	+
Rushes (all)	1	1	*	+
Willow (all)	1	1	*	(c)

(a) Terrestrial invertebrates are not included in this table because no species in these taxon were selected by the CRCIA Team as tentative Tier II species.
(b) The bullfrog, which received the highest rank, was not selected as the final Tier II species for the amphibian group. It is known to occur in ponds at the base of the White Bluffs along the Columbia River and in the W-B10 Wasteway Lake. According to an unpublished report by L.A. Hallock at the Nature Conservancy of Washington, the bullfrog may occur along the Hanford Reach, based on calls, but its presence there has not been confirmed by observation. Also according to Hallock, the adult Woodhouse's toad has been observed in the Columbia River sloughs, although it is not known whether it uses these sloughs for breeding. Because Woodhouse's toad has actually been observed using the Columbia River and because it is a state monitor species, Woodhouse's toad was selected as the final Tier II species for the amphibian group, although it received a lower rank than the bullfrog.
(c) Species with a life style and exposure scenario similar to that of another Tier II species:
- Belted King Fisher and osprey similar to bald eagle
- Bull trout similar to rainbow trout
- Caddis fly similar to mayfly
- Common merganser similar to American coot
- Duckweed similar to Columbia yellowcress
- Midge similar to mayfly
- Pied-billed grebe similar to diving duck
- Piute sculpin similar to channel catfish
- Red-winged blackbird similar to cliff swallow
- Spadefoot toad similar to Woodhouses's toad
- Steelhead trout similar to salmon
- Willow similar to all the other selected terrestrial vegetation

(d) Species with low average summary scores.
(e) Species that virtually never occur in the river or riparian zone.
(f) Although not strictly a macrophyte, Columbia yellowcress is grouped with them because it is submerged part of the year and has much the same exposure characteristics as macrophytes.
\+ One of the 52 Tier II species

Table 4.17. Tier II Species

Taxa/Species[a]	Rank Based on Highest Average Summary Scores	Rank Based on Composite Scores	Selected by CRCIA Team as Tentative Tier II Species	Final Tier II Species
Algae				
Periphyton	1	1	*	+
Phytoplankton	1	1	*	+
Amphibians				
Bullfrog	1	1	*	(b)
Spadefoot toad	2	1	*	(c)
Woodhouse's toad	2	1	*	+(b)
Aquatic Invertebrates				
Caddis fly	1	1	*	(c)
Crayfish	1	1	*	+
Fresh water shrimp	1	1	*	+
Mayfly	1	1	*	+
Midge	1	1	*	(c)
Clams/mussels/snails	1	1	*	+
Water flea	10	10	*	+
Birds				
American coot	1	1	*	+
Common snipe	3	2	*	+
Canada goose/mallard	6	6	*	+
Diving ducks (primarily carnivorous; e.g., bufflehead)	7	20	*	+
Great blue heron	8	5	*	+
Forster's tern	9	22	*	+
American white pelican	10	6	*	+
Pied-billed grebe	10	6	*	(c)
Common merganser	10	21	*	(c)
California quail	13	11	*	+
Cliff swallow	17	23	*	+
Red-winged blackbird	18	24	*	(c)
Belted kingfisher	18	24	*	(c)
Osprey	18	24	*	(c)
Bald eagle	22	28	*	+
Northern harrier	26	13	*	+

Table 4.4. Contaminant Source Areas and Their Potentially Contaminated Media within the Study Area

Contaminant Source Areas	Media					
	Sediment	Surface Water	Pore Water	Groundwater	Soil	Air
Outfall Structure	•	•	•	•	•	•
In-River						
McNary Pool	•	•	•			
Sloughs	•	•	•			
Deep Holes	•	•	•			
Near-Shore Areas	•	•	•			
Seep/Spring		•		•	•	•

Note: Filled cells indicate contaminated media at the source areas. Blank cells indicate media at the source areas that are not contaminated or have very low contamination levels relative to the other media.

contaminants were biomagnifying or non-biomagnifying. All media scores were scaled from 1 to 4 to ensure that all pathways/media were considered of equal importance in their contribution to an individual's overall exposure. In some pathway/media exposure scenarios, scores were scaled from 0 to 4 (see Sections 4.1.2.2.3-4.1.2.2.6) because these scenarios included the possibility of no exposure. The use of the zero, however, did not change the sum of the species' scores or the ultimate rankings. Sections 4.1.2.2.2-4.1.2.2.8 describe the basis and provide examples of the score assignments.

- Exposure Duration: Scores were assigned to each species based on the amount of time they reside in the study area. Exposure duration scores were scaled from 1 to 4. Section 4.1.2.2.9 describes the basis and provides examples of the score assignments.

- Acute Radiation Sensitivity: For exposure to radiation, scores were assigned to each species based on the dose that is lethal to 50 percent of test organisms (LD_{50}) (Whicker and Schultz 1982). Acute radiation sensitivity scores were also scaled from 1 to 4. Section 4.1.2.2.10 describes the basis and provides examples of the score assignments.

Three types of score summaries were performed:

First, scores of exposure to media were summed separately for biomagnifying and non-biomagnifying contaminants with all media assumed to contribute equally to exposure.

Second, media scores were weighted to reflect the degree of exposure to contaminants at the two types of source areas (in-river and outfall structure, see Section 4.1.2.2.8). Weighted scores were summed for biomagnifying and non-biomagnifying contaminants at the two types of source areas. Weighted scores

Table 4.1. Selection Process and Criteria Used to Identify Species for the Screening Assessment of Ecological Risk to the Columbia River

Species Lists	Selection Process and Criteria	No. of Species
Master (listed in Table C.1, Appendix C, Part I)	List developed by PNNL staff based on species found in riverine and riparian habitats of the Columbia River between the vicinity of Priest Rapids Dam and the Columbia River estuary	496
Study Area (denoted as selected in Table C.1)	List developed by PNNL staff based on species found in riverine and riparian habitats of the study area: the Columbia River between the vicinity of Priest Rapids Dam and McNary Dam	368
Tier I (listed in Table C.2, Appendix C, Part I)	List developed by ◆ Panel of regional biologists based on - Commercial or recreational importance - Legal protection status - Key predator or prey species - High potential exposure to contaminants - Available toxicological information - Representative of a foraging guild ◆ PNNL selection of highest-scoring species from panel screening, resulting in 93 species ◆ CRCIA Team identification of key species based on cultural and ecological importance, resulting in 88 additional species	181
Interim Grouping (listed in Table C.3, Appendix C, Part I)	List developed by ◆ PNNL grouping some species based on similar life styles and trophic levels, resulting in 121 species/groups of species ◆ CRCIA Team adding 5 species based on cultural and ecological importance	126
Tentative Tier II (listed in Table 4.17)	List developed by ◆ PNNL based on highest rank in - Exposure to biotic and abiotic media - Exposure duration - Acute radiation sensitivity ◆ CRCIA Team based on - Cultural and ecological importance	66
Tier II (denoted as selected in Table 4.17)	List developed by PNNL with concurrence of CRCIA Team based on excluding ◆ Species with a life style similar to that of another Tier II species ◆ Species with low average summary scores ◆ Species that virtually never occur in the river or riparian zone	52

Table 3.1. Data Decisions by the CRCIA Team

Date	Decision
1/30/96	Agreement was reached to collect data from January 1, 1990 to present and fill data gaps with older data where it is available for the initial phase of the screening assessment.
1/30/96	The primary geographic focus area for the screening assessment is from the vicinity of Priest Rapids Dam to McNary Dam. A rationale will be provided justifying this area by including in the report a discussion of historical levels/trends in contaminant data over time showing levels typically upstream of McNary, including Hanford data, Oregon data, and Washington data.
2/13/96	All data will be provided on a diskette in the final report.
2/13/96	There will be no soil medium. Soil data will be generated from other media where needed. There are no soil samples associated with the outfall pipe locations, and no other soil data were needed for the screening assessments.
2/13/96	The river (between Priest Rapids Dam and McNary Dam) will be broken into 27 segments. This partially defines the spatial aggregation of the data.
2/13/96	Corridor widths were chosen by segment based on sampling sites available to characterize contamination. Reactor areas 100 B/C, D, F, H, K, N and the 300 Area have 0.4-kilometer (1/4-mile) corridor widths. (N Reactor width was originally 0.8 kilometer but changed to 0.4 kilometer at 3/5/96 CRCIA Team meeting.) The non-trench portion of the 100-K Area has a 0.6-kilometer (3/8-mile) corridor width. All other segments have a 0.8-kilometer (½-mile) width. This completes the definition of the spatial aggregation of the data.
2/13/96	A representative value for each groundwater well in each segment will be chosen. A mechanized process needs to be developed to choose the representative value. It is expected that the mechanized process will be adequate for about 80 percent of the values. Remaining values will need to be looked at by hand. A team was formed to develop the algorithm.
2/20/96	Where there is a clear upward or downward trend, a representative value will be chosen from the most recent data.
2/20/96	The maximum representative value for each data set should be an observed data point.
2/20/96	The set of representative data in each segment for each medium will be assumed to be lognormally distributed. The parameters for the lognormal distribution will be estimated from the representative data. Log-probability plots will be provided.
2/20/96	Data for both filtered and unfiltered water will be used in the identification of representative data and in determining the parameters for the lognormal distribution.
2/27/96	Dixon's test will be used to eliminate, at most, a single outlier data point in each data set. In the data section of the final report, every data point that is eliminated will be explained.
2/27/96	For the elimination of outliers, log transformation of the data will be used.
8/12/96	If no groundwater data are available, no other data will be substituted for the missing data. Substitute data would be used for sediment, seep water (groundwater data as a surrogate where available), and surface water. For surface water, if no measured data are available for Segment 1, extrapolate from Segment 2 if available; in Segments 2-27, extrapolate from the nearest upstream segment with measured data.
10/1/96	Proposed system for substituting data when no sediment data are available is not workable so no substitutions will be made.

The references used as data sources are annotated in Section 2.1. A composite list of radionuclides and chemicals identified as being present in environmental samples is presented in Section 2.2. The numerical approach to screening the several hundred analytes into those evaluated in the assessment is presented in Section 2.3. The results of the screening process are listed in Section 2.4. A discussion of discrete radioactive particles in the sediment of the Columbia River shoreline and islands is given in Section 2.5. Section 2.6 addresses special effects from Hanford facilities located adjacent to the river. Section 2.7 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 2.8. Section 2.9 provides a perspective on the selected contaminants in relation to potential risk. Supporting material is made available in Appendix I-A. The references for this section are found in Section 7.0 of Part I.

2.1 Data Sources

To find which materials might have harmful effects on humans or the environment, we looked at recent information gathered by monitoring the Columbia River and groundwater, river sediment, and soil in the 100, 300, and 1100 Areas of the Hanford Site. Those are the areas next to the river most affected by hazardous materials. We only looked at groundwater information gathered from within 500 feet of the Columbia River because the screening assessment is primarily looking at current conditions. Any contaminants in the groundwater further than 500 feet away from the river would not currently be reaching the river. In this section, we have listed all the documents we used to find information on what contaminants are in or near the river today. Knowing the documents we used, helps other scientists to follow our footsteps and verify our results.

An annotated bibliography of the sources used to identify the analytes sampled in environmental media are provided in this section. No single document or electronic database was available that covered the entire scope of contaminants for this research. Baseline efforts similar to the scope of our task were done in a project by Fowler et al. (1993). However, because that project covered all exposure pathways, numerous DOE sites, and identified only the presence of contaminants and not their concentrations, it is not directly applicable or as comprehensive as required for this task.

The CRCIA Project developed a compendium of existing data on Columbia River contamination (Eslinger et al. 1994). The compendium is a large bibliography of Hanford and non-Hanford sources that potentially contain relevant environmental monitoring information. This compendium was used as a starting point for data information.

The screening assessment is primarily concerned with the potential risk from current levels of contaminants of Hanford origin. Therefore, the most recent sampling data were used in the selection of the contaminants. Because the potential for future contamination of the river from Hanford facilities away from the river is a concern (albeit beyond the scope of the screening assessment), summary information related to existing groundwater plumes that are outside the 100 Areas or farther than 150 meters (500 feet) from the Columbia River on the Hanford Site was also reviewed.

To understand some of the key terms in the bibliography, it is necessary to know that the radioactive, hazardous chemical, and mixed wastes are found in various individual waste sites, referred to as waste management units, located throughout the Hanford Site. These individual waste management units include past practice sites; surplus facilities; and treatment, storage, and disposal (TSD) facilities. Past practice sites and TSD facilities may take the form of spills, cribs, ditches, ponds, tanks, trenches, landfills, burial

A screening assessment by its very nature is a limited assessment. Such limited assessments are used to indicate whether the issues under study warrant a full investigation. Screening assessments often express risk in relative terms rather than absolute because of the number and type of assumptions required to drive risk models, the degree of uncertainty inherent in model input, and the limitations in available environmental data. The value of conducting a screening assessment is that the assumptions, uncertainties, and limitations are applied consistently across the study area resulting in useful information relative to the areas thought to be of greatest concern. The limitations of the CRCIA screening assessment were that it was restricted to 1) current conditions, 2) the area between the vicinity of Priest Rapids Dam and McNary Dam, 3) a limited number of contaminants, 4) a limited amount of monitoring data, 5) a limited number of species, and 6) a limited number of scenarios.

The study area for the screening assessment (see Figure 1 in the Site Characterization section) extends from upstream of the Hanford Site in areas unaffected by Hanford Site operations down to McNary Dam, which is the first dam downstream of the Hanford Site. Historical data indicate that the concentrations of contaminants in this reach of the Columbia River are as high as or higher than those in areas downstream of McNary Dam (see the environmental monitoring reports for the Hanford Site published since 1958, the most recent of which is Dirkes and Hanf 1996). Other factors determining the study area include the availability of appropriate environmental data to conduct the screening assessment, the lack of such data downstream of McNary Dam, the known discharge of contaminants into the river (primarily via groundwater seepage) along the Hanford Site, and the resource constraints (time and dollars) originally imposed on the screening assessment. The specific parameters of the scope are:

Area — Columbia River (vicinity of Priest Rapids Dam to McNary Dam), groundwater (up to 0.8 kilometer/0.5 mile in from the river), and adjacent riparian zone

Time — January 1990 - June 1996 (most recent date of data used in the screening assessment) with data gaps filled by earlier data where available

Contaminants

Radionuclides
- tritium (hydrogen-3)
- carbon-14
- cobalt-60
- strontium-90
- technetium-99
- iodine-129
- cesium-137
- europium-152
- europium-154,
- uranium-234
- uranium-238
- neptunium-237

Carcinogenic Chemicals
- benzene
- chromium

Toxic Chemicals
- ammonia
- chromium
- copper
- cyanide
- lead
- mercury
- nickel
- nitrates
- nitrites
- phosphates
- sulfates
- zinc
- diesel constituents (diesel oil, kerosene, xylenes)

See Section 2.0 and Appendix I-A

Data Sources — City of Pasco, City of Richland, Environmental Restoration Contractors, Hanford Environmental Information System, Oregon State Department of Energy, Pacific Northwest National Laboratory, U.S. Army Corps of Engineers, U.S. Geological

Because of scientific uncertainty, the overall potential impact on the riparian ecosystems is not known. There is insufficient knowledge about the distribution of species, their migration patterns, and their interactions over the entire Hanford Reach. It is possible to say that there is a risk to individual members of certain species, those that frequent the locations of highest contamination.

Perspective

The CRCIA screening assessment was, by definition, limited in some respects. The screening assessment was restricted to current conditions, the area between Priest Rapids Dam and McNary Dam, a limited number of contaminants, a limited amount of monitoring data, a limited number of species, and a limited number of scenarios. For the results of the assessment to be useful, these limitations, the assumptions in the study, and the process through which the study was conducted must be understood and considered in context with the intended use. Site-specific considerations should be added to the general results presented here during the decision-making process to ensure responsible actions that are protective of the Columbia River.

The analyses completed for the screening assessment are based on the currently available data. Information is not available for all contaminants in all river segments during this time period. Where appropriate, data were extrapolated or surrogated to fill some of the data gaps, but others remain. The final results of the screening assessment, therefore, are limited by the scope constraints and the available information. The assessments have indicated that there are portions of the Hanford Reach of the Columbia River in which concentrations of contaminants, particularly in sediment and groundwater, are relatively high, pose a potential risk to human and ecological receptors under some scenarios, and may warrant additional investigation.

The density of data available for the assessment is illustrated in Section 3.0. For some river segments, relatively few data were available during the study period. These are areas for which additional sampling may be advisable. However, before proceeding with additional sampling or any remedial action, considerations must be made of additional information not used in this analysis and of the likelihood of acquiring additional useful information. For example, systematic radiological surveys have been made in the past (Sula 1980, EG&G 1990) that indicate the potential for finding additional highly radiologically contaminated areas along the river is small.

The spatial extent of the river segments as defined for the analysis is large enough to partially mask the presence of hot spots. The stochastic risk results tend to average out over segments as much as a few miles long. As a result of this and the data density issue discussed above, it is not possible to state categorically that elevated levels of contaminants do not exist in areas other than those previously identified.

Recent studies of rivers other than the Columbia also provide indications that the Hanford Reach is not unique (Pinza et al. 1992). Contaminants in Columbia River water, groundwater, seep water, sediment, and soil may have potential for impact on human or ecological health in areas immediately adjacent to the Hanford shorelines or throughout the Hanford Reach. However, there are sources of contaminant, primarily heavy metal, releases to the Columbia River upstream of Hanford. Thus, there are amounts of these metals, particularly chromium, copper, lead, mercury, and zinc, in sediment and water being (chromium and strontium-90), Segments 7-9 (chromium), Segment 10 (chromium, strontium-90, and uranium-238), Segment 11 (copper), Segment 13 (chromium), Segment 14 (copper), Segment 17 (copper, lead, and tritium), Segment 18 (chromium), Segment 19 (chromium and uranium-238), Segment 20 (chromium and uranium-238), Segments 23-27 (copper).

Data were not available in every segment for all contaminants in all media. Data availability is discussed in Section 3.0, where lack of specific contaminant data is identified by segment. Surface water data for europium-152 were absent in Segments 1-18, so risk from this isotope was not estimated in those segments. Segments 11, 18, and 22-27 did not have sufficient seep water data (or a groundwater surrogate), so this medium was not included in the human health assessment in these segments. Seep water was generally not the primary contributor to potential human health risk, however, as indicated in Table S.1. Surface water data were extremely limited downstream of Segment 21 and were, therefore, extrapolated from Segment 21 for Segments 22-27 with few exceptions.

Uncertainty is inherent in any risk assessment. The uncertainty within the ecological and human health assessments is discussed in Sections 4.2.10 and 5.2.3.3, respectively. Uncertainties include those associated with the exposure models, measured media data, representativeness of the data, use of surrogate and extrapolated data, exposure scenarios, accuracy of modeled processes, and toxicological and dose response references.

Hanford and Non-Hanford Sources of Contaminants

Contaminants present in the Columbia River environs result from operations at Hanford as well as from human activities upstream of the Hanford Site. Contaminants for which a Hanford source appears to be indisputable include ammonia, cesium-137, chromium, cobalt-60, europium-152, europium-154, nitrates, strontium-90, technetium-99, tritium (hydrogen-3), and uranium isotopes. Other contaminants for which the Hanford Site may be a contributor, at least at specific locations, include copper, cyanide, lead, mercury, and zinc. The analyses indicate relatively high potential risk from these latter contaminants. However, the upstream risk from these contaminants is also high, and the Hanford Site increment over the upstream value is generally factors of two to three or less, making exact identification difficult.

Potentially Hazardous Contaminants

The contaminants discussed here are those identified by the ecological and human health screening assessments to be potentially hazardous (see Figure S.1 and Table S.1). The intent of the discussion of each potentially hazardous contaminant is to enhance the understanding of the potential risks and focus possible remedial decisions on those contaminants and media with the potential for the greatest risk reductions.

Benzene. Benzene is seen in low concentrations in seep water, frequently in conjunction with xylenes. It is a measurement surrogate for petroleum hydrocarbons. Some instances of petroleum contamination are known at the Hanford Site. The highest levels are seen at the 100-K and 100-F Areas. The primary exposure pathway is consumption of seep water.

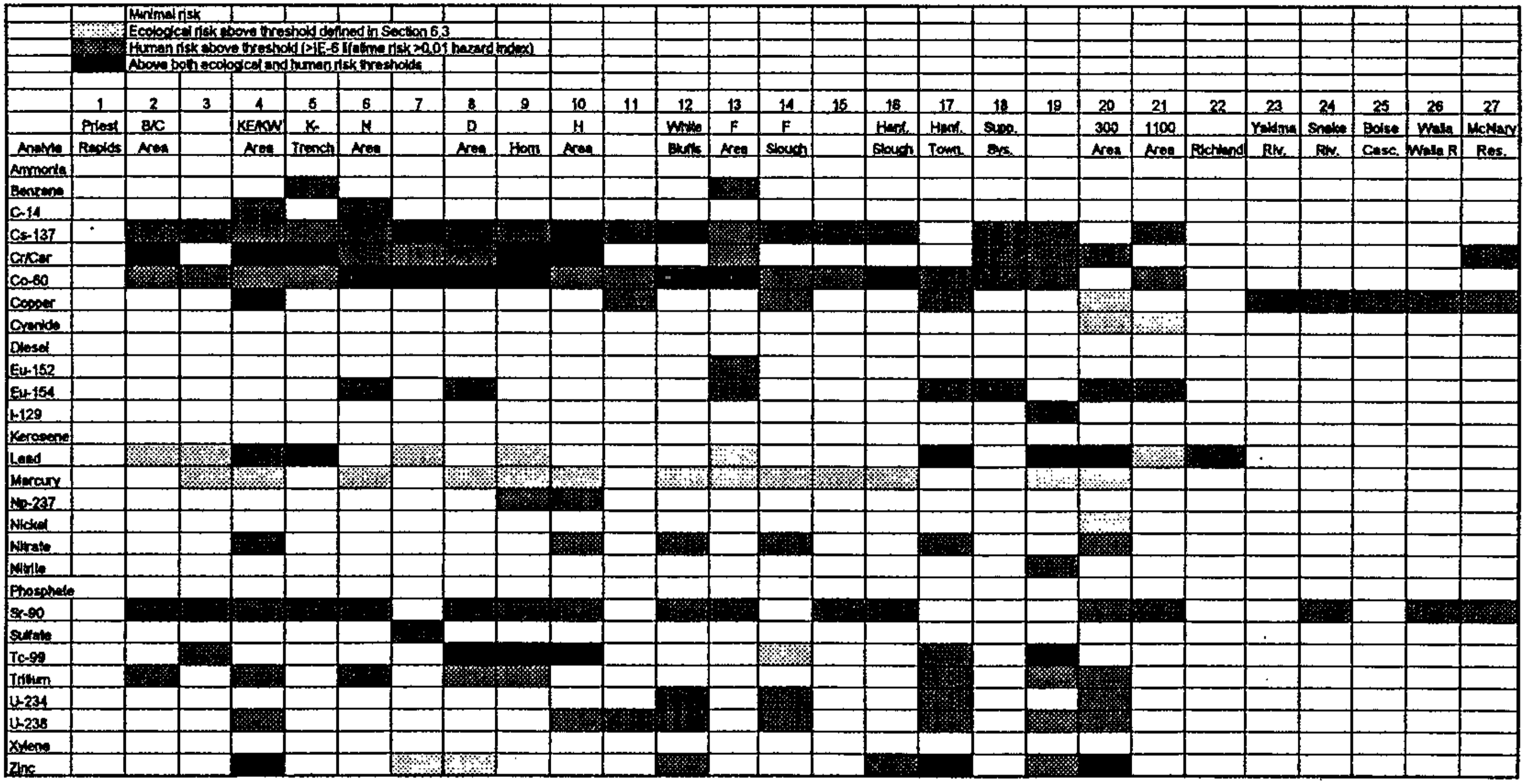

Figure S.1. Summary of the Screening Assessment of Risk to the Ecosystem and Human Health (The reporting thresholds in this figure identify potentially hazardous contaminants, chronic and acute effects to all plants and animals, and toxic and carcinogenic impacts on human health for all scenarios considered in this report.)

Study Domain and Spatial Scale

The study area was first broken down into 27 segments to best represent the current environmental conditions and the state of knowledge relative to contaminant concentrations in the river environment. The segmentation also provides meaningful information associated directly with the site operable units that will be useful in evaluating future remedial actions. Selection of the segments was based in part on environmental measurement densities, existing data representativeness, historical operations, and site knowledge of contaminated groundwater plumes entering the river. Some adjustments in the borders and size of individual segments were made as a result of CRCIA Team consultation and recommendations. Human health and ecological risk assessments were performed on the segments individually to provide a consistent basis on which to determine areas of potential concern.

Contaminants of Interest

The approach to estimating risk to the environment and humans began by determining which contaminants should be evaluated in the screening assessment. Contaminants of interest were identified prior to completing the source term data collection activity to focus the data gathering efforts on the specific contaminants to be evaluated in the assessment. This contaminant identification process, described in Section 2.2, consisted of a review of easily available records and was based on process knowledge and environmental measurements in surface water, riverbank seeps, soils, sediments, and groundwater. The initial list contained nearly 100 potential Hanford-origin contaminants.

The initial list of 100 potential contaminants was screened (using a multi-stage screening process described in Section 2.3) to a manageable number of contaminants likely to produce the greatest environmental or human health risks. This process was based on screens for human toxicity, human carcinogenicity, acute and chronic aquatic biota toxicity, and water quality standards. The final contaminants of interest list was established to provide reasonable assurance that the dominant contributors to human and ecological risk were included in the screening assessment. Additional consideration was given to contaminants known to be of public, stakeholder, or tribal concern. As a result, a list of 26 contaminants of interest was established that would be included in the human health and ecological assessments.

Species of Interest

A master species list, consisting of 368 species known to exist between Priest Rapids Dam and McNary Dam, was established that became the basis for the selection of the species to be included in the screening assessment. From the master list, a Tier I list of 93 species was generated by ranking the master list against 6 criteria. The CRCIA Team added 88 additional species to the Tier I list. Tier II ranking, a qualitative ranking of the Tier I list, resulted in the selection of 52 species to be included in the screening assessment. The Tier II ranking provided for balance across taxonomic groups and exposure pathways. The list of 52 species includes (see Section 4.1 and Appendix I-C):

Algae - periphyton, phytoplankton

Amphibians - Woodhouse's toad

Part I. Screening Assessment

The purpose of the CRCIA screening assessment is to support decisions on Interim Remedial Measures and to focus a subsequent and more comprehensive assessment. The objective of the screening assessment is to identify areas where the greatest potential exists for adverse effects on humans or the environment. The Hanford Reach of the Columbia River was evaluated in the screening assessment in a way that will be useful in the CERCLA process but not necessarily in strict accordance with CERCLA procedures (for example, risk assessment methodology and remedial decision making). The screening assessment focused on a sub-set of potential contaminants, selected from a relatively broad set of possible contaminants. Part I of this report discusses the scope, technical approach, and results of the screening assessment. The screening assessment was conducted by the Pacific Northwest National Laboratory in consultation with the CRCIA Team.

Scope

The scope of the CRCIA screening assessment is to evaluate potential risk to the environment and human health resulting from current levels of Hanford-derived contaminants. The study area for the screening assessment (see Figure 1 in the Site Characterization section) extends from upstream of the Hanford Site in areas unaffected by Hanford Site operations down to McNary Dam, which is the first dam downstream of the Hanford Site. The specific parameters of the scope are:

- Human health risk
- Ecological risk
- Columbia River and adjacent riparian zone (vicinity of Priest Rapids Dam to McNary Dam)
- Current conditions: January 1990-June 1996 (most recent date of data used in the screening assessment)
- Contaminants of interest
  - Radionuclides: tritium (hydrogen-3), carbon-14, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, europium-152, europium-154, uranium-234, uranium-238, neptunium-237
  - Carcinogenic chemicals: benzene, chromium
  - Toxic chemicals: ammonia, chromium, copper, cyanide, diesel constituents (diesel oil, kerosene, xylenes), lead, mercury, nickel, nitrates, nitrites, phosphates, sulfates, zinc

Interim Remedial Measures, and 2) a definition of the essential work remaining to provide an acceptable comprehensive river impact assessment. The results of the screening assessment are described in Part I of this report. The requirements for the essential work remaining are described in Part II of this report.

Additional phases of CRCIA will be identified and decisions made regarding the conduct of the remaining work based on submittal of information as required by Tri-Party Agreement milestones M-15-80A, M-15-80B, and M-15-80B-T01.

The primary contractor conducting the screening assessment is the Pacific Northwest National Laboratory. Bechtel Hanford, Inc. provides technical and public involvement coordination with environmental restoration activities. Independent technical peer reviewers are evaluating the initial phase of the CRCIA work under the guidance of the Directors of the Oregon Water Resources Research Institute and State of Washington Water Research Center. Eight of these reviewers were chosen by the Directors based on nominations from the public, regulatory agencies, and contractors. Also, the Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, and Yakama Indian Nation each chose a reviewer. The reviewers evaluate CRCIA work independently. There is no intent to coordinate consensus opinion among the reviewers.

Background

The Hanford Site occupies approximately 1450 square kilometers (560 square miles) in the southeastern portion of Washington State. It is located northwest of the Tri-Cities of Richland, Kennewick, and Pasco. The site is partially bordered on the north and east by the Columbia River and includes a buffer zone north of the river referred to as the Wahluke or North Slope.

From 1944-1987, the U.S. Department of Energy (DOE) conducted nuclear production operations at the Hanford Site along the Hanford Reach of the Columbia River. The Hanford Reach extends 85 kilometers (51 miles) downstream from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam) near the City of Richland, Washington. These past nuclear operations resulted in the release of hazardous chemicals and radionuclides to the Columbia River and into the soil. These operations also resulted in the storage of wastes and nuclear materials, some of which have escaped containment or have the potential for doing so depending on the effectiveness of DOE waste management decisions and activities. Current conditions of the Columbia River reflect that contamination is reaching the river primarily via the groundwater pathway.

In addition to contamination resulting from past and present Hanford operations, there is the potential for more contamination because the Hanford Site is being used for storage and disposal of nuclear materials, radioactive waste, chemically hazardous waste, and mixed waste (nuclear materials mixed with hazardous chemicals). For example, presently two-thirds of the nation's high-level defense nuclear waste is being stored at the Hanford Site with continuing shipments of nuclear waste being received (DOE 1993). Much of this nuclear waste may remain at the Hanford Site. The storage of these nuclear wastes could potentially contribute to the contamination of the Columbia River (depending on the performance of the chosen containment solution) for thousands of years.

As a result of the known contamination in 1989, four areas of the Hanford Site (the 100, 200, 300, and 1100 Areas) were placed by the U.S. Environmental Protection Agency (EPA) on the national priorities list for cleanup. The national priorities list is a component of the *Comprehensive Environmental Response,*

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