5.0 Screening Assessment of Risk to Human Health

The results of the screening assessment indicate the potential risk to human health and the environment from Hanford-derived contaminants in the Columbia River. This section describes the process used to assess potential risk to human health and the results. Section 5.1 describes the twelve human exposure scenarios used in the screening assessment. Section 5.2 provides the calculations used in the computer model and the resulting estimated risks to humans. Section 4.0 describes the process used to assess potential risk to the environment and the results.

5.1 Human Exposure Scenarios for the Screening Assessment

Because the objective of the human risk assessment is to determine whether Hanford-derived contaminants from the Columbia River pose a threat to humans in the study area, the first step was to identify possible scenarios of human activities. This section describes the scenarios selected and the exposure parameters used as the basis for estimating the potential range of risk to human health. The second step in the assessment was to estimate the potential risk to humans based on the scenarios. Section 5.2 describes the process and results of the human risk assessment.

To assess potential risk to humans from Hanford-derived contaminants from the Columbia River, we need to make assumptions about the life styles of those who might be affected. In this section, we describe the assumptions for the twelve scenarios we - used in the screening assessment. The twelve scenarios and the key assumptions are shown in Table 5.1. The parameters for each scenario are described in the respective sections and summarized in a table in each section.

In Section 5.2, we use these assumptions (parameters) in equations, the results of which provide us with the estimate of the potential risk to humans.

5.1.1 Scope of and Approach to Exposure Scenarios

Contaminants in the Columbia River could affect people involved in a wide range of activities. Therefore, various scenarios have been developed on which to base the risk assessment. The twelve scenarios developed and used in this screening assessment illustrate the range of activities possible by members of the public coming in contact with the Columbia River so that the impact of contaminants in the river on human health can be assessed. Each scenario, listed in Table 5.1, illustrates particular activity patterns by a specific group.

Numerous proposals are being considered for the future use of the Hanford Site and, in particular, the Hanford Reach. These proposals span a variety of land uses and human activity patterns, ranging from industrial use to conservation and Native American uses. Because the goal of CRCIA is to assess potential impact, scenarios (based on current conditions in the Columbia River) have been developed to reflect the possible uses of the Hanford Site in the near future. The scenarios used in the screening assessment are for this study only. They do not represent recommendations by the CRCIA Team as to actual land use. Although the scenarios are based on current conditions, that does not imply that people

Table 5.1. Overview of Key Assumptions for the Scenarios

Scenarios	Derived from HSRAM[a]	Key Deviations from HSRAM[a]	Exposure Locations	Activities	Days of Exposure/ Year	Hours of Exposure/ Day	Plants and Animals Ingested	Water Ingested/ Day
Industrial Worker	Industrial Scenario	Slight Modification: Columbia River water, not groundwater; only contact with environmental media, not other substances	Onsite Indoors with some outdoor activity	Works	250	8	None	1 liter[b]
Fish Hatchery Worker	Industrial Scenario	Numerous Modifications: Statistics on fish hatchery work time onsite used; only contact with environmental media, not other substances	Onsite with 50% outdoor activity	Works	250	8	None	1 liter
Ranger	Industrial Scenario	Numerous Modifications: Less time onsite but more time in outdoor activity when onsite	Offsite office Onsite visits	Visits habitat	150	9	None	None
Avid Recreational Visitor	Recreational Scenario	Numerous Modifications: Information on fishing and hunting practices used	Onsite Upland regions River	Fishes frequently Hunts frequently	365	4	Fish Deer Upland birds Waterfowl	2 liters
Casual Recreational Visitor	Recreational Scenario	Slight Modification	On/near site River	Boats Fishes occasionally Hunts occasionally Swims	7	8	Fish Deer	4 liters

Table 5.1. (Cont'd)

Scenarios	Derived from HSRAM[(a)]	Key Deviations from HSRAM[(a)]	Exposure Locations	Activities	Days of Exposure/ Year	Hours of Exposure/ Day	Plants and Animals Ingested	Water Ingested/ Day
Native American Subsistence Resident	Agricultural Scenario	Numerous Modifications: Limited information on tribal activities used	Onsite All habitats	Fishes Gathers Hunts Pastures Prepares Bathes (Sweat Lodge)	365	24	Fish Fruit & vegetables Animal protein Organs Milk Upland birds Waterfowl Wild bird eggs	6 liters
Native American Upland Hunter	Agricultural Scenario	Numerous Modifications: Limited information on tribal activities used	Onsite Upland areas	Hunts	150	24	Animal protein Organs Upland birds	3 liters
Native American River-Focused Hunter and Fisher	Agricultural Scenario	Numerous Modifications: Limited information on tribal activities used	On/near site River	Fishes Hunts	150	24	Fish Waterfowl Wild bird eggs	6 liters
Native American Gatherer of Plant Materials	Agricultural Scenario	Numerous Modifications: Limited information on tribal activities used	Onsite All habitats	Gathers Prepares	365	24	Fruit & vegetables	6 liters
Native American Columbia River Island User	Agricultural Scenario	Numerous Modifications: Limited information on tribal activities used	Near site Islands	Visits	2	24	None	None
Resident	Residential Scenario	Slight Modification: Columbia River water, not groundwater	Onsite	Fishes Gardens Resides	365	24	Fish Fruit Vegetables	4 liters
Agricultural Resident	Agricultural Scenario	Slight Modification: Columbia River water, not groundwater	Onsite	Farms Fishes Hunts Resides	365	24	Fish Fruit Vegetables Deer Beef Dairy	4 liters

(a) Hanford Site Risk Assessment Methodology.
(b) 1 liter = 1.057 quarts.

are currently exposed to the risk. The risk estimated is potential risk if people in the near future were to start performing the activities assumed in the scenarios.

In line with the scope of work for the screening assessments, the scenarios are Hanford Site specific. DOE has developed generic scenarios for the Hanford Site (DOE 1995). At present, only four of these generic exposure scenarios (DOE's Hanford Site Risk Assessment Methodology, HSRAM) are available for current conditions on the Hanford Site: an industrial scenario and a recreational scenario that represent current uses, and a residential scenario and an agricultural resident scenario that represent potential future uses. HSRAM provides a set of uniform methods and inputs for use at Hanford so that assessments performed at various times by different organizations have a consistent basis. HSRAM, in turn, consolidates recommendations from other agencies such as EPA (1991a) and the Washington Administrative Code (WAC 1991). Because HSRAM is an accepted method that has been previously reviewed, all scenarios defined for the screening assessment have their bases in one of the four HSRAM scenarios (Table 5.1).

People are exposed to contaminants when they come in contact with any substance that is transporting a contaminant. The substances (media) we investigated are soil, air, seep/spring water, surface water, sediment, biota, and cultural media. (Cultural media include specific plants, animal products, or other items used in unique cultural activities.)

To determine the parameters for the equations, we needed to estimate the amounts of these media that people might contact, ingest, inhale, or receive an external radiation exposure from over an assumed period of time. DOE has already developed such assumptions for people who are currently industrial workers and for those who spend their leisure time in the vicinity of the Hanford Site. DOE has also developed such assumptions for people who sometime in the future might be residents or agricultural workers on the Hanford Site. The assumptions we used in our scenarios have their basis in the DOE assumptions. Any changes we made to DOE assumptions are the result of information supplied by the CRCIA Team.

Four of the screening assessment scenarios are almost identical to the HSRAM scenarios. These four are designated as "slightly modified HSRAM" scenarios in the list of scenarios below. Eight of the screening assessment scenarios have numerous modifications. In several instances, the parameters for the same media and exposure pathway within the HSRAM scenarios were varied. In such cases, a consistent parameter was selected with CRCIA Team guidance for the affected scenarios in the screening assessment.

The total suite of twelve scenarios was needed to capture at least the main possible human activities upon which parameters (based on current conditions) can be screened to assess potential risk. The scenarios are designed to provide insights into various exposure pathways and the range of potential risk associated with different kinds of activity. The intent is to indicate the potential range of risk associated with activities ranging from occasional, casual exposure through intensive, continual contact. The human scenarios used in the screening assessment of human risk are as follows:

- Industrial/Commercial Scenarios

  - Industrial Worker (slightly modified HSRAM scenario using Columbia River water instead of groundwater) (DOE 1995)
  - Fish Hatchery Worker

- Wildlife Refuge/Wild and Scenic River Scenarios

  - Ranger
  - Avid Recreational Visitor
  - Casual Recreational Visitor (slightly modified HSRAM scenario with radionuclide, carcinogenic chemical, and toxic chemical information pulled into one table) (DOE 1995)

- Native American Scenarios

  - Subsistence Resident (an unrestricted use scenario included as a baseline for comparison)
  - Upland Hunter
  - River-Focused Hunter and Fisher
  - Gatherer of Plant Materials
  - Columbia River Island User (for application to cobalt-60 particles)

- General Population Scenarios

  - Resident (slightly modified HSRAM scenario using Columbia River water instead of groundwater) (DOE 1995)
  - Agricultural Resident (slightly modified HSRAM scenario using Columbia River water instead of groundwater) (DOE 1995)

As the detailed descriptions of each scenario indicate, not all scenarios are applicable to all areas designated for study in the screening assessment. For example, segments of the river investigated include populated areas of the cities of Richland, Kennewick, and Pasco, for which scenarios such as the hunter are obviously inappropriate.

The twelve scenarios were selected with present and possible use of the Hanford Site in mind. For example, if portions of the Hanford Reach of the Columbia River were established as a wildlife refuge, the activities associated with that use might include ranger, hunter/fisher, or recreational visitor. Not all activities currently occurring on the site were evaluated. For example, tours of the B Reactor are being conducted. While exposure information for visitors on such tours might be desired in the future, for the initial phase of the CRCIA work, no B Reactor Visitor Scenario was defined. The exposure scenarios selected are based on general agreement by the CRCIA Team and do not represent recommendations as to actual land use or cleanup levels.

The scenario definitions are based on activities rather than location. The potential of the Hanford Reach becoming a wildlife refuge illustrates the reason for this. The ranger, avid recreational visitor, and casual recreational visitor would have different degrees of contact with the surface water, spring water, soils, sediment, and foods. Therefore, the exposures and risk to these three types of people could be quite different at the same location. Location is taken into account when the scenarios are applied to particular areas of the Hanford Site.

For consistency with other Hanford activities, the HSRAM (DOE 1995) industrial and casual recreational scenarios were adopted with few changes. However, statistical ranges have been added to all parameters, and the media to which people could be exposed are customized to the CRCIA situation (e.g., river water instead of groundwater is used in the Industrial Worker Scenario). The HSRAM residential and agricultural resident scenarios were modified to account for using Columbia River water instead of groundwater. For the Fish Hatchery Worker Scenario, information about actual time spent on the Hanford Site by fish hatchery workers was used. The Ranger Scenario is a variant of the HSRAM industrial scenario. Information about actual hunting and fishing practices in the counties surrounding the Hanford Site was used to develop the Avid Recreation Scenario. Limited tribal information was used to develop the Native American Scenarios. For applications other than the screening risk assessment, the Native American Scenarios will need to be reviewed and modified by tribal technical staff.

Key Points

- **The scenarios are intended to include the activities of most importance to particular user groups and to translate those activities into activity-based exposures.**
- **Each of the scenarios contains assumptions about frequency and duration of the activities, ranging from a few days per year to much more intense use over long time frames. The particular assumptions are specific to individual scenarios.**
- **The Native American scenarios will need to be reviewed and modified by tribal technical staff before being used in other studies. The Native scenarios described here are solely for use in the CRCIA screening assessment of risk.**

The two main parameter groups to be defined for each scenario are the contaminant pathways (media and exposure route of that media) and the exposure parameters (intake/contact rate, exposure frequency, exposure duration, and special parameters that apply to only certain media and exposure routes).

A contaminant pathway describes a unique mechanism by which an individual is exposed to chemical or physical agents at or originating from a particular location. The media providing potential contamination to humans vary according to the particular scenario. The media considered were soil, air, seep/spring water, surface water, sediment, biota, and cultural. (Cultural media include specific plants, animal products, or other items used in unique cultural activities.) These media come in contact with humans through the exposure routes of ingestion, external radiation exposure, dermal contact, and inhalation.

Exposure parameters were based on the scenario to be modeled. The exposure parameters defined in the scenarios for the screening assessment of risk are the intake/contact rate, exposure frequency, exposure duration, and other parameters that apply to only certain media and exposure routes. For instance, skin surface area is another parameter that was accounted for when estimating the dermal contact.

Each scenario is made up of components that may appear to be exclusive, for example, drinking water from springs while simultaneously drinking water from the river. For the screening risk assessment, the exclusive nature of these related pathways was ignored, and both components were included. Thus, for the example of drinking water, the total quantity of water consumed is actually twice what might really be expected. To account for human behavior being unpredictable and to capture the potential for risk from both the springs and river water, no attempt was made to apportion either pathway. The exposure from

separate pathways will rarely be of the same magnitude, so the resulting effect is that the highest exposure was automatically assigned to the most contaminated source. This philosophy is similar to that used for scenario development in HSRAM (DOE 1995).

The life style of any given individual typically involves several scenarios. For example, a fish hatchery worker might go on vacation and become a recreational visitor. However, the CRCIA screening assessment of risk to human health follows the HSRAM practice of basing risk assessments on separate scenarios rather than on an individual's life style, which might incorporate a variety of the scenarios. The exposures and risk may be reasonably apportioned and combined. The way to perform this addition and examples are described in Appendix I-E.

An objective of CRCIA is to provide the uncertainty of the risk information that is developed. This risk information has been developed using a stochastic analysis of the risk, which incorporates the uncertainties inherent in the concentrations of the contaminants. In addition, the exposure parameters selected for the screening assessments will have variability, both inherent uncertainty about the selected parameters and the inability to capture exactly the life style of people simulated in the scenarios. For each scenario, the range for each intake/contact rate is given in terms of a minimum and maximum value and a corresponding deterministic value. The deterministic values are intended to be conservatively selected, such that exposures to contaminants should be near the upper-end of the anticipated range and represent a reasonable maximum exposure. The majority of these minima and maxima have been selected using the professional judgment of the authors. Thus, they serve as opening suggestions in what is anticipated to be a continuing discussion.

5.1.2 Industrial/Commercial Scenarios

In the CRCIA screening assessment, two industrial/commercial scenarios were assessed for risk: an Industrial Worker Scenario and a Fish Hatchery Worker Scenario. Industrial, commercial, and waste management activities occur both on and off the Hanford Site along the Columbia River. The worker scenario developed in HSRAM is a standard industrial/commercial scenario focused on worker exposures to residual environmental contamination. For the scenarios in this section, only the potential exposure from contact with environmental media was considered (as opposed to substances encountered as part of the job, unless the environmental media are encountered at work).

A Fish Hatchery Worker Scenario was developed because of the current hatchery activities in the K Area and at Ringold. The new scenario is compared with the HSRAM industrial scenario. When possible, employees working under these conditions provided documentation. However, the data supplied by the interviewed employees have not been validated.

5.1.2.1 Industrial Worker

The HSRAM industrial scenario (DOE 1995) has been adopted with minimal modification because it is an accepted method that has been previously reviewed. However, in the Columbia River screening assessment of risk, water is assumed to come from the Columbia River rather than groundwater. This

scenario represents exposures that may occur to a person whose job onsite is primarily indoors but would also include some outdoor activities, for example, building and grounds maintenance. Such a scenario could represent workers with indoor/outdoor job responsibilities such as hardware/lumber sales or farm equipment sales. The scenario assumes that the workers do not wear protective clothing. The worker is assumed to spend 8 hours/day in indoor activities with incidental exposures to soil and river water, to breathe materials suspended from the soils, and to shower at work. The worker is assumed to take a 10-minute/day shower with river-derived water.

The primary pathways included in the Industrial Worker Scenario include direct soil, air, and surface water, such as the following:

- ingestion of contaminated soil
- external exposure from radionuclides in the soil
- dermal contact with the soil
- inhalation of fugitive dust
- ingestion of surface water
- dermal contact with surface water
- inhalation of contaminants from water use at work

The Model Toxics Control Act Cleanup Regulation (MTCACR) provides standard exposure parameters for exposure to soil at industrial sites (WAC 1991, sect. 745). These parameters are used in evaluating soil ingestion; and the same exposure frequency, exposure duration, body weight (70 kilograms, 154 pounds), and averaging time (20 years) are also applied to dermal contact with soil. Other parameters are based on EPA (1992). MTCACR also provides parameters for evaluating industrial/commercial exposures to airborne contaminants under WAC (1991, sect. 750). The exposure frequency of 250 days/year is used to represent the number of working days per year (EPA 1991a). MTCACR assumes a frequency of contact of 0.4 to represent a reasonable maximum soil exposure, resulting in an exposure frequency of 146 days/year to soil. A shielding parameter (a reduction in the radiation dose rate by building walls and other deviations from a uniformly contaminated, flat surface) of 0.8 is used (DOE 1995). Because Hanford has hot summers and cold winters, this scenario assumes that most workers would not participate in outside activities every day.

Parameters for ingesting water are based on EPA (1991a) because the parameters suggested in MTCACR (body weights, exposure times) are not typical of workplace conditions. Standard parameters for dermal contact and inhalation of waterborne materials are used from EPA (1991a) and EPA (1991b).

For this assessment, the HSRAM rates for air inhalation were revised. The HSRAM inhalation rate is given as 20 m^3/day, but this value is intended to represent a full 24-hour day. Therefore, for an 8-hour workday, this value is reduced to 10 m^3 (EPA 1989). The parameters used for the Industrial Worker Scenario are presented in Table 5.2.

5.1.2.2 Fish Hatchery Worker

Currently, the Yakama Indian Nation is conducting an experiment in commercial aquaculture by rearing domesticated coho salmon and steelhead/rainbow-trout hybrids in partnership with Scientific Ecology Group Inc., Northwest. The Fish Hatchery Worker Scenario is included because these projects are expected to continue. Present and proposed future operations include developing a fish hatchery at the 183-K East and West Filter Plants, Sedimentation and Flocculation Basins, Coagulation Basins, and the Purification Pools. This hatchery will be similar in function and size of that currently administered by the State Hatchery Program.

The Fish Hatchery Worker description is based on duties described in the job classifications provided by the State Hatchery Program Office for the Hanford pilot, as well as information gathered from the Eastbank State Hatchery in Ringold. The Eastbank Hatchery is a mid-sized operation that should be comparable to the size of the Tribal Hatchery in the near future. A state hatchery employee may work on a full-time permanent, full-time temporary, or seasonal basis. According to the job descriptions provided by the State Hatchery Program, the hatchery employee works an average of 250 days/year (estimate based on current employee records) and spends approximately 50-60 percent of working hours out-of-doors. The worker is assumed to be exposed 8 hours/day to pools of Columbia River derived water. The worker is assumed to drink 1 liter (about 1 quart)/day of river water while at work (following the assumptions of the Industrial Worker Scenario) and to work with the fish or around the pools for an average of 1 hour/day, resulting in dermal exposures.

The greatest distinction of this scenario from the standard worker scenario developed by HSRAM is the exposure frequency. In addition, the exposure duration is raised to 30 years for the screening assessment of risk. The rationale for exposure parameter values for this scenario, summarized in Table 5.3, is as follows:

- **Soil: Ingestion, External Radiation Exposure, Dermal Contact, Inhalation** - The fish hatchery worker is assumed to ingest and/or inhale resuspended dust inadvertently during time spent on the Hanford Site. The daily ingestion intake (100 milligrams/day) is twice the HSRAM value to account for potentially wet and muddy conditions. External radiation exposure is based on an 8-hour working day with minimal shielding. Dermal contact with soil is increased to 1 mg/cm^2 per day, which is a multiple of the recommended value of 0.2 mg/cm^2 per day (EPA 1989). The inhalation intake (10 m^3/day) is based on an 8-hour working day (EPA 1989).

- **Air: Inhalation** - While on the Hanford Site the fish hatchery worker may inhale fugitive dust or gases from varying sources. The individual is assumed to inhale 10 m^3/day, based on an 8-hour work day (EPA 1989).

Table 5.2. Exposure Parameters for the Industrial Worker Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	50 mg	10 - 150	146[(a)]	100 - 275	20	1 - 50	--	--
	External	8 hr	2 - 10	146	100 - 275	20	1 - 50	0.8	Shielding parameter
	Dermal	0.2 mg/cm^2	0.05 - 0.5	146	100 - 275	20	1 - 50	5,000 cm^2	Skin surface area
	Inhalation	10 m^3	8 - 20	146	100 - 275	20	1 - 50	50 $\mu g/m^3$	Air mass loading
Air	Inhalation	10 m^3	8 - 20	250	100 - 275	20	1 - 50	--	--
Surface Water	Ingestion	1 L	0 - 3	250	100 - 275	20	1 - 50	--	--
	External	8 hr	2 - 10	250	100 - 275	20	1 - 50	--	--
	Dermal	0.17 hr	0 - 1	250	100 - 275	20	1 - 50	20,000 cm^2	Total skin surface

(a) Derived from frequency of exposure of 0.4 of a year.

Table 5.3. Exposure Parameters for the Fish Hatchery Worker Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	100 mg	10 - 150	250	100 - 275	30	1 - 50	--	--
	External	8 hr	2 - 10	250	100 - 275	30	1 - 50	0.8	Shielding parameter
	Dermal	1 mg/cm^2	0.1 - 5	250	100 - 275	30	1 - 50	5,000 cm^2	Skin surface area
	Inhalation	10 m^3	8 - 20	250	100 - 275	30	1 - 50	50 $\mu g/m^3$	Air mass loading
Air	Inhalation	10 m^3	8 - 20	250	100 - 275	30	1 - 50	--	--
Surface Water	Ingestion	1 L	0 - 3	250	100 - 275	30	1 - 50	--	--
	External	8 hr	2 - 10	250	100 - 275	30	1 - 50	0.25	Geometry correction
	Dermal	1 hr	0 - 1	250	100 - 275	30	1 - 50	5,000 cm^2	Skin surface area

- **Surface Water: Ingestion, External Radiation Exposure, Dermal Contact -** Ingestion of surface water occurs advertently from using processed Columbia River water as drinking water onsite and inadvertently from surface water spray while working around the open water. For this screening, however, the HSRAM default value of 1 liter/day for on-the-job ingestion was used. The individual is assumed to be exposed to external radiation from river water in the basins. Geometry parameters account for some equivalent shielding; in other words, the worker is not immersed in the water. A parameter of 0.25 (the ratio of the skin surface area exposed to the total skin area) is used as an approximation. Frequent contact with the fish provides a route for dermal absorption. The value of 1 hour/day was selected, greater than the 0.17-hour default in HSRAM, but with a reduced body surface area to acknowledge that the worker is not usually immersed while working.

- **Groundwater**: No contact with groundwater occurs at present for the tribal fish hatchery worker, although much of the water used in the Eastbank Hatchery comes from the uncontaminated Ringold Springs.

5.1.3 Wildlife Refuge/Wild and Scenic River Scenarios

In the CRCIA screening assessment, three wildlife refuge/wild and scenic river scenarios were assessed for risk: a Ranger Scenario, an Avid Recreational Visitor Scenario, and a Casual Recreational Visitor Scenario.

The Hanford Site contains several areas of undisturbed ecosystems. Various options have been proposed to preserve some or all of these areas, including use as a wildlife refuge or designation as a wild and scenic river. If portions of the Hanford Site are designated as a wildlife refuge, no onsite continuous residence by humans is expected. Even the rangers would not live onsite. The lands would be open to the public for a variety of uses, although no residential or agricultural uses would be permitted. The following recreational and professional scenarios are possible under the wildlife refuge designation, although not all of them were the basis of specific exposure scenario development:

- archeologist
- bird watcher
- fisher
- hunter
- intruder/vandal/trespasser
- other and general recreational users
- reactor tour guide
- refuge ranger
- scientific study, monitoring and surveillance workers

Recreational uses include many possible activities such as backpacking, bird watching, camping, picnicking, river boat touring, swimming, water skiing, and wildlife viewing. While developing recreational facilities on the south shore of the Columbia River is not currently being planned, possible development could include a boat-only overnight camping facility, self-guided auto tour routes, and hiking trails.

Public Law 100-605 directs the U.S. Department of Interior, in consultation with DOE, to make recommendations for preserving the Hanford Reach of the Columbia River. One alternative considered is assigning the Hanford Reach to the National Wild and Scenic Rivers System. If the Hanford Reach is designated a wild and scenic river, human exposure scenarios in addition to those provided in the HSRAM recreational scenario are needed to provide insight into the spectrum of potential risk. The first step in developing the new scenarios is to define wild and scenic river. The second is to understand what significant features would be protected under this classification. The last step is to determine what future land uses are possible given the definition and significant features.

The Wild and Scenic River Act (Public Law 90-542, as amended) uses the following definitions to designate wild or scenic areas. Wild river areas are rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent the vestiges of primitive America. Scenic river areas are rivers or sections of rivers that are free of impoundments, with shorelines and watersheds still largely primitive and shorelines largely undeveloped but accessible in places by roads. Recreational wild rivers are those that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

The location of significant features is important when assessing an actual exposure pathway. Significant features of the area were determined in the Hanford Reach Environmental Impact Statement (NPS 1994). Nationally significant features include the following:

- fall chinook salmon
- intact ecosystem
- Native American cultural resources
- archeological sites
- hydrology and geology (for energy facility siting)
- federally recognized rare plant species
- federally recognized rare animal species

Regionally significant features include the following:

- endangered plants and animals listed by the state
- flat water recreation
- historic sites
- hunting
- Ringold agricultural area
- sport fishing
- White Bluffs along the north bank of the Hanford Reach

Uses allowed by the Wild and Scenic River Act would include the following:

- backpacking
- bird and wildlife viewing
- camping
- fishing
- horse packing
- hunting
- motorized and non-motorized river craft
- mountain bike riding (non-motorized)
- picnicking
- swimming/skiing
- ranching, grazing, farming, and occupation of homes that exist on the date of the enactment

Several of these exposure pathways are covered under the HSRAM (DOE 1995) recreational scenario (see Section 5.1.3.3). Three scenarios have been selected for evaluation that should cover the range of potential exposures under the wildlife refuge and wild and scenic rivers possibilities: ranger, avid recreational visitor, and casual recreational visitor. The Ranger Scenario represents an individual who regularly visits most habitat types on the site. The Avid Recreational Visitor Scenario represents an individual who visits the site frequently to fish and to hunt for deer, waterfowl, and upland game birds, and ingests the fish and game taken. The Casual Recreational Visitor Scenario is similar to the Avid Recreational Visitor Scenario, but the casual visitor spends less time in the vicinity. The following sections describe the exposure pathways and parameters for each of the three selected scenarios.

5.1.3.1 Ranger

In this scenario the ranger works out of an offsite facility and spends about 3 days/week (150 days/year) on the site. The ranger is assumed to be stationed offsite because administration of Hanford as a wildlife refuge is assumed to be handled out of the Othello office of the U.S. Fish and Wildlife Service. A field facility on Hanford is unlikely to be established. While on the site, the ranger spends a third of the time in each type of habitat: 1) upland range land, 2) along the shoreline, and 3) in a boat on the Columbia River.

The ranger does not drink water from the site. The Ranger Scenario is very similar to the HSRAM industrial scenario except that, although less time is spent onsite, more time is spent in outdoor activities. The ranger is assumed to work in the area for 30 years. The rationale for the exposure parameter values for this scenario, summarized in Table 5.4, is as follows:

Table 5.4. Exposure Parameters for the Ranger Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	100 mg	10 - 150	150	30 - 275	30	1 - 50	--	--
	External	3 hr	0 - 4	150	30 - 275	30	1 - 50	1.0	Shielding parameter
	Dermal	0.2 mg/cm^2	0.05 - 0.5	150	30 - 275	30	1 - 50	5000 cm^2	Skin surface area
	Inhalation	10 m^3	8 - 20	150	30 - 275	30	1 - 50	50 $\mu g/m^3$	Air mass loading
Air	Inhalation	10 m^3	8 - 20	150	30 - 275	30	1 - 50	--	--
Surface Water	Boating External	3 hr	0 - 4	150	30 - 275	30	1 - 50	0.5	Shielding correction
	Dermal	1 hr	0 - 4	150	30 - 275	30	1 - 50	5000 cm^2	Skin surface area
Sediment	Ingestion	100 mg	10 - 150	150	30 - 275	30	1 - 50	--	--
	External	3 hr	0 - 4	150	30 - 275	30	1 - 50	0.2	Geometry correction
	Dermal	0.2 mg/cm^2	0.05 - 0.5	150	30 - 275	30	1 - 50	5000 cm^2	Skin surface area

- **Soil: Ingestion -** The ranger is assumed to ingest soil inadvertently during time spent on the site and in the field. The standard assumption of 100 milligrams/day is used (EPA 1991a). The entire daily intake is assumed to be related to the site.

- **Soil: External Radiation Exposure -** The ranger is assumed to be onsite 9 hours/day with a third of the time spent in each of three location types: shoreline, boating, and upland. The daily exposure period is set to 3 hours, representing the time distribution for the ranger. Because this is an outdoor scenario, no shielding of the radiation fields is assumed.

- **Soil: Dermal Contact -** Dermal contact is assumed to occur with the inadvertent soil ingestion pathway. Soil adheres to the skin at a rate of 0.2 mg/cm^2 per day. Contact occurs over a total skin surface area of 5000 cm^2 (EPA 1991a).

- **Soil: Resuspended Soil Inhalation -** Resuspension of soil with subsequent inhalation is assumed to occur at all times while the ranger is onsite. The amount of resuspension is determined by using the mass loading approach based on an ambient air mass loading value of 50 $\mu g/m^3$ (40 CFR 50.5[b]). The pollutant concentration in the particulate matter in air is assumed to be the same as the pollutant concentration in soil. The ranger is assumed to inhale a total of 10 m^3 of air during the 9 hours while onsite (EPA 1989). This provides an average daily intake rate of 10 m^3/day for the exposure analysis.

- **Air: Inhalation -** While onsite, the ranger is potentially exposed to airborne contamination via inhalation. The ranger is assumed to inhale a total of 10 m^3 of air during the 9 hours while onsite (EPA 1989). This provides an average daily intake rate of 10 m^3/day for the exposure analysis. The inhalation exposure occurs for all onsite activities and is included for the entire 9 hours/day.

- **Surface Water: Boating External Radiation Exposure -** While involved in boating activities, the ranger is assumed to be exposed to radiation emitted from contamination in the water. The exposure frequency is 150 days/year and one-third of the 9-hour work day (3 hours/day). A shielding geometry parameter of 0.5 is applied because the dose rate is evaluated using parameters for total immersion in water (swimming); but, while boating, the source is effectively one-half that of total immersion (Jaeger et al. 1968).

- **Surface Water: Dermal Contact** - Boating and frequent contact with biota provide a route for dermal absorption. Contact is assumed to occur at the rate of 1 hour/day over a total skin surface area of 5000 cm^2 (EPA 1991a).

- **Sediment: Ingestion** - Contact is assumed to occur with shoreline sediment while the ranger is involved in activities along the Columbia River. The contact rate is assumed to be the same as for general soil contact. For the time spent along the shore, an intake of 100 milligrams/day is assumed, which is the total daily intake (EPA 1991a).

- **Sediment: External Radiation Exposure -** The ranger is assumed to be exposed to radiation emitted from the sediment while standing on the sediment. The rate of exposure is evaluated in a manner similar to that for standing on contaminated ground, except that a geometry/shielding parameter of 0.2 is applied to account for the finite width of the shoreline (DOE 1995). The exposure frequency is 150 days/year and one-third of the 9-hour work day. The daily exposure period is set to 3 hours, representing the time distribution for the ranger.

- **Sediment: Dermal Contact -** Dermal contact occurs along with sediment ingestion and is evaluated in the same manner as soil ingestion. Soil adheres to the skin at a rate of 0.2 mg/cm^2 per day (one contact event per day). Contact occurs over a total skin surface area of 5000 cm^2 (EPA 1991a).

5.1.3.2 Avid Recreational Visitor

The Avid Recreational Visitor Scenario involves an individual who fishes and hunts for game birds and animals onsite. The individual is exposed to soil and air while hunting in upland regions, to shoreline sediment while fishing or hunting, and to river water while fishing and from ingestion of fish, birds, amphibians, and deer. Upland hunting is considered in this analysis for the Columbia River because game could be potentially contaminated from forays into the riparian zone to forage or drink water.

Exposure to contaminated soil occurs during hunting trips to the site. The hunter success rate is assumed to be typical, but the total catch of this reasonable maximum individual is 10 times the regional average: for waterfowl 100 ducks per season (2 ducks per day) and for upland game birds 25 pheasants per season (0.5 pheasants per day) (Washington Department of Fish and Wildlife 1995a, 1994, 1993, 1992). That implies the hunter makes 50 trips hunting for each type of bird: 50 to shoreline environments and 50 to upland areas. Each hunting trip involves 4 hours of onsite exposure with soil or sediment contact at the daily average value.

The maximum number of days that could be spent hunting deer in a season is the length of the various deer hunting seasons (bow, muzzle loader, and firearm). In state game management regions around Hanford (272, 278, 281, 284, 371, and 372) this is 48 days (Washington Department of Fish and Wildlife 1995b). However, an individual hunter is not likely to spend the entire 48 days hunting. A maximum number of 20 days is used in the analysis. The total time spent in upland areas (deer hunting plus upland game bird hunting) is 70 days/year. This season could conceivably be longer if hunting seasons for other species such as doves and quail are included. This possibility is included in the uncertainty ranges assigned. The remaining 50 days is spent on the river shoreline or boating in the river. Note that the precision implied by this time distribution is an artifact of the way it was developed; the times are used to represent an average over a 70-year lifetime. Because the lifetime includes childhood years, selected pathways used slightly different parameters for the childhood portion. The rationale for the exposure parameter values for this scenario, summarized in Table 5.5, is as follows:

Table 5.5. Exposure Parameters for the Avid Recreational Visitor Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	200 mg (C) 100 mg (A)	100 - 250 10 - 150	70 70	8 - 100 8 - 100	6 24	1 - 6 1 - 64	--	--
	External	4 hr	0 - 8	70	8 - 100	30	1 - 70	1.0	Shielding parameter
	Dermal	0.2 mg/cm^2	0.05 - 0.5	70	8 - 100	30	1 - 70	5000 cm^2	Skin surface area
	Inhalation	10 m^3	7 - 15	70	8 - 100	30	1 - 70	50 $\mu g/m^3$	Air mass loading
Air	Inhalation	10 m^3	7 - 15	120	8 - 180	30	1 - 70	--	--
Surface Water	Ingestion	2 L	0 - 3	50	8 - 80	30	1 - 70	--	--
	External	4 hr	0 - 8	50	8 - 80	30	1 - 70	0.5	Geometry correction
	Dermal	1 hr	0 - 4	50	8 - 80	30	1 - 70	5000 cm^2	Skin surface area
Sediment	Ingestion	200 mg (C) 100 mg (A)	100 - 250 10 - 150	50 50	8 - 80 8 - 80	6 24	1 - 6 1 - 64	--	--
	External	4 hr	0 - 8	50	8 - 80	30	1 - 70	0.2	Geometry correction
	Dermal	0.2mg/cm^2	0.05 - 0.5	50	8 - 80	30	1 - 70	5000 cm^2	Skin surface area
Biota	Fish	54 g[(a)]	0 - 100	365	180 - 365	30	1 - 70	0.5	Diet Fraction
	Deer	15 g	0 - 30	365	180 - 365	30	1 - 70	--	--
	Upland Birds	9 g	0 - 20	365	180 - 365	30	1 - 70	--	--
	Waterfowl	35 g	0 - 50	365	180 - 365	30	1 - 70	--	--

(a) Parameter recommended in WAC 1991 (173-340-730).

C = Child
A = Adult

- **Soil: Ingestion -** The hunter is assumed to ingest soil inadvertently during time spent onsite and in the field. The entire daily intake of 100 milligrams/day for adults is assumed to be related to the site (EPA 1991a). For children, the daily intake rate is assumed to be 200 milligrams/day.

- **Soil: External Radiation Exposure -** The hunter is assumed to be onsite 4 hours/day in upland areas with exposure to soil occurring during that period. Because this is an outdoor scenario, no shielding of the radiation fields is assumed.

- **Soil: Dermal Contact -** Dermal contact is assumed to occur with the inadvertent soil ingestion pathway. Soil adheres to the skin at a rate of 0.2 mg/cm^2 per day (one contact event per day). Contact occurs over a total skin surface area of 5000 cm^2 (EPA 1991a).

- **Soil: Resuspended Soil Inhalation -** Resuspension of soil with subsequent inhalation is assumed to occur at all times while the hunter is onsite. The amount of resuspension is determined by using the mass loading approach as described for the Ranger Scenario. The hunter is assumed to inhale a total of 10 m^3 of air during the 4 hours while onsite (EPA 1989).

- **Air: Inhalation -** While onsite, the hunter is potentially exposed to airborne contamination via inhalation. The individual is assumed to inhale a total of 10 m^3 of air during the 4 hours while onsite (EPA 1989). The inhalation exposure occurs for all onsite activities and is included for the entire 4 hours/day.

- **Surface Water: Ingestion -** While onsite, the visitor is assumed to drink 2 liters (2.1 quarts)/day from available surface water.

- **Surface Water: Boating External Radiation Exposure -** While involved in boating activities, the individual is exposed to radiation emitted from contamination in the water. The exposure frequency is 50 days/year and 4 hours/day. A shielding geometry parameter of 0.5 is applied because the dose rate is evaluated using parameters for total immersion in water (swimming). However, while boating, the source is effectively one-half that of total immersion (Jaeger et al. 1968).

- **Surface Water: Dermal Contact -** While engaged in boating or fishing activities, the visitor is assumed to come in contact with surface water for 1 hour/day.

- **Sediment: Ingestion -** Contact is assumed to occur with shoreline sediment while the hunter is involved in waterfowl and deer hunting along the Columbia River. The contact rate is assumed to be the same as for general soil contact. An intake of 100 milligrams/day for adults is assumed, which is the total daily intake (EPA 1991a). For children, the daily intake rate is assumed to be 200 milligrams/day.

- **Sediment: External Radiation Exposure -** The hunter is exposed to radiation emitted from the sediment while standing on the sediment. The rate of exposure is evaluated in a manner similar to that

for standing on contaminated ground, except that a geometry shielding parameter of 0.2 is applied to account for the finite width of the shoreline. The exposure frequency is 50 days/year and 4 hours/day.

- **Sediment: Dermal Contact -** Dermal contact occurs along with sediment ingestion and is evaluated in the same manner as soil ingestion. Soil adheres to the skin at a rate of 0.2 mg/cm^2 per day (one contact event per day). Contact occurs over a total skin surface area of 5000 cm^2 (EPA 1991a).

- **Biota: Fish Ingestion** - The fish are assumed to be consumed by the individual and the family. The HSRAM recreational rate of 54 grams (1.9 ounces)/day is retained (DOE 1995 from WAC 1991, sect. 730).

- **Biota: Deer Ingestion -** One deer per season is assumed to be shot and eaten by the hunter and his family. (Elk are not included in this analysis because Hanford elk remain on the Fitzner-Eberhardt Arid Land Ecology reserve almost exclusively and rarely travel across Highway 240 to the Columbia River.) The deer is assumed to have a total weight of 45 kilograms (99 pounds), of which a 50-percent yield of deer meat is assumed for a total edible meat weight of 22.5 kilograms (49.6 pounds)/deer (Paustenbach 1989). For an individual in the hunter family of four, the intake rate per individual for one 45-kilogram deer is 15 grams (0.5 ounces)/day.

- **Biota: Upland Game Bird Ingestion -** The upland game birds are assumed to be consumed by the hunter family of four. The weight of meat from each bird is taken to be 0.5 kilogram (1.1 pound) (50 percent of a 1-kilogram bird). The total weight of upland game birds (25 birds per season) is 12.5 kilograms (27.5 pounds), with consumption by a member of the hunter family of 9 grams (0.3 ounces)/day.

- **Biota: Waterfowl Ingestion -** Waterfowl is assumed to be consumed by the hunter family of four. The weight of meat from each bird is taken to be 0.5 kilogram (50 percent of a 1-kilogram bird). The total weight of water fowl meat (100 waterfowl per season) is 50 kilograms (110 pounds, with consumption by each member of the hunter family of 35 grams [1.2 ounces]/day).

5.1.3.3 Casual Recreational Visitor

This individual is included because many people currently use the Hanford Reach and adjacent wildlife refuge areas. Although a variety of year-round recreational activities occur, one of the most popular is sport fishing. The average angler catches salmon, steelhead, sturgeon, and small mouth bass. This individual may fish along the shoreline or from a motorized or non-motorized boat (DOA 1993). Fishing seasons in Washington are regulated by the Washington Department of Fish and Wildlife, and special rules and seasons are provided for trout, salmon, and sturgeon (Washington Department of Fish and Wildlife 1995c). Other activities might include hunting, water skiing, and swimming.

Jet and propeller-driven boats are used along the entire Hanford Reach, while non-motorized boats generally stay in the vicinity of the three primitive river access areas: Vernita Bridge, White Bluffs Ferry Landing (east side only), and Ringold Hatchery. Public access to shorelines and islands is restricted, and

no overnight camping is allowed within the Hanford Site. Recreational boating is only a day-use activity. Data on daily fishing and boating stay times per individual have not been determined. However, current parameters as reported in HSRAM indicate that this individual may be potentially exposed 7 days/year averaged over a 70-year lifetime.

For this study, the standard HSRAM recreational scenario is used as a baseline. If the Hanford Reach is designated wild and scenic, the access to and use of the Reach would likely increase somewhat, and the 7 days/year exposure frequency for visitors might need to be increased. For the screening assessment, the HSRAM recreational scenario is included with minimal modification. Inhalation of resuspended soil has been added for consistency with other scenarios. The screening assessment variations of the HSRAM-specified parameters for this scenario are provided in Table 5.6.

5.1.4 Native American Scenarios

In the CRCIA screening assessment, five Native American scenarios were assessed for risk: a Subsistence Resident Scenario, Upland Hunter Scenario, River-Focused Hunter and Fisher Scenario, Gatherer of Plant Materials Scenario, and a Columbia River Island User Scenario.

The range of possible Native American activities on the Hanford Site is very broad. They include activities specifically delineated in the treaties and other activities related to traditional life styles and to preservation of natural and cultural resources. Specific activities or activity categories include—but are not limited to—collecting, fishing, gathering, hunting, and processing of the catch along the shoreline, and pasturing of livestock, as well as ceremonial, educational, seasonal, social, and trade activities. The environmental contact rates of some of these activities are analogous to common suburban activities, but some are unique and have no suburban surrogate.

This screening assessment describes an initial version of a Native American subsistence scenario as well as several habitat-focused activity sets (upland hunting, river-focused hunting and fishing, gathering of plant materials across several habitats, and use of Columbia River islands). These scenarios have been specifically developed for Columbia Basin climatic conditions (hot and dry), ecosystems (high desert, river), and indigenous activity patterns (high fish consumption, seasonally active life styles). The Subsistence Resident Scenario and the Gatherer of Plant Materials Scenario are composite year-round scenarios that cross all habitats, while the Upland Hunter Scenario focuses on seasonal upland activities and resources, and the River-Focused Hunter and Fisher Scenario includes activities that could occur on or near the river. This habitat approach to human activity patterns was taken because of the potential for these scenarios to be used to answer questions about whether particular areas are safe to use. Therefore, it seemed reasonable to combine activities that a person might pursue in different areas into separate scenarios. It should be noted that only the subsistence scenario is an unrestricted use scenario. The other scenarios are partial scenarios for individual activity sets or food sources.

The specific activities presented here reflect several, but not all, treaty-reserved rights (fishing, gathering, hunting, and pasturing). In traditional communities, different people tend to specialize in

Table 5.6. Exposure Parameters for the Casual Recreational Visitor Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate[a] (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration[a] (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	200 mg (C) 100 mg (A)	100 - 250 10 - 150	7	1 - 8 1 - 8	6 (C) 24 (A)	1 - 6 1 - 64	--	--
	External	8 hr	2 - 12	7	1 - 8	30	1 - 70	1.0	Shielding correction
	Dermal	0.2 mg/cm^2	0.05 - 0.5	7	1 - 8	30	1 - 70	5000 cm^2	Skin surface area
	Inhalation	10 m^3	5 - 15	7	1 - 8	30	1 - 70	50 $\mu g/m^3$	Air mass loading
Air	Inhalation	10 m^3	5 - 15	7	1 - 8	30	1 - 70	--	--
Seep/Spring Water	Ingestion	2 L	0 - 3	7	1 - 8	30	1 - 70	--	--
	Dermal	0.17 hr	0 - 1	7	1 - 8	30	1 - 70	20,000 cm^2	Skin surface area
Surface Water	Ingestion	2 L	0 - 3	7	1 - 8	30	1 - 70	--	--
	Dermal	2.6 hr	1 - 8	7	1 - 8	30	1 - 70	20,000 cm^2	Skin surface area
Sediment	Ingestion	200 mg (C) 100 mg (A)	20 - 500 10 - 150	7	1 - 8	6 (C) 24 (A)	1 - 6 1 - 64	--	--
	Dermal	0.2 mg/cm^2	0.05 - 0.5	7	1 - 8	30	1 - 70	5000 cm^2	Skin surface area
Biota	Fish	54 g[b]	0 - 100	365	1 - 365	30	1 - 70	0.5	Diet fraction
	Plants	--	--	--	--	--	--	--	--
	Deer	15 g	0 - 90	365	1 - 365	30	1 - 70	--	--
	Waterfowl	--	--	--	--	--	--	--	--

(a) Parameters recommended in EPA (1991a) except as noted.
(b) Parameter recommended in WAC (1991) (173-340-730).

C = Child
A = Adult

different activities, and therefore they spend more time at their special activities than a subsistence person would be able to allocate. The Subsistence Resident Scenario is a composite scenario in which a person divides her/his time throughout a full year among all the specific activities rather than specializing in one or two. The Upland Hunter and River-Focused Hunter and Fisher Scenarios are not year-round scenarios, nor do they include exposure estimates for other site visits (such as visiting cultural sites) or food sources outside of the particular habitat/activity. The result is that the River-Focused Hunter and Fisher Scenario includes fish ingestion but not plant ingestion.

These five Native American scenarios are most likely to be used to answer questions about whether a location is suitable for a particular activity (in other words, "Is it safe to fish here?"), so only those exposures related directly to fishing were included in the scenario (time spent fishing, uptake of contaminants by the fish, amount of fish ingested by the hunter, etc.). It is very important to note, however, that such questions cannot be answered without considering other exposures. The answer to the fishing question might be that it is safe to fish in a particular area only if no other exposures are received elsewhere and if no other activities occur in the same area along with fishing.

There is a tendency to evaluate each exposure as if no other exposures occurred, and each contaminant as if no other contaminants were present, and each source of contamination as if no other sources contributed to the same pool of contamination. Because our goal is to protect entire life styles, not just isolated activities, the role that a particular activity or location plays in the overall life style is an important part of the evaluation. This applies to both the life style of a traditional individual and to the collective community dose or total contaminant burden that a community and its resources bears from all sources.

The overall rationale in developing these scenarios was to ensure that the exposure parameters reflect general traditional activities using native plants and medicines within an active life style that includes higher environmental contact rates than a suburban scenario over a full lifetime of 70 years. While the exact percentile of exposure this represents for traditional tribal members has not been determined, this scenario clearly does not represent the highest potential exposure. It was designed to represent average traditional life styles or somewhat above-average traditional, thus partially satisfying EPA's recommendation to evaluate average members of the highest exposure groups. It also partially satisfies Executive Order 12898 (59 FR 7629), which requires subsistence life styles to be evaluated as part of the evaluation of impacts to human health and the social and economic impacts of federal actions. These scenarios also are intended to provide approximately the same level of conservatism for a subsistence life style as the conventional residential scenario does for a suburban life style.

The approach to developing these scenarios began with a conventional suburban residential farmer (agricultural) scenario and then was fine tuned on the basis of information provided by a tribal representative to determine which of the exposure parameters should be increased to account for a life style that is more active and in closer contact with the environment. These scenarios were developed using estimates for tribal environmental contact and dietary ingestion rates while specifically avoiding the disclosure of confidential information by tribal staff. The critical data needed by the risk assessor included the number of days per year spent hunting, the amount of plant material in the diet, or other information about the duration and frequency of exposure. The risk assessor did not need to know the particular

species of plants because the model does not include species-specific uptake information. In future assessments to avoid revealing proprietary information, tribal technical staff need to determine the complete array of exposure parameters for the Native American scenarios.

From a Native American perspective, focusing on human exposure isolated from environmental effects is inherently unsatisfactory. Human beings cannot be separated from the environment, and evaluating human health involves much more than making simple mechanistic exposure estimates. The Native American belief is that people in general, and Native Americans in particular, are not truly healthy unless the environment is healthy and unless their community is healthy. In fact, traditional tribal communities are so closely associated with their environs that community health and ecological health are essentially synonymous. Thus, the scenarios presented here will help answer questions about whether particular activities can be safely pursued at particular locations, but they do not answer the full question about how contaminants or other stressors affect eco-cultural systems or overall human-eco-cultural health. They merely provide information about how much exposure a person might receive during particular activities. Further, current models do not take into account the many ways that people interact with the environment nor the many ways that people and the environment are mutually interdependent. Any given resource might have ceremonial, material, nutritional, or religious uses. However, since much of this information is confidential and could not be accommodated by current limited models even if the details were known, it may make more sense in some situations to simply incorporate a cultural safety parameter in the exposure assessment to account for these types of recognized, but poorly defined, pathways.

The Native American tribes involved in CRCIA feel strongly that these scenarios cannot be used by themselves to estimate risk, which would then be used to determine environmental cleanup levels. As explained above, any attempt to set risk-based cleanup levels must consider more than just human exposure. It must include ecological and community quality of life parameters as well. It must also consider a range of health effects (for example, cancer, noncancer, organ toxicity, cumulative population effects) and co-risk parameters (for example, differences in physiological sensitivity and additional expected exposures). In addition, cleanup levels must be temporally apportioned so that both toxicity and environmental persistence are considered, and must be spatially apportioned so that both the concentration and the total area degraded are considered.

Five semi-quantitative scenarios were constructed to span the range of treaty-reserved activities that are reasonably expected to occur along the Columbia River:

- Subsistence Resident
- Upland Hunter
- River-Focused Hunter and Fisher
- Gatherer of Plant Materials across all habitats
- Columbia River Island User (for application to cobalt-60 particles)

The Subsistence Resident Scenario is intended to represent a reasonable set of activities that reflect a traditional life style with activities occurring for a full 70-year lifetime on what is now the Hanford Site. It is a composite scenario that includes a mix of representative, but not all-inclusive, activities spread over the entire year. This is a moderately active life style with access to both the shoreline and to seeps/springs as well as upland areas near the river. Seep/spring water is assumed to be used for ingestion and biotic uptake directly from in situ groundwater and around the springs. Of the scenarios developed, this one has the full diet of meat (game and pastured livestock), fish, and plants. It can be considered an almost completely unrestricted scenario, but it does not include maxima for fishing, gathering, or hunting and does not necessarily include visits to special areas or sites for non-food purposes such as ceremonies or teaching.

The Upland Hunter Scenario is a seasonal, localized scenario that extends for the 70-year lifetime. However, this scenario is included in the screening assessment since upland habitats might be included in future assessments. The Upland Hunter Scenario assumes that a fairly proficient hunter obtains 90 percent of the bag limit for various fowl and game species and some amount of non-game animals. It assumes that the hunter specialist spends 150 days/year hunting, which is more time hunting than the subsistence person could spend, but assumes that the meat is stored, traded, and eaten year-round. Note that only game is considered in the diet because this scenario was designed to answer habitat-focused questions about hunting and hunting-related activities rather than about a full traditional life style of someone whose primary tribal role is to hunt. The hunter is assumed to carry spring water while hunting.

The River-Focused Hunter and Fisher Scenario is also a seasonal, localized scenario that includes fishing and hunting of waterfowl and waterfowl eggs from the river and the shoreline for a 70-year lifetime. This person is assumed to spend 150 days/year at the river and therefore be in contact with river water and sediment. This scenario was designed to answer questions about whether it might be safe to hunt and fish along the river, but is not designed to fully answer whether the river and river corridor are safe for unrestricted use.

The Gatherer of Plant Materials Scenario is a year-round scenario that assumes seasonal gathering of plant materials across relevant habitats for foods, medicines, and crafted goods, as well as their preparation, ingestion, and other use. This is a year-round scenario because, while actual gathering is assumed to occur for 270 frost-free days/year, daily cleaning, preparation, and ingestion of stored plants and crafting of plant materials into household goods will occur throughout the year (Harris 1995, 1993). This scenario focuses on plant habitats and does not include game and fish ingestion.

The Columbia River Island User Scenario is a localized scenario intended to specifically address concerns regarding potential exposures to discrete radioactive particles containing cobalt-60. The scenario is based on traditional Native American uses of the islands and shoreline involving extended occupation as a base for fishing and other traditional uses. Pathways evaluated include inhaling a particle, ingesting a particle during incidental ingestion of small amounts of sediment, receiving direct external radiation exposure without contact, and lodging a particle on the skin.

5.1.4.1 Subsistence Resident

In this scenario, a person spends full time (365 days, 24 hours/day) onsite for a lifetime of 70 years. Activities include collecting, fishing, gathering, hunting, and pasturing livestock. Pasturing livestock, such as cattle, is included here because human exposure could result; but pasturing of horses would be considered part of an ecological assessment because the horse is not commonly part of the human food chain. Exposures related to these activities can occur from ingesting food and water as well as from contact with environmental media during gathering, preparation, and non-ingestion uses. Access to the shoreline and access to seep/spring water for all uses including irrigation of pasture and crops or native plants growing around springs are assumed. Preliminary assumptions and selection of exposure parameters are described below.

- **Soil: Ingestion** - A person is assumed to continue a child's soil ingestion rate of 200 milligrams/day throughout life (EPA 1991a). Resuspension of dust with deposition on plants and pasture is included. If soil is contaminated, a soil-plant-animal-human pathway would also exist. If contaminated soil or dust deposits on plants and pasture, an additional exposure route would exist.

- **Soil: External Radiation Exposure** - Because this scenario assumes full-time residence, the person is assumed to be onsite 24 hours/day; and for this example, the time is not divided among location types (shoreline, boating, and upland). A shielding reduction parameter of 0.8 (a reduction in the dose rate by building walls and other deviations from a uniformly contaminated, flat surface) is applied per HSRAM (DOE 1995), which assumes that the person is standing on contaminated soil during the entire exposure period.

- **Soil: Dermal Contact** - Dermal contact is assumed to occur at the rate of one event per day with soil adhering to the skin at a rate of 1 mg/cm^2 per day, which is a multiple of the 0.2 mg/cm^2 default value (EPA 1991a). The duration of the event is not used because dermal absorption is time-independent. Contact would occur over a skin surface area of 5000 cm^2, which represents 25 percent of the total skin surface area (EPA 1991a). The skin absorption fraction is contaminant-specific. The increased soil adherence rate needs to be reviewed to ensure that it adequately represents not only initial contact during gathering but also cleaning and preparation.

- **Soil: Resuspended Soil Inhalation** - Resuspension of soil with subsequent inhalation of the dust in the air is assumed to occur at all times while the person is onsite. The amount of resuspension is determined by using the mass loading approach based on an ambient air mass loading value of 100 $\mu g/m^3$, which is twice the EPA recommended value for suburban areas (40 CFR 50.6[b]). The pollutant concentration in the particulate matter is assumed to be the same as the pollutant concentration in the soil. During the 24 hours while onsite, the person is assumed to inhale 30 m^3 of air. This is 150 percent of the average value to account for a more active outdoor life style (EPA 1989).

- **Air: Inhalation** - The person is assumed to inhale 150 percent of the default volume of air per day (30 m^3/day) to account for a more active life style (EPA 1989). If an airborne radiological plume exists, immersion of people, plants, and animals in that plume is also included.

- **Seep/Spring Water: Ingestion** - For this scenario, the person is assumed to drink 3 liters (3.2 quarts)/day of seep/spring water, which is assumed to be undiluted groundwater. No decay of radionuclides between withdrawal of seep/spring water and ingestion is assumed, and no filtration of particulate matter is assumed. In other words, the concentration of contaminant in unfiltered groundwater is the appropriate comparison value. In addition, deliberate irrigation of pasture and some amount of domestic crops is assumed to occur, resulting in a pathway from groundwater to plants via direct uptake by the roots of domestic and/or native plants (for example, cattails growing in contaminated seeps). In the present example, game animals are also assumed to drink from the springs, and groundwater or springs are used as the source of drinking water for pastured animals. If the seeps form a wetland, several of the exposure assumptions will need to be revised to construct a true wetland scenario.

- **Seep/Spring Water: External Radiation Exposure** - A person is assumed to be close enough to the spring or to soil dampened by spring water to receive exposure to external radiation 12 hours every day.

- **Seep/Spring Water: Dermal Contact** - On the average, 1 hour every day is assumed to be spent in activities associated with groundwater, seeps, or springs, including bathing, digging for roots, collecting medicines, or drawing water. The complete skin surface area is assumed to be exposed to the water. In addition, sediment or groundwater-soaked soil is assumed to adhere to the skin during one contact event every day.

- **Seep/Spring Water: Inhalation** - The inhalation rate of 15 m^3/day represents volatilization of pollutants from seep/spring water into a relatively small space or short distance. This pathway typically includes year-round indoor activities such as showering and cooking. Because these activities or analogues of these activities could be expected to occur during subsistence living, the default parameter is included here unchanged (EPA 1991a). The quantity of water in indoor air is based on the absolute humidity (Andelman 1990).

- **Surface Water: Ingestion** - For this scenario, the person is assumed to drink 3 liters (3.2 quarts)/day of surface water. A person is also expected to inadvertently ingest water during swimming at a rate of 0.01 liter (0.01 quarts)/hour x 2.6 hours/swim) (DOE 1995), but this is not expected to add significantly to the total daily water intake and so is not listed separately. In the present example, no irrigation is assumed to occur, but game and domestic animals are assumed to drink from the river, and fish might bioconcentrate some contaminants.

- **Surface Water: External Radiation Exposure** - Swimming and boating are assumed to occur for 2.6 hours/day for 70 days/year, and shoreline use is assumed to occur for 12 hours/day for 270 days/year. During boating, the dose rate at the water surface is one-half that of immersion (Jaeger

et al. 1968), while the shoreline geometry is expected to reduce the dose by 20 percent. There is no shielding while directly swimming in the river.

- **Surface Water: Swimming Dermal Contact** - The dermal contact during swimming assumed 2.6 hours of swimming (EPA 1991a) for 70 days with dermal contact with water over 20,000 cm^2 of skin surface area (EPA 1991a). The absorption coefficient is contaminant-specific. Swimming is also assumed to result in dermal contact with sediment over 5000 cm^2 of skin surface area (EPA 1991a).

- **Surface Water: Inhalation** - The person is assumed to inhale near-surface volatiles year-round as in conventional indoor surface water use (EPA 1991a).

- **Sediment: Ingestion, External Radiation Exposure, Dermal Contact** - The rates used for contact with sediment are similar to soil except the contact is assumed to be 12 hours/day because the individual lives permanently above the high water line. Also, the exposure frequency per year is lower (270 days instead of 365 days) because inclement weather, high water, or other activities are assumed to reduce the overall time spent on or near sediment.

- **Biota: Ingestion** - A fish consumption rate of 540 grams (1.2 pounds)/day was chosen to represent a reasonable maximum intake (CRITFC 1994; Hunn 1990; DOI 1942; CRCIA Team meeting minutes February 6, 1996). Tribal input indicates that fresh fish and dried fish are consumed in roughly equal ratios, so the overall consumption rate was estimated as follows. One-quarter of the 540-gram daily consumption (135 grams/day or 4.8 oz.) is assumed to be fresh, and three-quarters (405 grams [14.2 ounces]/day) is assumed to be dried. The 405 grams/day that is dried is estimated to lose about two-thirds of its mass during drying, resulting in a dry weight of about 135 grams. Thus, a person is assumed to eat 135 grams/day fresh and 135 grams/day dry, which is equivalent to 540 grams of wet weight.

  On the basis of tribal input, the ingestion rate for fruits and vegetables was set at 660 grams (1.4 pounds)/day based on the same principle of 50 percent fresh and 50 percent dried. It will not be useful to investigate specific ingestion rates of roots, fruits, etc., unless uptake parameters to specific plant parts (roots versus leaves) or specific plant species are available. Medicinal and other uses of plant material may provide reason to increase this ingestion rate.

  The HSRAM value for meat and game intake is superseded with a single animal protein consumption rate based on tribal input of 75 grams (2.6 ounces)/day of animal protein (which may include flesh, fat, marrow, etc.), of which 50 percent is fresh and 50 percent is dried. Converting to fresh weight, assuming a wet-to-dry ratio of 3, gives the equivalent fresh weight of 150 grams (5.3 ounces)/day. The waterfowl and upland game bird consumption rates are assumed to be the same for subsistence as they are for the Upland Hunter Scenario. This needs to be reviewed for seasonal take, length of season, and special hunting privileges. Again, because contaminant concentration among animal/fowl species is

currently modeled solely on the basis of proportional animal body weight, determining consumption rates of specific species or animal organs/tissues will not be useful unless information about contaminant uptake and tissue distribution is available.

The caloric content of fresh salmon is approximately 500 kilocalories/275 grams (9.6 ounces) (chinook) or 400 kilocalories/275 grams (sockeye). The rate of 540 grams/day therefore represents about 800-1000 kilocalories/day depending on the type of salmon. The caloric requirements for moderately active adults is approximately 3000 kilocalories/day for males, 2200 kilocalories/day for females, with an additional 500 kilocalories/day for pregnant or lactating females (or 80,000 kilocalories per pregnancy). If the daily protein requirement is about 75 grams for a 75 kilogram male (about 165 pounds) for a sedentary life style and 25 percent more for a moderately active life style, and salmon contains 17 grams (0.6 ounces) protein per 100 grams (3.5 ounces) wet weight, then the salmon would provide close to the required daily amount of protein and one-third to one-half of the caloric requirement. Hunn (1990) estimated that a traditional diet consists of 1300 grams (2.8 pounds)/day roots (or 1830 kilocalories/day) plus 1400 grams (3.1 pounds)/day of other vegetation (or 1390 kilocalories/day) plus 500 grams (1.1 pound)/day salmon (or 850 kilocalories/day) plus 240 grams (8.4 ounces)/day venison (or 300 kilocalories/day) for a total of 2500 kilocalories/day. This varies somewhat from the estimates used in this screening assessment, especially for the amount of venison and the amount versus caloric content of native plants, although the overall caloric estimates are close.

For the screening-level risk assessment, ingestion pathways for milk from locally grazing cattle and for eggs collected from local nests have also been included. However, the values in Table 5.7, which summarizes the exposure parameters for the Subsistence Resident, are approximations requiring additional tribal staff input. Organs other than meat are also consumed, such as fish eggs and liver. For this screening scenario, this category is identified as a data gap and uses as a placeholder value one that is equal to one-tenth of the fish ingestion. This is a critical data gap that may be addressed in the future.

- **Cultural: Inhalation, Dermal** - For the screening level risk assessment, sweat bathing is explicitly added. Based on tribal descriptions, a nominal time of 1 hour/day is assumed to be spent inside a sweat lodge kept at 50 to 80 degrees Celsius (120 to 180 degrees Fahrenheit). Air inside the sweat lodge is assumed to be saturated with groundwater (equivalent to 0.1 to 0.3 kilogram [3.5 to 10.6 ounces] of water per m^3 of air and 0.1 to 0.3 L/m^3 of semivolatiles), which are then available for inhalation and dermal absorption over the entire body. During the 1 hour of use, 4 liters (about 1 gallon) of water is used.

Areas for Future Work. Certain limitations were highlighted while the Native American scenarios were being developed. Those limitations are identified here as data gaps and need to be refined and addressed in the future. These gaps apply to the Subsistence Resident Scenario as well as to the subsequent scenarios developed from it.

Table 5.7. Exposure Parameters for the Native American Subsistence Resident Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion[a]	200 mg	20 - 500	365	180 - 365	70	1 - 70	--	--
	External	24 hr	12 - 24	365	180 - 365	70	1 - 70	0.8	Shielding parameter
	Dermal	1 mg/cm^2	0.5 - 5	365	180 - 365	70	1 - 70	5000 cm^2	Skin surface area
	Inhalation	30 m^3	20 - 35	365	180 - 365	70	1 - 70	100 µg/m^3	Air mass loading
Air	Inhalation	30 m^3	20 - 35	365	180 - 365	70	1 - 70	--	--
Seep/Spring Water	Ingestion	3 L	2 - 5	365	180 - 365	70	1 - 70	--	--
	External	12 hr	1 - 24	365	180 - 365	70	1 - 70	0.8	Shielding parameter
	Dermal[b]	1 hr	0 - 2	365	180 - 365	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[c]	15 m^3	10 - 20	365	180 - 365	70	1 - 70	0.1-0.3 L/m^3	Volatilization equivalent
Surface Water	Ingestion	3 L	2 - 5	365	180 - 365	70	1 - 70	--	--
	External	2.6 hr	0.5 - 4	70	30 - 100	70	1 - 70	0.5	Geometry correction
	Dermal[d]	2.6 hr	1 - 4	70	30 - 100	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[e]	15 m^3	10 - 20	70	30 - 100	70	1 - 70	0.1 L/m^3	Volatilization equivalent
Sediment	Ingestion	200 mg	20 - 500	270	100 - 365	70	1 - 70	--	--
	External	12 hr	4 - 24	270	100 - 365	70	1 - 70	0.2	Geometry correction
	Dermal	1 mg/cm^2	0.5 - 5	270	100 - 365	70	1 - 70	5000 cm^2	Skin surface area
Biota[f]	Fish[g]	540 g	100 - 600	365	180 - 365	70	1 - 70	--	--
	Fruit and vegetation	660 g	200 - 800	365	180 - 365	70	1 - 70	--	--
	Animal protein[h]	150 g	75 - 200	365	180 - 365	70	1 - 70	--	--
	Other Organs[i]	54 g	1 - 100	365	180 - 365	70	1 - 70	--	--
	Milk	0.6 L	0 - 1	365	180 - 365	70	1 - 70	--	--
	Upland Birds	18 g	5 - 20	365	180 - 365	70	1 - 70	--	--
	Waterfowl	70 g	5 - 100	365	180 - 365	70	1 - 70	--	--
	Wild bird eggs	45 g	5 - 135	365	180 - 365	70	1 - 70	--	--

Table 5.7. (Cont'd)

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Cultural[(j)]	Dermal	1 hr	0.5 - 3	365	180 - 365	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation	1 hr	0.5 - 3	365	180 - 365	70	1 - 70	0.1 L/m^3	Volatilization equivalent

(a) Soil ingestion is typically separated into child (200 mg/d) and adult (100 mg/d) parameters, but considering the activities included in these scenarios, it seems reasonable to assume that the higher rate would persist throughout a lifetime.
(b) The dermal parameter for seep/spring water in HSRAM reflects bathing. For this scenario, seep/spring water is assumed to be encountered regularly while gathering roots.
(c) In HSRAM, seep/spring water use is a household scenario where inhalation comes from volatilization during showering and other household use. To the extent that analogous activities occur, this parameter is retained.
(d) For surface water, only swimming (2.6 hours/day) is included.
(e) For seep/spring water, exposures may still occur that are the equivalent of suburban household exposures.
(f) Foodchain pathways include deposition, soil uptake, and seep/spring water uptake, as well as aquatic pathways. Also, additional parameters are relevant to human ingestion, such as additional plant parts used or eaten (and multiple parts per plant that rotate through the seasons), medicinal uses (infusions, teas, poultices, etc.), and other potential contact with people or their foods (food storage basketry, sleeping mats, extensive contact during basketmaking, use of bones, feathers, and sinews).
(g) Fish consumption includes multiple species and parts eaten, prepared both fresh and dried. Equivalent fresh weight is given here.
(h) The animal protein consumption rate includes meat, fat, and marrow, prepared fresh or dried. The equivalent fresh weight is given here.
(i) Approximated as 10 percent of the fish ingestion value.
(j) The unique pathway related to volatilization of contaminants from water during sweat bathing is included here. The absolute humidity is based on saturated conditions at a temperature of 50 to 80 degrees Celsius (120 to 180 degrees Fahrenheit).

- **Children's Scenario** - At present, the only age stratification is to evaluate years 1-6 using a child's body weight, a child's skin surface area, half the adult's drinking water ingestion rate, and half the adult's food ingestion rate. Several parameters are not yet available, such as a child-specific gastrointestinal absorption parameter, or child-specific toxicity parameters.

- **Mother's Milk** - Another critical data gap is the lack of a mother's milk pathway. For this screening analysis, cow's milk bioaccumulation parameters are used.

- **Elderhood** - The present scenarios extend for 70 years. However, if elderhood is assumed to begin at age 70 and extend for another 20 years, this would result in additional exposures during a period of increased physiologic sensitivity.

- **Other Site Activities** - Additional activities, such as restoration activities, ceremonial uses, or teaching activities would increase the number of visits to particular areas/sites. Such activities need to be considered by tribal technical staff to evaluate whether the resources in a particular area would cause increased use and exposure.

- **Species-Specific Uptake Parameters** - Exposure pathways for key animal and plant species are still rudimentary and do not discriminate among species. Animals are modeled on the basis of body weight in the human exposure models and by simple trophic levels in some of the ecological models. In the human exposure model, no individual plant species or plant parts (roots versus fruits) are modeled; only a generic soil-to-plant or water-to-plant transfer parameter is used, followed by an estimate of the mass of plant material ingested.

- **Habitat Specificity** - A wetlands-specific scenario is lacking at present. Although relatively few wetland areas exist along the Hanford Reach, they are sought out and used intensively by tribal members. Many species of plants and animals occur in wetlands, including additional food species as well as medicinal and material species. Many species have multiple uses and could contribute to exposures in multiple ways. Bioaccumulation patterns are likely to be different in wetlands and marshes, and sedimentation patterns are also different. For example, a full assessment for cattails (such as for food or for baskets for food storage) throughout various seasonal periods and with a more thorough consideration of sediment and soil exposures could provide both a more accurate estimation of exposure and a better basis for uncertainty analysis.

- **Community Exposures** - In addition to individual exposure estimates, a trade and social network in traditional communities spreads the total exposure (in other words, the community contaminant burden) much further than the individual. Guidance needs to be developed on how to evaluate exposures to the individual's immediate family and to the extended family network who will also be exposed if contaminated resources are gathered and used. For example, game animals are entirely consumed. Therefore, in addition to the amount the hunter might eat, other people eat the rest, so one contaminated deer exposes many people. While the doses to those people may not be as high as the dose to the hunter himself, the total dose to the community will be additive across all contaminated resources. Community quality of life can also be adversely affected by contaminant exposures of the individual,

the wider community network, and the environmental and natural resources on which the community depends. The intent of these types of evaluation is much more than deciding whether the dose to the most exposed person is tolerable, but also whether the collective dose to the community is tolerable even if no single person is excessively exposed. Evaluating these types of impacts from contaminants is a critical data gap.

- **Gender Stratification** - Women are most likely to participate in gathering activities, especially women of child-bearing age. This puts the fetus at risk from any contaminants to which the mother is exposed. Women also manage the household, clean and prepare stored foods, and do much of the crafting of household goods.

5.1.4.2 Upland Hunter

This terrestrial scenario is included here for completeness; it is not strictly applicable to the riparian concerns of the CRCIA. The river-based hunting scenarios (water fowl and bird eggs) are included in the River-Focused Fishing and Hunting Scenario below. The hunting scenario assumes that a fairly proficient hunter obtains 90 percent of the bag limit for various fowl and game species and also obtains some amount of non-game animals. If there are tribal exceptions to hunting seasons or bag limits, these should be included in future applications of this scenario. The ingestion rate of meat for the hunter is equal to the amount in the subsistence scenario, rather than being scaled proportionally to the number of days spent hunting, because the hunter stores some of the meat for winter use and trades or gives to someone else what the hunter does not eat. Of course, the hunter also eats plant material, but the purpose of this partial scenario is to determine how much exposure a person (plus his trade network) would receive while hunting.

Hunting is assumed to result in 150-days/year exposure for hunting for 70 years. Ingestion rates are 150 grams (5.6 ounces)/day animal protein and 18 grams (0.6 ounces)/day upland birds and some additional non-game animal intake, with no fish or vegetation intake. The other parameters remain the same as the subsistence scenario, except that the number of days spent hunting are used to estimate the frequency of soil, air, and water contact. Note that the precision implied by this time distribution is an artifact of the way it was developed; the times are used to represent an average over a 70-year lifetime.

Consumption of organs other than meat also must be considered. Additional parts of the animal besides muscle might be eaten and would result in additional exposures to contaminants that could accumulate in those tissues. For example, lipophilic substances accumulate in fatty tissues (skin, marrow), and many xenobiotics would be found in the liver. The tissue distribution of various materials needs to be reviewed in some detail to develop species-specific parameters for other organs. In addition, other parts of the animal have non-ingestion uses (skin, sinew, horns, etc.) that can result in additional human exposure if the animal is contaminated. These data gaps may be addressed in the future.

Two basic types of exposure might occur: both the hunter and the animal might come in direct contact with contaminated areas, or the animal might be exposed but the hunter might not or vice versa. Without such information as animal home range, both the hunter and animal are assumed to be exposed. Pasturing

might also be an upland activity and is not considered in the hunting scenario. If animals are pastured for consumption, this might involve irrigation as well. This scenario at present does not consider that any contact occurs with upland water (ponds, etc.). Except for differences indicated above, the rationale for the exposure parameter values used for the Upland Hunter Scenario, summarized in Table 5.8, is the same as for the values for the Subsistence Resident.

5.1.4.3 River-Focused Hunter and Fisher

This scenario includes river-based food pathways such as fishing, waterfowl hunting, and gathering waterfowl eggs. Exposure pathways include ingestion of fish, fowl, and eggs, and contact with surface water, sediment, and shoreline contamination. A person is assumed to spend 150 days per year engaged in these activities and to eat those items year-round for a lifetime of 70 years. Because this scenario is designed to answer questions about fishing and hunting, it does not include ingestion of plant materials, and, as with the other partial scenarios, does not assume that other river activities or any upland activities occur that result in additional exposures. Exposure to groundwater in springs is assumed to occur during those 150 days at daily contact rates similar to the subsistence scenario. Except for differences denoted above, the rationale for the exposure parameter values used for the River-Focused Hunter and Fisher Scenario, summarized in Table 5.9, is the same as for the values for the Subsistence Resident.

5.1.4.4 Gatherer of Plant Materials

This is a year-round scenario that includes gathering plants for foods, medicines, and crafted goods across all likely habitats (terrestrial, riparian, and wetlands) and preparing, using, and ingesting these materials. The gatherer is assumed to work 365 days/year for a 70-year lifetime with the same exposure parameters as the Subsistence Resident Scenario, but without the fish and game ingestion. This is a year-round scenario because while actual gathering might occur for the 270 frost-free days/year, cleaning and preparation of stored foods, crafting of materials into households goods, and year-round ingestion of stored foods occur daily. As with the Subsistence Resident Scenario, boating and swimming are assumed to occur 70 days/year.

This scenario needs much more consideration before it can be used beyond this screening assessment because of the complex ways that resources are used and recycled back into the environment. This is a particular concern for long-lived radionuclides and other persistent contaminants. Even a single resource might have a wide variety of ways for contamination to be transferred to people. The cattail provides an example. In the spring, the shoots are eaten, the roots are consumed, and the fibrous stalks are split, woven or twisted into baskets, mats, or cook hole layers. Later in the year, the pollen is used for breads. Each activity involves selecting and gathering the plants from marshy areas and sorting, cleaning, stripping, peeling, splitting, chewing, and using various parts of the plant. Cuts on the hands from sharp edges could facilitate dermal absorption; and, in addition to contacting the plant itself, the individual also comes in contact with sediment and water.

Table 5.8. Exposure Parameters for the Native American Upland Hunter Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion[a]	200 mg	20 - 500	150	100 - 270	70	1 - 70	--	--
	External	24 hr	12 - 24	150	100 - 270	70	1 - 70	0.8	Shielding parameter
	Dermal	1 mg/cm^2	0.5 - 5	150	100 - 270	70	1 - 70	5000 cm^2	Skin surface area
	Inhalation	30 m^3	20 - 35	150	100 - 270	70	1 - 70	100 µg/m^3	Air mass loading
Air	Inhalation	30 m^3	20 - 35	150	100 - 270	70	1 - 70	--	--
Seep/Spring Water	Ingestion	3 L	2 - 5	150	100 - 270	70	1 - 70	--	--
	External	1 hr	1 - 3	150	100 - 270	70	1 - 70	0.8	Shielding parameter
	Dermal[b]	1 hr	0 - 2	150	100 - 270	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[c]	1 m^3	0 - 2	150	100 - 270	70	1 - 70	0.1 L/m^3	Volatilization equivalent
Biota	Animal protein[d]	150 g	75 - 200	365	180 - 365	70	1 - 70	--	--
	Organs[e]	15 g	1 - 100	365	180 - 365	70	1 - 70	--	--
	Upland Birds	18 g	5 - 20	365	180 - 365	70	1 - 70	--	--

(a) Soil ingestion is typically separated into child (200 mg/d) and adult (100 mg/d) parameters, but considering the activities included in these scenarios, it seems reasonable to assume that the higher rate would persist throughout a lifetime.
(b) The dermal parameter for seep/spring water in HSRAM reflects bathing. For this scenario, seep/spring water is assumed to be encountered regularly while acquiring water.
(c) In HSRAM, seep/spring water use is a household scenario where inhalation comes from volatilization during showering and other household use. For this scenario, volatilization near the spring encountered while collecting water is assumed.
(d) The animal protein consumption rate includes meat, fat, and marrow, prepared fresh or dried. The equivalent fresh weight is given here.
(e) Approximated as 10 percent of the meat/fat ingestion value.

Table 5.9. Exposure Parameters for the Native American River-Focused Hunter and Fisher Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion[a]	200 mg	20 - 500	150	100 - 270	70	1 - 70	--	--
	External	24 hr	12 - 24	150	100 - 270	70	1 - 70	0.8	Shielding parameter
	Dermal	1 mg/cm^2	0.5 - 5	150	100 - 270	70	1 - 70	5000 cm^2	Skin surface area
	Inhalation	30 m^3	20 - 35	150	100 - 270	70	1 - 70	100 µg/m^3	Air mass loading
Air	Inhalation	30 m^3	20 - 35	150	100 - 270	70	1 - 70	--	--
Seep/Spring Water	Ingestion	3 L	2 - 5	150	100 - 270	70	1 - 70	--	--
	External	12 hr	1 - 24	150	100 - 270	70	1 - 70	0.8	Shielding parameter
	Dermal[b]	1 hr	0 - 2	150	100 - 270	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[c]	15 m^3	10 - 20	150	100 - 270	70	1 - 70	0.1 L/m^3	Volatilization equivalent
Surface Water	Ingestion	3 L	2 - 5	150	100 - 270	70	1 - 70	--	--
	External	2.6 hr	0.5 - 4	150	100 - 270	70	1 - 70	0.5	Geometry correction
	Dermal[d]	2.6 hr	1 - 4	150	100 - 270	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[e]	15 m^3	10 - 20	150	100 - 270	70	1 - 70	0.1 L/m^3	Volatilization equivalent
Sediment	Ingestion	200 mg	20 - 500	150	100 - 270	70	1 - 70	--	--
	External	12 hr	4 - 24	150	100 - 270	70	1 - 70	0.2	Geometry correction
	Dermal	1 mg/cm^2	0.5 - 5	150	100 - 270	70	1 - 70	5000 cm^2	Skin surface area
Biota[f]	Fish[g]	540 g	100 - 600	365	180 - 365	70	1 - 70	--	--
	Waterfowl	70 g	5 - 100	365	180 - 365	70	1 - 70	--	--
	Wild bird eggs	45 g	5 - 135	365	180 - 365	70	1 - 70	--	--

(a) Soil ingestion is typically separated into child (200 mg/d) and adult (100 mg/d) parameters, but considering the activities included in these scenarios, it seems reasonable to assume that the higher rate would persist throughout a lifetime.
(b) The dermal parameter for seep/spring water in HSRAM reflects bathing. For this scenario, seep/spring water is assumed to be encountered regularly while gathering roots.
(c) In HSRAM, seep/spring water use is a household scenario where inhalation comes from volatilization during showering and other household use. To the extent that analogous activities occur, this parameter is retained.
(d) For surface water, only swimming (2.6 hours/day) is included.
(e) For seep/spring water, exposures may still occur that are the equivalent of suburban household exposures.
(f) Foodchain pathways include deposition, soil uptake, and seep/spring water uptake, as well as aquatic pathways.
(g) Fish consumption includes multiple species and parts eaten, prepared both fresh and dried. Equivalent fresh weight is given here.

This scenario should include all of the ingested plant materials, but several specific pathways must be investigated in more detail, such as the variety of medicinal preparations and ways of administration (concentrated teas, poultices, etc.). The exposure parameter values used for this scenario in the screening assessment are summarized in Table 5.10.

5.1.4.5 Columbia River Island User

Discrete radioactive particles, primarily cobalt-60, have been found lodged in the sediment on islands and along the shores of the Columbia River (Sula 1980) and were identified as of interest to the screening assessment (see Section 2.0). The Columbia River Island User Scenario is based on Native American traditional uses of the island involving extended occupation and bases for fishing or other traditional uses. Within the basic scenario, several pathways are evaluated. These include ingesting a particle during incidental ingestion of small amounts of sediment, receiving direct external radiation exposure without contact, lodging a particle on the skin (dermal contact), and inhaling a particle. Except for the exposure parameters discussed below, the exposure parameters used for this scenario are per HSRAM (DOE 1995).

The time spent on the island is important in calculating the likelihood that a person will interact with a particle. For the screening assessment, a distribution of times is used. The distribution used assumes an individual spends a minimum of 4 hours and a maximum of 40 days on the island every year. The most likely value is 2 days. The rationale for the exposure parameter values for this scenario, summarized in Table 5.11, is as follows:

- **Sediment: Ingestion** - The individual is assumed to continue a child's ingestion rate of 200 milligrams/day (EPA 1991a) throughout life.

- **Sediment: External Radiation Exposure** - The individual is assumed to remain on the island during the occupancy period for 24 hours per day. No credit is assumed for shielding from direct irradiation other than that afforded by the distributed nature of the particles in soil.

- **Sediment: Dermal Contact** - Standard values are provided by HSRAM for uptake of soil onto skin (DOE 1995). Dermal contact of 0.2 mg/cm^2 is used. A distribution of the retention time of the soil on the skin is used. Soil is assumed to remain on the skin from 0 to 48 hours in a triangular distribution, with a most likely value of 2 hours. Exposed skin area is assumed to be at least 5000 cm^2 and ranges uniformly up to the total skin area of 20,000 cm^2.

- **Sediment: Inhalation** - Resuspension of soil with subsequent inhalation of the dust in the air is assumed to occur at all times while the person is onsite. The amount of resuspension is determined by using the mass loading approach based on an ambient air mass loading value of 100 $\mu g/m^3$, which is twice the EPA-recommended value for suburban areas (40 CFR 50.6b).

Table 5.10. Exposure Parameters for the Native American Gatherer of Plant Materials Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion[a]	200 mg	20 - 500	365	180 - 365	70	1 - 70	--	--
	External	24 hr	12 - 24	365	180 - 365	70	1 - 70	0.8	Shielding parameter
	Dermal	1 mg/cm^2	0.5 - 5	365	180 - 365	70	1 - 70	5000 cm^2	Skin surface area
	Inhalation	30 m^3	20 - 35	365	180 - 365	70	1 - 70	100 µg/m^3	Air mass loading
Air	Inhalation	30 m^3	20 - 35	365	180 - 365	70	1 - 70	--	--
Seep/Spring Water	Ingestion	3 L	2 - 5	365	180 - 365	70	1 - 70	--	--
	External	12 hr	1 - 24	365	180 - 365	70	1 - 70	0.8	Shielding parameter
	Dermal[b]	1 hr	0 - 2	365	180 - 365	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[c]	15 m^3	10 - 20	365	180 - 365	70	1 - 70	0.1 L/m^3	Volatilization equivalent
Surface Water	Ingestion	3 L	2 - 5	365	180 - 365	70	1 - 70	--	--
	External	2.6 hr	0.5 - 4	70	30 - 100	70	1 - 70	0.5	Geometry correction
	Dermal[d]	2.6 hr	1 - 4	70	30 - 100	70	1 - 70	20,000 cm^2	Skin surface area
	Inhalation[e]	15 m^3	10 - 20	70	30 - 100	70	1 - 70	0.1 L/m^3	Volatilization equivalent
Sediment	Ingestion	200 mg	20 - 500	270	100 - 365	70	1 - 70	--	--
	External	12 hr	4 - 24	270	100 - 365	70	1 - 70	0.2	Geometry correction
	Dermal	1 mg/cm^2	0.5 - 5	270	100 - 365	70	1 - 70	5000 cm^2	Skin surface area
Biota[f]	Fruit and vegetation	660 g	200 - 800	365	180 - 365	70	1 - 70	--	--

(a) Soil ingestion is typically separated into child (200 mg/d) and adult (100 mg/d) parameters, but considering the activities included in these scenarios, it seems reasonable to assume that the higher rate would persist throughout a lifetime.
(b) The dermal parameter for seep/spring water in HSRAM reflects bathing. For this scenario, seep/spring water is assumed to be encountered regularly while gathering roots.
(c) In HSRAM, seep/spring water use is a household scenario where inhalation comes from volatilization during showering and other household use. To the extent that analogous activities occur, this parameter is retained.
(d) For surface water, only swimming (2.6 hours/day) is included.
(e) For seep/spring water, exposures may still occur that are the equivalent of suburban household exposures.
(f) Foodchain pathways include deposition, soil uptake, and seep/spring water uptake, as well as aquatic pathways. Additional parameters also are relevant to human ingestion, such as additional plant parts used or eaten (and multiple parts per plant that rotate through the seasons), medicinal uses (infusions, teas, poultices, etc.), and other potential contact with people or their foods (food storage basketry, sleeping mats, extensive contact during basketmaking, and use of bones, feathers, and sinews).

Table 5.11. Exposure Parameters for the Native American Columbia River Island User Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency (days/year)**	**Exposure Frequency Range**	**Exposure Duration (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Sediment	Ingestion	200 mg	20 - 500	2	0.2 - 40	70	1 - 70	3.77 mrem/µCi	Dose conversion parameter for cobalt-60 particles
	External	24 hr	8 - 24	2	0.2 - 40	70	1 - 70	1.0	No shielding parameter
	Inhalation	30 m^3	10 - 30	2	0.2 - 40	70	1 - 70	100 µg/m^3	Air mass loading
	Dermal	2 hr	0 - 48 hr	2	0.2 - 40	70	1 - 70	20,000 cm^2 0.2 mg/cm^2	Skin surface area Dermal contact per skin surface area

The pollutant concentration in the particulate matter is assumed to be the same as the pollutant concentration in the soil. During the 24 hours onsite, the person is assumed to inhale 30 m^3 of air, which is 150 percent of the average value to account for a more active outdoor life style (EPA 1989).

5.1.5 General Population Scenarios

In the CRCIA screening assessment, two general population scenarios were assessed for risk: a Resident Scenario and an Agricultural Resident Scenario. Except for the differences indicated below, the parameters used for both of these scenarios are from HSRAM (DOE 1995).

5.1.5.1 Resident

Residential land use of the Hanford Site does not currently occur and does not appear likely in the foreseeable future (DOE 1990). However, because residences are currently located downwind, down river, and in the vicinity of the Site, the Resident Scenario is included in the screening assessment. Current residential exposures are primarily limited to contaminant levels measured in offsite air, water, and sediment and in some biota such as fish or wildlife. If residential use occurs in the future, onsite biota would also have the potential for exposure to soil and seep/spring water.

A residential scenario was developed in HSRAM (DOE 1995) to evaluate the risk associated with common residential activities. In the residential scenario, individuals reside year-round at the specified location with concurrent exposure to contaminants in soil and sediment and exposures through incidental ingestion of soil, sediment, and water. The individual also catches fish from the river and tends a small garden that provides limited supplies of fruit and vegetables.

All parameters in the scenario have been adapted from the HSRAM (DOE 1995) tables but made internally consistent. For example, the breathing rates have been standardized at 20 m^3/day and the drinking of river and spring water standardized at 2 liters (2.1 quarts)/day. Ingestion and dermal exposures to sediment have been established to correspond with the time spent swimming in the river (EPA 1992). The volatilization equivalent for inhalation of seep/spring and surface water is based on Andelman (1990). The parameters for this scenario are provided in Table 5.12.

5.1.5.2 Agricultural Resident

The Columbia Basin area is extensively farmed. The HSRAM (DOE 1995) established an Agricultural Resident Scenario to account for potentially increased exposures as a result of living on a farm affected by Hanford contaminants. The Agricultural Resident Scenario is very similar to the Residential Scenario with increases in the quantity of locally produced food and animal products.

All parameters in the scenario have been adapted from the HSRAM (DOE 1995) tables but made internally consistent. For example, the breathing rates have been standardized at 20 m^3/day and the drinking of river and spring water standardized at 2 liters/day. Ingestion and dermal exposures to

Table 5.12. Exposure Parameters for the Resident Scenario

Pathway		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate[a] (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency[b] (days/year)**	**Exposure Frequency Range**	**Exposure Duration[a] (year)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	200 mg (C) 100 mg (A)	20 - 500 10 - 150	365	270 - 365	6 (C) 24 (A)	1 - 6 1 - 64	--	--
	External	24 hr	8 - 24	365	270 - 365	30	1 - 70	0.8	Shielding parameter
	Dermal	0.2 mg/cm^2	0.05 - 0.5	180	100 - 365	30	1 - 70	5000 cm^2	Skin surface area
Air	Inhalation	20 m^3	15 - 30	365	270 - 365	30	1 - 70	--	--
Seep/Spring Water	Ingestion	2 L[b]	0 - 3	365	270 - 365	30	1 - 70	--	--
	Dermal	0.17 hr	0 - 1	365	270 - 365	30	1 - 70	20,000 cm^2	Skin surface area
	Inhalation	15 m^3[c]	10 - 20	365	270 - 365	30	1 - 70	0.1 L/m^3	Volatilization equivalent
Surface Water	Ingestion	2 L[b]	0 - 3	365	270 - 365	30	1 - 70	--	--
	Dermal/showering	0.17 hr	0.1 - 1	365	270 - 365	30	1 - 70	20,000 cm^2	Skin surface area
	Dermal/swimming	2.6 hr	0 - 8	7	1 - 20	30	1 - 70	20,000 cm^2	Skin surface area
	Inhalation	15 m^3[c]	10 - 20	365	270 - 365	30	1 - 70	0.1 L/m^3	Volatilization equivalent
Sediment	Ingestion	200 mg (C) 100 mg (A)	20 - 500 10 - 150	7	1 - 20	6 (C) 24 (A)	1 - 6 1 - 64	--	--
	Dermal	0.2 mg/cm^2	0.05 - 0.5	7	1 - 20	30	1 - 70	5000 cm^2	Skin surface area
Biota	Fish	54 g[d]	0 - 100	365	270 - 365	30	1 - 70	0.5	Diet fraction
	Fruit	42 g[e]	0 - 100	365	270 - 365	30	1 - 70	--	--
	Vegetable	80 g[e]	0 - 200	365	270 - 365	30	1 - 70	--	--

(a) Parameters recommended in EPA (1991a) except as noted.
(b) Parameters recommended in WAC (1991) (sects.720, 740, 750, Method B) except as noted.
(c) Indoor inhalation rate (EPA 1991a).
(d) Parameter recommended in WAC (1991) (sect. 730).
(e) Based on wet weight (EPA 1991a).

C = Child
A = Adult

sediment have been established to correspond with the time spent swimming in the river (EPA 1992). The volatilization equivalent for inhalation of seep/spring and surface water is based on Andelman (1990). The parameters for this scenario are provided in Table 5.13.

5.2 Results: Human Risk Screening Assessment

The results of the screening assessment of human risk were estimated by putting the monitoring data (Section 3.0), the results of the ecological screening assessment (Section 4.2), and the parameters of the human scenarios (Section 5.1) into a computer model. This section provides the calculations used in the model and the resulting estimated risk to humans from the Columbia River.

To estimate the potential risk to human health, we put the data described in Section 3.0, the ecological risk results described in Section 4.2, and the parameters for the scenarios described in Section 5.1 into a computer model. The computer model consisted of a series of equations that estimated risk. 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. The results are the possible risk to humans from the Columbia River.

The contaminants assessed fall into one of three categories: carcinogenic chemicals, toxic chemicals, and radionuclides. Because the three categories of contaminants result in different types of risk, the estimates for each category are reported differently. The estimates for carcinogenic chemicals are reported as the probability of the incidence of cancer. The estimates for toxic chemicals are reported as a ratio (a hazard index) between the reference dose determined by EPA to be safe and the dose that has been estimated. The estimates for radionuclides are reported as the risk of cancer fatality.

5.2.1 Exposure Equations

The exposure equations described in this section were used to assess human risk at a screening level. The parameters in the various scenarios were used in these equations, which were based on the exposure routes: external radiation, dermal, inhalation, and ingestion. These exposure equations were adapted and expanded from those in Appendix I-D of the Hanford Site Risk Assessment Methodology (HSRAM) (DOE 1995). The same notation and terminology were used for consistency with HSRAM. Additions (described in Section 5.1) were made to the equations to make them more directly applicable to the CRCIA screening assessment scenarios. The equations also were revised so that the risk from each of the media to which people might be exposed could be reported separately. Therefore, the equations are presented in two forms here: the first in conventional pathway analysis format and the second in a media analysis format. The presentations are equivalent in that the theory and results are the same. The first presentation is for anyone interested in the overall exposure. The second is anyone interested in the details of the assessment.

Table 5.13. Exposure Parameters for the Agricultural Resident Scenario

Pathways		Exposure Parameters							
Media	**Exposure Route**	**Intake/Contact Rate[a] (per day)**	**Intake/Contact Rate Range Min - Max**	**Exposure Frequency[b] (days/year)**	**Exposure Frequency Range**	**Exposure Duration[a] (years)**	**Exposure Duration Range**	**Other Parameters**	**Other Parameter Definitions**
Soil	Ingestion	200 mg (C) 100 mg (A)	20 - 500 10 - 150	365	270 - 365	6 (C) 24 (A)	1 - 6 1 - 64	--	--
	External	24 hr	8 - 24	365	270 - 365	30	1 - 70	0.8	Shielding parameter
	Dermal	0.2 mg/cm^2	0.05 - 0.5	180	100 - 365	30	1 - 70	5000 cm^2	Skin surface area
Air	Inhalation	20 m^3	15 - 30	365	270 - 365	30	1 - 70	--	--
Seep/Spring Water	Ingestion	2 L[b]	0 - 3	365	270 - 365	30	1 - 70	--	--
	Dermal	0.17 hr	0 - 1	365	270 - 365	30	1 - 70	20,000 cm^2	Skin surface area
	Inhalation	15 m^3[c]	10 - 20	365	270 - 365	30	1 - 70	0.1 L/m^3	Volatilization equivalent
Surface Water	Ingestion	2 L[b]	0 - 3	365	270 - 365	30	1 - 70	--	--
	Dermal/showering	0.17 hr	0.1 - 1	365	270 - 365	30	1 - 70	20,000 cm^2	Skin surface area
	Dermal/swimming	2.6 hr	0 - 8	7	1 - 20	30	1 - 70	20,000 cm^2	Skin surface area
	Inhalation	15 m^3[c]	10 - 20	365	270 - 365	30	1 - 70	0.1 L/m^3	Volatilization equivalent
Sediment	Ingestion	200 mg (C) 100 mg (A)	20 - 500 10 - 150	7	1 - 20	6 (C) 24 (A)	1 - 6 1 - 64	--	--
	Dermal	0.2 mg/cm^2	0.05 - 0.5	7	1 - 20	30	1 - 70	5,000 cm^2	Skin surface area
Biota	Fish	54 g[d]	0 - 100	365	270 - 365	30	1 - 70	0.5	--
	Fruit	42 g[e]	0 - 200	365	270 - 365	30	1 - 70	--	--
	Vegetable	80 g[e]	0 - 300	365	270 - 365	30	1 - 70	--	--
	Deer	15 g[f]	0 - 100	365	270 - 365	30	1 - 70	0.19	--
	Beef	75 g	0 - 150	365	270 - 365	30	1 - 70	--	--
	Dairy	300 g	100 - 1000	365	270 - 365	30	1 - 70	--	--

(a) Parameters recommended in EPA (1991a) except as noted.
(b) Parameters recommended in WAC (1991a) (sects. 720, 740, 750, Method B) except as noted.
(c) Indoor inhalation rate (EPA 1991).
(d) Parameters recommended in WAC (1991a) (173-340-730.)
(e) Based on wet weight (EPA 1991a).
(f) Intake adjusted for upperbound hunter success rate of 19 percent for game management unit 370.

C = Child
A = Adult