

## **Exposure Scenario for CTUIR Traditional Subsistence Lifeways**

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# 1. Introduction

This report presents the updated exposure factors for the CTUIR exposure scenario. Some of the exposure factors in the original reference (Harris and Harper, 1977) were updated in the Spokane Tribe's scenario (Harper et al., 2002). The present report includes those updated exposure factors and further research.

## 1.1 Basis

The scenario reflects a traditional cultural subsistence lifestyle. Information on the CTUIR eco-cultural lifestyle has been presented previously, and is summarized as follows.

The CTUIR culture, which has co-evolved with nature through thousands of ecological education, has provided its people with their traditional environmental knowledge. Throughout the year, when the CTUIR traditional American Indian participates in activities such as hunting and gathering for foods, medicines, ceremonies, and subsistence, the associated activities are as important as the end product. All of the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one, but more often in many ways. The people of the CTUIR community follow cultural teachings brought down through history from the elders. Our individual and collective well-being is derived from membership in a healthy community that has access to ancestral lands and traditional resources and from having the ability to satisfy the personal responsibility to participate in traditional community activities and to help maintain the spiritual quality of our resources. This is an ancient oral tradition of cultural norms. The material or fabric of this tradition is unique, and is woven into a single tapestry that extends from far in the past to long into the future. In order to encompass the wide range of factors directed tied to the traditional American Indians of the CTUIR, a risk assessment has to be designed and scaled appropriately (Harris, 1998).

EPA is required to identify populations who are more highly exposed; for example, subsistence populations and subsistence consumption of natural resources (Executive Order 12898<sup>1</sup>). EPA is also required to protect sensitive populations.<sup>2</sup> Some of the factors known to increase sensitivity include developmental stage, age (very young and very old), gender, genetics, and health status<sup>3</sup>, and this is part of EPA's human health research strategy.<sup>4</sup>

"The Superfund law requires cleanup of the site to levels which are protective of human health and the environment, which will serve to minimize any disproportionately high and adverse environmental burdens impacting the EJ community"<sup>5</sup>.

CERCLA ARARs include Treaties such as the Migratory Bird Treaty Act of 1918, 16 U.S.C. § 703 et seq. Therefore, CTUIR believes that other Treaties, including the Treaty of 1855, are ARARs as well. In addition, the situation that existed when Hanford was established

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<sup>1</sup> White House, 1994. Federal Actions To Address Environmental Justice In Minority Populations And Low income Populations: Feb. 11, 1994; 59 FR 7629, Feb. 16, 1994.

<sup>2</sup> *Superfund Exposure Assessment Manual*. EPA/540/1-88/001 OSWER directive 9285.5-1. U.S. Environmental Protection Agency Office of Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. 1988.

<sup>3</sup> [http://www.epa.gov/nheerl/research/childrens\\_health.html](http://www.epa.gov/nheerl/research/childrens_health.html)

<sup>4</sup> EPA/600/R-02/050, September 2003 (posted at <http://www.epa.gov/nheerl/publications/>).

<sup>5</sup> <http://www.epa.gov/region02/community/ej/superfund.htm>

included CTUIR members living in permanent fishing villages along the Hanford Reach. This scenario reflects that fact.

Section 120(a)(2) of CERCLA provides that all guidelines, rules, regulations, and criteria for preliminary assessments, site investigations, National Priorities List (NPL) listing, and remedial actions are applicable to federal facilities to the same extent as they are applicable to other facilities. No federal agency may adopt or utilize any such guidelines, rules, regulations, or criteria that are inconsistent with those established by EPA under CERCLA.<sup>6</sup>

CTUIR believes that this CERCLA language means that DOE and USFWS cannot abrogate the Treaty of 1855 by developing land use plans that do not include the exercise of Treaty rights where they existed before Hanford was established, or do not recognize case law such as fishing and hunting rights cases.

## 1.2 Scenario Construction

This scenario was developed in a manner consistent with CERCLA guidance<sup>7</sup> and the EPA Exposure Factors Handbook.<sup>8</sup> Constructing these scenarios requires a basic understanding of the subsistence (or traditional) lifestyle. What do “subsistence” and “tradition” mean with respect to exposure scenarios? Traditional lifestyles are often misunderstood to be a recreational (e.g. sport hunting) supplement to an otherwise suburban scenario, rather than being an entire cultural/spiritual lifestyle inextricable from the environment. Another misconception is that some activities are ‘cultural’ or ‘religious’ while others are secular and optional. This leads to flawed concepts, for instance, that only ceremonial meals are cultural, while all others are merely nutritional and therefore a personal preference or lifestyle choice. To the contrary, in a traditional lifestyle all food has both nutritional and spiritual benefits, and all activities have practical survival as well as spiritual aspects. Therefore, our exposure scenarios do not separate exposure factors into cultural or residential subsets.

The exposure scenario reflects a traditional subsistence lifestyle. “Subsistence” refers to the hunting, fishing, and gathering activities that are fundamental to the way of life of many indigenous peoples. Subsistence utilizes traditional, small-scale technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. Because it is often misinterpreted, an explanation of “subsistence” is taken from the National Park Service:

“While non-natives tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. It defines who they are as a people. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. While it is important to the economic well-being of their communities, the subsistence lifestyle is also the basis of cultural existence and survival. It is a communal activity. It unifies communities as cohesive functioning units through collective production

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<sup>6</sup> 40CFR300 National Oil and Hazardous Substances Pollution Contingency Plan, Preamble  
<http://www.epa.gov/superfund/action/guidance/remedy/pdfs/ncppreamble61.pdf>

<sup>7</sup> EPA Risk Assessment Guidance for Superfund, several volumes at  
<http://www.epa.gov/superfund/programs/risk/toolth.htm>.

<sup>8</sup> EPA (1997). *Exposure Factors Handbook*, EPA/600/P-95/002Fa, <http://www.epa.gov/ncea/pdfs/efh/sect5.pdf>

and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Most require young hunters to distribute their first catch throughout the community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources. This relationship is portrayed in native art and in many ceremonies held throughout the year.”<sup>9</sup>

In economic terms, a subsistence economy is one in which currency is limited because many goods and services are produced and consumed by the same families or bands. Today, currency (inedible symbols of specified quantities of useful resources) is limited, but important.

“The modern-day subsistence family depends on the tools of the trade, most of which are expensive. Snowmobiles, gasoline, guns, fishing nets, and sleeping bags are necessities. Subsistence households also enjoy many of the modern conveniences of life, and are saddled with the economic demands which come with their acquisition. Today's subsistence family generates much-needed cash as wage-labourers, part-time workers and trappers, professional business people, traditional craftmakers, and seasonal workers. A highly-integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors has evolved.”<sup>10</sup>

Once the activities comprising a particular subsistence lifestyle are known, they are translated into a format that is used for risk assessment. This translation captures the degree of environmental contact that occurs through activities and diet, expressed as numerical “exposure factors.” Direct exposure pathways include exposure to abiotic media (air, water, and soil), which can result in inhalation, soil ingestion, water ingestion, and dermal exposure. Indirect pathways refer to contaminants that are incorporated into biota and subsequently expose people who ingest or use them. There are also unique exposure pathways that are not accounted for in scenarios for the general public, but may be significant to people with certain traditional specialties such as pottery or basket making, flint knapping, or using natural medicines, smoke, smudges, paints and dyes. These activities may result in increased dust inhalation, soil ingestion, soil loading onto the skin for dermal exposure, or exposure via wounds, to give a few examples. While the portals of entry into the body are the same (primarily via the lungs, skin, mouth), the amount of contaminants may be increased, and the relative importance of some activities (e.g., basketmaking, wetlands gathering), pathways (e.g., steam immersion or medicinal infusions) or portals of entry (e.g., dermal wounding) may be different than for the general population.

Together, this information is then used to calculate the direct and indirect exposure factors. This process follows the general sequence:

1. Environmental setting – identify what resources are available;
2. Lifestyle description – activities and their frequency, duration and intensity, and uses of natural resources;
3. Diet (indirect exposure factors);
4. Pathways and media;

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<sup>9</sup> National Park Service: [http://www.cr.nps.gov/aad/cg/fa\\_1999/Subsist.htm](http://www.cr.nps.gov/aad/cg/fa_1999/Subsist.htm)

<sup>10</sup> <http://arcticcircle.uconn.edu/NatResources/subsistglobal.html>

5. Exposure factors - Crosswalk between pathways and direct exposure factors; cumulative soil, water and air exposures.

Traditional or subsistence scenarios are similar in format to existing residential recreational, or occupational exposure scenarios, but reflect and are inclusive of tribal cultural and lifestyle activities. They are comprised of:

1. standard exposure pathways and exposure factors (such as inhalation or soil ingestion but with increased environmental contact rates),
2. traditional diets composed of native plants and animals possibly supplemented with a home garden, and
3. unique pathways such as the sweatlodge.

Tribal exposure scenarios pose a unique problem in that much of the specific cultural information about the uses of plants and animals for food, medicine, ceremonial, and religious purposes is proprietary. Therefore, the challenge to the scenario developer is to ensure that all human exposures received during the procurement and use of every resource are accounted for without revealing confidential information. Risk assessment methods are fairly qualitative and high-level. Risk assessment exposure equations require simple summary input parameters. For example, the dietary portion of CERCLA risk assessments is quite general (fish, meat, above-ground and below-ground vegetation, or root-fruit-leafy plants, sometimes with a little more detail), and typically uses generic soil-to-plant transfer factors that are not species specific. Therefore, the choices for the risk assessor are:

(1) to create an encyclopedia of activities and resources, and then perform thousands of exposure calculations based on the myriad of activities and the typical 200+ species used in a subsistence lifestyle, and then sum the exposures with the knowledge that the species and activity lists are inevitably incomplete and probably include proprietary information. Further, species-specific uptake information is lacking so generic assumptions are used.

(2) to sum intakes of long lists of species into single global intakes of above- and below-ground plants before applying generic uptake or bioconcentration factors, thus losing any detail that had been achieved by developing the long lists.

(3) using representative species and ignoring other members of each trophic level or feeding guild and the details of different uses, preparation methods, and so on (for example; using an estimate that a hunter obtains x number of deer per year while ignoring other large and small game, the different parts consumed, and losing the whole-diet and multiple-uses concepts).

(4) asking a Tribe to identify a few areas and species that are particularly important, and doing the risk assessment only for those areas and species, thus losing all cumulative perspective of the lifestyle and the risks it could pose.

(5) ensuring that all potential species and their uses are accounted for by taking a top-down rather than bottom-up (inventory or encyclopedia) approach, with staple resources representing classes of resources such that a full-calorie diet is achieved and 24 hours per day are accounted for.

We have chosen the last option based on a decade of experience. This is the level of detail that a risk assessment can handle, does not waste time by constructing long lists of species that are simply rolled up into global sums, includes a consideration of all species and variations on their uses, and avoids revealing proprietary information. It is also comparable to the feeding guild approach to ecological risk assessments, and allows an easier use of the results of the ecological risk assessment as input to the native diet portion of the human risk assessment.

The process for ensuring a full accounting of species, uses, and environmental contacts are presented in the following sections. The summary exposure factors are then compared to literature and guidance for further documentation. Because the primary exposure factors are larger than EPA typically uses, extensive documentation is included in appendices.

## 2. Assumptions and Approach

This scenario reflects an active, outdoor lifestyle with a subsistence economic base. Subsistence food sources include gathering, gardening, hunting, pasturing livestock, and fishing. The forager relies all or in part on native foods and medicines, while the residential farmer relies on domesticated but self-produced foods. Thus, the CTUIR scenario is at the foraging end of the subsistence spectrum, while the residential farmer is at the domesticated end of the subsistence spectrum. Both are active, outdoor lifestyles, and are consistent with the reasonable maximum exposure (RME) approach to baseline risk assessment.

This is a full-time multipathway scenario, to be applied within each area being assessed, consistent with EPA guidance on performing baseline risk assessments. The purpose of CERCLA baseline risk assessments is to evaluate the risks that would occur to a person engaging in defined sets of activities *absent* land use restrictions. It reflects the activities that the person would engage in if the site were not contaminated. Therefore, a baseline risk assessment is applied irrespective of possible institutional controls or other restrictions that may be needed as part of the remedy in order to protect human health.

Unrestricted access is the typical baseline risk assessment “no action” scenario. This includes CTUIR residence, because permanent year-round fishing villages with resident CTUIR members were present along the Hanford Reach when Hanford was established. This scenario is not a visiting scenario like a recreational scenario. It is a full-time scenario. This means that the forager may obtain a site-specific percentage of his and her food from an irrigated garden to supplement the native plants in his or her diet. The ratio of gathered to grown plants will vary with the size and resources of the assessment area, as will the ratio of game to livestock, upland to riparian resources, and so on. The forager also uses a well and/or seep and/or river for drinking water, sweat lodge water, and irrigation, also consistent with the general CERCLA principles of evaluating reasonable maximum exposures.

Exposure factors for the traditional CTUIR lifestyle are presented below. One of the key misunderstandings is how a subsistence lifestyle can be applied to a constrained area. The risk assessment methodology uses an interface between lifestyle and contamination termed an exposure point concentration. The guidance for risk assessment is to assume that the RME individual is constrained to the area being assessed (for subsistence or residential scenarios), or receives exposures only during visits to the area being assessed (for recreational or occupational scenarios). The subsistence scenario is not to be divided into partial scenarios, such as upland hunting or localized gathering, unless those are also complete scenarios, accounting for a full life but with emphasis on a specialized activity (e.g., the subsistence person who specializes in fishing for himself and others and trades fish for game and plants, or the subsistence person who specializes in gathering food and medicinal plants and materials and trades those items for fish and game).

## 2.1 Major Activities

A description of activities for the purposes of developing exposure factors includes parameters describing:

- Frequency of activity
  - Daily, weekly, monthly
- Duration of activity
  - Hours at a time
  - Number of years
- Intensity of environmental contact and intensity of activity
  - For soil ingestion and dermal exposure, is the activity more than, less than, or equal to gardening, camping, construction/excavation, or sports?
  - For inhalation rates and calorie needs, is the activity level more than, less than, or equal to standard EPA activity levels for specific activities with known respiration rates and caloric expenditure?

A brief description of major activities in the subsistence lifestyle is presented here (Table 1). This table and the following material is presented to explain the complexity and variety of activities involved in each activity. It is not really possible to separate “hunting” from other activities, since hunting is simply part of living, just as going to the grocery store is part of suburban living. However, we have found it useful to explain some aspects of the lifestyle because this sets the stage for developing exposure factors.

Table 1. Major Activity Categories

<b>Activity Type</b>	<b>General Description</b>
<b>Hunting</b>	Hunting includes a variety of preparation activities of low to moderate intensity. Hunting occurs in terrain ranging from flat and open to very steep and rugged. It may also include setting traplines, waiting in blinds, digging, climbing, etc. After the capture or kill, field dressing, packing or hauling, and other very strenuous activities occur, depending on the species. Subsequent activities include cutting, storing (e.g., smoking or drying), etc.
<b>Fishing</b>	Fishing includes building weirs and platforms, hauling in lines and nets, gaffing or gigging, wading (for shellfish), followed by cleaning the fish and carrying them to the place of use. Activities associated with smoking and constructing drying racks may be involved.
<b>Gathering</b>	A variety of activities is involved in gathering, such as hiking, bending, stooping, wading (marsh and water plants), digging, and carrying.
<b>Sweatlodge Use</b>	Sweatlodge building and repairing is intermittent, but collecting firewood is a constant activity.
<b>Materials and Food Use</b>	Many activities of varying intensity are involved in preparing materials for use or food storage. Some are quite vigorous such as pounding or grinding seeds and nuts into flour, preparing meat, and tanning hides. Many others are semi-active, such as basket making, flintknapping, construction of storage containers, cleaning village sites, sanitation activities, home repairs, and so on.

The following figure lists some of the activities involved in the major categories. The purpose of this figure is to show that many activities are involved in major activity categories, and that resources and activities are interlinked. For instance, materials gathered in one area may be required to construct implements (such as baskets) used when gathering in a second location, or a hide must be brain-tanned to make a drum head to sing the songs required for ceremonies in preparation for fishing.

**Figure 1. Traditional Lifeways – Typical activities in the activity categories.**

<b><i>Hunting</i></b>	<b><i>Sweatlodge</i></b>	<b><i>Gathering</i></b>	<b><i>Fishing</i></b>
<i>Learn skills, TEK</i>	<i>Learn skills, songs</i>	<i>Learn skills, TEK</i>	<i>Learn skills, TEK</i>
<i>Making tools</i>	<i>Build lodge from natural materials</i>	<i>Previous gathering</i>	<i>Make nets, poles, platforms, tools</i>
<i>Sweat Purify</i>	<i>Gather rocks</i>	<i>Make baskets, bags</i>	<i>Travel to location</i>
<i>Vigorous activity in hunting</i>	<i>Chop firewood</i>	<i>Hike to areas</i>	<i>Catch fish, haul out</i>
<i>Pack meat out</i>	<i>Prepare for use, get water</i>	<i>Cut, dig, harvest</i>	<i>Clean, can, hard dry, soft dry, smoke, eat whole fish or fillet or liver or soup</i>
<i>Process</i>	<i>Use Lodge, sing, drink water, inhale steam and smudges</i>	<i>Carry out items</i>	<i>Return carcasses to ecosystem, use as fertilizer</i>
<i>Scrape hides</i>		<i>Wash, peel, process, split, spin, dye</i>	
<i>Tan, use other parts</i>	<i>Close area &amp; fire</i>	<i>Cook and eat or make product or make medicine</i>	
<i>Cook, smoke, dry, eat meat and organs</i>			
<i>Diff. habitats</i>			

Table 2 shows the thought process in cross-walking activity categories with exposure pathways and media in order to develop exposure factors. Because exposure factors are specific to media and exposure pathways (via portals of entry into the body), they must sum across activities. The basic process is to sum inhalation rates according to the amount of time spent in each activity. The time or activity profile is presented in the next section; Table 2 shows the thought process and identifies some of the factors that must be considered to ensure that the complexity of activities and diversity of resources are accounted for.

**Table 2. Examples of factors to consider within major activity categories.**

This is not a complete listing; it is an example of the thought process used to cross-walk exposure pathways and categories of subsistence activities.

	<i>Hunting and associated activities</i>	<i>Fishing and associated activities</i>	<i>Gathering and associated activities</i>	<i>Sweatlodge and associated activities</i>	<i>Material and food use and processing</i>	<i>Totals for major exposure factor categories</i>
<b>Indirect pathways - food, medicine, tea, other biota ingestion (diet)</b>	<i>n</i> deer /yr diet; Total large-small game, fowl. Organs eaten	<i>n</i> fish /yr diet; Total pounds or meals/day-wk-yr; Organs eaten.	Includes foods, medicines, teas, etc.	No food, but herbal particulates are inhaled.	Both as-gathered and as-eaten forms; cleaning and cooking methods.	Must account for all calories and 100-200 plant species; parts eaten
<b>Soil, sediment, dust, and mud ingestion</b>	Terrain types; Degree of dermal contact; How much dirt and mud.	Sediment contact, dust and smoke if drying; weir construction in mud.	External soil on plants; cooking method such as pit cooking; ingestion when gathering.	Includes building the sweat lodge and getting materials..	Includes incidental soil remaining on foods; pit cooking	Must consider living area, roads, and gap identification.
<b>Inhalation rates</b>	Days per terrain; Exertion level; hide scraping; load & grade.	Exertion level – nets and gaffing methods; cleaning effort.	Exertion level for load and grade; or gardening. Include making items.	Includes building the lodge, chopping firewood, singing.	Exertion level for pounding, grinding, etc.	Must account for exertion levels; smokes and smudges.
<b>Groundwater and Surface water pathways</b>	Drinking water; wash water; water-to-game pathways.	Drinking water; incidental ingestion	Drinking water, cooking water, etc.	Steam in lodge; drinking water during sweat.	Soaking, possibly other uses.	Must account for climate, sweat lodge, ritual bathing.
<b>Dermal exposure</b>	Soil, air and water pathways, plus pigments etc.	Immersion considerations.	Same as hunting.	Immersion with open skin pores.	Includes basketmaking, wounds.	Must consider skin loading and habitat types.

## 2.2 The Family, The Day, and The Lifetime

This section describes a family-based exposure scenario based on traditional CTUIR lifestyles and diets. Only the fish-based diet is discussed here, since it is to be applied within 20 miles of a major fishing river. It is based on habits of members who live in the sagebrush steppe, gather native foods supplemented with a home garden, have a high rate of subsistence activities, have a regular schedule of other cultural activities, and work as field workers monitoring natural and cultural resources, taking environmental samples, and doing reclamation or restoration work. The lifestyles are moderately active outdoor lifestyles, with daily sweat lodge use.

### 2.2.1 Lifestyle of a Representative Traditional CTUIR Family

The families are intended to be reasonable composites. Each family includes an infant/child (age 0-2 years) who breastfeeds for two years and crawls and plays; a child (age 2-6) who plays in the house and outdoors, a youth (age 7-16) who attends school, plays outdoors near his/her residence, and is learning traditional practices; two adult workers (one male, one female, age 17-55; the female breastfeeds the infant) who work outdoors on reclamation and environmental and cultural activities and who also engage in subsistence activities; and an elder (age 56-75) who is partly at home and partly outdoors teaching and demonstrating traditional cultural practices. All members (except the infant from 0 - 2 years) partake in family sweat lodge use and in cultural activities throughout the year.

**Location and Type of Residence.** The residence is located within the assessment area. The family lives in a house with little or no landscaping other than the natural vegetation. Each house has its own well for domestic use and a garden irrigated with groundwater or surface water (whichever is more contaminated). This is not a fully traditional pit house or tule mat house, but a typical reservation-quality house, with seasonally open windows. The road and driveway are not paved.

### 2.2.2 Activity Patterns of Each Family Member

**Infant.** The infant breast-feeds for 2 years, and crawls on the floor (with housedust exposure) from age 6 months to 2 years. Infants ingest more fluid per body weight than children do, and toddlers (6 months to 2 years) are likely to have the highest of the children's exposures due to crawling and mouthing behaviors, and their higher food and water per capita ingestion rates.

**Child (ages 2-6 years).** Beginning at age 2, the child eats the same food as everyone else, participates in family sweat lodge, and spends some time accompanying the mother as she gardens and gathers.

**Youth (ages 7-16).** The adolescent is learning to hunt, gather, and fish (and spends equal time in each activity in their respective locations), plays outdoors, and attends school.

**Adult Worker (ages 17-55).** Workers are assumed to work for the Tribe collecting environmental samples, engaging in restoration/remediation or construction work, and

carrying for natural and cultural resources and tribal property. This type of activity is dusty in the summer and muddy in the winter. Both males and females are currently employed in this type of activity. Workers could be exposed to external irradiation, surface soil and dust, vegetation, surface water, sediments, seeps, and radon and daughter products in outdoor air and water. These workers have an average 8-hour workday.

**Adult Hunter/Fisher/Gatherer.** Each adult also hunts (male), fishes (male), or gardens and gathers plants (female). These activities are roughly analogous with respect to environmental contact, and therefore are assumed to result in the same amount of soil ingestion and so on for males and females. The additional time and contact during game processing, plant washing and preparation, and so on are also roughly equal. The location of hunting small game or fowl is in the same area as the residence, and the location of big game hunting covers a larger area, although the livestock are located in the same area as the residence. The time spent hunting or fishing versus livestock tending is proportional to the diet and the size of the assessment area. The garden is at the place of residence and uses the same water as the household, while the gathering occurs in a larger area, also proportional to the size of the assessment area. All of the hunters, gatherers and fishers spend some time near water, if it is present in the area, on activities such as washing plants or game, gathering aquatic plants and mollusks/crustacean, and so on, with concomitant exposure to mud or sediment.

**Elder (ages 56-75).** The elder gathers plants and medicines, prepares them, uses them (e.g., making medicines or baskets, etc.) and teaches a variety of indoor and outdoor traditional activities. The elder also provides childcare in the home.

**Sweat Lodge Use (ages 2-75).** The daily use of the sweat lodge is an integral part of the lifestyle that starts at age 2. Sweat lodge construction has been described in the open literature. Although the details vary among tribes and among individual families, they are generally round structures (6 feet in diameter for single-family use) constructed of natural materials (i.e. branches, moss, leaves with a dirt floor covered with mats or cedar boughs) near a source of surface or groundwater. A nearby fire is used to heat rocks that are brought into the sweat lodge. Water (4L) is poured over the rocks to form steam (a confined hemispheric space with complete evaporation of the water which is available for inhalation and dermal exposure over the entire skin area). Either groundwater or surface water may be used. Inhalation and heart rates may be higher depending on activities that occur during the sweat lodge ceremony (e.g. singing).

**Cultural Activities.** All persons participate in day-long outdoor community cultural activities once a month, such as pow-wows, horse races, and seasonal ceremonial and private cultural activities (together averaging about 0.5 hours/day). These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. Individuals also tend to be active, resulting in a greater inhalation and water ingestion rates.

**Seasonality.** The changes in activity patterns over the annual seasonal cycle has been modified in modern times, but the ecological cycle has not, so people must still gather plants according to when they are ripe, hunt according to game and fowl patterns, and fish when the spawning runs occur. Items are gathered during a harvest season for year-round use. While specific activities change from season to season, they are replaced by other activities with a similar environmental contact rate. For instance, a particular plant may be gathered during one month, while another month may be spent hunting, and a winter month may include cleaning and using the items obtained previously. Therefore, since we are

assuming that all activities are roughly equal, there is no decrease in environmental contact rates during winter months.

**Special Activities.** It is recognized that there are special circumstances when some people may be highly exposed (and their exposure would be underestimated). For instance, some men hunt or fish for the general community, and many people provide roots and fish and game to elders in addition to their own families. Flintknappers may receive additional exposure through obtaining and working with their materials. Healers handle pharmacologically active plants, some of which may differentially uptake contaminants. These type of activities may require special consideration with respect to exposures.

**Basketmaking.** Exposure specific to basketmakers is a well-recognized problem<sup>11</sup>, but it has not been fully researched for this scenario. Gathering of some plants (e.g., willows, cattails, tules, reeds and rushes) can be very muddy, and river shore or lakeshore activities with sediment exposure may be underestimated. Washing, peeling, weaving rushes, and other activities results in additional exposure, such as dust deposited on leaves or soil adhered to roots. Some of the materials are held in the mouth for splitting, and cuts on the fingers are common. As more information becomes available, it will be evaluated to ensure that the exposure factors account for the particular exposure pathway.

### 2.2.3 Time allocation throughout the day

The time adds up to slightly more than 24 hours per day, as is typical for any exposure scenario, in order to allow specific pathways to drive the risk should they be contaminated. This also accounts for specialization by the person who spends more than an average amount of time in particular activities.

**Identical Activities:** From the age of 2 to 75 years, 15 hours of every day are similar: 8 hours sleep, 2.5 hours in other indoor activities, 2 hours in the sweat lodge, 1 hour in nearby outside activity such as small game hunting, 0.5 hour in community cultural activities, and 0.5 hour traveling on unpaved roads. These activities are referred to as "**common time**" because they are common to all individuals.

**Infant:** Standard infant exposure parameters are used. Housedust is assumed to have similar concentrations of contaminants as outside soil. The infant is breastfed for 2 years, assuming two different scenarios: (1) the mother has received 25 years of prior exposure from a contaminated area; and (2) the mother has not received such exposure. The issue of fetal exposure remains to be determined.

**Child:** The child, up through age 6, spends the same amount of common time in the same activities, and 4 hours indoors and 5 hours outdoors with the mother as she gardens and gathers.

**Youth:** "Common time" plus 6 hours at school 5 days/week (averaging 4.5 hours/day over a full week), 2.5 hours indoors, and 3 hours outdoors playing or accompanying an adult or elder learning traditional activities. It is assumed that the school is uncontaminated unless there is data about chemical usage or contamination, and it is also assumed that his or her

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<sup>11</sup> <http://www.cdpr.ca.gov/docs/envjust/documents/basketweaver.pdf>

near-residence outdoor time results in a higher amount of soil contact than at other ages, therefore, the youth's average contact rates are the same as the child and adult's.

**Adult:** "Common time" plus 8 hours working 5 days/week (about 5.5 hours/day), 0.5 hour at home, and 3 hours in one of the subsistence activities (hunting = 1 hour plus 2 hours processing, smoking, etc.; fishing = 2 hours plus 1 hour processing; gathering/gardening = 1 hour gathering in the assessment area, 1 hour gardening at home, and 1 hour washing, processing, etc.).

**Elder:** "Common time" plus 3 hours at home providing child care, 3 hours outdoors teaching, 1 hour gardening or gathering, and 2 hours at home processing materials and making items.

## 2.2.4 The Lifetime

Traditionally, daily tasks were somewhat different for males and females: males hunt and fish, while females gather and cook. However, upon consultation with traditional tribal members, it was determined that while the activities are different, the rates of environmental contact are probably similar. Today, both women and men are employed as environmental and construction workers, as well. Therefore, for the purposes of the exposure scenario, the genders have identical exposure factors, although a brief description is provided here.

**Male Lifetime.** The male lifetime consists of the standard infancy, childhood, and youth. At age 17 he specializes in either hunting or fishing and begins working as a reclamation/restoration/environmental worker. These activities are specified solely to determine their locations, which may have different contaminant concentrations. As an elder he changes his activity patterns to teaching and demonstrating as described above.

**Female Lifetime.** The female lifetime consists of the standard infancy, childhood, and youth. At age 17 she engages in gathering and gardening and also works the same job as the male. During motherhood, the woman may remain at home, which is located in the same sparsely populated area, and she continues to garden and gather, so her exposure does not diminish. Her earlier exposure contributes to fetal development and breast milk.

## 2.3 Media, Pathways, and Exposure Factors

Contaminant transport and exposure pathways are generally presented as Conceptual Site Models or CSMs. The pathways that are described below are intended to highlight some of the pathways that should be reflected in conceptual site models, the RME, and the baseline and residual risk assessments.

**Ground Water and/or Surface Water.** Ground water and/or surface water are directly ingested as drinking water. Both are also used to create steam in the sweatlodge. Other uses of water include typical household use can result in aerosolization or vaporization (e.g. flushing, cooking, bathing, and showering), or can transfer contamination to biota through irrigation of crops and/or garden, and livestock.

**Air and Dust.** Inhalation of volatiles, aerosols, and particulates is associated with almost all of the aforementioned activities. Inhalation of fire smoke or smudge should be included because some of these pathways can be frequent and significant. Dust resuspension from unpaved road should be included as part of the inhalation exposure pathway.

**Soil and Sediment.** This pathway includes soil ingestion from hand to mouth activities associated with daily activities, gathering (e.g., digging roots) and gardening, food and material processing (e.g. grinding, scraping, pit cooking). This pathway also includes direct ingestion resulting from residual soil on roots and bulbs. The as-gathered and as-eaten condition of plants is important. Some vegetable foods are eaten raw on the spot after being brushed off. Grinding seeds and nuts also adds rock dust to the flour.

### **2.3.1 Exposure factors for direct exposure pathways.**

Table 3 includes three adult scenarios: the suburban resident, the rural residential farmer-gardener, and the subsistence forager. Each scenario is intended to be physiologically “coherent,” which means that the activity levels and inhalation rates match each other, and match the degree of environmental contact as reflected in soil and water ingestion rates as well as the proportion of grown or foraged food. We have included the rural residential farmer-gardener information as a suggestion to be considered, since this is a lifestyle intermediate between suburban and subsistence foraging.

Table 2 shows the thought process for considering the wide range and numerous activities associated with the major activity categories (hunting, fishing, gathering, and sweatlodge use). Figure 1 lists a number of individual activities within each major category; this is included because most non-Indians have not learned much about traditional lifestyles and the complexity of daily life.

#### **Drinking Water.**

Harper et al. (2002) estimated an average water ingestion rate of 3 L/day for adults, based on total fluid intake for an arid climate. In addition, each use of the sweatlodge requires an additional 1L for rehydration, for a total of 4L per day.

#### **Inhalation Rate**

An inhalation rate of 30 m<sup>3</sup>/d is more accurate for the active outdoor lifestyle than the EPA default rate of 20 m<sup>3</sup>/d (EPA, 1997). Using EPA guidance, an average rate of 26.2 m<sup>3</sup>/d is obtained from 8 hours sleeping, 2 hours sedentary, 6 hours light activity, 6 hours moderate activity, and 2 hours heavy activity. This represents minimal heavy activity (construction, climbing hills, etc), and is an average rather than a reasonable maximum.

#### **Soil Ingestion.**

Soil ingestion by young children (0-6 years) is assumed to be 400 mg/day for 365 days/year. This is higher than the prior EPA default value of 200 mg/day (USEPA, 1989), and is the children’s upper bound value. This rate reflects both indoor dust and continuous outdoor activities analogous to gardening or camping, but it is less than a single-incident sports or construction ingestion rate. For adults, the soil ingestion value is also 400 mg/day, reflecting an unspecified upper percentile (EPA, 1997).

Table 3. Exposure factors for direct pathways

<b>Direct Pathway</b>	<b>Exposure Factors (Adults)</b>		
	<b>Default Suburban</b>	<b>Rural Residential Gardener</b>	<b>Subsistence Forager</b>
<b>Inhalation</b>	20 m <sup>3</sup>	25 m <sup>3</sup> While EPA does not have official exposure factors for this lifestyle, it is reasonable to assume that a person who farms, gardens, irrigates, and cares for livestock has an intermediate inhalation rate.	30 m <sup>3</sup> /day. This rate is based on a lifestyle that is an outdoor active lifestyle, based on EPA activity databases, foraging theory and ethnographic description of the activities undertaken to obtain subsistence resources as well as allotment-based food (livestock and garden). It is higher than the conventional 20 m <sup>3</sup> /day because the activities with associated respiration rates are higher than suburban activities.
<b>Drinking water ingestion</b>	2L/d	3L/day. This rate is based on water requirements in an outdoor, moderately arid environment.	3L/d plus 1 L for each use of the sweat lodge.
<b>Soil ingestion</b>	100 mg/d (conventional suburban); 50 mg/d (manicured suburban; less outdoor time).	300 mg/d.	400 mg/d. This rate is based on indoor and outdoor activities, a greater rate of gathering, processing, and other uses of natural resources, as well as on residual soil on grown and gathered plants. Episodic events (1 gram each) are considered, such as very muddy gathering, sports with higher soil contact, and so on. It does not specifically include geophagy or pica.
<b>Other parameters</b>			
<b>Exposure frequency</b>	Up to 365 days per year, but varies. Hours per day varies; typically 24 hrs/d.	Up to 365 days per year, but varies. Hours per day varies; typically 24 hrs/d.	365 days per year. Hours per day varies; typically 24 hrs/d.
<b>Exposure duration</b>	30 years	30 or 70-75 years	70-75 years
<b>Body weight</b>	70 kg	70 kg	70 kg

## **Sweat Lodge**

Inhalation and dermal exposure in the sweat lodge are evaluated by assuming: (1) one hour of use daily; (2) 4 liters of water is poured on heated rocks resulting in instant vaporization; (3) the sweat lodge is a hemisphere 6 feet in diameter; and (4) dermal exposure is over the entire body surface area. More detail is given in the Appendix.

## **Children's Exposure Factors**

Children's exposure factors are based on "Child-Specific Exposure Factors Handbook"<sup>12</sup> but scaled from the adult subsistence values for inhalation rate. Soil ingestion is 400 mg/d for all age groups.

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<sup>12</sup> U.S. Environmental Protection Agency (EPA). (2002) Child-specific exposure factors handbook. National Center for Environmental Assessment, Washington, DC; EPA/600/P-00/002B. Available from: National Information Service, Springfield, VA; PB2003-101678 and <<http://www.epa.gov/ncea>>.

### 2.3.2 Summary of Exposure Factors

A summary of primary exposures are presented in Table 4. Further documentation is provided in appendices for the 3 major exposure factors: inhalation rate, soil ingestion rate, and the fish consumption rate. Additional detail on exposure factors or guidance on the application of the scenario to particular locations will be provided on request.

**Table 4. Summary of Exposure Factors.** This summary draws on the 1997 and 2004 references. All exposure duration and averaging times are daily for 70 years unless otherwise noted. Children's factors are scaled from adults except where noted.

<i>Medium</i>	<i>Exposure Pathway</i>	<i>Exposure Factor</i>	<i>Value</i>
Soil	Ingestion	Ingestion Rate	400 mg/d (all ages)
Soil	Dermal	Adherence rate (<150 um particle size)	1 mg/cm <sup>2</sup> (all ages)
Soil	Dermal	Skin surface area (head, hands, forearms, lower legs)	5700 cm <sup>2</sup> (adult) 2800 cm <sup>2</sup> child)
Air	Inhalation	Inhalation Rate	30 m <sup>3</sup> /day (adult)
Water	Dermal	Skin surface area	18,000 cm <sup>2</sup> (adult) 14,900 cm <sup>2</sup> (child)
Water	Dermal and Ingestion	Swimming	13 days /yr, 2.6 hrs/event, 50 ml/event.
Water	Ingestion	Ingestion Rate	4 L/d
Biota	Foodchain	Fish ingestion rate	500 lbs per capita per year, or 620 gpd
Biota		Game, meat, fowl	125 gpd
Biota		Fruit, greens (unprotected)	Berries – 125 gpd Greens – 300 gpd Other - 125 gpd
Biota		Below-ground roots	800 gpd
Biota		Milk	Use children's rate (children only)
<p>Notes.</p> <ul style="list-style-type: none"> <li>• Soil adherence rate is correlated to grain size; soil samples must be sieved, and data for particle size &lt;0.044 cm (RAGSe, App. C, Table C-4) should be used for dose estimation. Inhalation is also related to particle size, so the dust resuspension estimate must also include particle size. The adherence rate of 1 mg/cm<sup>2</sup> is higher than most commercial rates but lower than the kid-in-mud rate (RAGSe, Ch.3, Table C-3) to account for longer events and more wet soil (riparian, wetlands) contact.</li> <li>• Animal meats include organs, which have a bioconcentration potential. Assume that 10% of animal food is organs with 10x higher concentration.</li> <li>• Sweatlodge parameters are included in the attached appendix.</li> </ul>			

### 2.3.3 CTUIR River-based Food Pyramid

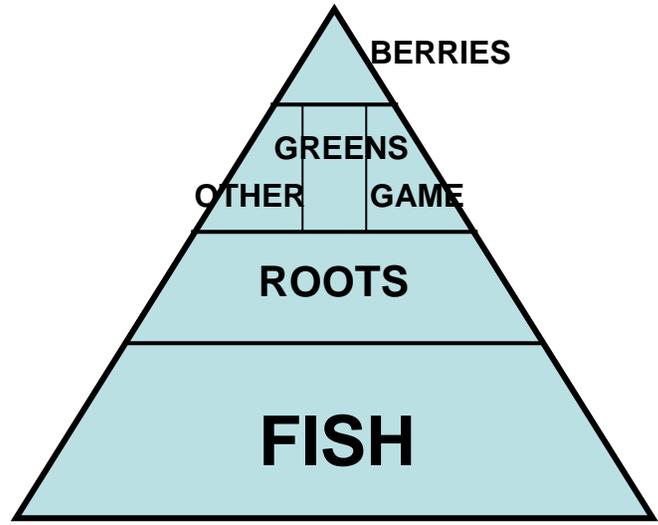
Approximately 135 species of plants are used as foods, flavorings, or beverages; approximately 125 species are used in traditional technologies; nearly 120 species of medicinal plants are used by the southern plateau tribes and up to 200 by northern Plateau tribes (Hunn, 1990). This wide variety of plants is typical of foraging societies. For risk assessment, however, this is collapsed into a few food categories. This is because the simple risk equations cannot handle more detailed information, and data on species-specific soil-to-plant uptake is lacking. Further compounding this problem is the tendency of game to be treated like livestock, and native plants like domesticated plants. Many pathways such as medicines and teas are typically ignored altogether. For this reason, the upper bounds for food categories are evaluated in the same way that direct exposure factors are rounded up to account for the myriad of small and otherwise ignored pathways.

There are two distinct diets within the Umatilla Tribes: the game-focused diet and the fish-focused diet. Because this scenario is applied to Hanford and the Columbia River, only the fish-based diet is presented here (Table 5, Figure 2). After making appropriate simplifying assumptions, the general CTUIR 2500 kcal subsistence diet that is focused on the Rivers is estimated as follows (based on references by Hunn and Walker; see also DOE<sup>13</sup>). CTUIR can be contacted if more detail is needed (for instance, the ratio between tubers and bulbs, from different plant families, and so on).

**Table 5. Dietary Food Categories for the Fish-based CTUIR Traditional Diet.**

Food Category	Grams per day Wet wt.	Kcal per day	% of 2500 kcal	Comments
Fish - 75% anadromous - 25% resident	620	1000	40%	Consumption of parts with higher lipid content needs to be added to this total. The lipid content will vary with species; the ratio of species can be provided on request.
Game, fowl	125	150	6	Consumption of organs with higher contaminant concentration (10x) needs to be added to this total. If 10% is organ meat with 10X bioconcentration, the total is <b>250 gpd</b> equivalents.
Roots (unspeciated, including tubers, corms, bulbs)	800	800	32	Depending on the habitat, this needs to be allocated among tubers and bulbs (different plant families) and terrestrial or aquatic species.
Berries, fruits	125	125	5	
Greens, medicinal leaves, tea, stems, pith, cambium	300	300	12	Above-ground plants may have contaminants translocated from the roots as well as dust deposited on the leaves.
Other: sweeteners, mushrooms, lichens.	125	125	5% combined	General assumption of 1 kcal per gram.
<b>Total</b>	<b>2095g</b>	<b>2500</b>	<b>100%</b>	This is 4.6 pounds of food per day; this includes a much higher fiber content than domesticated varieties, which were bred for lower fiber and

<sup>13</sup> [www.hanford.gov/doe/culres/mpd/toc.htm](http://www.hanford.gov/doe/culres/mpd/toc.htm)



**Figure 2. CTUIR River-Based Food Pyramid**

**3. REFERENCES**

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