

## APPENDIX W

### AMERICAN INDIAN TRIBAL PERSPECTIVES AND SCENARIOS

This appendix contains the perspectives on proposed plans for cleanup of the Hanford Site from three American Indian tribal groups: the Confederated Tribes and Bands of the Yakama Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. Included are copies of the treaties negotiated in June 1855 between representatives of the United States and leaders of various Columbia Plateau American Indian tribes and bands as mentioned in Chapter 8 of this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. Also provided are the results of the U.S. Department of Energy's (DOE's) risk analysis of exposure to radioactive and chemical constituents of potential concern using the American Indian tribal scenarios as provided to DOE.

#### **W.1 AMERICAN INDIAN TRIBAL PERSPECTIVES**

The Confederated Tribes and Bands of the Yakama Nation (Yakama Nation), the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) each submitted to the U.S. Department of Energy (DOE) copies of the tribal perspective on proposed plans for cleanup of the Hanford Site and risk analysis scenarios that should be considered by DOE. These are presented in the following sections:

- W.1.1, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment*, prepared for the Yakama Nation's Environmental Restoration and Waste Management Program
- W.1.2, *Nez Perce Perspective at Hanford*
- W.1.3, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*
- W.1.4, *A Method for Tribal Environmental Justice Analysis Under NEPA (Draft)*, prepared by the CTUIR

DOE requested and invited the American Indian perspectives included in this appendix to ensure fair consideration of differing views and to inform the agency's decisionmaking process. DOE respects those views and has considered them for the purposes of preparing this final environmental impact statement (EIS). However, inclusion of these perspectives does not mean or imply that DOE is in agreement with them.

### **W.1.1      Yakama Nation Exposure Scenario for Hanford Site Risk Assessment**

The following correspondence from the Yakama Nation to DOE transmits, as an enclosure, the *Yakama Nation Exposure Scenario for the Hanford Site Risk Assessment*, prepared for the Yakama Nation's Environmental Restoration and Waste Management Program.

**To:** Mr. David A. Brockman, U.S. Department of Energy  
**From:** Mr. Russell Jim, Confederated Tribes and Bands of the Yakama Nation  
**Date:** September 7, 2007  
**Subject:** Yakama Nation Exposure Scenario for Hanford Site Risk Assessment



**Confederated Tribes and Bands  
of the Yakama Nation**

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Established by the  
Treaty of June 9, 1855

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September 7, 2007

Mr. David A. Brockman  
U.S. Department of Energy  
Richland Operations Office  
P. O. Box 550  
Richland, WA 99352

Subject: Yakama Nation Exposure Scenario for Hanford Site Risk Assessment

Dear Mr. Brockman:

This letter is to transmit the Yakama Nation Exposure Scenario for Hanford Site Risk Assessment. Development of this scenario is an initial step to addressing the potential risks to members of the Yakama Nation who may utilize resources at the Hanford Site and surrounding areas, or otherwise be exposed to Hanford contaminants.

The Yakama Nation intends for this information to be used in a manner that comprehensively and completely evaluates all risks posed by Hanford contaminants to Yakama Tribal members. To be scientifically conservative and credible, such a risk assessment must consider the unique risks to Tribal members as additive to the generic maximally exposed individual. In other words, Tribal exposure pathways cannot be limited with non-conservative assumptions, whereas unique Treaty protected lifestyle and diet factors which add incremental risk must be accounted for.

We remain concerned at the many individual risk assessments being conducted for limited portions of the site, for particular management programs or for environmental impact statements. This scattered and fragmented approach will not cumulatively analyze all risk to human health in general or to the Yakama Nation in particular.

Yakama Nation uses will result in unique contaminant pathways and exposure rates from living on the site and using the natural resources. High level, transuranic, low-level and mixed radioactive wastes, nuclear facilities, proposed waste treatment operations, contaminated biota, and polluted water pose threats to the Yakama Nation, the health of our people, and the vitality of our traditional subsistence lifeways. To protect Yakama Nation uses, all contaminant sources and hazards should be identified and assessed comprehensively to make cleanup decisions. We expect that the Department of Energy will consider the total risk to Yakama members and analyze all exposure routes, including potential groundwater consumption, to evaluate cleanup actions.

Mr. David Brockman  
September 7, 2007  
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As a first step, we request that the Yakama Nation Exposure Scenario be incorporated into the Risk Assessment Report for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment. However, in doing so, we point out that it will not be a complete picture of risk as many geographic areas and contaminant sources are not included in that Assessment. We expect that actual contaminant concentrations in media and biota be used to assess risk, although it is our understanding that site-specific data of that type is not available for many plants and animals that the Yakama Nation uses.

Of major concern is how the Yakama exposure scenario will be utilized to inform cleanup decisions. In this regard, the Yakama Nation has repeatedly asked for technical assistance funding to participate in Hanford risk assessment in an active and meaningful way. We have yet to receive approval or funding of our risk assessment scope of work. We again request the necessary resources to participate effectively, and look forward to meeting with you to address this matter in our upcoming discussions about the FY 2008 Yakama Nation Cooperative Agreement scope of participation.

Sincerely,



Russell Jim  
Manager, ERWM Program

Enclosure

Cc:           Jane Hedges, WA NWP  
              Nick Ceto, Hanford EPA

**YAKAMA NATION EXPOSURE SCENARIO  
FOR HANFORD SITE RISK ASSESSMENT  
RICHLAND, WASHINGTON**

PREPARED FOR THE

**YAKAMA NATION  
ERWM PROGRAM**

**YAKAMA NATION EXPOSURE SCENARIO  
FOR HANFORD SITE RISK ASSESSMENT  
RICHLAND, WASHINGTON**

Prepared for the

Yakama Nation  
ERWM Program

Prepared by

RIDOLFI Inc.

September 2007

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Yakama Nation Exposure Scenario  
for Hanford Site Risk Assessment  
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## **EXECUTIVE SUMMARY**

An exposure scenario for risk assessment was developed for the Confederated Tribes and Bands of the Yakama Nation to describe their traditional subsistence lifestyle, including dietary patterns and seasonal activities. This lifestyle may result in exposure to radioactive and hazardous chemical contamination, now and in the future, from the nearby Hanford Nuclear Reservation in southeastern Washington. The Hanford Site is located within the Yakama Nation ceded territory.

This scenario describes the maximum exposure reasonably expected to occur in the Yakama population, who currently subsist on natural resources in the vicinity of Hanford. Upon adequate cleanup, the Yakama hope to regain access to the Hanford Site, which is part of their usual and accustomed use areas. Without compromising confidential information, details of this scenario will be used by the U.S. Department of Energy to complete an exposure assessment to evaluate potential risks to the Yakama Nation from Hanford-associated contamination.

Using ethnographic interview methods, adult Yakama members described fishing, hunting, and gathering practices, sweathouse use, feasts, and ceremonies, all of which remain critical aspects of their subsistence lifestyle and unique culture. These data were compiled to provide a qualitative description of the current and anticipated future Yakama lifestyle and develop quantitative exposure parameters.

This project resulted in a conceptual site model that was developed to illustrate potential exposure pathways from Hanford Site contaminant releases to soil, water, plants, fish and other animals, which may ultimately impact the Yakama people. Surveys found that the Yakama depend heavily on the harvest and consumption of fish from local rivers, including the Columbia River, which passes through the Hanford Site. They also depend upon wild game and an abundance of local native plants, including shoots, roots, leafy material, and berries. These resources provide not only foods and medicines, but also material for tools, shelter, and accessories.

Federal guidance documents currently do not include adequate exposure information pertinent to a Native American subsistence lifestyle. This scenario compiles information specific to the

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Yakama Nation to be considered in evaluating potential risk from Hanford Site contamination and to support appropriate cleanup decisions. Exposure parameters were estimated for inhalation, dermal contact, and ingestion of air, soil, water, fish, meat, vegetables, fruit, and milk, and reflect the current and anticipated subsistence lifestyle. The Yakama expect that this scenario will be used to evaluate risk in a comprehensive manner for the entire Hanford Site, incorporating all sources, radiological and chemical contaminants, exposure pathways, and natural resource uses.

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#### **LIST OF ABBREVIATIONS AND ACRONYMS**

CERCLA	Comprehensive Environmental Restoration, Compensation, and Liability Act (Superfund)
CRITFC	Columbia River Inter-Tribal Fish Commission
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERWM	Yakama Nation Environmental Restoration and Waste Management (Program)
NPL	National Priorities List (for Superfund)
RESRAD	Residual Radiation (modeling program)
RME	Reasonable Maximum Exposure
Yakama Nation	Confederated Tribes and Bands of the Yakama Nation

#### **LIST OF UNITS**

g/d	grams per day
hr/d	hours per day
L/d	liters per day
lb/d	pound per day
m <sup>3</sup> /hr	cubic meters per hour
mg/d	milligrams per day

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## **1.0 INTRODUCTION**

This report describes an exposure scenario developed for the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation) to better understand their traditional Native American lifestyle patterns and seasonal activities. This lifestyle may result in risks from exposure to Hanford Site contamination now and into the future. The material provided herein is intended to serve as a summary of the unique aspects of Yakama lifeways. In order to preserve uses for future generations, the Hanford Site cleanup process should be adequate to protect all natural resources and human populations, both tribal and non-tribal, in the region.

Ridolfi prepared this report on behalf of the Yakama Nation Environmental Restoration and Waste Management (ERWM) Program. The ERWM Program focuses on Hanford impacts to the Yakama people and their culture, and the land and the natural resources on which they depend. This report is based upon research and interviews with a sub-set of the population, qualitatively evaluates the Yakama lifestyle in general, and develops basic quantitative exposure parameters. Information in this scenario is intended to be used by the U.S. Department of Energy (DOE) to complete an exposure assessment for evaluating potential risks to the Yakama Nation from Hanford Site contamination. Identifying immediate and future risks is critical to the cleanup process.

### **1.1 Background**

This section provides an introduction to the Yakama Nation, a summary of Yakama Treaty Rights, a brief summary of the Hanford Site and a description of the federal risk assessment process.

#### **1.1.1 The Yakama Nation**

The Yakama Nation is one of four federally recognized tribes in the vicinity of Hanford, along with the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe. Figure 1 shows the location of the Yakama Nation Reservation, which currently occupies an area of nearly 1.3 million acres in southeastern Washington State, and the nearly 12 million acres of land ceded to the United States

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in the Treaty of 1855 (Williams and Babcock, 1983; CRITFC, 2007). By 2006, the total membership of the Yakama Nation reached a population size of 9,872 individuals (ERWM personal communication, 2006-2007).

Unlike many Native American tribes residing on reservations in the United States, the Yakama Nation settled upon the land previously occupied by their ancestors for thousands of years. Although land was ceded to the United States, the Yakama retain for use the ceded area that encompasses the elevation gradient from the eastern Cascade mountain range eastward, which is an area of principle importance to their lifestyle and heritage (Williams and Babcock, 1983).

The Yakama Nation's traditional homeland is an area where ancient cultures have survived for thousands of years. During a long and dynamic tenure, the Yakama Native Americans developed an intimate understanding of the complex relationships between the land and associated natural resources. Resources used by the Yakama are broadly classified as roots, fibers, berries, fish, birds and other animals, minerals, and places of spiritual guidance and strength. As a place, the Yakama Nation's ceded and reserved land offers a multitude of resources important to former, current, and future generations.

### **1.1.2 Yakama Treaty Rights**

On June 9, 1855, a treaty agreement was reached between the Yakama Nation and the United States. Appointees from the Yakama, Palouse, Pisquouse, Wenatshapam, Klikatat, Klinquit, Kow'was-say-ee, Li-ay-was, Skin-pah, Wish-ham, Shyiks, Oche-chotes, Kah-milt-pah, and Se-ap-cat tribes and bands of Native Americans were joined by this treaty agreement to be considered as one nation, under the name of "Yakama." Kamiakun was named as "head chief," and all members were to be relocated to the designated reservation. Another regional tribe, the Wanapum (known locally as River People), were not included in the treaty, but many eventually enrolled as members of the Yakama Nation (ERWM personal communication, 2006-2007; Williams and Babcock, 1983).

The treaty was ratified by the United States Senate on March 8, 1859 and signed by the President on April 18, 1859, thus establishing a government-to-government relationship between the two

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sovereign powers. According to the treaty, “the exclusive right of taking fish in all the streams, where running through or bordering said reservation, is further secured to said confederated tribes and bands of Native Americans, as also the right of taking fish at all usual and accustomed places, in common with citizens of the Territory, and of erecting temporary building for curing them; together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land” (Treaty with the Yakama, 1855, Article 3).

### **1.1.3 The Hanford Site**

The Hanford Site is a 586 square-mile former plutonium production facility located within Yakama Nation’s traditional homeland (ceded area), approximately 20 miles east of the current Yakama Nation Reservation. The site, which has been operated by DOE, its predecessor agencies, and its contractors since its inception in 1943, is located primarily in Benton County (with portions of the site in Grant, Franklin, and Adams counties) along the Columbia River, just north of the city of Richland.

As part of plutonium operations, radioactive and chemical wastes were both intentionally and unintentionally discharged to the air, ground and waters. Contaminants have migrated from the soil vadose zone to the groundwater, ultimately discharging into the adjacent Columbia River. Hanford contaminants have been found in the region’s soils, waters, plants, fish and other animals, affecting the health of these natural resources and area residents. Figure 2 shows the location of the Hanford Site in relation to the Yakama Reservation, as well as the extent of current ground water radionuclide and hazardous chemical contamination at the Hanford Site (WADOE, 2006).

When plutonium production ceased in 1989, DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology signed a “Tri-Party Agreement.” This agreement effectively transformed the site’s mission from nuclear weapons production to cleanup and environmental restoration. Soon thereafter, specific areas on the Site (100, 200, 300, and 1100 Areas) were listed on the National Priorities List (NPL) for cleanup under the federal Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA); the 1100 Area was later delisted from the NPL in 1996 (Ridolfi, 2006). The

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exposure scenario described in this report is not limited to the NPL sites, but includes the entire Hanford Site and any areas where Hanford-associated contaminants have come to be located.

The Yakama Nation, a trustee for the area's natural resources, currently participates in the Hanford cleanup process. The Yakama Nation's goals for the Hanford cleanup center on protecting Yakama Nation Treaty Rights, including the health of the Yakama people and natural resource interests. To accomplish these goals, the Yakama Nation takes a holistic approach to the cleanup, recognizing that all things interrelate. This requires considering the impacts on air, land, water, and all plants and animals. The Yakama Nation believes the cleanup actions conducted or planned by DOE thus far are not adequate to remedy the extensive contamination to attain these goals. It is essential to the Yakama to safeguard human health, and the health of the environment now and for future generations.

#### **1.1.4 The Risk Assessment Process**

According to EPA, risk assessment for CERCLA is defined as a "qualitative or quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence or release of hazardous substances, pollutants or contaminants" (EPA, 2006). DOE is currently in the process of conducting multiple risk assessments for the Hanford Site, including the Columbia River corridor and central plateau.

An exposure assessment is one of four major components of the risk assessment process, along with hazard identification, toxicity (dose-response) assessment, and risk characterization.

According to EPA, "exposure assessment is the process by which potentially exposed populations are identified, potential pathways of exposure and exposure conditions are identified, and chemical intakes/potential doses are quantified" (EPA, 2004a). The primary purpose of an exposure assessment is to estimate potential dose to an exposed individual or population, which can then be used to calculate risk and determine appropriate cleanup levels. Figure 3 illustrates the basic risk assessment process, including the exposure assessment phase.

Exposure scenario development is a key element of an exposure assessment. Using the scenario technique requires information about potential contact time with contaminant concentrations and

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other information specific to the potentially exposed population. Physical and behavioral information on the exposed population may be obtained from interviews with individuals representing that population, including assumptions to account for future conditions (EPA, 1992).

Exposure is defined as human contact with a chemical or physical agent, which may occur via inhalation, ingestion, dermal absorption, or irradiation, and is dependent on the intensity, frequency, and duration of contact. Exposure parameters, which are based upon human physiological and behavioral factors, include inhalation rates; consumption rates of soil, water, and foods; skin surface area; body weight; exposure frequency and duration; and any other modifying factors (EPA, 1989 and 2004a). Risk assessments are generally limited to the evaluation of a lifetime of an individual (e.g., 70 years), although many contaminants persist in the environment affecting many generations (e.g., radionuclides with half lives of thousands of years).

The risk assessment process used by government agencies to calculate and manage risk associated with contaminant exposure has generally not been adequate for assessing risks to Native Americans, whose lifestyle and close association with natural resources is not always recognized in a typical evaluation. When conducting a risk assessment, both physical health and traditional cultural practices that are closely tied to individual and community health should be protected (Arquette, et al., 2002). Figure 4 illustrates a holistic view of the many Hanford contaminant sources, including high-level radionuclide waste, reactor facilities, and contaminated media/biota, which pose imminent and chronic threats to the Yakama Nation, their health and the health of their traditional subsistence<sup>1</sup> lifeways.

## **1.2 Purpose and Scope**

The purpose of this project is to develop a Yakama Nation exposure scenario. This scenario will facilitate identification of Hanford Site contaminants that are associated with unacceptable risk to human health for members of the Yakama Nation living a traditional subsistence lifestyle on and in the vicinity of the Hanford Site, now and in the future. The Yakama Nation ERWM Program is working towards the goal of a Hanford Site that no longer threatens the health of the

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<sup>1</sup> Subsistence refers to a means of supporting life or sustenance; a living or livelihood.

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Yakama people by pollutant releases. The Yakama Nation wants Hanford cleaned up as the law requires, and wants the natural resources properly addressed (Rigdon, 2006).

### **1.2.1 Objectives**

In an effort to develop a Yakama-specific exposure scenario, objectives of this project include: describing the Yakama population; identifying the daily and seasonal activities in which Yakama members participate; identifying potential pathways of exposure associated with the Yakama traditional and/or subsistence lifestyle; and providing exposure parameters that best represent the Yakama people now and in the future using the Hanford Site.

DOE is evaluating other exposure scenarios, such as rural-resident, worker, recreational user, etc., for the Hanford Site risk assessment process. This document is intended to provide summary information for the Yakama Nation exposure scenario, including aspects of the daily life and associated exposure pathways for tribal members. This exposure scenario for Yakama members is a subsistence fisher-hunter-gatherer scenario for an individual living on the site, drinking surface and ground water, harvesting fish from the Columbia River, and using all usual and accustomed places year round.

### **1.2.2 Scope of Work**

The scope of work defined for this project includes producing a conceptual site model, which illustrates exposure pathways for potential risks from Hanford Site contamination to the Yakama Nation, and developing a Yakama-specific qualitative and quantitative exposure scenario. This includes identifying and describing characteristics of the cultural population of interest that is the Yakama Nation, the study area that includes the Hanford Site and all surrounding areas potentially impacted by Hanford that comprise usual and accustomed areas, and the timeframe that accounts for current practices and estimates of future uses.

This exposure scenario describes the traditional Yakama lifestyle now and anticipated for the future, identifies potential exposure pathways of Hanford Site contamination, and quantifies applicable exposure factors. This report also provides recommendations for using these results,

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as well as limitations and uncertainties of this study and the risk assessment process in general, and future study needs.

### **1.2.3 Yakama and DOE Expectations**

DOE has produced scoping statements for different land use scenarios during the risk assessment process, including a scoping statement for Native American subsistence scenario. DOE stated that, "each Tribe will be asked to provide their own use scenario for the Columbia River Component risk assessment. Anticipated uses by the Tribes include hunting, fishing, gathering of plants, and religious and ceremonial uses of the land, river, and other natural resources" (DOE, 2004). It is expected that DOE will use the information presented in this report to evaluate potential exposure pathways and risks for Native American traditional uses.

The type of information that is needed to complete an exposure assessment for the Yakama Nation at the Hanford Site is summarized in the following table. The information needed is categorized as descriptive in nature (qualitative) or numerical (quantitative). The lead organization responsible for providing the information, either DOE or the Yakama Nation, is also listed. The information required of the Yakama Nation is provided in this exposure scenario report. Information in the descriptive scenario can be used for DOE's complete exposure assessment, which will include contaminant concentration data.

#### **Exposure Assessment Data Needs**

Information Needed	Information Type	Lead
Description of Hanford Site (exposure) setting	Qualitative	DOE
Characterization of site contaminants	Quantitative	DOE
Description of contaminant exposure pathways	Qualitative	Yakama
Characterization of exposed population (current/future)	Qualitative	Yakama
Estimation of exposure parameters (for contaminant transfer)	Quantitative	Yakama
Calculation of current/future dose to estimate potential risk	Quantitative	DOE

A description of the Yakama exposure scenario and specific exposure parameters is being provided to DOE as part of the risk assessment process and to estimate the reasonable maximum

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exposure (RME) expected to occur at the Hanford Site. According to EPA and Washington State, site-specific risk assessments must consider the RME, which is "the highest exposure that is reasonably expected to occur at a site under current and potential future site use" (EPA, 1989; WADDOE, 2001). It is anticipated that a subsistence lifestyle will have the greatest potential for exposure and thus will represent the RME for Hanford due to regular use of and contact with the natural resources; exposure parameters for the Yakama Nation will likely provide an estimate of one of the most highly exposed populations at the Hanford Site.

Exposure parameters (such as consumption rates) identified and proposed for the Yakama Nation are based upon maximum values to conservatively protect all Yakama individuals. Expectations for using the information provided in this report are provided in more detail in Section 4.

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## **2.0 APPROACH AND METHODS**

The approach for identifying the traditional subsistence exposure scenario for the Yakama Nation involved research of available literature and guidance, as well as site visits and interviews with Yakama members, described in the following sections.

### **2.1 Literature Review**

Literature review involved consultation with federal and state guidance documents, examples of previous exposure assessments, and other documents related to evaluating contaminant exposure and risks to Native Americans. All literature obtained and referenced was compiled into a project-specific database using FileMaker Pro 6® for organization and accessibility. Appendix A provides a list of the complete bibliography of resources compiled for this study.

### **2.2 Ethnographic Interview Approach**

To obtain information directly from Yakama members, a population sample was selected for interviews. The primary focus was to obtain information to describe lifestyle patterns and estimate general activity levels rather than to inventory every specific activity and species-specific resource use. Prior to conducting the study interviews, data needs were identified, an approach for collecting the data was established, and procedures for protecting data confidentiality were clarified.

#### **2.2.1 Data Needs**

To identify the information to solicit during interviews, Ridolfi worked closely with the Yakama Nation ERWM Program to identify activities common to a majority of Yakama members. Traditional lifestyle activity patterns that were identified for research included fishing, hunting, and gathering, and cultural activities such as sweating, feasts, and ceremonies. Table 1 provides a Yakama Nation lifestyle activity matrix that was developed during the planning process to outline the traditional lifestyle and help identify data needs.

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It was determined that information was needed regarding the environmental setting and lifestyle, including the natural resources available for use, such as plants, fish and other animals, and confirmation from Yakama members on the degree of consumption, use, and collection of these natural resources. Determining the daily and seasonal activities and dietary patterns facilitates defining potential contaminant pathways and exposure parameters for the exposure scenario.

### **2.2.2 Data Collection**

Information was collected by direct consultation with the ERWM Program office as well as interviews with Yakama tribal community members, which allowed for a description of daily, seasonal, and lifetime activities of men and women, children and elders from different families and geographical locations. Input was obtained throughout the project from tribal representatives at ERWM, who are acknowledged experts due to their experience working with natural resource issues.

To survey tribal members, ethnographic interview techniques were used to provide a scientific description of the culture (Riley, et al., 2006). These techniques involved establishing community standing and personal credibility, demonstrating cultural sensitivity and an understanding of proprietary information. This was accomplished by working closely with the ERWM Program office, members of which spoke with potential interviewees about the project, as well as publishing informational articles in the local tribal newspaper, the Yakama Nation Review. The published news articles are provided in Appendix B.

### **2.2.3 Confidentiality**

During the interview process, all participants were made aware of the criticality of protecting confidential information, such as names, locations, and species. Both interviewer and respondent signed an Informed Consent Form at the time of the interview to guarantee that no confidential information will be released to anyone outside of the ERWM Program office, where the final record of responses will be permanently secured. Respondents were told that they could skip any question at any time, and elaborate on answers, as they felt comfortable.

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## **2.3 Yakama Member Interviews**

The interview process is discussed in the following sections, including development of the questionnaire, a description (without names) of the individuals ultimately interviewed, and details of the interview process.

### **2.3.1 Questionnaire Development**

Development of the questionnaire was an iterative process, based upon initial research of previous tribal interviews, input provided from the ERWM Program office, and input from lessons learned during the interview process itself. The questionnaire was divided into several major categories based upon potential exposure activity type (fishing, hunting, gathering, etc.) to obtain qualitative and quantitative information about the Yakama lifestyle.

A copy of the questionnaire (including plant and animals species on/near the Hanford Site) is provided in Appendix C. The interviews included questions on consumption, use, and harvesting of plants, fish, and other animals from the area to identify the extent to which Yakama members depend upon natural resources that may be impacted from Hanford contamination. Other information regarding daily and seasonal activities was also solicited in an effort to qualitatively describe the Yakama lifestyle, identify culturally important activities and resources, and quantify as best as possible exposure values that may be used for risk assessment.

Photographs of select plant, fish, and other species, some of which were used during the interviews, are provided in Appendix D. Information was also gathered about contact with water and soil in order to identify other potential pathways. Respondents were asked for their opinion on the health of the natural resources that they use, as well as their thoughts and knowledge about potential impacts from Hanford. Questions about future use of the Hanford Site were contingent upon unrestricted use of a theoretically remediated site so that responses were not skewed towards avoidance or other behavior that may intentionally restrict use.

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### **2.3.2 Survey Respondents**

Ridolfi worked with the ERWM Program office to prepare an initial list of potential interviewees. Enrolled members of the Yakama Nation must be, as defined by the General Council, individuals who are least one-quarter ethnic Yakama Native American. The goal was to interview enrolled members who could provide adequate information regarding current lifestyle, including daily, seasonal, and dietary patterns, consider changes from past practices, and estimate intended future use of the Hanford Site and surrounding areas. Questions about child lifestyle and consumption patterns were also asked of the adult respondents.

A total of 16 Yakama members were ultimately interviewed from a larger list of candidates. Although 16 interviews (from a membership enrollment of over 9,700) is a small sample population, the selected interviewees provided an adequate cross-sectional representation of the population as a whole for the purposes of this study. The sample group was targeted towards elders for their rich oral traditions and long history with changes in the area over time; younger adults were also interviewed to obtain a broader prospective of the general Yakama population. Respondents were asked consumption questions not only for themselves (direct response), but also for their parents and children to obtain data on additional adult and child patterns, respectively (indirect response).

Potential respondents were contacted directly by ERWM staff by visitation, phone call, and/or email. The 16 respondents, interviewed between February and May 2007, were aged 24 to 75 years; seven were male and nine were female. All respondents were associated with multiple longhouses,<sup>2</sup> although for some, there was a primary longhouse to which they belonged and others that they attended periodically.

### **2.3.3 Interview Process**

Interviews were conducted by four Yakama Nation members and a Ridolfi risk assessor. A brief introduction to the project and its purpose was given at the time of initial contact, and additional

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<sup>2</sup> Longhouse refers to any Native American communal gathering place.

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details about the study were provided at the start of each interview (included in the introduction of the Questionnaire, provided in Appendix C).

Individual interviews lasted between 45 minutes to slightly over 3 hours, depending upon how much an individual chose to elaborate on specific answers or tangentially share oral histories or personal stories. Interviewers generally asked all questions on the survey, except when time was constrained. In few cases, the respondent gave free-form testimony in lieu of the questionnaire. Respondents were asked information about themselves, as well as of their parents (to represent other adults) and children (for child values). Samples of fish, meat, and plants were used for estimating serving sizes, as well as measuring cups. All interviews were tape recorded, with the respondents' permission, to supplement the hand-written notes taken by the interviewer. The interviewer and respondent both signed the disclaimer form ensuring protection of confidential information. All completed forms, hand-written and typed notes, and cassette tapes will be permanently secured at the ERWM Program office.

#### **2.4 Data Analysis and Reporting**

Notes taken during the interview were transferred by the primary interviewer into electronic format, and combined with any other notes compiled similarly from secondary interviewers who were present. The notes (text and tables) were edited and formatted, and then sent to the respondent with a cover letter and self-addressed stamped envelope to give them the opportunity to correct any mistaken information or interpretations. Upon receipt of edits, a corrected version of the notes was re-sent to the respondents for their records. The majority of respondents did not provide corrections or additions, however, and the recorded notes and values are assumed to be correct.

Once all data were collected, quantitative values were compiled into a spreadsheet to evaluate exposure rates. When an individual provided a range of values, analysis of the data considered the maximum of this range. Basic statistics (minimum, maximum, and average) values were calculated for all individuals combined. Consumption rates for fish and meat are estimated by the respondents based upon meals; data were not converted to raw tissue values.

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During the data evaluation phase, it was discovered that respondents considered children to be through the age of 18 and, consequently, many of the values were comparable to the adult values. Since EPA considers the sensitive child stage as 0 to 6 years, the more broadly defined age group of Yakama-child data are not summarized here. Assumptions are made, however, regarding child exposure values from the literature (discussed in Section 3). This report includes information specific to the Yakama Nation, without compromising confidentiality (i.e., names are not included).

## **2.5 Potential Sample Bias and Data Uncertainties**

Sampling may have been biased by any of the following: small sample size; targeted sampling towards knowledgeable elders; varying degrees of experience with Hanford and hazardous waste contamination issues in general; respondent recollection; use of example servings of a particular size; use of cooked versus raw samples for serving size estimation; survey layout and length; and mistrust of scientific survey methods and/or cultural differences. Also, respondents may have reported higher rates during high consumption months and reported lower rates during relatively lower consumption months. Although likely an insignificant modifying factor, actual body weights were not used for exposure parameter calculations.

This exposure scenario does not take into account variations in population susceptibility that may exist within the Yakama Nation, or Native American populations in general, compared to the general U.S. population. Genetic susceptibility and overall health, for example, may increase risk from contaminant exposure (Arquette, et al., 2002). The risk assessment process in general also does not consider impacts and risks to the social, cultural, and spiritual practices of the Yakama people, which are considered an important link to personal health. These uncertainties, biases, and omissions noted during from this study should be taken into account in future studies.

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### **3.0 EXPOSURE SCENARIO**

The exposure scenario presented in this section includes factual data, assumptions, and inferences to describe contaminant exposure pathways, characterize the potentially exposed population, and develop exposure parameters. This section provides the study results, including development of a conceptual site model, description of traditional activities associated with the Yakama lifestyle, and proposal of Reasonable Maximum Exposure parameters for the Yakama Nation.

#### **3.1 Conceptual Site Model**

An exposure pathway “describes the course a chemical or physical agent takes from the source to the exposed individual” (EPA, 1989). The Yakama Nation conceptual site model identifies the exposure pathways, linking Hanford Site contamination with population locations and activity patterns by identifying contaminant releases, media in which the contaminant is retained and transported, and the exposure route, such as ingestion and dermal absorption.

A simplified Yakama conceptual site model is shown graphically in Figure 5 as a visual illustration of source contamination from the Hanford Site, potential exposure pathways through site media and biota, and various activities in which Yakama members participate as part of their traditional and cultural lifeways that may lead to contaminant exposure. Table 2 provides a more detailed Yakama conceptual site model as a narrative flow chart.

##### **3.1.1 Target Population**

For this study, the Yakama Nation is identified as the potentially exposed population, whose use of and extensive dependence upon local natural resources and close proximity to the Hanford Site place them at risk from exposure to contamination from Hanford Site releases. Federal guidance documents do not include adequate exposure information pertinent to a Native American subsistence lifestyle, such as ingestion rates of wild game, roots, berries, and medicinal plants. The extent and duration of tribal exposure to soil, water, and foods differs from the general population due to unique daily, seasonal, and important cultural activities that should be considered in the estimation of risk (ITRC, 2002).

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Categories of information needed for an exposure scenario include consumption patterns, food preparation methods, exposure time, and concurrent exposures from all sources. EPA has acknowledged that, although comprehensive guidance is not currently available, there is a growing trend towards characterization of exposures to an individual throughout their different life stages (EPA, 2004a). All life stages for men and women should be considered, including infant, child, adult, and elder.

### **3.1.2 Site Use**

To determine future use of the Hanford Site with respect to the Yakama people, current uses of natural resources were considered on the Reservation and surrounding areas (since use of the site itself is currently restricted), as well as past uses to provide further insight into traditional lifestyles that occurred previously on the Site. Future site use combined with current uses of modern technologies and lifestyles is the most accurate reflection of Yakama people's intended uses when the Hanford Site is cleaned up. This exposure scenario for Yakama members is a subsistence fisher-hunter-gatherer scenario for an individual living on the site, drinking surface and ground water, fishing at all usual and accustomed places and harvesting plants and animals year round.

### **3.1.3 Natural Resource Use**

Native Americans of the Columbia River Basin, including members the Yakama Nation, depend on the Columbia River, known as *Nch'i-wa'na* ("Big River") for their livelihood. The spring Chinook salmon is considered a "first food," celebrated with a feast each spring to recognize the availability and abundance of food at the start of each growing season (ERWM personal communication, 2006-2007; Relander, 1986). In addition to dependence on fish as a major part of their diet for both nutritional and cultural health, the Yakama also depend on hunting local wild animals and birds for food and materials. They are also extremely dependent on the rich abundance and variety of wild plants, from above and below ground, which are used for food and medicine and some of which are also celebrated as "first foods."

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Activities representing the traditional subsistence lifeways of the Yakama people may occur daily, seasonally, or annually, depending upon purpose and availability of the resource. The intensity, frequency, and duration of these activities also vary. Figure 6 provides a generalized illustration of historical seasonal activities based upon natural resource availability. The major activities in which the Yakama participated historically and to this day include:

- Fishing, including the preparation, consumption, and use of fish for food, medicine, and materials;
- Hunting, including the preparation, consumption, and use of meat, organs, and other parts of the animal for food, medicine, and materials;
- Gathering, including preparation, consumption, and use of roots, shoots, stems/stalks, leaves, and berries for food, medicine, and materials;
- Consumption and use of water (surface water and ground water);
- Other daily activities, such as time spent outdoors (for work and recreation, potentially exposed to dust), and natural materials production (handling and using natural resources to make shelter, clothing, tools, and accessories); and
- Cultural activities, including sweating and participating in various celebrations, ceremonies, and memorials.

### **3.2      Exposure Activities**

Qualitative descriptions of the key Yakama lifestyle activity patterns are provided in the following sections, along with quantitative summaries of the exposure parameters obtained from the interviews. These activities are associated with multiple exposure routes, such as inhalation, absorption, ingestion, and irradiation of potentially contaminated air, soil, ground water, surface water sediment, and biota. In cases where individual respondents provided a range of consumption values, maximum values were used for data analysis. Basic descriptive statistics (minimum, maximum, and average values) were calculated for all respondents combined.

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### **3.2.1 Fish Harvest, Use, and Consumption**

The harvesting, preparation, consumption, use, and trade of fish are critical components of the Yakama lifestyle. Despite a decrease in fish abundance from historical levels in the Columbia River and the Yakima River (EPA, 2002a), the loss of available fishing sites from dam construction, and concern over fish health from agricultural runoff, Hanford contamination, and human encroachment, the Yakama continue to depend upon fish as a major part of their diet. Fishers generally harvest most of their lives and collect enough fish to feed their extended families as well as communal longhouse feasts and elders who can no longer provide for themselves.

The primary fish of importance is salmon, including spring and fall Chinook, coho, sockeye, and chum salmon, steelhead and cutthroat trout. Other anadromous as well as resident fish species of key importance to the Yakama diet include bass, bull trout, smelt, lamprey (eel), suckers, whitefish, and sturgeon. These and other fish species are harvested from the Columbia River and have been identified specifically at the Hanford Reach. The Yakama fish year round, depending upon the fish reproductive cycles.

Fish are caught using fish gill nets, dip nets, gaffs (large hooks), and poles and lines. The harvested fish are gutted, washed, and depending upon the species, filleted. Fish are preserved by smoking, salting, drying, freezing, and canning. For example, sockeye (red or blueback) salmon is generally canned, fall Chinook (or King) salmon is generally smoked and salted for preservation, and lamprey is generally dried. Cooking methods for all fish include roasting, baking, broiling, pan- and deep-frying, poaching, and boiling in stew.

Adult fish consumption rates calculated for salmon and other species from the survey results are shown in Figure 7. Fish consumption includes whole body (i.e., all fish parts) as well as fillet only. Based upon maximum values provided by respondents, the adult fish consumption rate ranged from 3 grams per day (g/d) to 451 g/d, with an average of 150 g/d. The maximum rate of 451 g/d is equivalent to approximately 1 pound per day (lb/d) or 2 (8-ounce) meals per day. Although respondents were asked about fish consumption rates by children in their family, these data are not provided because exact ages of the children were not identified. Based upon this

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study, salmon comprise the majority of fish species consumed by the Yakama, approximating as much as 90% of all fish consumed.

Respondents were asked about consumption patterns of particular species that are known to be found in the Columbia River, particularly the Hanford Reach. Assuming the responses reflect accurate amounts of fish consumed by current (and future) adults, these values may reflect suppressed rates. Other studies of Native American fish consumption have noted that historical consumption rates are generally much higher than current rates. Most of the respondents in this study said they would like to eat as much if not more fish in the future (except for cases where aging is a factor in reduced consumption). Many members, however, expect a reduction in future fish consumption rates, not by choice, but because of decreasing fish availability and decreasing numbers of fishers providing for the communities.

As shown in the conceptual site model (Table 2), potential exposure routes for fishing include inhalation of air, ingestion and dermal absorption of surface water and sediment, and ingestion of fish tissue.

### **3.2.2 Meat Harvest, Use, and Consumption**

Hunting was a common practice historically for the Yakama, and continues to be practiced regularly today, despite the increased availability and consumption of domestic animals. The Yakama hunt year round, and harvest many species of wild mammals<sup>3</sup> and birds, primarily deer and elk, but also rabbit, goat, sheep, beaver, pheasant, wild turkey, duck, and (in previous times of food scarcity) chipmunk and squirrel, and (historically) bear. Nearly all parts of the hunted animal are consumed or used; for example, deer/elk antlers and hides are used for tools, shelter, clothing, accessories, and drums; sausage casings are made from intestines and sinew (tendon), and (historically) beaver tail, wild bird eggs, and stewed bear claws were eaten. The Yakama are not constrained by state laws dictating hunting seasons or limited quantities, although the Tribal Council (governing body for the Yakama Nation) does impose harvesting restrictions on female

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<sup>3</sup> The coyote is the only mammal commonly found on the Hanford Site and surrounding areas that the Yakama do not hunt because this animal is considered a sacred brother to the people.

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animals during the breeding and rearing months of January through June in order to sustain the population.

A typical hunt involves primarily hunting of large game. Deer and elk are generally hunted using a rifle; however, some members still use bow and arrow as a test of skill. After a large game animal is killed, it is generally gutted and skinned and the offal left for other animals, while the remaining carcass is hung for several hours or overnight. The meat is then sectioned and processed for immediate consumption (by roasting, baking, boiling, frying, or stewing) or preservation (smoking, drying, freezing, or canning). Organs, such as the heart and liver are also eaten, while the brain has been used for curing the hide. The hide is dried to use for making clothing (moccasins, leggings, chaps, and dresses), shelter (tipis) and accessories (drums), and is traded for other goods. Other parts of the animal are used for decoration, such as the antlers, hooves (during medicine dances), and teeth (earrings, necklaces, and ornaments). Hides have also been used from less commonly hunted animals such as weasel and otter.

Adult meat consumption rates calculated for hunted and domestic meat from the survey results are shown in Figure 8. Based upon maximum values provided by respondents, the adult meat consumption rate ranged from 23 g/d to 704 g/d, with an average of 245 g/d. The maximum of 704 g/d is equivalent to approximately 1.6 lb/d or 3 (8-ounce) meals per day. Although respondents were asked about meat consumption rates by children in their family, these data are not provided because the exact ages of the children were not identified. The current meat diet of many Yakama today includes a high dependence on domestic meat, comprising a total of approximately 60% of the total meat consumed, which is due in part to restricted access to hunting grounds (e.g., Hanford Site) and the physical inability to hunt. This indicates the need for consideration of risk due to consumption of both domestic and wild animal meat, both of which may be impacted by Hanford contamination.

As shown in the Yakama conceptual site model (Table 2), potential exposure routes for hunting and meat consumption include inhalation of air and soil/dust that is suspended during hunting, ingestion and dermal absorption of soil and ground water, and ingestion of animal tissue, including wild and domestic animals on the Hanford Site.

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### 3.2.3 Plant Harvest, Use, and Consumption

Gathering of wild plants for food, medicine, and materials has always been, and remains, a critical component of the Yakama dietary and cultural lifestyle. Plant roots, shoots, stems/stalks, leaves, and berries of more than 70 different plant species are harvested seasonally according to plant lifecycles and availability. Plants commonly used as food include Indian celery, biscuitroot, bitterroot, Indian carrot, yellow bell, huckleberries and choke cherries. Plants are also used for medicine, such as boiled rose bush for health and spiritual cleansing, and materials, such as bulrush for tule mats, Indian hemp for rope, and willow for sweathouse and tool construction.

Natural edible plant parts include tubers, bulbs, roots, and sprouts. Indian celery, which is a “first food” collected in early spring when it first sprouts (the mature plant is not edible), grows in small streams and springs; this plant is eaten during annual feasts and is used medicinally to cleanse the body. Bitterroot and other plants are collected in late spring. The Indian carrot is collected in August for its sweet, white root, and is dried, ground, and re-hydrated into a paste. Certain species of plants in the *Lomatium* genus, commonly gathered by the Yakama, contain a quality that, when dried, ground, and mixed, make ideal dough for bread or candy<sup>4</sup> (ERWM personal communication, 2006-2007).

Another popular root that is gathered (although not from the Hanford Site) is camas, a small scaly bulb that is dried, ground, and baked for several hours in a hot coal-heated and hot rock-heated pit, layered with willow leaves and covered with earth. Other roots may be baked in a similar fashion, but with water poured down a hole and sealed to create steam. Lichen is collected year round, and acorns are collected in fall and baked underground similar to Camas (Relander, 1986).

Yakama members generally start gathering with their families at a very young age, such as five to seven years old, and continue to do so until they are “too old to walk.” People gather for most of their lives, and generally within the same collection areas. Gathering is a family affair, with

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<sup>4</sup> *Lomatium spp.* plants are identified by flower tops, which become difficult to identify when destroyed, such as may occur from cattle grazing.

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mothers and grandmothers teaching their very young sons and daughters the specialized art of plant identification and timing of collection. Although women generally do most of the gathering as adults, some men continue to do so as well. Tools used for gathering include a root digging instrument made of deer or elk antlers or wood, and carrying baskets made of hemp or cedar (or synthetic materials).

Adult plant consumption rates calculated for wild plants (including roots, berries, and stalks/leaves) and garden/domestic plants from the survey results are shown in Figure 9. Based upon maximum values provided by respondents, the total adult plant consumption rate ranged from 33 g/d to 1,208 g/d, with an average of 264 g/d. The maximum is equivalent to approximately 2.7 lb/d or 5 (8-ounce) meals per day. When vegetables and fruits were considered separately, garden plants were estimated to be half vegetable and half fruit, which was then summed with wild roots and stalks/leaves (for vegetable total) and with wild berries (for fruit total); the average vegetable and fruit consumption was 1,118 g/d and 299 g/d, respectively.<sup>5</sup> Although respondents were asked about plant consumption rates by children in their family, these data are not provided because the exact ages of the children were not identified.

Although many domestic fruits and vegetables are consumed, roots, berries and other wild plant parts generally comprise more than half of the total (and even more so for children). Some members expect a reduction in future plant consumption rates, not by choice, but because of restricted access. Members recognize that access to areas for plant collection (root digging, berry picking) is decreasing because of land disturbed by development and construction, population growth and increasing private land ownership restricting access to historical gathering grounds (including the Hanford Site). Members also cited increased agricultural contamination from pesticide spraying and runoff restricting future use of plants.

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<sup>5</sup> The average total vegetable and fruit rates represent different individuals, which is why together the total does not equal the average total for all plants consumed.

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As shown in the Yakama conceptual site model (Table 2), potential exposure routes for gathering and plant consumption include inhalation of air and soil/dust, ingestion and dermal absorption of soil and ground water, and ingestion of plant tissue.

### **3.2.4    Liquid Ingestion Rates**

Other daily intakes that are important to consider for risk assessment include rates of water consumption (surface water and ground water pathways) and milk consumption (biotic pathway). Similar to food consumption rates, child data are not provided because the exact ages of the children were not indicated.

#### **3.2.4.1    Water Consumption**

The Yakama drink water on a daily basis, and increase consumption during sweathouse use and active outdoor activities. Adult water consumption rates calculated from the survey results are shown in Figure 10. Based upon maximum values provided by respondents, the adult water consumption rate ranged from 0.2 liters per day (L/d) to 3.0 L/d, with an average of 1.4 L/d. The maximum, which does not account for additional consumption during sweathouse use, is equivalent to approximately 13 (8-ounce) glasses per day. Many respondents noted that ground water wells served as their primary source of drinking water (in addition to tap and bottled water); use of contaminated ground water is an important Hanford exposure pathway.

#### **3.2.4.2    Milk Consumption**

Adult liquid consumption rates calculated for milk consumption from the survey results are shown in Figure 10. The adult milk consumption rate ranged from 0.004 L/d to 1.18 L/d, with an average of 0.24 L/d. The maximum is equivalent to five 8-ounce glasses per day. Consumption of milk, which may be from local dairy cows, is a potential exposure pathway for Hanford contamination.

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### **3.2.5 Other Daily Activities**

Time spent outdoors in general is an important factor to consider in assessing potential contaminant exposure, as is time spent doing strenuous activities, recreational and otherwise, that may involve increased inhalation rates. The Yakama also spend time handling natural resources, such as animal hides and bone, plant fibers and dyes, to produce various items for shelter, tools, clothing, and accessories, producing additional exposure potential.

#### **3.2.5.1 Outdoor and Recreational Activities**

Time spent outdoors in general provides a good indication of potential exposure to contaminated air and soil/dust, particularly time spent doing strenuous activities, during which time inhalation rates are higher than normal resting rates. Based upon maximum respondent data, time spent outdoors (for both work and recreation) ranged from half an hour to 7 hours per day; with an average of approximately 4 hours. Although the extent of time doing strenuous activities varied greatly and according to age, an average of about half of an individual's time spent outdoors was spent being involved in active or strenuous activities (e.g., dancing, running); other recreational activities noted were breaking horses, biking, hiking, and sports.

#### **3.2.5.2 Natural Materials Production**

Respondents described a variety of materials that they and other Yakama members make from natural resources. The time spent handling plant materials, for example, creates potential exposures from dermal contact with contaminated soil and inadvertent ingestion. Plant material is used for shelter, such as bulrush used to make tule mats for longhouses. Bags and baskets are made from cedar, Indian hemp, corn husks, bear grass, and and/or berries (for dye). Preparation time, and thus exposure time, was reported up to approximately 21 days (assuming 8 hours per day) to complete one item. Water-tight baskets are made from weaving cedar, which is often pulled taut with ones teeth. Strong, durable string made from Indian hemp is also used to make fish nets, tied together using cedar and willow.

Other items made from plant resources include: bowls made from hollowed out oak tree roots; cooking pottery made from plant roots; woven hats made from hemp string and corn husks; and

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paints made from saprophytic shelf fungus that grow on dying trees. Historically, gorge hooks and three-pronged spears used for harvesting fish were made of hard wood, tied with braided hemp set lines (Relander, 1986). Many of these traditional Yakama materials continue to be made today.

Many items are also made from animal resources, particularly cured/tanned hide. Respondents described the use of deer and elk hide to make drums (for religious services) and suitcases, each of which may take 5 days to produce. Hide is also often used to make moccasins for men, women, and children (10 days to produce, depending on the degree of bead work added), and leggings (or chaps), birch cloth, and vests for men (total of 33 days to produce). Men wear these items along with a shirt, necklace, and blanket during traditional services, while women wear a wing dress, necklace, hair ties, and a blanket. Jewelry and other accessories are crafted by the Yakama from animal teeth and rocks/minerals. Tools, such as the digging sticks used for gathering roots, are made from deer and elk antlers and bone.

Yakama members work with all of the materials just described; some make these items on a regular basis. Consequently, one individual may be exposed to contaminants by handling a variety of plant and animal products throughout their lives. Although these preparation times are not converted to actual exposure quantities (e.g., soil ingestion rate) in this report, it is important to consider these exposure pathways qualitatively in risk assessment.

### **3.2.6 Cultural Activities**

The Yakama participate in various cultural activities that are unique and important to their lifestyle and to maintain a connection to their ancestral past, including sweating, feasting, and participating in other cultural activities. As shown in the conceptual site model, these activities create potential exposure pathways via inhalation of water vapors and soil/dust, dermal contact with water and soils, and ingestion of water, soils, fish, meat, and plants.

#### **3.2.6.1 Sweathouse Use**

Use of a sweathouse for physical and spiritual cleansing is an important activity of the Yakama, practiced historically using mobile structures and continuing today with more permanent

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structures, which are generally used on a daily basis. Respondents noted the use of willow branches to construct the sweathouse frame, which not only provides the structure, but also releases its medicinal component during the steaming process. Fir boughs and blankets and other materials complete the construction.

A fire is made outside of the sweathouse (avoiding processed wood or orchard wood that may be contaminated with organic compounds) to heat rocks, which are then used inside the sweathouse to create heat and steam within the confinement of the enclosure. Only porous rocks are used, which may be collected from the Columbia River, to avoid heat-induced explosions. Water is poured over the rocks to create water vapor inside the sweathouse and is used to rinse and re-hydrate outside. The source of water is either surface water (river) or ground water (springs, wells, tap water, etc.). Sweat houses were historically situated near a water source (e.g., alongside a river or, at higher elevations, near ground water springs). Rattlesnake Ridge, for example, which is a unique and sacred area on the Hanford Site, has over 100 different springs that could be useful for situating sweat houses.

Based upon interview data, respondents spend varying amounts of time inside of the sweathouse. Maximum time spent inside the confinement sweating ranged from a total of only 90 minutes per year for those individuals who sweat infrequently (e.g., once or twice per year) or for little duration (e.g., no more than 15 minutes per event), to as much as 7 hours per day for those individuals who sweat at least daily or for several hours per event; the average was 5 hours per week inside the sweathouse. Sweat house use also increases the general water consumption rate in order to replenish water loss during sweating.

### **3.2.6.2 Celebrations and Ceremonies**

The Yakama participate in many different cultural activities, some religious in nature, others strictly festive or recreational. Celebrations include holidays, such as the Indian New Year that is celebrated each year during the winter solstice over a period of two days, as well as other federally-recognized holidays. A very common celebration is the pow-wow that generally occurs multiple times per year (respondents participated an average of approximately 72 hours per year). Treaty day occurs every year on June 9 in celebration of the signing of the Treaty of

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1855 between the U.S. government and the Yakama Nation. Other celebrations include rodeos, tournaments, and trade fairs, each of which may last up to three days.

The Yakama also participate in several types of ceremonies. A burial is a very important 3-day ceremony that occurs whenever there is a death, when the body is lowered into the ground, and is attended by friends, family, and anyone paying respects to the deceased. There are at least five Indian cemeteries identified alongside the Columbia River at the Hanford Site, which, some fear, will be disturbed in future investigations and remediation activities. One year following the burial, a memorial is held for one day to remember the deceased and end the mourning period for family members. Ceremonies are also held to recognize one's "first hunt" and traditional "name giving," which are held in honor of an individual's first hunting kill and in honor of officially passing on an Indian name to an individual, respectively. Currently, to accommodate modern work schedules, these events are generally held for a full day on Saturdays. Other less common ceremonies include a medicine dance, which is conducted by a group of people to help heal a sick individual; a war dance, borrowed from more war-like tribes further east; a smoke dance; and a canoe ceremony (practiced with seafaring tribes on the Pacific coast).

The primary cultural activity is religious services and feasts, centered around the longhouse (and, in more recent times, churches), involving prayer, feasting, singing and dancing. Drums are used during ceremonies, the beat of which is considered the heartbeat of the earth and the heartbeat of the children. Religious ceremonies include the traditional *Washat* services held on Sundays.

The *Washat* services involve prayer, singing, dancing (often on dirt floors), and feasting. Community gathering places include (alphabetically): Celilo longhouse, Priest Rapids (Wanapum) longhouse, Satus longhouse, Satus Shaker church, Shaker church (of 1910), Shaker church (Independent, of White Swan), Toppenish church, Toppenish community center, Toppenish Creek longhouse (of White Swan), Toppenish longhouse, Wapato longhouse, and the White Swan Community Center. Members also gather at several shorthouses in the area as well as members' homes.

"First food" feasts are extremely important ceremonies conducted several times per year to celebrate a food that has made itself available to sustain the Yakama people for another year, such as the first salmon caught swimming up river, the first celery to sprout from the ground, or

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the first berries to form on the bush. These important foods, in addition to being formally recognized during “first food” feasts, are also eaten during weekly *Washat* services, and include salmon, deer or elk meat, and a variety of roots and berries, which are each introduced in the service in that specific order. Feasts also include other food items, such as fry bread.

Historically, Yakamas spent one week before and after the winter solstice feasting at Columbia Point longhouse where the Columbia and Yakima Rivers converge.

Important geographical locations for the Yakama include Signal Peak on the western heights of Toppenish Ridge and Satus Peak. Historically, when tribesmen gathered together for a full week each July in Toppenish, the tribesmen held council, danced, and played stick and bone games. Traditional customs and beliefs, strictly upheld by the Yakama, have been passed on through oral tradition through the generations for thousands of years (Relander, 1986). Rattlesnake Ridge, which is currently part of the Hanford Site, is a very sacred site for the Yakama, providing a wealth of plants to gather for food and medicine, and historically a vision site for children to find their “gift.”

### **3.3 Yakama Exposure Parameters**

Tables 3, 4, 5, and 6 provide published exposure factors for the air pathway, soil / sediment pathway, surface / ground water pathway, and biota pathway, as compiled from the literature, primarily Native American research studies as well as EPA guidance and DOE documents. These tables also include maximum values for the Yakama Nation identified from the interview process, presented in the previous section. Reasonable maximum exposure parameters for the Yakama Nation, developed using results of the ethnographic interviews from this study and published values, are provided in these tables. The proposed exposure values are summarized in Table 7.

#### **3.3.1 Air Pathway**

Table 3 lists exposure parameters for the air pathway. Although air inhalation rates are based upon physiology, and generally do not differ among culturally unique populations, a maximum inhalation rate for the Yakama Nation was estimated using EPA’s average activity level rates.

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Since interview data for this study only included time spent outdoors (light to moderate activity) and time involved in strenuous activity, the rate was calculated by adding the following: maximum time spent outdoors (7 hours per day [hr/d]) multiplied by the EPA average outdoor worker inhalation rate (1.3 cubic meters per hour [ $m^3/hr$ ]), which falls between the range of light and moderate activity levels), added to the maximum time spent doing strenuous activities (7 hr/d) multiplied by the EPA average rate for heavy activity ( $3.2 m^3/hr$ ), added to an assumed sleeping/resting rate for the remaining hours in a day ( $10 \text{ hr/d} * 0.4 m^3/hr$ ). The sum of all activities at average inhalation rates results in a maximum daily rate of  $35 m^3/d$  (assumed for 365 d/yr). This rate cannot likely be maintained for a lifetime of 70 years of exposure.

Consequently, the next highest value reported for strenuous activities, 4 hr/d, was used as a more realistically sustainable rate (multiplied by  $3.2 m^3/hr$ ), resulting in a total rate of  $26 m^3/d$ . This value, which is physiologically plausible for an active lifestyle, is proposed for the Yakama adult inhalation rate. Since no Yakama-specific child data are available, the average inhalation rate (moderate activity) of young U.S. children (age 3 to 5.9 years) of  $16 m^3/d$  is proposed for the Yakama child scenario (Table 7). General exposure factors associated with all pathways are described in Section 3.3.8.

### **3.3.2    Soil / Sediment Pathway**

Table 4 lists exposure parameters for the soil / sediment pathway. The inhalation rate for soil is assumed to be the same as the general inhalation rate calculated in Section 3.3.1, particularly since that rate was calculated based upon time spent outdoors and time involved in strenuous activities, which generally involves exposure to suspended dust particulates. Consequently, the rate for soil/dust inhalation proposed for Yakama adults and children (<6 years) is  $26 m^3/d$  and  $16 m^3/d$ , respectively.

Although data were not collected to estimate Yakama soil ingestion rates in this survey, several lifestyle factors should be noted regarding potential exposure to soil:

- The Yakama Nation traditional subsistence lifestyle involves many hours spent outdoors to fish, hunt, gather, and attend cultural events.

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- Weekly *Washat* services held in longhouses usually involve dancing on a dirt floor, creating dust suspension and inhalation.
- Interview respondents spend a maximum of 7 hr/d outdoors.

Based upon these high exposure activities, the upper percentile of soil ingestion rates (calculated from other studies) are appropriate for the Yakama lifestyle. The soil ingestion rates proposed for Yakama adults is 200 mg/d and for children is 400 mg/d (Table 7). General exposure factors associated with all pathways are described in Section 3.3.8.

### **3.3.3 Surface Water / Ground Water Pathway**

Table 5 lists exposure parameters for the water pathway. Similar to the general inhalation rate calculated in Section 3.3.1, the inhalation rate for water vapor was calculated using EPA recommended activity level rates. The maximum time spent inside a sweathouse (7 hr/d) was multiplied by the EPA average moderate activity inhalation rate ( $1.6 \text{ m}^3/\text{hr}$ ), which was added to the EPA recommended upper range of bathing times ( $15 \text{ min/d} * 1.6 \text{ m}^3/\text{hr}$ ) to account for other water vapor exposures.

The sum of all activities at average inhalation rates results in an RME daily rate of approximately  $12 \text{ m}^3/\text{d}$ . This value does not take into account, however, water vapor potentially inhaled during all other uses of warm and hot water (e.g., hand washing dishes, clothes, etc.); nor does it consider increased breathing rates that occur during sweating. Consequently, the general air inhalation rate of  $26 \text{ m}^3/\text{d}$  and  $16 \text{ m}^3/\text{d}$  for adults and children, respectively (discussed in Section 3.3.1), are proposed for the Yakama water vapor inhalation rate.

The maximum water ingestion rate for all adult Yakama respondents interviewed for this study of 3 L/d (discussed in Section 3.2.4.1) falls within the range of published water ingestion values listed in Table 5. The minimum value listed is 1.4 L/d used by DOE to estimate dose with the RESRAD (RESidual RADiation) modeling program (ITRC, 2002). The maximum value listed is 4 L/d developed for the CTUIR, which accounts for an additional liter per day due to sweathouse use (Harris, 2004). Although respondents for this study were not asked directly

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about additional water consumption during sweathouse use, follow up discussions with ERWM confirmed that additional water (up to 1 L) is consumed during sweathouse use. Consequently, a rate of 4 L/d is a more accurate adult Yakama water ingestion rate. The maximum child water ingestion rate reviewed of 2 L/d (Table 5) is proposed for the drinking water ingestion rate for Yakama children (< 6 years); and assumes that children may ingest approximately 50% of adults (Table 7). General exposure factors associated with all pathways are described in Section 3.3.8.

### **3.3.4 Biota Pathway - Fish**

Table 6 lists exposure parameters for the fish ingestion pathway. The maximum consumption value for fish (and shellfish) for all adult Yakama respondents interviewed for this study was 451 g/d (discussed in Section 3.2.1). This value falls within the range of published literature values reviewed for this study. The minimum value listed is 170 g/d, which is the 95<sup>th</sup> percentile for Native American subsistence populations calculated by the Columbia River Inter-Tribal Fish Commission (CRITFC) and used by the EPA in the Exposure Factors Handbook (CRITFC, 1994; EPA, 1999). The maximum value listed is 1,060 g/d, which is the “high fish diet” ingestion rate (including shellfish) developed for the Spokane Tribe (Harper et al., 2002) and comparable to the rate developed by Walker in 1985 that was based upon a pre-dam estimate for Columbia River Plateau Tribes (Harris, 2004).

The Yakama rate of 451 g/d may be an under-estimation of the RME for Yakama fish consumption for the following reasons:

- Many of the respondents were elders (nearly half were aged 60 years and older), who eat less in general, including less fish because they can no longer fish themselves and depend on friends and family for provisions.
- Many respondents appeared to under-estimate serving size.
- There are sub-sets of the Yakama population who depend more heavily on fish consumption than others, who may not have been reflected in the limited sample set.
- Current rates likely reflect suppressed rates that do not represent a subsistence lifestyle.

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Consequently, other published values were considered more closely. In EPA's report, Estimated Per Capita Fish Consumption in the United States (EPA, 2002b), "fish consumers" were evaluated separately from the rest of the population. The 99<sup>th</sup> percentile of 519 g/d for adults and 363 g/d for children (< 6 years) estimated by EPA for fish consumers (of all fish, uncooked) are proposed as more accurate Yakama adult and child fish consumption rates, respectively (Table 7). General exposure factors associated with all pathways are described in Section 3.3.8.

### **3.3.5 Biota Pathway - Meat**

Table 6 lists exposure parameters for the meat ingestion pathway. The maximum consumption value for meat (hunted and domestic) for all adult Yakama respondents interviewed for this study was 704 g/d (discussed in Section 3.2.2). This value falls within the range of published literature values reviewed for this study. The minimum value listed is 125 g/d developed for the CTUIR, which does not include domestic beef (Harris, 2004), and the maximum value is 935 g/d developed for the Spokane Tribe (Harper et al., 2002). Until additional Yakama-specific meat consumption information can be collected, the respondent data provide in this study is relied upon to develop a Yakama meat consumption value.

The meat ingestion rate of 704 g/d is summarized in Table 7. The only child rate reviewed of 212 g/d, used by the Washington State Department of Health (DOH, 2003), is proposed for the Yakama child meat ingestion rate. General exposure factors associated with all pathways are described in Section 3.3.8.

### **3.3.6 Biota Pathway - Plants**

Table 6 lists exposure parameters for the plant ingestion pathway. The maximum plant consumption rate for all roots, berries, stalks and leaves of gathered wild and garden plants for all adult Yakama respondents was 1,208 g/d (discussed in Section 3.2.3). When the plant consumption data are separated into vegetables (including roots) and fruits (including berries), the maximum values are 1,118 g/d and 299 g/d, respectively (maximums representing different individuals).

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The vegetable consumption value falls within the range of published literature values reviewed for this study. The minimum value listed is 7.4 g/d used by DOE to estimate dose with the RESRAD modeling program (ITRC, 2002), and the maximum value is 1,600 g/d developed for the Spokane Tribe (Harper et al., 2002). The fruit consumption value also falls within the range of published values reviewed. The minimum value listed is 125 g/d developed for the CTUIR (Harris, 2004), and the maximum is the EPA rate of 868 g/d, which is the 95<sup>th</sup> percentile for the general population (EPA, 1999). Until additional Yakama-specific plant consumption information can be collected, the respondent data provide in this study is relied upon to develop a Yakama plant consumption value.

The vegetable and fruit ingestion rates of 1,118 g/d and 299 g/d, respectively, are summarized in Table 7. The only child rates reviewed of 187 g/d and 127 g/d, used by the Washington State Department of Health (DOH, 2003), are proposed for the Yakama child vegetable and fruit ingestion rates, respectively. General exposure factors associated with all pathways are described in Section 3.3.8.

### **3.3.7 Biota Pathway - Milk**

Table 6 lists exposure parameters for the milk ingestion pathway. The maximum ingestion rate for milk for all adult Yakama respondents interviewed for this study was 1.2 L/d (discussed in Section 3.2.4.1). This value falls within the range of published literature values reviewed for this study. The minimum value listed is 0.49 L/d developed for by Harris and Harper (1997), and the maximum value is the EPA rate of 2.2 L/d, which is the 95<sup>th</sup> percentile for the general population (EPA, 1999). Until additional Yakama-specific milk ingestion information can be collected, the respondent data provide in this study is relied upon to develop a Yakama ingestion value.

The milk ingestion rate of 1.2 L/d proposed for Yakama adults is summarized in Table 7. The only child milk ingestion rate reviewed for this study of 0.5 L/d (Harper et al., 2002) is proposed for the Yakama child rate. General exposure factors associated with all pathways are described in Section 3.3.8.

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### **3.3.8 Other Exposure Factors**

Since the maximally exposed Yakama individual is a subsistence fisher-hunter-gatherer living on the Hanford site year round, the maximum exposure frequency proposed for the adult Yakama is 365 days per year.

The exposure duration constitutes an entire lifetime. Although detailed demographic data are not available for the entire Yakama Nation population, nearly half of the respondents were elders (age 60 years and older) and many of these were older than 70 years. EPA's life expectancy for the general U.S. population (projected for 2010) is 78 years. Based upon this information, the adult exposure duration would be 72 years (78 life time minus 6 childhood years); however, the default value of 70 years is adequate as an average lifetime for risk calculations. For children, the exposure lifetime is considered 6 years.

The maximum weight of the respondents was much greater than the U.S. general population adult default value of 70 kg; however, without further demographic information about all members of the Yakama Nation, the average adult body weight of 70 kg should be used as default. Similarly, the default value of 16 kg is proposed for children.

### **3.4 Exposure Scenario Summary**

This exposure scenario for Yakama members is a subsistence fisher-hunter-gatherer scenario for an individual living on the site, conducting daily and seasonal activities on the entire site and surrounding areas, eating local fish and wildlife, drinking local ground water and surface water, breathing local air, and using all usual and accustomed places year round. Dietary habits, natural resource use, and exposure to potentially contaminated media and biota should be considered for the Yakama Nation, which differs from the general population. A safe and healthy subsistence lifestyle should remain an option for the Yakama in their ancestral lands. Potential contaminant exposure from such a lifestyle is expected to be considered when calculating allowable dose and estimating risk from radionuclide and hazardous chemical contaminants from Hanford Site releases.

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This exposure scenario provides a compilation of general information about the Yakama Nation traditional and subsistence lifestyle, including cultural practices that intimately connect this Native American population to regional natural resources. It is not, however, all inclusive. Other aspects of the Yakama lifestyle remain to be researched and addressed, such as additional dietary patterns (e.g., grain intake), rate of breast feeding, highly sensitive individuals, and overall general health.

Although a limited sample group was interviewed for this study, these individuals provided information representative of the general Yakama Nation population. These individuals provided information not only about their own dietary and activity patterns, but also those of their parents and children. Although specific daily activity patterns of children (age 0-6 years) are not described here, they were found to participate in many of the same activities as the adults; for example, families often bring their children on plant gathering expeditions about the age of 5 years. Men and women may participate in slightly different daily and seasonal activities, but the general exposure time to environmental media is likely to result in a comparable exposure.

Although this report was divided into various exposure activities, members of the Yakama Nation generally participate in all of the activities described in this scenario. The lifestyle is considered active, with a lot of time spent outdoors. Fishing, hunting, and gathering remain an important aspect of daily life, including the consumption and use of the resources that are harvested and distributed. Items such as tools, shelter, clothing, and accessories continue to be made by hand using raw plant and animal materials. Cultural practices, such as weekly religious services, events to recognize achievement, and memorials for those passed away, are the foundation of the cultural fabric of the nearly 10,000 members who comprise the Yakama Nation.

The Hanford Site is situated within the ancestral lands of the Yakama Nation, members of which spent winters on the site, then dispersed in other seasons to collect food from all areas and all elevations. The Yakamas were restricted from entering the site, however, between 1943 and 1988, when the Hanford Site was an active plutonium production plant, and access remains restricted during the cleanup process. There are areas of the Site, such as Rattlesnake Ridge and

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islands in the Columbia River, that are unique and sacred, produce important foods and medicines, and which are revered and used for prayer. It is hoped that all areas will become available as cleanup actions are successfully completed.

The Yakama Nation is determined to ensure that the Hanford Site is cleaned up, efficiently and thoroughly, to protect and preserve the soils, waters, plants, fish and other animals of the area, and the health of the people that depend upon, and have rights to, these natural resources now and for future generations. The Yakama dependence on the consumption and use of natural resources suggests that the Yakama represent a maximally exposed population, potential contaminant exposures to whom should be evaluated during a comprehensive risk assessment of the Hanford Site.

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## **4.0 RECOMMENDATIONS AND DATA NEEDS**

This section provides recommendations for data use as well as additional data needs.

### **4.1 Data Use**

It is expected that DOE will use this Yakama Nation exposure scenario and the lifeways described herein to conduct Hanford Site risk assessment. Cumulative risk should be evaluated for all exposure pathways, all contaminants, and all locations (including down wind and downstream of the site boundaries) over an individual Yakama's lifetime. High-level radioactive waste, nuclear reactor facilities, chemical processing operations, contaminated groundwater, polluted sediment, and plants and animals all pose risks to Yakama individuals. Consideration of all sources, areas, and management activities together will provide a more holistic evaluation of the Hanford Site than conducted thus far. The risk assessment should consider qualitative information provided in this exposure scenario, which explains the extent to which the Yakama depend upon the use of the soil and water, plants, fish and other animals, in addition to the quantitative exposure parameters.

During DOE's assessment, contaminant concentration terms should be used that spatially represent the entire Hanford Site. It is vital that DOE use adequate concentration data to evaluate potential risk, without parcelling the site or dismissing usable data. Use of appropriate concentration terms together with Yakama Nation exposure parameters and appropriate toxicologic data will facilitate estimating cancer, non-cancer risk, and radiation exposure. These calculations should evaluate the potential exposure to the Yakama Nation as a "receptor group" and should be combined to obtain a cumulative exposure assessment.

Based upon an increased emphasis on the evaluation of chemical mixtures, aggregate exposures, and cumulative risk assessments, it is recommended that DOE use the results of the exposure assessment described in this report to quantify aggregate exposures. These aggregate exposures should combine the exposure of an individual to a specific contaminant by various exposure routes (e.g., summing exposure to an agent via ingestion of water and food, dermal contact, etc.). It should also quantify cumulative risk, which combines the aggregate exposures of multiple

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chemical or physical agents (i.e., daily activity patterns combined to evaluate an entire lifetime); and determine cleanup based on a holistic paradigm that evaluates the risk assessment combined with an evaluation of community health and environmental restoration, which are intrinsically linked (Arquette, et al., 2002; EPA, 2004b).

Ultimately, to protect the Yakama Nation, it is expected that DOE will thoroughly investigate and characterize the Hanford Site, utilize available historical information and monitoring data, and incorporate the information into a comprehensive risk assessment for the entire site. Hazards identified during the risk assessment process should be addressed in the cleanup to allow safe use of the Hanford Site and surrounding areas.

#### **4.2 Data Needs**

The following additional data needs are recommended for further study and to provide a statistically robust data set to expand upon the Yakama Nation exposure scenario presented in this report:

- Conduct additional interviews to allow a greater sample size.
- Collect additional data regarding child-specific consumption rates, which are likely the most sensitive receptor group.
- Collect additional historic, demographic, and nutritional health information on the entire Yakama Nation population.

These data needs are recommended for future studies and do not discount the exposure scenario presented in this report.

Actual site media and biota contaminant concentrations should be used for exposure point values. For example, concentrations of radionuclide and hazardous chemicals measured in roots and berries from the Hanford site should be used with RME ingestion rates to calculate risks from this pathway. The Yakama Nation hopes to work closely with DOE, EPA, and other stakeholders to ensure the scenario is applied appropriately to the risk assessment process and to

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ensure an adequate cleanup of the Hanford Site. Involvement of the Yakama Nation throughout the risk assessment process is critical to ensuring issues are addressed and data are used appropriately in the cleanup process.

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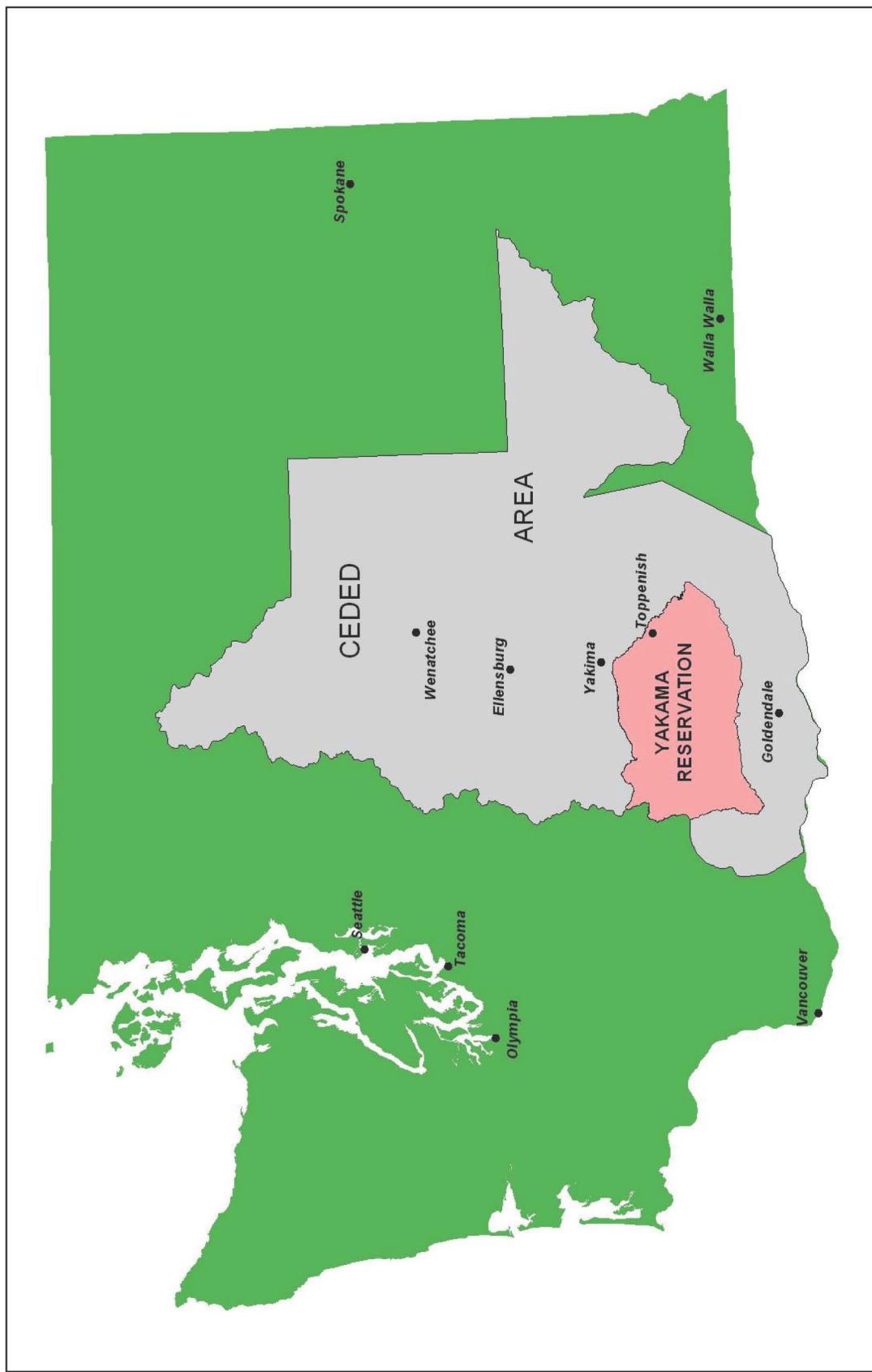
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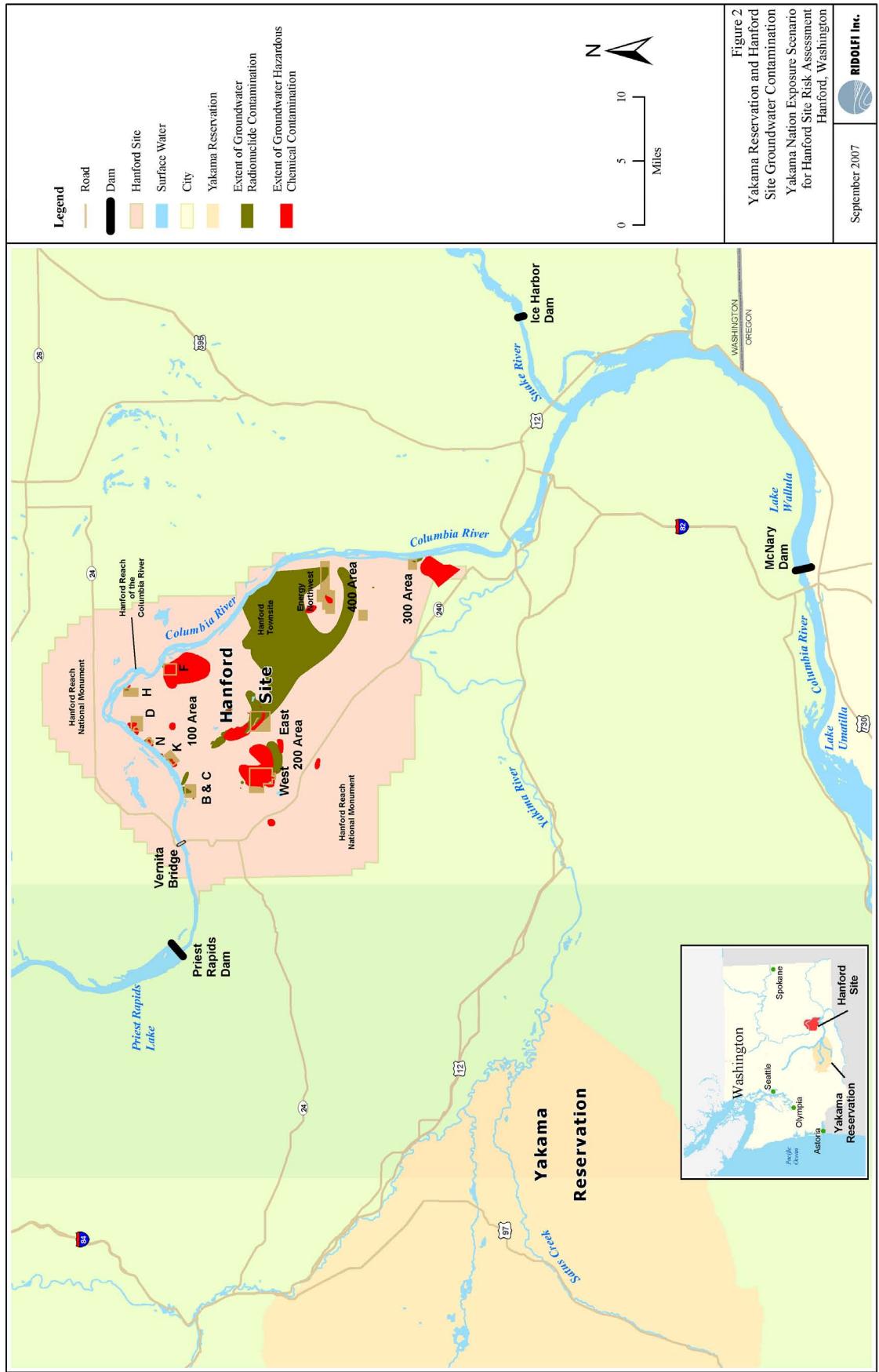
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## **FIGURES**

**Figure 1. Yakama Nation Reservation and Ceded Lands**

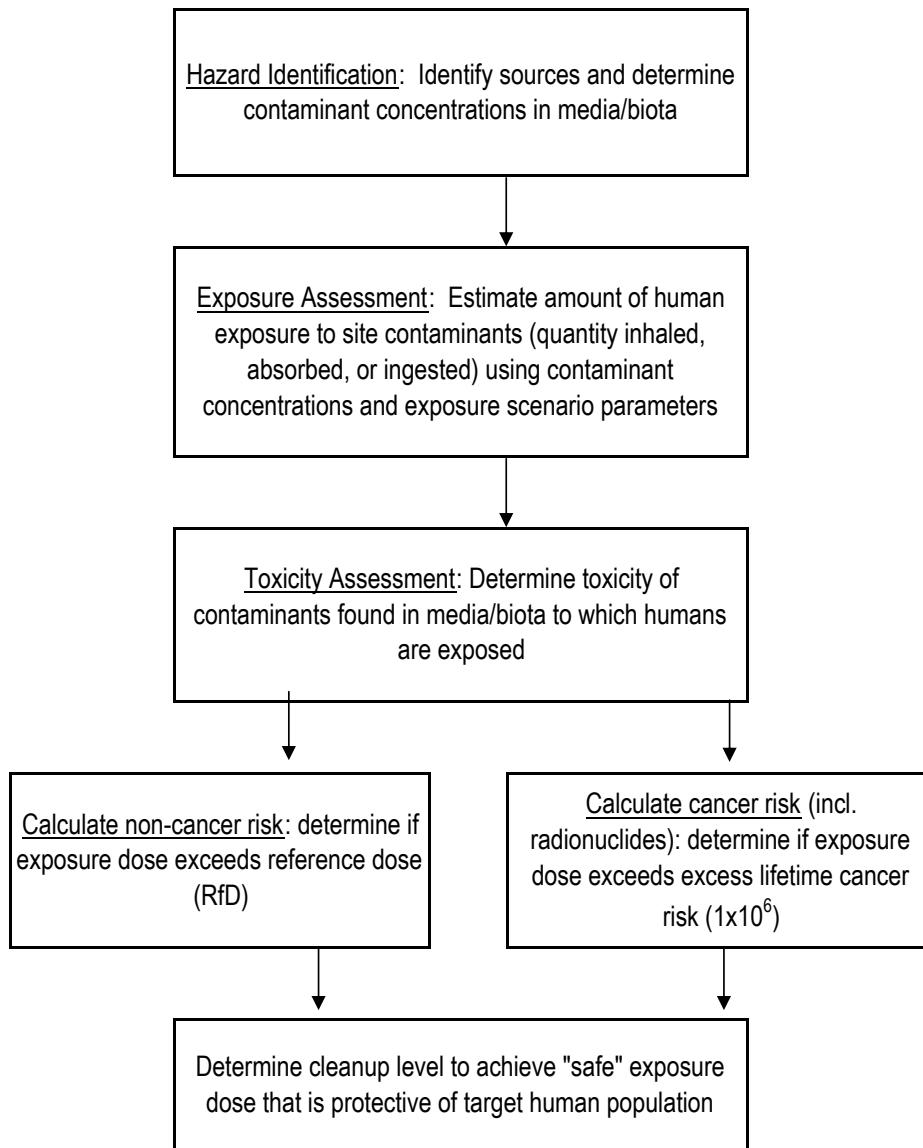




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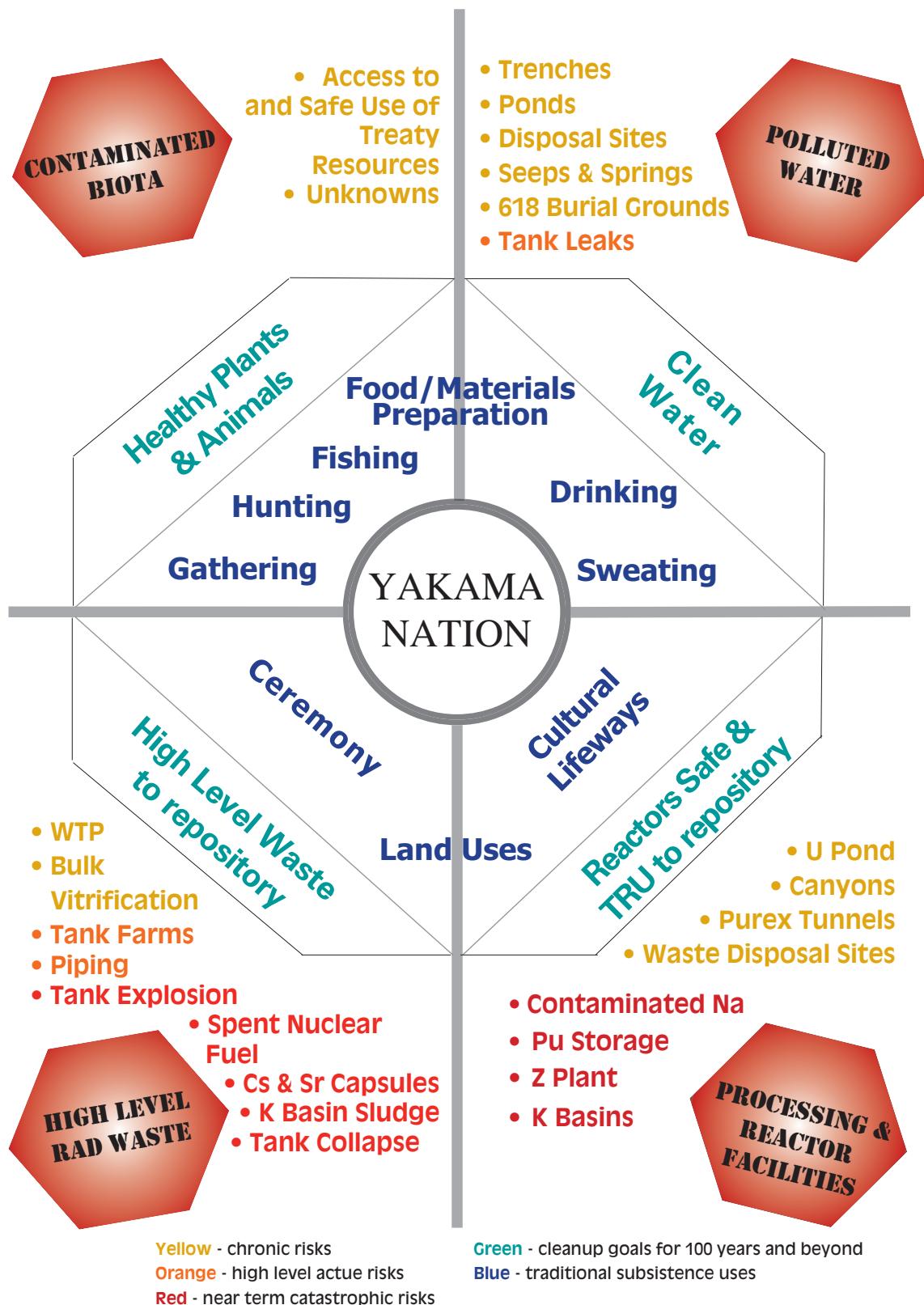
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**Figure 3. Human Health Risk Assessment Flow Chart**

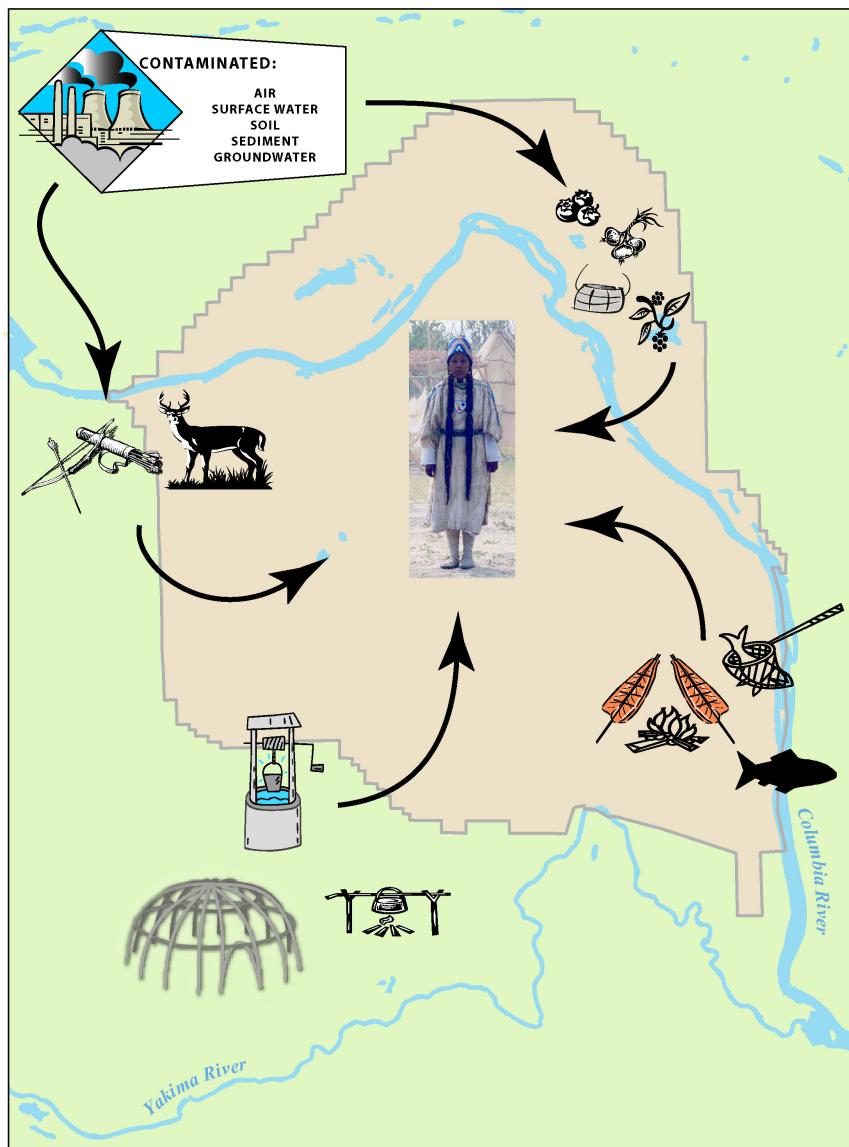


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**Figure 4. Holistic View for Cleanup of Hanford Threats**



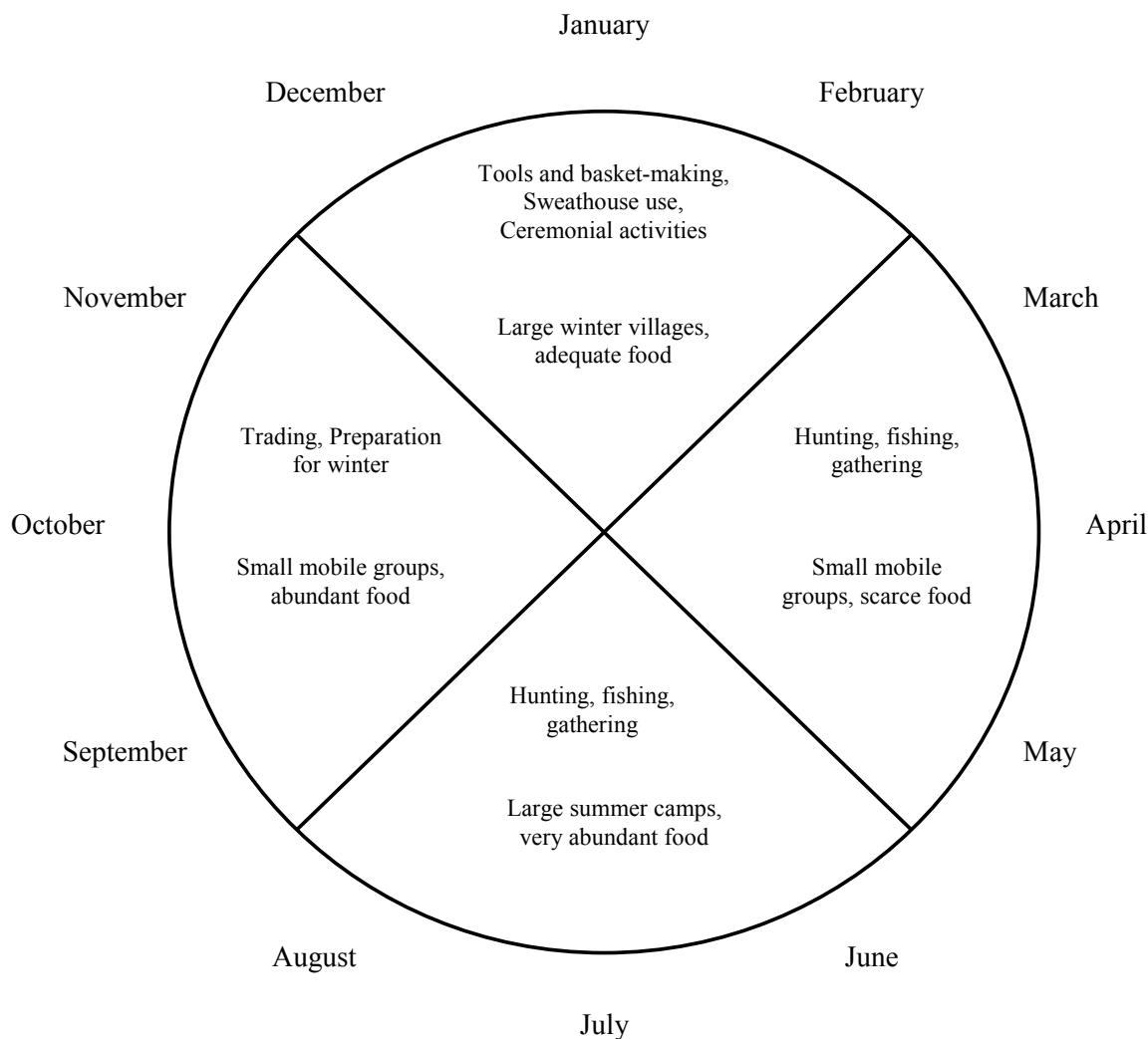
**Figure 5. Yakama Nation Conceptual Site Model  
for Hanford Site Contaminant Exposure**



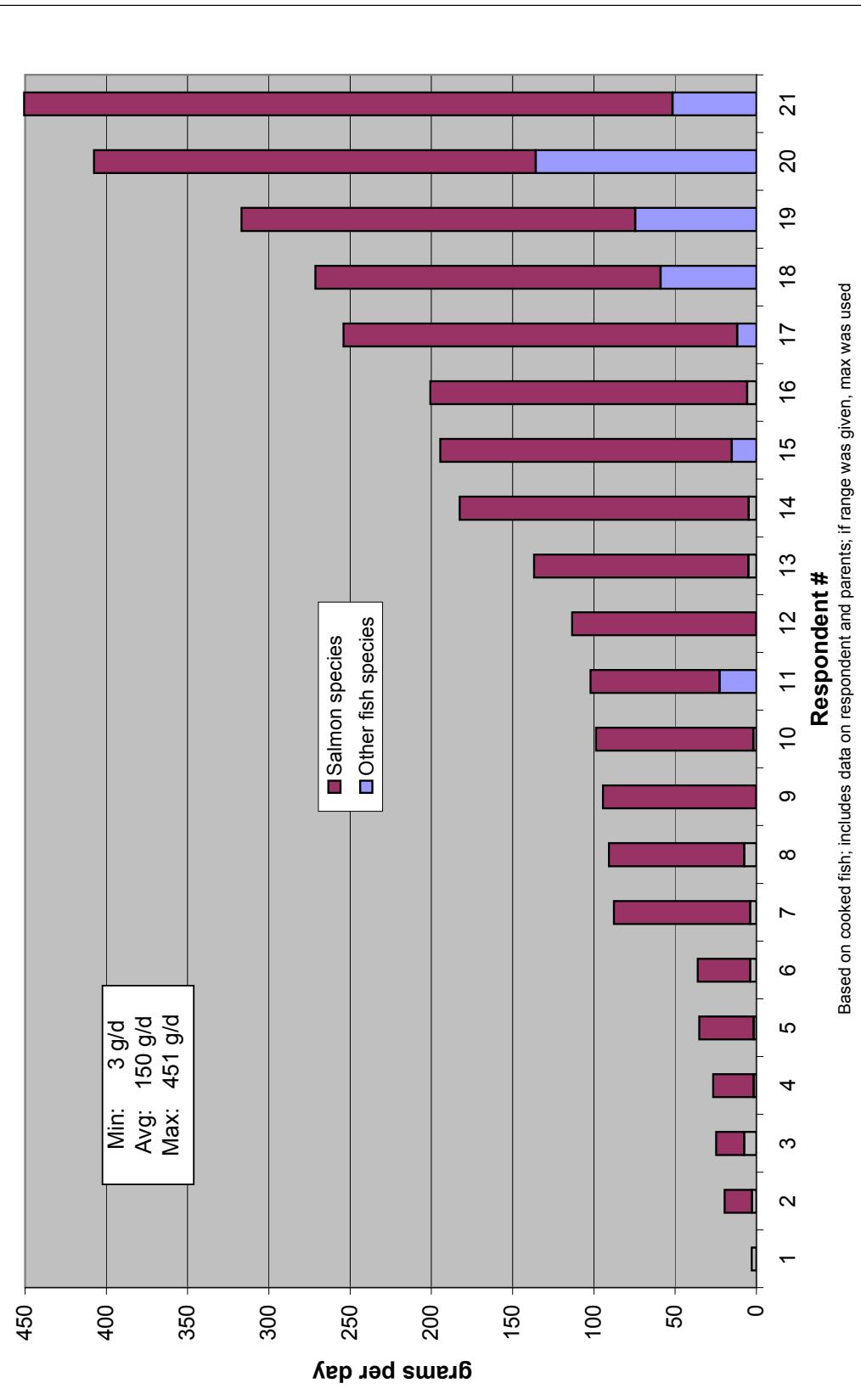
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**Note:** This figure represents a Yakama member conducting all of his or her daily and seasonal activities, including fishing, hunting, gathering, sweating, celebrating, eating local resources, drinking local ground water and surface water, and breathing local air, on the entire Hanford Site and surrounding areas.

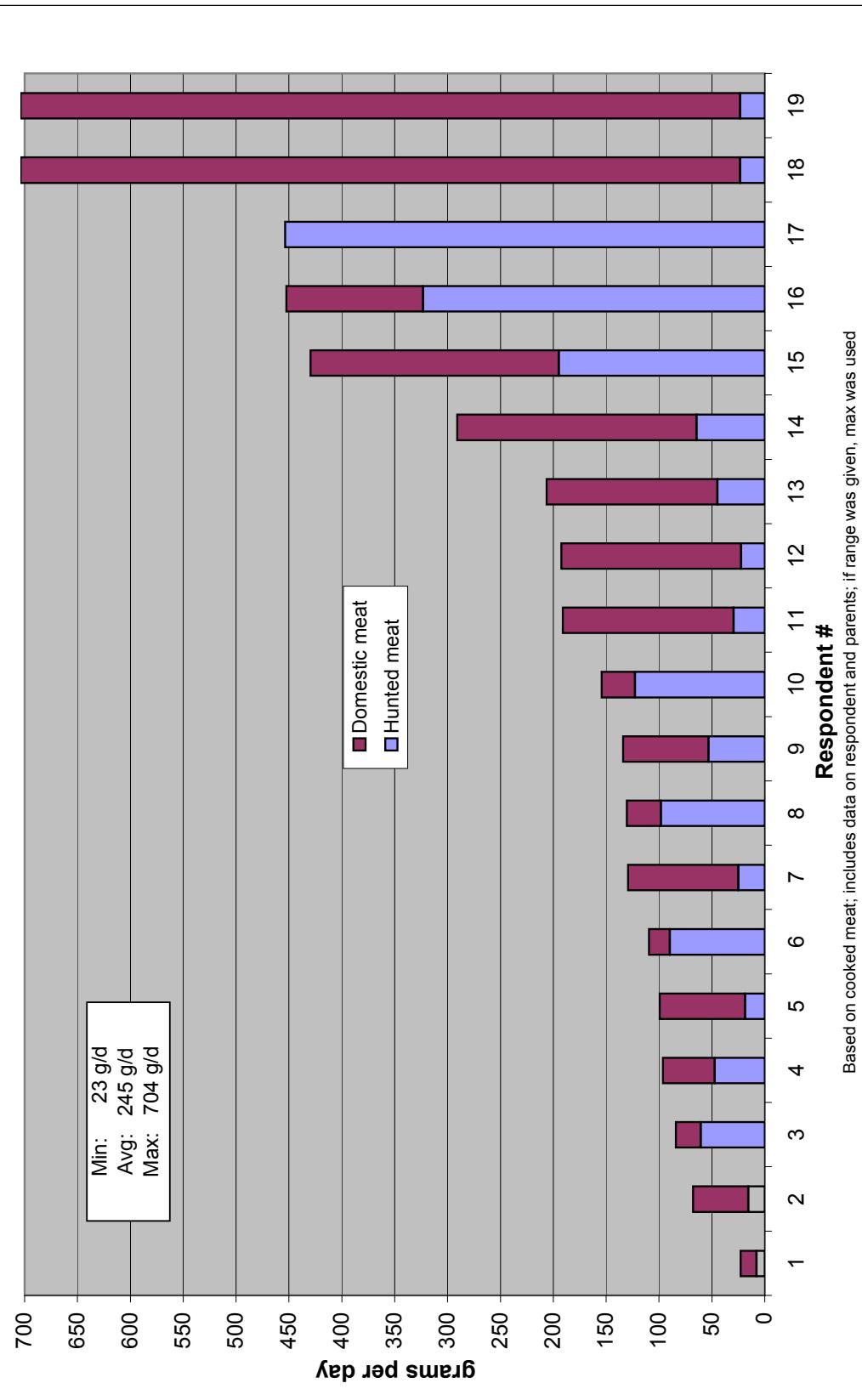
**Figure 6. Yakama Nation Historical Seasonal Activities**



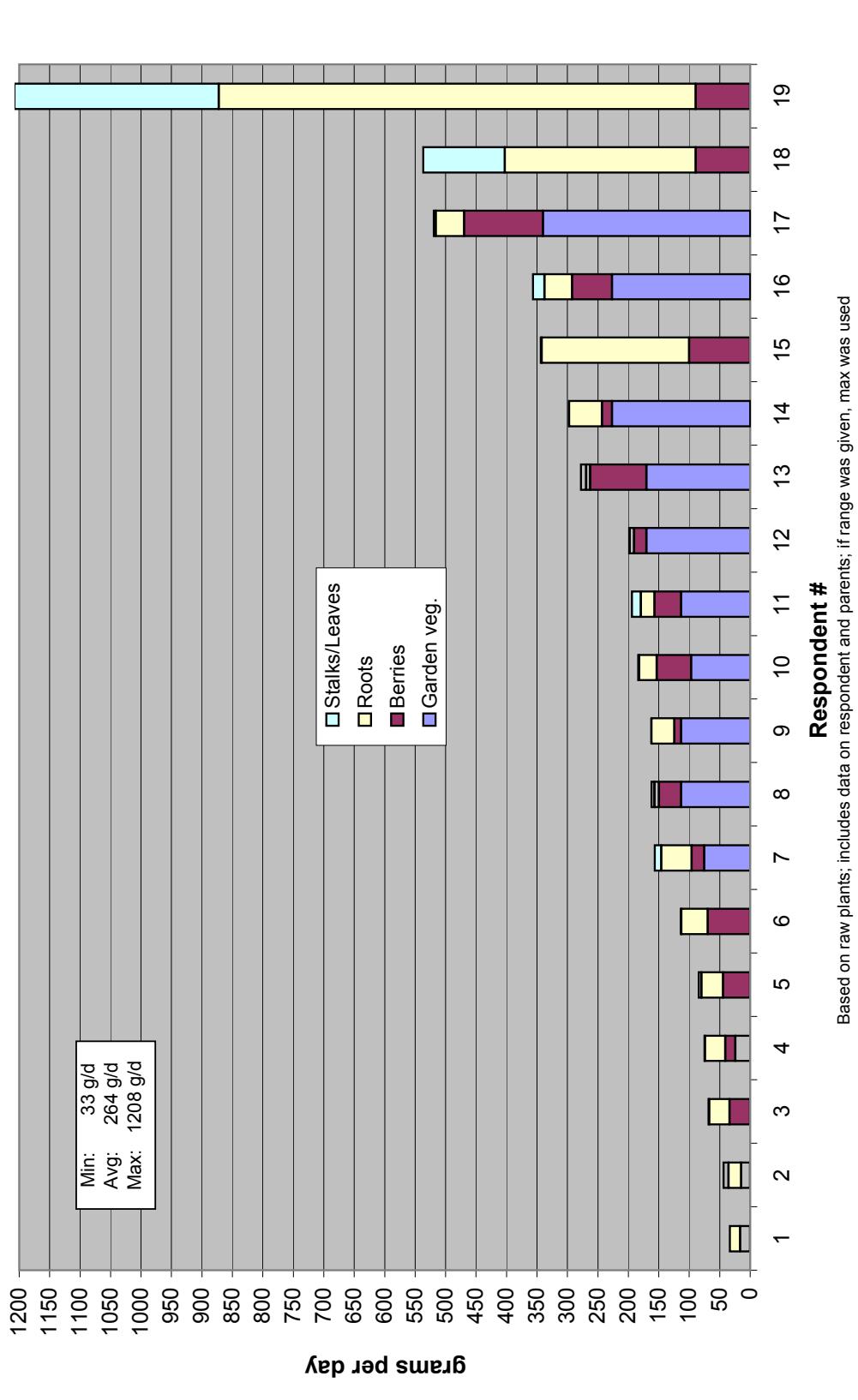
**Figure 7. Adult Fish Consumption (g/d)**

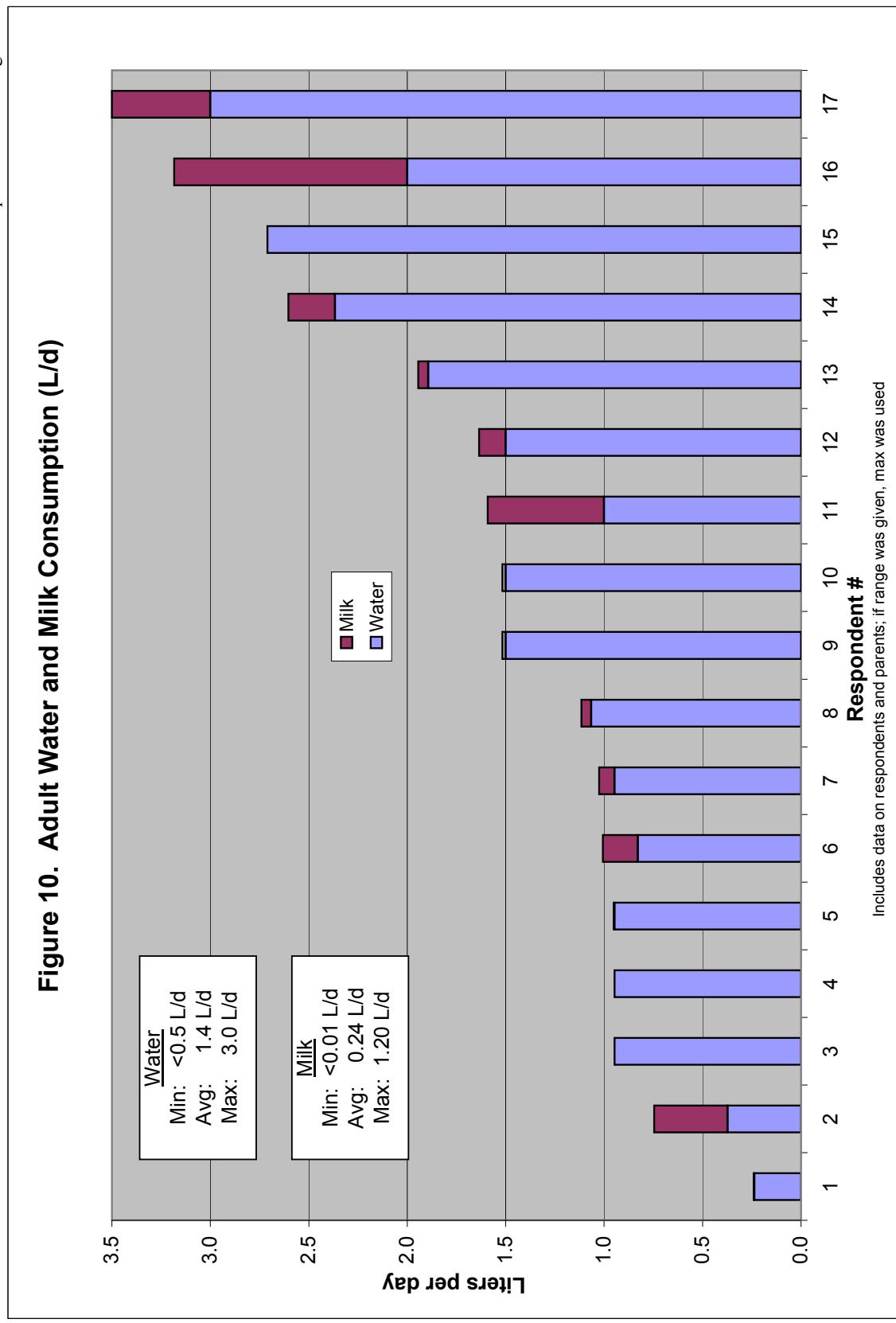


**Figure 8. Adult Meat Consumption (g/d)**



**Figure 9. Adult Plant Consumption (g/d)**





*Tank Closure and Waste Management Environmental Impact Statement for the  
Hanford Site, Richland, Washington*

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**RIDOLFI Inc.**

Yakama Nation Exposure Scenario  
for Hanford Site Risk Assessment  
September 2007

## **TABLES**

## Appendix W ▪ American Indian Tribal Perspectives and Scenarios

RIDOLFI Inc.

Yakama Nation Exposure Scenario  
for Hanford Site Risk Assessment  
September 2007 Page 1 of 1

**Table 1. Yakama Nation Lifestyle Activity Matrix**

Questions	Fishing	Hunting	Gathering	Materials Production	Other Daily Living Patterns	Sweathouse	Ceremonial / Cultural Events
WHAT (process)	Travel to fishing area, and actively fish, harvest, and carry out fish	Travel to hunting area, and await, pursue, hunt, and carry out animals	Travel to gathering areas, dig, cut, harvest, and carry out plants	Make tools for hunting, including spears, bows and arrows	Bathe and shower	Gather wood and other materials and construct sweathouse	Gather to eat, pray, sing, and dance (including First Feast)
	Eviscerate fish; clean and fillet carcass	Eviscerate animal; skin/scrape hide, debone/quarrel carcass	Wash, peel, and process plant parts	Make tools for fishing, including poles, reed nets, dip nets	Rest and sleep	Gather, haul, and chop firewood, and prepare fire	Attend Washat and other religious services
	Separate fillets, bones, head, and organs	Cut meat and remove organs	Separate plant roots, stalks, leaves, and berries for food, medicine, or materials use	Make tools for gathering, including digging implements (antlers, sticks)	Work and play	Gather rocks to heat in fire	Attend burials, memorials, first hunt and naming ceremonies
	Cook edible fish parts by roasting/broiling, baking, boiling/coaching, frying	Cook meat and organs for stew, roast, and jerky	Prepare plants by steaming, boiling, frying, and raw	Weave baskets from plants for water, food, and storage	Camp in new locations	Gather water for steam and rinsing	Attend recreational events (pow-wows, tournaments, Treaty Days, etc.)
	Preserve fish by smoking, drying, salting, freezing, and canning	Preserve meat by smoking, drying, freezing, and canning	Preserve plants by drying and grinding to powder	Grind seeds and other plant parts for food and medicines	Recreational activities	Sit in sweat house, create steam, talk, sing, and chant	Send children to mountain for spiritual guidance (historical)
	Clean fish bones for materials use	Tan hide and use antlers/bones for materials use	Extract dyes for materials use	Construct long house, sweat house			
WHAT (species)	• Salmon • Trout • Lamprey (eel) • Smelt • Whitefish • Sturgeon • Walleye • Sucker	• Deer • Elk • Rabbit • Otter • Beaver • Pheasant • Duck	• Balsamroot • Bitterroot • Gray's desert parsley • Gardner's yampah • Indian hemp • Indian celery • Chokecherry • Blue elderberry • Huckleberry	• Willow • Indian hemp • Cedar	• Water • Soil / dust	• Willow • Fir boughs • Cedar • Rose bush • Water • Rocks	
WHEN (duration, timeline)	Year round, depending on species migration patterns	Year round, depending on species migration patterns	Mar - Nov, depending on species growth cycles	Year round, primarily in winter	Jan - Dec	Year round	Year round
	Spring Chinook salmon eaten -March for First Feast	No female elk/deer Jan to Jun (allowing for reproduction)	Spring roots, summer plants, fall berries		Bathe 0.5 hr/d; Sleep 8 hr/d		Determined by food availability and events
WHERE (location)	Columbia River, Hanford Reach	Laleek (sacred Rattlesnake Mtn), And Lands Ecology	Laleek (sacred Rattlesnake Mtn), And Lands Ecology	All areas	All areas	Near Columbia River	Lock Island - burial site
	West side of Lock Island - salmon spawning area	Gable Mountain and other upland areas	Snively basin (cold creek)			Near upland springs	
	Beyond Hanford Reach, e.g. Yakima River, previously Celilo Falls	"Open and unclaimed land" (Treaty)	Toppenish Mountain (Poisal Butte)				
	"Usual and accustomed" fishing areas (Treaty)	"Open and unclaimed land" (Treaty)					
WHO (bands; sexes, ages)	All (incl. Wanapum)	All	All	All	All	All	All
	Primarily males, some females	Primarily males, some females	Primarily females, some males				
	Primarily adults, some youth	Primarily adults, some youth	Adults and youth	Adults and youth			
HOW (all possible exposure pathways)	Inhale air from exertion of fishing activities	Inhale air from exertion of hunting activities	Inhale air from exertion of gathering activities	Inhale air from exertion of materials preparation activities	Inhale air from exertion of living pattern activities	Inhale air from exertion of sweathouse use activities	Inhale air from exertion of ceremonial/cultural event activities
	Inhale soil from dust disturbed during fishing activities	Inhale soil from dust disturbed during hunting activities	Inhale soil from dust disturbed during gathering activities	Inhale soil from dust disturbed during materials preparation activities	Inhale soil from dust disturbed during living pattern activities	Inhale soil from dust disturbed during sweathouse use activities	Inhale soil from dust disturbed during ceremonial/cultural event activities
	Dermally contact soil / sediment during fishing activities	Dermally contact soil/dust during hunting activities	Dermally contact soil during gathering activities	Dermally contact soil during materials preparation activities	Dermally contact soil during living pattern activities	Dermally contact soil during sweathouse use activities	Dermally contact soil during ceremonial/cultural event activities
	Ingest soil / sediment during fishing activities	Ingest soil during hunting activities	Ingest soil during gathering activities	Ingest soil / sediment during materials preparation activities	Ingest soil during living pattern activities	Ingest soil during sweathouse use activities	Ingest soil during ceremonial/cultural event activities
	Inhale water vapors during fishing activities	Inhale water vapors during hunting activities	Inhale water vapors during gathering activities	Inhale water vapors during materials preparation activities	Inhale water during living pattern activities	Inhale water vapors during sweathouse use activities	Inhale water vapors during ceremonial/cultural event activities
	Dermally contact water during fishing activities	Dermally contact water during hunting activities	Dermally contact water during gathering activities	Dermally contact water during materials preparation activities	Dermally contact water during living pattern activities	Dermally contact water during sweathouse use activities	Dermally contact water during ceremonial/cultural event activities
	Drink water during fishing activities	Drink water during hunting activities	Drink water during gathering activities	Drink water during materials preparation activities	Drink water during living pattern activities	Drink water during sweathouse use activities	Drink water during ceremonial / cultural event activities
	Ingest edible fish and shellfish parts collected from fishing	Ingest wild game and waterfowl collected from hunting	Ingest plants collected from gathering		Ingest plants and animals during living pattern activities		Ingest plants and animals during ceremonial / cultural event activities
WHY (survey questions)	Discuss fishing activities	Discuss hunting activities	Discuss gathering activities	Discuss food/materials preparation activities	Discuss daily/seasonal living patterns	Discuss sweathouse use	Discuss ceremonial / cultural activities
	What do/would you fish?	What do/would you hunt?	What do/would you gather?	What materials do/would you make?	What are your living patterns?	What sweathouse do/would you use?	What ceremonies do/would you practice?
	When do/would you fish?	When do/would you hunt?	When do/would you gather?	When do/would you make these materials?	When do/would you do these activities?	When do/would you use the sweathouse?	When do/would you practice?
	Where do/would you fish?	Where do/would you hunt?	Where do/would you gather?	Where do/would you make these materials?	Where do/would you do these activities?	Where do/would you use the sweathouse?	Where do/would you practice?
	How often/long do/would you fish?	How often/long do/would you hunt?	How often/long do/would you gather?	How often do/would you make these materials?	How often do/would you do these activities?	How often do/would you use the sweathouse?	How often do/would you practice?

Table 1. Activity Matrix.xls



**Table 3. Exposure Parameters for Air Pathway**

Media Pathway	Exposure Parameter	Inhalation			Air exposure time/frequency/duration			Modifying Factors			BW	BW <sub>c</sub>
		IR	IR <sub>c</sub>	ET	EF	ED	ED <sub>c</sub>	Child	Adult/Child	Adult		
Abbreviation	Receptor	Adult	Child	hrs/d	d/yr	yr	yr	kg	kg	kg	kg	kg
Units		m <sup>3</sup> /d	m <sup>3</sup> /d									
<b>Native American Rates</b>												
TWRS, 1996	30	15	24	365	64	6	70	16				
Haris & Harper, 1997	20	-	24	365	70	-	70	-				
CRCLA, 1998	30	-	24	365	70	-	70	-				
Harper et al., 2002	30	-	-	-	-	-	-	-				
DOH, 2003	30	15	24	365	-	-	-	70	16			
Haris, 2004	30	-	-	365	70	-	-	-				
<b>U.S. Residential Rates</b>												
EPA, 1999 and 2002	31 <sup>a</sup>	16	-	365	78 <sup>c</sup>	-	72 <sup>d</sup>	-				
DOE (RESRAD)	20	-	-	-	30	-	-	-				
<b>Statistics</b>												
Min		20	15	24	365	30	6	70	16			
Max		31	16	24	365	78	6	72	16			
<b>Yakama Nation</b>												
Yakama Max*		26 <sup>b</sup>	n/a	24	365	75	n/a	145	n/a			
<b>Yakama Proposed</b>		26	16	24	365	70	6	70	16			

**Notes**

\* Yakama maximum exposure factors are based on data provided by interview respondents from this study.

a. Yakama mean for outdoor workers is 1.3 m<sup>3</sup>/hr, recommended by EPA.

b. Rate is based on maximum time spent outdoors x EPA average population inhalation rate added to the 2nd-highest time during strenuous activities x EPA avg heavy activity inhalation rate, added to the assumed sleeping/relaxing rate for remaining 10 hours of day (max values for all individuals) ( $7\text{ hr}/d \times 1.3\text{ m}^3/\text{hr}$ ) + ( $4\text{ hr}/d \times 0.4\text{ m}^3/\text{hr}$ ).

c. Exposure duration is life expectancy projected for general U.S. population in 2010.

d. Body weight = average of general U.S. population.

n/a = not available (not enough information to calculate).

**References**

- TWRS, 1996 = Tank Waste Remediation System Environmental Impact Statement (cited in DOH, 2003)
- Haris & Harper, 1997 = a Native American Scenario Risk Analysis, 17(6):789-795 (also cited in DOH, 2003)
- CRCLA, 1998 = Columbia River Comprehensive Impact Assessment, DO-RL-98-16 (cited in DOH, 2003)
- Harper et al., 2002 = The Spokane Tribe's Multipathway Substance Exposure Scenario and Screening level RME Risk Analysis, 22(3):513-526
- DOH, 2003 = Radiological Risk Assessment (Appendix I) for Final Environmental Impact Statement, Washington Department of Health [www.ecy.wa.gov/programs/stop/index.html].
- Haris, 2004 = Exposure Scenario for CTUR Traditional Substance Lifeways Confederated Tribes of the Umatilla Indian Reservation
- EPA, 1999 = Environmental Protection Agency, Exposure Factors Handbook, EPA/600/C-99/001 (mean values for U.S. population).
- EPA, 2002 = Environmental Protection Agency, Child-Specific Exposure Factors Handbook, EPA/600/P-00/002 (average moderate activity [playing] inhalation rate for U.S. children <5 yrs).
- DOE (RESRAD) = U.S. Department of Energy, RESRAD Radiation dose modeling system, input parameters cited in ITRC, 2002.
- ITRC, 2002 = Technical and Regulatory Document, Determining Clean-up Goals at Radioactively Contaminated Sites: Case Studies, The Interstate Technology and Regulatory Council.

**Table 4. Exposure Parameters for Soil / Sediment Pathway**

Media Pathway	Exposure Parameter	Inhalation				Soil/Sediment Ingestion				Soil and Sediment				Modifying Factors			
		IR	IR <sub>c</sub>	Soil/sediment, inhalation rate	IR	IR <sub>c</sub>	Soil/sediment, ingestion rate	ED	ED <sub>c</sub>	Soil exposure time/frequency/duration	ED	ED <sub>c</sub>	Body weight	BW	BW <sub>c</sub>		
Abbreviation	Receptor	Adult	Child	Adult	Child	Adult/Child	Adult/Child	yr	yr	Adult	Child	kg	kg	kg			
Units		m <sup>3</sup> /d	m <sup>3</sup> /d	m <sup>3</sup> /d	m <sup>3</sup> /d	m <sup>3</sup> /d	m <sup>3</sup> /d	hr/d	hr/d	yr	yr	kg	kg	kg			
<b>Native American Rates</b>																	
TWRs, 1996		30	15	200	200	24	365	64	6	70	16						
Harris & Harper, 1997	20	-	200	200	24	180	70	-	70	-	-						
CRCLA, 1998	30	-	200	200	24	365	70	-	70	-	-						
Harper et al. 2002	30	-	400	-	-	-	-	-	-	-	-						
DOH, 2003	-	-	200	200	24	365	-	-	-	-	70	16					
Harris, 2004	30	-	400	400	-	365	70	-	-	-	-						
<b>U.S. Residential Rates</b>																	
EPA, 1999 and 2002	-	16	50	400 <sup>b</sup>	-	-	180	78 <sup>c</sup>	-	72 <sup>d</sup>	-						
DOE (RESRAD)	20	-	100	-	-	-	-	30	-	-	-						
<b>Statistics</b>																	
Min		20	15	50	200	24	180	30	6	70	16						
Max		30	16	400	400	24	365	78	6	72	16						
<b>Yakama Nation</b>																	
Yakama Max*		26 <sup>a</sup>	n/a	n/a	n/a	24	365	75	n/a	145	n/a						
<b>Yakama Proposed</b>		<b>26</b>	<b>16</b>	<b>200</b>	<b>400</b>	<b>24</b>	<b>365</b>	<b>70</b>	<b>6</b>	<b>70</b>	<b>16</b>						

**Notes**

- \*Yakama maximum exposure factors are based on data provided by interview respondents from this study.
- b. Rate is based on maximum time spent outdoors / EPA average population inhalation rate added to the 2nd highest time doing strenuous activities x EPA avg. heavy activity inhalation rate added to the assumed sleeping/resting rate for remaining 10 hours of day (max values for all individuals). ( $7 \text{ hr/d} * 1.3 \text{ m}^3/\text{hr} + (4 \text{ hr/d} * 3.2 \text{ m}^3/\text{hr}) + (10 \text{ hr/d} * 0.4 \text{ m}^3/\text{hr})$ )
- b. Child soil ingestion rate is upper percentile of EPA recommended values for children (<9 yrs).
- c. Exposure duration is life expectancy projected for general U.S. population in 2010.
- d. Body weight is a average of general U.S. population.
- n/a = not available (not enough information to calculate).

**References**

- TWRs, 1996 = Tank Waste Remediation System Environmental Impact Statement (cited in DOH, 2003).
- Harris & Harper, 1997 = A Native American Scenario Risk Analysis, 1761789-795 (also cited in DOH, 2003).
- CRCLA, 1998 = Columbia River Comprehensive Impact Assessment, D0ERL96-16 (cited in DOH, 2003).
- Harper et al., 2002 = The Spokane Tribe's Multipathway Substance Exposure Scenario and Screening level RME Risk Analysis, 22(3):513-526
- DOH, 2003 = Radiological Risk Assessment (Appendix I) for Final Environmental Impact Statement, Washington Department of Health [www.ecy.wa.gov/programs/hwp/index.html].
- Haris, 2004 = Exposure Scenario for C-UR Traditional Indigenous Lifeway's Confederated Tribe of the Umatilla Indian Reservation.
- EPA, 1999 = Environmental Protection Agency, Exposure Factors Handbook, EP-A900/C-94/001 mean values to U.S. population).
- EPA, 2002 = Environmental Protection Agency, Child-Specific Exposure Factors Handbook, EP-A600/P-00/002B (average moderate activity [playing], inhalation rate for U.S. children <9 yrs),
- DOE (RESRAD) = U.S. Department of Energy, RESRAD-Dose modelling system, input parameters (cited in ITRC, 2002).
- ITRC, 2002 = Technical and Regulatory Document, Determining Cleanup Goals at Radioactive Contaminated Sites: Case Studies. The Interstate Technology and Regulatory Council.

Table 5. Exposure Parameters for Surface Water / Ground Water Pathway

Media Pathway	Exposure Parameter	Inhalation				Ingestion				Surface Water and Ground Water				Modifying Factors				
		IR	IR <sub>c</sub>	Water vapor inhalation rate	IR	Child	Adult	IR <sub>c</sub>	Water ingestion rate	ET <sub>sw</sub>	Sweathouse hr/d	Adult d/yr	EF	ED <sub>c</sub>	ED	ED <sub>c</sub>	BW	BW <sub>c</sub>
Receptor Units	Abbreviation	IR	IR <sub>c</sub>	m <sup>3</sup> /d	IR	Child	Adult	IR <sub>c</sub>	IR	ET <sub>sw</sub>	Sweathouse hr/d	Adult d/yr	EF	ED <sub>c</sub>	ED	ED <sub>c</sub>	BW	BW <sub>c</sub>
<b>Native American Rates</b>	TWRS, 1996	30	15		3	1.5	1			365		64	6	70	70	16		
Harris & Harper, 1997		15	-		3	-	1			365		-	-	-	-	70	-	
CRCIA, 1998		30	-		3	-	1			365		-	-	-	-	70	-	
Harper et al., 2002		30	-		4	-	2			-		-	-	-	-	-	-	
DOH, 2003		-	-		3	-	2			-		-	-	-	-	70	16	
Harris, 2004		30	-		4	-	1			365		64	6	70	70	-	-	
<b>U.S. Residential Rates</b>	EPA, 1999 and 2002	-	16	2.3 <sup>b</sup>	1 <sup>c</sup>	-				365		78 <sup>d</sup>	-	72 <sup>e</sup>	-	-		
DOE (RESRAD)		20	-	1.4	-	-				-		30	-	-	-	-	-	
<b>Statistics</b>	Min	15	15	1.4	1.5	1				365		30	6	70	70	16		
Max	30	16	4	2	1					365		78	6	72	72	16		
<b>Yakama Nation</b>																		
Yakama Max <sup>f</sup>		12 <sup>a</sup>	n/a	3	n/a	7				365		75	n/a	145	n/a			
<b>Yakama Proposed</b>		28*	16	4	2	7				365		70	6	70	16			

## Notes

\* Yakama maximum exposure factors are based on data provided by interview respondents from this study.

\*\* See Tables 3 and 4. Yakama max inhalation rate calculation

a. Rate is based on maximum time spent in sweathouse + EPA average moderate activity inhalation rate plus EPA recommended bathing time x same inhalation rate. (7 hr/d \* 1.6 m<sup>3</sup>/hr + [15 min/d \* 1.6 m<sup>3</sup>/hr] \* other water vapor exposures) not considered.

b. Rate is 20% percentile of general adult U.S. population.

c. Rate is approx. 95 percentile of general U.S. population of children (<4 yrs).

d. Exposure duration is life expectancy projected of general U.S. population in 2010.

e. Body weight is average of general U.S. population (EPA, 1999).

f. n/a = not available (not enough information to calculate).

## References

- TWRS, 1996 = Tank Waste Remediation System Environmental Impact Statement (cited in DOH, 2003)
- Harris & Harper, 1997 = A Native American Scenario Risk Analysis, 176(178)-755 (also cited in DOH, 2003)
- CRCIA, 1998 = Columbia River Comprehensive Impact Assessment, DOE/ER-16 (cited in DOH, 2003)
- Harper et al., 2002 = The Spokane Tribe's Multifamily/Residence Exposure Scenario and Screening-level RME, Risk Analysis, 22(3):513-526
- DOH, 2003 = Radiological Risk Assessment (Appendix I) for Final Environmental Impact Statement, Washington Department of Health ([www.ecy.wa.gov/og/bgs/mw/index.htm](http://www.ecy.wa.gov/og/bgs/mw/index.htm))
- Harris, 2004 = Exposure Scenario for CTUR Traditional Lubricants - Lewis Confederated Tribe of the Umatilla Indian Reservation
- EPA, 1999 = Environmental Protection Agency, Exposure Factors Handbook, EPA/600/C-99/01 (mean values for U.S. population)
- EPA, 2002 = Environmental Protection Agency, Child-Specific Exposure Factors Handbook, EPA/600/P-00/02B (mean moderate activity rate for U.S. children <6 yrs).
- DOE (RESRAD) = U.S. Department of Energy RESRAD dose modeling system, input parameters (cited in ITRC, 2002)
- ITRC, 2002 = Technical and Regulatory Document: Determining Cleanup Goals at Radioactively Contaminated Sites: Case Studies. The Interstate Technology and Regulatory Council.

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**Table 6. Exposure Parameters for Biota Pathway**

Media Pathway	All Food											
	Modifying Factors						Body weight					
Exposure Parameter Abbreviation	Fish			Meat			Veg.			Fruit		
	Ingestion	Fish/shellfish ingestion rate	Meadow ingestion rate	Ingestion	IR <sub>c</sub>	IR <sub>e</sub>	Ingestion	IR <sub>c</sub>	IR <sub>e</sub>	Ingestion	IR <sub>c</sub>	IR <sub>e</sub>
Receptor Units	Adult g/d	Child g/d	Adult g/d	Child g/d	Adult g/d	Child g/d	Adult g/d	Child g/d	Adult g/d	Adult g/d	Child g/d	Adult g/d
<b>Native American Rates</b>												
Hewes, 1973	498	-	-	-	-	-	-	-	-	-	-	-
Walker, 1985	1,000	-	-	-	-	-	-	-	-	-	-	-
CRIFC, 1984 (95th %ile)	389	-	-	-	-	-	-	-	-	-	-	-
Toy et al., 1995 (95th %ile)	177	-	-	-	-	-	-	-	-	-	-	-
TWRS, 1996	-	-	34 <sup>a</sup>	-	330	-	-	0.6	-	365	70	6
Harris & Harper, 1997	540 <sup>a</sup>	-	276 <sup>a</sup>	-	343	-	231	0.49	-	365	70	70
CRICIA, 1998	540	-	337 <sup>a</sup>	-	330	-	330	0.6	-	365	70	70
Suquamish, 2000 (95th %ile)	798	-	-	-	-	-	-	-	-	-	-	-
Harper et al., 2002	1,060 <sup>b</sup>	-	935 <sup>b</sup>	-	1,600 <sup>b</sup>	-	-	-	0.5	-	-	-
DOH, 2003	-	-	348 <sup>c</sup>	212	343 <sup>c</sup>	187	231	127	-	-	-	70
Harris, 2004	620	-	125 <sup>c</sup>	-	1,100	-	125	-	-	-	6	16
<b>US Residential Rates</b>												
EPA, 1999 <sup>d</sup>	170 <sup>c</sup>	-	35 <sup>c</sup>	-	700 <sup>f</sup>	-	868 <sup>f</sup>	2.2 <sup>f</sup>	-	365	78 <sup>f</sup>	72 <sup>f</sup>
EPA, 2002 <sup>d</sup> (95th %ile)	519	363	-	-	-	7.4	-	-	-	-	-	-
DOE (RESRAD)	-	-	-	-	-	-	301	-	-	-	-	-
<b>Statistics</b>												
Min	170	-	125	212	7.4	187	125	127	0.49	0.5	365	70
Max	1,060	-	935	212	1,600	187	868	127	2.2	0.5	365	78
<b>Yakama Nation</b>												
Yakama Max*	451	n/a	704	n/a	1,118 <sup>i</sup>	187	299 <sup>j</sup>	n/a	1.2	n/a	365	75
<b>Yakama Proposed**</b>	<b>519</b>	<b>363</b>	<b>704</b>	<b>212</b>	<b>1,118</b>	<b>187</b>	<b>299</b>	<b>127</b>	<b>1.2</b>	<b>0.5</b>	<b>365</b>	<b>70</b>
<b>Notes</b>												

<sup>a</sup> All rates represent general U.S. population except fish consumption rate (see footnote c)

<sup>b</sup> Yakama maximum exposure factors represent fish and shellfish (uncorrected) of the general U.S. population of adult & child (<5 yrs) fish consumers only.

<sup>c</sup> See Table 7 for rationale behind selection of Yakama Nation proposed exposure parameters

<sup>d</sup> Rate is reasonable subsistence intake, and excludes shellfish.

<sup>e</sup> Rate is 50% percentile for Native American subsistence population (from CRIFC, 1984)

<sup>f</sup> Includes organ meats at 10x meat concentration, 24% consumed at 0.1 frequency of meat (organic eggs).

<sup>g</sup> Rate includes big game, small game, and fowl (still game = fowl = 50 g), but does not include beef.

<sup>h</sup> Vegetable includes gathered (20% above-ground, 10% below-ground, 20% aquatic) + garden (10% above-ground).

<sup>i</sup> Yakama vegetable = 1/2 garden plants (assume equal ratio vegetal+stems/leaves and roots) (gathered plants).

<sup>j</sup> Yakama fruit = 1/2 garden plants (assume equal ratio vegetal+stems/leaves and roots) (gathered plants).

<sup>k</sup> Exposure duration is life expectancy projected for general U.S. population in 2010.

<sup>l</sup> Body weight is average of general U.S. population

<sup>m</sup> n/a = not available (not enough information to calculate)

**References**

- Hewes, 1973 = Indian Fisheries Productivity in Pre-Contact Times in the Pacific Salmon Area (salmon only consumption rate)
- Walker, 1985 = Pre-dam estimate of Columbia River Tribes (cited in Harris, 2004).
- CRIFC, 1994 = Columbia River Inter-Tribal Fish Commission Survey of the Umatilla, Nez Perce, Yakama, & Warm Springs Tribes.
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Table 7. Summary of Proposed Yakama Nation RME Parameters

Pathway	Route	Exposure Parameter	Abbrev.	Receptor	Units	RME	Rationale
Air (see Table 3)	Inhalation	Air inhalation rate	IR	Adult	m <sup>3</sup> /d	26	Yakama calculated value
			IR <sub>c</sub>	Child	m <sup>3</sup> /d	16	EPA average child value (<6 yrs) for moderate activity
	Modifying factors	Air exposure time/frequency/duration	ET	Adult/Child	hr/d	24	Max exposure time for all populations
			EF	Adult/Child	d/yr	365	Max exposure frequency for all populations
			ED	Adult	yr	70	Average lifetime (default )
			ED <sub>c</sub>	Child	yr	6	Average childhood lifetime (default )
	Inhalation	Soil inhalation rate	IR	Adult	m <sup>3</sup> /d	26	See air inhalation value
			IR <sub>c</sub>	Child	m <sup>3</sup> /d	16	See air inhalation value
	Soil and sediment (see Table 4)	Soil ingestion rate	IR	Adult	mg/d	200	Upper percentile adult value (Native American studies)
			IR <sub>c</sub>	Child	mg/d	400	Upper percentile EPA child value
		Soil exposure time/frequency/duration	ET	Adult/Child	hr/d	24	Max exposure time for all populations
			EF	Adult/Child	d/yr	365	Max exposure frequency for all populations
			ED	Adult	yr	70	Average lifetime (default )
			ED <sub>c</sub>	Child	yr	6	Average childhood lifetime (default )
Surface and ground water (see Table 5)	Inhalation	Water vapor inhalation rate	IR	Adult	m <sup>3</sup> /d	26	See air inhalation value
			IR <sub>c</sub>	Child	m <sup>3</sup> /d	16	See air inhalation value
	Ingestion	Water ingestion rate	IR	Adult	L/d	4	Max Yakama value, plus additional consumption during sweathouse use
			IR <sub>c</sub>	Child	L/d	2	EPA child rate, plus additional consumption during sweathouse use
	Modifying factors	Water exposure time/frequency/duration	ET <sub>sw</sub>	Sweathouse	hr/d	7	Max Yakama value of time spent inside sweathouse
			EF	Adult	d/yr	365	Max exposure frequency for all populations
			ED	Adult	yr	70	Average lifetime (default )
			ED <sub>c</sub>	Child	yr	6	Average childhood lifetime (default )
Fish (see Table 6)	Ingestion	Fish/shellfish ingestion rate	IR	Adult	g/d	519	EPA upper percentile for adult "fish consumers"; within range of published rates
			IR <sub>c</sub>	Child	g/d	363	EPA upper percentile for child "fish consumers"
Meat (see Table 6)	Ingestion	Meat/game ingestion rate	IR	Adult	g/d	704	Max Yakama value; within range of published rates
			IR <sub>c</sub>	Child	g/d	212	Washington DOH estimated child rate
Veg. (see Table 6)	Ingestion	Vegetable/root ingestion rate	IR	Adult	g/d	1,118	Max Yakama value; within range of published rates
			IR <sub>c</sub>	Child	g/d	187	Washington DOH estimated child rate
Fruit (see Table 6)	Ingestion	Fruit/berry ingestion rate	IR	Adult	g/d	299	Max Yakama value; within range of published rates
			IR <sub>c</sub>	Child	g/d	127	Washington DOH estimated child rate
Milk (see Table 6)	Ingestion	Milk ingestion rate	IR	Adult	L/d	1.2	Max Yakama value; within range of published rates
			IR <sub>c</sub>	Child	L/d	0.5	Published child rate (Native American studies)
All Food	Modifying factors	Food exposure frequency/duration	EF	Adult	d/yr	365	Max exposure frequency for all populations
			ED	Adult	yr	70	Average lifetime (default )
			ED <sub>c</sub>	Child	yr	6	Average childhood lifetime (default )
General	Modifying factors	Body weight	IR	Adult	kg	70	Average adult body weight (default)
			IR <sub>c</sub>	Child	kg	16	Average child body weight (default)

Notes:

DOH - Washington State Department of Health

EPA - United States Environmental Protection Agency

Child is considered age 0-6 years (EPA, 1999)

These exposure parameters are relevant to the entire Hanford Site and beyond, used by Yakama members for all activities (see Figure 5 and Tables 3-6 for details)

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**APPENDIX B**  
**Published News Articles**

**HANFORD NUCLEAR RESERVATION**

## Radioactive materials discharges accidental, intentional

By RUSSELL JIM

The Hanford Site is a 580-square-mile U.S. Department of Energy (DOE) facility located near Richland, just 20 miles from the eastern border of the Yakama Reservation.

Operations at the site produced plutonium for U.S. nuclear weapons programs for 45 years until the end of the Cold War in 1989. Releases of radioactive materials and toxic chemicals at the site began with the onset of operations in 1944 and continue to this day.

As part of operations, radioactive and chemical wastes were both intentionally and unintentionally discharged to the air, ground and waters at the site. These contaminants can be found in the region's soils, waters, plants, fish and other animals, potentially affecting the health of these natural resources as well as area residents.

When plutonium production ended at the Hanford Site, the focus switched to environmental cleanup. In May, 1989, the DOE, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology signed the Hanford Federal Facility Agreement and Consent Order, better known as the Tri-Party Agreement, which committed DOE to cleaning up the Hanford Site.

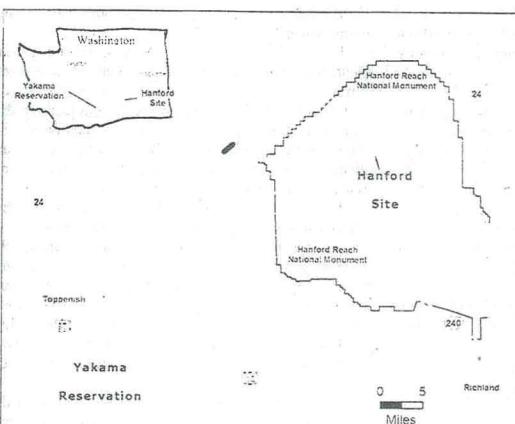
The Confederated Tribes and Bands of the Yakama Nation, a Trustee for the area's natural resources, participates in the Hanford cleanup.

The Yakama Nation's goals for the Hanford cleanup center on protecting Yakama Nation Treaty rights, including the health of the Yakama people and natural resource interests protected by the Yakama Treaty of June 9, 1855.

To realize these goals, the Yakama Nation takes a holistic approach to the cleanup, recognizing that all things interrelate, which requires considering the impacts on air, land, water, and all plants and animals. The Yakama Nation believes the cleanup actions conducted or planned by DOE thus far, will not sufficiently remedy the extensive contamination to attain these goals, and to safeguard human health and the health of the environment in the future.

### What is the Hanford problem?

Widespread contamination is present over the Hanford Site as a result of 45 years of plutonium production. During this period over 200 billion gallons of liquid waste containing plutonium, uranium, and other radioactive and toxic chemicals were dumped directly to the ground.



These wastes moved downward to the water table, eventually making 270 billion gallons of ground water over an area of 80 square miles unsafe to drink. Some of this ground water has already reached, and is discharging into the Columbia River.

Additionally, 53 million gallons of some of the most dangerous mixed radioactive and chemical waste in the world is stored in 177 underground storage tanks at the Hanford Site. Several of these tanks have already leaked about one million gallons of this stored waste into the soil.

The potential also exists for catastrophic failure of these aging tanks, which would result in widespread radioactive contamination.

Some efforts are currently underway by DOE to cleanup the most immediate threats at Hanford. These localized efforts are not effective for all types of contamination, however, and only cover a part of a very large site with complex contamination issues.

### Why is the Nation involved?

Before Hanford existed, the Yakama people and other Native Americans used the area's natural resources for thousands of years for hunting, fishing, gathering, and religious ceremonies.

In the Treaty of 1855, the Yakama Nation retained their rights to fish in all usual and accustomed places, and to hunt and gather foods and medicines on open and unclaimed land beyond the Reservation.

An effective cleanup of Hanford is critical for protecting the health of the Yakama people, not only physical health, but also cultural and spiritual health, and for protecting the treaty rights of the Yakama Nation.

Natural resources, such as the plants and animals that have been

impacted by Hanford contamination, are critical to the traditional way of life for the Yakama people, who are recognized stewards of the land.

The Yakama Nation is involved in the cleanup process in an effort to protect their people and the land to which they are intimately tied, and to protect the health of all people. The Hanford Site must be cleaned up and the natural resources must be restored to allow future use of the site.

### What are the health risks?

Exposure to radioactive and toxic chemicals, such as those released at the Hanford Site, has been shown to impact the health of people as well as plants and other animals. No level of radiation exposure is considered safe. Health effects may include damage to liver and other organs, reduced immune system function, reproductive effects, and cancer.

Wastes in the underground storage tanks, which have been leaking into the soil and migrating to ground water, include radioactive contamination that may pose a substantial health risk for as long as 200,000 years.

Fish, an abundant resource in the Columbia River, are an important part of a healthy diet, and for Native Americans in the Pacific Northwest, an important cultural resource.

Salmon and other fish have been declining in numbers and health in the river over the past century. Some efforts to restore salmon in the river have succeeded (fish hatcheries, etc.), but unsafe levels of contaminants have been found in these fish, potentially affecting the health of the people eating them.

Without effective cleanup, risks from Hanford contamination may result from:

- Harvesting and eating fish and other animals (elk, deer, etc.);
- Gathering and using plants (roots, leaves, berries) for foods and medicines;
- Drinking water or using water for sweat lodge and other cultural activities.

### What is the Nation doing?

Both the Yakama Nation's Environmental Restoration & Waste Management (ERWM) Program, and the Department of Natural Resources advocate complete cleanup of Hanford for the protection of all Yakama people and the public.

The Hanford Site is part of the "usual and accustomed" areas retained by the Yakama Nation for fishing, hunting, and gathering, and thus, safe use of the site must be secured for the future.

The DOE is currently conducting risk assessments to evaluate potential threats to human health and the environment from the Hanford Site's radioactive and chemical wastes.

A risk assessment involves consideration of the people that may use the site both now and in the future, and evaluation of their activities that may lead to exposure to contamination. The Yakama people are an important group of land users at the Hanford Site, particularly in practicing their traditional activities.

Yakama Nation uses must be protected. With the objective of assisting DOE to correctly consider Yakama Nation uses in the risk assessments, the ERWM is developing a Native American Exposure Scenario. The scenario will be based on a traditional subsistence lifestyle, with adjustments to take aspects of modern life into account.

The ERWM plans to gather input from Yakama Nation members to describe this subsistence lifestyle from their past experiences, cultural knowledge, and envisioned future uses of the site.

It is hoped that the Hanford Site will eventually be cleaned up and restored to the point where the Yakama people can return to conduct activities, if they so desire, in areas currently too contaminated to use.

Russell Jim is the manager of the Yakama Nation Environmental Restoration & Waste Management Program, a former Yakama Tribal Council member and a practitioner of traditional Yakama beliefs.

[Editor's Note: This is the first in a series, with future articles on the Yakama Exposure Scenario Project and how the public can become involved to help the Yakama Nation promote cleanup and restoration of the Hanford Site.]

**ENVIRONMENTAL STEWARDS**

## Program needs tribal members' input, help with survey

### HANFORD NUCLEAR RESERVATION

Hanford – is it safe for the Yakama People?

By RUSSELL JIM

*[This is the second of three articles about chemical releases from the Hanford Site and how exposure to these chemicals may affect the Yakama Nation. In the first article, we described the contamination at the Hanford Site. This article describes some of the work currently being done by the Yakama Nation to assure that chemicals released from Hanford do not pose a risk to people. Imagine the Hanford Site completely cleaned up and safe for you to live there. How would you and your family engage in a healthy and modern subsistence lifestyle?]*

#### How can the health of the Yakama people be protected?

The Yakama Nation's Environmental Restoration and Waste Management (ERWM) program is working with the U.S. Department of Energy (DOE) to ensure that the Yakama people and their ways of life are protected from exposure to environmental contaminants. This includes the safe and unencumbered use of clean natural resources, such as water, plants and animals that are integral to the traditional life ways that make up the Yakama cultural landscape.

The DOE is in the process of cleaning up the Hanford Site. Cleanup decisions are based in part on evaluating threats to people and the environment. With the objective of a protective cleanup, the ERWM is providing input to DOE to ensure that all possible risks to the Yakama people are considered during the cleanup process at Hanford.

To accomplish this, ERWM, with technical assistance from RIDOLFI Inc., would like your help in describing the lifestyle of the Yakama people. We want to document what you consider to be a traditional lifestyle, including hunting, fishing, gathering, cultural activities, and other details unique to the Yakama. We will provide some of the information, only that which is not confidential, to the DOE to help them assess the potential threats that may exist to the Yakama people from



Hanford contamination, with the hope that people may be able to use the Hanford site again in the future.

#### How will we describe the Yakama lifestyle?

In order to consider all possible ways a Yakama individual may be exposed to Hanford contamination, an "exposure scenario" will be developed that includes present day information about how people live, supplemented with assumptions about the future. This will help to describe how Yakama people can be exposed to potential contaminants in the air, water, soil, plants and animals through their daily activities.

The Yakama "exposure scenario" will include a general description of how the Yakama people live, including estimates of how a sustainable diet was, and is, maintained, how often cultural activities occurred, and may occur, as well as other information that may cause disproportionate impacts from contamination. The Yakama lifestyle needs to be documented and taken into account by the DOE during the cleanup of Hanford.

#### How will the information be used?

The DOE needs basic information about the Yakama lifestyle to assess potential risk from Hanford contamination and determine cleanup levels. The DOE requires that information that is used for cleanup decisions be transparent and legally- and scientifically-defensible. However, it is most important that Yakama tribal confidentiality be respected and secured. Only non-proprietary and non-confidential information will be provided to the DOE; all other data will be secured at ERWM.

ERWM staff would like to interview any member with the time and interest to share their thoughts and information. The confidentiality of this information is of the highest importance and no sensitive information (including names of individuals, exact locations of plant and animal collection, medicinal or cultural practices, etc.) will be published or released from the sole care of the Yakama Nation ERWM.

#### How can you become involved?

The ERWM staff hopes to collect information primarily from personal interviews, through informal conversations with Yakama members or mailed surveys. With this information, ERWM will develop a picture of the Yakama lifestyle now and in the future.

We invite you to participate in this important opportunity to ensure that the Hanford Site is adequately cleaned up to protect the Yakama Nation and the natural resources on which the people so intimately depend. Your lifestyle will be represented, your confidential information will be respected, and your voice will be heard. For information, please contact Russell Jim at the ERWM Program at (509) 865-5121.

*[The final article will provide a preview of what the Yakama lifestyle looks like to date based on information gathered from Yakama Nation members.]*

Russell Jim is the manager of the Yakama Nation Environmental Restoration/Waste Management Program; is a former Yakama Tribal Councilman; and a practitioner of traditional Yakama beliefs.

# Yakama Nation Review

RED FROM COVER TO COVER

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## Tribe determined to protect usual and accustomed sites

By the Yakama Nation ERWM Program and RIDOLFI Inc.

*[Preface: This is the third and final article in a series about radioactive and chemical releases from the Hanford Nuclear Reservation and how exposure to these contaminants may affect the people of the Yakama Nation. In the first article, we described the extent of contamination at the Hanford Site and the potential environmental impacts. In the second article we described the work being done by the Yakama Nation to assure that contaminants released from Hanford do not pose a risk to the Yakama people now and in the future. In this third and final article, we provide a look at how some Yakama members describe their traditional lifestyle and consider how dietary and cultural activities may lead to exposure to Hanford contamination. The Yakama envision a future where the Hanford Site is completely cleaned up and safe for all Yakama members to live off of the land and engage in a healthy and modern subsistence lifestyle.]*

cestors have done for thousands of years.

These plants, as well as the fish and the wildlife, provide food and medicine, tools and shelter, which are critical to the survival of the Yakama culture.

Accordingly, feasts are held annually to celebrate the abundance and importance of these natural resources.

Russell Jim, manager of the Yakama Nation Environmental Restoration and Waste Management (ERWM) Program, stresses the importance of "the salmon, the deer, the elk, the food out of the ground, and the berries as necessary medicine, with strong genes, to provide a strong body, heart and life."

The ERWM program has developed an "exposure scenario" that describes what life is like as a Yakama. This portrayal of the traditional lifestyle will be used to help assess potential threats from the nearby Hanford Site.

Aspects of this lifestyle that involve consuming or contacting the soil, water, plants and animals, may result in risks to the Yakama from exposure to radioactive and hazardous chemical contamination that has been released from Hanford over many years.

The Hanford Site lies within the ancestral lands of the Yakama people, who used to spend winters on the site, and then travel in other areas to collect food from all areas and elevations.

However, between 1943 and 1988, the Yakama were not allowed on the Hanford Site while it was producing plutonium.

Rattlesnake Ridge, for example, is a unique and sacred area at Hanford with limited access that continues to produce very important foods and medicines for the Yakama, and which is still revered and used for prayer today.

As part of the exposure scenario project, Yakama adults and elders were interviewed and provided information on traditional fishing, hunting, and gathering practices, as well as sweathouse use and ceremonies.

Those interviewed discussed their methods for collecting traditional foods and the amounts of the foods they ate. All of these activities are still critical aspects of Yakama subsistence and culture today, connecting the people to the land for generations to come.

The interviews show that the Yakama depend heavily on the harvest and consumption of fish from local rivers such as the Columbia River, which passes through the Hanford Site; as well as wild game and an abundance of local native plants, including shoots, roots, leafy material and berries.

A Yakama woman, gathering roots and berries every year since she was a child, says she will continue to gather traditional plants until she is "too old to walk." This reflects the determination of the Yakama people to make use of the local resources, just as their an-

cestors did. Tools, shelter, clothing and accessories are made by hand using raw plant and animal materials.

Weekly religious services, memorials for those passed away, events to recognize achievement, and other traditions are woven into the cultural fabric of the Yakama Nation.

Like previous generations, the Yakama continue to subsist on natural resources in the vicinity of Hanford.

The Yakama envision a future where the Hanford Site, which is part of the Yakama "usual and accustomed" use areas, is cleaned up and they can return.

Without compromising confidential information, results from the "exposure scenario" will be shared with the U.S. Department of Energy to evaluate potential risks to the Yakama from Hanford contamination.

The Yakama Nation is deter-

mined to ensure that the Hanford

Site is cleaned up efficiently and

thoroughly, to protect and preserve

the soils, waters, plants, fish and

other animals of the area; and the

health of the people that depend

upon, and have rights to, these

natural resources now and for fu-

ture generations.

*[For more information, please con-*

*tact Russell Jim at the ERWM Pro-*

*gram at (509) 865-5121.*

### **W.1.2      Nez Perce Perspective at Hanford**

The following text reflects the Nez Perce Tribe's viewpoint on the proposed cleanup of the Hanford Site, with emphasis on the tribe's treaty-reserved rights of unrestricted access to the land and resources of the lower Columbia River region.

**NEZ PERCE PERSPECTIVE AT HANFORD:**

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Nez Perce Tribe, P.O. Box 365, Lapwai, ID 83540

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**Abstract.**

The Nez Perce Tribe, like other federally-recognized tribes, is a sovereign nation, and the United States is required to consult on a government-to-government basis with the Tribe on actions that stand to affect the tribal resources, such as the cleanup of nuclear wastes at the Hanford facility near Richland WA. The following provides an overview of how the Nez Perce view the environmental resources at Hanford and their importance to sustaining tradition lifeways, including use of natural resources, gathering times, and tribal values and perspectives of these resources. While this writing focuses on the Department of Energy's (DOE) obligation to Hanford's cleanup, the Tribe's ultimate interest includes, but is not limited to, the Tribe's treaty-reserved rights to unrestricted access and use of uncontaminated treaty resources at Hanford.

**NEZ PERCE PERSPECTIVE AT HANFORD:**

**1.0 Introduction**

The Nez Perce Tribe has powers and authorities derived from its inherent sovereignty, from its status as the owner of land, and from legislative delegations from the Federal government. The Tribe is also a cultural entity charged with the responsibility of protecting and transmitting that culture which is uniquely Nez Perce. The Tribe is a beneficiary within the context of federal trust relationship, and a trustee responsible for the protection and betterment of its members and the protection of their rights and privileges.

The DOE – Nez Perce Tribal relationship at Hanford is defined by the trust relationship between the Federal government and the Tribe by treaty, federal statute, executive orders, administrative rules, case law, DOE's American Indian Policy, and by the mutual interest in the safe, efficient and expeditious cleanup of the DOE weapons complex. This relationship is expressed in a Cooperative Agreement between the Nez Perce Tribe and DOE-Hanford with focus on site-specific cleanup of Hanford and extends to all trust-related activities by DOE.

The Tribe sees itself not only as a trustee of resources at Hanford, but also as technical and cultural advisors to DOE decision-making. We are asked to review and comment on documents and activities by DOE as a means to uphold their trust responsibilities and comply with other federal statutes, laws, regulations, executive orders and memoranda governing the United States' relationship with Native Americans and the Nez Perce people. Several Nez Perce tribal departments lend their respective technical expertise to DOE Hanford issues and present recommendations to the Nez Perce Tribal Executive Committee (NPTEC) for consideration and

guidance. The NPTEC may also request formal consultation with the federal agency to further discuss a proposal or issue.

There are limitations of the National Environmental Policy Act (NEPA). Federal regulations implementing NEPA define a set of rules for analyzing the effect of federal undertakings on the quality of the human environment. These rules include generating alternatives, evaluating the natural and human environment, and engaging the public. NEPA does not provide a framework where Tribal values or traditional lifeways are given appropriate consideration in comparison to mainstream values. However, the regulations to provide that affected Tribes have a right to participate in the NEPA process. This includes involvement in scoping, alternatives development, determining the area of potential effect (APE), and impacts analysis. It is not enough that we are invited to comment, it is our legal right to participate as a Trustee. DOE must understand that as a trustee, our perspective and values are just as valid as other trustees associated with Hanford Cleanup.

We ask that DOE begin to invite tribal participation early in the NEPA process in an attempt to allow equal input into their federal decision-making. It is paramount that the Nez Perce people carry-on their culture, which includes preserving access and use of the lower Columbia, including Hanford.

## **2.0 Background on Nez Perce Lifeways**

For DOE decision-makers to fully understand our perspective, they must understand our past at Hanford, its historical value to us as a people, and accept our present and future role in preserving our culture that includes Hanford resources. In the past, the Nez Perce traditional lifestyle was often mislabeled as nomadic. We were a people that relied on the salmon, but more importantly, we followed a seasonal round.

### **2.1. Seasonal Rounds**

The seasonal round is best described as a *return to a specific area* for the purpose of gathering resources: food, medicinal or otherwise. The seasonal round advanced in area and elevation simultaneously. It is not the act of following resources wherever they occur but rather a return to an area to gather resources based on prior knowledge or experience. It is also marked by the availability as warming seasonal temperatures foster development of the resource. Examples are the return to root digging areas as spring or summer temperatures have warmed plants to the point of opening the opportunity to harvest, or a return to a hunting area in the fall before temperatures drop to low. The map below shows how the Hanford area fits into the area used by the Nez Perce over time (Figure 1). The time for gathering resources is marked by lunar changes. Since there were more foods than there were moons during the year some resource gathering times were simultaneous. The diagram below shows how the seasons for gathering various foods correspond to the commonly used twelve-month calendar and four seasons. The Nez Perce changed elevations depending on the warming weather and this is shown through another diagram showing the names of the gathering seasons and the elevations.

The seasonal round also covered an elevation from sea level up to ten thousand feet. The map titled "Silhouette of the Northwest" shows the elevation difference in the usual and accustomed

areas used by the Nez Perce. The beginning of the seasonal round is marked with a Ke'uyit or first foods ceremony in the spring. Ke'uyit translates to "first bite" and is an annual ritual of prayer immersed in song for the first foods of the year. Traditional foods are laid out on the floor in the order in which they are gathered throughout the year beginning with Salmon. This annual ritual is an expression of gratitude to the foods

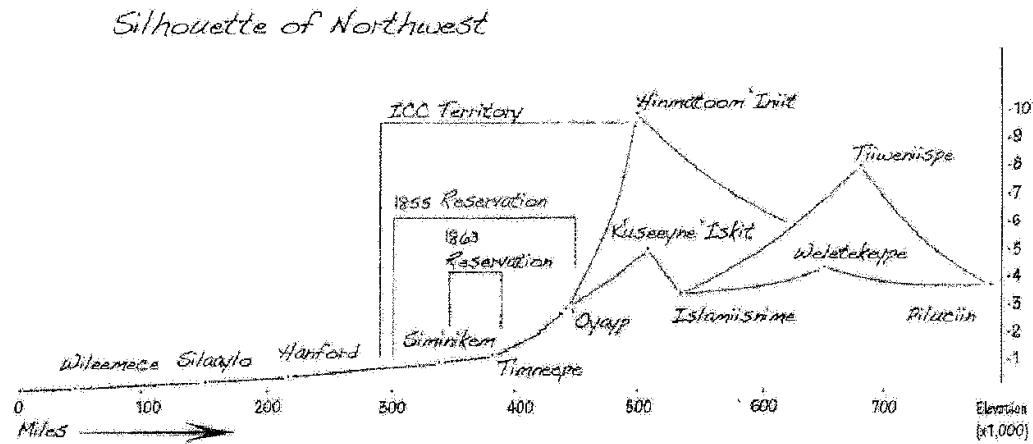
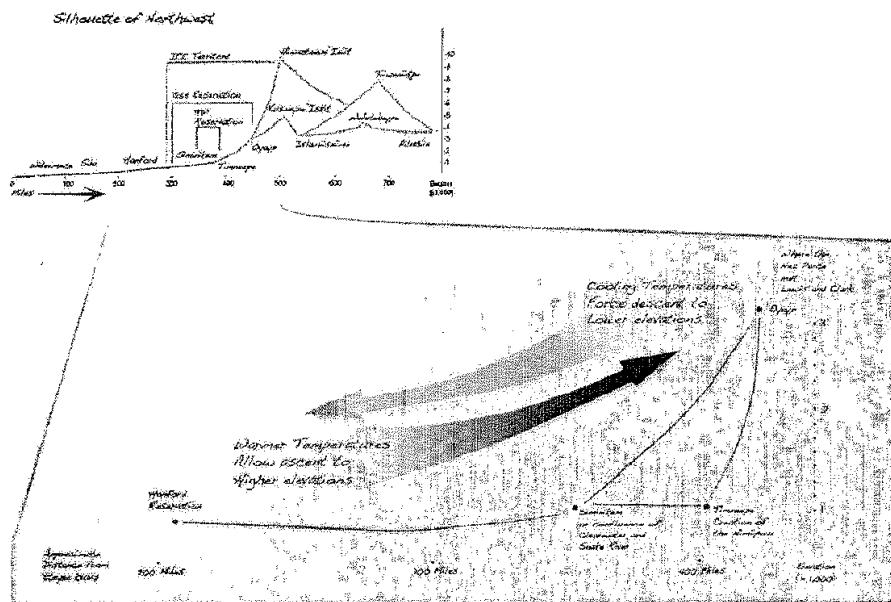


Figure 1. Elevation profile

for their return and for those gathered during the seasonal round. Other tribes have more than one feast such as a root feast and a huckleberry feast but the Nez Perce only have one and it is held toward the latter part of the spring (Figure 2).



*Figure 2. Elevational profile illustrating the Seasonal Round traveled by the Nez Perce.*

## 2.2. Gathering Times

Gathering times are extremely important to the Nez Perce. Examples of resource gathering times are shown in Figure 3 and discussed below.

Wiluupup: Time when cold air travels. Often corresponds to the month of January.

'Alatam'aal: Time between winter and spring or the time for fires (often corresponds to the month of February) 'Ala=fire

Miseemi latiit'al: Time of false blossoms roughly corresponding to early March. Miseemi=to lie or speak falsely, Latiit'=to bloom or blossom.

Latiit'al or Latiit'aal: Time when flowers bloom. Roughly corresponds to the month of March. Latii=to bloom or blossom.

Qeqiit'aal or qaqiit'aal: Time of gathering qeqiit roots. Roughly corresponds to April.

'Apa'aal: Time for digging roots and making them into small cakes called 'Apa. Roughly corresponds to the month of May or June.

Tustimasaatal: Ascend to higher mountain areas. Roughly corresponds to the month of June. Tusti=higher/above

'Il'aal: The time of the first run of Salmon. Roughly corresponds to the month of June.

Haso'al: The time to gather eels or Pacific Lamprey. Roughly corresponds to the month of June.  
Heesu=eel.

Qama'aal: Time for digging and roasting qem'es bulbs. Often corresponds to the month of July.  
Qem'es=camas bulbs.

Q'ooyxc'aaf: Time of gathering Blueback Salmon. Often around the month of July. Q'ooyxc=Blueback Salmon

Waw'ama'aq'aal: Season when salmon swim to the headwaters of streams (often corresponds to August)  
Waaw'am=headwaters

Pik'unma'ayq'al or pik'onma'ayq'aal: Time when Chinook Salmon return to the main river and steelhead begin their ascent. Roughly corresponds to September. Pik'un=river

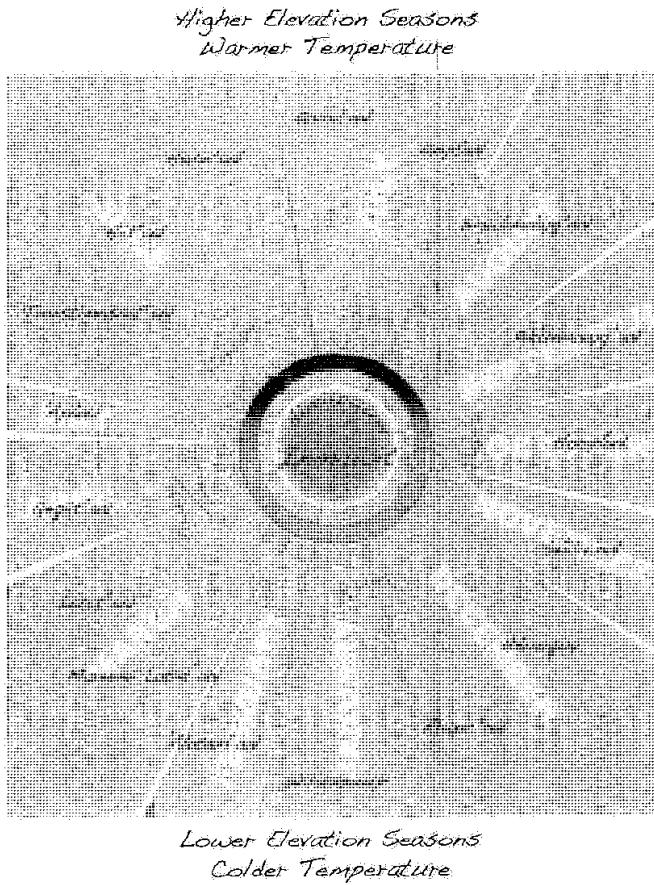
Hoopl'al: Time when Tamarack needles begin to fall. Huup=to fall (as Pine needles do). Roughly corresponds to October.

Sexliw'aal: Autumn or the time roughly corresponding to November.

He'uquy: Time of elk fetus gestation roughly corresponding with winter and the month of December.

'Alwac'aal: Time of Bison Yearling roughly corresponding to December. 'Alawa=bison yearling.

*Illustrating the extent of travels by the Nez Perce*



*Figure 3. Seasonal periods recognized by the Nez Perce and their correspondence to the 12-month calendar*

### **3.0 Nez Perce Tribal Values and Environmental/Tribal Health**

#### **3.1. Oral Histories**

Oral histories imparted basic beliefs, taught moral values, explained the creation of the world, the origin of rituals and customs, the location of food, and the meaning of natural phenomena. Oral tradition provides accounts and descriptions of the region's flora, fauna, and geology. Fish and other animals are characters in many of these stories. Coyote, is the main character in many

because he exhibits all the good and bad traits of human beings. Although characters and themes may differ slightly, many of these same stories are held in common by Columbia Basin tribes.

### **3.2. Tribal Values**

Tribal values lie imbedded within the rich cultural context of oral tradition and are conveyed to the next generation by the depth of the Nez Perce language. How to properly perceive life and land are among the core tenets of which the stories speak. The numerous landmarks that season the landscape are reminders to the events, stories, and cultural practices of our people. The values are what must endure and they can only be properly conveyed by the oral traditions and language. Overall the values are intent on protecting, preserving and perpetuating resources for the sake of survival. The Nez Perce taught these values to our children for generations just as we still teach them today. The most appropriate way to understand our cultural values is to view our cultural practices conducted today on our landscape. They reflect a complex tradition showing high regard for the land. By utilizing mother earth's resources, we only take what we need while preserving the resource to propagate their continued existence. Resources would not be jeopardized by the actions of the present generation at the expense of future generations. We value the landscape for the rich resources it offers our children for survival.

The Nez Perce Tribe utilized resource areas with several other tribes that carried similar resource values. The landscape is full of powerful reminders in the form of rock features associated with oral traditions that relate exploits of tribal people and the animal people. The Nez Perce elders recall hunting and fishing areas taught to them when they were young. These are the same places learned about from their elder kinsmen. The women dig roots and harvest berries in the same places that they learned from their grandmothers.

Each place utilized for resources was maintained to sustain future generations. Each plant had a window of harvest in which it could be gathered. The window of harvest was always honored because gathering at another time would either affect its strength or viability. When women were gathering *qem'es* bulbs, they would evaluate the field to ensure that others had not already gathered past the threshold of the resource's stability. If the field looked as though others had already been there and the resource needed to be left so it could continue on, then they would simply go to another place. When a place was found which could be used for harvest, the digging would begin with prayer songs and it was common for many of the women to sing as they continued to dig. When the work was finished for the day it was closed with a prayer song just as it had began. They were cautious about the way in which they gathered the roots as well. Arguing and fighting didn't occur while gathering foods, even among the young, because it was strictly forbidden. Root diggers were reminded by the elderly to be prayerful and concentrate on good thoughts as they conducted their work, avoiding negative feelings that might be carried by the foods to those that would consume them. Feelings from the roots always were to be returned to the original grounds from which they came or buried in the earth. They are never to be simply thrown in the garbage. Regardless of where the oral tradition originated, these stories communicate values of the site while practicing usual and accustomed rights. These teachings are tied to the landscape and illustrate a land ethic that has existed for thousands of years and has become our culture.

Fishing and hunting were conducted in the same way. Young boys were raised with the guidance of elder kinsmen. A group of hunters or fishermen would depart for areas that were, on occasion, previously scouted for the presence of fish and/or game. Young hunters and fishermen would observe the actions of those that were responsible for imparting knowledge of how to conduct oneself appropriately as game was stalked or fish were caught. Expectations were similar to those of the young women; concentrate on good thoughts and feelings, prohibited acts included fighting and arguing. Excessive pride and boasting were frowned upon by elder kinfolk since the hunt was to be conducted with the utmost humility. Hunters and fisherman learned to avoid catching the largest fish or killing the largest animal they could find because it preserved the gene pool that replaced that size animal. Upon return, the hunters were not questioned as to the number each hunter killed and it was never announced because it was deemed as a group activity. One exception was when a young hunter killed an animal for the first time or caught his first fish. At this time the family recognized the young hunter or fisherman as a provider with a ceremonial feast. The elder fisherman and hunters sat around the meat which was to be boiled, baked or prepared in some traditional fashion as stories were told conveying more teachings and proper conduct. As the elder hunters and fishermen consumed the meat the newly recognized hunter or fisherman was not allowed to partake of even a morsel of the meal. Everyone else was to eat before the hunter or fisherman could consume a meal. This reinforced their role as a provider rather than someone that merely killed game or caught fish for recreational purposes. Young hunters were taught proper shot placement, as it was crucial to the hunting experience. Young hunters were taught to shoot an animal so that it would be killed as quickly and limit the animal's suffering as much as possible. Shooting an animal or catching a fish was only part of the overall commitment to the animal's sacrifice. It had to be cleaned and taken care of with the same regard as the roots and berries. The utmost gratitude and respect was offered to the animal's spirit for imparting a tremendous gift of life to the people.

Spiritual or religious aspects of natural resources are at the heart of Indian culture. There isn't a daily activity of a traditional lifestyle that doesn't have oral traditions telling how the activity is part of the land and plays a role in taking care of the land. Even landmarks have oral traditions associated with them. These landmarks are tangible cultural reminders.

### **3.3. Value of Uncontaminated Resources**

For natural resources to be uncontaminated as part of Niimiipuu physical and spiritual well-being, then land and waters and air from which they come should be uncontaminated otherwise the risk to human health increases the potential for illness and other ailments. For tribal use of natural resources to be fully utilized, the example of manufacturing and using a *wistiitam'o* or sweat lodge is presented. One purpose of a sweat lodge is for purification. It is for cleansing and a time for meditation, spiritual reflection, healing, sharing oral history and teaching. The *wistiitam'o* is often a place where the Nez Perce return to have spiritual well-being restored after family losses. It is a place of contemplation and an opportunity to relieve stress and anxiety built up from the day's activities. It is a place for centering your soul through prayer and meditation. It is also a place where many socialize with family and friends and learn what is happening in the community.

For these reasons, it is imperative that the materials used in making a sweat lodge come from the natural environment. The structure is made of willows gathered from the immediate vicinity of where the sweat lodge will stand. The covering is to be of animal hides, or other natural materials. The water for the bathing after sweating is to be from a natural spring or stream. Herbs are collected in their proper season with prayers and gratitude offered for their service.

Sitting in a sweat bath is a rigorous activity. While outwardly relaxed, your inner organs are as active as though you were exercising. The skin is the largest organ of the body and through the pores it plays a major role in the detoxifying process along with the lungs, kidneys, bowels, liver and the lymphatic and immune systems. Capillaries dilate permitting increased flow of blood to the skin in an attempt to draw heat from the surface and disperse it inside the body. The heart is accelerated to keep up with the additional demands for circulation. Impurities in the liver, stomach, muscles, brain, and most other organs are flushed from the body. It is in this way that purification occurs.

#### **4.0 NEPA and DOE Fiduciary Responsibility**

The following sections of the CEQ regulations afford affected Tribes the right to participate throughout the NEPA process and provide comment to the lead agency. As a result, DOE's request of Tribal involvement provides the opportunity to communicate a Nez Perce perspective of Hanford resources.

Section 1501.1.6(a) and 1508.5 states that affected tribes have the right to be invited as a cooperating agency. A cooperating agency would participate throughout the entire NEPA process as a partner to the lead agency and can request the role as lead agency. Section 1501.7(a)(1) states that affected tribes are afforded the right to be a participant in the scoping process. Scoping is the term for the early meetings that define the purpose and need of the project and develops the initial range of preliminary alternatives that defines the area of potential effect (APE). Section 1503.1(a)(2ii) recognizes that Tribal governments have the right to comment on NEPA proposals. An important regulation is Section 1507.2(b) that states that "presently unquantified environmental entities and values may be given appropriate consideration". In other words, tribal perspectives, traditional values and spiritual significance can be considered as part of the NEPA evaluation process.

In essence, tribal values are intent on protecting, preserving and perpetuating resources for the sake of perpetuating our culture. While completing NEPA, DOE must invite us early to the process and allow us to determine the extent of our involvement. DOE can meet trust obligations by incorporating tribal views on resource protection while moving forward with their proposed action. When tribal views conflict with the proposed actions, then consultation becomes an important resolution exercise for the benefit of both DOE and tribes.

Often times federal trust obligations are not clearly articulated during the NEPA process or in federal documents. When there are foreseen conflicts between the agency's proposed action and their fiduciary responsibility of trust resources, DOE personnel sometimes will avoid tribal involvement to the point of exclusion, except for providing comment opportunities along with

the general public. If tribes are kept uninformed, we may not know the full extent of the impacts to treaty reserved rights until after implementation of a proposed action.

The Nez Perce Tribe's approach is to fully engage DOE early when making important decisions about cleanup strategies and long-term stewardship of Hanford trust resources. By participating early and communicating our perspective through government consultation, we believe better decisions will be made for both DOE and the Nez Perce for future generations.

### **5.0 Tribal Perspective of Hanford Cleanup (in NEPA format)**

In 2009, DOE invited Affected Tribes to participate in the development of a Programmatic EIS that would look at several locations around the country to place Greater-Than Class-C (GTCC) nuclear waste in a long-term repository. We chose to participate and develop a Tribal narrative for the benefit of the grander scheme of communicating our perspective and fostering more open dialog with DOE in future proposals at Hanford. With coordination with Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the Wanapum people, we created a list of specific issues that are uniquely a Tribal perspective. This narrative should serve only as a template to aid consultation with DOE and develop better decision-making with Nez Perce Tribe during Hanford cleanup.

The Nez Perce Tribe anticipates that DOE will incorporate the following Tribal perspective in all future decision-making. More importantly, we expect a more thorough dialog between DOE and the Nez Perce Tribe; one that embraces tribal values and includes our perspective into the NEPA process. As a Hanford stakeholder, our perspective should be valued as much as other stakeholders.

Our issues summary follows the general outline of a NEPA document in order to make it easier for DOE to incorporate into Hanford decision documents.

#### **5.1. Climate, Air Quality and Noise**

##### **5.1.1. Climate**

Climate is one of the dominate issues of our time. Any programmatic EIS that makes decisions about radio-active waste storage for thousands of years must give serious consideration to the likelihood of climate change on a storage facility. The false assumption that the climate is a constant when considering long-term storage decisions could lead to inadequate design. The reality is that nuclear waste storage will last for thousands of years and climate will likely be different with potential to reach similar condition of history. For instance, the last glacial period ended approximately 11,000 years ago. The maximum extent of glaciation was approximately 18,000 years ago. This is a brief time period considering the half-life of many radio-active isotopes.

Columbia Plateau Tribes have stories about the world being transformed from a time considered prehistoric to what is known today. The Nez Perce remember volcanoes, great floods, and animals now extinct. Oral histories also indicate a time when the climate was much wetter and supported vast forests in the region.

These distinct climatic periods have occurred during which Tribal life had to adapt for our people to survive. Our oral history tells of our struggles against volcanic activity where our world seemed on fire, of great floods, and of the previous ice age. Scientific and historic knowledge validates our oral history for many thousands of years.

Oral histories describe a time when Gable Mountain or *Nookshia* (Relander 1986: 305), a major landscape feature on the Hanford Reservation, rose out of the Missoula floods. There is a story about Indian people who fought severe winds that were common a long time ago. One story tells of how a family trained their son by having him fight with the ice in the river until he became strong enough to fight the cold winds.

Holocene (Roberts 1998) is the term used to describe the climate during the last glaciers (110,000 to 11,700 years ago), covering much of the northwestern North America. Arctic foxes found at Marmes Rock Shelter provide some of this archeological record (Brownman and Munsell 1969; Hicks 2004). The Palynological data would be a good source for recreating climates that supported ecosystems of the past 10,000 years. This information should be a minimal basis for climate analysis relative to decision-making on long-term storage of radio-active waste at Hanford.

### 5.1.2. Air Quality

Air quality monitoring results of past and present monitoring of the Hanford site should be summarized and presented in a NEPA document. This should include measures of radio-active dust at locations like the Environmental Restoration Disposal Facility (ERDF), various plant emission stacks, venting systems, and power generation sites. Also, fugitive dust needs to be described relative to inversions and health risks. Also, this section should describe seasonal and daily wind patterns where fugitive dust could impact visibility and the Hanford viewshed.

The Nez Perce believe that radioactivity is brought into the air and distributed by the high winds that commonly occur at Hanford. Past Hanford NEPA documents provided little if any information about radio-active soil/dust dispersal capabilities of wind. ERDF Site managers occasionally send workers home and close down the facility due to blowing dust impairing worker visibility and creating an unsafe work environment. These situations are part of the existing environment and yet are not described.

There is typically no mention of high winds or their ability to pick up contaminated soils from active demolition areas or waste soils placed at ERDF. Do the ERDF or demolition sites operate with work stoppage if wind speeds exceed some level? Do excavation or demolition sites that create radio-active debris operate under temporary structures to prevent wind dispersals? This type of information needs to be presented.

Winds commonly blow 40-45 miles per hour and intermittently much stronger at Hanford (<http://www.bces.wa.gov/windstorms.pdf>). High winds over 150-mile per hour were recorded in 1972 on Rattlesnake Mountain; and in 1990, winds on the mountain were recorded at 90 miles per hour. Dust devils can be massive in size, spin up to 60 miles per hour, and frequently occur at the site. Tornadoes have been observed in Benton County which is regionally famous for

receiving strong winds. It is important to understand how wind has the potential to distribute radio-active and chemical waste at Hanford during excavation, handling, transport, and storage of these contaminates.

#### **5.1.3. Noise**

Non-natural noise can be offensive to native people during traditional ceremonies. Noise-generating projects can interrupt the thoughts and focus and thus the spiritual balance and harmony of the Tribal community at a ceremony (Greider 1993). The general values or attributes from a tribal perspective is for the natural environment to provide solitude, quietness, darkness and an uncontaminated environment. These attributes provide unquantifiable value that allows for spiritual connection to mother earth. These attributes of nature are fragile.

The noise generated by the Hanford facility may have the potential to interfere with ceremonies held at sites like Gable Mountain and Rattlesnake Mountain. The disruption of natural harmony at ceremonial sites has not been surveyed or even discussed.

The Nez Perce Tribe recommends that quiet zones and time periods be identified for known Native American ceremonial locations on and near the Hanford site. Not all ceremonial sites have been shared with DOE or the non-Indian public. For this reason, tribal values of the Hanford environment that already supports solitude should be documented. These values are also discussed in our new recommended section that we titled "Viewshed".

#### **5.1.4. Light Pollution**

Light pollution is a broad term that refers to multiple problems, all of which are caused by inefficient, unappealing, or (arguably) unnecessary use of artificial light. Artificial light can create measurable harm to the environment by affecting nocturnal and diurnal animals. It can affect reproduction, migration, feeding and other aspects of animal survival. Artificial light can also reduce the quality of experience during tribal cultural and ceremonial activities. Presently, there is no discussion in an EIS about how artificial light may cause harm to the Hanford environment especially those areas regularly visited by tribal members for ceremonial purposes.

### **5.2. Geology and Soils**

#### **5.2.1. Geology**

##### **5.2.1.1. Physiography**

The Yakima Fold Belt and the Palouse Slope play potentially very significant roles at Hanford both culturally and geologically. Rattlesnake and Gable Mountains are examples of folded basalt structures within the Yakima Fold Belt. These geological features have direct bearing on the groundwater and its flow direction. There are oral history accounts of these basalt features above the floodwaters of Lake Missoula. Many other topography features have oral history explanations such as the Mooli Mooli (ground undulations found along the river terrace) and the sand dunes.

### **5.2.1.2. Site Geology and Stratigraphy—**

#### **Central Plateau**

The Central Plateau is underlain by suprabasalt sediments comprised of the Ringgold, Cold Creek, and Hanford formations. There is a large amount of variability in the geology and hydraulic conductivity underneath the Central Plateau. Better understanding of the geology is probably one of the most important elements for evaluating potential Hanford remediation strategies. It should be noted that within both the vadose zone and aquifer, there are major erosional channels filled with gravel that can be traced across the Central Plateau.

Clastic dikes are networks of vertical features like cracks that developed in the vadose zone. How clastic dikes may influence contaminant transport is not well understood. There is a question as to whether or not the DOE has looked for them at the proposed site. They are known to be present in the 200 Areas.

**Regional Seismicity** —The Pasco Basin has been tectonically active and needs consideration if there is interest in putting more contaminants in the ground at Hanford. The local region is under north-south compressional force that has caused the surface to wrinkle in folds that trend approximately east-west, thus creating the Yakima Fold Belt. Fault movement along these folds occurs periodically, and studies have shown these to be considered active fault zones (Repasky, TR, et.al., 1998; Campbell, N.P., et.al., 1995). Emerging research being reported through the USGS is highlighting the importance of the Cascadian subduction zone under the Cascades into the Yakima Fold Belt.

The Pasco Basin includes a feature called the Olympic-Wallowa Lineament (the OWL). Surface features are used to identify a structural “line” within the earth’s crust that can be traced roughly from southeast of the Wallowa Mountains, under Hanford, through the Cascades and Puget Sound.

The 1936 earthquake and the 1973 earthquakes at Hanford justify the requirement earthquake-resistant buildings. Any storage structure of highly contaminated nuclear waste should also have backup safety systems as a secondary line of defense against earthquakes.

### **5.2.2. Soils**

Soil is part of mother earth that supports plant and animal life which Native people rely for our traditional lifeways. We understand the importance of soils and minerals through our traditional use of them. Clays were used as a building material, for creating mud baths, and for making pottery. One of the best known attributes of soils is its ability to filter water. Hanford has delineated contamination areas called operable units (OUS) for surface contamination. It is essential for the soils section of the Affected Environment Chapter to graphically illustrate and describe the surface contamination OUs. The influence of past releases on soil chemistry and properties are not understood. Sandy soils at Hanford already have high transmissivity. Such changes could increase water and contaminant transport.

Oral histories document medicinal properties of soil for healing wounds. Soils from the White bluffs were used for cleaning hides, making paints, and whitewashing villages.

### **5.3. Minerals and Energy Resources**

The extent and value of mineral resources displaced by the present contamination in the Central Plateau has not been documented. DOE has designated this area as industrial use according to the Comprehensive Land Use Plan (CLUP). It appears that DOE's present vision is to allow temporary and long-term waste storage at the uncontaminated surface in this area while continuing pump and treat technology and natural attenuation for managing vadose and groundwater contamination. This may seem like a reasonable strategy by DOE from a technical standpoint but this strategy will likely prevent tribal use of the area for thousands of years. As a result, there is a loss of resource use to the Nez Perce, including use of soils and minerals.

### **5.4. Water Resources**

#### **5.4. 1. Groundwater**

Purity of water is very important to the Nez Perce, considering their cultural connection and direct use of water. We expect DOE to manage for optimum achievable water quality and not for a minimum water quality threshold.

There is insufficient characterization of the vadose zone and groundwater. It is essential for the Groundwater section of the Affected Environment chapter to describe existing groundwater contamination and where information is lacking. Hanford has delineated operable units (OUS) for subsurface contamination based in existing characterization data. But, DOE needs to better characterize these OUs and graphically illustrate them in the document.

From the perspective of the Nez Perce Tribe, the greatest long-term threat at the Hanford site lies in the groundwater contamination and its difficulty to be cleaned up. There is a tremendous volume of radioactive and chemical contamination in the groundwater that needing further evaluation. For instance, the mechanisms of flow and transport of contaminants through the soil

to the groundwater are still largely speculative. This coupled with limited technical ability to remediate the vadose and groundwater puts the Columbia River at continual risk.

#### **5.4.2. Water Use**

The Columbia River is the lifeblood of the Nez Perce people. It supports the salmon and every traditional food or material that our people rely for subsistence. It is an essential human right to have clean water. If water is contaminated then it contaminates all living things including tribal members that exercise a traditional lifestyle. Making a sweat lodge and sweating is a perfect example. It is a process of cleansing and purification. However, if water is contaminated and/or the sweat lodge materials then the process of cleansing would actually contaminate the individual.

Tribal people are well known for adopting technology if instituted wisely or didn't threaten our people or elements of the environment. This approach applies to tribal use of groundwater too. Even though groundwater was not used except at springs, tribes would have developed wells eventually if seen as an appropriate use. Existing contamination is considered an impact to tribal rights to utilize springs and groundwater.

The hyporheic zone in the Columbia River needs to be more fully characterized to understand how contaminated groundwater is entering the Columbia River. Contaminated groundwater plumes at Hanford are moving towards the Columbia River and some contaminants like chromium are already recharging to the river. It is the philosophy of the Columbia River Tribes that groundwater restoration and protection be paramount in DOE's management of Hanford. Institutional controls such as preventing use of groundwater should only be a temporary safety measure for human health and the environment. We prefer a proactive corrective cleanup strategy over DOE's inference to use surface barriers, natural attenuation and institutional controls as a long-term management option. In our opinion, monitoring natural attenuation is not a cleanup strategy. By not actively pursuing cleanup of vadose and groundwater contamination, DOE is limiting surface land use to none other than waste disposal or energy parks. Future waste disposal or development of energy parks does not meet the Nez Perce Tribes end-state vision and actually places limitations to future tribal use. Such important land use decisions or proposed changes to land use must be consulted with our Tribal leadership on a government to government basis.

#### **5.5. Human Health**

Nez Perce health involves access to traditional foods and places. Both are located on the Hanford facility and can be limited by institutional controls or impacted by inadequate cleanup.

*Definition of Tribal health-* Native American ties to the environment are much more complex and intense than is generally understood by risk assessors (Harris 1998, Oren Lyons; [http://www.ratical.org/many\\_worlds/6Nations/OLatUNin92.html](http://www.ratical.org/many_worlds/6Nations/OLatUNin92.html); <http://www.youtube.com/watch?v=hDF7ia23hVg>). All of the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one way, but more often in many ways. Therefore, if the link between a person and his/her environment is severed

through the introduction of contamination or physical or administrative disruption, the person's health suffers, and the well being of the entire community is affected.

To many American Indians, individual and collective well being is derived from membership in a healthy community that has access to, and utilization of ancestral lands and traditional resources. This wellness stems from and is enhanced by having the opportunity and ability to live within traditional community activities and values. If the links between a tribal person and his or her environment were severed through contamination or DOE administrative controls, the well being of the entire community is affected.

#### **5.6. Risk Assessments**

Risk assessments should take a public health approach to defining community and individual health. Public health naturally integrates human, ecological, and cultural health into an overall definition of community health and well-being. This broader approach used with risk assessments is adaptable to indigenous communities that turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life (Harris, 1998, 2000; Harper and Harris, 2000).

"Subsistence" in the narrow sense refers to the hunting, fishing, and gathering activities that are fundamental to the way of life and health of many indigenous peoples. The more concrete aspects of a subsistence lifestyle are important to understanding the degree of environmental contact and how subsistence is performed in contemporary times. Also, traditional knowledge can be learned directly from nature. Through observation this knowledge is recognized and a spiritual connection is often attained as a result. Subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. The following is a useful explanation of "subsistence," slightly modified from the National Park Service:

*"While non-native people 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. It defines who they are as a people. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. The subsistence lifestyle is a communal activity that is the basis of cultural existence and survival. It unifies communities as cohesive functioning units through collective production 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. Nez Perce young hunters and fisherman are required to distribute their first catch throughout the community at a first feast (first bite) ceremony. It is a ceremony that illustrates the young hunter is now a man and a provider for his 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.” (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))*

The following four environmental categories contribute to individual and community health. Impacts to any of these can adversely affect health. Metrics associated with impacts within each of these categories are presented in Harper and Harris (1999).

#### **5.6.1 Human Health-related Goods and Services**

This category includes the provision of water, air, food, and native medicines. In a tribal subsistence situation, the land provided all the food and medicine that was necessary to enjoy long and healthy lives. From a risk perspective, those goods and services can also be exposure pathways.

#### **5.6.2 Environmental Functions and Services**

This category includes environmental functions such as soil stabilization and the human services that this provides, such as erosion control or dust reduction. Dust control in turn would provide a human health service related to asthma reduction.

Environmental functions such as nutrient production and plant cover would provide wildlife services such as shelter, nesting areas, and food, which in turn might contribute to the health of a species important to ecotourism. Ecological risk assessment includes narrow examination of exposure pathways to biota as well as examination of impacts to the quality of ecosystems and the services provided by individual biota, ecosystems, and ecology.

#### **5.6.3 Social and Cultural Goods, Functions, Services, and Uses**

This category includes many things valued by suburban and tribal communities about particular places or resources associated with intact ecosystems and landscapes. Some values are common to all communities, such as the aesthetics of undeveloped areas, intrinsic existence value, environmental education, and so on.

#### **5.6.4 Economic Goods and Services**

This category includes conventional dollar-based items such as jobs, education, health care, housing, and so on. There is also a parallel non-dollar indigenous economy that provides the same types of services, including employment (i.e., the functional role of individuals in maintaining the functional community and ensuring its survival), shelter (house sites, construction materials), education (intergenerational knowledge required to ensure sustainable survival throughout time and maintain personal and community identity), commerce (barter items and stability of extended trade networks), hospitality, energy (fuel), transportation (land and water travel, waystops, navigational guides), recreation (scenic visitation areas), and economic support for specialized roles such as religious leaders and teachers.

### **5.7. Ecology**

The Nez Perce people have lived in these lands for a very long time and learning about the resources and their ecological interrelationships. We knew about environmental indicators that foretold seasons and their conditions to come. Mother earth will communicate to you, if you are willing to pay attention. When Cliff Swallows first appear in the spring, their arrival is an indicator that the fish are coming up the river. Doves are our fish counters, telling if the fish will be abundant. Many natural phenomena foretell the earth is about to come alive again in spring, even though things are still dormant underground. The Nez Perce have traditional ecological knowledge and even have ceremonies that acknowledge them, like the arrival of spring. The winds also bring information about what will happen in our environment and provides guidance about how to bring balance to our lands.

#### **5.7.1. Biodiversity on the National Monument**

The Monument encompasses a biologically diverse landscape containing an irreplaceable natural and historic legacy. Limited development at Hanford over approximately 70 years of Government operation has allowed for the Monument to become a haven for important and increasingly scarce plants and animals of scientific, historic and cultural interest. It supports a broad array of newly discovered or increasingly uncommon native plants and animals. Migrating salmon, birds and hundreds of other native plant and animal species, some found nowhere else in the world, rely on its natural ecosystems. The Monument also includes 46.5 miles of the last free-flowing, non-tidal stretch of the Columbia River, known as the “Hanford Reach.”

#### **5.7.2. Salmon**

The Columbia River tribes see themselves as the keepers of ancient truths and laws of nature. Respect and reverence for the perfection of Creation are the foundation of our cultures. Salmon are a large part of our spiritual and cultural identity. Tribal values are transferred from generation to generation through fishing and associated activities tied to the salmon returns. Without salmon, Columbia River tribes would lose the foundation of their spiritual and cultural identity.

Columbia River salmon runs, once the largest in the world, have declined over 90% during the last century. The 7.4 – 12.5 million average annual numbers of fish above Bonneville Dam have dropped to 600,000. Of these, approximately 350,000 are produced in hatcheries. Many salmon stocks have been removed from major portions of their historic range (Columbia Basin Fish and Wildlife Authority, 2009).

Multiple salmon runs reach the Hanford Nuclear Reservation. These runs include Spring Chinook, Fall Chinook, Sockeye, Silver and Steelhead. The runs tend to begin in April and end in November. Salmon runs have been decimated as a result of loss and change of habitat. The losses were and are largely due to non-tribal commercial fisheries, agriculture and irrigation diversion, and especially construction of hydro-projects on the Columbia River. Protection and preservation of anadromous fisheries were not a priority when the 227 Columbia River dams were constructed during the last half-century. Some dams were constructed without fish ladders, eliminating approximately half of the spawning habit available in the Columbia System.

The Hanford Reach is approximately 51 miles long and is the only place on the upper mainstem of the Columbia River where Chinook salmon still spawn naturally. This reach is the last free flowing section of the Columbia River above Bonneville Dam. It produces about eighty to ninety percent of the fall Chinook salmon run on the Columbia River.

The Columbia River Tribes, out of a deep commitment to the fisheries and in spite of the odds, plan to restore stocks of Chinook, Coho, Sockeye, Steelhead, Chum, Sturgeon and Pacific Lamprey to the Columbia and its tributaries. This effort was united in 1995 under a recovery plan called the Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon). Member tribes are the Nez Perce, Umatilla, Warm Springs and Yakama. Affected Tribes are co-managers of Columbia River fisheries and assist in tagging fry and counting redds along the Hanford Reach for the purpose of estimating fish returns. This information is essential in the negotiation of fish harvest between the United States and Canada as well as between Indian and non-Indian fishermen.

In many ways, the loss of salmon mirrors the plight of native people along the Columbia River. Elders remind us that the fate of humans and salmon are linked. The circle of life has been broken with the loss of traditional fishing sites and great declines in salmon runs. Our goal is to restore this great resource and in that effort, perpetuate our heritage and culture.

## **5.8. Socioeconomics**

### **5.8.1. Modern Tribal Economy**

A subsistence economy is one in which currency is limited because many goods and services are produced and consumed within families or bands, and currency is based as much on obligation and respect as on tangible symbols of wealth and immediate barter. It is well-recognized in anthropology that indigenous cultures include networks of materials interlinked with networks of obligation. Together these networks determine how materials and information flow within the community and from the environment. Today there exists with tribal people an integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors. This relationship must be considered when thinking of economics and employment of tribal people ([http://www.ratical.org/many\\_worlds/6Nations/OlatUNin92.html](http://www.ratical.org/many_worlds/6Nations/OlatUNin92.html); <http://www.youtube.com/watch?v=hDF7ia23hVg>).

Indian people engage in a complex web of exchanges that often involves traditional plants, minerals, and other natural resources. These exchanges are a foundation of community and intertribal relationships. Indian people catch salmon that become gifts to others living near and far. Sharing self-gathered food or self-made items is a part of establishing and maintaining reciprocal relationships. People have similar reciprocal relationships with mother earth including physical places and elements of nature. This mutual respect applies to all. Present contamination at Hanford, extended timelines for cleanup, and proposals to place more waste at Hanford may displace or limit traditional and contemporary tribal use of resources, and thus limit the long-term direct production that permeates Indian life.

Use of the Hanford site and surrounding areas by tribes was primarily tied to the robust Columbia River fishery. Tribal families and bands lived along the Columbia either year round or

seasonally for catching, drying and smoking salmon. Past associated activities included gatherings for such events like marriages, trading, ceremonial feasts, harvesting, fishing, and mineral collection. The loss of salmon runs, the loss of fishing sites now under water, and the loss of habitat and access have limited the once natural surplus of the Hanford area. This once robust area used to support the gifting and barter system of Columbia River Tribes when traveling and living along the river.

It is likely that the future of salmon in the Columbia system will be determined within the lifetime of Hanford clean-up and the lifecycle of stored waste temporarily stored at Hanford. With the tremendous efforts to recover salmon (and other fish species) by tribes, government agencies, and conservation organizations, Tribal expectations are that these species will be recovered to stronger healthy populations. If salmon and other anadromous fish species were to recover, the regional economy and tribal barter economy would likely greatly improve. Higher fish returns and the associated social and economic potential needs to be considered within the lifecycle of waste at Hanford. Salmon and other species are at the heart of the Nez Perce culture. Any cleanup decisions at Hanford that affect tribal use for hundreds or thousands of years must consider the inherent risk to tribal rights and culture, including social and economic elements tied to salmon runs.

#### **5.8.2. Direct Production**

Direct production by tribes is part of the economy that needs to be represented, especially considering the Tribe's emphasis on salmon recovery. This type of individual commerce in modern economics is termed and calculated as "direct production". The increase in direct production would be relational to the region's salmon recovery, yet there is no economic measure (within the NEPA process) to account for this robust element of a traditional economy.

In a traditional sense, direct production is a term of self and community reliance on the environment for existence as opposed to employment through modern economies. Direct production is use of salmon and raw plant materials for foods, ceremonial, and medicinal needs and the associated trading or gifting of these foods and materials. Direct production needs to be understood and should include the role of plant foods, ceremonial plants, medicinal plants, beadwork, hide work, tule mats and dried salmon.

To provide an example, consider the season prior to the flooding of Celilo Falls when an estimated 1500 native fisherman assembled at the site during peak fishing season. Now consider these men and their families trading and gifting. This would be a substantial economic element to consider, and it is directly tied to salmon and associated Columbia River. It would make for a tremendous scene today to see that number of people fishing and drying meat. What would be the direct production generated from 1500 fishermen and their families trading and gifting salmon, dentalia shells, mountain sheep horns, bows, horses, baskets, tule mats, buffalo robes, leather, rawhide, and hand-made art like bead work? It is a day worth someday witnessing again.

#### **5.9. Environmental Justice**

President Clinton signed Executive Order 12898 to address Environmental Justice issues and to commit each federal department and agency to “make achieving Environmental Justice part of its mission.” (Environmental Biosciences Program 2001). According to the Executive Order, no single community should host disproportionate health and social burdens of society’s polluting facilities. Many American Indians are concerned about the interpretation of “Environmental Justice” by the U.S. Federal Government in relation to tribes. By this definition, tribes are included as a minority group. However, the definition as a minority group fails to recognize tribes’ sovereign nation-state status, the federal trust responsibility to Tribes, or protection of treaty and statutory rights of American Indians. Because of a lack of these details, tribal governments and federal agencies have not been able to develop a clear definition of Environmental Justice in Indian Country, and thus it is difficult to determine appropriate actions in cases like Hanford.

If federal decision-making does not fully protect trust resources to the degree necessary to protect aboriginal uses, those decisions could be interpreted to be a violation of aboriginal rights. Decisions that cause continued degradation of trust resources could place undue burden to tribal people and could also be considered an Environmental Justice issue. Many federal and state environmental laws and regulations designed to protect the environment are not interpreted by regulators to fully address the concerns of Native Americans. This topic deserves more review and discussion among regulators to better define what constitutes a violation of federal trust responsibilities. When does a loss of protected tribal use by government action(s), like those occurring at Hanford, become a violation of aboriginal rights and trigger an environmental justice issue? A review of existing case law might summon such an argument or opinion.

### **5.10. Land Use**

The Nez Perce Tribe recommends that DOE continue efforts to identify special places and landscapes with spiritual significance. Newly identified sites would be added to those already requiring American Indian ceremonial access and protection through long-term stewardship. Native people maintain that aboriginal and treaty rights allow for the protection, access to, and use of resources. These rights were established at the origin of the Native People and persist forever. There are sites or locations within the existing Hanford reservation boundary with tribal significance that are presently restricted through DOE’s institutional controls and should be considered for special protections or set aside for traditional and contemporary ceremonial uses. Sites like the White Bluffs, Gable Mountain, Rattlesnake Mountain, Gable Butte, and the islands on the river are known to have special meaning to Tribes and should be part of the discussion for special access and protection. These locations should be placed in co-management with DOE, FWS and the Tribes for long-term management and protection.

#### **5.10.1. Tribal Access**

There are several federal regulations, policies, and executive orders that define tribal access at Hanford, assuming hazard risk levels are acceptable. Institutional controls associated with the CIUP or the CCP should not override tribal rights to access areas that no longer have human health hazards. The following is a brief summary of those legal and regulatory references:

According to the *American Indian Religious Freedom Act*, tribal members have a protected right to conduct religious ceremonies at locations on public lands where they are known to have occurred before. There has been an incomplete effort to identify the full extent of tribal ceremonial use at Hanford. Part of the reason may be affected Tribes desire to not share such information. *Executive Order 13007* supports the American Religious Freedom Act by stating that Tribal members have the right to access ceremonial sites. This includes a directive to agencies to maintain existing trails or roads that provide access to these sites.

DOE managers that are considering moving waste or placement of new waste at Hanford must evaluate potential impacts to ceremonial access as part of DOE's trust responsibilities. There are locations that have specific protections due to cultural significance like burial sites, artifact clusters, etc. These types of areas are further described under the Cultural Resources Section of this writing. As DOE decommissioning and reclamation occurs across the Hanford site, findings of culturally significant areas will continue to expand the list of sites with special protections. These protections override existing land use designation of the CLUP or other DOE documents and should be stated as such in these documents to direct managers in their legal obligations.

#### **5.10.2. Comprehensive Land Use Plan (CLUP)**

The present DOE land use document for Hanford, called the Comprehensive Land Use Plan (CLUP), has institutional controls that limit present and future use by Native Americans. DOE plans to remove some institutional controls over time as the contamination footprint is reduced as a result of instituting their 2015 vision along the river and the proposed cleanup of the 200 area. With removal of institutional controls, the affected tribes assume they can resume access to usual and accustomed areas.

Future decisions about land transfer must consider the implications for Usual and Accustomed uses (aboriginal and treaty reserved rights) in the long-term management of resource areas. The 50-year management time horizon of the CLUP does not create permanent land use designations. On the contrary, land use designations or their boundaries can be changed in the interim at the discretion of DOE and/or through requests to DOE by Hanford stakeholders. The CLUP is often misused by assuming designations are permanent. Also, it is important to note that the interim land use designations in the CLUP cannot abrogate treaty rights. That requires an act of Congress.

#### **5.10.3. Hanford National Monument**

A Presidential Proclamation established the Hanford Reach National Monument (Monument) (Presidential Proclamation 7319) and directed the DOE and the U.S. Fish and Wildlife Service (FWS) to jointly manage the monument. The Monument covers an area of 196,000 acres on the Department of Energy's (DOE) Hanford Reservation. DOE agreements and permits delegate authorities to FWS for 165,000 acres while DOE still directly manages approximately 29,000 acres, and the Washington Department of Fish and Wildlife manages the remaining 800 acres (approximately) through a separate DOE permit.

The co-management of the Monument directs each agency to fulfill several missions. The FWS is responsible for the protection and management of Monument resources and people's access to lands under FWS control. The FWS also has the responsibility to protect and recover threatened and endangered species; administer the Migratory Bird Treaty Act; and protect fish, wildlife and Native American trust resources and other trust resources within and beyond the boundaries of the Monument (USFWS, 2008).

The FWS developed a comprehensive conservation plan (CCP) for management of the Monument as part of the National Wildlife Refuge System as required under the National Wildlife Refuge System Improvement Act. The CCP is a guide to managing the Monument lands. It should be understood that FWS management of the Monument is through permits or agreements with the DOE.

Tribes participated in the development of the CCP with regard to protection of natural and cultural resources and tribal access. Based on the Presidential Proclamation that established the Hanford Reach National Monument, affected tribes assume that all of Hanford will be restored and protected (Federal Register, 36 (23):1271-1329).

#### **5.10.4. Operable Units ((OUs)**

Hanford has delineated contamination areas called operable units (OUs) for both surface and subsurface contamination. It is essential for the soils and groundwater sections of the Affected Environment Chapter to graphically illustrate and describe the surface and subsurface OUs. Land under consideration for long-term waste retrieval or disposal should describe the Land Use designation (according to the CLUP) but also describe the extent of surface and subsurface contamination that primarily dictated that designation. For example, the 200 West area lies over part of the 200 ZP-1 groundwater OU. This OU has contamination from uranium, technetium, iodine 129 and other radioactive and chemical constituents. The extent and timeframe for its cleanup should be understood within the context of any proposed actions on its surface.

Land use designations in the CLUP may allow a waste repository or energy generation facility to be placed, but without considering the contamination underneath, such actions could be in the way of future characterization needs and cleanup strategies of vadose contamination or groundwater plumes.

#### **5.11. Transportation**

##### **5.11.1 Traditional Transportation**

Indian people have been traveling their homeland to usual and accustomed areas for a very long time. Early modes of transportation began with foot travel. Domesticated dogs were utilized to carry burdens. Dugout canoes were manufactured and used to traverse the waterways when the waters were amiable. Otherwise, trails following the waterways were best means for travel. With the arrival of the horse, it changed how people traveled. Numerous historians note that horses arrived to the Columbia Plateau in the late 1700's. That is incorrect according to Tribal history. The arrival of the horse was actually a full century earlier in the late 1600's. Their acquisition quickened tribal movement on an already extant and heavily used travel network. This travel

network was utilized by many tribal groups on the Columbia Plateau and was paved by thousands of years of foot travel. Early explorers and surveyors utilized and referenced this extensive trail network. Some of the trails have become major highways and the Columbia and Snake Rivers are still a crucial part of the modern transportation network.

The Middle Columbia Plateau of the Hanford area is the crossroads of the Columbia Plateau located half way between the Great Plains and the Pacific Northwest Coast. Major Columbia River tributaries including the Walla Walla, Snake, and Yakima Rivers flow into this section of the main stem Columbia River. These rivers form a critical part of a complex transportation network through the region that includes the Hanford reach. The slow water at the Wallula Gap was one of the few places where horses could traverse the river year round. This river crossing provided access to a vast web of trails that crossed the region, including portions of these trails known to cross Hanford.

#### **5.11.2. Present Transportation**

There are two interstate highways [Interstate 90 (I-90) and Interstate 84 (I-84)], an interstate rail line and the Columbia River barging system that support Hanford. If Hanford is proposing the transportation of hazardous chemicals including waste, DOE needs to provide number of shipments, the method of transportation, and timing. DOE must also provide an emergency response plan and have available response equipment in case of an emergency.

The interstate highway system is a primary transportation corridor for shipping nuclear waste through the states of Oregon, Washington, and Idaho. Waste moving across these states will cross many major salmon bearing rivers that are important to the Tribes. Major rail lines also cross multiple treaty resource areas.

The Nez Perce Tribe believes that decision-making criteria for selecting rail, barge or highway routing should be made public and should allow tribal input. Criteria for protecting treaty resources and other environmental protections must be part of that matrix. The public needs to be assured that the public health and highly valued resources like salmon and watersheds are properly considered and protected when it comes to transporting waste into and out of Hanford.

Northwest river systems have received significant federal and state resources over recent decades in an attempt to recover salmon and rehabilitate damaged watersheds. DOE needs to describe how public safety, and the protection of salmon and watersheds “fit” into the criteria selection process for determining transportation options. The protection and enhancement of existing river systems are critical to sustaining tribal cultures along the Columbia River.

#### **5.12. Cultural Resources**

From a tribal perspective, all things of the natural environment are recognized as a cultural resource. This is a different perspective from those who think of cultural resources as artifacts or historic structures. The natural environment provides resources for a subsistence lifestyle for tribal people. This daily connection to the land is crucial to Nez Perce culture and has been throughout time. All elements of nature therefore are the connection to tribal religious beliefs

and the foundation of their aboriginal rights recognized in the 1855 treaty. Oral histories confirm this cultural and religious connection.

"According to our religion, everything is based on nature. Anything that grows or lives, like plants and animals, is part of our religion..." *Horace Axtell (Nez Perce Tribal Elder)*

#### **5.12.1. Landscape and Ethno-habitat**

For thousands of years American Indians have utilized the lands in and around the Hanford Site. Historically, groups such as the Yakama, the Walla Walla, the Wanapum, the Palouse, the Nez Perce, the Columbia, and others had ties to the Hanford area. "The Hanford Reach and the greater Hanford Site, a geographic center for regional American Indian religious activities, is central to the practice of the Indian religion of the region and many believe the Creator made the first people here" (DOI 1994). Indian religious leaders such as Smoholla, a prophet of Priest Rapids who brought the Washani religion to the Wanapum and others during the late 19<sup>th</sup> century, began their teachings here (Refander 1986). Prominent landforms such as Rattlesnake Mountain, Gable Mountain, and Gable Butte, as well as various sites along and including the Columbia River, remain sacred. American Indian traditional cultural places within the Hanford Site include, but are not limited to, a wide variety of places and landscapes: archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant gathering areas, holy lands, landmarks, important places in Indian history and culture, places of persistence and resistance, and landscapes of the heart (Bard 1997). Because affected tribal members consider these places sacred, many traditional cultural sites remain unidentified."

NEPA 18.4.6.1.2 (p. 4.120).

#### **5.13.2. Viewshed**

The Nez Perce Tribe utilizes vantage points to maintain a spiritual connection to the land. Viewsheds tend to be panoramic and are made special when they contain prominent uncontaminated topography. The viewshed panorama is further enhanced by abrupt changes in topography and or habitats.

Nighttime viewsheds are also significant to indigenous people who still use the Hanford Reach. Each tribe has stories about the night sky and why stars lie in their respective places. The patterns convey spiritual lessons which are conveyed through oral traditions. Often, light pollution from neighboring developments diminishes the view of the constellations.

There are several culturally significant viewsheds located on the Hanford site. The continued tribal use of these sites brings spiritual renewal. The potential to impact viewsheds should be considered when accessing new DOE proposals. Special travel considerations should be given to tribal elders and youth to accommodate their desire to reach traditional ceremonial sites that have viewshed values.

#### **5.13.3. Salmon as a Cultural Resource**

Nez Perce life is perceived as being intertwined with the life of the salmon. Salmon remain a core part of oral traditions of Columbia Plateau Tribes and still maintains a presence in native

peoples' diet just as it has for generations. Salmon are recognized as the first food at tribal ceremonies and feasts. One example is the *ke'iyit*, which translates to "first bite." It is a Nez Perce ceremonial feast that is held in Spring to recognize the foods that return to take care of the people. It is a long-standing ceremony that attendees immerse themselves in prayer, songs and dancing throughout its activities.

A core tenant of the plateau people is to extend gratitude to the foods for sustaining their life. A parallel exists between the dwindling numbers of salmon returning to the Columbia and the struggle of the Nez Perce people (Landeen and Pinkham 1999).

#### **5.14. Waste Management**

The Nez Perce Tribe will continue to work with DOE through its cooperative agreement to ensure that cleanup decisions protect human health, the environment, and tribal rights. The Nez Perce Tribe's goal of the Hanford cleanup is to restore the land to uncontaminated pre-Hanford conditions for unrestricted use. Our end-state vision would allow Tribal members to utilize the area in compliance with the Usual and Accustomed treaty rights reserved and guaranteed in the 1855 treaty (Nez Perce Tribe 2005).

#### **5.15. Cumulative Impacts**

As part of any EIS process, a cumulative risk assessment needs to be developed for Hanford. This risk assessment needs to utilize the three existing Hanford Tribal risk scenarios (CTUIR, Yakama Indian Nation, and DOE-Hanford), and include existing calculated values as part of Hanford risk to determine cumulative impacts.

The cumulative loss of tribal access through use of institutional controls, including fencing needs to be clearly graphically displayed. This public and tribal access limitation must be described as part of the existing environment. Any change to size and time extent of existing access due to additional restrictions from the proposed action, especially tribal access, needs to be clearly understood. For example, the proposed placement of a waste repository with 10,000-year half-life of waste products would greatly extend the time of access limitations.

The Natural Resource Damage Assessment and Restoration Program (NRDA) directs Federal Agencies like DOE to restore natural resources injured as a result of oil spills or hazardous substance releases into the environment. Damage assessments provide the basis for determining the restoration needs that address the public's loss and use of natural resources. If restoration is not met then compensation and mitigation will complete redress of loss of use.

This existing loss of use of the central plateau from deep vadose and groundwater contamination has not yet been quantified. Present land use designation of industrial use by the CLUP could compromise and add complexity to the NRDA process by allowing or targeting industrial use with no regard or understanding of how this surface use may limit future cleanup strategies. The consequences of such surface use proposals blur the lines of what is considered a loss of use from waste contamination versus loss of use due to access restrictions for safety reasons associated with surface uses like waste storage.

Land use designation is largely due to contamination but should not be the sole point of directing surface use to long-term waste storage extending time to cleanup existing contamination. There is no discussion of how surface uses may hinder cleanup strategies or placement of pump and treat wells or their associated monitoring wells. Overall, there is a need to consider how any surface proposed actions will affect long-term cleanup and/or the NRDA process.

#### **6. Acknowledgments**

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## Appendix A.

### **Legal Framework**

#### **TREATY RIGHTS AND OBLIGATIONS**

The Nez Perce Tribe is a sovereign government whose territory comprises over 13 million acres of what are today northeast Oregon, southeast Washington, and north-central Idaho. In 1855 the Nez Perce Tribe entered into a treaty with the United States, securing, among other guarantees a permanent homeland, as well as fishing, hunting, gathering, and pasturing rights. (Treaty with the Nez Perces, June 11, 1855; 12 Stat. 957).

Since 1855, many federal and state actions have recognized and reaffirmed the Tribe's treaty-reserved rights. Because these rights are of enormous importance to the Tribe's subsistence and cultural fabric, the ecosystems that support fish and wildlife must remain undamaged and productive. DOE recognizes the existence of reserved treaty rights and has shown a commitment to identifying and assessing impacts of all DOE activities to both on and off-reservation lands.

The Nez Perce Tribe has the responsibility to protect the health, welfare, and safety of its members, and the environment and cultural resources of the Tribe. Therefore, activities related to the Hanford operations and cleanup should avoid endangering the Tribe's environment and culture, or impairing their ability to protect the health and welfare of Tribal members.

#### **The Nez Perce Tribe Treaty of 1855**

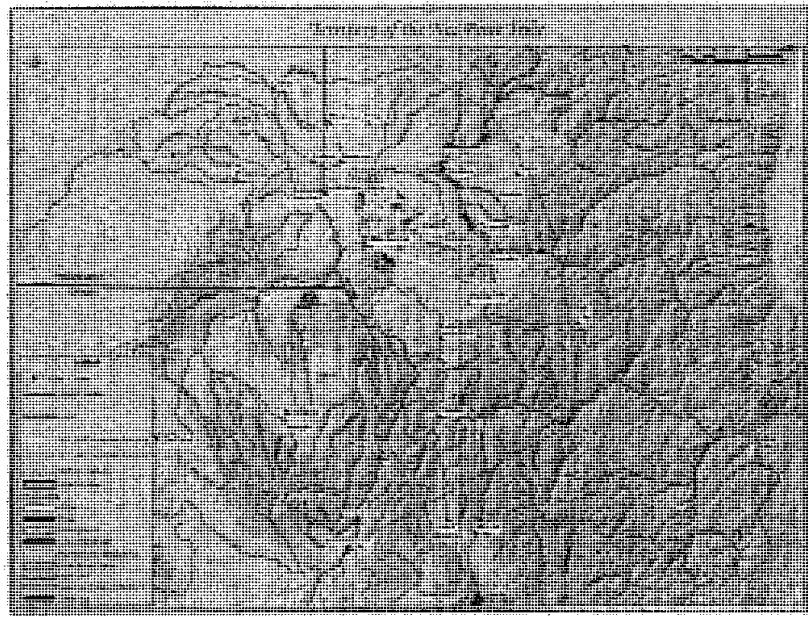
The Nez Perce Tribe Treaty of 1855 promulgated articles of agreement between the United States and the Tribe. The Treaty is superior to any conflicting state laws or state constitutional provisions under the Supremacy Clause of the U.S. Constitution (Art. VI, cl. 2).

Under the Treaty of 1855, the Tribe ceded certain areas of its aboriginal lands to the United States and reserved for its exclusive use and occupation certain lands, rights, and privileges; and the United States assumed fiduciary responsibilities to the Tribe.

Rights reserved under the Treaty of 1855 include those found in Article 3 of the Treaty, "*The exclusive right of taking fish in all the streams where running through or bordering said reservation is further secured to said Indians; as also the right of taking fish at all usual and accustomed places in common with citizens of the Territory; and of erecting temporary buildings for curing, together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land.*"

The reserved rights to the aforementioned areas are a fundamental concern to the Nez Perce Tribe. The fish, roots, wild game, religious sites, and ancestral burial and living sites remain integral to the Nez Perce culture. The Tribe expects, accordingly, to be the primary consulting

party in all federal actions related to Hanford that stand to affect or implicate the Tribe's treaty-reserved or cultural interests.



#### ***Treaty Reserved Resources***

Treaty reserved resources situated on and off the Reservation (hereinafter referred to as "Tribal Resources") include but are not limited to:

Tribal water resources located within the Columbia, Snake, and Clearwater River Basins including those water resources associated with the Tribe's usual and accustomed fishing areas and Tribal springs and fountains described in Article 8 of the Nez Perce Tribe Treaty of 1863;

Fishery resources situated within the Reservation, as well as those resources associated with the Tribe's usual and accustomed fishing areas in the Columbia, Snake, and Clearwater River Basins;

Areas used for the gathering of roots and berries, hunting, pasturing and other cultural activities within open and unclaimed lands including lands along the Columbia, Clearwater, and Snake River Basins;

Open and unclaimed lands which are or may be suitable for grazing;

Forest resources situated on the Reservation and within the ceded areas of the Tribe;

Land holdings held in trust or otherwise located on and off the Nez Perce Reservation in the States of Idaho, Oregon; and Washington;

Culturally sensitive areas, including, but not limited to, areas of archaeological, religious, and historic significance, located both on and off the Reservation.

## FEDERAL RECOGNITION OF TRIBAL SOVEREIGNTY

A unique political relationship exists between the United States and Indian Tribes, as defined by treaties, the United States Constitution, statutes, federal policies, executive orders, court decisions, , which recognize Tribes as separate sovereign governments.

As a fiduciary, the United States and all its agencies owe a trust duty to the Nez Perce Tribe and other federally-recognized tribes. See *United States v. Cherokee Nation of Oklahoma*, 480 U.S. 700, 707 (1987); *United States v. Mitchell*, 463 U.S. 206, 225 (1983); *Seminole Nation v. United States*, 316 U.S. 286, 296-97 (1942). This trust relationship has been described as “one of the primary cornerstones of Indian law,” Felix Cohen, *Handbook of Federal Indian Law* 221 (1982), and has been compared to one existing under the common law of trusts, with the United States as trustee, the tribes as beneficiaries, and the property and natural resources managed by the United States as the trust corpus. See, e.g. *Mitchell*, 463 U.S. at 225.

The United States’ trust obligation includes a substantive duty to consult with a tribe in decision-making to avoid adverse impacts on treaty resources and a duty to protect tribal treaty-reserved rights “and the resources on which those rights depend.” *Klamath Tribes v. U.S.*, 24 Ind. Law Rep. 3017, 3020 (D.Or. 1996). The duty ensures that the United States conduct meaningful consultation “in advance with the decision maker or with intermediaries with clear authority to present tribal views to the ... decision maker.” *Lower Brûlé Sioux Tribe v. Deer*, 911 F. Supp 395, 401 (D. S.D. 1995).

Consistent with the United States’ trust obligation to Tribes, Congress has enacted numerous laws to protect Tribal resources and cultural interests, including, but not limited to the National Historic Preservation Act (NHPA) of 1966; the Archaeological Resources Protection Act of 1979; the Native American Graves Protection and Repatriation Act (NAPRA) of 1990; and the American Indian Religious Freedom Act (AIRFA) of 1978.

### **Executive Orders**

**Executive Order 13307** (*May 24, 1994*) Updated Ap. 16, 2000. In Federal lands, each executive branch agency with statutory or administrative responsibility for the management of Federal lands shall, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, (1) accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and (2) avoid adversely affecting the physical integrity of such sacred sites. Where appropriate, agencies shall maintain the confidentiality of sacred sites.

This Executive Order directs Federal land-managing agencies to accommodate Native Americans' use of sacred sites for religious purposes and to avoid adversely affecting the physical integrity of sacred sites. {267} Some sacred sites may be considered traditional cultural properties and, if older than 50 years, may be eligible for the National Register of Historic Places. Thus, compliance with the Executive Order may overlap with Section 106 and Section 110 of NHPA. Under the Executive Order, Federal agencies managing lands must implement procedures to carry out the directive's intent. Procedures must provide for reasonable notice where an agency's action may restrict ceremonial use of a sacred site or adversely affect its physical integrity. {268} Federal agencies with land-managing responsibilities must provide the President with a report on implementation of Executive Order No. 13007 one year from its issuance.

Executive Order No. 13007 builds upon a 1994 Presidential Memorandum concerning government-to-government relations with Native American tribal governments. The Memorandum outlined principles Federal agencies must follow in interacting with federally recognized Native American tribes in deference to Native Americans' rights to self-governance. {269} Specifically, Federal agencies are directed to consult with tribal governments prior to taking actions that affect federally recognized tribes and to ensure that Native American concerns receive consideration during the development of Federal projects and programs. The 1994 Memorandum amplified provisions in the 1992 amendments to NHPA enhancing the rights of Native Americans with regard to historic properties.

### **Executive Order 11593**

Section 1. Policy. The Federal Government shall provide leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation. Agencies of the executive branch of the Government (hereinafter referred to as "Federal agencies") shall (1) administer the cultural properties under their control in a spirit of stewardship and trusteeship for future generations, (2) initiate measures necessary to direct their policies, plans and programs in such a way that federally owned sites, structures, and objects of historical, architectural or archaeological significance are preserved, restored and maintained for the inspiration and benefit of the people, and (3), in consultation with the Advisory Council on Historic Preservation (16 U.S.C. 4701), institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural or archaeological significance.

The Executive Order requires Federal agencies to administer cultural properties under their control and direct their policies, plans, and programs in such a way that federally owned sites, structures, and objects of historical, architectural, or archeological significance were preserved, restored, and maintained. {250} To achieve this goal, Federal agencies are required to locate, inventory, and nominate to the National Register of Historic Places all properties under their jurisdiction or control that appear to qualify for listing in the National Register. {251} The courts have held that Executive Order No. 11593 obligates agencies to conduct adequate surveys to locate "any" and "all" sites of historic value, {252} although this requirement applies only to federally owned or federally controlled properties. {253} Moreover, the Executive Order directs agencies to reconsider any plans to transfer, sell, demolish, or substantially alter any property determined to be eligible for the National Register and to afford the Council an opportunity to

comment on any such proposal. {254} Again, the requirement applies only to properties within Federal control or ownership. {255} Finally, the Executive Order requires agencies to record any listed property that may be substantially altered or demolished as a result of Federal action or assistance and to take necessary measures to provide for maintenance of and future planning for historic properties. {256}

#### **Executive Order 13175, November 6, 2000**

Executive Order 13175 establishes regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes. The executive Order applies to all federal programs, projects, regulations and policies that have Tribal Implications.

E.O. further provides that each “agency shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.” According to the President’ April 29, 1994 memorandum regarding Government-to-Government Relations with Native American Tribal Governments, federal agencies “shall assess the impacts of Federal Government plans, projects, programs, and activities on tribal trust resources and assure that Tribal government rights and concerns are considered during the development of such plans, projects, programs, and activities.” As a result, Federal agencies must proactively protect tribal interest, including those associated with tribal culture, religion, subsistence, and commerce. Meaningful consultation with the Nez Perce Tribe is a vital component of this process.

On November 5, 2009 President Obama issued a Presidential Memorandum for the Heads of Executive Departments and Agencies. That Memorandum affirms the United States’ government-to-government relationship with Tribes, and directs each agency to submit to the Office of Management and Budget (OMB), within 90 days and following consultation with tribal governments, “a detailed plan of actions the agency will take to implement the policies and directives of Executive Order 13175.”

#### **U.S. Department of Energy American Indian Policy**

On November 29, 1991, DOE announced a seven-point American Indian Policy, which formalizes the government-to-government relationship between DOE and federally recognized Indian Tribes. A key policy element pledges prior consultation with Tribes where their interests or reserved treaty rights might be affected by DOE activities. The DOE American Indian Policy provides another basis for the Cooperative Agreement. The Cooperative Agreement will also serve as an Office of Environmental Management Implementation Plan for the DOE American Indian Policy regarding interactions with the Nez Perce Tribe.

### **THE ROLES OF THE NEZ PERCE TRIBE AT HANFORD**

The Tribe has a duty to protect its reserved treaty rights and privileges, environment, culture, and welfare as well as to educate its members and neighboring public to its activities. The Tribe assumes many different roles. It is a governmental entity with powers and authorities derived from its inherent sovereignty, from its status as the owner of land, and from legislative delegations from the Federal government. The Tribe exercises its powers and authority to serve its members and to regulate activities occurring within the reservation. The Tribe is also a cultural entity and is accordingly charged with the responsibility of protecting and transmitting that culture which is uniquely Nez Perce. The Tribe is also a beneficiary within the context of federal trust relationship with, and obligations to Indian Tribes. The Tribe is a trustee responsible for the protection and betterment of its members and the protection of its and their rights and privileges. The Tribe is also party to treaties between itself and the United States government.

#### **Nez Perce and DOE Relationship**

The relationship between the Tribe and DOE is defined by the trust relationship that exists between the Federal government and the Tribe, by treaty, federal statute, executive orders, administrative rules, caselaw, DOE's American Indian Policy, and by the mutual and generally convergent interests of the parties in the efficient and expeditious cleanup of the DOE weapons complex, and by the Cooperative Agreement. The structured relationship embodied by the Cooperative Agreement can best be described as a partnership grounded in the site-specific cleanup of Hanford, and extends to all trust-related activities of the Department.

The Tribe sees itself not only as an advisor to DOE, but also as an technical resource available to assist DOE. The Tribe sees its members and employees as a source of technically trained and certified labor for environmental restoration and decontamination and decommissioning work. The continuation of the Cooperative Agreement contemplates an approach that will integrate these and other roles into a comprehensive Nez Perce-DOE program.

The Tribe is asked to review and comment on documents and activities by DOE implicates our Treaty reserved rights and DOE's acknowledgement of other federal statutes, laws, regulations, executive orders and memoranda governing the United States' relationship with Native Americans and the Nez Perce people. Several tribal departments lend their respective technical expertise to DOE Hanford issues and present recommendations to the Nez Perce Tribal Executive Committee (NPTEC), for consideration and guidance. The NPTEC also may request formal consultation with the federal agency to discuss a proposal or issue further.

#### **Consultation with Native Americans**

DOE's consultation responsibilities to the Tribe are enumerated generally in the document entitled, Consultation with Native Americans. This policy defines consultation in relevant part:

"Consultation includes, but is not limited to: prior to taking any action with potential impacts upon American Indian and Alaska Native nations, providing for mutually agreed protocols for timely communication, coordination, cooperation, and collaboration to determine the impact on traditional and cultural lifeways, natural resources, treaty and other federally reserved rights involving appropriate tribal officials and representatives through the decision making process."

In regard to security clearance, none of the various provisions of the continuation of the Cooperative Agreement shall be construed as providing for the release of reports or other classified information designated as "classified" or "Unclassified Controlled Nuclear Information" to the Nez Perce Tribe, or as waiving any other security requirements. Classified information includes National Security Information (10 CFR Part 1045) and Restricted Data (10 CFR Part 1016). Unclassified Controlled Nuclear Information is described in 10 CFR Ch. X, Part 1017.

In the event that reports or information requested under the provisions of the continuation of the Cooperative Agreement, while not "classified" or "Unclassified Controlled Nuclear Information," are determined by DOE-RL to be subject to the provisions of the Privacy Act, or the exemptions provided under the Freedom of Information Act, DOE-RL may, to the extent authorized by law, provide such reports or information to the Tribes upon receipt of the Tribe's written assurance that the Nez Perce Tribe will maintain the confidentiality of such data.

### **W.1.3      Exposure Scenario for CTUIR Traditional Subsistence Lifeways**

This section contains an update of the exposure scenario developed by the CTUIR bearing on DOE plans for cleanup of the Hanford Site and emphasizing the exposure factors unique to the CTUIR's traditional subsistence lifestyle.



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

Confederated Tribes of the Umatilla Indian Reservation

Department of Science & Engineering

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September 15, 2004

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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 ( <u>marsh and water plants</u> ), 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>Hunting</b>	<b>Sweatlodge</b>	<b>Gathering</b>	<b>Fishing</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>
<i>Indirect pathways - food, medicine, tea, other biota ingestion (diet)</i>	n deer /yr diet; Total large-small game, fowl. Organs eaten	n 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
<i>Soil, sediment, dust, and mud ingestion</i>	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.
<i>Inhalation rates</i>	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.
<i>Groundwater and Surface water pathways</i>	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.
<i>Dermal exposure</i>	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

caring 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. Radon and its daughters accumulate in the sweat lodge while not in use, as well as during the ceremony. Inhalation and heart rates may be higher depending on activities that occur during the sweat lodge ceremony (e.g. singing). More detail is provided in Appendix 4.

**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

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

there is data about chemical usage or contamination, and it is also assumed that his or her 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; see the soil ingestion appendix for more discussion of the often-dusty Columbia Basin.

**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 4 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 2 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, a median 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 a median rather than a reasonable maximum. See Appendix 1 for more detail.

#### 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). See Appendix 2 for more detail.

Table 3. Exposure factors for direct pathways

<i>Direct Pathway</i>	<i>Exposure Factors (Adults)</i>		
	<i>Default Suburban</i>	<i>Rural Residential Gardener</i>	<i>Subsistence Forager</i>
<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/c.	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.
<i>Other parameters</i>			
<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. See Appendix 4 for more detail.

### 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.

### 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. Primary CTUIR Exposure Factors

<i>Updated Exposure Factor</i>	<i>Rate</i>
<b>Inhalation Rate</b>	30 m <sup>3</sup> /d (adult)
<b>Soil Ingestion Rate</b> - soil (depths to be negotiated) - deeper soil drilled and used in garden	400 mg/d (all ages)
<b>Water Ingestion Rate</b> - 100% groundwater - 100% seeps - 100% river water (filtered & unfiltered) - combination	4L/d (3L drinking + 1L / sweat lodge)
<b>Fish Consumption Rate</b>	620 g/d*
<b>Exposure Frequency</b>	365 d/yr
<b>Exposure Duration</b>	70 yr
<b>Sweat lodge steam calculations</b>	Daily use; Appendix 4
<b>Fraction obtained on-site/ time on-site</b>	1
<b>Game or livestock</b>	Ratio to be determined for each assessment area
<b>Native plants or garden produce</b>	Ratio to be determined for each assessment area

\* Boldt, 1974 (District Judge George Boldt, U.S. v. Washington, February 12, 1974, note 151).

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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>>.

### 2.3.3 CTUIR 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 risk-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	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 <u>250 gpd</u> equivalents.
Roots (unspecified, 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 easier commercial processing.

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

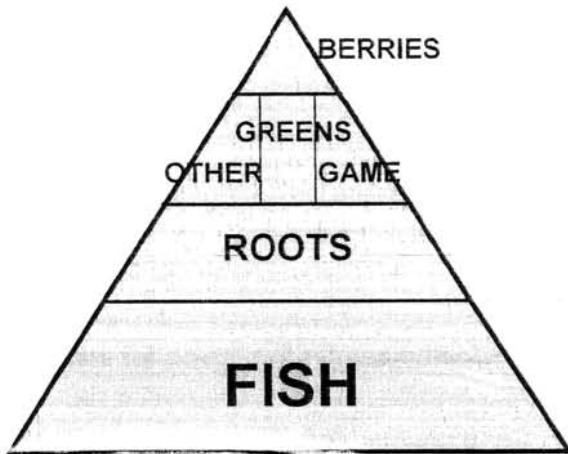


Figure 2. CTUIR Food Pyramid

### 3. REFERENCES

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**APPENDIX 1. Supplemental information for INHALATION RATE**

**APPENDIX 2. Supplemental information for SOIL INGESTION RATE**

**APPENDIX 3. Supplemental information for FISH CONSUMPTION RATE**

**APPENDIX 4. Sweatlodge parameters**

## **APPENDIX 1. Inhalation Rate**

## APPENDIX 1.

### Supplemental information for INHALATION RATE

**CTUIR Inhalation Rate = 30 m<sup>3</sup>/d (adult)**

#### SUMMARY

The inhalation rate in the CTUIR scenario reflects the active, outdoor lifestyle of traditional tribal members, including youth who are learning traditional subsistence skills, adult outdoor workers who also hunt, gather, and fish, and elders who gather plants and medicines, and prepare and use them (e.g., making medicines or baskets, etc.) and who teach a variety of indoor and outdoor traditional activities. Traditional tribal communities have no sedentary members except the frail elderly, whereas one-quarter of modern American adults of all ages report no leisure time physical activity at all.<sup>14</sup> We have documented the activity levels associated with this lifestyle and diet with published anthropological studies, ethnographic literature on foraging theory, hunting-gathering lifestyles, and interviews with Tribal members. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is a median rate of 26.2 m<sup>3</sup>/d, based on 8 hours sleeping at 0.4 m<sup>3</sup>/hr, 2 hours sedentary at 0.5 m<sup>3</sup>/hr, 6 hours light activity at 1 m<sup>3</sup>/hr, 6 hours moderate activity at 1.6 m<sup>3</sup>/hr, and 2 hours heavy activity at 3.2 m<sup>3</sup>/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is a median rate. This is inconsistent with the usual RME approach used in Superfund risk assessments, and could result in under-protection of children, the elderly, athletes, asthmatics, and the half of the population with above-average inhalation rates. Due to a tribal desire to protect more than just the average traditional person, we have chosen to round up from 26.2 m<sup>3</sup>/d to 30 m<sup>3</sup>/day.

#### 1.0 Population-specific physiology

Perhaps the most relevant factors associated with ethnic specificity of metabolic and inhalation rates are the thrifty genotype(s), insulin use, and oxidation and adiposity patterns (Goran, 2000; Fox et al., 1998; Muzzin et al., 1999; Rush et al., 1997; Saad et al., 1991; Kue Young et al., 2002), as well as ethnic differences in spirometry (Crapo et al., 1988; Lanese et al., 1978; Mapel et al., 1997; Aidaraliyev et al., 1993; Berman et al., 1994). Research on the thrifty genotype suggests that there may be several stress response genes that enable indigenous populations to respond to environmental stresses and to the rapid transition between extremes, including feast and famine, heat and cold, disruption in circadian rhythms, dehydration, seasonality, and explosive energy output or rapid transitions between minimum and maximum exercise and VO<sub>2max</sub> (Kimm et al., 2002; Snitker et al., 1998). These genes "uncouple" several energy expenditure parameters (Kimm et al., 2002), and generally support the logic of using a higher inhalation rate for active, outdoor lifestyles, especially in Native American populations.

<sup>14</sup> (<http://www.cdc.gov/brfss/pdf/2001prvrpt.pdf> and <http://www.cdc.gov/brfss/pubrfdat.htm>).

## 2.0 Short-term versus long-term inhalation rates.

Most federal and state agencies either use the EPA default value of 20m<sup>3</sup>/d or use activity levels to estimate long-term inhalation rates. The derivation of this rate is somewhat obscure. We anticipate that further research by EPA would reveal differences in inhalation rates for different strata of the general US population: white collar versus blue collar occupations, those who exercise (recreate, sing, dance, etc.) versus those who don't, and children while they are playing. For example, the National Radiation Protection Board (UK) uses 23m<sup>3</sup>/d as a daily average for people engaged in light activity work and 27m<sup>3</sup>/d for people engaged in occupations with some 1 hour of heavy activity<sup>15</sup>. As more information is obtained, this will be incorporated.

When we developed the exposure scenario, we evaluated activity levels through anthropological data and confirmatory interviews, and used the NHAPS and CHAD-based EPA recommendations for ventilation rate for the different activity levels. Several examples of similar approaches are:

- EPA's National Air Toxics Assessment (homepage: <http://www.epa.gov/ttn/atw/nata/natsa3.html>) uses the CHAD<sup>16</sup> databases in its HAPEM4 model to estimate national average air toxics exposures even though "the lack of activity pattern data that extend over longer periods of times presents a challenge for HAPEM4 to predict the long-term (yearly) activity patterns that are required to determine chronic exposures." Therefore, "an approach of selection of a series of single day's patterns (from CHAD) to represent an individual's activity pattern for a year was developed."
- The California Air Resources Board (CARB, 2000) reviewed daily breathing rates based on activity levels and measured ventilation rates for many activities in the CHAD database. The average hourly rate for sleeping was 0.5 m<sup>3</sup>/hr, light activities at 0.55 m<sup>3</sup>/hr, moderate activities at 1.4 m<sup>3</sup>/hr, and heavy rates of activity levels at 3.4 m<sup>3</sup>/hr. The CARB concluded that 20 m<sup>3</sup>/d represents an 85<sup>th</sup> percentile of typical adult sedentary/light activity lifestyles. This is based on 8 hours sleeping and 16 hours of light activity with no moderate or heavy activity, or 1 hour day of moderate and heavy activity each, according to various citations.
- In their technical guidance document, "Long-term Chemical Exposure Guidelines for Deployed Military Personnel," the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) recommended an inhalation rate of 29.2 m<sup>3</sup>/d for US service members. Deployed personnel were assumed to spend 6 hours sleeping at an inhalation rate of 0.4 m<sup>3</sup>/hr, 4 hours in sedentary activities (at 0.5 m<sup>3</sup>/hr), 6 hours in light duties (at 1.2 m<sup>3</sup>/hr), and 8 hours in moderate duties (at 2.2 m<sup>3</sup>/hr).<sup>17</sup>

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<sup>15</sup> [http://www.nrbp.org/publications/w\\_series\\_reports/2003/nrbp\\_w41.pdf](http://www.nrbp.org/publications/w_series_reports/2003/nrbp_w41.pdf)

<sup>16</sup> Consolidated Human Activity Database, <http://www.epa.gov/chadnet1/>

<sup>17</sup> [http://www.gulfink.osd.mil/particulate\\_final/particulate\\_final\\_s06.htm](http://www.gulfink.osd.mil/particulate_final/particulate_final_s06.htm) and <http://www.gulfink.osd.mil/gulfink.htm>

- EPA used 30 m<sup>3</sup>/day for a year-long exposure estimate for the general public at Hanford, based on a person doing 4 hours of heavy work, 8 hours of light activity, and 12 hours resting.<sup>18</sup>
- The DOE's Lawrence Berkeley Laboratory also used 30 m<sup>3</sup>/d: "the working breathing rate is for 8 hours of work and, when combined with 8 hours of breathing at the active rate and 8 hours at the resting rate, gives a daily equivalent intake of 30 m<sup>3</sup> for an adult."<sup>19</sup>

### **3.0 The use of population-specific information rather than national averages.**

EPA instructs risk assessors to identify the receptor population and their activities or land use.<sup>20</sup> "Assessors are encouraged to use values which most accurately reflect the exposed population."<sup>21</sup> The OSWER Land Use Directive<sup>22</sup> requires the identification of land uses for the baseline risk assessment; when the affected resources are on reservations or areas where tribes retain usory rights, a subsistence/residential land use must be assumed if the Tribe so indicates. Executive Order 12898<sup>23</sup> requires the identification of subsistence consumption of natural resources, and for Indian Tribes this includes the activities required to obtain those resources.

EPA recognizes that inhalation rates may be higher in certain populations, such as athletes or outdoor workers, because levels of activity outdoors may be higher over long time periods. "If site-specific data are available to show that subsistence farmers and fishers have higher respiration rates due to rigorous physical activities than other receptors, that data may be appropriate."<sup>24</sup> Such subpopulation groups are considered 'high risk' subgroups.<sup>25</sup> EPA (1997) recommends calculating their inhalation rates using the following median hourly intakes for various activity levels (in m<sup>3</sup>/hr): resting = 0.4, sedentary = 0.5, light activity = 1, moderate activity = 1.6, heavy activity = 3.2. EPA's median rate for outdoor workers is 1.3 m<sup>3</sup>/hr, with an upper percentile of 3.3 m<sup>3</sup>/hr, depending on the ratio of light, moderate and heavy activities during the observation time. Other EPA risk assessments typically use 4.8 m<sup>3</sup>/hr for construction workers, 2.5 m<sup>3</sup>/hr for groundskeepers, and similar values applied to an 8 hour work day and extended for an entire worklife.

<sup>18</sup> "Report of Radiochemical Analyses for Air Filters from Hanford Area" Memorandum from Edwin L. Sensintaffar, Director of the National Air and Radiation Environmental Laboratory to Jerrold Leitch, Region 10 Radiation Profram Manager (<http://yosemite.epa.gov/R10/AIRPAGE.NSF/webpage/Hanford+Environmental+Perspective>)

<sup>19</sup> ([www.lbl.gov/ehs/epg/tritium/TritAppB.html](http://www.lbl.gov/ehs/epg/tritium/TritAppB.html))

<sup>20</sup> <http://www.epa.gov/superfund/programs/risk/ragsd/table4instructions.pdf>.

<sup>21</sup> Exposure Factor Handbook, Volume 1, page 5-23

<sup>22</sup> OSWER Directive 9355.7-04, "Land Use in the CERCLA Remedy Selection Process" (May 25, 1995)

<sup>23</sup> White House, 1994. Federal Actions To Address Environmental Justice In Minority Populations And Lowincome Populations: Feb. 11, 1994; 59 FR 7629, Feb. 16, 1994.

<sup>24</sup> EPA (OSWER) "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Support Materials Volume 1: Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities" page 6-4, at ([http://www.epa.gov/earth1r6/6pd/rcra\\_c/protocol/volume\\_1/chpt6-hh.pdf](http://www.epa.gov/earth1r6/6pd/rcra_c/protocol/volume_1/chpt6-hh.pdf))

<sup>25</sup> Exposure Factors Handbook, 1997, Volume 1. page 5-24

Since we have population-specific data, we believe that EPA is required to use it in order to meet its statutory mandate to protect human health – and particularly if there is a group of people who are identifiably discrete. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is a median rate of  $26.2 \text{ m}^3/\text{d}$ , based on 8 hours sleeping at  $0.4 \text{ m}^3/\text{hr}$ , 2 hours sedentary at  $0.5 \text{ m}^3/\text{hr}$ , 6 hours light activity at  $1 \text{ m}^3/\text{hr}$ , 6 hours moderate activity at  $1.6 \text{ m}^3/\text{hr}$ , and 2 hours heavy activity at  $3.2 \text{ m}^3/\text{hr}$ . Unlike most other exposure factors, which are upper bounds, the inhalation rate is a median rate. EPA says "an upper percentile is not recommended"<sup>26</sup> with no reason given. This is inconsistent with the usual RME approach used in Superfund risk assessments, and could result in under-protection of children, the elderly, athletes, asthmatics, and the half of the population with above-average inhalation rates. Due to a tribal desire to protect more than just the average traditional person, we have chosen to round up from  $26.2 \text{ m}^3/\text{d}$  to  $30 \text{ m}^3/\text{day}$ .

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## **APPENDIX 2**

### **Soil Ingestion**

## APPENDIX 2

### Supplemental information for SOIL INGESTION RATE

**CTUIR Soil Ingestion Rate = 400 mg/d (all ages)**

#### SUMMARY

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. The CTUIR soil ingestion rate is based on a review of EPA guidance, soil ingestion studies in suburban and indigenous settings, pica and geophagia, and dermal adherence studies. It is also based on Plateau subsistence lifestyles with their higher environmental contact rates, local climatic and geologic conditions, and the frequency of dust storms in the Columbia Plateau<sup>27</sup>.

The soil ingestion rate of 400 mg/d for all ages is the published upper bound for suburban children (EPA), and is within the range of outdoor activity rates for adults. Subsistence lifestyles were not considered by the EPA guidance, but are generally considered to be similar in soil contact rates to construction, utility worker or military soil contact levels. However, 400 mg/d is lower than the typical 480 mg/d applied to outdoor work to allow for some low-contact days. It considers many 1-gram days and events such as root gathering days, tule and wapato gathering days, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work). While we could justify 500 mg/d with equal confidence, we have chosen the lower rate (400 mg/d) as within the appropriate range.

#### 1.0 EPA Guidance

EPA has reviewed the studies relevant to suburban populations and has published summaries in its Exposure Factors Handbook (1989, 1991, and 1997). In the current iteration of the Exposure Factors Handbook<sup>28</sup>, EPA reviewed the available scientific literature for children and identified seven key studies that were used to prepare recommended guidelines for evaluating the amount of soil exposure. The mean daily values in these studies ranged from 39 mg/day to 271 mg/day with an average of 146 mg/day for soil ingestion and 191 mg/day for soil and dust ingestion. Based on these studies, EPA

<sup>27</sup> WA Department of Ecology (2003) Columbia Plateau Windblown Dust Natural Events Action Plan. Publication 03-02-014. Website: <http://www.ecy.wa.gov/pubs/0302014.pdf>. Note that soil resuspension at Hanford is (or was) assumed to be 50 ug/m<sup>3</sup> (HSRAM Rev 3; DOE/RL-91045, 1995), while Haywood and Smith (1990) measured 1 to 1.5 mg/m<sup>3</sup> in the aboriginal camp and field microenvironments in the arid Maralinga region. We believe that this is a significant data gap at Hanford, given the number of windy dusty days, and also considering the activities that generate localized (as opposed to regional meteorological) dust.

<sup>28</sup> Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.

originally recommended a value of 200 mg/day. EPA now recommends 100 mg/d as a mean value for children in suburban settings, 200 mg/day as a conservative estimate of the mean, and a value of 400 mg/day as an "upper bound" value (exact percentile not specified). Most state and federal guidance uses 200 mg/d for children.

For adults, the USEPA now suggests a mean soil ingestion rate in suburban settings of 50 mg/day for adults (USEPA, 1997), which has been decreased from 100 mg/d as recommended in earlier guidance. However, EPA says that this rate is still highly uncertain and has a low confidence rating due to lack of data. An adult soil ingestion rate of 100 mg/day is most commonly used for residential or agricultural settings.

Other EPA guidance such as the Soil Screening Level Guidance<sup>29</sup> recommends using 200 mg/d for children and 100 mg/d for adults, based on RAGS HHEM, Part B (EPA, 1991) or an age-adjusted rate of 114 mg/d assuming 30 years of exposure averaged over 70 years of life.

A value for an ingestion rate for outdoor activities is no longer given in the 1997 Exposure Factors Handbook for adults as "too speculative." However, the soil screening guidance still recommends 330 mg/d for a construction or other outdoor worker, and risk assessments for construction workers typically use a rate of 480 mg/d.

Other recommended values are also used by risk assessors. For example, some states recommend the use of 1 gram per acute soil ingestion event<sup>30</sup> to approximate a non-average day for children, such as an outdoor day.

## 2.0 Military Guidance

The US military assumes 480 mg per exposure event<sup>31</sup> or per field day. For military risk assessment, the US Army uses the Technical Guide 230 as the tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures.<sup>32</sup> No database is available to estimate incidental soil ingestion for adults in general or for military populations either during training at continental U.S. facilities or during deployment. Department Of Defense (2002)<sup>33</sup> recommendations for certain activities such as construction or landscaping which involve a greater soil contact rate is a soil ingestion

<sup>29</sup> EPA (1996) Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, July 1996 (<http://www.epa.gov/superfund/resources/soil/toc.htm#p2>), and EPA (2002) Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites. OSWER 9355.4-24 ([http://www.epa.gov/superfund/resources/soil/ssg\\_main.pdf](http://www.epa.gov/superfund/resources/soil/ssg_main.pdf)),

<sup>30</sup> MADEP (1992). Background Documentation For The Development Of An "Available Cyanide" Benchmark Concentration. [http://www.mass.gov/dep/ors/files/cn\\_soil.htm](http://www.mass.gov/dep/ors/files/cn_soil.htm)

<sup>31</sup> [http://www.gulfink.osd.mil/pesto/pest\\_s22.htm](http://www.gulfink.osd.mil/pesto/pest_s22.htm), citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

<sup>32</sup> USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine. Website: <http://www.grid.unep.ch/btf/missions/september/dufinal.pdf>

<sup>33</sup> Reference Document (RD) 230, "Exposure Guidelines for Deployed Military" A Companion Document to USACHPPM Technical Guide (TG) 230, "Chemical Exposure Guidelines for Deployed Military Personnel", January 2002. Website: <http://chppm-www.apgea.army.mil/desp/>; and <http://books.nap.edu/books/0309092213/html/83.html#pagetop>.

rate of 480 mg/day. This value is based on the assumption that the ingested soil comes from a 50 µm layer of soil adhered to the insides of the thumb and the fingers of one hand. DOD assumed that the deployed military personnel would be exposed at both the high ingestion rate and a mean ingestion rate throughout the year. The two ingestion rates were averaged (half the days were spent at 480 and half at 50 mg/d) for a chronic average rate of 265 mg/d. There is no discussion of different climates in this manual.

The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day<sup>34</sup>.

Anecdotally, US forces deployed in Iraq report frequent grittiness in the mouth and food. Haywood and Smith (1990) also considered sensory reports of grittiness in their estimate of 10 g/d in aboriginal Australians. Therefore, we believe that the DOD assumption is probably too low for arid dusty or desert climates, particularly since it is not possible in deployed field situations to leave that environment in order to justify low-ingestion (50 mg/d) employment half of the time.

### **3.0 Studies in suburban or urban populations**

Written knowledge that humans often ingest soil dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure to soil parasite eggs and other infections. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants, and risk assessments initially used a high inadvertent, based on studies of pica children (e.g., Kimbrough, 1984). This triggered a great deal of research with industry funding (e.g., the Calabrese series) or federal funding (e.g., the DOE-funded studies of fallout and bomb test contamination).

Some of the key studies are summarized here. Other agencies (including the EPA<sup>35</sup> and California OEHHA) have reviewed more studies and provide more detail. To quote form OEHHA:

"There is a general consensus that hand-to-mouth activity results in incidental soil ingestion, and that children ingest more soil than adults. Soil ingestion rates vary depending on the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, the surface on which that activity occurs, and personal hygiene practices. Some children exhibit pica behavior which can result in intentional ingestion of relatively large amounts of soil."<sup>36</sup>

In general, two approaches to estimating soil ingestion rates have been taken. The first method involves measuring the presence of (mostly) non-metabolized tracer elements in the feces of an individual and soil with which an individual is in contact, generally in controlled (largely indoor) situations. The other method involves measuring the dirt adhered to an individual's hand and observing hand-to-mouth activity. Results of these studies are

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<sup>34</sup> UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict.  
[www.grid.unep.ch/btf/missions/september/dufinal.pdf](http://www.grid.unep.ch/btf/missions/september/dufinal.pdf)

<sup>35</sup> <http://www.epa.gov/ncea/pdfs/efh/sect4.pdf> and the Children's Exposure Factor Handbook.

<sup>36</sup> California Office of Environmental Health Hazard Assessment, Technical Support Document for Exposure Assessment and Stochastic Analysis, Section 4: Soil Ingestion.  
[http://www.oehha.ca.gov/air/hot\\_spots/pdf/chap4.pdf](http://www.oehha.ca.gov/air/hot_spots/pdf/chap4.pdf)

associated with large uncertainty due to their somewhat qualitative nature, but some studies include specific activities relevant to outdoor lifestyles.

### 3.1 Studies in Children

Early studies in children focused on pica (see below) and unique food-related events. In particular, one study of soil ingestion from "sticky sweets" was estimated at 10 mg to 1 g/d (Day et al., 1975).

Hawley (1985) estimated that the amount ingested by young children during outdoor activity between May and October is 250 mg/d. For outdoor activities from May through October, Hawley estimated the ingestion amount as 480 mg per active day, assuming that 8 hours is spent outdoors per day, 2 d/week.

Other early tracer studies in American children (Binder, et al., 1986) resulted in large ranges of estimates of soil ingestion for several reasons. In the Binder study (as in all subsequent studies), the particular tracer element makes a large difference in soil ingestion estimates. Clausing et al. (1987) followed basically the same approach for Dutch rather than American children. Neither study included the trace minerals from food or medicine. A third study (Van Wijnen et al., 1990) used the same approach, and was the first to include a consideration of camping and the presence or absence of gardens.

Thompson and Burmaster (1991) reanalyzed the original data on children from Binder et al. (1986) to characterize the distribution of soil ingestion by children. In studies with large numbers of children, pica children may be present, but most studies did not try to diagnose pica. On the other hand, not all children with high ingestion rates are pica children, so caution must be exercised when identifying pica children merely on the basis of high soil ingestion. The reanalysis indicates a mean soil ingestion rate of 91 mg/d, and a 90<sup>th</sup> percentile of 143 mg/d.

Davis et al. (1990), in Calabrese's laboratory, included an evaluation of food, medicine, and house dust as a better approximation of a total mass balance. As with the earlier studies, using titanium as the tracer results in estimates of large soil ingestion rates, while Al and Si tracers resulted in a narrower range of soil ingestion rates. Ti, however, is problematic because of its variability in food, Al is difficult to control since it is the third most abundant soil mineral and present in many household products, and Si is widespread and an essential trace element for plants and animals (although apparently not for humans). This illustrates the difficulty of using mineral tracers to calculate mass balance and soil ingestion, but trace studies provide the most quantitative estimates.

Calabrese et al. (1989) based estimates of soil ingestion rate in children in a home and university daycare setting on measurements of eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The study population consisted of 64 children between one and four years old in the Amherst, Massachusetts. They used a method similar to Binder et al. (1986) but included an improved mass balance approach. They evaluated soil ingestion over eight days rather than three days, and collected duplicate samples of food, medicine, and house dust. In addition, the children used tracer-free toothpaste and ointment. The adult ( $n = 6$ ) validation portion of the study indicated that study methodology could adequately detect soil ingestion at rates expected by children. Recovery data from the adult study indicated that Al, Si, Y, and Zr had the best

recoveries (closest to 100%). Zirconium as a tracer was highly variable and Ti was not reliable in the adult studies. The investigators conclude that Al, Si, and Y are the most reliable tracers for soil ingestion. This was also the first study to evaluate whether pica children were present in the sampled population; one diagnosed pica child was found.

Stanek and Calabrese (1995a) adjusted their 1989 data for the 64 children. The primary adjustment was related to intestinal transit time, which allowed an adjustment for clearance of minerals on days when fecal samples were not collected. They concluded that daily intake based on the "overall" multi-tracer estimates is 45 mg/day or less for 50 percent of the children and 208 mg/day or less for 95 percent of the children. When extended to an annual estimate, the range of average daily soil ingestion in the 64 children was 1 – 2268 mg/d; the median (lognormal) was 75 mg/d, the 90<sup>th</sup> % was 1190 mg/d, and the 95<sup>th</sup>% was 1751 mg/d. The known pica child was not included, and individual "outlier" results for individual tracers were also omitted. Even so, the range of rates is so large that it is evident that there are still methodological difficulties.

Stanek and Calabrese (1995a) also evaluated the number of days a child might have excessive soil ingestion events. An estimated 16% of children are predicted to ingest more than 1 gram of soil per day on 35-40 days of the year. In addition, 1.6% would be expected to ingest more than 10 grams per day for 35-40 days per year.

Stanek and Calabrese (1995b) published a separate reanalysis combining the data from their 1989 study with data from Davis et al. (1990) and using a different methodology. This methodology, the Best Tracer Method (BTM), is designed to overcome intertracer inconsistencies in the estimation of soil ingestion rates. The two data sets were combined, with estimates as follows: 50<sup>th</sup> = 37 mg/d, 90<sup>th</sup> = 156mg/d, 95<sup>th</sup> = 217mg/d, 99<sup>th</sup> = 535mg/d, mean = 104mg/d  $\pm$ 758. Even with this method, they conclude that the large standard deviation indicates that there are still large problems with "input-output misalignment." They also says that soil ingestion cannot even be detected, in comparison to food, unless more than 200 mg/d is ingested, rather than lower rates as they indicated in 1989.

Stanek et al. (2000) conducted a second study of 64 children aged 1-4 at a Superfund site in Montana, using the same methods as they did in their earlier study, with 3 additional tracers. Soil, food and fecal samples were collected for a total mass balance estimate. The home or daycare settings were not described, nor were the community conditions or the typical daily activities of the children, and 32% of the soil ingestion estimates were excluded as outliers. In addition, only soil with a grain size of 250 um or less was used; no explanation of concentration differences between large and small grain sizes were given (see discussion on dermal adherence) and no concentration data were included.

### **3.2 Studies in Adults**

Only a few soil ingestion studies in adults have been done because the attention has been focused on children, who are known to ingest more soil and are more vulnerable to toxicity of contaminants. Stanek, Calabrese and co-authors (1997) conducted a second adult pilot study ( $n = 10$ ) to compare tracers. This study was done as a method validation, and was "not designed to estimate the amount of soil normally ingested by adults." Each adult was followed for 4 weeks. The median, 75th percentile, and 95th percentile soil ingestion estimates were 1, 49, and 331 mg/day, with estimates calculated as the median of the three trace elements Al, Si, and Y.

#### 4.0 Studies in Indigenous Populations

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests such as the Marshall Islands (tropical island) and Maralinga (Australian desert) evaluations.

Haywood and Smith (1990, 1992) evaluated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia, where nuclear weapons tests in the 1950s and 1960s resulted in widespread residual radioactive contamination. Annual doses to individuals following an aboriginal lifestyle could result in an annual effective dose equivalents of several mSv within contours enclosing areas of several hundred square kilometers. The most significant dose pathways are inhalation of resuspended dust and ingestion of soil by infants. Haywood and Smith constructed a table showing hours per week sleeping, sitting, hunting or driving, cooking or butchering, and other activities. The authors state that in this climate

"virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. A total soil intake in the region of 1 gpd was estimated based on fecal samples of nonaboriginals during field trips. This must be regarded as a low estimate of soil ingestion by aborigines under camp conditions. In the absence of better information, a soil intake of 10 gpd has been assumed in the assessment for all age groups."

They noted a "very high occurrence of cuts and scratches with a high percentage being classified as dirty...puncture wounds on the feet were frequent."

Haywood and Smith (1990) also evaluated dust loading in the air in the Maralinga and Emu areas of aboriginal Australia. This is an arid, dusty region with unpaved roads. They considered both meteorological data and microenvironments associated with particular activities. Passive activities generated  $0.5 \text{ mg/m}^3$  locally, semi-active activities generated  $1 \text{ mg/m}^3$ , and active work or play generated  $5 \text{ mg/m}^3$ . Weighted average dust loading in the air for adults, children and infants were 1, 1.5, and  $1.5 \text{ mg/m}^3$ , according to the types of activities undertaken by the different age groups.

The Marshall Island indigenous peoples have also been studied. In a study of the gastrointestinal absorption of plutonium, Sun and Meinhold (1997) assumed a soil ingestion rate of  $500 \text{ mg/d}$ . This was based on the primary work of Haywood and Smith who "reported an average soil intake of  $10,000 \text{ mg/d}$  in dose assessments for the Emu and Maralinga nuclear weapons testing sites in Australia." The authors state that:

"Haywood and Smith specifically discussed the effects of lifestyle on plutonium ingestion for the Australian aboriginal people: an average soil intake of  $1,000 \text{ mg/d}$  was established from the fecal samples of the investigators who made field trips to the affected areas."

"It is difficult to quantitatively compare the amount of soil ingested by the Marshall Islanders and the Aboriginal people because of their different lifestyles. However, both societies live in close contact with their natural environment, although the Australian aboriginal people are nomadic, while the Marshallese have a lifestyle nearly like to that of industrial nations. LaGoy (1987) reported a maximum intake of  $500 \text{ mg/d}$  for adults in developed nations who do not exhibit habitual pica. This value, then, was taken to be a reasonably conservative average

for the Marshallese people. Therefore, this work adopts 500 mg/d as the average life-time intake of soil by the Marshallese.”

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Certain lifestyles, occupations, and living conditions will likely put different individuals or different groups at risk to inadvertent soil ingestion. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Most of the studies that Simon reviewed were related to geophagia (intentional soil ingestion; see below), which is relatively common worldwide. Simon recommends using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommends using 3 g/d for all indigenous children. Geophagia is assumed not to occur; if geophagia is common, Simon recommends using 5 g/d. These are all geometric means (lognormal) or modes (triangular distribution), not maxima.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same coprolites as mussels and roots. She concludes that “the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption. Charcoal was present in every coprolite examined.”

## 5.0 Geophagia

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams, 1997; Callahan, 2003; Johns and Duquette, 1991; Reid, 1992). It also routinely occurs in primates (Krishnamani and Mahaney (2000). Indigenous peoples and third world countries have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads) and as condiments or spices (in the Philippines, New Guinea, Costa Rica, Guatemala, the Amazon and Orinoco basins of South America). Clays are also often used in medications (e.g., kaolin clay in Kaopectate). But the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day, is pregnancy. In some cultures, well-established trade routes and clay traders make rural clays available for geophagy even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan, 2003; Johns and Duquette, 1991).

There are two types of edible clays, sodium and calcium montmorillonite<sup>37</sup>. Sodium montmorillonite is commonly known as bentonite; the name is derived from the location of the first commercial deposit mined at Fort Benton, Wyoming USA. Bentonite principally consists of sodium montmorillonite in combination with 10 to 20% of various mineral impurities such as feldspars, calcite, silica, gypsum, and others. Calcium montmorillonite,

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<sup>37</sup> [http://www.the-vu.com/edible\\_clay.htm](http://www.the-vu.com/edible_clay.htm)

the second type of montmorillonite, is also known as "living clay" for it principally consists of nutritionally essential minerals.

Geophagia has long been viewed as pathological by the western medical profession. However, this practice is so widespread and physiologically significant that is presumed to be important in the evolution of human dietary behavior due to its antidiarrheal, detoxification, and mineral supplementation potentials (Reid, 1992; Krishnamani and Mahaney, 2000).

Krishnamani and Mahaney (2000) propose several hypotheses that may contribute to the prevalence of geophagy:

- (1) soils adsorb toxins.
- (2) soil ingestion has an antacid action.
- (3) soils act as an antidiarrheal agent.
- (4) soils counteract the effects of endoparasites.
- (5) geophagy may satiate olfactory senses.
- (6) soils supplement nutrient-poor diets. Some clays release calcium, copper, iron, magnesium, manganese, or zinc in amounts of nutritional significance (Johns and Duquette, 1991). This is especially important in pregnancy and at high altitudes.

Several studies of geophagia in pregnancy have been done. In countries such as Uganda where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may be very important as a mineral supplement, particularly iron and calcium during pregnancy (Abrahams, 1997). One widely held theory suggests that iron deficiency is a major cause of geophagia<sup>38</sup>. Several reports have described an extreme form of geophagy (pica) in individuals with documented iron deficiency, although there has been uncertainty as to whether the iron deficiency was a cause of pica or a result of it. Some studies have shown that pica cravings in individuals with iron deficiency stop once iron supplements are given to correct the deficiency, suggesting that iron deficiency induces pica (and other) cravings during pregnancy. In addition, low blood levels of iron commonly occur in pregnant women and those with poor nutrition, two populations at higher risk for pica.

Edwards et al. (1994) studied 553 African American women who were admitted to prenatal clinics in Washington, D.C.. Serum ferritin concentrations of pica women were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were significantly lower in pica women than their nonpica counterparts. Although not significantly different, the iron (66 vs. 84% RDA) and calcium (60 vs. 75% RDA) contents of the diets of pica women were less than those of nonpica women.

A further hypothesis is presented by Callahan (2003). Regular consumption of soil might boost the mother's secretory immune system. Monkeys that regularly eat dirt have lower parasite loads. In some cultures, clays are baked before they are eaten, which could boost

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<sup>38</sup> <http://www.ehendrick.org/healthy/001609.htm>

immunity from previous exposures. For decades aluminum salts, like those found in clays, have been used as adjuvants in human and animal vaccines. Adjuvants are compounds that nonspecifically amplify immune response. Aluminum compounds make effective adjuvants because they are relatively nontoxic; the charged surfaces of aluminum salts absorb large numbers of organic molecules. Note that Al was one of Calabrese's preferred tracers due to the assumption that it is not adsorbed and inert at trace levels (it is quite toxic at high levels).

## **6.0 Acute Soil Ingestion and Pica**

There is a gradient between geophagy and pica, and there is not a clear distinction between the conditions. Pica is an obsessive-compulsive eating disorder typically defined as the persistent eating of nonnutritive substances for a period of at least 1 month at an age in which this behavior is developmentally inappropriate. The definition also includes the mouthing of nonnutritive substances. Individuals presenting with pica have been reported to mouth and/or ingest a wide variety of nonfood substances, including, but not limited to, clay, dirt, sand, stones, pebbles, hair, feces, lead, laundry starch, vinyl gloves, plastic, pencil erasers, ice, fingernails, paper, paint chips, coal, chalk, wood, plaster, light bulbs, needles, string, and burnt matches.

Pica is generally thought of as a pediatric condition, but pica diagnoses include psychiatric conditions like schizophrenia, developmental disorders including autism, and conditions with mental retardation. These conditions are not characterized by iron deficiency, which supports a psychological component in the cause of pica.

Pica is seen more in young children than adults, with 10-32% of children aged 1 to 6 may exhibit pica behavior at some point<sup>39</sup>. LaGoy (1987) estimated that a value of 5 gpd is a reasonable maximum single-day exposure for a child with habitual pica. In June 2000, the U.S. Agency for Toxic Substances and Disease Registry appointed a committee to review soil pica. The committee settled on a threshold of pathological levels as consumption of more than 500 mg of soil per day but cautioned that the amount selected was arbitrary<sup>40</sup>. With this criterion, studies in the literature estimate that between 10 and 50% of children may exhibit pica behavior at some point. While this threshold may be appropriate in relatively clean suburban settings, it may not be appropriate for defining the pica threshold in rural settings where average soil ingestion is likely to be higher.

The occurrence of pica has been discussed with respect to risk assessment, especially for acute exposures. Calabrese et al. (1997) recognized that some children have been observed to ingest up to 25-60 g soil during a single day. When a set of 13 chemicals were evaluated for acute exposures with a pica exposure rate, four of these chemicals would have caused a dose approximating or exceeding the acute human lethal dose.

Regulatory guidance recommends 5 or 10g/d for pica children. Some examples are:

- (1) EPA (1997) recommends a value of 10g/d for a pica child.

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<sup>39</sup> <http://www.nlm.nih.gov/medlineplus/ency/article/001538.htm#Causes,%20incidence,%20and%20risk%20factors>

<sup>40</sup> Summary report for the ATSDR Soil-Pica Workshop, Atlanta, Georgia, 2000. Available from: URL: <http://www.atsdr.cdc.gov/NEWS/soilpica.html>

(2) Florida recommends 10g per event for acute toxicity evaluation<sup>41</sup>

(3) ATSDR uses 5 g/day for a pica child<sup>42</sup>

## 7.0 Data from dermal adherence

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested, as well. Although this body of literature is not typically used to estimate a quantitative contribution to soil ingestion, it can give relative estimates of soil contact rates between activities.

Two relevant papers from Kissel's laboratory are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm<sup>2</sup> for 6 children and an average of 58 mg/cm<sup>2</sup> for another 6 children. Reed gatherers were next highest at 0.66 mg/cm<sup>2</sup> and an upper bound for reed gatherers of >1 mg/cm<sup>2</sup>. This was followed by farmers and rugby players (approximately 0.4mg/cm<sup>2</sup>) and irrigation installers (0.2mg/cm<sup>2</sup>). Holmes et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm<sup>2</sup>), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm<sup>2</sup>). Since reed gatherers, farmers, and gardeners had higher skin loadings, this is supporting evidence that these activities also have higher than average soil ingestion rates.

One factor that has not received enough attention is the grain size of adhering and ingested soil. Stanek and Calabrese (2000) said that variability in estimating soil ingestion rates using tracer elements was reduced when a grain size less than 250 um were excluded in order to reduce variability. Driver et al. (1989) found statistically significant increases in skin adherence with decreasing particle size. Average adherences of 1.40 mg/cm<sup>2</sup> for particle sizes less than 150 µm, 0.95 mg/cm<sup>2</sup> for particle sizes less than 250 µm and 0.58 mg/cm<sup>2</sup> for unsieved soils were measured (see EPA, 1992<sup>43</sup> for more details).

A consideration of grain size could affect the estimation of soil ingestion rates because the mineral and organic composition within a particular soil sample can vary with particle size and pore size. If soil adherence studies are conducted in a manner wherein sand is brushed off the hands while smaller grain sizes remain adhered, then tracer ratios could be altered, and would be different from the original unsieved soil. Soil loading on various parts of the body is collected with wipes, tape, or rinsing in dilute solvents, which would generally collect the smaller particle sizes<sup>44</sup>.

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<sup>41</sup> Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, [www.dep.state.fl.us/waste/quick\\_topics/publications/wc/csf/focus/csf.pdf](http://www.dep.state.fl.us/waste/quick_topics/publications/wc/csf/focus/csf.pdf).

<sup>42</sup> For Example: El Paso Metals Survey, Appendix B, [www.atsdr.cdc.gov/HAC/PHA/elpaso/epc\\_toc.html](http://www.atsdr.cdc.gov/HAC/PHA/elpaso/epc_toc.html).

<sup>43</sup> EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B

<sup>44</sup> Soils are classified according to grain size (1mm = Very coarse sand; 0.5mm = Coarse sand; 0.25mm = Medium sand; 0.10mm = Fine sand; 0.05mm = Very fine sand; 0.002mm = Silt; <0.002mm = Clay). The Wentworth scale classifies particle sizes as ranges: sand = 1/16 to 2 mm; silt = 1/256 to 1/16 mm; clay = <1/256 mm.

## **8.0 Data from washed or unwashed vegetables.**

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton, 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. However, there is very little quantitative data about soil on vegetation as-gathered, as-prepared, or as-eaten, which is a separate issue from root uptake of soil contaminants into edible materials. However, there is information on interception rate of dust particles deposited onto leafy surfaces, and information on soil ingestion by pasture animals. For example, Beresford and Howard (1991) found that soil adhesion to vegetation was highly seasonal, being highest in autumn and winter, and is important source of radionuclides to grazing animals. Palacios et al. (2002) evaluated lead levels in the aerial part of herbage near a Superfund site. A water washing pre-treatment of the vegetal samples considerably diminished the concentration of lead.

Kissel et al. (2003) evaluated concentrations of arsenic and lead in rinsed, washed, or peeled garden vegetables. He found that concentrations of lead and arsenic in washed or peeled potatoes or lettuce were generally lower, as expected, although the concentration of lead in peeled potatoes was higher than in rinsed or washed potatoes.

## **9.0 Subsistence lifestyles and rationale for soil ingestion rate**

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle is lived in close contact with the environment.
- Plateau winds and dust storms are fairly frequent. Incorporated into overall rate, rather than trying to segregate ingestion rates according to number of high-wind days per year because low-wind days are also spent in foraging activities.
- The original Plateau lifestyle – pit houses, caches, gathering tules and roots - includes processing and using foods, medicines, and materials. This is considered but not as today's living conditions.
- The house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater.
- 400 mg/d is based on the following:
  1. 400 mg/d is the upper bound for suburban children (EPA); traditional or subsistence activities are not suburban in environs or activities
  2. This rate is within the range of outdoor activity rates for adults (between 330 and 480); subsistence activities are more like the construction, utility worker or military soil contact levels. However, it is lower than 480 to allow for some low-contact days.
  3. The low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999) such as root gathering days, tule and wapato gathering days, pow wows, rodeos, horse training and riding days,

- sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
4. This rate is lower than Simon estimate of 500 mg/d and lower than the recommendations of 3 g/d for indigenous children and 2 g/d for indigenous adults in arid environments. It is also lower than the 5 or 10 grams he estimated for purely aboriginal lifestyles. For original housing conditions a higher rate would be clearly justified; for today's housing conditions, a lower rate is adequate.
  5. This rate does not account for pica or geophagy
  6. Primary data is supported by dermal adherence data in gatherers and 'kids in mud'. Tule and wapato gathering are kid-in-mud activities
  7. This rate includes a consideration of residual soil on roots (a major food category) through observation and anecdote, but there is no quantitative data.
  8. This rate includes a consideration of the number of windy-dusty days, but without further quantification of air particulates.

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**APPENDIX 3.**

**Fish Consumption Rate**

## APPENDIX 3

### Supplemental information for FISH CONSUMPTION RATE

**CTUIR Fish Consumption Rate = 620 g/d or 500 pounds per year (adult) .**

#### SUMMARY

The Confederated Tribes (Cayuse, Umatilla, Walla Walla) have relied on resident and anadromous fish in the Columbia River and its tributaries for at least 10,000 years. Salmon and the people are inseparable, and people will and must continue to partake in the circle of life with salmon as a partner. We regard current depressed fish numbers as a temporary condition, and we are working to achieve continuing improvement through concerted efforts in watershed restoration. Therefore, since remedial actions must remain protective for thousands of years, we are using our subsistence consumption rate, not the current suppressed consumption rate.

Although many indigenous peoples living along coasts or major waterways originally had very high fish consumption rates, most are now suppressed due to destruction of fisheries, lost access to aboriginal lands, or awareness of contamination. Therefore, studies that assess the current fish consumption rates are not measuring the true subsistence rate, but a modern suppressed rate. Even so, a subset of tribal members remain heavily fish-dependent, creating a bimodal distribution that is missed in most conventional survey methods.

The CTUIR subsistence consumption rate is an average of 620 grams per day for adults. This is known through anthro-historical data, anecdotal information by early observers such as Lewis & Clark, nutritional analysis, documentation from the era of dam construction (1920-1950), interviews of current subsistence fishers, and literature review. Table 1 shows examples of the range of consumption rates that were reviewed.

Table 1. Summary of fish ingestion rates evaluated.

<b>Fish Ingestion Rate</b>	<b>Derivation</b>
6.5 g/day	Previously used in federal promulgations based on national food consumption surveys of the general non-tribal population; now superceded by 17.5 g/d.
17.5 g/day	EPA's new recommendation for the general non-tribal population and recreational fishers for setting water quality standards.
48.5 g/day	The Food & Drug Administration and EPA currently recommend eating two 6-ounce meals of fish per week, or 48.5 gpd
54 g/d	MTCA and OSWER
63.2 g/day (about 1 pound/week)	CRITFC (1994) average for current tribal fish consumers, excluding subsistence fishers. See commentary below.
142.4 g/day	EPA proposed average rate for tribal subsistence fishers and 99 <sup>th</sup> % of the general non-tribal population
389 g/day	CRITFC 99 <sup>th</sup> percentile of non-subsistence fish consumers plus non-consumers, minus 7 "outliers." The 90 <sup>th</sup> percentile was between 97 and 130 g/day, and the 95 <sup>th</sup> percentile was between 170 and 194 g/day.
454 g/day (1 pound/day)	Anecdotal subsistence estimate, commonly cited during interviews with traditional and subsistence people..
540 g/day	Harris & Harper (1997), based on averages for traditional CTUIR fishing families, and the lower end of the Treaty-based range; approved by BOT for use at Hanford and Columbia River. The authors sought out and interviewed traditional and subsistence fishing members.
<b><u>620 g/day</u></b>	Cited in the Boldt decision ("Salmon, however, both fresh and cured, was a staple in the food supply of these Indians. It was annually consumed by these Indians in the neighborhood of 500 pounds per capita.") U.S. District Judge George Boldt, U.S. v. Washington, February 12, 1974, note 151. Note: Boldt was referring to Columbia mainstem fishers when he wrote this. This does not include resident fish.
650 g/day	Walker (1999) mid-range of top third of Yakama members using the Columbia River during the 1950s and 1960s (both resident and anadromous fish). This is based on interviews of tribal fishermen, fish market records, nutritional analysis, archaeological and ethnographic evidence, and literature reviews. Walker cites other studies that support this number. Walker estimated that minimal river users ate 80 g/d, and the median river user ate 350 g/d. The BOT endorsed the numbers in this paper.
1000 g/day	Walker (1985) estimate of pre-dam rates for Columbia Plateau Tribes, accounting for calorie loss as fish migrate upriver and other documentation.
<p>To convert from ounces to grams, multiply by 28.35. There are 3.53 ounces in 100 grams.          To convert from pound to gram, multiply by 453.6          There are 16 ounces in a pound.          100 grams or 3.5 ounces is about the size of a deck of cards.          Meal sizes are generally assumed to be 6 or 8 ounce portions for adults</p>	

## **1.0 Approach and Assumptions**

Within the Confederation of Cayuse, Walla Walla and Umatilla Tribes, there are different family natural resource uses according to the specific area that a family is from. Nevertheless, while the Cayuse Tribe emphasized hunting more than fishing and the Walla Walla and Umatilla Tribes emphasized fishing more than hunting, both diets are "subsistence" diets because they provide all the food and medicine that a family needs to survive and thrive. However, in this scenario we are using the term "subsistence fisher" to refer to original consumption rates along the Columbia River and its major tributaries, and which the Treaty of 1855 was intended to protect.

The development of the CTUIR fish consumption rate was based on the following premises:

- Subsistence consumption rates were practiced by many or all members of a Tribe, but today are practiced by a subset of tribal members;
- Within tribes or confederations of tribes there may be distinct patterns of natural resource use that are obscured by statistical cross-sectional surveys. Therefore, cross-sectional fish consumptions surveys in tribal communities may not be able to identify subsistence fishers;
- In order to develop a subsistence consumption rate, subsistence fishers must be specifically identified and interviewed, and existing studies must be reviewed to determine whether they are suitable for developing true subsistence rates.

Our goal was to identify the subsistence consumption rate (not the current suppressed rate) because that is the rate that the Treaty of 1855 was designed to protect and which is upheld by case law. It also reflects tribal fish restoration goals and healthy lifestyle goals. We also know that a subset of tribal members eat that rate of fish today, but are often overlooked in typical cross-sectional surveys.

As other investigators have done (Walker, in particular), the CTUIR fish consumption rate was developed using multiple lines of evidence: literature review of ethnohistorical evidence, review of cross-sectional fish consumption surveys (a combination of subsistence and non-subsistence fishers), interviews of current subsistence fishers, and caloric and nutritional analysis.

## **2.0 Current Federal and State Guidance**

The EPA Office of Water provides guidance for setting ambient water quality standards for surface water, and includes a consideration of fish consumptions rates. The prior national fish consumption rate for the general population [6.5 gpd] was based on the mean national per capita (both consumer and non-consumers) consumption rate of freshwater and estuarine finfish and shellfish from 3-day diary results that were reported in the 1973-74 National Purchase Diary Survey (Javitz, 1980).

The EPA Office of Water<sup>45</sup> now recommends a default fish intake rate of 17.5 grams/day to protect the general population of fish consumers including sport fishers, and 142.4 grams/day for subsistence fishers. The basis for the fish intake rates is the 1994-96 Continuing Survey of Food Intake by Individuals and 1998 Continuing Survey of Food Intakes by Individuals (CSFII) conducted by the U.S. Department of Agriculture.

The Food & Drug Administration and EPA currently recommend eating two meals (12 ounces) of fish per week, or 48.5 gpd<sup>46</sup>.

When Tribes develop ambient water quality standards, EPA<sup>47</sup> recommends using either an upper percentile of a cross-section or an average rate specific for a higher fishing group, according to the policies of the Tribe. EPA says that the two numbers should be compared to ensure that the higher fishing group (if one is present within a general tribal population) is protected. In the case of CTUIR, these two numbers are quite different (see discussion below), so the CTUIR rate is based on the average rate specific to the higher fishing group rather than the average for the whole Tribe.

The U.S. EPA Office of Solid Waste and Emergency Response (OSWER) also considers fish consumption in the Superfund program. OSWER's policy is to assume an ingestion rate of 54g/day for high recreational consumers of locally caught fish [OSWER directive 9285.6-03]. This number is based on recreational, not Native American data. Region 10 of the U.S. EPA recommends the use of results from local or regional seafood intake surveys for use in the regional Superfund program<sup>48</sup>. If Tribal-specific or local information is not available, EPA-OSWER recommends using the U.S. EPA Exposure Factors Handbook, which recommends a mean and 95th percentile for the general U.S. population of 20.1 g/day and 63 g/day, respectively (U.S. EPA, 1997). For Native American "subsistence" populations the recommended value for mean intake is 70 g/day and the recommended 95th percentile is 170 g/day. This assumes that current rates and true subsistence rates are identical, while they clearly are not except for some Alaska Tribes.

The Washington State Department of Ecology recently recommended a *draft* statewide default of 177g/day to protect all Washington residents including the highest consumers, subsistence fishers. The draft report recommends "final default consumption values of approximately 178 and 175 g/day for marine and freshwater areas, respectively. These values represent approximately the 90th percentile of the fish consumption rate distribution from the Toy et al. study and the 95th percentile from the CRITFC study, respectively<sup>49</sup>. State-wide criteria may use the mid-point between these values, or 177 g/day as a reasonably protective default. Shellfish may be separated out from the marine values. Shellfish estimates are recommended as 68 g/day based on the Toy et al. study."

<sup>45</sup> Estimated Per Capita Fish Consumption in the United States. (EPA-821-C-02-003) (August 2002). [http://www.epa.gov/waterscience/fish/consumption\\_report.pdf](http://www.epa.gov/waterscience/fish/consumption_report.pdf); and Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000) EPA-822-B-00-004, October 2000. <http://www.epa.gov/waterscience/humanhealth/method/chapter4.pdf>

<sup>46</sup> <http://www.fda.gov/bbs/topics/news/2004/NEW01038.html>

<sup>47</sup> [www.epa.gov/ost/standards/tribal/tribalfact2004.html](http://www.epa.gov/ost/standards/tribal/tribalfact2004.html) or [www.epa.gov/ost/standards/tribal/tribalfact2004.pdf](http://www.epa.gov/ost/standards/tribal/tribalfact2004.pdf).

<sup>48</sup> Currently being revised: <http://yosemite.epa.gov/r10/oea.nsf/af6d4571f3e2b1698825650f0071180a/db6a5cf0b287291c88256c55006cd81e?OpenDocument>

<sup>49</sup> Washington Department of Ecology, Analysis and selection of fish consumption rates for Washington State risk assessments and risk-based standards, external review draft, March 1999. <http://www.ecy.wa.gov/biblio/99200.html>

The Washington Department of Ecology's 1997 standards for surface water refer to WAC 173-340-730 (Model Toxics Control Act), which includes a "placeholder" for fish consumption of 54 gpd.

### 3.0 Fish Consumption Surveys of Current Suppressed Rates

Several studies have evaluated current Tribal fish consumption rates in the Pacific Northwest in order to evaluate current exposures and risks (Table 2). None of them addressed the issue of original fish consumption rates which are protected by Treaty and/or by judicial decisions, and none addressed the current tribal conditions which forced many people off the River and away from their hereditary or Usual and Accustomed fishing sites. Additionally, none of them specifically consider the range of lifestyles within tribal communities, but assumed that today's Tribes are all composed of a homogeneous population even if Tribes with different histories, homelands and even languages were forced onto the same reservation. This results in bimodal or more distributions within many tribes. In the case of the Confederated Umatilla Tribes, there is a subset of tribal members who maintain high fishing rates and consumption rates (see next section). The studies summarized in Section 3 assumed that Tribes were homogeneous in their activities and lifestyles, and therefore took a statistical cross-section approach. In contrast, the studies summarized in Section 4 specifically focused on the subset of tribal members who maintain a true subsistence lifestyle, and on documenting original consumption rates.

Table 2. Major Pacific Northwest cross-sectional studies.

Survey	Mean (converted to g/person/d)			95th	99th
	finfish	shellfish	combined	Fish + shellfish	
<b>CRITFC</b>	63.2	-	63.2	170-194	389
<b>Squamish</b>	81.8	132.7	213.9	798	ND
<b>Toy - Tulalip/Squaxin</b>	48.8	22.3	72.9	177	ND
<b>Sechena - Asian / Pac Isl.</b>	-	-	119.3	?	?

CRITFC – outliers were eliminated from the database (implies a presumption of not valid).  
Squamish – no labeling of high end consumers as outliers; says they were assumed to be accurate reports.  
Tulalip – recoded outliers (implies a presumption that these were valid but mistaken)

#### 3.1 CRITFC (1994)

CRITFC (1994). "A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin." CRITFC Technical Report No. 94-3, Portland, OR.

The CRITFC fish consumption survey was designed in a way that is conventionally used in typical suburban populations. It used statistical rather than ethnographic research methods. Both methods are "scientific" in that they are systematic, repeatable, and verifiable, but they are suitable for different populations and situations. The CRITFC survey was a random cross-section of tribal members (names were randomly selected from enrollment lists), with ultimate participation by 126 Warm Springs, 133 Nez Perce, 131 CTUIR, and about 130

Yakama members. The mean age of respondents was 39 years old (less than 10% were elders 60 years old or older). Tribal members were contacted by phone, mail, or in person. They were asked to drive to a central location on a particular day, and answer a lengthy set of questions read from a script (for consistency) by an interviewer. The overall response rate was 69% (31% of selected people either refused, could not be located, or did not participate for unknown reasons). It is likely that traditional members were under-represented due to refusal, lack of a phone, car, or permanent address, or inability to respond for the small amount of payment (\$40).

Seven individuals reported that they ate more than 389 g/day, or more than 99% of the amount eaten by fish consumers (4 people ate 486 g/day, and one person each ate 648 g/d, 778 g/d, and 972 g/d). These values were treated as statistical outliers and were eliminated from the database. No follow-up was done to find out whether these higher rates were accurate or not, but we assume that these people are true subsistence fishers. Because these numbers are based on a reported meal frequency and size, we assume that the underlying answers by the interviewees were accurate, because people can provide information about meal frequency more easily than poundage.

During the research for the Harris & Harper paper (1977) traditional members who had been included in the CRITFC survey were asked if they gave accurate information, and several said no. Some traditional fishers said they simply refused to participate, or reported lower consumption rates than reality, due to a fear of law enforcement or fear of being accused of knowingly eating contaminated fish. Other factors are unknown, such as whether traditional members were away from home during a fishing season, or otherwise engaged in activities that prevented them from participating. The personal experiences of the people we are most interested in (elders and subsistence fishing families) make them less likely to answer questions, even when posed by a member of the community. Fishing families often have a family history of having to fish clandestinely and being persecuted by authorities or jailed as a result of fishing in their own rivers to feed their families.

The point of this discussion is that the makeup and history of the community must be understood before conducting a conventional survey. In addition to the above items, we know that elders tend to eat more traditionally (including people who return to traditional ways as they get older). Within the Umatilla and Walla Walla membership there are people who lost access to their hereditary fishing sites, or who have full-time day jobs or other family circumstances that prevent them from designating a family member as a fish provider.

Summary of CRITFC statistics:

Arithmetic mean = 63.2 grams/day

50<sup>th</sup> percentile = 42 gpd

90<sup>th</sup> percentile = 127 gpd (Table 10 says the weighted 90<sup>th</sup> = 97 – 130 gpd).

95<sup>th</sup> percentile = 182 (Table 10 says the weighted 95<sup>th</sup> = 170 – 194 gpd. The 95<sup>th</sup> % is also cited as 175 from Table 18 for the Portland Harbor Superfund site)

98<sup>th</sup> percentile = 317 gpd

99<sup>th</sup> percentile = 389 gpd

Average serving size = 8.42 oz +/- 0.13 oz.

### 3.2 TOY et al. (1996).

Toy KA, Polissar NL, Liao S, and Mittelstaedt GD. (1996) "A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region." Tulalip Tribes, Department of the Environment, 7615 Totem Beach Road, Marysville, WA 98721.

This survey was designed to focus on frequency (daily, weekly, monthly, annually) and portion size of fish and shellfish, both fresh and frozen. Commercial fishing and shellfishing is an important source of income for both tribes, but for the Tulalip, "at present, the consumption of shellfish is limited to a personal-use activity." Sample size goals were developed by assuming a homogeneous (not bimodal) population and a certain standard deviation. Random names were generated, and children were evaluated if a parent was included (limited to one child per family). The final sample sizes were 73 Tulalip and 117 Squaxin adults over 18 and 68 children. A scripted questionnaire with food models was used.

52 edible species were divided into anadromous, pelagic, bottom fish, shellfish, and other (canned tuna or trout) categories. Consumption per body weight was recorded (average weight = 81 kg). Participants were paid \$25. There was no correlation of consumption with income (i.e., low income did not drive people to eat more fish; high income did not allow more fish as a luxury purchase; or the two factors balanced each other).

"Outliers" were recoded to the 3 SD value. "The distribution of consumption rates was skewed toward large values." At least 25 people (out of 190, or 13% of participants) ate more than the 95<sup>th</sup> % of total finfish. This suggests that there is an underlying bimodal distribution of higher consumers, rather than being a single homogeneous population.

Weighted means (after the outliers were recoded) are:

- Tulalip median = 0.55 g/kg/d of all fish (53 g/d male and 34 g/d female);
- Squaxin median= 0.52 g/kg/d (66 g/d male and 25 g/d female).

Table 3. Combined Tulalip and Squaxin Island results. Results are given in grams per kg body weight per day and grams per person (assumed to weigh 70 kg) per day.

	<i>Finfish g/kg/d</i>	<i>Finfish g/d (per person)</i>	<i>Shellfish g/kg/d</i>	<i>Shellfish g/d (per person)</i>
50 <sup>th</sup> %	0.317	25.7	0.115	9.32
90 <sup>th</sup>	0.84	68	1.75	142
95 <sup>th</sup>	1.31	106	2.19	177
99 <sup>th</sup>	Not calculated	Not calculated	Not calculated	Not calculated

### 3.3 Suquamish (2000).

Suquamish Tribe (2000). "Fish Consumption Survey of the Suquamish Indian Tribe of The Port Madison Indian Reservation, Puget Sound Region." Suquamish Tribe, Fisheries Department, PO Box 498, Suquamish, WA.

This study used a questionnaire with food models, as well as maps, pictures, and interviews. The study used scripted statistical methods for the questionnaire and ethnographic methods for oral history and elders' interviews. There were 3 special interest groups: children under 6, women between 16 and 42, and elders 55 and over. The importance of fish continues:

"Despite degraded water quality and habitat, tribal members continue to rely on fish and shellfish as a significant part of their diet. All species of seafood are an integral component of the cultural fabric that weaves people, the water, and the land together in an interdependent linkage which has been experienced and passed on for countless generations."

Given a SD of 1.26 (from the span of ingestion rates for the Toy study), and a target precision of +/-20%, the target sample size was  $n = 150$ , indicating that one-quarter of the adults should be sampled. The final sample size was 92 adults (out of 425 eligible) and 31 children. Participants were paid \$25. The participation rate was 65%.

Consumption rates "have very little correlation with body weights among adults," but people did not want to report their weights or be weighed. The average weight (males and females combined) was 79 kg. As with the Tulalip study, some people report eating more for health benefits, but twice as many people ate less now than 20 years ago due to contamination and restricted access.

Outliers were not recoded because high values were believed to reflect actual high consumption. When tested, it was found that recoding outliers had "virtually no effect" on results. The distribution graph again appears bimodal, with a group of people eating 9-10 g/kg/d (750 g/d), but the "best fit" line obscures this. One respondent reported an ingestion of 1 kg/d, which is nutritionally possible, although it may also have reflected a short-term seasonal availability – it is known that people tend to overestimate whatever is seasonally available and underestimate whatever is out of season.

#### Summary of Suquamish statistics:

Adults total average finfish and shellfish = 2.7 g/kg/d.

Average finfish = 1.03 g/kg/d; shellfish = 1.68 g/kg/d.

90<sup>th</sup> percentile = 2.5 finfish, 4.6 shellfish, 6.2 total (all in g/kg/d) (or 197.5, 363.4, 490.0 in g/70kg/d)

95<sup>th</sup> percentile = 3.4 finfish, 7.75 shellfish, 10.1 total (all in g/kg/d)  
(or 269, 612, 798 in g/70kg/d)

99<sup>th</sup> percentile = not calculated

### 3.4 Sechena et al. (1999)

R Sechena, C Nakano, S Liao, N Polissar, R Lorenzana, S Truong, and R Fenske (1999) "Asian and Pacific Islander Seafood Consumption Study," (EPA 910/R-99-003). Seattle: EPA Region 10; <http://www.epa.gov/r10earth/offices/oea/risk/a&pi.pdf>

Sechena R, Liao S, Lorenzana R, Nakano C, Polissar N, and Fenske R. (2003) "Asian American and Pacific Islander seafood consumption -- a community-based study in King County, Washington." J Expo Anal Environ Epidemiol. 13(4):256-66.

This study describes and quantifies seafood consumption rates and acquisition and preparation habits of 202 first- and second-generation Asian and Pacific Islanders (A/PI) from 10 ethnic groups (Cambodian, Chinese, Filipino, Hmong, Japanese, Korean, Laotian, Mien, Samoan, and Vietnamese) in King County, Washington in 1997.

A sample size of 200 fish consumers was the target, and 202 people actually participated, with 5-30 interviews per ethnic group. Because it was not possible to pre-identify first and second generation A/PI for random name generation, half the participants were invited to participate from rosters provided by community leaders for random contact, and half were volunteers who had previously been recruited for a Dietary Habits Study. The interviewee pool was adjusted to reflect age and gender of the populations (from census and other information), so the participants had to fit the ethnic, age and gender profiles before inclusion in the study. If groups were still too small, relatives of participants were actively recruited. The sample size of some ethnicities was deliberately larger than others, according to a judgment about how well established that group was in the Seattle area (e.g., they knew where and how to get fish, etc.). The majority of the 202 respondents (89%) were first generation (i.e., born outside the United States). There were slightly more women (53%) than men (47%), and 35% lived under the 1997 Federal Poverty Line. Participants were paid \$25 or given a store voucher

In general, the A/PI members consumed seafood at a high rate. The average overall consumption rate for all seafood combined was 1.891 grams/per kilogram body weight/day (g/kg/day), with a median consumption rate of 1.439 g/kg/day (or a mean of 117.2 and a median of 89 g/day for a 70 kg person). Seafood consumption based on gender, age, income, and "fishermen" status did not differ significantly. However, mean consumption rates varied significantly between ethnic groups with Vietnamese (2.63 g/kg/day) and Japanese (2.18 g/kg/day) having the highest average consumption rates, and Mien (0.58 g/kg/day) and Hmong (0.59 g/kg/day) the lowest.

The predominant seafood consumed was shellfish (46% of all seafood). The most frequently consumed finfish and shellfish were salmon (93% of respondents), tuna (86%), shrimp (98%), crab (96%), and squid (82%). Fish fillets were eaten with the skin 55% of the time, and the head, bones, eggs, and/or other organs were eaten 20% of the time. Crabmeat including the hepatopancreas was consumed 43% of the time.

Outliers (more than 3 SD from the mean) had "large but uncertain" ingestion rates. They were recoded to 3 SD. Again, fish consumption rates were skewed considerably for all fish groups. The skewed distribution indicates that a few respondents had a larger consumption rate than other respondents. Because outliers had already been recoded within each fish group, these large consumption rates reflected the fact that some A/PI members were, indeed, higher consumers of seafood.

People over 55 ate more fish (131 gpd) than younger people (111 gpd). There was no correlation with income. Volunteer participants ate very slightly more than roster recruits (random contact from lists). Fishermen and non-fishermen did not show any statistical difference, and there was little or no difference between first generation (foreign born) and second generation (bore here).

TABLE 4. Consumption Rates of Asian/Pacific Islanders in King County (From Sechena et al.. 1999). [LCI= lower confidence interval; UCI = upper confidence interval]

Category	N	Mean g/kg/d	Median g/kg/d	Percentage of consumption	S.E.	95% LCI g/kg/d	95%UCI g/kg/d	90% g/kg/d
Anadromous Fish	202	0.093	0.201	10.6%	0.008	0.187	0.216	0.509
Pelagic Fish	202	0.215	0.382	20.2%	0.013	0.357	0.407	0.829
Freshwater Fish	202	0.043	0.110	5.8%	0.005	0.101	0.119	0.271
Bottom Fish	202	0.047	0.125	6.6%	0.006	0.113	0.137	0.272
Shellfish Fish	202	0.498	0.867	45.9%	0.023	0.821	0.913	1.727
Seaweed/Kelp	202	0.014	0.084	4.4%	0.005	0.075	0.093	0.294
Miscellaneous Seafood	202	0.056	0.121	6.4%	0.004	0.112	0.130	0.296
<i>All Finfish</i>	202	0.515	0.818	43.3%	0.023	0.774	0.863	1.638
<i>All Fish</i>	202	1.363	1.807	95.6%	0.042	1.724	1.889	3.909
<i>All Seafood</i>	202	1.439	1.891	100.0%	0.043	1.805	1.976	3.928
All Seafood, converted to g/person/d (*63.5)	91.4	120.1				114.6	125.5	249.4

#### **4.0 Studies of true subsistence fishers and Treaty-based consumption rates**

In order to document original fish consumption rates, as well as to evaluate the subset of tribal members who maintain a subsistence level of fish consumption, a combination of historical documentation, literature review, and additional ethnographic interviews was used. These three lines of evidence indicate that the range of original rates (also referred to as a Treaty-protected rate) is 540 to 1000 gpd. Interviews confirm that there are quite a few people who consume fish two to three times a day in various forms (whole fillet, soup, powdered thickener or flavoring, dried or smoked as snacks). Some of the primary references are summarized below, with citations of other literature included. It should be noted that these rates persist to the present despite the decimation of salmon runs by canneries and dams, knowledge of contamination, and attempts by authorities to restrict Tribal fishing.

#### 4.1 Harris and Harper (1997)

Harris, S.G. and Harper, B.L. (1997) "A Native American Exposure Scenario." *Risk Analysis*, 17(6): 789-795.

Harris interviewed 75 people in order to identify members of the special interest group (the higher fishing group). A subset of 35 traditional fishers, including many elders, were then interviewed in detail using ethnographic methods. The ethnographic interview is actually a process (Schensul et al., 1999a,b; Spradley, 1979; Emerson et al., 1995; Fetterman, 1998; Thornton, 1998; Mihesuah, 1998). It involves establishing community standing and personal credibility, and demonstrating cultural sensitivity and an understanding of what information is proprietary. Without this process, information collected from interviews or questionnaires with Native Americans risks being inaccurate. Interviewees were asked how the accuracy of their responses compared to other studies, including the CRITFC study, and many stated that they do not try to provide accurate information (or actively seek to avoid revealing accurate information) unless they know the person and know how the information could be used or misused. The authors consider this to be an essential part of the bioethics and informed consent safeguards, even if this takes considerably more time than simply asking people to answer questions.

Interviewees reported eating fish daily, with fresh and dried fish in equal weights. This amount reflects one 4-ounce portion of fresh fish and 4 ounces of dried fish, which is equivalent to 12 ounces of wet weight. Since these interviews, more research has been done which indicates that several forms of fish consumption were overlooked, including use as a thickener and flavoring, and the use of whole fish and eggs were probably underestimated.

Anecdotally, people are now eating more fish as the salmon runs are being restored in the Umatilla and Walla Walla Rivers in the last several years. The Umatilla Tribes have invested a large amount of money, time, and effort to restore these runs, with the goal of regaining subsistence fishing capabilities.

#### 4.2 Walker (1967).

Walker DE (1967. Mutual Cross-Utilization of Economic Resources in the Plateau: from aboriginal Nez Perce Fishing Practices. Washington State University Laboratory of Anthropology, Report of Investigations, No. 21, Pullman WA.

Walker estimated that fish consumption rates before dam construction ranged from 365 to 800 pounds per year per capita.

#### 4.3 Walker (1985)

cited in: Scholtz A, O'Laughlin K, Geist D, Peone D, Uehara J, Fields L, Kleist T, Zozaya I, Peone T, and Teesatuskie K, (1985), "Compilation of information on salmon and steelhead total run size, catch, and hydropower related losses in the Upper Columbia River Basin, above Grand Coulee Dam." Fisheries Technical Report No. 2.,

Upper Columbia United Tribes Fisheries Center, Eastern Washington University,  
Department of Biology, Cheney, WA 99004.

Walker reviewed the ethno-historical and scientific literature to estimate the pre-dam fish consumption rates of Tribes along the Columbia River. He estimated that total fish consumption (not harvest) was up to 1000 lbs per capita for lower Columbia Tribes, of which 75% were salmon (Umatilla and Yakama estimates), and the Nez Perce ate 1000 lbs per capita of which 90% were salmonids (including trout and whitefish). Other estimates (Hewes; Boyd) are very close to this. Hewes, (1947, 1973) originally estimated from 50 to 900 pound per year for Plateau Tribes by estimating a total catch, subtracting an estimate of the amount of salmon that was traded, used as dog food, and other uses, and adding additional 1/3 of the weight of salmon to account for resident fish consumption during the 1/3 of the year that salmon are not running, (but considering that dried, pounded [pemmican or powder] fish are eaten in the winter).

Walker improved on Hewes' estimate by using actual historical observational counts of the Indian catch, rather than a global estimate of a Tribe's entire catch for a season. The median annual per capita consumption of salmonids for the Columbia Plateau Tribes derived by Walker was 585 pounds per capita. "Walker's figures provide a more accurate picture of the catch... based on direct observation and ethnographic fieldwork."

Other authors were also cited in this reference. "Schalk (1985) pointed out that the early caloric estimates were for salmon flesh in the ocean. Since salmon lose calories as they migrate upstream, tribes living upriver would actually have to take more fish than tribes living downriver to obtain an equivalent amount of calories." He estimated that 1.5 pounds of wet weight are equivalent to 1 pound dried, and that 20% of a whole fish is entrails. Schalk estimated that a family needs 250 to 500 dried fish per family.

Walker also cited Swindell (1942), who interviewed 55 family heads from Yakama, Umatilla and Warm Springs (not specifically fishing families) for an average of 322 pounds/yr in 1941 (the time when the canneries were taking a large percentage of the fish, leaving fewer for the Indians). Yakama, Klickitat, Wanapum, and Palus were estimated to eat 400 lbs, and Nez Perce were estimated to eat 300 lbs. Hewes estimated that Cayuse ate 365 pounds per capita, while Umatilla and Walla Walla ate 500 pounds per person. Of the three CTUIR Tribes, the Cayuse were upland dwellers who traded for much of their fish, while the Umatilla and Walla Walla Tribes lived on their namesake rivers and along the Columbia mainstem.

Hudson Bay records from 1827, 1829, and 1830 indicated that the company supplemented the regular supplies that were shipped to them by purchasing about 535 lbs of fish per person (about 30 people were housed at the Colville Post), as well as around 100 lbs dried venison (for the 30 men), 1500 pounds of fresh venison, 10 beavers, 275 ducks, 200 geese, 10 cranes, 75 dogs, 50 grouse, and a few swans, beaver tails, and small fish.

#### 4.4 Walker (1992)

Walker, D.E. (1992). Productivity of Tribal Dipnet Fishermen at Celilo Falls: Analysis of the Joe Pinkham Fish Buying Records. *Northwest Anthropol. Res. Notes.* 26(2):123-135.

Walker discussed an earlier reference (Anastasio, 1972), which reviewed historical accounts of early explorers, as well as thoroughly reviewing ethnographic and ethnohistoric research. Archaeological research indicates that this region has been the scene of relatively continuous anadromous fishing activity for at least 10,000 years. Walker reviewed fish buying records in 1945, a time when fish runs were declining rapidly, continuing a trend begun with the canneries. Over the years, packing house and cannery records support statements that salmon runs have been 99% decimated.

#### **4.5 Walker (1999)**

**Walker, D.E. and Pritchard, L.W.(1999). "Estimated Radiation Doses to Yakama Tribal Fishermen: An Application of the Columbia River Dosimetry Model for the Hanford Environmental Dose Reconstruction Project." Boulder, CO: Walker Research Group.**

This study relied on the use of officially recorded fishing sites along the Columbia River mainstem, and interviews with the individuals who actually used those sites between 1950 and 1971. Fishermen were grouped as maximum, median, or minimum river users according to how many fishing sites they held. Minimum river users used between 1 and 9 fishing sites, and ate 64 pounds per year (29 kg/yr or 80 gpd). Median river users used between 10 and 19 sites and ate 282 pounds per year (128 kg or 350 gpd). Maximum river users "would be considered subsistence fishermen," and used 20 or more fishing sites. They ate 522 pounds per year (237 kg or 650 gpd). 75% of fish were caught between April 1 through October 31; of this 75%, 90% was anadromous and 10% was resident. Between November 1 and March 31, 25% of the annual catch was caught; of this 75% were resident and 25% anadromous.

#### **4.6 Hunn (1990)**

**Hunn ES (1990). Nch'i-Wana, The Big River: Mid-Columbians and Their Land. Seattle: University of Washington Press.**

Hunn estimated that 30-40% of caloric needs supplied by salmon. Table 13 (Hunn, 1990, page 150) provides estimates of salmon consumption per capita from Hewes (not including resident fish during the winter quarter): Wishram (400 pounds per year), Tenino (500 pounds), Umatilla (500 pounds), and Nez Perce (382 pounds from Hewes estimate and 582 pounds from Walker's estimates), including the adjustment for caloric loss as fish move upstream.

#### **4.7 Ray (1977)**

**Ray, V.E. (1977). "Ethnic Impact of the Event Incident to Federal Power Development on the Colville and Spokane Indian Reservations." Prepared for the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians, Port Townsend, WA. Available at Eastern Washington State Historical Society, Spokane WA.**

Ray provided expert testimony of the amount of fish consumption of the upper Columbia River Tribes during the discussions of the impact of the Grand Coulee Dam. Ray estimates 1.25 pound per person per day based on 50 years of observation and research,

including fish counts, catch rates, early observers. This is also supported by contemporaneous observations at Celilo during the late 1940s.

"The salmon and other fish taken from the rivers provided around half of the native subsistence, and the lands immediately adjacent to the rivers supplied a significant part of the game which was taken."

"Apart from fish and game, the most important component of the Indian diet was roots."

"Salmon was the staple food for both the Colvilles and the Spokanes. The fish were taken during the long fishing seasons – May to October – but during the same period great quantities were dried to serve and the basic item of subsistence during the winter."

#### **4.8 Boldt (1994) case law**

Judge Boldt stated that "Salmon, however, both fresh and cured, was a staple in the food supply of these Indians. It was annually consumed by these Indians in the neighborhood of 500 pounds per capita."<sup>50</sup> Boldt was referring to Columbia mainstem fishers when he wrote this. This does not include resident fish.

#### **4.9 Bimodality in Tribal communities**

In the above discussion, we have suggested that the cross-sectional tribal surveys summarized in Section 3 reveal a bimodal distribution, with a cluster of people consuming high amounts of fish. We believe that these are accurate reports from members of a distinct group of subsistence consumers, and that most of this group is missed in cross-sectional surveys because they decline to participate in conventional surveys. However, this raises the question of how a tribal or tribal confederation should be stratified, and whether this reflects simply a high end tail of a normal distribution defined by an arbitrary upper percentile or standard deviation, or whether there is a discernible subset of tribal members with a distinct lifestyle and/or a statistically detectable consumption rate.

- In the Sechena study, respondents were divided into low (<75<sup>th</sup> percentile) or higher (> 75<sup>th</sup> percentile) consumers; the basis for this is not given.
- In the Walker (1999) study, Columbia River mainstem fishers were divided into three groups according to how many fishing sites were used by a fisherman; the basis for this was not given.
- In the three tribal cross-sectional studies, there appear to be clusters of high consumers. Since no follow-up was done to investigate the characteristics or accuracy of these individuals, we conclude (as others have concluded) from indirect evidence that these people are members of a subsistence subset that is otherwise obscured by poor study design, and that their reports were indeed accurate.
- In our review of subsistence and cross-sectional studies, we have concluded that a lower threshold for subsistence consumption rates in Columbia River tribal communities is roughly 1 pound per day.

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<sup>50</sup> U.S. District Judge George Boldt, U.S. v. Washington, February 12, 1974, note 151.

The Confederated Umatilla Tribes have distinct subsets of natural resource use according to the original Tribe's homeland; Cayuse emphasized upland hunting more than fishing, while Walla Walla and Umatilla Tribes emphasized fishing more than hunting. During ethnographic interviews, several subsistence consumers confirmed our supposition that traditional subsistence fishers generally decline to participate in surveys by people they don't know, or who give information that they assume is "correct" rather than accurate.

## **5.0 Conclusions**

We conclude that the subsistence consumption rate for the Confederated Tribes is in the range of 540 to 650 gpd or more (particularly at permanent fishing villages such as Celilo). Within this range, we have concluded that the best estimate is 500 pounds per year (or 620 gpd) as the central tendency of subsistence fish consumption, as well as being recognized in a widely-cited legal decision.

- The CRITFC study (1994) is judged to reflect the median river user (350 gpd from Walker) and minimum river users (80 gpd from Walker). This is comparable to the CRITFC 95<sup>th</sup> and 99<sup>th</sup> percentiles (175-182 gpd and 389 gpd) and the CRITFC median (63 gpd), further indicating that the CRITFC study captured data for the minimum and median river users, not the maximum river users.
- The CRITFC "outliers" (reporting a consumption rate of 486-972 gpd) are comparable to Walker's maximum river users (650 gpd), which reflect subsistence use.
- Most per capita estimates of fish consumption rates for subsistence fishers are approximately 500 pounds per year, or 620 gpd as a mean value. These results are based on direct observation of early observers, fish buying records, interview with current members, caloric and nutritional calculations, and ecological and archaeological information.
- Salmon supplied 30% to 40% of the total calories in the river-based subsistence diet. At an average of 175 kcal per 100g of raw fish weight, 620 gpd would provide roughly 1000 kcal daily, which is 40% of a 2500 kcal diet. This conforms with the estimates of Hunn and others that salmon provide 30-40% of the subsistence diet.
- The number of people in the high consumer or maximum river user group diminished as runs were decimated, dams were constructed, and awareness of contamination increased. However, the existence of the subsistent or maximum river user clearly persists to this day, and in fact may be increasing recently as runs are restored and health benefits of eating fish are emphasized.
- The annual amount of 500 pounds per capita has been recognized in the most widely-cited legal decision regarding fishing rights in the Pacific northwest.
- For exposure scenarios that are applied within 20 miles of a major fishing river, we assume that a fish-based diet (rather than a game-based) is applicable.

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## **APPENDIX 4**

### **Sweatlodge Parameters**

## Native American Sweat Lodge Exposure Scenario – Exposure Equations

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### Inhalation in Sweat Lodge

In this analysis it is assumed that the internal temperature of the sweat lodge is maintained at a constant 150 °F. It is further assumed that the geometry of the lodge can be estimated as a hemisphere of radius  $r$  so that the internal volume is equal to:

$$V_{lodge} = \frac{2}{3} \cdot \pi \cdot r^3 \quad (1)$$

where:

$V_{lodge}$  = Internal volume of the sweat lodge ( $\text{m}^3$ )

$r$  = radius of sweat lodge (m)

$\pi$  = the constant pi (unitless);  $\pi \approx 3.14159$

Finally, contaminants, termed Compounds of Potential Concern (COPC), are assumed to be introduced into the sweat lodge predominately through the water used to create steam.

### Volatile and Semi-Volatile Compounds

Inhalation rates are typically estimated as:

$$I_{inh} = \frac{C_v \cdot IR \cdot ET \cdot EF \cdot ED}{BW \cdot AT \cdot CF} \quad (2)$$

where:

$I_{inh}$  = inhalation exposure to COPCs in the sweat lodge (mg/kg-day)

$C_v$  = vapor phase COPC concentration ( $\text{mg}/\text{m}^3$ )

$IR$  = inhalation rate ( $\text{m}^3/\text{hr}$ )

$ET$  = exposure time (hr/event)

$EF$  = exposure frequency (events/yr)

$ED$  = exposure duration (yr)

$BW$  = body weight (kg)

$AT$  = averaging time for carcinogens ( $AT_C$ ) or noncarcinogens ( $AT_N$ ) (yr)

$CF$  = units conversion factor of 365 (day/yr)

For compounds that preferential partition to the air phase it is assumed that a negligible quantity deposit on surfaces or partition into condensed liquid. Thus, the bulk of

contaminants added in the water will remain in the vapor phase throughout the sweat and the vapor concentration of an individual COPC is given by:

$$C_v(t) = C_{dw} \left( \frac{V_w(t)}{V_{lodge}} \right) \quad (3)$$

where:

$C_{dw}$  = dissolved surface water concentration of the COPC (mg/L); calculated according to EPA 1998a, Appendix B

$C_v(t)$  = time dependent vapor phase concentration of the COPC in the sweat lodge (mg/m<sup>3</sup>)

$V_w(t)$  = cumulative volume of water used in the sweat at time  $t$ ; see the discussion of  $V_w(t)$  below (L)

Combining Equations 1 through 3 and recognizing that the total inhalation exposure for a single sweat requires integration of the volume function over the duration of the sweat then the following equation for inhalation exposure results:

$$\int_0^{ET} I_{inh}(t) \cdot dt = I_{inh} = \frac{C_{dw} \cdot \left( \frac{1}{\frac{2}{3} \cdot \pi \cdot r^3} \right) \cdot IR \cdot EF \cdot ED}{BW \cdot AT \cdot CF} \cdot \int_0^{ET} V_w(t) \cdot dt \quad (4)$$

If it is assumed that water is poured over heated rocks at a constant rate throughout the sweat, then the volume function would be described by the following linear equation:

$$V_w = \frac{V_{w,total}}{ET} \cdot t \quad (5)$$

Where  $V_{w,total}$  is the total amount of water that will be used in the sweat to create steam in units of liters (L).

Noting that:

$$\int_0^{ET} V_w(t) \cdot dt = \frac{V_{w,total}}{ET} \cdot \int_0^{ET} t \cdot dt = \frac{V_{w,total}}{2} \cdot ET \quad (6)$$

then the intake by inhalation is described by the following equation:

$$I_{inh} = \frac{C_{dw} \cdot \left( \frac{V_{w,total}}{2} \right) \cdot \left( \frac{1}{\frac{2}{3} \cdot \pi \cdot r^3} \right) \cdot IR \cdot ET \cdot EF \cdot ED}{BW \cdot AT \cdot CF} \quad (7)$$

If more water is poured over the heated rocks during the first part of the sweat, then the following form would be more appropriate:

$$V_w(t) = \frac{V_{w,total} \cdot t}{k + t} \quad (8)$$

where  $V_{w,total}$  is the maximum amount of water poured over the heated rocks during a sweat and  $k$  indicates the time when half of the water has been used. Integration of the above equation between the limits of 0 and  $ET$  results in the following expression for intake via inhalation:

$$I_{inh} = \frac{C_{dw} \cdot \left( \frac{V_{w,total}}{\frac{2}{3} \cdot \pi \cdot r^3} \right) \cdot \left( ET + k \cdot \ln\left(\frac{k}{ET + k}\right) \right) \cdot IR \cdot EF \cdot ED}{BW \cdot AT \cdot CF} \quad (9)$$

The assumptions regarding the mathematical representation of water volume in the sweat lodge are an uncertainty in estimating intake via inhalation for the Native American adult. For simplicity, the linear assumption represented by Equations 5 and 7 is a reasonable approximation for intake via inhalation of volatile and semivolatile compounds in the sweat lodge. Table 1 provides a list of typical values for the parameters used in Equation 7.

**Table 1:** Typical Parameter Values for Calculating  $I_{inh}$  for Volatile and Semi-volatile compounds

Parameter	Typical Value	Unit
Volume of water used in a sweat ( $V_{w,total}$ )	4	L
Radius of a hemispherical sweat lodge ( $r$ )	1	m
Inhalation rate ( $IR$ )	30	$m^3/day$
Length of a sweat event ( $ET$ )	1	hr
Number of sweats per year ( $EF$ )	365	events/yr
Number of years a person sweats in a life time ( $ED$ )	68	yr
Average body weight ( $BW$ )	70	kg
Averaging time ( $AT$ )	1	yr
Conversion factor ( $CF$ )	365	day/yr

Nonvolatile Compounds

The sweat lodge vapor concentration for nonvolatile compounds can be estimated by assuming that:

- Nonvolatile COPC become airborne as an aerosol as the water they were carried in vaporizes.
- Once airborne, nonvolatile compounds deposit onto solid surfaces with aqueous condensation.
- The ideal gas law can be applied to air and water vapor at the temperature and pressure of the sweat lodge.

With these assumptions the quantity of nonvolatile constituents in the air phase is limited to that which is carried into the air phase by the volume of liquid water needed to create saturated conditions in the lodge. Numerically this can be expressed as:

$$C_v = \left( \frac{V_{w,sat}}{V_{lodge}} \right) \cdot C_{dw} \quad (10)$$

where  $V_{w,sat}$  represents the volume of liquid water needed to create a saturated vapor in the sweat lodge in units of liters (L). From the ideal gas law and the properties of liquid water,  $V_{w,sat}$  can be determined from:

$$V_{w,sat} = \left( \frac{p \cdot V_{w,air}}{R \cdot T} \right) \left( \frac{MW_w}{\rho_w} \right) \quad (11)$$

where:

$V_{w,air}$  = volume of air space in sweat lodge occupied by water vapor ( $m^3$ )

$p$  = ambient pressure (mmHg)

$\rho_w$  = density of liquid water (g/L)

$T$  = temperature of the sweat lodge (K)

$R$  = ideal gas law constant ( $0.06237 \text{ (mmHg}\cdot m^3\text{)/(gmole}\cdot K)$ )

$MW_w$  = molecular weight of water (AMU)

The volume of water vapor in the sweat lodge air can be estimated from the vapor pressure of water at the temperature of the sweat lodge (assumed constant at 150 °F), the ambient pressure, and the internal volume of the lodge.

$$V_{w,air} = \left( \frac{p^*}{p} \right) \cdot V_{lodge} \quad (12)$$

where  $p^*$  represents the vapor pressure of water at temperature  $T$  (mmHg). The vapor pressure of water as a function of temperature is given by the Antoine equation as follows:

$$\ln(p^*) = 18.3036 - \frac{3816.44}{T - 46.13} \quad (13)$$

Combining Equations 10 through 13 allows the concentration of nonvolatile COPC in the air to be determined as follows:

$$C_v = C_{dw} \cdot \left( \frac{MW_w}{R \cdot T \cdot \rho_w} \right) \cdot \exp \left( 18.3036 - \frac{3816.44}{T - 46.13} \right) \quad (14)$$

Application of Equation 14 to the definition of vapor inhalation exposure given in Equation (2) yields the following result for nonvolatile compounds:

$$I_{inh} = \left( \frac{IR \cdot ET \cdot EF \cdot ED}{BW \cdot AT \cdot CF} \right) \cdot C_{dw} \cdot \left( \frac{MW_w}{R \cdot T \cdot \rho_w} \right) \cdot \exp \left( 18.3036 - \frac{3816.44}{T - 46.13} \right) \quad (15)$$

Table 2 provides a list of typical values for the parameters used in Equation 15.

**Table 2: Typical Parameter Values for Calculating  $I_{inh}$  for Nonvolatile compounds**

Parameter	Typical Value	Unit
Temperature of the sweat lodge (T)	389 (150)	K (F)
Ideal gas law constant (R)	0.06237	(mmHg·m <sup>3</sup> )/(gmole·K)
Inhalation rate (IR)	30	m <sup>3</sup> /day
Length of a sweat event (ET)	1	hr
Number of sweats per year (EF)	365	events/yr
Number of years a person sweats in a life time (ED)	68	yr
Average body weight (BW)	70	kg
Averaging time (AT)	1	yr
Conversion factor (CF)	365	day/yr
Molecular weight of water (MW <sub>w</sub> )	18	g/gmole
Density of liquid water ( $\rho_w$ )	1000	g/L

### Dermal Exposure in Sweat Lodge

Dermal exposure to COPC in a sweat lodge can come from skin contact with contaminates in both the air and in water that condenses on the skin. Calculation of dermal exposure to COPC from water contacting the skin is typical represented by the following equations:

$$I_{d,l} = \frac{C_{dw} \cdot SA \cdot Kp \cdot ET \cdot EF \cdot ED \cdot CF_3}{BW \cdot AT \cdot CF_2} \quad (16)$$

where:

- $I_{d,l}$  = intake of COPCs from dermal absorption to liquid within the sweat lodge (mg/kg-day)
- $C_{dw}$  = dissolved-phase surface water concentration (mg/L); calculated according to EPA 1998a, Appendix B
- $V_W$  = volume of water (L) used in a single sweat
- $SA$  = body surface area available for contact ( $m^2$ )
- $Kp$  = COPC-specific permeability constant (cm/hr)
- $ET$  = exposure time (hr/event)
- $EF$  = exposure frequency (events/yr)
- $ED$  = exposure duration (yr)
- $CF_1$  = units conversion factor of 0.01 (m/cm)
- $CF_2$  = units conversion factor of 365 (day/yr)
- $CF_3$  = units conversion factor of 10 ( $L/m^2\text{-cm}$ )
- $BW$  = body weight (kg)
- $AT$  = averaging time for carcinogens ( $AT_C$ ) or noncarcinogens ( $AT_N$ ) (yr)

Dermal exposure resulting from skin contact with contaminants in the air is calculated as:

$$I_{d,v} = \frac{C_v \cdot SA \cdot Kp \cdot ET \cdot EF \cdot ED \cdot CF_1}{BW \cdot AT \cdot CF_2} \quad (17)$$

where:

- $I_{d,v}$  = intake of COPCs from dermal absorption to vapor within the sweat lodge (mg/kg-day)
- $C_v$  = vapor-phase concentration for a COPC ( $mg/m^3$ )
- $CF_1$  = units conversion factor of 0.01 (m/cm)

#### Volatile and Semi-Volatile Compounds

Dermal exposure should be calculated using the same assumptions described for inhalation exposure. For volatile and semivolatile compounds, 100% volatilization with a hemispherical sweat lodge was assumed. Hence, the primary exposure pathway will be from vapor and exposure from condensed water can be neglected. The vapor concentration of COPC causing dermal exposure is identical to the inhalation concentration and is given by Equations 3 and 5. Combining Equations 3 and 5 with Equation 17 and integrating between the limits of 0 and ET results in the following prediction from dermal exposure to volatile and semi-volatile compounds.

$$I_{d,total} = I_{d,v} = \frac{C_{dw} \cdot \left( \frac{V_{w,total}}{2} \right) \cdot \left( \frac{1}{\frac{2}{3} \cdot \pi \cdot r^3} \right) \cdot SA \cdot Kp \cdot ET \cdot EF \cdot ED \cdot CF_1}{BW \cdot AT \cdot CF_2} \quad (18)$$

where  $I_{d,total}$  is the total dermal exposure rate for volatile and semi-volatile compounds. Table 3 provides a list of typical values for the parameters used in Equation 18.

**Table 3:** Typical Parameter Values for Calculating  $I_{d,total}$  for Volatile Semi-volatile compounds

Parameter	Typical Value	Unit
Volume of water used in a sweat ( $V_{w,total}$ )	4	L
Radius of a hemispherical sweat lodge ( $r$ )	1	m
Body surface area available for contact ( $SA$ )	1.8	$m^2$
COPC-specific permeability constant ( $Kp$ )	1 to 1E-5	cm/hr
Length of a sweat event ( $ET$ )	1	hr
Number of sweats per year ( $EF$ )	365	events/yr
Number of years a person sweats in a life time ( $ED$ )	68	yr
Average body weight ( $BW$ )	70	kg
Averaging time ( $AT$ )	1	yr
Conversion factor ( $CF_1$ )	0.01	m/cm
Conversion factor ( $CF_2$ )	365	day/yr

#### Nonvolatile Compounds

For non-volatile compounds, the dermal exposure assumptions would result in a concentration in condensed water equal to that of the water added to the heated rocks and a vapor concentration as described by Equation 14. Thus, exposure through dermal contact would be calculated using the following equation:

$$I_{d,I} = \frac{C_{dw} \cdot SA \cdot Kp \cdot ET \cdot EF \cdot ED \cdot CF_3}{BW \cdot AT \cdot CF_2} \quad (19)$$

The dermal exposure to COPC in the vapor phase is represented by combining Equations 17 and 14 as follows:

$$I_{d,v} = \left( \frac{SA \cdot Kp \cdot ET \cdot EF \cdot ED \cdot CF_3}{BW \cdot AT \cdot CF_2} \right) \cdot C_{dw} \cdot \left( \frac{MW_w}{R \cdot T \cdot \rho_w} \right) \cdot \dots \\ \dots \exp \left( 18.3036 - \frac{3816.44}{T - 46.13} \right) \quad (20)$$

The total dermal exposure for nonvolatile compounds is thus represented by the sum of  $I_{d,v}$  and  $I_{d,l}$ . That is:

$$I_{d,total} = I_{d,v} + I_{d,l} \quad (21)$$

Table 4 provides a list of typical values for the parameters used in Equations 19 through 21.

**Table 4:** Typical Parameter Values for Calculating  $I_{d,total}$  for Nonvolatile compounds

Parameter	Typical Value	Unit
Volume of water used in a sweat ( $V_{w,total}$ )	4	L
Radius of a hemispherical sweat lodge ( $r$ )	1	m
Body surface area available for contact ( $SA$ )	1.8	$m^2$
COPC-specific permeability constant ( $Kp$ )	1 to 1E-5	cm/hr
Length of a sweat event ( $ET$ )	1	hr
Number of sweats per year ( $EF$ )	365	events/yr
Number of years a person sweats in a life time ( $ED$ )	68	yr
Average body weight ( $BW$ )	70	kg
Averaging time ( $AT$ )	1	yr
Molecular weight of water ( $MW_w$ )	18	g/gmole
Density of liquid water ( $\rho_w$ )	1000	g/L
Temperature of the sweat lodge ( $T$ )	389 (150)	K (F)
Ideal gas law constant ( $R$ )	0.06237	(mmHg· $m^3$ )/(gmole·K)
Conversion factor ( $CF_1$ )	0.01	m/cm
Conversion factor ( $CF_2$ )	365	day/yr
Conversion factor ( $CF_3$ )	10	$L/m^2\text{-cm}$

#### **W.1.4 A Method for Tribal Environmental Justice Analysis Under NEPA (Draft)**

This white paper presents the CTUIR view of environmental justice from the perspective of actions under the National Environmental Policy Act and the impacts thereof on populations with a traditional subsistence lifestyle.

**ATTACHMENT 2 – Environmental Justice**

**A Method for Tribal Environmental Justice**

**Analysis under NEPA**

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**ABSTRACT**

The goal of environmental justice (EJ) is for all peoples to receive or achieve the same degree of protection from environmental and health hazards. However, methods for EJ analysis under NEPA have never been suitable for Native American tribes, particularly in the western US. The Confederated Tribes of the Umatilla Indian Reservation have developed a method for evaluating and quantifying disproportionate impacts under NEPA. Because many traditional tribal communities are inseparable from their environment, we recommend identifying whose resources are affected as the first step, rather than simply counting the numbers people in various ethnic groups within a predefined zone of analysis. The second step is to describe the eco-traditional system that pertains to the tribe and its resource interests. The features, attributes, goods, and services provided by the baseline conditions of the ethno-habitat and its resources are described, and quantifiable measures to evaluate interruptions in service flow and risks to traditional lifeways over multiple generations are applied. A subsistence exposure scenario and risk assessment based on traditional lifeways is included in this step. Finally, we look at cumulative impacts to the eco-traditional system and to the subsistence economic systems that are crucial for tribal health and well-being. To evaluate cumulative disproportionality or risk disparities for the entire tribe, we evaluate what proportion of the community is affected and the pre-existing co-risk factors that make the community more vulnerable, and compare the results to other population segments or communities.

## **A. INTRODUCTION**

Environmental Justice has been defined by EPA's Office of Environmental Justice<sup>1</sup> as:

*"The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies."*

We believe that the goal of this "fair treatment" is not to distribute risks evenly among populations, but to identify potential disproportionately high and adverse impacts in different populations and reduce the inequities. Although inequities can exist in any setting, impacts of federal actions are most often evaluated through an environmental impact statement prepared under the National Environmental Policy Act (NEPA). All federal agencies are encouraged to consider environmental justice in their NEPA analysis, evaluate disproportionate impacts, and identify alternative proposals that may mitigate these impacts. The fundamental policy of NEPA is to "encourage productive and enjoyable harmony between man and his environment," so that the United States may:

- (1) *fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;*
- (2) *assure for all Americans safe, healthful, productive, and aesthetically and traditionally pleasing surroundings;*
- (3) *attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;*
- (4) *preserve important historic, traditional, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;*
- (5) *achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and*
- (6) *enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.*

In considering how to evaluate progress in reaching these aspirational goals, the Council on Environmental Quality (CEQ) defined effects or impacts to include "ecological...aesthetic, historic, traditional, economic, social or health impacts, whether direct, indirect or cumulative."<sup>2</sup> Recognizing that these types of impacts might disproportionately affect different communities or groups of people, President Clinton issued Executive Order 12898 in 1994<sup>3</sup>, directing each federal agency to, among other things,

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<sup>1</sup> [http://www.epa.gov/compliance/resources/policies/ej/ej\\_guidance\\_nepa\\_epa0498.pdf](http://www.epa.gov/compliance/resources/policies/ej/ej_guidance_nepa_epa0498.pdf)

<sup>2</sup> <http://ceq.hss.doe.gov/nepa/regs/ej/justice.pdf>

<sup>3</sup> President Clinton, WJ: "Federal actions to address environmental justice in minority populations and low-income populations," 59 FR 32: 7629-7633 (Executive Order 12898; February 11, 1994).

- “*Make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations,*”
- “*Identify differential patterns of consumption of natural resources among minority populations and low-income populations,*”
- *Evaluate differential consumption patterns by identifying “populations with differential patterns of subsistence consumption of fish and wildlife,” and*
- “*Collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence.*”

The CEQ’s Guidance for Environmental Justice under the National Environmental Protection Act<sup>4</sup> recognized that tribes might bear disproportionate burdens (emphasis added):

- Agencies should consider the composition of the affected area, to determine whether minority populations, low-income populations, or Indian tribes are present *in the area* affected by the proposed action, and if so whether there may be disproportionately high and adverse human health or environmental effects on minority populations, low-income populations, or Indian tribes.
- Agencies should consider the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards; Agencies should consider these multiple, or *cumulative effects*, even if certain effects are not within the control or subject to the discretion of the agency proposing the action.
- Agencies should recognize the *interrelated* traditional, social, occupational, historical, or economic factors that may *amplify* the natural and physical environmental effects of the proposed agency action. These factors should include the physical sensitivity of the community or population to particular impacts; the effect of any disruption on the *community structure* associated with the proposed action; and the nature and degree of impact on the physical and social structure of the community.
- Agencies should be aware of the diverse constituencies within any particular community Agencies should seek tribal representation in the process in a manner that is consistent with the government-to-government relationship between the United States and tribal governments, the federal government’s *trust responsibility* to federally-recognized tribes, and any treaty rights.

Methods for identifying and evaluating disproportionate environment burdens still lag far behind these goals<sup>5</sup>, particularly for Native Americans. We believe this is due to the language in EPA guidance directing agencies to “collect, maintain and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have substantial environmental, human health, or economic effect on the surrounding populations,”

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<sup>4</sup> <http://ceq.hss.doe.gov/nepa/regs/ej/justice.pdf>

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which led to developing guidance and data based solely on spatial analysis of demographic data<sup>6</sup>. Compounding this is the conventional threshold criterion that 20% of a local community must be of a single ethnic group or below a certain income level in order to be recognized as an environmental justice community<sup>7</sup>.

Identifying an EJ community by geospatial ethnicity is not the same as identifying a disadvantaged layer coexisting within a community<sup>8</sup>. Distinct populations may live differently and separately, and if federal actions or pollution sources are unevenly spaced, then exposures and impacts may be unequal<sup>9</sup>. Multi-variate analysis may be required to determine whether race plays an explanatory role in risk distribution even after controlling for other economic, land-use, and population factors<sup>10</sup>.

Using this combined threshold determination (does a particular ethnic group comprise >20% of the population within a certain distance of the site?), disproportionate impacts to Native Americans are often overlooked. Further, reliance on conventional methods for economic and cumulative analysis as well as lack of consideration of the federal Trust obligations (and Treaties, where they exist) makes most EJ analysis under NEPA almost completely irrelevant to American Indians.

### **The Trust relationship between Native Sovereign Nations and the Federal Government**

“The Federal Government has enacted numerous statutes and promulgated numerous regulations that establish and define a trust relationship with Indian tribes. The United States continues to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, tribal trust resources, and Indian tribal treaty and other rights”<sup>11</sup>. The Supreme Court, in defining the trust responsibility, has held that:

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<sup>6</sup> [http://www.epa.gov/compliance/resources/policies/ej/ej\\_guidance\\_nepa\\_epa0498.pdf](http://www.epa.gov/compliance/resources/policies/ej/ej_guidance_nepa_epa0498.pdf);

Mohai, P. and Saha, R. (2006) Reassessing Racial and Socioeconomic Disparities in Environmental Justice Research. *Demography*, 43: 383-399.

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<sup>10</sup> Morello-Frosch, R., Pastor, M., and Sadd, J (2001). Environmental Justice and Southern California’s “Riskscape:” The Distribution of Air Toxics Exposures and Health Risks among Diverse Communities. *Urban Affairs Rev.* 36: 551-578.

<sup>11</sup> Executive Order 13175, 65 Fed. Reg. 67249 (November 6, 2000); Presidential Memorandum of November 5, 2009, 74 Fed. Reg. 215: 57881 (published on November 11, 2009)

[The federal government] has charged itself with moral obligations of the highest responsibility and trust. Its conduct, as disclosed in the acts of those who represent it in dealing with the Indians, should therefore be judged by the most exacting fiduciary standards. *Seminole Nation v. United States*, 316 U.S. 286, 296-97 (1941).

Both CERCLA and OPA define "natural resources" broadly to include "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources..." Both statutes limit "natural resources" to those resources held in trust for the public. While there are slight variations in their definitions, both CERCLA and OPA state that a "natural resource" is a resource "belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by" the United States, any State, an Indian Tribe, a local government, or a foreign government [CERCLA §101(16); OPA §1001(20)].<sup>12</sup> Thus, for American Indian Tribes the evaluation of disproportionate impacts is more often a question of natural resource use rather than demographics.

## **B. Framework for EJ Analysis**

A framework for Tribal EJ analysis is presented here, including natural resource usage patterns, tribal health risk assessment that considers traditional uses of natural resources, and cumulative analysis that considers preexisting stressors that may cluster in tribal communities.<sup>13</sup>

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<sup>12</sup> <http://www.epa.gov/superfund/programs/nrd/primer.htm>

<sup>13</sup> Harper,B.L. (1995). *The Earth and Myself Are of One Mind: Achieving Equity in Risk Based Decision Making and Land Use Planning*. EPA's State and Tribal Risk Forum, Albuquerque, NM.

Harris, S. & Harper, B. (1998). Using eco-traditional risk in risk-based decision making. *American Nuclear Society Environmental Sciences Topical meeting, Richland WA*.

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Harris, S. (1999). Native American perspectives on environmental justice and environmental permitting. *Keynote Speaker, Native American Heritage Month, sponsored by Argonne National Laboratory, the Department of Energy's Center for Risk Excellence. Chicago*.

Harper, B.L. & Harris, S.G. (1999). Measuring Risks to Community Health and Quality of Life. 9<sup>th</sup> ASTM Symposium on Environmental Toxicology and Risk Assessment, (Paper #6034, Committee E47), published in "Environmental Toxicology and Risk Assessment" (F Price, K Brix and N Lane, eds.), 2000, pages 195-211. Harris,

Harris, S. & Harper, B. (1999). Environmental justice in Indian country: using equity assessments to evaluate impacts to trust resources, watersheds, and eco-traditional landscapes. Proceedings of "Environmental Justice: Strengthening the Bridge Between Tribal Governments and Indigenous Communities, Economic Development and Sustainable Communities" (posted at <http://www.iirm.org/publications/EnvJust/paper0~1.pdf>)

S.G. (2000). Environmental Justice and Native Perspectives. *Invited presentation at the meeting "How Should Environmental Justice be Addressed in Indian Country?" Sponsored by the Federal Interagency Working Group, Albuquerque*.

Harris, S.G. (2000). Risk analysis: changes needed from a Native American perspective. *Human and Ecological Risk Assessment 6*, 529-535.

Harper, B. & Harris, S. (2001). Equity Assessment and tribal eco-traditional risk. *Alaska Forum on the Environment*.

Harper, B. & Harris, S. (2001). *An Integrated Framework for Characterizing Cumulative Risks To Tribal Health And Well-Being And Subsistence Lifeways*. IIRM, Denver CO ([www.iirm.org](http://www.iirm.org)), and Report to EPA/OSWER.

*Step 1. Resource and Community Identification.*

The Resource Identification regarding a site or area is defined as the probability of a natural or traditional resource of tribal importance being present and potentially impacted. Particularly in the western United States, asking the following questions may reveal unrecognized potential for disparate impacts:

- What potential EJ populations use the resources from the impacted zone?
- How is the area or resource used; how important are those resources or places to the EJ population; what attributes of the resource or system does the community value?
- Is the affected area linked ecologically, traditionally, visually, or hydrologically to other tribal resources or areas? Is the affected area within a tribal historic area (usual and accustomed area, ceded area), a traditional traditional property, a viewshed, or a tribally important landscape?
- Is a tribe a Natural Resource Trustee of the affected resource or lands?
- Does the affected area include sacred sites, historical/ archaeological sites, burial sites, and sites containing important traditional traditional materials or with associated traditional uses or history?

*Step 2. Damage Potential.*

This step describes the baseline and existing conditions and potential for damage due to physical disturbance, contamination, desecration or aesthetic degradation.

- Describe the affected resources and eco-traditional systems, and the uses that different population segments make of the area and its resources.
- Describe the features and attributes of the ecosystem or eco-traditional system that people value.
- Describe the goods and services flowing from the system under baseline conditions. For convenience, these may be grouped in various ways, such as (a) ecological, traditional, recreational and general impact categories<sup>14</sup>, (b) health, ecological, socio-traditional, and socio-economic endpoints<sup>15</sup>, or (c) natural, human, built, and economic systems<sup>16</sup>.
- Estimate the time until, and duration of, adverse impact (a measure of threat imminence or urgency as well as recovery time).
- Describe the existing stressors and resiliency of the affected systems, both ecological and human (a measure of vulnerability).
- Describe the socio-economic system; subsistence economy if applicable.

*Step 3. Consequence Potential.*

This step evaluates the interruptions of service flows, the cumulative impacts (health risk, impacts to the subsistence or socio-economic system, cumulative health risks and impacts, and socio-traditional impacts), and the disparity between the tribe's impacts and those of the general population.

- Measure injury or impact to individual and combined resources and reductions in service flows, at local, eco-system, and regional scales.
- If the potential for any amount of contamination exists, evaluate multi-pathway, multi-contaminant health risks using exposure scenarios for each population segment (traditional subsistence scenario for tribal uses).
- Evaluate cumulative health impacts considering existing community circumstances and tribal definitions of health and well-being.

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<sup>14</sup> C. Ridolfi, personal communication, 2009.

<sup>15</sup> Harper and Harris, *ibid*.

<sup>16</sup> [http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/ROGUE%20WS\\_FINAL.pdf](http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/ROGUE%20WS_FINAL.pdf)

- Measure socio-traditional and socio-economic impacts using tribally-relevant parameters.
- Describe of disparities between populations across all consequences.

Table 1 presents an example of the systematic consideration of affected resources and the information needed for the equity analysis and cumulative impact analysis in an Environmental Impact Statement. This format is followed in the Hanford example that follows.

*Table 1. Example of table for each resource*

Affected Resource	Features and Attributes of the baseline resource	Goods and Services provided under baseline conditions	Measurement Endpoints (parameters, direction of improvement or decrement)
Landscape	Sacred geography	Religious experience Linguistic landmarks Traditional mnemonics	Degrees of vision with undisturbed viewshed
Groundwater	Undegraded GW	Drinking water Domestic uses Agriculture-Pasture Sweatlodge use	Gal-yrs > dw std Gal-yrs > cum risk Acre-ft-yrs > Ag std Gal-yrs > d.l.
Salmon	Wholesome food, eco-traditional resource, indicator of ecosystem health	First Food, income and barter services, oral tradition, language, education, behavioral role model, ecological services	Detectable Hanford-related contaminants; Degree of health risk at tribal consumption rates (modeled and measured).

### **C. Hanford Site NEPA Analysis**

This section is an example of language from the perspective of the Confederated Tribes of the Umatilla Indian Reservation that could be included in Hanford Environmental Impact Statements.

#### **C.1 Environmental Setting and Worldview**

People have inhabited the Columbia Basin from the Younger Dryas era (13,000 to 10,000 years ago) at the end of the Pleistocene era and throughout the Holocene era to the present. Throughout this time climate changed, vegetation changed, and water tables fell, rose, and fell again.<sup>17</sup> The human ethnohistory in the Columbia Basin is divided into traditional periods that parallel the climatic periods and represent traditional adaptations to changing environmental conditions. Throughout this entire period the oral history continually added information needed for survival and resiliency as the climate fluctuated. These teachings were built over thousands of years, and still teach each generation how to live and behave to sustain themselves and the community. The oral tradition provides accounts and descriptions of the region's flora, fauna, and geology. Some stories and oral histories contain factual information and accurate explanations of environmental processes such as ancient floods, lava flows, the meaning of fossils, identification of extinct plants and animals and their habitats, or ecological principles and relationships such as the role of salmon carcasses in the riverine nutritional cycle. Other oral teachings are expressed in symbolic terms and contain social principles and traditional values (e.g., a coyote fable associated with a physiographic feature used to teach a moral lesson or serve as a mnemonic for practical behavioral instructions). Oral histories impart basic beliefs, teach moral values and the land ethic, and help explain the creation of the world, the origin of rituals and customs, the location of food, and the meaning of natural phenomena. Cameron (2008)<sup>18</sup> examined archaeological, ethnographic, paleo-environmental, and oral historical studies from the Interior Plateau of British Columbia, Canada, from the Late Holocene period, and found correlations among all four sources of information.

The Columbia River flows through what was a traditional and economic center for the Plateau communities. The land and its many entities and attributes provided for all their needs: hunting and fishing, food gathering, and endless acres of grass on which to graze their horses, commerce and economy, art, education, health care, and social systems. All of these services flowed among the natural resources, including humans, in continuous interlocking cycles. Adverse impacts to any resource ripple through the entire web and through interconnected biological and human communities. Therefore, if the link between a person and his/her environment is severed through the introduction of contamination or physical or administrative disruption, natural resource service flows may be interrupted, the person's health suffers, and the well being of the entire community is affected<sup>19</sup>.

These relationships form the basis for the unwritten laws or *Tamanwit* that were taught by those who came before, and are passed on through generations by oral tradition in order to protect those yet to arrive.

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<sup>17</sup> <http://www.oregon-archaeology.com/archaeology/oregon/>;  
[http://www.wac6.org/livesite/precirculated/1803\\_precirculated.pdf](http://www.wac6.org/livesite/precirculated/1803_precirculated.pdf);

Mehringer, P.J. (1996) "Columbia River Basin EcosystemsL Late Quaternary.

<http://www.icbemp.gov/science/mehringe.pdf>.

<sup>18</sup> Cameron, I (2008) "Late Holocene environmental change on the Interior Plateau of Western Canada as seen through the archaeological and oral historical records." World Archaeological Congress 6, Dublin, Ireland.

<sup>19</sup> S Harris. "Traditional Legacies: Challenge to the Risk Community." Plenary Address, Society for Risk Analysis Annual Meeting, Phoenix, AZ, December 7, 1998;  
Cajete, G (1999). A People's Ecology. Clear Light Publishers, Santa Fe, New Mexico.

The ancient responsibility to respect and uphold these teachings is directly connected to the culture, the religion, and the landscape along the Columbia Plateau. Individual and collective well-being is derived from membership in a healthy community that has access to, and utilization of, ancestral lands and traditional resources, so that each person may fulfill his or her part of the natural cycles and the responsibility to uphold the natural law. The traditional identity, survival, and sovereignty of the native nations along the Columbia River and its tributaries are maintained by adhering to, respecting, and obeying these ancient unwritten laws.

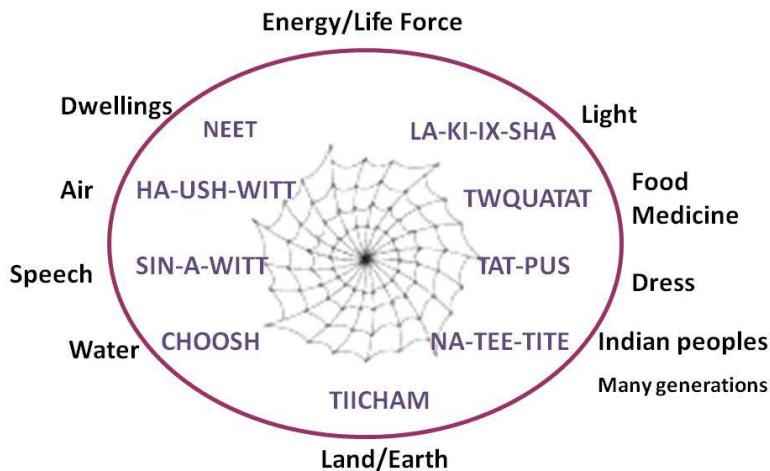


Figure 1. Depiction of CTUIR Tamanwit, the Natural Law.

## C.2 Affected Resources

In a NEPA analysis, impacts of proposed federal actions on a range of environmental attributes are evaluated, as well as potential impacts to a variety of health, economic, and other endpoints. The term “impact” implies an adverse effect, but of course a federal action may also result in improvements, so the metrics used for the evaluation need to be amenable to both decrements and benefits.

### C.2.1 Aesthetic and Physiographic Resources

It is well known that environmental attributes or qualities such as wilderness, solitude, peace, calm, quiet, and darkness are important to individual species that need large undisturbed habitat as well as to humans who value those experiential qualities<sup>20</sup>. Quiet is an important resource. Noise can affect living organisms in the ecosystem through interruption of reproductive cycles and migration patterns, and driving away species that are sensitive to human presence. Non-natural noise can be offensive while traditional ceremonies are being held. Light at night affects nocturnal animals such as bats, owls, night crawlers and other species. Night light also has known affects on diurnal creatures and plants by interrupting their natural patterns. Light can affect reproduction, migration, feeding and other aspects of a living organism's survival. Light at night also disrupts the quality of human experience, including star gazing and traditional activities.<sup>21</sup>

Viewscapes tend to be panoramic and are traditional and sacred landscapes when they contain prominent topography or vantage points from which to view a panorama composed of multiple songscapes and storyscapes. Traditional landscapes have been defined by the World Heritage Committee as distinct geographical areas or properties uniquely representing the combined work of nature and of man. They identified and adopted three categories of landscape: the purely natural landscape, the human-created landscape, and an associative traditional landscape which may be valued because of the religious, artistic or traditional associations of the natural and/or human elements. Traditional landscapes may be invisible unless they are disclosed by the peoples to whom they are important. Tribal values lie embedded within the rich traditional landscape and are conveyed to the next generation through oral tradition by the depth of the Indian languages. Numerous landmarks are mnemonics to the events, stories, and traditional practices of native peoples. Within this landscape are songs and fables associated with specific places; when access is denied a song or fable may be lost.

Within a broad sacred landscape there may be numerous individual traditional sites and resources. They can be mountains, rivers, lakes, caves, forest groves, coastal waters, and entire islands. The reasons for their sacredness are diverse. They may be perceived as abodes of deities and ancestral spirits; as sources of healing water and plants; places of contact with the spiritual, or communication with the 'beyond-human' reality; and sites of revelation and transformation. As a result of access restrictions, many sacred places are now important reservoirs of biological diversity. Sacred natural sites such as forest groves, mountains and rivers, are often visible in the landscape as vegetation-rich ecosystems, contrasting dramatically from adjoining, non-sacred, degraded environments.<sup>22</sup>

Aesthetic and Physiographic Resources			
Affected Resource	Features and Attributes of the baseline resource	Goods and Services provided under baseline conditions	Measurement Endpoints (parameters, direction of improvement or decrement)

<sup>20</sup> [http://findarticles.com/p/articles/mi\\_m1145/is\\_n8\\_v29/ai\\_15769900/](http://findarticles.com/p/articles/mi_m1145/is_n8_v29/ai_15769900/);

[http://findarticles.com/p/articles/mi\\_m1145/is\\_n8\\_v29/ai\\_15769900/](http://findarticles.com/p/articles/mi_m1145/is_n8_v29/ai_15769900/)

<sup>21</sup> [http://www.miller-mccune.com/science\\_environment/blinded-by-the-light-1501](http://www.miller-mccune.com/science_environment/blinded-by-the-light-1501)

<sup>22</sup> Oviedo, G. (2002). member of the Task Force of Non-Material Values of Protected Areas of the World Commission on Protected Areas (WCPA), at the Panel on Religion, Spirituality and the Environment of the World Civil Society Forum, Geneva, 17 July 2002.

Stoffle, R.W., Halmo, D.B., Austin, D.E. (1998). Traditional Landscapes and Traditional Properties: a Southern Paiute View of the Grand Canyon and Colorado River. American Indian Quarterly, Vol. 21: 229-250.

Walker, D.E., 1991. "Protection of American Indian Sacred Geography," in: *Handbook of American Indian Religious Freedom*, Vecsey, C., Ed., Crossroad, New York, NY, pp. 100-115.

Greaves, T., 1996. "Tribal Rights," *Valuing Local Knowledge*, Brush, S.B. and Stabinsky, D., eds., Island Press, Washington, D.C., pp. 25-40.

Landscape(s) and viewshed	Intact scape for places, names, songs, calendar, other services. Undisturbed physiographic profile.  Sacred geography;  Vista for general public	Religious experience Linguistic landmarks Traditional mnemonics Quality of recreational experience	Impact on physiographic profile;  Loss or recovery of native scapes.  Degrees of vision with undisturbed viewshed;  Degradation or improvement in viewshed; changes in physiographic profile over time (lifecycle);  Significance of direction or features of interruption (line of sight);  Duration of impacts;  Quality of recovery plan after operation is over.
Wilderness	Solitude, ‘nature’	Quality of religious or recreational experience; safety from intrusion	Distance to nearest disturbance;  Preservation of or recovery of baseline or target conditions (uncontaminated, biodiverse)
Quiet			Detectable noise night and day
Darkness			Degrees of vision with and without lights

### C.2.2 Water, Soil, and Air.

Water sustains all life. As with all resources, there is both a practical and a spiritual aspect to water. Water is sacred to the Indian people, and without it nothing would live. When having a feast, a sip of water is taken either first or after a bite of salmon, then a bite of salmon, then small bites of the four legged animals, then bites of roots and berries, and then all the other foods.

The concept of sacred water or holy water is global, and often connects people, places, and religion; religions that are not land-connected may lose this concept.<sup>23</sup> The quality of purity is very important for ceremonial use of water. For example, making a sweat lodge and sweating is a process of cleansing and purification, and the water used for sweat-bathing should be uncontaminated. From a ceremonial perspective, the most important drop of contamination is not the drop that causes a body of water to

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<sup>23</sup> Altman, N. (2002) Sacred Water: the Spiritual Source of Life. Mahwah, NJ: Hidden Spring Publ.; Marks, W.E. (2001) The Holy Order of Water. Vancouver BC: Steiner Books Inc.; Burmil, S., Daniel, T.C., and Hetherington, J.D. (1999). Human values and perceptions of water in arid landscapes. *Landscape and Urban Planning*, 44: 99-109; Mazumdar, S. and Mazumdar, S. (2004). Religion and place attachment: A study of sacred places. *Journal of Environmental Psychology*, 24: 385-397.

exceed a numerical standard, but the drop that changes the quality of the water from pure to impure. Additionally, concepts related to the flow of services from groundwater and the valuation of groundwater are receiving increased attention.<sup>24</sup>

<b>Air, Water, Soil</b>			
<b>Affected Resource</b>	<b>Features and Attributes of the baseline resource</b>	<b>Goods and Services provided under baseline conditions</b>	<b>Measurement Endpoints (parameters, direction of improvement or decrement)</b>
Surface water	Ecological	Habitat and provisions for plants, fish and wildlife; ground water recharge	Ecological measures include water quality standards, and other measures not listed here.
	Traditional	Habitat for sacred plants, fish, and wildlife; subsistence use; ceremonial drinking; support for traditional lifeways	Gal-yrs > tribal risk-based std Gal-yrs > cum risk target level Gal-yrs > d.l. Multiplier for traditional importance; Any institutional control needed to protect human (including tribal) health
	Recreational	Sport fishing; hunting; boating; swimming; wildlife observations	Gal-yrs > general dw std
	General	Commercial fishing; transportation; irrigation; drinking; pasture	Acre-ft-yrs > Ag std
Groundwater	Ecological	Surface water recharge; wetland recharge, river upwelling	See other sections
	Traditional	Ceremonial and spiritual use and drinking	Gal-yrs > d.l. Gal-yrs > cum risk
	Recreational	Drinking water	Gal-yrs > dw std
	General	Commercial, municipal, industrial, and domestic use; irrigation; pasture; public drinking	Gal-yrs > dw std Acre-ft-yrs > Ag std Any institutional control needed to protect human (including tribal) health
Air		Human health	Sitewide emissions profile over lifespan of activity; Standards: NAAQS, NESHAPS, PM, diesel, ozone, other standards. Dust resuspension Airborne doses

<sup>24</sup> National Research Council (1997) Valuing Ground Water: Economic Concepts and Approaches. Washington D.C.: National Academy Press.

		Visibility	Haze rule; Indirect impacts from energy production, ozone emissions, diesel use. Contribution or benefit to PSD area or attainment status. Greenhouse gas emissions.
Soil and sediment	Clean soil	Matrix for life support	Total vadose zone inventory of contaminants; Undisturbed soil profile;
		Human health	Soil pathways with tribal soil ingestion rate; Soil pathways as part of cumulative multimedia exposure Exceedance of sediment standards (biota) and dose to people (as above) Any institutional control needed to protect human (including tribal) health  Exceedance of human or biotic standard
		Tribal uses (pigments, clays, etc.), pottery	Degree of Tribal access to special materials
		Biotic health; Habitat for sacred plants, fish, and wildlife;	Microbial quality (crust, nutrient cycling, etc.)
		Fill material	Volume, area, and diversity of clean fill area; Quality of mitigation actions; Minimization of disturbance and linked resource impacts

### **C.3 Terrestrial and Aquatic Biological Resources**

#### Ecosystem Scale.

An ethnoecological approach to describing terrestrial resources will complement the purely ecological descriptions that conventionally are included in sections about affected resources in an EIS. These sections begin with descriptions of the potential natural vegetation within the Columbia Basin ecozones (e.g., using EPA Ecoregion Level 1-4 maps and vegetation descriptions), and then describe the natural resource usage patterns of the Plateau Area.<sup>25</sup>

<sup>25</sup> <http://www.fs.fed.us/land/pubs/ecoregions/ch48.html#342I>

Biological resources are integral to many traditional practices and celebrations throughout the year, many of which honor the traditional foods or First Foods. Based on the importance and many uses of the natural resources, an exposure scenario reflecting the underlying ethnohabitat or eco-traditional system was developed for use in dose and risk assessments at Hanford (Harper and Harris 1997; Harris and Harper 2000; CTUIR 2004)<sup>26</sup>. Ethno-habitats or eco-traditional systems can be defined as the set of traditional, religious, nutritional, educational, psychological, and other goods and services provided by intact, functioning ecosystems and landscapes. A healthy ethno-habitat or eco-traditional system is one that supports its natural plant and animal communities and also sustains the biophysical and spiritual health of its native peoples. Ethno-habitats are places clearly defined and well understood by groups of people within the context of their culture. These are living systems that serve to help sustain modern Native American peoples' way of life, traditional integrity, social cohesion, and socio-economic well-being. The lands, which embody these systems, encompass traditional Native American homelands, places, ecological habitats, resources, ancestral remains, traditional landmarks, and traditional heritage. Larger ethno-habitats can include multiple interconnected watersheds, discrete geographies, seasonal use areas, and access corridors.<sup>27</sup> A depiction of the eco-traditional system for the CTUIR is shown as a seasonal round that includes both terrestrial and aquatic resources.



<sup>26</sup> Harris, S.G. and Harper, B.L. "A Native American Exposure Scenario." *Risk Analysis*, 17(6): 789-795, 1997; S Harris and B Harper. "Using Eco-Traditional Dependency Webs in Risk Assessment and Characterization." *Environmental Science and Pollution Research*, 7(Special 2): 91-100, 2000;

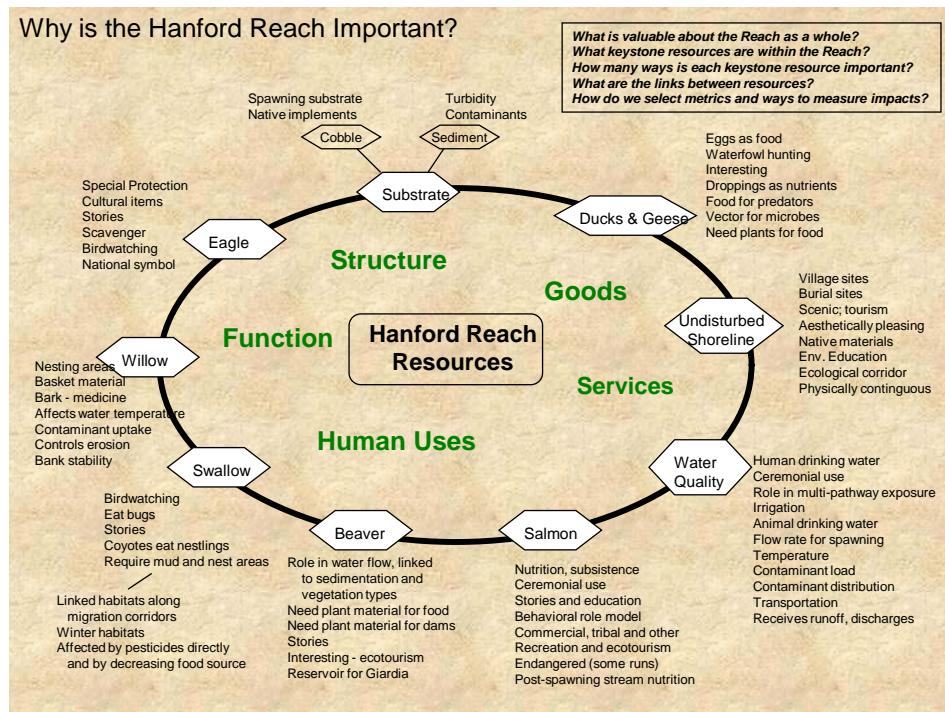
Harper, B.L., Harding, A.D., Waterhous, T. & Harris, S.G. (2008). *Traditional Tribal Subsistence Exposure Scenario and Risk Assessment Guidance Manual* US Environmental Protection Agency EPA-STAR-J1-R831-46; posted at <http://www.hhs.oregonstate.edu/ph/tribal-grant-main-page>.

<sup>27</sup> Modified from the East-Side EIS of the Interior Columbia Environmental Management Plan (ICBEMP).

The Columbia River, which cuts through the Hanford site, is the life blood of the region, with rich diverse fisheries delicately balanced on thriving aquatic ecosystems. The Hanford Reach is the last free-flowing segment of the Columbia River and is home of the last remaining naturally spawning fall Chinook.

Ancestral CTUIR fisheries sites are located throughout the Hanford Reach. The health of the Hanford Reach is the keystone essential to the survival of Columbia Basin fisheries and CTUIR Treaty rights and resources.

Aquatic resources in the Hanford Reach (the area of the river flowing through the Hanford site) include many species, including people<sup>28</sup>. An illustration of resource interconnections and services is shown in the following figure.



### Traditional and ecological keystone species

All natural resources are significant to tribal culture as part of functioning ecosystems, and many are individually important as useful for food, medicines, materials, or other uses. As both the seasonal round and the Hanford Reach web show, some species have more prominent roles than others for a variety of reasons. Identifying the keystone species important to different groups of people provides information about the disproportionate impacts to those groups of people.

<sup>28</sup> Harris, S.G. & Harper, B.L. (2000). Using eco-traditional dependency webs in risk assessment and characterization of risks to tribal health and cultures. *Environmental Science and Pollution Research* 2, 91-100.

## **D. EJ Analysis**

EJ analysis is basically a comparison of the degree of impacts among different human communities. This can entail comparing Town A to Town B, comparing impacts on migrant workers to the general population, comparing impacts on children and elders to healthy adults, or comparing impacts on resources and services important to different population segments. The summary step should provide a thoughtful comparison of impacts and benefits; for example, development might provide a few jobs for the general population at the expense of losing a ceremonial spring that affects an entire tribe. A strict economic analysis might portray the project as a net benefit to a county, while not recognizing the negative impacts that accrue to a tribe. If reduced to simply a dollar valuation, tribal impacts are inevitably undervalued. Therefore, part of the EJ analysis must find another way to bring tribal interests into parity. One way to do this is by examining the proportion of the EJ population that is adversely affected rather than absolute numbers.

Some of the aspects that are most relevant to many tribal situations include (but are not limited to):

1. Disparities in the significance of natural resource impacts across various human populations (e.g., tribal, general population, recreational community);
2. Disparities in contamination-based human health risk based on exposure scenarios relevant to different populations;
3. Disparities in socio-traditional impacts (interruptions of socio-traditional services);
4. Disparities in economic impacts;
5. Disparities in cumulative risk (risk to health, culture, economy, homeland security, etc) based on the tribal definition of health and well-being; identification of vulnerabilities and co-risk factors.
6. Overall equity summary; proportion of EJ population affected.

### **D.1 Natural Resource Impacts**

Parameters for evaluating harm to natural resources have been suggested above, so they are not further discussed here.

### **D.2 Health Risk Analysis**

“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>29</sup>.

When tribal resources and services are impacted by contamination, a tribal exposure scenario may be warranted. Traditional or subsistence scenarios are similar in format to existing residential, recreational, or occupational exposure scenarios, but reflect and are inclusive of tribal traditional and lifestyle activities<sup>30</sup>. They are comprised of:

1. standard exposure pathways and exposure factors (such as inhalation rates or soil ingestion rates but with increased environmental contact rates),
2. traditional diets composed of native plants and animals, and
3. unique pathways such as the sweatlodge, gathering and use of basket materials, etc.

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<sup>29</sup> <http://www.epa.gov/region02/community/ej/superfund.htm>

<sup>30</sup> Harris, S.G. & Harper, B.L. (1997). A Native American exposure scenario. *Risk Analysis*. 17, 789-795.

Harris S.G. & Harper B.L. (2004). *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*. Pendleton, OR: Confederated Tribes of the Umatilla Indian Reservation

Tribal exposure scenarios pose a unique problem in that much of the specific traditional information about the uses of plants and animals for food, medicine, ceremonial, and religious purposes is proprietary. However, the basic activities (e.g., fishing, hunting, gathering) as well as significant traditional activities (e.g., basketmaking, pottery, firewood gathering, sweating) are shorthand labels that identify some of the most visible activities within this personally self-sufficient or subsistence economy. Major activities in the generally-recognized activity categories can be described in enough detail to understand the basic frequency, duration, and intensity of environmental contact within each category and habitat. This allows the identification of exposure pathways and estimation of 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.

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 (or would be available if uncontaminated and undegraded);
2. Lifestyle description – activities and their frequency, duration and intensity, and uses of natural resources;
3. Diet (indirect exposure factors);
4. Pathways and media;
5. Exposure factors - Crosswalk between pathways and direct exposure factors; cumulative soil, water and air exposures.

The basic components of the exposure scenario are given below. Details are posted at [www.phs.oregonstate.edu/ph/tribal-grant-main-page](http://www.phs.oregonstate.edu/ph/tribal-grant-main-page).

- Soil ingestion = 400 mg/d for all age groups
- Inhalation rate = 25 m<sup>3</sup>/d for adults, with children scaled from the adult value

- Drinking water = 3L/d for adults, with children scaled from the adult value; an additional 1L is ingested during each use of the sweat lodge.
- Based on the ecological resources and on the anthropological literature, the CTUIR developed two relevant diets, one for the Columbia River regions where salmon forms a large percentage of the protein source, and one for upland and mountain areas with resident fish and spawning areas for anadromous species.

#### D.3 Socio-traditional Impacts

Examples of socio-traditional activities that are generally tied to the land and that might be disproportionately affected by federal actions are listed below. For individual sites, tribes should be consulted to develop site-specific measures.

- Impact on societal structure and cohesion (e.g., hours per year unavailable for social interaction through loss or reduced value of the resource or area)
- Educational opportunity (e.g., lost study areas associated with traditional stories or place names or family history or traditional practices; lost R&D opportunity)
- Integrity of traditional resources: number of sites with any disturbance or contamination, weighted by type and years of history associated with the site.
- Access to traditional lands: degree of restricted access (e.g., full restriction to any area or resource evidenced by institutional controls or barriers or reduced visits), fraction of ceremonial resources available relative to original quantity and quality
- Traditional landscape quality: proxy scale with elicited judgment based on original condition; total remaining landscape size without encroachments
- Degree of compliance with Treaty rights (e.g., proxy scale based on access, safety, natural and traditional resource integrity and quality, freedom from encroachments, hassle-free exercise of rights)
- Degree of Compliance with Trusteeship obligations with evaluation of tribal services.
- Preservation of future land use and remedial options (e.g., acres of permanent losses including plumes, number of uses no longer viable, number of curies x half-life in irretrievable waste forms)
- Degree of sustainability of the resource, its degree of permanent administrative protection, and associated exercise of Treaty rights of access and use.

#### D.4 Economic Impacts

The eco-traditional system described in other sections includes human, biological, and physical components, and supports the flow of nutritional, religious, spiritual, educational, sociological, and economic services. In the general population these service flows are quantified in the symbolic form of dollars or other trusted and agreed-on exchange systems.

Indigenous economies provide the same types of services as any other economy, including employment (i.e., the roles of individuals in maintaining the functional community and ensuring its survival), shelter (house sites, construction materials), education (intergenerational knowledge required to ensure sustainable survival through time and maintain personal and community identity), commerce (barter items and stability of extended trade networks), hospitality, energy (fuel), transportation (land and water travel, waystops, navigational guides), recreation (scenic visitation areas), and economic support for specialized roles such as religious leaders and teachers.

As in dollar-based economies, indigenous subsistence communities use exchange systems composed of networks of materials with labor-based value (how long does it take to acquire or make the item, what skill is required, what effort is expended, what importance does the item have, what status does the item confer). Indigenous communities ensure the flow of goods and services with interlinked networks of reciprocity, obligation, and trust. Together these networks determine how materials, services, and information flow within the community and between the environment and the community. Wealth and security include the accumulation of knowledge, skills, and obligations as well as, or more than, the accumulation of material items including ‘money.’ In economic terms, this system is called a subsistence economy. An explanation of “subsistence” developed by the EPA Tribal Science Council is as follows.<sup>31</sup>

“Subsistence is about relationships between people and their surrounding environment, a way of living. Subsistence involves an intrinsic spiritual connection to the earth, and includes an understanding that the earth’s resources will provide everything necessary for human survival. People who subsist from the earth’s basic resources remain connected to those resources, living within the circle of life. Subsistence is about living in a way that will ensure the integrity of the earth’s resources for the beneficial uses of generations to come.”

A subsistence economy includes people with a wide range of ‘jobs’ such as food procurement, processing, and distribution; transportation (pasturing and veterinary); botany/apothecary services; administration and coordination (chiefs); education (elders, linguists); governance (citizenship activities, conclaves); finance (trade, accumulation and discharge of obligations); spiritual health care; social gathering organization; and so on. The categories of ‘fish, hunt, and gather’ each include a full cross section of these activities. This is why ‘hunting’ is not just the act of shooting and eating an animal, but includes a full cross-section of all the activities that a hunter-specialist does within their community.

Many contemporary tribal families include members engaged in both monetary and subsistent activities as wage-laborers, part-time workers, professional business people, traditional craft makers, seasonal workers, hunters, fishers, artisans, and so on. Tribal governments engage in the western dollar-based economies but also use traditional and modern technologies for harvesting and preserving foods as well as for distributing goods and services through communal networks of sharing and caring.

NEPA analysis should include subsistence economics, and not simply dollar economics.

#### D.5 Cumulative Risk

There is a growing recognition that conventional risk assessment methods do not address all of the things that are “at risk” in communities facing the prospect of contaminated waste sites, permitted chemical or radioactive releases, or other environmentally harmful situations. Conventional risk assessments do not provide enough information to “tell the story” or answer the questions that people ask about risks to their community, health, resource base, and way of life. As a result, cumulative risks, as defined by the community, are often not described, and therefore the remedial decisions may not be accepted. The full span of risks and impacts needs to be evaluated within the risk assessment framework in order for cumulative risks to be adequately characterized<sup>32</sup> (National Research Council, 1994, 1996; President's Commission, 1997).

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<sup>31</sup> Tribal Science Council (2002). “Subsistence: A Scientific Collaboration between Tribal Governments and the USEPA.” Provided by John Persell (jpersell@lldrm.org).

<sup>32</sup> National Research Council, 1994. *Building Consensus: Risk Assessment and Management in the Department of Energy’s Environmental Remediation Program*. National Academy Press, Washington, D.C.

### Health, Security, and Quality of Life

Because many communities need more information than simply risk and dose results, the Environmental Protection Agency developed a Comparative Risk method over a decade ago for adding a community welfare or quality of life component<sup>33</sup>. The Comparative Risk field has been developing methods for community Quality of Life (QOL) that combine traditional, social, and economic measures along with aesthetics and any other factor the community identifies as important<sup>34</sup>. We have modified this concept to reflect traditional tribal traditional values as well as secular or social community aspects that apply to suburban as well as to tribal communities<sup>35</sup> (Harper et al., 1995; Harper and Harris, 2000).

John M. Last defines individual human health as “a state characterized by anatomic integrity, ability to perform personal, family, work, and community roles; ability to deal with physical, biological, and social stress; a feeling of well-being; and freedom from the risk of disease and untimely death”<sup>36</sup>. This definition is broader than the regulatory approach which tends to equate good health with lack of excessive exposure. Definitions of health and functionality from the public health literature include a variety of medical and functional measures, but may not specifically call out the fact that the survival and well-being of every individual and culture depends on a healthy environment. This broader approach used with risk assessments is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life.<sup>37</sup>

**Homeland Security.** A secure homeland means the same for tribal sovereign nations as it does for any other level of government. Impacts to homeland security of native sovereign nations may be a relevant part of EJ analysis.

- Land Base – a secure land base with jurisdiction and ownership, free from encroachment or legal threat to sovereignty or self-government or jurisdiction.

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National Research Council, 1996. *Understanding Risk: Informing Decisions in a Democratic Society*. National Academy of Science, Washington, D.C.

Presidential/Congressional Commission of Risk Assessment and Risk Management, President’s Commission: *Framework for Environmental Health Risk Management (Final Report, Volume 1* (1529 14<sup>th</sup> Street, NW, Suite 420, Washington, D.C., 1997) and (<http://www.riskworld.com>).

<sup>33</sup> U.S. Environmental Protection Agency, 1993. “A Guidebook to Comparing Risks and Setting Environmental Priorities.” EPA-230-B-93-003.

<sup>34</sup> L Lindholm, M Rosen and M Emmelin How many lives is equity worth? A proposal for equity adjusted years of life saved. *Journal of Epidemiology and Community Health* 1998;52:808-811;  
Ponce, RA., Bartell, SA., Wong, EY, LaFlamme, D., Carrington, C., Lee, RC., Patrick, DL., Faustman, EM., and Bolger, M. (2002) Use of Quality-Adjusted Life Year Weights with Dose-Response Models for Public Health Decisions: A Case Study of the Risks and Benefits of Fish Consumption. *Risk Anal.* 20: 529-542.

<sup>35</sup> Harper, B.L., Bilyard, G.R., Broh, E.H., Castleton, K.J., Dukelow, J.S., Hesser, W.A., Hostick, C.J., Jarvis, T.T., Konkel, R.S., Probasco, K.M., Staven, L.H., Strenge, D.L., Thiede, M.E., and Traynham, J.C., 1995. “Hanford Risk Management Program and Integrated Risk Assessment Program: Cost/Risk/Benefit Analyses: A K-Basin Example.” Pacific Northwest National Laboratory, Richland, WA., May 1995.

<sup>36</sup> John Last, 1998. *Public Health and Human Ecology*, 2<sup>nd</sup> ed. Stamford, CT: Appleton & Lange.

<sup>37</sup> Harris and Harper, ibid and loc. Cit.

Donatuto, J. and Harper, B. (2008). Issues in Evaluating Fish Consumption Rates for Native American Tribes. *Risk Analysis* 26(6): 1497-1506;

Donatuto, J. (2008). When Seafood Feeds the Spirit yet Poisons the Body: Developing Health Indicators for Risk Assessment in a Native American Fishing Community. Dissertation. University of British Columbia.

- Governance – stable, balanced government with self-determination of the tribal nation.
- Resources – natural, traditional, legal, technical, organizational, and human resources adequate to define and meet threats to stability, self-determination, resources, culture, mental and physical health, religion, economy and security. Technical and legal staff. Health and human services adequately funded.
- Capital Resources – infrastructure, cyber, and domestic resources designed to respond to threats and protect tribal values and resources with strength and understanding in a traditional manner. Adequate housing, etc.
- Security – confidence in natural resource adequacy and quality, confidence in a leadership that looks out for the members and the resources, confidence in adequate economic well-being; confidence that the culture, language, values, and people will survive; freedom from legal battles brought by the federal and other governments.
- Culture – appreciation of individuals, creativity, support of the needy, devotion to the people, justice, and the shared history and blood ties to the land and to each other, according teachings of our elders.
- Religion – freedom to choose and practice any religion.
- Economy – adequate food, clothing, shelter for individual and tribal needs, both in dollars and barter, but also including riches of the landscape, heritage, and knowledge.

#### Vulnerability

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>38</sup>). EPA is also required to protect sensitive populations.<sup>39</sup> Some of the factors known to increase biological sensitivity include developmental stage, age (very young and very old), gender, genetics, and health status<sup>40</sup>, and this is part of EPA's human health research strategy.<sup>41</sup>

In addition, disadvantaged groups may also experience a wide range of stressors or co-risk factors<sup>42</sup>, such as poverty, disproportionate job hazards, existing health disparities and co-morbidities, limited access to health care, later diagnosis and less access to advanced care, pervasive discrimination, overburdened or aged infrastructure, dependence on subsistence resources with increasing legal threats to hunters and fishers, loss of access to fishing, hunting, and gathering grounds, contamination of subsistence resources (fish toxics in particular), rural dumps, lower quality of utilities and communication capabilities, poorer schools, increased domestic violence, loss of religion, loss of language, increased mental health issues, greater jail time than non-natives, higher smoking and substance abuse rates, poorer housing (mold, lead, asbestos, crowded, not handicap-accessible), lack of homeowner loans and higher interest rates, and lack of money to get technical and legal expertise needed for equal participation to decision processes,

Because these factors tend to cluster in tribal communities, the overall psychological impact is the assumption that tribal lives are less important, and tribal perspectives are not important, and that tribes do not deserve the same level of protection. Consistent federal actions and attitudes over the centuries have taught many tribal members that they are not deserving of the same level of assistance from the federal

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<sup>38</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.

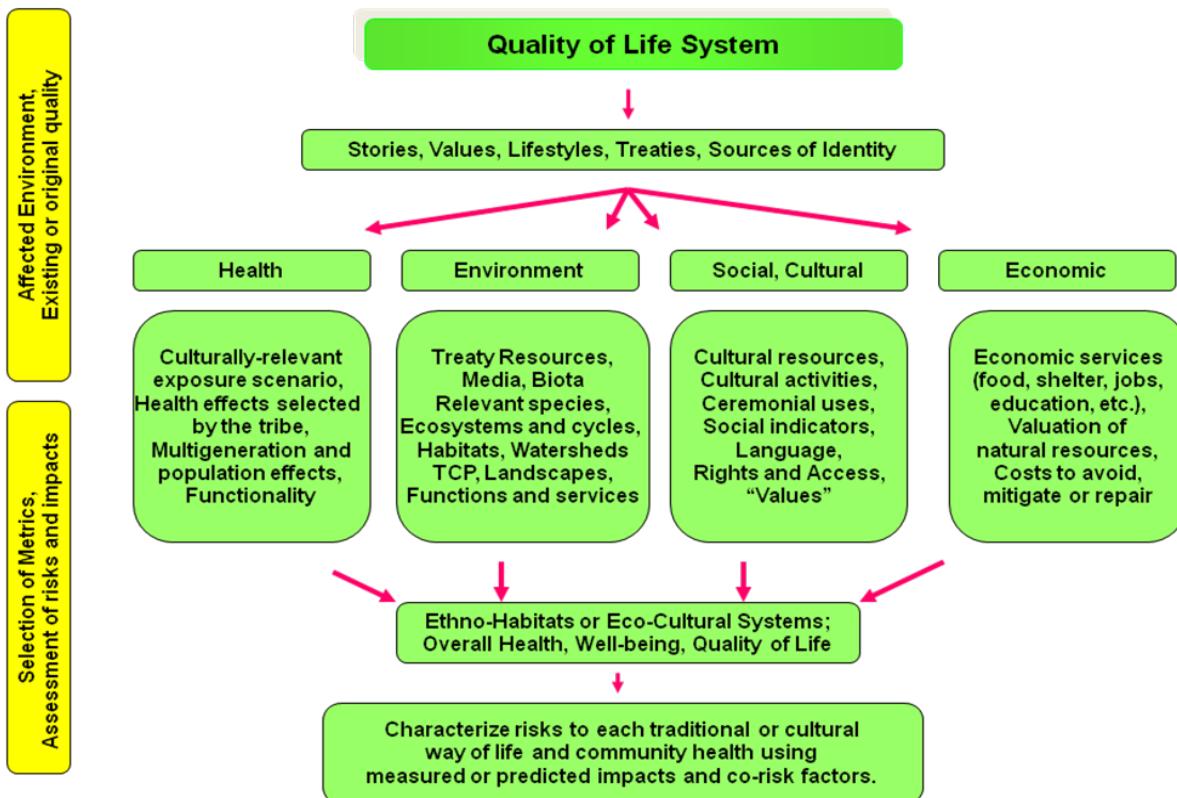
<sup>39</sup> *Superfund Exposure Assessment Manual*. EPA/540/1-88/001 OSWER directive 9285.5-1. U.S. Environmental Protection Agency Office of Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. 1988.

<sup>40</sup> [http://www.epa.gov/nheerl/research/childrens\\_health.html](http://www.epa.gov/nheerl/research/childrens_health.html)

<sup>41</sup> EPA/600/R-02/050, September 2003 (posted at <http://www.epa.gov/nheerl/publications/>).

<sup>42</sup> Flaskerud, JH. and Winslow, B. (1998). Conceptualizing Vulnerable Populations. *Nursing Research*, 47:69-78.

government and should not expect equal treatment, becoming a self-fulfilling prophecy that tribal governments are struggling to overcome.



#### D.6 Equity analysis.

Evaluating disproportionate impacts to Native Americans involves the following:

- Are the exposures different when the tribal subsistence scenario is used as compared to the rural residential or other non-native scenario? Whose risks are highest?
- Are the natural resources of tribal interest more impacted than those identified by the general population? How important are those resources or places? How many ways are those resources or places important? How large is the impacted area from a tribal perspective?

- Do disparities in impact accumulate over many generations, and do they accumulate at a higher rate in the EJ communities? Have the next seven or more generations been taken into consideration?<sup>43</sup>
- Is the tribe already vulnerable (at risk) due to existing health disparities, economic disadvantages, higher exposure to other toxics, or existence of several dozen co-risk factors (e.g., poor housing, high unemployment, etc – contact authors for more details)?
- What proportion of tribal members is affected (rather than absolute numbers of people)?
- Is the federal fiduciary Trust obligation being met?
- Is traditional awareness and respect shown equitably to the affected tribes as to the local civic entities?<sup>44</sup>

Example of Summary Impacts (complete for each population segment).

Resource or Topic	Features, Attributes, Functions, Goods, Services	Measures of loss or benefit (positive or negative movement; degree of movement)
Sitewide Integrity	(See above tables)	
Landscape		
Light, Noise, other aesthetic attributes.		
Viewshed		
Air quality, dust		
Soil,		
Minerals, gravel, fill, barrier material		
Sediments		
Water		
Terrestrial Ecosystems		
Terrestrial habitats and species		
Aquatic Ecosystems		
Aquatic habitats and species, shorelines		
Transportation	Features and events related to safety and vulnerability of adjacent areas.	General transportation risks; Routes through tribal lands; Routes near critical habitats, rivers.
Hazardous	Baseline (target) is lack of	Amount of hazardous material imported,

<sup>43</sup> Harper, B. and Harris, S. (2001) An Integrated Framework for Characterizing Cumulative Tribal Risks. Posted at [www.iirm.org.](http://www.iirm.org/); Harper, B.L. and Harris, S.G., "Measuring Risks to Tribal Community Health and Culture," *Environmental Toxicology and Risk Assessment: Recent Achievements in Environmental Fate and Transport, Ninth Volume, ASTM STP 1381*, F. T. Price, K. V. Brix, and N. K. Lane, Eds., American Society for Testing and Materials, West Conshohocken, PA, 1999.

<sup>44</sup> From: American Indian and Alaskan Native Environmental Justice Roundtable. Albuquerque, New Mexico August 3-4, 2000; Final Report, January 31, 2001. Edited by the Environmental Biosciences Program, Medical University of South Carolina Press.

substances; safety aspects	contamination; current condition is tremendous contamination.	generated, stored, or disposed. Amount of hazardous material already on site, both permitted and contaminated.
Human Health	Target is both lack of excessive exposure and active multi-dimensional health promotion.	Individual and community doses and risks using Tribal scenarios, Multigenerational exposures and risk, Consideration of broader health context.
Env Justice	Tribally-appropriate EJ analysis needed to understand disproportionate impacts.	Compliance with Treaty and Trust; Presence of disadvantaged or disproportionately affected groups-Tribes; Eco-spatial basis for tribal EJ analysis.
Economic	Recognition of subsistence economy methods.	Convention analysis for general pop; Impacts to subsistence for tribes.
Traditional Resources	Need evaluation of likelihood of adverse or beneficial impacts to sites, zones, districts.	Amount of activity in TCP, archaeological zone, sacred sites, and NHPA sites.
Energy and Infrastructure	Need lifecycle energy and infrastructure evaluation, including adequacy of closure plans.	Energy requirement Infrastructure footprint Replacement-mitigation of resources Road needs, water and sewer needs. Intensity of security needs
Climate-Energy Values	Targets of energy efficiency, net zero, sustainability, planning for climate change.	Net-zero operations Carbon footprint
Cumulative	Lifeways support	Impacts to health, ecology, traditional, socio-economic, other analyses. Space-time mapping of impacts. Lifecycle impacts and costs. Sitewide totals of hazardous materials, footprints; impact on the ability to reach a fully restored endstate.
Homeland Security		

### **Making the Decision**

In the case that disproportionate impacts occur, what would cause (or allow) a regulator to make a decision that reduces the disparities in impacts, especially if it costs money? Often the community at disproportionate risk is expected to take responsibility for reducing their risk by changing their heritage, religious, or ceremonial activities, rather than removing the underlying cause of the inequity.<sup>45</sup> In reality, this magnifies the disproportionate impacts rather than reducing them. One of the most visible examples of this is the expectation that native sovereign nations reduce their fish consumption due to contamination, in effect requiring the Tribe to choose between health and religion.

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<sup>45</sup> O'Neill, C.A. (2003). Risk avoidance, traditional discrimination, and environmental justice for indigenous peoples. *Ecology Law Quarterly* 30, 1-57.

A methodology for evaluating disproportionate impacts is presented here. The real challenge is to the federal government to reduce the inequity by making more protective decisions.

## **W.2 TREATIES WITH AMERICAN INDIAN TRIBES OF THE HANFORD REGION**

DOE's relationship with American Indians is based on treaties, statutes, and DOE directives. Representatives of the United States negotiated treaties with leaders of various Columbia Plateau American Indian tribes and bands in June 1855 at Camp Stevens in the Walla Walla Valley. The negotiations resulted in three treaties, one with the 14 tribes and bands of the group that would become the Confederated Tribes and Bands of the Yakama Nation, one with the Nez Perce Tribe, and one with the 3 tribes that would become the Confederated Tribes of the Umatilla Indian Reservation. The U.S. Senate ratified the treaties in 1859. The negotiated treaties are presented in the following sections:

- W.2.1, Treaty with the Yakima (June 9, 1855; 12 Stats. 951)
- W.2.2, Treaty with the Nez Perces (June 11, 1855; 12 Stats. 957)
- W.2.3, Treaty with the Walla Walla, Cayuse and Umatilla (June 9, 1855; 12 Stats. 945)

The Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation, the Nez Perce Tribe of Idaho, and the Confederated Tribes of the Umatilla Indian Reservation are federally recognized tribes that are eligible for funding and services from the U.S. Bureau of Indian Affairs by virtue of their status as Indian tribes (68 FR 68180, December 5, 2003).

The terms of the three treaties are similar. Each of the three tribal organizations agreed to cede large blocks of land to the United States. The Hanford Site is within the ceded lands. The treaties reserved to the tribes certain lands for their exclusive use (the three reservations). The treaties also secured to the tribes certain rights and privileges to continue traditional activities outside the reservations. These included (1) the right to fish at usual and accustomed places in common with citizens of the United States and (2) the privileges of hunting, gathering roots and berries, and pasturing horses and cattle on open and unclaimed lands. The following are copies of these three treaties.

**W.2.1      Treaty with the Yakima, 1855**

## **TREATY WITH THE YAKIMA, 1855.**

**June 9, 1855. | 12 Stat., 951. | Ratified Mar. 8, 1859. | Proclaimed Apr. 18, 1859.**

*Articles of agreement and convention made and concluded at the treaty-ground, Camp Stevens, Walla-Walla Valley, this ninth day of June, in the year one thousand eight hundred and fifty-nine, by and between Isaac I. Stevens, governor and superintendent of Indian affairs for the Territory of Washington, on the part of the United States, and the undersigned head chiefs, chiefs, headmen, and delegates of the Yakama, Palouse, Pisquouse, Wenatshapam, Klikatat, Klinquit, Kowwas-say-ee, Li-ay-was, Skin-pah, Wish-ham, Shyiks, Ochechotes, Kah milt-pah, and Se-ap-cat, confederated tribes and bands of Indians, occupying lands hereinafter bounded and described and lying in Washington Territory, who for the purposes of this treaty are to be considered as one nation, under the name of ““Yakama,”” with Kamaiakun as its head chief, on behalf of and acting for said tribes and bands, and being duly authorized thereto by them.*

### **ARTICLE 1.**

The aforesaid confederated tribes and bands of Indians hereby cede, relinquish, and convey to the United States all their right, title, and interest in and to the lands and country occupied and claimed by them, and bounded and described as follows, to wit:

Commencing at Mount Ranier, thence northerly along the main ridge of the Cascade Mountains to the point where the northern tributaries of Lake Che-lan and the southern tributaries of the Methow River have their rise; thence southeasterly on the divide between the waters of Lake Chelan and the Methow River to the Columbia River; thence, crossing the Columbia on a true east course, to a point whose longitude is one hundred and nineteen degrees and ten minutes, (119E° 10') which two latter lines separate the above confederated tribes and bands from the Okinakane tribe of Indians; thence in a true south course to the forty-seventh (47E°) parallel of latitude: thence east on said parallel to the main Palouse River, which two latter lines of boundary separate the above confederated tribes and bands from the Spokanes; thence down the Palouse River to its junction with the Moh-hah-ne-she, or southern tributary of the same; thence in a southeasterly direction, to the Snake River, at the mouth of the Tucannon River, separating the above confederated tribes from the Nez Percé tribe of Indians; thence down the Snake River to its junction with the Columbia River; thence up the Columbia River to the ““White Banks”” below the Priest’s Rapids; thence westerly to a lake called ““La Lac;”” thence southerly to a point on the Yakama River called Toh-mah-luke; thence, in a southwesterly direction, to the Columbia River, at the western extremity of the ““Big Island,”” between the mouths of the Umatilla River and Butler Creek; all which latter boundaries separate the

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above confederated tribes and bands from the Walla-Walla, Cayuse, and Umatilla tribes and bands of Indians; thence down the Columbia River to midway between the mouths of White Salmon and Wind Rivers; thence along the divide between said rivers to the main ridge of the Cascade Mountains; and thence along said ridge to the place of beginning.

### **ARTICLE 2.**

There is, however, reserved, from the lands above ceded for the use and occupation of the aforesaid confederated tribes and bands of Indians, the tract of land included within the following boundaries, to wit: Commencing on the Yakama River, at the mouth of the Attah-nam River; thence westerly along said Attah-nam River to the forks; thence along the southern tributary to the Cascade Mountains; thence southerly along the main ridge of said mountains, passing south and east of Mount Adams, to the spur whence flows the waters of the Klickitat and Pisco Rivers; thence down said spur to the divide between the waters of said rivers; thence along said divide to the divide separating the waters of the Satass River from those flowing into the Columbia River; thence along said divide to the main Yakama, eight miles below the mouth of the Satass River; and thence up the Yakama River to the place of beginning.

All which tract shall be set apart and, so far as necessary, surveyed and marked out, for the exclusive use and benefit of said confederated tribes and bands of Indians, as an Indian

reservation; nor shall any white man, excepting those in the employment of the Indian Department, be permitted to reside upon the said reservation without permission of the tribe and the superintendent and agent. And the said confederated tribes and bands agree to remove to, and settle upon, the same, within one year after the ratification of this treaty. In the mean time it shall be lawful for them to reside upon any ground not in the actual claim and occupation of citizens of the United States; and upon any ground claimed or occupied, if with the permission of the owner or claimant.

Guaranteeing, however, the right to all citizens of the United States to enter upon and occupy as settlers any lands not actually occupied and cultivated by said Indians at this time, and not included in the reservation above named.

*And provided,* That any substantial improvements heretofore made by any Indian, such as fields enclosed and cultivated, and houses erected upon the lands hereby ceded, and which he may be compelled to abandon in consequence of this treaty, shall be valued, under the direction of the President of the United States, and payment made therefor in money; or improvements of an equal value made for said Indian upon the reservation. And no Indian will be required to abandon the improvements aforesaid, now occupied by him, until their value in money, or improvements of an equal value shall be furnished him as aforesaid.

#### ARTICLE 3.

*And provided,* That, if necessary for the public convenience, roads may be run through the said reservation; and on the other hand, the right of way, with free access from the same to the nearest public highway, is secured to them; as also the right, in common with citizens of the United States, to travel upon all public highways.

The exclusive right of taking fish in all the streams, where running through or bordering said reservation, is further secured to said confederated tribes and bands of Indians, as also the right of taking fish at all usual and accustomed places, in common with the citizens of the Territory, and of erecting temporary buildings for curing them; together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land.

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#### ARTICLE 4.

In consideration of the above cession, the United States agree to pay to the said confederated tribes and bands of Indians, in addition to the goods and provisions distributed to them at the time of signing this treaty, the sum of two hundred thousand dollars, in the following manner, that is to say: Sixty thousand dollars, to be expended under the direction of the President of the United States, the first year after the ratification of this treaty, in providing for their removal to the reservation, breaking up and fencing farms, building houses for them, supplying them with provisions and a suitable outfit, and for such other objects as he may deem necessary, and the remainder in annuities, as follows: For the first five years after the ratification of the treaty, ten thousand dollars each year, commencing September first, 1856; for the next five years, eight thousand dollars each year; for the next five years, six thousand dollars per year; and for the next five years, four thousand dollars per year.

All which sums of money shall be applied to the use and benefit of said Indians, under the direction of the President of the United States, who may from time to time determine, at his discretion, upon what beneficial objects to expend the same for them. And the superintendent of Indian affairs, or other proper officer, shall each year inform the President of the wishes of the Indians in relation thereto.

#### ARTICLE 5.

The United States further agree to establish at suitable points within said reservation, within one year after the ratification hereof, two schools, erecting the necessary buildings, keeping them in repair, and providing them with furniture, books, and stationery, one of which shall be an agricultural and industrial school, to be located at the agency, and to be free to the children of the said confederated tribes and bands of Indians, and to employ one superintendent of teaching and

two teachers; to build two blacksmiths' shops, to one of which shall be attached a tin-shop, and to the other a gunsmith's shop; one carpenter's shop, one wagon and plough maker's shop, and to keep the same in repair and furnished with the necessary tools; to employ one superintendent of farming and two farmers, two blacksmiths, one tinner, one gunsmith, one carpenter, one wagon and plough maker, for the instruction of the Indians in trades and to assist them in the same; to erect one saw-mill and one flouring-mill, keeping the same in repair and furnished with the necessary tools and fixtures; to erect a hospital, keeping the same in repair and provided with the necessary medicines and furniture, and to employ a physician; and to erect, keep in repair, and provided with the necessary furniture, the building required for the accommodation of the said employees. The said buildings and establishments to be maintained and kept in repair as aforesaid, and the employees to be kept in service for the period of twenty years.

And in view of the fact that the head chief of the said confederated tribes and bands of Indians is expected, and will be called upon to perform many services of a public character, occupying much of his time, the United States further agree to pay to the said confederated tribes and bands of Indians five hundred dollars per year, for the term of twenty years after the ratification hereof, as a salary for such person as the said confederated tribes and bands of Indians may select to be their head chief, to build for him at a suitable point on the reservation a comfortable house, and properly furnish the same, and to plough and fence ten acres of land. The said salary to be paid to, and the said house to be occupied by, such head chief so long as he may continue to hold that office. And it is distinctly understood and agreed that at the time of the conclusion of this treaty Kamaikun is the duly elected and authorized

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head chief of the confederated tribes and bands aforesaid, styled the Yakama Nation, and is recognized as such by them and by the commissioners on the part of the United States holding this treaty; and all the expenditures and expenses contemplated in this article of this treaty shall be defrayed by the United States, and shall not be deducted from the annuities agreed to be paid to said confederated tribes and band of Indians. Nor shall the cost of transporting the goods for the annuity payments be a charge upon the annuities, but shall be defrayed by the United States.

#### ARTICLE 6.

The President may, from time to time, at his discretion, cause the whole or such portions of such reservation as he may think proper, to be surveyed into lots, and assign the same to such individuals or families of the said confederated tribes and bands of Indians as are willing to avail themselves of the privilege, and will locate on the same as a permanent home, on the same terms and subject to the same regulations as are provided in the sixth article of the treaty with the Omahas, so far as the same may be applicable.

#### ARTICLE 7.

The annuities of the aforesaid confederated tribes and bands of Indians shall not be taken to pay the debts of individuals.

#### ARTICLE 8.

The aforesaid confederated tribes and bands of Indians acknowledge their dependence upon the Government of the United States, and promise to be friendly with all citizens thereof, and pledge themselves to commit no depredations upon the property of such citizens.

And should any one or more of them violate this pledge, and the fact be satisfactorily proved before the agent, the property taken shall be returned, or in default thereof, or if injured or destroyed, compensation may be made by the Government out of the annuities.

Nor will they make war upon any other tribe, except in self-defence, but will submit all matters of difference between them and other Indians to the Government of the United States or its agent for decision, and abide thereby. And if any of the said Indians commit depredations on any other Indians within the Territory of Washington or Oregon, the same rule shall prevail as that provided in this article in case of depredations against citizens. And the said confederated tribes and bands of Indians agree not to shelter or conceal offenders against the laws of the United States, but to

deliver them up to the authorities for trial.

ARTICLE 9.

The said confederated tribes and bands of Indians desire to exclude from their reservation the use of ardent spirits, and to prevent their people from drinking the same, and, therefore, it is provided that any Indian belonging to said confederated tribes and bands of Indians, who is guilty of bringing liquor into said reservation, or who drinks liquor, may have his or her annuities withheld from him or her for such time as the President may determine.

ARTICLE 10.

*And provided,* That there is also reserved and set apart from the lands ceded by this treaty, for the use and benefit of the aforesaid confederated tribes and bands, a tract of land not exceeding in quantity one township of six miles square, situated at the forks of the Pisquouse or Wenatshapam River, and known as the ““Wenatshapam Fishery,”” which said reservation shall be surveyed and marked out whenever the President may direct, and be subject to the same provisions and restrictions as other Indian reservations.

ARTICLE 11.

This treaty shall be obligatory upon the contracting parties as soon as the same shall be ratified by the President and Senate of the United States.

In testimony whereof, the said Isaac I. Stevens, governor and superintendent of Indian affairs for the Territory of Washington, and the undersigned head chief, chiefs, headmen, and delegates of the aforesaid

[\*702]

confederated tribes and bands of Indians, have hereunto set their hands and seals, at the place and on the day and year hereinbefore written.

ISAAC I. STEVENS,

Governor and Superintendent. [L. S.]

Kamaiakun, his x mark. [L. S.]

Sklloom, his x mark. [L. S.]

Owhi, his x mark. [L. S.]

Te-cole-kun, his x mark. [L. S.]

La-hoom, his x mark. [L. S.]

Me-ni-nock, his x mark. [L. S.]

Elit Palmer, his x mark. [L. S.]

Wish-och-kmpits, his x mark. [L. S.]

Koo-lat-toose, his x mark. [L. S.]

Shee-ah-cotte, his x mark. [L. S.]

Tuck-quille, his x mark. [L. S.]

Ka-loo-as, his x mark. [L. S.]

Scha-noo-a, his x mark. [L. S.]

Sla-kish, his x mark. [L. S.]

Signed and sealed in the presence of —

James Doty, secretary of treaties,

Mie. Cles. Pandosy, O. M. T.,

Wm. C. McKay,

W. H. Tappan, sub Indian agent, W. T.,

C. Chirouse, O. M. T.,

Patrick McKenzie, interpreter,

A. D. Pamburn, interpreter,

Joel Palmer, superintendent Indian affairs, O. T.,

W. D. Biglow,

A. D. Pamburn, interpreter.

**W.2.2      Treaty with the Nez Perces, 1855**

Document:  
Nez Perce Treaty, 1855

Treaty with the Nez Perces, 1855

Articles of agreement and convention made and concluded at the treaty ground, Camp Stevens, in the Walla-Walla Valley this eleventh day of June, in the year one thousand eight hundred and fifty-five by and between Isaac I. Stevens, governor and superintendent of Indian affairs for the Territory of Washington and Joel Palmer, superintendent of Indian affairs for Oregon Territory on the part of the United States, and the undersigned chiefs, headmen, and delegates of the Nez Perce tribe of Indians occupying lands lying partly in Oregon and partly in Washington Territories, between the Cascade and Bitter Root Mountains, on behalf of, and acting for said tribe, and being duly authorized thereto by them, it being understood that Superintendent Isaac I. Stevens assumes to treat only with those of the above-named tribe of Indians residing within the Territory of Washington, and Superintendent Palmer with those residing exclusively in Oregon Territory.

ARTICLE 1.

The said Nez Perce tribe of Indians hereby cede, relinquish and convey to the United States all their right, title, and interest in and to the country occupied or claimed by them, bounded and described as follows, to wit: Commencing at the source of the Wo-na-ne-she or southern tributary of the Palouse River; thence down that river to the main Palouse; thence in a southerly direction to the Snake River, at the mouth of the Tucanon River; thence up the Tucanon to its source in the Blue Mountains; thence southerly along the ridge of the Blue Mountains; thence to a point on Grand Ronde River, midway between Grand Ronde and the mouth of the Woll-low-how River; thence along the divide between the waters of the Woll-low-how and Powder River; thence to the crossing of Snake River, at the mouth of Powder River; thence to the Salmon River, fifty miles above the place known [as] the "crossing of the Salmon River;" thence due north to the summit of the Bitter Root Mountains; thence along the crest of the Bitter Root Mountains to the place of beginning.

ARTICLE 2.

There is, however, reserved from the lands above ceded for the use and occupation of the said tribe, and as a general reservation for other friendly tribes and bands of Indians in Washington Territory, not to exceed the present numbers of the Spokane, Walla-Walla, Cayuse, and Umatilla tribes and bands of Indians, the tract of land included within the following boundaries, to wit: Commencing where the Moh ha-na-she or southern tributary of the Palouse River flows from the spurs of the Bitter Root Mountains; thence down said tributary to the mouth of the Ti-nat-pan-up Creek; thence southerly to the crossing of the Snake River ten miles below the mouth of the Al-po-wa-wi River; thence to the source of the Al-po-wa-wi River in the Blue Mountains; thence along the crest of the Blue Mountains; thence to the crossing of the Grand Ronde River, midway between the Grand Ronde and the mouth of the Woll-low-how River; thence along the divide between the waters of the Woll-low-how and Powder Rivers; thence to the crossing of the Snake River fifteen miles below the mouth of the Powder River; thence to the Salmon River above the crossing; thence by the spurs; of the Bitter Root Mountains to the place of beginning.

All which tract shall be set apart, and, so far as necessary, surveyed and marked out for the exclusive use and benefit of said tribe; as an Indian reservation; nor shall any white man, excepting those in the employment of the Indian Department, be permitted to reside upon the said reservation without permission of the tribe and the superintendent and agent; and the said tribe agrees to remove to and settle upon the same within one year after the ratification of this treaty. In the mean time it shall be lawful for

them to reside upon any ground not in the actual claim and occupation of citizens of the United States and upon any ground claimed or occupied, if with the permission of the owner or claimant, guarantying, however, the right to all citizens of the United States to enter upon and occupy as settlers any lands not actually occupied and cultivated by said Indians at this time. and not included in the reservation above named. And provided that any substantial improvement heretofore made by any Indian, such as fields enclosed and cultivated, and houses erected upon the lands hereby ceded, and which he may be compelled to abandon in consequence of this treaty, shall be valued under the direction of the President of the United States, and payment made therefore in money, or improvements of an equal value be made for said Indian upon the reservation and no Indian will be required to abandon the improvements afore- said, now occupied by him, until their value in money or improvements of equal value shall be furnished him as aforesaid.

#### ARTICLE 3.

And provided that, if necessary for the public convenience, roads may be run through the said reservation, and, on the other hand, the right of way, with free access from the same to the nearest public highway, is secured to them, as also the right, in common with citizens of the United States, to travel upon all public highways. The use of the Clear Water and other streams flowing through the reservation is also secured to citizens of the United States for rafting purposes, and as public highways.

The exclusive right of taking fish in all the streams where running through or bordering said reservation is further secured to said Indians: as also the right of taking fish at all usual and accustomed places in common with citizens of the territory, and of erecting temporary buildings for curing, together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land.

#### ARTICLE 4.

In consideration of the above cession, the United States agree to pay to the said tribe in addition to the goods and provisions distributed to them at the time of signing this treaty, the sum of two hundred thousand dollars, in the following manner, that is to say, sixty thousand dollars, to be expended under the direction of the President of the United States, the first year after the ratification of this treaty. In providing for their removal to the reserve, breaking up and fencing farms, building houses, supplying them with provisions and a suitable outfit, and for such other objects as he may deem necessary. and the remainder in annuities, as follows: for the first five years after the ratification of this treaty, ten thousand dollars each year, commencing September 1, 1856; for the next five years, eight thousand dollars each year; for the next five years, six thousand each year, and for the next five years, four thousand dollars each year.

All which said sums of money shall be applied to the use and benefit of the said Indians, under the direction of the President of the United States, who may from time to time determine, at his discretion, upon what beneficial objects to expend the same for them. And the superintendent of Indian affairs, or other proper officer, shall each year inform the President of the wishes of the Indians in relation thereto.

#### ARTICLE 5.

The United States further agree to establish, at suitable points within said reservation, within one year after the ratification hereof, two schools, erecting the necessary buildings, keeping the same in repair, and providing them with furniture, books, and stationery, one of which shall be an agricultural and industrial school, to be located at the agency, and to be free to the children of said tribe, and to employ one

superintendent of teaching and two teachers; to build two blacksmiths' shops, to one of which shall be attached a tinshop and to the other a gunsmith's shop; one carpenter's shop, one wagon and plough maker's shop, and to keep the same in repair, and furnished with the necessary tools; to employ one superintendent of farming and two farmers, two blacksmiths, one tinner, one gunsmith, one carpenter, one wagon and plough maker, for the instruction of the Indians in trades, and to assist them in the same; to erect one saw-mill and one flouring-mill, keeping the same in repair, and furnished with the necessary tools and fixtures, and to employ two millers; to erect a hospital, keeping the same in repair, and provided with the necessary medicines and furniture, and to employ a physician; and to erect, keep in repair, and provide with the necessary furniture the buildings required for the accommodation of the said employees. The said buildings and establishments to be maintained and kept in repair as aforesaid, and the employees to be kept in service for the period of twenty years.

And in view of the fact that the head chief of the tribe is expected, and will be called upon, to perform many services of a public character, occupying much of his time, the United States further agrees to pay to the Nez Perce tribe five hundred dollars per year for the term of twenty years, after the ratification hereof, as a salary for such person as the tribe may select to be its head chief. To build for him, at a suitable point on the reservation, a comfortable house, and properly furnish the same, and to plough and fence for his use ten acres of land. The said salary to be paid to, and the said house to be occupied by, such head chief so long as he may be elected to that position by his tribe, and no longer.

And all the expenditures and expenses contemplated in this fifth article of this treaty shall be defrayed by the United States, and shall not be deducted from the annuities agreed to be paid to said tribes nor shall the cost of transporting the goods for the annuity-payments be a charge upon the annuities, but shall be defrayed by the United States.

#### ARTICLE 6.

The President may from time to time, at his discretion, cause the whole, or such portions of such reservation as he may think proper, to be surveyed into lots, and assign the same to such individuals or families of the said tribe as are willing to avail themselves of the privilege, and will locate on the same as a permanent home, on the same terms and subject to the same regulations as are provided in the sixth article of the treaty with the Omahas in the year 1854, so far as the same may be applicable.

#### ARTICLE 7.

The annuities of the aforesaid tribe shall not be taken to pay the debts of individuals.

#### ARTICLE 8.

The aforesaid tribe acknowledge their dependence upon the Government of the United States, and promise to be friendly with all citizens thereof, and pledge themselves to commit no depredations on the property of such citizens; and should any one or more of them violate this pledge, and the fact be satisfactorily proved before the agent, the property taken shall be returned, or in default thereof, or if injured or destroyed, compensation may be made by the Government out of the annuities. Nor will they make war on any other tribe except in self-defense, but will submit all matters of difference between them and the other Indians to the Government of the United States, or its agent, for decision, and abide thereby and if any of the said Indians commit any depredations on any other Indians within the Territory of Washington, the same rule shall prevail as that prescribed in this article in cases of depredations against citizens. And the said tribe agrees not to shelter or conceal offenders against the laws of the United States, but to deliver them up to the authorities for trial.

## ARTICLE 9.

The Nez Perces desire to exclude from their reservation the use of ardent spirits, and to prevent their people from drinking the same; and therefore it is provided that any Indian belonging to said tribe who is guilty of bringing liquor into said reservation, or who drinks liquor, may have his or her proportion of the annuities withheld from him or her for such time as the President may determine.

## ARTICLE 10.

The Nez Perce Indians having expressed in council a desire that William Craig should continue to live with them, he having uniformly shown himself their friend, it is further agreed that the tract of land now occupied by him and described in his notice to the register and receiver of the land-office of the Territory of Washington, on the fourth day of June last, shall not be considered a part of the reservation provided for in this treaty, except that it shall be subject in common with the lands of the reservation to the operations of the intercourse act.

## ARTICLE 11.

This treaty shall be obligatory upon the contracting parties as soon as the same shall be ratified by the President and Senate of the United States.

In testimony whereof, the said Isaac I. Stevens governor and superintendent of Indian affairs for the Territory of Washington, and Joel Palmer, superintendent of Indian affairs for Oregon Territory, and the chiefs, headmen, and delegates of the aforesaid Nez Perce tribe of Indians, have hereunto set their hands and seals, at the place, and on the day and year herein before written.

Isaac I. Stevens, [L. S.] Governor and Superintendent of Washington Territory. Joel Palmer, [L. S.] Superintendent Indian Affairs.

Aleiya, or Lawyer, Head-chief of, the Nez Perces, [L. S.]  
Tippelanecbupooh, his x mark. [L. S.]  
Hah-hah-stilpilp, his x mark. [L. S.]  
Appushwa-hite, or Looking-glass, his x mark. [L. S.]  
Cool-cool-shua-nin, his x mark. [L. S.]  
Silish, his x mark. [L. S.]  
Joseph, his x mark. [L. S.]  
Toh-toh-molewit, his x mark. [L. S.]  
James, his x mark. [L. S.]  
Tuky-in-lik-it, his x mark. [L. S.]  
Red Wolf, his x mark. [L. S.]  
Te-hole-hole-soot, his x mark. [L. S.]  
Timothy, his x mark. [L. S.]  
Ish-coh-tim, his x mark. [L. S.]  
U-ute-sin-male-cun, his x mark. [L. S.]  
Wee-as-cus, his x mark. [L. S.]  
Spotted Eage, his x mark. [L. S.]  
Hah-hah-stoore-tee, his x ma rk. [L. S.]  
Stoop-toop-nin or Cut-hair, his x mark. [L. S.]  
Eee maht-sin-pooh, his x mark. [L. S.]  
Tow-wish-au-il-pilp, his x mark. [L. S.]

Tah-moh-moh-kin, his x mark. [L. S.]  
Kay-kay-mass, his x mark. [L. S.]  
Speaking Eagle, his x mark. [L. S.]  
Kole-kole-til-ky, his x mark. [L. S.]  
Wat-ti-wat-ti-wah-hi, his x mark. [L. S.]  
In-mat-tute-kah-ky, his x mark. [L. S.]  
Howh-no-tah-kun, his x mark. [L. S.]  
Moh-see-chee, his x mark. [L. S.]  
Tow-wish-wane, his x mark. [L. S.]  
George, his x mark. [L. S.]  
Wahpt-tah-shooshe, his x mark. [L. S.]  
Nicke-el-it-may-ho, his x mark. [L. S.]  
Bead Necklace, his x mark. [L. S.]  
Say-i-ee-ouse, his x mark. [L. S.]  
Koos-koos-tas-kut, his x mark. [L. S.]  
Wis-tasse-cut, his x mark. [L. S.]  
Levi, his x mark. [L. S.]  
Ky-ky-soo-te-lum, his x mark. [L. S.]  
Pee-oo-pe-whi-hi, his x mark. [L. S.]  
Ko-ko-whay-nee, his x mark. [L. S.]  
Pee-oo-pe-iecteim, his x mark. [L. S.]  
Kwin-to-kow, his x mark. [L. S.]  
Pee-poomekah, his x mark. [L. S.]  
Pee-wee-au-ap-tah, his x mark. [L. S.]  
Hah-hah-stil-at-me, his x mark. [L. S.]  
Wee-at-tenat-il-pilp, his x mark. [L. S.]  
Wee-yoke-sin-ate, his x mark. [L. S.]  
Pee-oo-pe-u-il-pilp, his x mark. [L. S.]  
Wee-ah-ki, his x mark. [L. S.]  
Wah-tass-tum-mannee, his x mark. [L. S.]  
Necalahtsin, his x mark. [L. S.]  
Tu-wesi-ce, his x mark. [L. S.]  
Suck-on-tie, his x mark. [L. S.]  
Lu-ee sin-kah-koose-sin, his x mark. [L. S.]  
Ip-nat-tam-moose, his x mark. [L. S.]  
Hah-tal-ee-kin, his x mark. [L. S.]  
Jason, his x mark. [L. S.]

Signed and sealed in presence of us-  
James Doty, secretary of treaties, W.T.  
Wm. McBean,  
Geo. C. Bomford.  
Wm. C. McKay, secretary of treaties, O.T.  
C. Chirouse, O.M.T.  
Mie. Cles. Pandosy,  
W.H. Tappan, sub-Indian agent,  
Lawrence Kip,  
William Craig, interpreter,  
W.H. Pearson.  
A.D. Pamburn, interpreter

**W.2.3      Treaty with the Walla Walla, Cayuse and Umatilla, 1855**

## Treaty with the Walla Walla, Cayuse and Umatilla 1855

**12 Stat. 945**

**June 9, 1855**

**Ratified March 8, 1859**

**Proclaimed April 11, 1859**

Articles of agreement and convention made and concluded at the treaty-ground, Camp Stevens, in the Walla Walla Valley, this ninth day of June, in the year one thousand eight hundred and fifty-five, by and between Isaac I. Stevens, governor and superintendent of Indian affairs for the territory of Washington and Joel Palmer, superintendent of Indian affairs for Oregon Territory, on the part of the United States and the undersigned chiefs, head-men and delegates of the Walla Wallas, Cayuses and Umatilla tribes and bands of Indians, occupying lands partly in Washington and partly in Oregon territories, and who, for the purpose of this treaty are to be regarded as one nation acting for and in behalf of their respective bands and tribes, they being duly authorized thereto; it being understood that Superintendent, I. I. Stevens assumes to treat with that portion of the above-named bands and tribes residing within the territory of Washington and Superintendent Palmer with those residing within Oregon.

ARTICLE 1. The above named confederated bands of Indians cede to the United States all their right, title, and claim to all and every part of the country claimed by them included in the following boundaries, to wit: Commencing at the mouth of the Tocannon River, in Washington Territory, running thence up said river to its source; thence easterly along the summit of the Blue Mountains, and on the southern boundaries of the purchase made of the Nez Perces Indians, and easterly along that boundary to the western limits of the country claimed by the Shoshonees or Snake Indians; thence southerly along that boundary (being the waters of Powder River) to the source of Powder River, thence to the head-waters of Willow Creek, thence down Willow Creek to the Columbia River, thence up the channel of the Columbia River(to the lower end of a large island below the mouth of the Umatilla River), thence northerly to a point on the Yakama River, called Tomah-luke, thence to Le Lac, thence to the White Banks on to the Columbia below Priest's Rapids, thence down the Columbia River to the junction of the Columbia and Snake Rivers, thence up the Snake River to the place of beginning;

Provided, however, That so much of the country described above as is contained in the following boundaries shall be set apart as a residence for said Indians, which tract for the purposes contemplated shall be held and regarded as an Indian reservation; to wit: Commencing in the middle of the channel of Umatilla River opposite the mouth of Wild Horse Creek, thence up the middle of the channel of said creek to its source, thence southerly to a point in the Blue Mountains, known as Lee's Encampment, thence in a line to the headwaters of Howtome Creek, thence west to the divide between Howtome and Birch Creeks, thence northerly along said divide to a point due west of the southwest corner of William C. McKay's land-claim, thence east along his line to his southeast corner, thence in a line to the place of beginning; all of which tract shall be set apart and, so far as necessary, surveyed and marked out for their exclusive use; nor

shall any white person be permitted to reside upon the same without permission of the agent and superintendent. The said tribes and bands agree to remove to and settle upon the same within one year after the ratification of this treaty, without any additional expense to the Government other than is provided by this treaty, and until the expiration of the time specified, the said bands shall be permitted to occupy and reside upon the tracts now possessed by them, guaranteeing to all citizen(s) of the United States, the right to enter upon and occupy as settlers any lands not actually enclosed by said Indians:

Provided, also, That the exclusive right of taking fish in the streams running through and bordering said reservation is hereby secured to said Indians, and at all other usual and accustomed stations in common with citizens of the United States, and of erecting suitable buildings for curing the same; the privilege of hunting, gathering roots and berries and pasturing their stock on unclaimed lands in common with citizens, is also secured to them.

And provided, also, That if any band or bands of Indians, residing in and claiming any portion or portions of the country described in this article, shall not accede to the terms of this treaty, then the bands becoming parties hereunto agree to reserve such part of the several and other payments herein named, as a consideration for the entire country described as aforesaid, as shall be in the proportion that their aggregate number may have to the whole number of Indians residing in and claiming the entire country aforesaid, as consideration and payment in full for the tracts in said country claimed by them.

And provided, also, That when substantial improvements have been made by any member of the bands being parties to this treaty, who are compelled to abandon them in consequence of said treaty, (they) shall be valued under the direction of the President of the United States, and payment made therefor.

ARTICLE 2. In consideration of and payment for the country hereby ceded, the United States agree to pay the band and tribes of Indians claiming territory and residing in said country, and who remove to and reside upon said reservation, the several sums of money following, to wit: eight thousand dollars per annum for the term of five years, commencing on the first day of September, 1856; six thousand dollars per annum for the term of five years next succeeding the first five; four thousand dollars per annum for the term of five years next succeeding the second five, and two thousand dollars per annum for the term of five years next succeeding the third five; all of which several sums of money shall be expended for the use and benefit of the confederated bands herein named, under the direction of the President of the United States, who may from time to time at his discretion, determine what proportion thereof shall be expended for such objects as in his judgment will promote their well-being, and advance them in civilization, for their moral improvement and education, for buildings, opening and fencing farms, breaking land, purchasing teams, wagons, agricultural implements and seeds, for clothing, provision and tools, for medical purposes, providing mechanics and farmers, and for arms and ammunition.

ARTICLE 3. In addition to the articles advanced the Indians at the time of signing this treaty, the United States agree to expend the sum of fifty thousand dollars during the first and second years after its ratification, for the erection of buildings on the reservation, fencing and opening farms,

for the purchase of teams, farming implements, clothing, and provisions, for medicines and tools, for the payment of employes, and for subsisting the Indians the first year after their removal.

ARTICLE 4. In addition to the consideration above specified, the United States agree to erect, at suitable points on the reservation, one saw-mill, and one flouring-mill, a building suitable for a hospital, two school-houses, one blacksmith shop, one building for wagon and plough maker and one carpenter and joiner shop, one dwelling for each, two millers, one farmer, one superintendent of farming operations, two school-teachers, one blacksmith, one wagon and plough maker, one carpenter and joiner, to each of which the necessary out-buildings. To purchase and keep in repair for the term of twenty years all necessary mill fixtures and mechanical tools, medicines and hospital stores, books and stationery for schools, and furniture for employes.

The United States further engage to secure and pay for the services and subsistence, for the term of twenty years, (of) one superintendent of farming operations, one farmer, one blacksmith, one wagon and plough maker, one carpenter and joiner, one physician, and two school-teachers.

ARTICLE 5. The United States further engage to build for the head chiefs of the Walla-Walla, Cayuse, and Umatilla bands each one dwelling-house, and to plough and fence ten acres of land for each, and to pay to each five hundred dollars per annum in cash for the term of twenty years. The first payment to the Walla-Walla chief to commence upon the signing of this treaty. To give to the Walla-Walla chief three yoke of oxen, three yokes and four chains, one wagon, two ploughs, twelve hoes, twelve axes, two shovels, and one saddle and bridle, one set of wagon-harness, and one set of plough-harness, within three months after the signing of this treaty.

To build for the son of Pio-pio-mox-mox one dwelling house, and plough and fence five acres of land, and to give him a salary for twenty years, one hundred dollars in cash per annum, commencing September first, eighteen hundred and fifty-six.

The improvement named in this section to be completed as soon after the ratification of this treaty as possible.

It is further stipulated that Pio-pio-mox-mox is secured for the term of five years, the right to build and occupy a house at or near the mouth of Yakama River, to be used as a trading-post in the sale of his bands of wild cattle ranging in that district: And provided, also, That in consequence of the immigrant wagon-road from Grand Round to Umatilla, passing through the reservation herein specified, thus leading to turmoils and disputes between Indians and immigrants, and as it is known that a more desirable and practicable route may be had to the south of the present road, that a sum not exceeding ten thousand dollars shall be expended in locating and opening a wagon-road from Powder River of Grand Round, so as to reach the plain at the western base of the Blue Mountain, south of the southern limits of said reservation.

ARTICLE 6. The President may, from time to time at his discretion cause the whole or such portion as he may think proper, of the tract that may now or hereafter be set apart as a permanent home for those Indians, to be surveyed into lots and assigned to such Indians of the confederated bands as may wish to enjoy the privilege, and locate thereon permanently, to a single person over twenty-one years of age, forty acres, to a family of two persons, sixty acres, to a family of three

and not exceeding five, eighty acres; to a family of six persons and not exceeding ten, one hundred and twenty acres; and to each family over ten in number, twenty acres to each additional three members; and the President may provide for such rules and regulations as will secure to the family in case of the death of the head thereof, the possession and enjoyment of such permanent home and improvement thereon and he may at any time, at his discretion, after such person or family has made location on the land assigned as a permanent home, issue a patent to such person or family for such assigned land, conditioned that the tract shall not be aliened or leased for a longer term than two years, and shall be exempt from levy, sale, or forfeiture, which condition shall continue in force until a State constitution, embracing such land within its limits, shall have been formed and the legislature of the State shall remove the restriction:

Provided, however, That no State legislature shall remove the restriction herein provided for without the consent of Congress:

And provided, also, That if any person of family, shall at any time, neglect or refuse to occupy or till a portion of the land assigned and on which they have located, or shall roam from place to place, indicating a desire to abandon his home, the President may if the patent shall have been issued, cancel the assignment, and may also withhold from such person or family their portion of the annuities or other money due them, until they shall have returned to such permanent home, and resumed the pursuits of industry, and in default of their return the tract may be declared abandoned, and thereafter assigned to some other person or family of Indians residing on said reservation:

And provided, also, That the head chiefs of the three principal bands, to wit, Pio-pio-mox-mox, Weyatenatemany, and Wenap-snoot, shall be secured in a tract of at least one hundred and sixty acres of land.

ARTICLE 7. The annuities of the Indians shall not be taken to pay the debts of individuals.

ARTICLE 8. The confederated bands acknowledge their dependence on the Government of the United States and promise to be friendly with all the citizens thereof, and pledge themselves to commit no depredation on the property of such citizens, and should any one or more of the Indians violate this pledge, and the fact be satisfactorily proven before the agent, the property taken shall be returned, or in default thereof, or if injured or destroyed, compensation may be made by the Government out of their annuities; nor will they make war on any other tribe of Indians except in self-defense, but submit all matter of difference between them and other Indians, to the Government of the United States or its agents for decision, and abide thereby; and if any of the said Indians commit any depredations on other Indians, the same rule shall prevail as that prescribed in the article in case of depredations against citizens. Said Indians further engage to submit to and observe all laws, rules, and regulations which may be prescribed by the United States for the government of said Indians.

ARTICLE 9. In order to prevent the evils of intemperance among said Indians, it is hereby provided that if any one of them shall drink liquor, or procure it for others to drink, (such one) may have his or her proportion of the annuities withheld from him or her for such time as the President may determine.

ARTICLE 10. The said confederated bands agree that, whenever in the opinion of the President of the United States the public interest may require it, that all roads highways and railroads shall have the right of way through the reservation herein designated or which may at any time hereafter be set apart as a reservation for said Indians.

ARTICLE 11. This treaty shall be obligatory on the contracting parties as soon as the same shall be ratified by the President and Senate of the United States.

In testimony whereof, the said I.I. Stevens and Joel Palmer, on the part of the United States, and the undersigned chiefs, headmen, and delegates of the said confederated bands, have hereunto set their hands and seals, this ninth day of June, eighteen hundred and fifty-five.

**Isaac I. Stevens**, [Legal Signature]

Governor and Superintendent Washington Territory.

**Joel Palmer** [L.S.]

Superintendent Indian Affairs, O.T. (Oregon Territory)

**Pio-pio-mox-mox**, his x mark [L.S.]

head chief of Walla-Wallas

**Meani-teat or Pierre**, his x mark [L.S.]

**Weyatenatemany**, his x mark [L.S.]

head chief of Umatilla

**Wenap-snoot**, his x mark [L.S.]

chief of Umatilla

**Kamaspello**, his x mark [L.S.]

**Steachus**, his x mark [L.S.]

**Howlish-wampo**, his x mark [L.S.]

**Five Crows**, his x mark [L.S.]

**Stocheania**, his x mark [L.S.]

**Mu-howlish**, his x mark [L.S.]

**Lin-tin-met-cheania**, his x mark [L.S.]

**Petamyo-mox-mox**, his x mark [L.S.]

**Watash-te-waty**, his x mark [L.S.]

**She-yam-na-kon**, his x mark [L.S.]

**Qua -chim**, his x mark [L.S.]

**Te-walca-temany**, his x mark [L.S.]

**Keantoan**, his x mark [L.S.]

**U-wait-quiack**, his x mark [L.S.]

**Tilch-a-waix**, his x mark [L.S.]

**La-ta-chin**, his x mark [L.S.]

**Kacho-rolich**, his x mark [L.S.]

**Kanocey**, his x mark [L.S.]

**Som-na-howlish**, his x mark [L.S.]

**Ta-we-way**, his x mark [L.S.]

**Ha-hats-me-cheat-pus**, his x mark [L.S.]

**Pe-na-cheanit**, his x mark [L.S.]

**Ha-yo-ma-kin**, his x mark [L.S.]

**Ya-ca-los**, his x mark [L.S.]

**Na-kas**, his x mark [L.S.]

**Stop-cha-yeou**, his x mark [L.S.]

**He-yeau-she-keaut**, his x mark [L.S.]

**Sha-wa-way**, his x mark [L.S.]

**Tam-cha-key**, his x mark [L.S.]

**Te-na-we-na-cha**, his x mark [L.S.]

**Johnson**, his x mark [L.S.]

**Whe-la-chey**, his x mark [L.S.]

## **W.3 AMERICAN INDIAN TRIBAL LONG-TERM HUMAN HEALTH RISK SCENARIOS**

An American Indian hunter-gatherer scenario, as described in Appendix Q, is used in the main body of this EIS to assess potential long-term human health impacts of each of the alternatives proposed in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. Like that of two other long-term impacts receptors—the resident farmer and the American Indian resident farmer—used in the alternative comparisons, the hunter-gatherer scenario is a composite intended to reflect lifestyle behaviors in a collective or general sense. (See Appendix Q for the discussion of the basis and implementation of each of these scenarios.) One consequence is that development of the exposure factors for the American Indian hunter-gatherer involved consideration of information from several sources. These sources include the documents found in Sections W.1 and W.2 of this appendix, as well as other general documents in the risk literature (e.g., EPA 1996; Kennedy and Strenge 1992; USDA and HHS 2010). The American Indian hunter-gatherer scenario has similarities with the American Indian resident farmer scenario, in which the exposed individual is assumed to be totally sustained by his/her own farm. The two receptors differ primarily in that the hunter-gatherer (1) utilizes traditional American Indian food sources in place of contemporary agricultural sources and (2) consumes a larger quantity of fish from the Columbia River.

In this section, two additional hunter-gatherer scenarios are analyzed for a representative EIS alternative, one using the CTUIR exposure parameters (Harris and Harper 2004) and the other, the Yakama Nation exposure parameters (Ridolfi 2007). The analyses yielded estimates of the radiological and chemical impacts on traditional CTUIR and Yakama hunter-gatherer lifestyles. In the paragraphs below, the results of these analyses are presented along with those for the Appendix Q hunter-gatherer. The accompanying discussion provides comparisons between the results for these three hunter-gatherers parameterizations and looks at the relative importance of the exposure pathways considered.

### **W.3.1 Basis and Implementation**

The intent of the additional scenario analyses is to develop estimated hunter-gatherer impacts using the specific exposure factors provided by the CTUIR (Harris and Harper 2004) and the Yakama Nation (Ridolfi 2007) and to compare those impacts with the American Indian hunter-gatherer impacts. DOE's Alternative Combination 2, defined in Chapter 4, Section 4.4, of the main text of this EIS, is used as the representative basis for which to make the estimates and comparisons.

The CTUIR and Yakama Nation human health impacts are estimated using the same radionuclide and chemical exposure pathway methodologies and corresponding implementations developed for the receptors addressed in Appendix Q. Most of the tribes' parameters were directly applicable inputs as provided, although in a few instances minor accommodations were needed to run the models. For example, the RESRAD [RESidual RADioactivity] code (Yu et al. 2001) used for some part of the radiological impact calculations has a built-in upper limit of 100 kilograms (220 pounds) per year for leafy plant intake, but the CTUIR rate of 300 grams (10.6 ounces) per day exceeds that limit by 9 kilograms (20 pounds). The solution to this restriction was to input the upper-limit leafy rate allowed by RESRAD and add the remaining mass to the annual rate of one of the other plant intakes considered in RESRAD. On the other hand, the models used in the chemical impacts calculations consider the annual intakes of different plant types to be collected into a single annual plant intake.

The hazardous chemical and radiological risks are examined individually. In addition to demonstrating the potential impacts on the traditional lifestyles of the tribes, these analyses help in identifying exposure pathways and other factors that contribute most to those impacts. The analyses also are seen as representative of the impacts on the Nez Perce, whose traditional lifestyle (Bohnee et al. 2010) appears similar to that of the CTUIR and the Yakama Nation.

### **W.3.2 Data from CTUIR Exposure Scenario**

The CTUIR comprises the Cayuse, Umatilla, and Walla Walla tribes. The current Umatilla Reservation is in northeastern Oregon, but the traditional land areas of the Umatilla People extended from northeastern Oregon into southeastern Washington. Formerly the Umatilla lived a hunter-gatherer life, depending largely on fishing for salmon as supplemented by the gathering of roots and berries and hunting of deer and elk (CTUIR 2011). Longhouses provided shelter for extended families and connection to the environment, and community, religious, and sweat lodge rituals sustained cultural and spiritual values.

To provide information for National Environmental Policy Act (NEPA) analysis conducted by government agencies, the CTUIR has developed an exposure scenario based on its traditional subsistence lifestyle and provided recommended values for exposure parameters to be used in estimating human health impacts for that scenario (Harris and Harper 2004). Hunting, fishing, gathering, and cultural activities integral to that scenario provide the framework for definition of specific exposure pathways. The primary exposure pathways are ingestion of water, fish, game, roots, and berries; inhalation and ingestion of soil; and inhalation of, and immersion in, steam produced by heating water in a sweat lodge.

The CTUIR-recommended values for exposure parameters are summarized in Table W-1. Allowing for minor accommodation of the models as mentioned in Section W.3.1, these values were adopted for the present CTUIR analysis. The results of that analysis are summarized below in Section W.3.4.

**Table W-1. Exposure Parameters and Values for the  
CTUIR Adult Traditional Subsistence Scenario<sup>a</sup>**

Parameter	Quantity
Inhalation, cubic meters per day	30
Drinking water, liters per day	4 <sup>b</sup>
Food, grams per day	
Fish	620
Game	125
Roots	800
Berries	125
Greens	300
Others <sup>c</sup>	125
Soil ingestion, milligrams per day	400
Sweat lodge use, hours per day	2

<sup>a</sup> Modified from Harris and Harper 2004:Tables 3 and 5.

<sup>b</sup> Includes consumption of 1 liter (0.3 gallons) per day in a sweat lodge.

<sup>c</sup> Sweeteners, mushrooms, and lichens.

**Note:** To convert cubic meters to cubic feet, multiply by 35.315; grams to ounces, by 0.03527; liters to gallons, by 0.26417; milligrams to ounces, by 0.00003527.

**Key:** CTUIR=Confederated Tribes of the Umatilla Indian Reservation.

### **W.3.3 Data from Yakama Nation Exposure Scenario**

The current reservation of the Yakama Nation is in south-central Washington west of the Yakima River, but traditional tribal land extended to the east to the Columbia River. Traditional lifeways of the Yakama Nation included hunting, gathering, and fishing, with particular reliance on salmon harvesting from local rivers (CRITFC 2011).

The Yakama Nation also has developed an exposure scenario based on its traditional subsistence lifestyle to provide information for NEPA analysis conducted by government agencies, and, as a part of this effort, has provided recommended values for exposure parameters to be used in estimating human health impacts

for the scenario (Ridolfi 2007). As with the CTUIR, hunting, gathering, fishing, and cultural activities are integral to the Yakama scenario, and thus the framework for definition of the exposure pathways. The primary exposure pathways are ingestion of water, fish, game, vegetables, and fruit; inhalation and ingestion of soil; and inhalation of, and dermal exposure to, steam produced by heating water in a sweat lodge.

Recommended values for Yakama Nation exposure parameters (see Table W–2) were developed from interviews with 16 members of the Nation (enrollment: 9,700), and are in general the maximum value reported by an interviewee for each parameter. These values were adopted for the present Yakama analysis, allowing for some minor accommodation for the models used in the calculation. Of special significance are the reported values for maximum time spent in the sweat lodge, which ranged from 90 minutes per year to 7 hours per day.

**Table W–2. Exposure Parameters and Values for the Maximally Exposed Individual in a Yakama Nation Traditional Subsistence Scenario<sup>a</sup>**

Parameter	Quantity
Inhalation, cubic meters per day	26
Drinking water, liters per day	4 <sup>b</sup>
Food	
Fish, grams per day	519
Meat, grams per day	704
Vegetables, grams per day	1,118
Fruit, grams per day	299
Milk, liters per day	1.2
Soil ingestion, milligrams per day	200
Sweat lodge use, hours per day	7 <sup>c</sup>

<sup>a</sup> Modified from Ridolfi 2007:Table 7.

<sup>b</sup> Yakama maximum use plus sweat lodge use of 1 liter (0.3 gallons) per day.

<sup>c</sup> Maximum hours per day.

**Note:** To convert cubic meters to cubic feet, multiply by 35.315; grams to ounces, by 0.03527; liters to gallons, by 0.26417; milligrams to ounces, by 0.00003527.

**Key:** Yakama Nation=Confederated Tribes and Bands of the Yakama Nation.

### W.3.4 Human Health Impacts: American Indian Hunter-Gatherer,<sup>1</sup> Yakama Hunter-Gatherer, and CTUIR Hunter-Gatherer Scenarios

Table W–3 presents the peak radiological and chemical human health impacts for the three hunter-gatherer scenarios. The estimated radiological impacts in the table are the peak doses and peak cancer morbidity risks for the year of the peak dose; the estimated chemical impacts, the Hazard Indices and cancer morbidity risks in the year of the peak Hazard Index. In addition, the year of peak occurrence for each health impact—i.e., dose, radiological risk, Hazard Index, nonradiological risk—are provided in the scenarios.

A survey of the results in Table W–3 indicates similar results for the three scenarios. The exposure factors for the American Indian hunter-gatherer and the CTUIR hunter-gatherer are very similar, and this is reflected in the close similarity of their results. The exposure factors for the Yakama hunter-gatherer generally entail greater food consumption and longer exposure times than for the other two hunter-gatherers, and these result in greater estimated impacts. The Yakama results are greater roughly by a factor of three. From the perspective of chemical-mediated cancer risks, this difference is a direct

<sup>1</sup> This is the hunter-gatherer described in Appendix Q.

result of much more exposure time in the sweat lodge in the Yakama scenario. (The maximum exposure of 7 hours per day was used—this compared with 2 hours per day for the others.) The sweat lodge exposure pathway determines the chemical cancer risk in all three scenarios, and this can be seen in the ratio of the Yakama risk to the CTUIR and American Indian hunter-gatherer risks. The former is approximately three and one-half times the risk of each of the latter two—coinciding with the ratio of their respective exposures, 7 hours per day and 2 hours per day, or 3.5:1.

**Table W-3. Peak Doses, Hazard Indices, and Risks for the American Indian Hunter-Gatherer, Yakama Nation Hunter-Gatherer, and CTUIR Hunter-Gatherer Scenarios**

Impact	American Indian Hunter-Gatherer <sup>a</sup>	Yakama Nation Hunter-Gatherer	CTUIR Hunter-Gatherer
<b>Radiological Health Impacts</b>			
<b>Dose (millirem per year)</b>			
Hydrogen-3 (tritium)	$1.21 \times 10^{-7}$	$3.27 \times 10^{-7}$	$2.72 \times 10^{-7}$
Technetium-99	$1.19 \times 10^{-2}$	$1.96 \times 10^{-2}$	$5.28 \times 10^{-3}$
Iodine-129	$2.60 \times 10^{-3}$	$4.85 \times 10^{-3}$	$2.02 \times 10^{-3}$
Total <sup>b</sup>	$1.45 \times 10^{-2}$ (2242)	$2.45 \times 10^{-2}$ (2242)	$7.31 \times 10^{-3}$ (2228)
<b>Risk</b>			
Hydrogen-3 (tritium)	$1.13 \times 10^{-12}$	$3.77 \times 10^{-12}$	$1.26 \times 10^{-12}$
Technetium-99	$6.38 \times 10^{-7}$	$1.18 \times 10^{-6}$	$3.22 \times 10^{-7}$
Iodine-129	$6.17 \times 10^{-8}$	$1.15 \times 10^{-7}$	$4.74 \times 10^{-8}$
Total <sup>b</sup>	$6.99 \times 10^{-7}$ (2254)	$1.30 \times 10^{-6}$ (2254)	$3.70 \times 10^{-7}$ (2254)
<b>Hazardous Chemical Impacts</b>			
<b>Hazard Index</b>			
Chromium	$3.12 \times 10^{-1}$	1.08	$3.12 \times 10^{-1}$
Nitrate	$7.22 \times 10^{-1}$	5.20	$7.57 \times 10^{-1}$
Total <sup>b</sup>	1.03 (2076)	6.29 (2076)	1.07 (2076)
<b>Risk</b>			
Chromium	$1.28 \times 10^{-5}$	$4.47 \times 10^{-5}$	$1.28 \times 10^{-5}$
Nitrate	0.00	0.00	0.00
Total <sup>b</sup>	$1.28 \times 10^{-5}$ (2076)	$4.47 \times 10^{-5}$ (2076)	$1.28 \times 10^{-5}$ (2076)

<sup>a</sup> This is the hunter-gatherer described in Appendix Q.

<sup>b</sup> The peak year appears in parentheses below the entry.

**Key:** CTUIR=Confederated Tribes of the Umatilla Indian Reservation; Yakama Nation=Confederated Tribes and Bands of the Yakama Nation.

While the sweat lodge exposure pathway assumes an equal use of ceremonial groundwater and surface water, only the groundwater contributes to the impacts of that pathway. This is because of the large amount of dilution that will occur given the river's large flow, and because the route of the surface water to the exposed individual is fairly direct, with no intervening bioaccumulation or other processes that would increase contaminant intakes. The sweat lodge exposure pathway also contributes to the radiological risks, but in general the important radiological exposure pathways are those calculated using RESRAD—the terrestrial pathways.

As can be seen in Table W–3, two radionuclides and two chemicals account for the peak impacts. Technetium-99 contributes approximately 72 to 82 percent of the radiation dose across the three scenarios and iodine-129 contributes the remainder. The results for the radiological risks are similar except that the contribution of the technetium-99 increases to about 90 percent of the risk. The chemical noncarcinogenic risks, i.e., the Hazard Indices, are due to two constituents: nitrate, which accounts for 70 to 83 percent of the Hazard Indices across the scenarios; and chromium, which accounts for the remainder.

A breakdown by exposure pathway—not part of the table—shows that nitrate’s peak impact occurs mostly as a result of the terrestrial food chain and the consumption of fish for the American Indian and the CTUIR hunter-gatherer scenarios. The impacts of these nitrate pathways in the Yakama scenario are similar in magnitude, but the largest contribution is by way of the subsistence dairy pathway—a terrestrial pathway not present in the other two scenarios. Chromium is responsible for 100 percent of the nonradiological cancer morbidity risk in the three hunter-gatherer scenarios, and as noted earlier in the section, that is by way of the groundwater half of the sweat lodge exposure pathway. Both the peak radiological doses and radiological risks in the three scenarios are largely due to the terrestrial food chain pathways and, to a lesser extent, the sweat lodge pathway.

The results presented in Table W–3 provide both a measure of the representativeness of the composite American Indian hunter-gatherer scenario from the perspective of the CTUIR and Yakama scenarios and parameterizations, and a look at the sensitivity of the hunter-gatherer scenario to variations in several key exposure parameters. Representativeness of the composite hunter-gatherer follows from the similarity of the results for the three scenarios. The variations in the results across rows in Table W–3 suggest a representative range of responses that one might expect from the models when their parameters are drawn from a range of values consistent with lifestyle behaviors. In addition, these present calculations demonstrate how in some parts of the analyses a single constituent and single exposure pathway—e.g., chromium cancer morbidity risks and the sweat lodge pathway—may be controlling, while in other parts, such as the peak radiological doses and risks, more than one constituent is contributing and more than one exposure pathway is important. The analyses also demonstrate that both groundwater pathways (including terrestrial) and surface-water pathways play a role in determining the estimated impacts for the hunter-gatherer scenarios.

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**APPENDIX X**

**SUPPLEMENT ANALYSIS OF THE DRAFT TANK CLOSURE AND WASTE  
MANAGEMENT ENVIRONMENTAL IMPACT STATEMENT FOR THE  
HANFORD SITE, RICHLAND, WASHINGTON**

Consistent with U.S. Department of Energy (DOE) Regulations (10 CFR 1021.314(c)(3)), “DOE shall make the determination and the related Supplement Analysis available to the public for information. Copies of the determination and Supplement Analysis shall be provided upon written request. DOE shall make copies available for inspection in the appropriate DOE public reading room(s) or other appropriate location(s) for a reasonable time.”

DOE posted the *Supplement Analysis of the “Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington”* on the DOE National Environmental Policy Act website, <http://energy.gov/nepa/office-nepa-policy-and-compliance>, on February 8, 2012, and on the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* website, <http://www.hanford.gov/index.cfm?page=1117&>, on February 9, 2012, and the supplement analysis (SA) was provided on February 14, 2012, to the DOE public reading room at 2770 University Drive, Room 101L, Richland, Washington 99352. The SA is also provided here as Appendix X of this *Final TC & WM EIS* for convenience only.



**SUPPLEMENT ANALYSIS**  
of the  
*Draft Tank Closure and Waste Management*  
*Environmental Impact Statement*  
*for the Hanford Site, Richland, Washington*

**February 2012**



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### List of Abbreviations and Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
COPC	constituent of potential concern
CY	calendar year
DOE	U.S. Department of Energy
DST	double-shell tank
EIS	environmental impact statement
ERDF	Environmental Restoration Disposal Facility
FBSR	fluidized-bed steam reforming
FFTF	Fast Flux Test Facility
GTCC	greater-than-Class C
<i>GTCC EIS</i>	<i>Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste</i>
Hanford	Hanford Site
HLW	high-level radioactive waste
IDF	Integrated Disposal Facility
IDF-East	200-East Area IDF
IDF-West	200-West Area IDF
IHLW	immobilized high-level radioactive waste
ILAW	immobilized low-activity waste
INL	Idaho National Laboratory
LAW	low-activity waste
LLBG	low-level radioactive waste burial ground
LLW	low-level radioactive waste
MCL	maximum contaminant level
MLLW	mixed low-level radioactive waste
NEPA	National Environmental Policy Act
RCRA	Resource Conservation and Recovery Act
RH-SC	remote-handled special component
ROD	Record of Decision
RPPDF	River Protection Project Disposal Facility
SA	supplement analysis
SIM	Soil Inventory Model
SNF	spent nuclear fuel
SST	single-shell tank
<i>TC &amp; WM EIS</i>	<i>Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington</i>
TPA	Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)
TRU	transuranic
WTP	Waste Treatment Plant



## **1.0 INTRODUCTION**

This supplement analysis (SA) was prepared for the U.S. Department of Energy's (DOE's) *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* (DOE/EIS-0391, 2009) in accordance with regulations implementing the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.). Specifically, Council on Environmental Quality (CEQ) NEPA regulations (40 CFR 1502.9(c)) require Federal agencies to prepare supplements to either draft or final environmental impact statements (EISs) if "(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns" or "(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts." In cases where it is unclear whether a supplemental EIS is required, DOE regulations (10 CFR 1021.314(c)) direct the preparation of an SA to assist in making that determination by assessing whether there is a change in the proposed action that is "substantial" or whether new circumstances or information are "significant," pursuant to the CEQ regulations (40 CFR 1502.9(c)).

Beginning in October 2009, DOE held a 185-day public comment period on the *Draft TC & WM EIS* (74 FR 56194), during which time eight public hearings were held and approximately 3,000 comments were received. DOE is considering all comments equally, whether written, spoken, faxed, mailed, or submitted electronically. In preparing to issue the *Final TC & WM EIS*, including responses to public comments, DOE identified updates or modifications to the technical data analyzed in the *Draft TC & WM EIS*, and expanded specific discussion areas, based on comments, where this could be helpful to the reader. None of this information changed the proposed actions stated in the draft EIS, but DOE found that, in some cases, it was unclear as to whether the updated, modified, or additional information that has become available since the *Draft TC & WM EIS* was issued could warrant a supplement to the draft EIS. Accordingly, DOE prepared this SA to make that determination. DOE identified 14 topics where it is unclear whether updated, modified, or expanded information warrants preparation of a supplemental or new draft EIS. The topics pertain to two major sections of the draft EIS: radioactive and nonradioactive inventories analyzed in the cumulative impacts analysis and changes to alternatives analyses. For each topic, this SA identifies the pertinent aspects of the *Draft TC & WM EIS*, the nature of the update, modification, or expansion, a comparative analysis of the changes, and a discussion in light of the criteria contained in the CEQ and DOE NEPA regulations (40 CFR 1502.9(c) and 10 CFR 1021.314(c)) regarding when a supplemental or new EIS is required.

## **2.0 PROPOSED ACTIONS AND ALTERNATIVES EVALUATED IN THE *DRAFT TC & WM EIS***

As part of its environmental cleanup and management mission at the Hanford Site (Hanford), DOE needs to accomplish a number of goals, which include three major areas of activity, as follows:

- Disposition of approximately 207 million liters (54.6 million gallons) of mixed radioactive and chemically hazardous waste<sup>1</sup> stored in 177 underground tanks and closure of the single-shell tank (SST) system
- Decommissioning of the Fast Flux Test Facility (FFTF), a nuclear test reactor, and removal of its associated waste and bulk sodium as part of the decommissioning process
- Management of low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) generated on site and from other DOE sites

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<sup>1</sup> Waste containing constituents subject to regulation under the Resource Conservation and Recovery Act.

## 2.1 Proposed Actions

DOE's proposed actions, which remain unchanged from the *Draft TC & WM EIS*, are as follows:

- **Tank Closure.** Retrieve, treat, and dispose of waste being managed in the high-level radioactive waste (HLW) SST and double-shell tank (DST) farms at Hanford and close the SST system, which includes disposition of the SSTs, ancillary equipment, and soils. The SST (149 tanks) and DST (28 tanks) systems contain both hazardous and radioactive waste (mixed waste).
- **FFTF Decommissioning.** Decommission Hanford's FFTF and ancillary facilities; manage the waste from the decommissioning process, including certain waste designated as remote-handled special components (RH-SCs); and manage disposition of Hanford's inventory of radioactively contaminated bulk sodium from FFTF and other facilities on site.
- **Waste Management.** Manage the waste resulting from tank closure and other Hanford activities, as well as limited volumes received from other DOE sites.

## 2.2 Decisions to Be Made

Through the proposed actions to retrieve, treat, and dispose of tank waste; decommission FFTF; and manage waste at Hanford to provide for disposal of on- and offsite waste, the *TC & WM EIS* is intended to support several decisions that DOE needs to make to meet its mission at the site. These potential decisions are described below.

- **Storage of Tank Waste.** All *TC & WM EIS* alternatives require tank farm waste storage; however, each alternative considers a different length of time. The *TC & WM EIS* evaluates the construction and operation of waste transfer infrastructure, including waste receiver facilities, which are below-grade storage and minimal waste-conditioning facilities; waste transfer line upgrades; and additional or replacement DSTs. The EIS also evaluates various waste storage facilities to manage the treated tank waste and the waste associated with closure activities. This includes construction and operation of additional immobilized high-level radioactive waste (IHLW) storage vaults, melter pads, transuranic (TRU) waste storage facilities, and immobilized low-activity waste (ILAW) storage facilities. The EIS also provides environmental impact information to assist in making informed decisions regarding continued storage of tank waste and storage to support treatment and disposal activities.
- **Retrieval of Tank Waste.** The EIS evaluates various retrieval technologies and benchmarks. The four waste retrieval benchmarks (0, 90, 99, and 99.9 percent) address various requirements or retrieval activities. The 0 percent retrieval benchmark represents the No Action Alternative, evaluated as required by NEPA; 90 percent retrieval represents a programmatic risk analysis for the tank farms as defined by Appendix H of the Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement [TPA]),<sup>2</sup> “Single Shell Tank Waste Retrieval Criteria Procedure”; 99 percent retrieval is the goal established by TPA Milestone M-45-00; and 99.9 percent retrieval reflects multiple deployments of retrieval technologies to support clean closure requirements.
- **Treatment of Tank Waste.** Additional waste treatment capability can be achieved by building new treatment facilities that are either part of, or separate from, the Waste Treatment Plant (WTP), which is currently under construction. DOE could also complete treatment sometime after 2028 without supplemental treatment by extending the current WTP operating period until

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<sup>2</sup> The TPA is an agreement signed in 1989 by DOE, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology that identifies milestones for key environmental restoration and waste management actions at Hanford.

all the waste is treated. The two primary choices that would comply with DOE's commitments are to treat all the waste in an expanded WTP or to provide supplemental treatment in conjunction with, but separate from, the WTP. DOE has conducted preliminary tests on three supplemental treatment technologies to determine whether one or more could be used to provide the additional capability needed to complete waste treatment. The decision on whether to treat all the waste in the WTP (as is or expanded) or to supplement WTP capacity by adding new treatment capability depends on demonstration of the feasibility of supplemental treatment technologies.

- **Disposal of Treated Tank Waste.** The *TC & WM EIS* addresses on- and offsite disposal, depending on the waste type. Onsite disposal includes disposal of treated tank waste and waste generated from closure activities that meet onsite disposal criteria. The decision to be made involves the onsite location of disposal facilities, specifically, one or two Integrated Disposal Facilities (IDFs), which would manage treated tank waste, and the River Protection Project Disposal Facility (RPPDF), which would manage closure activity waste. The EIS will provide the environmental impact information needed for informed decisions on tank waste that could be classified as TRU waste for disposal. Offsite disposal of tank waste determined to be TRU waste would occur at DOE's Waste Isolation Pilot Plant near Carlsbad, New Mexico.
- **Closure of the SST System.** The *TC & WM EIS* addresses closure of the SST system under all Tank Closure alternatives except Tank Closure Alternatives 1 and 2A (see Section S.2 of the *Draft TC & WM EIS* Summary for a description of the alternatives analyzed in the EIS). Although DOE is committed to retrieving at least 99 percent of the waste, consistent with the TPA, the range of potential impacts in the cases considered includes those of residual waste left in the tanks at different retrieval benchmarks (0, 90, 99, and 99.9 percent). Different closure scenarios are also evaluated: clean closure, selective clean closure/landfill closure, and landfill closure with or without contaminated soil removal. In addition, two structurally different landfill barriers are evaluated to determine the effectiveness of natural and engineered defense-in-depth barriers in minimizing any transport of waste over the long timeframes of interest.
- **Decommissioning of FFTF.** This decision would determine the end state for FFTF's aboveground, belowground, and ancillary support structures.
- **Disposal of Hanford Waste and Offsite DOE LLW and MLLW.** The decision to be made concerns the onsite location of disposal facilities for Hanford's waste and other DOE sites' LLW and MLLW. DOE committed in the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE 2004) Record of Decision (ROD) (69 FR 39449) to disposing of LLW in lined trenches. Thus, the decision is whether to dispose of LLW and MLLW in the 200-East Area IDF (IDF-East) or in a new IDF located in the 200-West Area (IDF-West).

## 2.3 Summary of Alternatives Analyzed

The alternatives evaluated in the *TC & WM EIS* were identified to represent the range of reasonable alternatives for completing DOE's three sets of proposed actions (tank closure, FFTF decommissioning, and waste management) and to provide an understanding of the differences between the potential environmental impacts of the range of reasonable alternatives. In the *TC & WM EIS*, DOE evaluates the impacts associated with 11 Tank Closure alternatives, 3 FFTF Decommissioning alternatives, and 3 Waste Management alternatives. A No Action Alternative is required under CEQ regulations to provide a basis for comparing the alternatives (40 CFR 1502.14(d)).

For Tank Closure alternatives, impacts resulting from storage, retrieval, treatment, disposal, and closure activities at Hanford's HLW tank farms were evaluated, as were the impacts of a No Action Alternative. These Tank Closure alternatives represent the range of reasonable approaches to removing waste from the tanks to the extent that is technically and economically feasible; treating the waste by vitrifying it in the WTP, and/or using one or more supplemental treatment processes; packaging the waste for either offsite shipment and disposal or onsite disposal; and closing the SST system to permanently reduce the potential risk to human health and the environment.

#### Tank Closure Alternatives

**Alternative 1:** No Action

**Alternative 2:** Implement the *Tank Waste Remediation System EIS Record of Decision with Modifications*

- **Tank Closure Alternative 2A:** Existing WTP Vitrification; No Closure
- **Tank Closure Alternative 2B:** Expanded WTP Vitrification; Landfill Closure

**Alternative 3:** Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

- **Tank Closure Alternative 3A:** Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure
- **Tank Closure Alternative 3B:** Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure
- **Tank Closure Alternative 3C:** Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

**Alternative 4:** Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

**Alternative 5:** Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

**Alternative 6:** All Waste as Vitrified HLW

- **Tank Closure Alternative 6A:** All Vitrification/No Separations; Clean Closure (Base and Option Cases)
- **Tank Closure Alternative 6B:** All Vitrification with Separations; Clean Closure (Base and Option Cases)
- **Tank Closure Alternative 6C:** All Vitrification with Separations; Landfill Closure

In addition, this *TC & WM EIS* evaluates the potential environmental impacts of proposed activities to decommission FFTF and associated ancillary facilities at Hanford, including management of waste generated by the decommissioning process (such as certain waste designated as RH-SCs) and disposition of Hanford's inventory of radioactively contaminated bulk sodium from FFTF and other onsite facilities.

#### FFTF Decommissioning Alternatives

- Alternative 1:** No Action
- Alternative 2:** Entombment
- Alternative 3:** Removal

The *TC & WM EIS* evaluates the impacts associated with Waste Management alternatives for managing the storage, processing, and disposal of solid waste at Hanford, as well as subsequent closure of associated disposal facilities. These alternatives represent the range of reasonable approaches to continued storage of LLW, MLLW, and TRU waste at Hanford; onsite waste processing using two expansions of the Waste Receiving and Processing Facility; onsite disposal of onsite-generated LLW and MLLW; disposal of onsite non-CERCLA [Comprehensive Environmental Response, Compensation, and Liability Act] and offsite-generated LLW and MLLW in new onsite facilities; and closure of disposal facilities to reduce water infiltration and the potential for intrusion.

#### Waste Management Alternatives

- Alternative 1:** No Action
- Alternative 2:** Disposal in IDF, 200-East Area Only
- Alternative 3:** Disposal in IDF, 200-East and 200-West Areas

Because of the large number of combinations of disposal facility configurations that could support the 11 Tank Closure alternatives and 3 FFTF Decommissioning alternatives, three waste disposal groups were analyzed in the *Draft TC & WM EIS* under both Waste Management action alternatives (Waste Management Alternatives 2 and 3). The size, capacity, and number of facilities associated with each disposal group were based on the amounts and types of waste generated under each of the three sets of action alternatives: Tank Closure, FFTF Decommissioning, and Waste Management.

DOE's Preferred Alternatives discussions for each of the three major areas of activity are presented (with minor editorial modifications) from the *Draft TC & WM EIS*, as follows:

### **Tank Closure**

Eleven alternatives for potential tank closure actions were evaluated in the draft EIS. These alternatives cover tank waste retrieval and treatment, as well as closure of the SSTs. In the *Draft TC & WM EIS*, DOE did not identify specific preferred alternatives for retrieval or treatment of the tank waste, but has identified a range of preferred retrieval and treatment options. For retrieval, DOE prefers Tank Closure alternatives that would retrieve at least 99 percent of the tank waste. All Tank Closure alternatives would do this, except Alternatives 1 (No Action) and 5. For treatment, DOE prefers Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5 because they would allow separation and segregation of the tank waste for management and disposition as LLW and HLW, according to the risks posed. In contrast, DOE does not prefer Tank Closure Alternatives 6A, 6B, or 6C because they would manage all tank waste as HLW. For closure of the SSTs, DOE prefers landfill closure, as provided under Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C, for the reasons described in Section S.5.4.1 of the *TC & WM EIS Summary*. The Tank Closure alternatives that capture each of DOE's preferred retrieval, treatment, and closure options are Alternatives 2B, 3A, 3B, and 3C. For storage, DOE prefers Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5. These alternatives assume shipment of IHLW canisters for disposal off site.

### **FFTF Decommissioning**

There are three FFTF Decommissioning alternatives from which the Preferred Alternative was identified: (1) No Action, (2) Entombment, and (3) Removal. DOE's Preferred Alternative for FFTF decommissioning is Alternative 2: Entombment, which would remove all above-grade structures, including the reactor building. Below-grade structures, the reactor vessel, piping, and other components would remain in place and be filled with grout to immobilize the remaining radioactive and hazardous constituents. Waste generated from these activities would be disposed of in an IDF, and an engineered modified Resource Conservation and Recovery Act (RCRA) Subtitle C barrier would be constructed over the filled area. The RH-SCs would be processed at DOE's Idaho National Laboratory (INL), but bulk sodium inventories would be processed at Hanford.

### **Waste Management**

Three Waste Management alternatives were identified for the proposed actions: (1) Alternative 1: No Action, under which all onsite-generated LLW and MLLW would be treated and disposed of in the existing, lined low-level radioactive waste burial ground (LLBG) 218-W-5 trenches and no offsite-generated waste would be accepted; (2) Alternative 2, which would continue treatment of onsite-generated LLW and MLLW in expanded, existing facilities and dispose of onsite-generated and previously treated offsite-generated LLW and MLLW in a single IDF (IDF-East); and (3) Alternative 3, which also would continue treatment of onsite-generated LLW and MLLW in expanded, existing facilities, but would dispose of onsite-generated and previously treated, offsite-generated LLW and MLLW in two IDFs (IDF-East and IDF-West). DOE's Preferred Alternative for waste management is Alternative 2, disposal of onsite-generated LLW and MLLW streams in a single

IDF (IDF-East). Disposal of SST closure waste that is not highly contaminated, such as rubble, soils, and ancillary equipment, in the RPPDF is also included under this alternative. After completion of disposal activities, IDF-East and the RPPDF would be landfill-closed under an engineered modified RCRA Subtitle C barrier. The Preferred Alternative also includes limitations on, and exemptions for, offsite waste importation at Hanford, at least until the WTP is operational, as those limitations and exemptions are defined in DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM).

## **2.4 Draft TC & WM EIS Summary of Key Environmental Findings**

### **Tank Closure**

- Tank Farm Waste Retrieval
  - Continued storage of tank waste with no removal would have negligible additional short-term impacts but significant long-term impacts.
  - Retrieving tank waste rather than leaving it in place would reduce long-term impacts on groundwater and human health.
- WTP Configuration
  - Using the existing WTP treatment configuration would extend treatment time and require replacement DSTs.
  - Using the existing WTP configuration supplemented by expanded ILAW treatment capacity would reduce treatment time and result in minor impacts on most resources.
  - Tank Closure Alternative 6A (all waste treated as HLW with no separation of ILAW and clean closure, i.e., tanks and contaminated soils removed) would have the highest demands for, and thus the greatest short-term impacts on, most resources.
  - Varying the WTP configuration would not change the quantity or performance of waste forms and, therefore, would have minor influence on long-term impacts.
- Primary-, Supplemental-, and Secondary-Waste Forms
  - Differences in potential short-term impacts of facility construction and supplemental treatment operations among the Tank Closure alternatives are relatively small for most resource areas.
  - Estimates of potential long-term human health impacts at the IDF-East barrier due to disposal show that segregation of the maximum amount of waste into ILAW glass, as opposed to other supplemental treatment waste forms, produces the lowest estimate of risk at the disposal facility (Tank Closure Alternative 2B).
  - A combination of ILAW glass with bulk vitrification glass and secondary waste results in the next-lowest estimate of impacts (Tank Closure Alternative 3A).
  - The cast stone waste form results in higher estimates of impacts due to the remaining inventory of technetium-99 not immobilized into IHLW glass and the relatively poor performance of the current Hanford site-specific grout formulation in retaining this radionuclide (Tank Closure Alternative 3B).

- The steam reforming waste form provides the poorest performance of the supplemental-waste forms, based on data on the assumed release mechanism (Tank Closure Alternative 3C).
- The analysis suggests that additional treatment or waste form development may be needed for secondary waste.
- Tank-Derived TRU Waste
  - Treating some tank-derived waste as TRU waste could decrease the amount of waste sent to the WTP and the supplemental treatment timeframes, thus reducing the volume of waste to be disposed of on site in an IDF and the associated long-term impacts (Tank Closure Alternatives 3A, 3B, 3C, 4, and 5).
- Technetium Removal in the WTP<sup>3</sup>
  - ILAW glass with technetium removal would have similar impacts, both short and long term, to ILAW glass without technetium removal.
  - The technetium removal process in the WTP would result in most of the technetium being incorporated in IHLW glass and some in secondary waste. The analysis indicates that removal of technetium and its disposal off site as IHLW glass would provide little reduction in the concentrations of technetium-99 at either the Core Zone Boundary or the Columbia River nearshore because the release rate of technetium-99 from ILAW glass is much lower than that from other sources such as Effluent Treatment Facility-generated secondary waste and tank closure secondary waste (Tank Closure Alternatives 2B and 3B).
- Sulfate Grout
  - Use of the sulfate removal technology to increase the waste loading in ILAW glass would result in a reduced treatment timeframe and reduced ILAW glass volume, with minimal potential short-term impacts and no long-term impacts (Tank Closure Alternative 5).
- Closure of the Six Sets of Cribs and Trenches (Ditches)
  - Cribs and trenches (ditches) are major contributors to potential long-term groundwater impacts for all Tank Closure alternatives due to their early discharges in the 1950s and 1960s.
- Closure of SST System Past Leaks
  - Over the short term, past leaks in and around the SST farms could affect clean closure activities. For example, construction dewatering to support clean closure may increase worker dose.
  - Past leaks are major contributors to potential long-term groundwater impacts.
- Closure of the SST System
  - Total short-term and peak short-term environmental impacts of SST farm closure activities would exceed facility construction impacts for most alternatives and would

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<sup>3</sup> Technetium-99 removal results in a significant portion of this radionuclide being removed from the waste feed and treated as IHLW.

substantially add to short-term environmental impacts overall, especially in terms of emissions, worker doses, and resource demands.

- Clean closure of the SST system when compared to landfill closure would have the following potentially adverse short-term impacts:
  - Total land commitments would increase twofold.
  - Electricity use would increase by one order of magnitude.
  - Geologic resource requirements would increase fivefold.
  - Sagebrush habitat affected would increase by over two orders of magnitude.
  - The average worker radiation dose from normal operations would increase more than twofold.
  - LLW and MLLW generation volumes would increase threefold.
  - Total recordable work occurrences would increase sixfold.
- There is a significant uncertainty regarding clean closure in terms of technical feasibility and risk due to the depth of excavation and soil exhumation that would be required.
- The Hanford barrier would have negligible human health benefits at the Core Zone Boundary when measured against the engineered modified RCRA Subtitle C barrier; it would delay release from landfills for only several hundred years.
- Estimates of human health impacts (radiological risk to the drinking-water well user) due to retrieval leaks and releases from tank farm residuals and ancillary equipment correlate to closure actions at the Core Zone Boundary, i.e., the higher the waste retrieval rate, the lower the long-term human health impacts (Tank Closure Alternatives 2B and 4).
- Clean closure of the SST farms would have some beneficial long-term impacts on the groundwater after calendar year (CY) 6000. However, it would provide little, if any, reduction in long-term impacts on the groundwater before then due to the early releases from past leaks and from the cribs and trenches (ditches) contiguous to the SST farms (Tank Closure Alternatives 6B, Base and Option Cases).
- Analysis shows that clean closure of the SST farms and contaminated soil would not reduce the concentrations of iodine-129 and technetium-99 from their respective benchmark<sup>4</sup> concentrations for at least the first 2,000 years; concentrations would remain within an order of magnitude above the benchmark concentrations through the duration of the period of analysis. Thus, there would still be groundwater impacts under the clean closure alternatives due to the early releases from past leaks and intentional releases through the cribs and trenches (ditches).

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<sup>4</sup> “Benchmark” refers to a dose or concentration known or accepted to be associated with a specific level of effect. Thus, Federal drinking water standards (Title 40 of the *Code of Federal Regulations*, Parts 141 and 143) are used as benchmarks against which potential contamination can be compared. Drinking water standards for Washington State are stated in *Washington Administrative Code* 246-290. “Benchmark” standards used in the environmental impact statement represent dose or concentration levels that correspond to known or established human health effects. For groundwater, the benchmark is the maximum contaminant level (MCL) if an MCL is available. For constituents with no available MCL, additional sources for benchmark standards include Washington State guidance and relevant regulatory standards, e.g., Clean Water Act, Safe Drinking Water Act. For example, the benchmark for iodine-129 is 1 picocurie per liter; for technetium-99, it is 900 picocuries per liter. These benchmark standards for groundwater impacts analysis were agreed upon by DOE and the Washington State Department of Ecology as the basis for comparing the alternatives and representing potential groundwater impacts.

## **FFTF Decommissioning**

- Potential short-term impacts on most resource areas would be similar under FFTF Decommissioning Alternatives 2 (Entombment) and 3 (Removal), with a few notable exceptions. Emissions of nonradioactive air pollutants associated with construction of facilities to support decommissioning activities and geologic resource requirements would be higher under FFTF Decommissioning Alternative 3. Worker radiation doses and waste generation due to removal activities would also be higher under this alternative.
- Potential long-term human health impacts under all alternatives would be minimal. There would be little difference between the No Action and Entombment Alternative impacts, except that Entombment would delay any impacts for 500 years.
- FFTF could remain in surveillance and maintenance status with little environmental impact on groundwater.

## **Waste Management**

- For the disposal groupings under Waste Management Alternatives 2 (disposal in IDF-East) and 3 (disposal in IDF-East and IDF-West), potential demands for, and short-term impacts on, most resources would vary primarily in direct relation to the size, i.e., disposal capacity, and operational lifespan of the disposal facilities.
- Potential total and peak short-term environmental impacts of disposal activities are projected to be very similar for Waste Management Alternatives 2 and 3. Thus, for short-term impacts, disposal facility configuration and location are not discriminators.
- LLBG 218-W-5, trenches 31 and 34
  - The analysis indicates that it would be safe to continue to dispose of onsite-generated non-CERCLA, nontank LLW and MLLW in these trenches. Potential short-term impacts of ongoing disposal operations would be negligible.
- Disposal of Waste in IDF-East and IDF-West
  - Total short-term impacts of constructing and operating two IDFs under Waste Management Alternative 3 would be substantially the same as those under Waste Management Alternative 2 across nearly all resource areas. This is because no economy of scale would be achieved by having two IDFs. Short-term impacts would be generally proportional to the total size, or disposal capacity, and operational lifespan of the disposal facilities rather than the number or location of the disposal facilities.
  - The long-term analysis indicates that an IDF in the 200-West Area would not perform as well as an IDF located in the 200-East Area because of the higher assumed infiltration rate for the 200-West Area location, which would cause the long-term human health impacts (radiological risk to the drinking-water well user) to be higher at the IDF-West barrier boundary than at the IDF-East barrier boundary.
- Disposal of Offsite Waste
  - The analysis shows that receipt of offsite waste streams that contain specified amounts of certain radionuclides, specifically iodine-129 and technetium-99, could have an adverse impact on the environment, i.e., groundwater impacts, suggesting the need to mitigate

such impacts by limiting the amount of technetium-99 and iodine-129 from offsite generators that could be disposed of at Hanford.

- Under Waste Management Alternatives 2 and 3, certain radionuclides, specifically iodine-129 and technetium-99, could have an adverse impact on the environment.
- Disposal of Tank Closure Waste in the RPPDF
  - The RPPDF would be a secondary contributor to human health impacts (radiological risk to the drinking-water well user at the Core Zone Boundary) throughout the period of analysis; the estimated radiological risks are less than  $1 \times 10^{-4}$ .

### **Cumulative Impacts**

- Alternative combinations would contribute little to short-term cumulative impacts. Alternative Combination 1 represents the potential impacts resulting from minimal DOE action, Alternative Combination 2 is a midrange case representative of DOE's Preferred Alternative(s), and Alternative Combination 3 represents a combination that generally results in maximum potential short-term impacts but the least long-term impacts.
- Alternative combinations would contribute little to long-term cumulative impacts on environmental justice.
- Long-term cumulative groundwater-related impacts generally would be highest with Alternative Combination 1 and lowest with Alternative Combination 3.
- Cumulative groundwater-related impacts would be dominated by the impacts of past releases.

## **3.0 ANALYSIS AND DISCUSSION OF THE UPDATED, MODIFIED, OR EXPANDED INFORMATION AS COMPARED WITH THE DRAFT TC & WM EIS**

DOE identified 14 topics where it is unclear whether updated, modified, or expanded information warrants a supplemental or new *Draft TC & WM EIS*. This information pertains to two major sets of analyses in the draft EIS, which will be used to group the following discussions:

- Radioactive and nonradioactive inventories used in the cumulative impacts analysis (Items 1 through 6)
- Changes to alternatives analyses (Items 7 through 14)

For each of the 14 topics, the following sections present a topic description, a comparison of the results reported in the *Draft TC & WM EIS* with any reanalysis results, and a discussion of any changes to information reported in the draft EIS.

### **3.1 Radioactive and Nonradioactive Inventories Used in the Cumulative Impacts Analysis**

Since publication of the *Draft TC & WM EIS*, revisions were made to the inventory database used for the cumulative impact analyses as a result of public comments and updated or corrected source references, such as SIM [Hanford Soil Inventory Model] (Corbin et al. 2005).

## (1) T Plant inventory correction

**Description:** In the source document for the T Plant inventory (Bushore 2002), results from the sampling of waste tank 15-1 taken between 1989 and 1993 were multiplied by 10,000 “for conservatism,” as stated in a footnote. In rechecking these data, DOE determined that, while such conservatism may have been appropriate for the originally intended use of the data (facility safety analyses), a multiplier of four orders of magnitude was likely to be overly conservative for the cumulative impacts analysis in the *Draft TC & WM EIS*. Accordingly, DOE, in the reanalysis, has now reduced the inventory associated with tank 15-1 by the same divisor (i.e., by 10,000) for the radionuclides reported in the source document. These isotopes include the constituents of potential concern (COPCs) carbon-14; strontium-90; technetium-99; iodine-129; cesium-137; uranium-233, -234, -235, and -238; and americium-241.

**Comparative Analysis:** Table 1 compares the draft EIS inventory estimates of these radionuclide COPCs with those revised in the reanalysis.

**Table 1. Comparison of *Draft TC & WM EIS* Radionuclide Constituents of Potential Concern Inventory Estimates with the Reanalysis for T Plant Waste Tank 15-1**

Radionuclide	Inventory Estimate (curies)	
	<i>Draft TC &amp; WM EIS</i>	Reanalysis
Carbon-14	$6.66 \times 10^1$	$6.66 \times 10^{-3}$
Strontium-90	$1.66 \times 10^4$	1.66
Technetium-99	$4.03 \times 10^1$	$4.03 \times 10^{-3}$
Iodine-129	$1.40 \times 10^1$	$1.40 \times 10^{-3}$
Cesium-137	$5.24 \times 10^4$	5.24
Uranium isotopes (includes uranium-233, -234, -235, -238)	$1.26 \times 10^1$	$1.26 \times 10^{-3}$
Americium-241	$5.49 \times 10^1$	$5.49 \times 10^{-3}$

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

**Discussion:** The inventory corrections (reductions) are to inventories analyzed in the cumulative impacts analysis and are not included in the proposed actions(s) and alternatives as described in the *Draft TC & WM EIS*. Comparison of the reanalysis results using the inventory corrections with the draft EIS cumulative impacts analysis results shows that the COPC concentrations at the Core Zone Boundary and the Columbia River nearshore did not change the results reported in the *Draft TC & WM EIS*.

## (2) Magnesium and mercury inventory corrections for Z Area cribs and trenches (ditches)

**Description:** After the draft EIS was published, DOE became aware of an error in SIM (Corbin et al. 2005). In this case, the magnesium inventories had been incorrectly reported as mercury inventories for several Z Area cribs and trenches (ditches); thus, the mercury inventory was overstated and the magnesium inventory understated. The inventory database for the reanalysis was revised to reflect this correction.

**Comparative Analysis:** The estimated mercury inventory in the *Draft TC & WM EIS* cumulative impacts analysis for the Z Area cribs and trenches (ditches) was  $7.57 \times 10^5$  kilograms. This estimate was corrected to  $3.98 \times 10^2$  kilograms in the reanalysis per the conclusions in a later report (Teal 2007). Groundwater and human health impacts associated with mercury are limited by the large retardation factor (mercury moves at less than

1 percent of the pore-water velocity). Because of limited mobility in the vadose zone and groundwater system, human health impacts in the reanalysis associated with mercury are essentially unchanged from the draft EIS. Magnesium is not a COPC and therefore is not analyzed in detail in the EIS.

**Discussion:** The corrections are to inventories analyzed in the cumulative impacts analysis and are not included in the proposed actions(s) as described in the *Draft TC & WM EIS*. The inventory changes do not result in any significant change to the cumulative impacts analysis in the draft EIS.

### (3) Addition of inventories for greater-than-Class C (GTCC) LLW and GTCC-like LLW

**Description:** At the time the *Draft TC & WM EIS* was issued, Hanford had been identified as a potential disposal site for GTCC waste (GTCC LLW and GTCC-like LLW) in the *Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (GTCC EIS)* (DOE/EIS-0375D, 2011), then in preparation. However, the GTCC waste inventory estimates were not available for the cumulative impacts analysis in the *Draft TC & WM EIS*. The *Draft GTCC EIS* was issued in February 2011, and, as a result, DOE has expanded the cumulative impacts inventory for the *TC & WM EIS* with a reanalysis of the cumulative impacts that includes this GTCC waste inventory at the Hanford reference location (200-East Area) analyzed in the *Draft GTCC EIS*.<sup>5</sup>

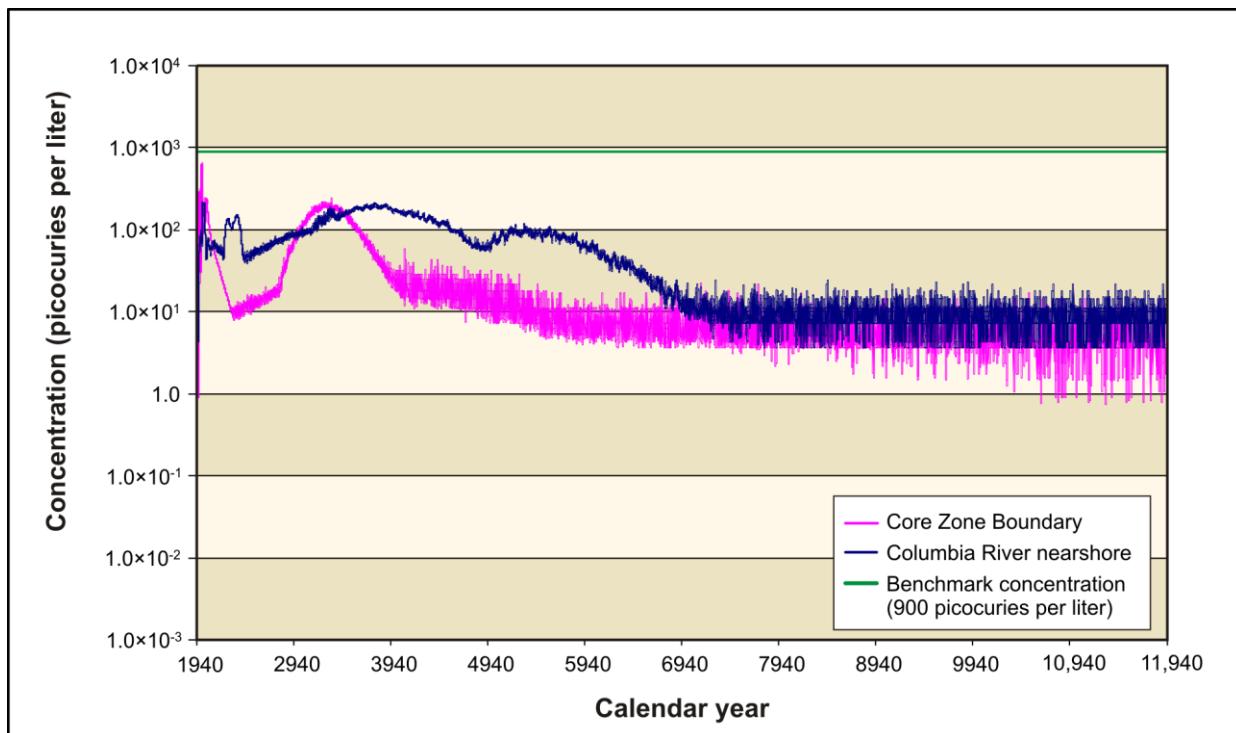
**Comparative Analysis:** Of the added inventories for the GTCC waste disposal site analyzed at the Hanford reference location, only two COPCs, technetium-99 and iodine-129, were predicted to release to the aquifer over the 10,000-year model period. Figure 1 shows the technetium-99 concentration-versus-time results at the Core Zone Boundary and the Columbia River nearshore for all the cumulative impacts analysis (i.e., non-*TC & WM EIS*) sites, including GTCC waste. This concentration-versus-time graph is shown as a point of comparison for the individual source locations discussed below. The technetium-99 concentration is estimated to be close to the benchmark for the early peak (CY 1960) and within an order of magnitude for the later peak (CY 3500). The early rise in the technetium-99 concentration-versus-time curve is due to liquid releases and is affected by the travel time through the vadose zone, which is relatively rapid. The later peak is due to partitioning-limited releases and is affected by the travel time through the vadose zone, which is slower because of lower moisture content.

Figure 2 shows the iodine-129 concentration-versus-time results at the Core Zone Boundary and the Columbia River nearshore for all the cumulative impacts analysis (i.e., non-*TC & WM EIS*) sites, including GTCC waste. The iodine-129 concentration-versus-time graph shows a behavior similar to the technetium-99 concentration versus time; however, the peaks are elevated and the early peak is more than an order of magnitude above the benchmark and the later peak is at or above the benchmark.

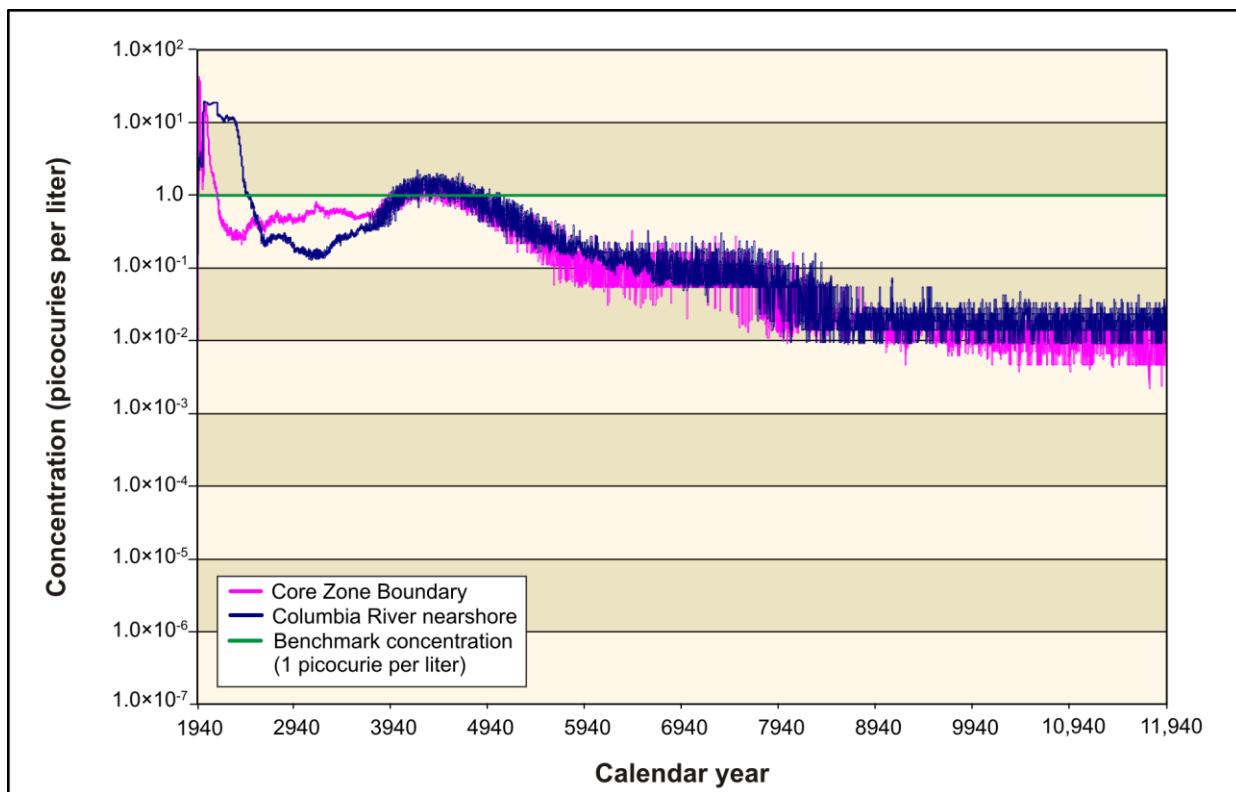
Figures 3 and 4 show concentrations versus time for technetium-99 and iodine-129, respectively, at the Core Zone Boundary and Columbia River nearshore for the GTCC waste disposal site. These figures can be directly compared to Figures 1 and 2. Note that GTCC waste disposal site (Figures 3 and 4) sources produce peak concentrations more than an order of magnitude less than the peaks for the combined cumulative impacts analysis sources (Figures 1 and 2).

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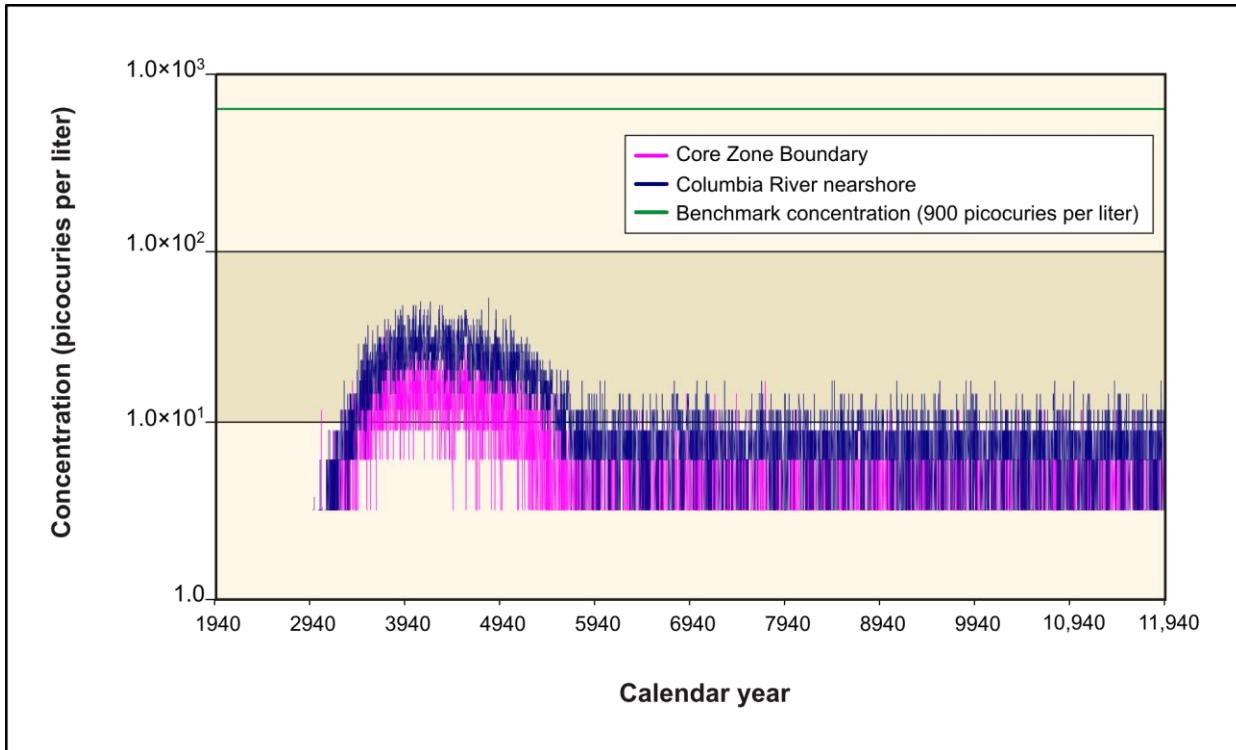
<sup>5</sup> DOE did not identify a preferred alternative in the *Draft GTCC EIS*; however, DOE did announce its preference not to dispose of GTCC or GTCC-like waste at Hanford (74 FR 67189), consistent with DOE's commitment to not ship offsite waste, including GTCC or GTCC-like waste, to Hanford, at least until the WTP is operational, currently projected for 2022.



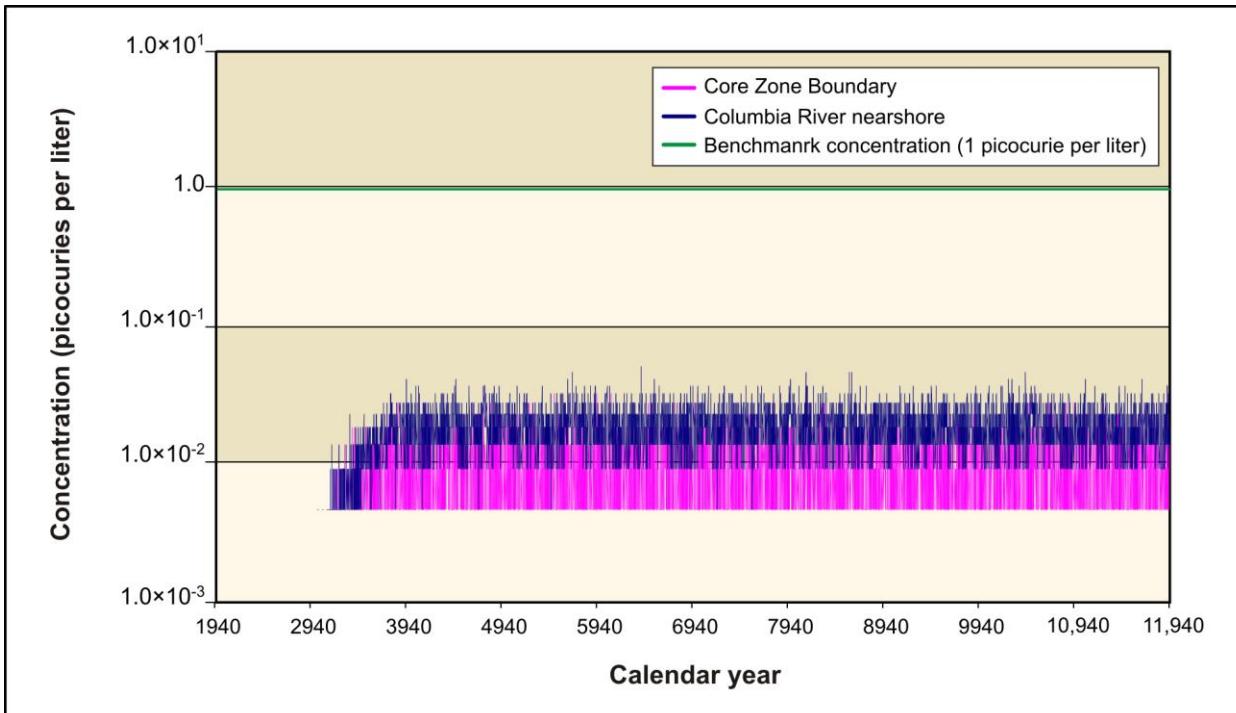
**Figure 1. Technetium-99 Concentration Versus Time for All Non-TC & WM EIS Sites (Including Greater-Than-Class C Waste Inventory)**



**Figure 2. Iodine-129 Concentration Versus Time for All Non-TC & WM EIS Sites (Including Greater-Than-Class C Waste Inventory)**



**Figure 3. Technetium-99 Concentration Versus Time  
(Greater-Than-Class C Waste Disposal Site)**



**Figure 4. Iodine-129 Concentration Versus Time  
(Greater-Than-Class C Waste Disposal Site)**

**Discussion:** Although the inclusion of the GTCC and GTCC-like waste in the *TC & WM EIS* cumulative impacts analysis adds to the total radionuclide concentrations from other sources, the concentrations of technetium-99 and iodine-129 from the GTCC waste disposal site remain below both benchmarks and below the concentration-versus-time results for all the cumulative impacts analysis sites. In other words, the addition of the GTCC waste inventory has no effect on the cumulative impacts analysis provided in the *Draft TC & WM EIS*. This is mainly because of the low moisture content, which limits the peak concentrations and greatly slows the travel times.

#### (4) Environmental Restoration Disposal Facility (ERDF) inventory update

**Description:** DOE reanalyzed *Draft TC & WM EIS* impacts in light of updated inventories for ERDF to include waste streams actually disposed of through March 2010. These updated inventories do not include projections of future waste inventories that are analyzed in the cumulative impacts analysis in the *TC & WM EIS* to account for the inventory from CERCLA sites.

**Comparative Analysis:** Table 2 compares the draft EIS inventory estimates of ERDF COPCs with those revised in the reanalysis.

**Table 2. Comparison of *Draft TC & WM EIS* Radionuclide Constituent of Potential Concern Inventory Estimates with the Reanalysis for ERDF**

Constituent of Potential Concern	Inventory Estimate (curies)	
	<i>Draft TC &amp; WM EIS</i>	Reanalysis
Hydrogen-3 (tritium)	$1.50 \times 10^4$	$9.26 \times 10^3$
Carbon-14	$1.20 \times 10^2$	$2.08 \times 10^2$
Potassium-40	6.01	$4.17 \times 10^1$
Strontium-90	3.70	$1.20 \times 10^4$
Zirconium-93	-	$4.44 \times 10^1$
Technetium-99	$2.01 \times 10^{-1}$	$8.35 \times 10^1$
Iodine-129	-	$2.00 \times 10^{-2}$
Cesium-137	3.70	$1.55 \times 10^4$
Thorium-232	$1.40 \times 10^{-1}$	1.03
Uranium isotopes (includes uranium-233, -234, -235, -238)	$5.40 \times 10^1$	$4.11 \times 10^2$
Neptunium-237	-	$3.70 \times 10^{-1}$
Plutonium-239, -240	9.16	$3.39 \times 10^2$
Americium-241	2.71	$4.37 \times 10^2$

**Note:** Dash (-) means no data found or inventory is estimated to be 0 or below detectable levels.

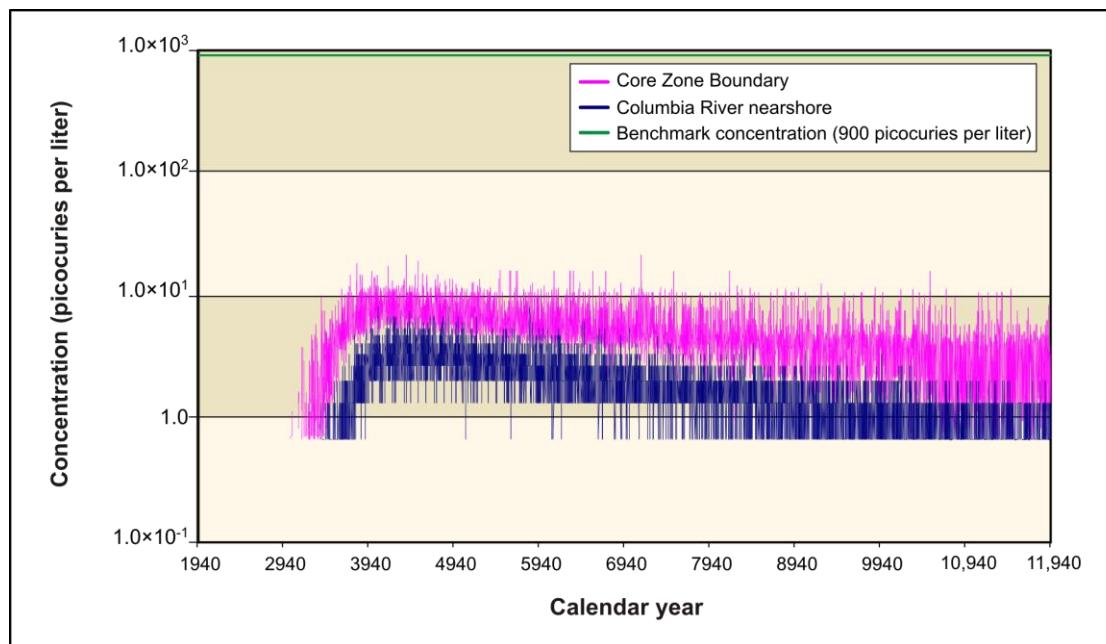
**Key:** ERDF=Environmental Restoration Disposal Facility; *TC & WM EIS*=*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Table 2 shows that most of the COPC inventory estimates increased in the reanalysis from those used for the *Draft TC & WM EIS*. In addition, comparison of the reanalysis results using the inventory corrections with the draft EIS cumulative impacts analysis results shows that the non-COPC concentrations at the Core Zone Boundary and the Columbia River nearshore did not change.

The estimated concentrations of the two key risk drivers, technetium-99 and iodine-129, at both the Core Zone Boundary and the Columbia River nearshore due to the revised ERDF inventories remain a minimum of one order of magnitude below the benchmark concentrations, as can be seen in Figures 5 and 6, respectively. A comparison with Figures 1 and 2 which provide the concentrations versus time for technetium-99 and iodine-129, respectively, for all non-TC & WM EIS sites (cumulative impacts analysis sites), shows that ERDF remains a minor contributor to the total concentrations of technetium-99 and iodine-129 at the Core Zone Boundary and Columbia River nearshore.

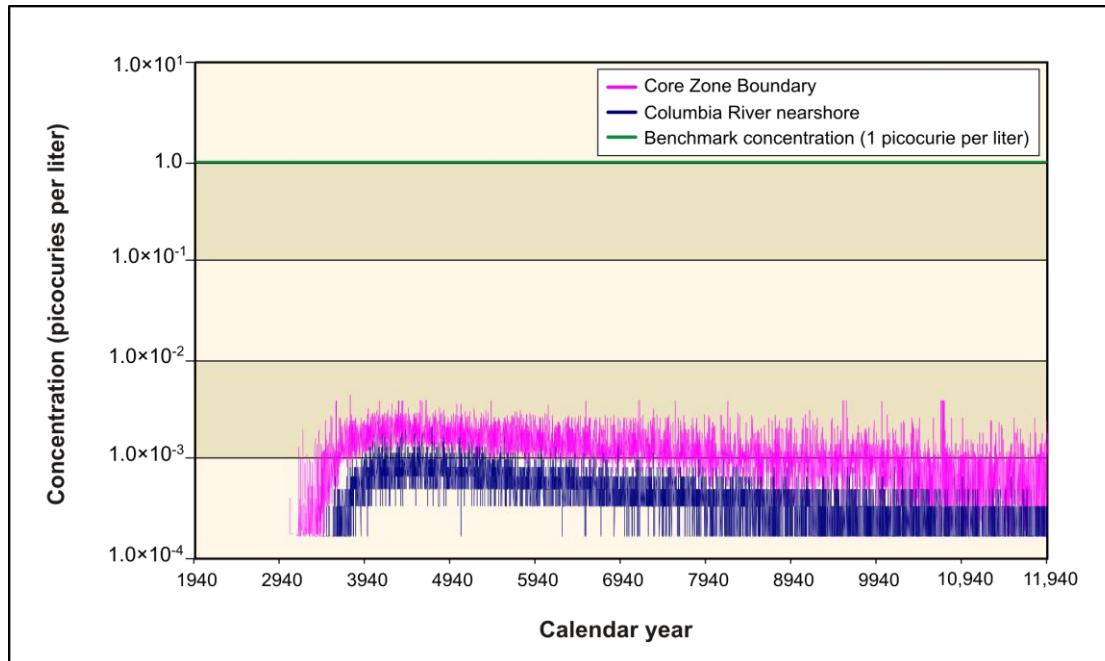
Also included for comparison with Figures 1 and 2 are technetium-99 and iodine-129 concentration-versus-time graphs for three other disposal sites, all in close proximity to ERDF: an IDF (Tank Closure Alternative 2B), Figures 7 and 8; the proposed GTCC waste disposal site, Figures 9 and 10; and the US Ecology Commercial LLW Disposal Site, Figures 11 and 12.

Figure 5 shows the relative contribution of technetium-99 at the Core Zone Boundary and Columbia River nearshore from ERDF.



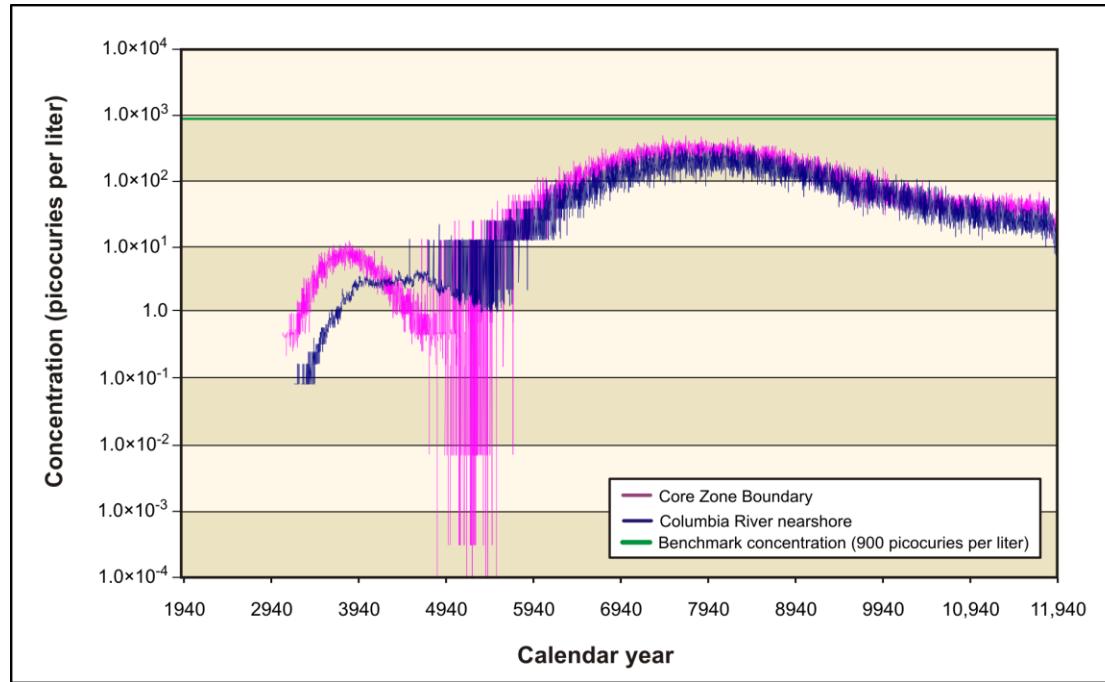
**Figure 5. Technetium-99 Concentration Versus Time  
(Environmental Restoration Disposal Facility)**

Figure 6 shows the relative contribution of iodine-129 at the Core Zone Boundary and Columbia River nearshore from ERDF.



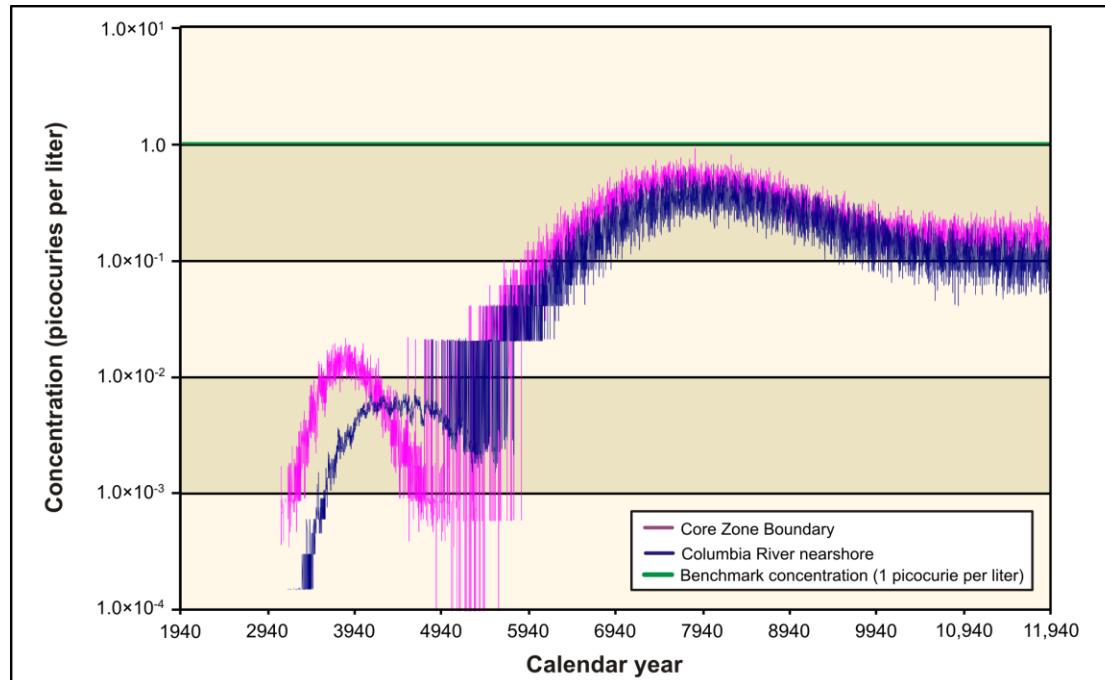
**Figure 6. Iodine-129 Concentration Versus Time  
(Environmental Restoration Disposal Facility)**

Figure 7 shows the relative contribution of technetium-99 at the Core Zone Boundary and Columbia River nearshore from IDF-East.



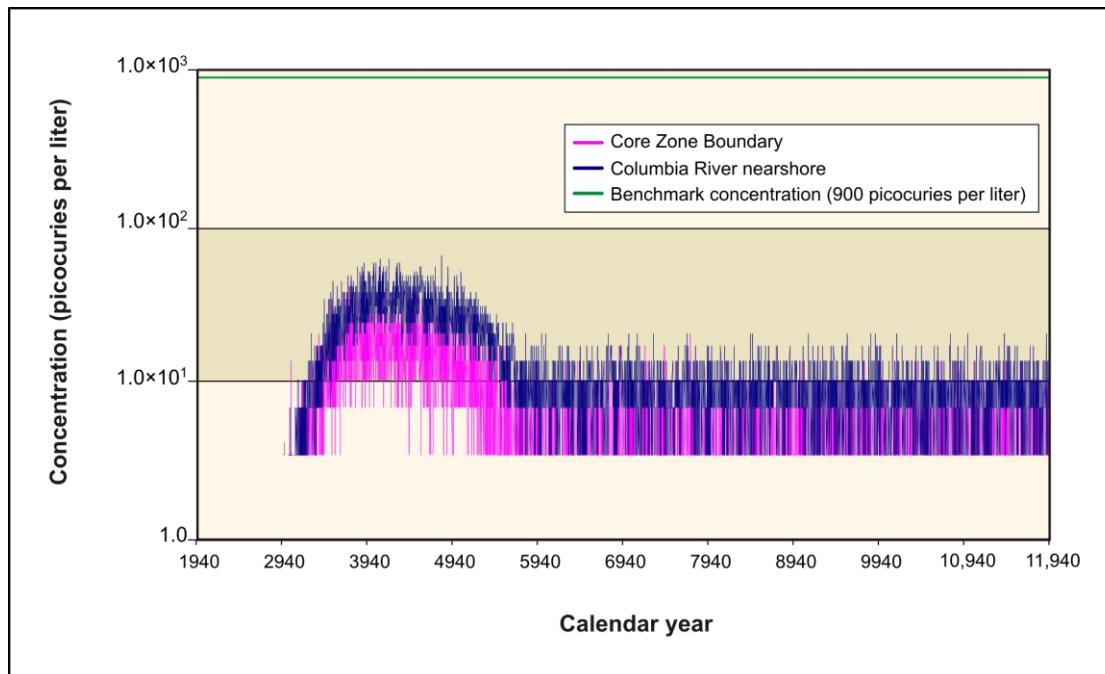
**Figure 7. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A,  
Technetium-99 Concentration Versus Time (200-East Area Integrated Disposal Facility)**

Figure 8 shows the relative contribution of iodine-129 at the Core Zone Boundary and Columbia River nearshore from IDF-East.



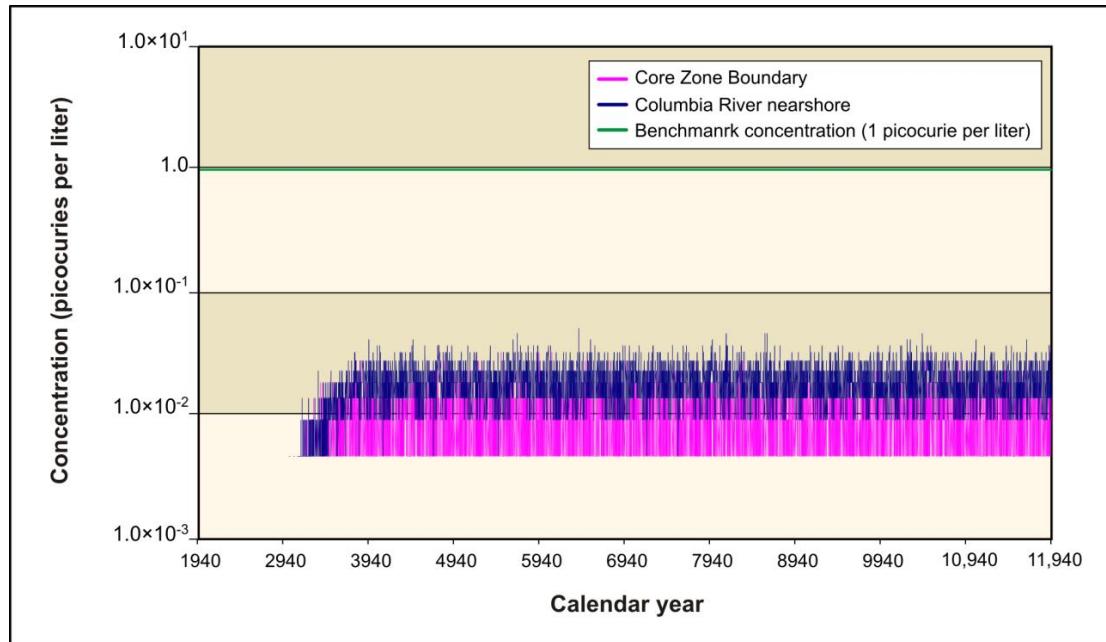
**Figure 8. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time (200-East Area Integrated Disposal Facility)**

Figure 9 shows the relative contribution of technetium-99 at the Core Zone Boundary and Columbia River nearshore from the proposed GTCC waste disposal site.



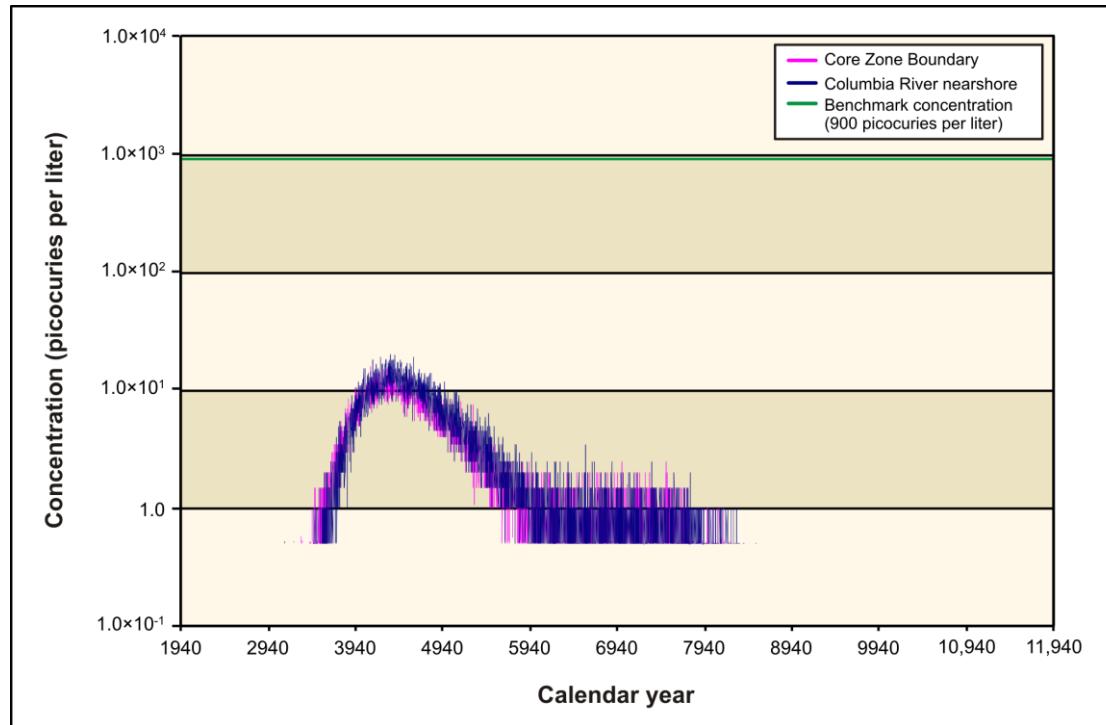
**Figure 9. Technetium-99 Concentration Versus Time (Greater-Than-Class C Waste Disposal Site)**

Figure 10 shows the relative contribution of iodine-129 at the Core Zone Boundary and Columbia River nearshore from the proposed GTCC waste disposal site.



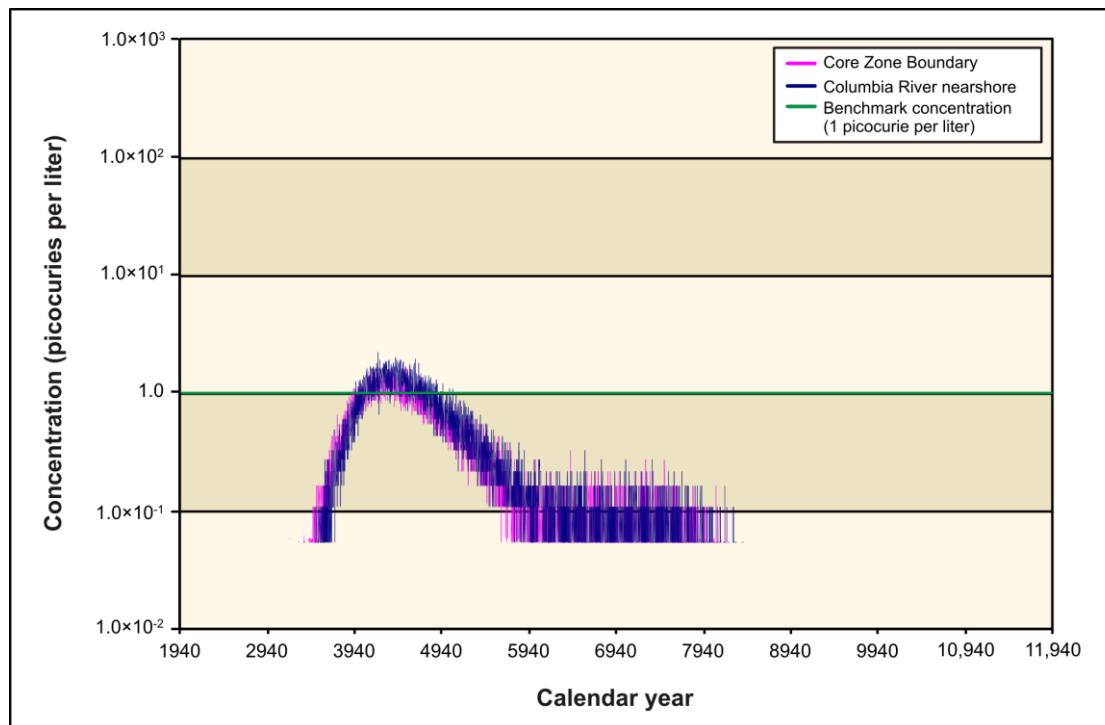
**Figure 10. Iodine-129 Concentration Versus Time  
(Greater-Than-Class C Waste Disposal Site)**

Figure 11 shows the relative contribution of technetium-99 at the Core Zone Boundary and Columbia River nearshore from the US Ecology Commercial LLW Disposal Site.



**Figure 11. Technetium-99 Concentration Versus Time  
(US Ecology Commercial Low-Level Radioactive Waste Disposal Site)**

Figure 12 shows the relative contribution of iodine-129 at the Core Zone Boundary and Columbia River nearshore from the US Ecology Commercial LLW Disposal Site.



**Figure 12. Iodine-129 Concentration Versus Time  
(US Ecology Commercial Low-Level Radioactive Waste Disposal Site)**

**Discussion:** The increases of technetium-99 and iodine-129 in ERDF as shown in Table 2 and Figures 5 and 6, with the inventory corrections, are not significant contributors to the estimated concentrations of technetium-99 and iodine-129 at the Core Zone Boundary and Columbia River nearshore. ERDF is a low-discharge site, and the mobility of constituents is limited by low soil-moisture content in the vadose zone. Consequently, technetium-99 and iodine-129 concentrations from ERDF are highly attenuated and do not contribute significantly to impacts at the Core Zone Boundary or Columbia River nearshore. As can be seen, ERDF's contribution to the estimated concentrations of technetium-99 and iodine-129 at the Core Zone Boundary and Columbia River nearshore is less than that from any of the other three sites (IDF-East, the GTCC waste disposal site, and the US Ecology Commercial LLW Disposal Site), all in close proximity to ERDF. The contribution of each of the four disposal sites relative to each other for technetium-99 and iodine-127 concentrations at the Core Zone Boundary and Columbia River nearshore remains the same in the reanalysis as in the *Draft TC & WM EIS* analysis.

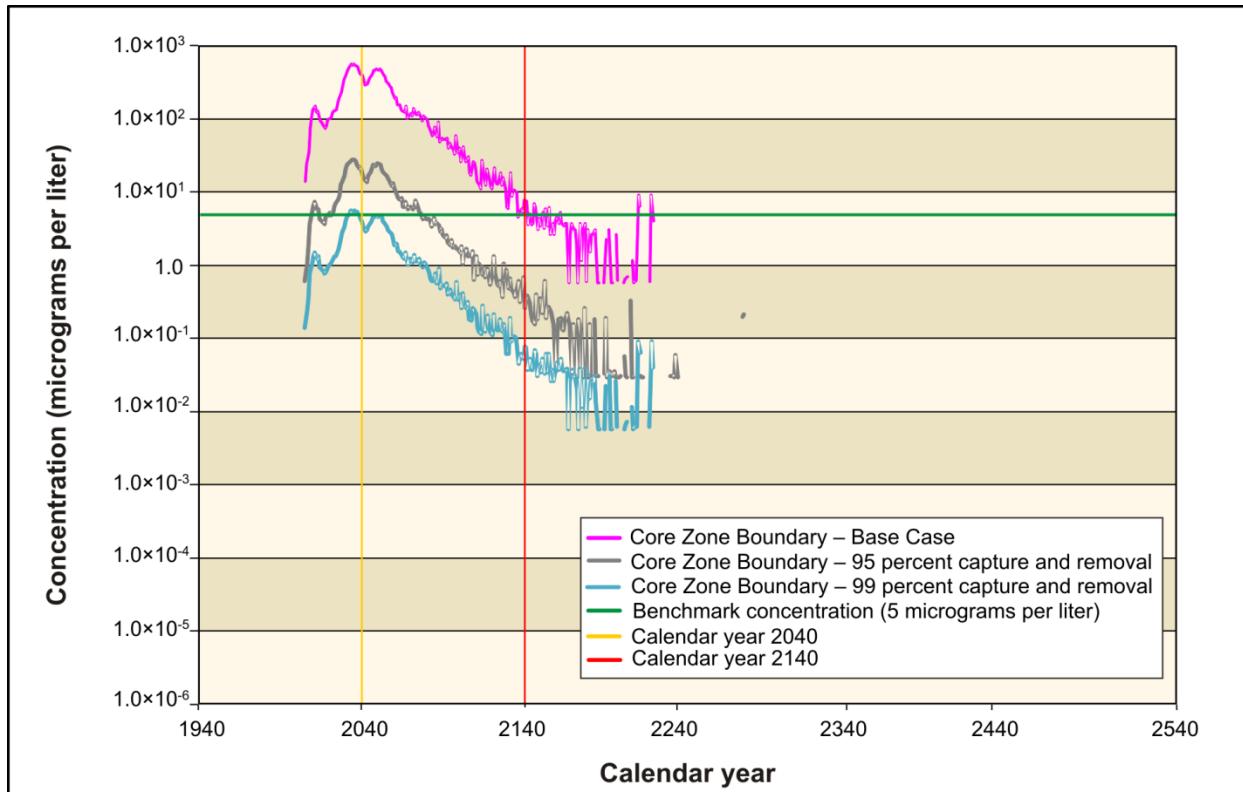
## (5) Carbon tetrachloride inventory correction

**Description:** DOE corrected the inventory of carbon tetrachloride by removing the inventory of sources in the 200-West Area that were already accounted for in the groundwater plume inventory. In addition to removing this “double counting” of inventory, DOE developed a sensitivity analysis to reflect groundwater remediation activities for carbon tetrachloride, which have been ongoing in the 200 Areas since CY 1994. Annual environmental reports show the carbon tetrachloride plume is 11.48 square kilometers (4.43 square miles), which DOE is planning to remediate using “pump and treat” technology. DOE issued a CERCLA ROD for the 200-ZP-1 Operable Unit (EPA 2008), which implements the pump-and-treat strategy for this plume.

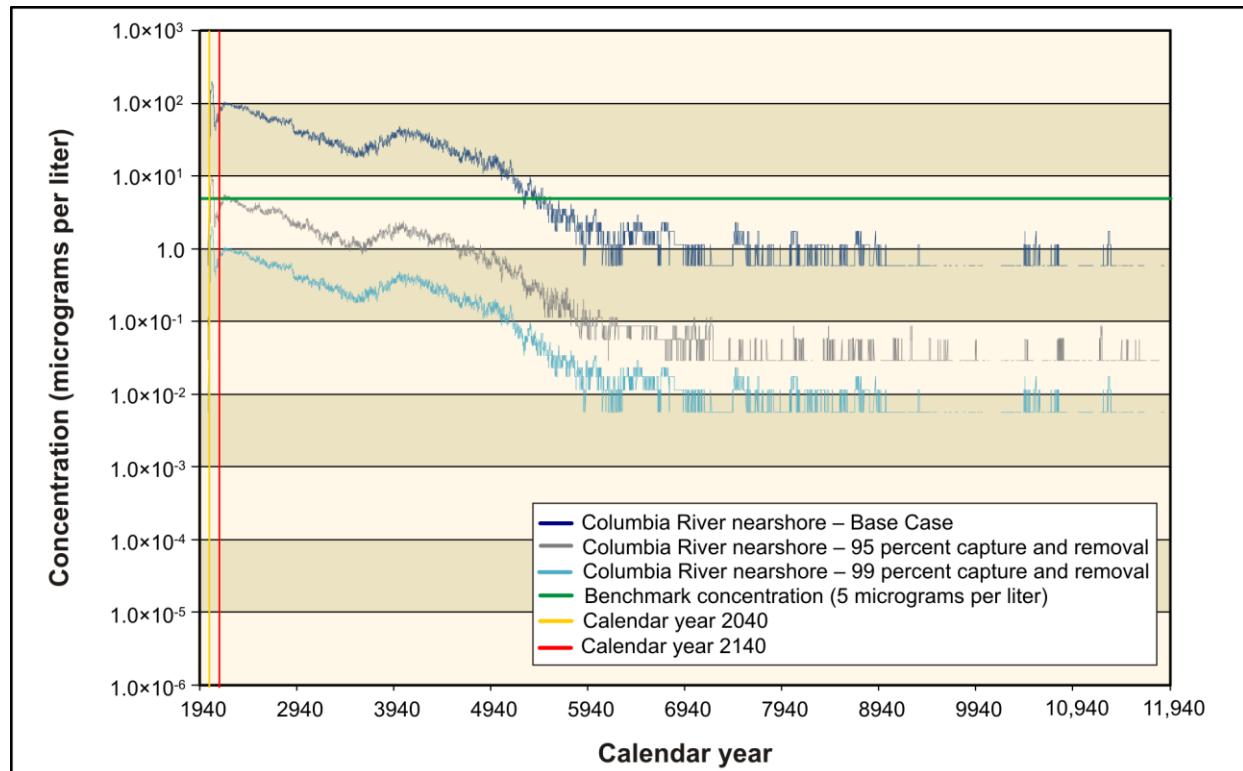
**Comparative Analysis:** The 2007 groundwater monitoring report estimates the range of dissolved carbon tetrachloride in the unconfined aquifer of the 200-West Area of the Core Zone Boundary as 55,900 to 64,600 kilograms (123,000 to 142,000 pounds) (Hartman and Webber 2008). The draft EIS used a value near the upper end of this range, i.e., 65,000 kilograms (143,000 pounds). In addition, the draft EIS included some sources of carbon tetrachloride that contributed to the dissolved carbon tetrachloride plume, essentially double-counting part of the inventory. The primary sources of the carbon tetrachloride are three of the 216-Z cribs and trenches (ditches) that received waste from the Plutonium Finishing Plant (DOE 2010). In the draft EIS cumulative impacts analysis, 65,000 kilograms (143,300 pounds) of carbon tetrachloride was assumed, for analysis purposes, to be released directly to the aquifer in CY 2005. This did not account for current or planned containment and removal of carbon tetrachloride from the aquifer. The remedial action objective, as defined in the interim ROD (EPA 1995) and carried forward into the final ROD (EPA 2008), states that the pump-and-treat remedy will capture the carbon tetrachloride plume in the upper 15 meters (49 feet) of the unconfined aquifer (DOE 2010). The capture-and-removal scenario was designed to evaluate the potential response of the carbon tetrachloride plume to mass removal from the aquifer that results from pump-and-treat operations.

In the reanalysis, three variations, in which specified masses of aqueous-phase carbon tetrachloride, chromium, and technetium-99 were assumed to be released directly to the aquifer beneath the 200-West Area, are evaluated in the capture-and-removal scenario (uranium was not included in this sensitivity analysis because the uranium cleanup targets will not be added until after completion of the CERCLA process for the 200-UP-1 Operable Unit). The base case assumed no pump-and-treat system; 65,000 kilograms (143,000 pounds) of aqueous-phase carbon tetrachloride, 3,000 kilograms (6,610 pounds) of chromium, and 1.75 curies of technetium-99 were assumed to be released directly to the aquifer in CY 2005 and to migrate under the prevailing hydraulic conditions. The double counting of some sources of carbon tetrachloride was removed in the reanalysis. The second case was designed to represent 95 percent carbon tetrachloride removal, which was implemented by simulating the release of 5 percent of the mass of carbon tetrachloride (3,250 kilograms [7,170 pounds]), chromium (150 kilograms [331 pounds]), and technetium-99 (0.0875 curies) in CY 2040. This case is consistent with the CERCLA ROD for the 200-ZP-1 Operable Unit (EPA 2008). The third case was designed to represent 99 percent removal by releasing 1 percent of the mass of carbon tetrachloride (650 kilograms [1,430 pounds]), chromium (30 kilograms [66.1 pounds]), and technetium-99 (0.0175 curies) in CY 2040. For the pump-and-treat simulations (second and third cases), the effect of pumping on the flow field was not explicitly considered; all three scenarios utilized the groundwater flow field that was used in the draft EIS cumulative impacts and alternatives analyses.

Figures 13 and 14, from the reanalysis, demonstrate that, with no remediation (base case), the projected carbon tetrachloride concentration would remain above the 5-microgram-per-liter benchmark standard until approximately CYs 2140 and 5500 at the Core Zone Boundary and Columbia River nearshore, respectively. With 95 percent removal, the carbon tetrachloride concentration at both locations would fall below the benchmark standard in less than 100 years following active treatment, which is consistent with the 200-ZP-1 Operable Unit ROD. With 99 percent removal, the carbon tetrachloride concentration at both locations would not exceed the benchmark standard and would remain near or up to three orders of magnitude below the benchmark standard for the next 10,000 years. It should be noted that the time scale (x axis) on Figure 13 represents 600 years of the model simulation for ease in interpreting the differences between the concentration-versus-time curves at the Core Zone Boundary. The time scale for Figure 14 represents the entire length of the model simulation (10,000 years).



**Figure 13. Carbon Tetrachloride Concentration Versus Time at the Core Zone Boundary (Three Cases) (Results from Reanalysis)**



**Figure 14. Carbon Tetrachloride Concentration Versus Time at the Columbia River Nearshore (Three Cases) (Results from Reanalysis)**

**Discussion:** A sensitivity analysis based on 95 percent removal of carbon tetrachloride, identified in the CERCLA ROD for the 200-ZP-1 Operable Unit (EPA 2008), shows a potential reduction in the concentration to below the benchmark standard in about less than 100 years following active treatment at both the Core Zone Boundary and Columbia River nearshore. This analysis does not account for additional contributions of carbon tetrachloride to the groundwater from the vadose zone. Any adjustments to address how the pump-and-treat system works, once it is installed, related to carbon tetrachloride will be evaluated in the CERCLA 5-year review process related to the 200-ZP-1 Operable Unit ROD. Carbon tetrachloride is not a COPC that is related to any of the *TC & WM EIS* action alternatives, and the results have no bearing on the comparative analysis of the *TC & WM EIS* alternatives, either from a cumulative impacts standpoint or individually. Carbon tetrachloride is not a contaminant that is present in the tank waste, nor is it expected to be generated as a result of tank waste retrieval or treatment.

#### **(6) 300 Area Process Trenches inventory corrections**

**Description:** The draft EIS inventory database used the inventories for waste sites 316-1, 316-2, and 316-5 as reported in SIM (Corbin et al. 2005), which relied upon a surrogate waste stream from the plutonium-uranium extraction process cooling-water/steam condensate, including 12.8 curies of plutonium-239 and -240. Since the issuance of the draft EIS, a correction to SIM (Mehta 2011) has been issued (in June 2011), which entails deletion of the plutonium inventory at these three waste sites.

**Comparative Analysis:** The entire inventory of 12.8 curies of plutonium-239 and -240 was deleted in the reanalysis. Plutonium has not been identified as a risk driver in the 300 Area.

**Discussion:** Comparison of the reanalysis results using the inventory corrections with the draft EIS cumulative impacts analysis results shows that since the plutonium moves very slowly through the soil the concentrations at the Core Zone Boundary and the Columbia River nearshore did not change.

### **3.2 Changes to Alternatives Analyses**

#### **(7) Unplanned-releases inventory modifications**

**Description:** To address the comments on the *Draft TC & WM EIS* that some waste site inventories may not have been included, DOE reviewed tank farm waste inventories in the draft EIS and determined that the inventory for a number of unplanned releases was inadvertently omitted. This inventory is relatively minor, but the inventory estimates and the groundwater analysis were revised to include these additional sources. DOE also revised the inventories estimated for historical leaks to reflect recently updated field investigation reports. These two activities, i.e., updates of inventory for the unplanned releases and updates based on field characterization data, resulted in changes in inventory in the reanalysis, which are reflected in Table 3.

**Comparative Analysis:** Table 3 compares the inventories of past tank leaks and other releases from the SSTs used for analysis in the *Draft TC & WM EIS* to the updated values resulting from the two changes listed above used in the reanalysis. All of the differences are decreases, except for hydrogen-3 (tritium), which increased from 327 curies to 328 curies (0.3 percent) and is not a radiological risk driver. There is no change to the mercury inventory.

**Table 3. Comparison of Inventory Changes for  
Historical Leaks and Unplanned Releases**

	Inventory Estimate	
	Draft TC & WM EIS	Reanalysis
<b>Radioactive COPC (curies)</b>		
Hydrogen-3 (tritium)	$3.27 \times 10^2$	$3.28 \times 10^2$
Carbon-14	$4.32 \times 10^1$	$3.48 \times 10^1$
Strontium-90	$1.49 \times 10^5$	$1.27 \times 10^5$
Technetium-99	$3.12 \times 10^2$	$2.63 \times 10^2$
Iodine-129	$5.99 \times 10^{-1}$	$5.10 \times 10^{-1}$
Cesium-137	$5.65 \times 10^5$	$3.91 \times 10^5$
Uranium-233, -234, -235, -238	$1.97 \times 10^1$	$1.48 \times 10^1$
Neptunium-237	1.19	$9.90 \times 10^{-1}$
Plutonium-239, -240	$7.21 \times 10^1$	$6.65 \times 10^1$
<b>Chemical COPC (grams)</b>		
Chromium	$9.81 \times 10^6$	$9.44 \times 10^6$
Mercury	$2.20 \times 10^3$	$2.20 \times 10^3$
Nitrate	$5.91 \times 10^8$	$5.68 \times 10^8$
Lead	$3.07 \times 10^5$	$3.02 \times 10^5$
Total uranium	$2.54 \times 10^7$	$1.80 \times 10^7$
Butanol (n-butyl-alcohol)	$1.56 \times 10^6$	$1.13 \times 10^6$

**Note:** To convert grams to ounces, multiply by 0.03527.

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

**Discussion:** The changes to all radioactive and chemical nonradioactive COPC inventories, except tritium and mercury, decreased the inventory estimates analyzed in the *Draft TC & WM EIS*. Tritium, with a short half-life and an inventory increase of less than 1 percent, is not a risk driver in the groundwater or human health impacts analysis. The inventory changes are not large enough to change the results reported in the *Draft TC & WM EIS*.

## (8) IHLW Interim Storage Facility

**Description:** The Secretary of Energy has determined that a Yucca Mountain repository is not a workable option for permanent disposal of spent nuclear fuel (SNF) and HLW. However, DOE remains committed to meeting its obligations to manage and ultimately dispose of these materials. The Administration has convened the Blue Ribbon Commission on America's Nuclear Future to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of SNF and HLW. By January 2012, the commission will provide its final recommendations that will form the basis of a new solution to managing and disposing of SNF and HLW.

DOE will need to store WTP IHLW and melters until a path forward is implemented for the disposition of the Nation's SNF and HLW, including the WTP IHLW and melters. Accordingly, DOE has expanded its analysis of storage capabilities.

**Comparative Analysis:** In reviewing the draft EIS, DOE determined that, because it is now unclear when IHLW shipments off site will begin, each Tank Closure alternative should assume

storage (a maximum of 145 years) of all the IHLW canisters produced. Therefore, additional IHLW canister storage capacity would be needed, as follows: (1) Alternative 2A would require an additional 1.5 modules, from 2.0 to 3.5; (2) Alternative 2B would require an additional 0.5 modules, from 3.0 to 3.5; and (3) Alternative 6C would require an additional 0.5 modules, from 3.0 to 3.5. There were no changes to the other Tank Closure alternatives.

For each of these three Tank Closure alternatives, information was developed to support the construction, operations, and deactivation analyses and impacts for each area of analysis in the draft EIS.

**Discussion:** The results of a review of the additional resources required for construction, operations, and deactivation of the additional storage capacity show that they would be minimal. For example, for Tank Closure Alternative 2A, which would require the largest increase in storage modules (1.5 modules), the increases for electricity, diesel fuel, gasoline, and water would be 0, 0.2, 1.4, and 0 percent, respectively. Additionally, it was found that, relative to the draft EIS, the short-term environmental effect changes would be minimal; the long-term effects would be unchanged; and there are no changes to the human health impacts analysis due to the additional storage modules under Tank Closure Alternatives 2A, 2B, and 6C.

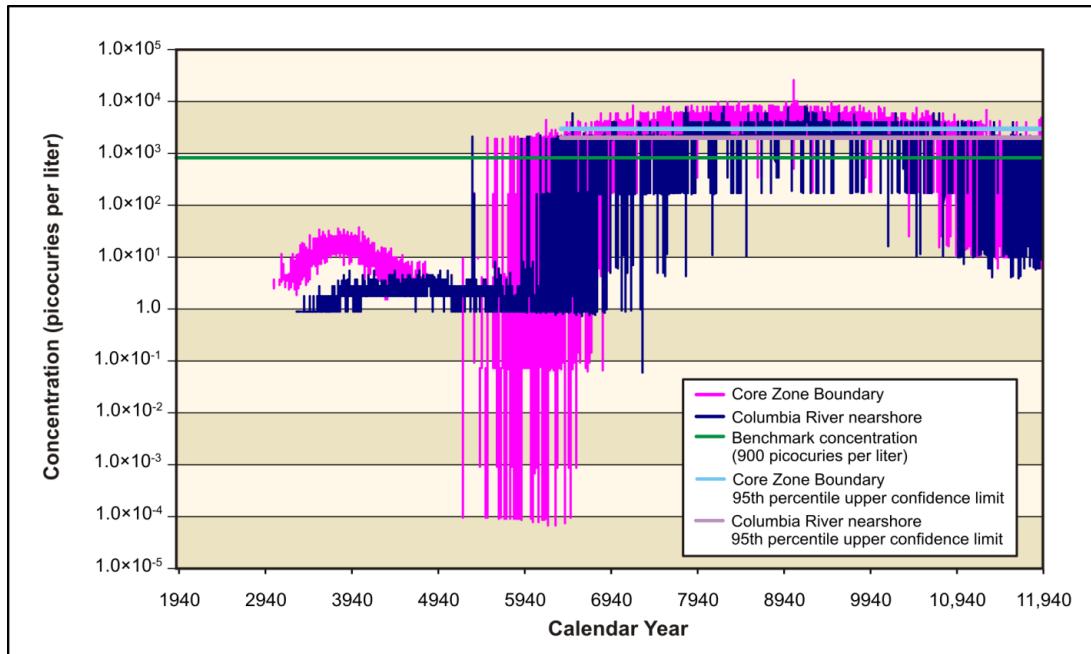
## (9) Steam Reforming Facility waste form performance

**Description:** DOE updated its discussion of steam reforming technology, a potential supplemental treatment technology for low-activity waste (LAW), based on emerging technical information on the performance of steam-reformed final waste forms. This discussion addresses characterization of steam reforming solids and their performance based on solid-phase solubility controls, as well as the performance needed to result in groundwater concentrations at the Core Zone Boundary below benchmark standards, as analyzed in Tank Closure Alternative 3C, using IDF-East. This proposed action is evaluated in Waste Management Alternatives 2 and 3 (Disposal in IDF, 200-East Area Only, and Disposal in IDF, 200-East and 200-West Areas, respectively) in the disposal group associated with Tank Closure Alternative 3C (Disposal Group 1, Subgroup 1-D). In both Waste Management Alternatives 2 and 3, the fluidized-bed steam reforming (FBSR) waste form resulting from the steam reforming supplemental treatment process is analyzed with a final disposal location in IDF-East.

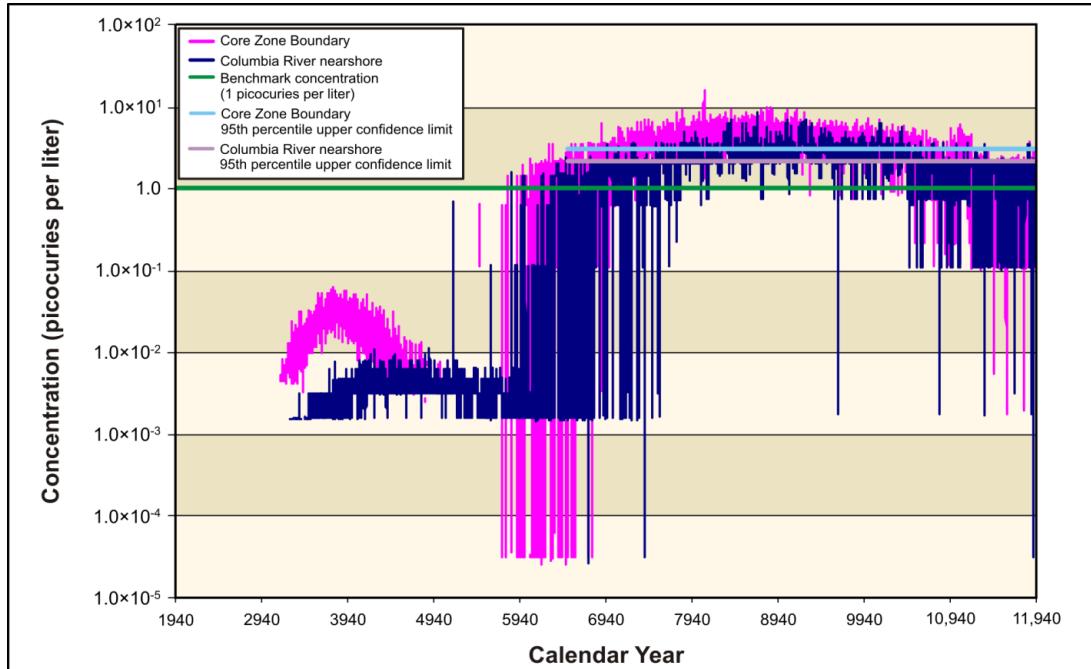
An important factor governing the long-term groundwater impacts analysis is the rate at which key radionuclides and chemicals transfer from the FBSR product into pore waters moving through IDF-East. The preferable approach to the analysis would involve use of experimentally determined waste-form-leaching data collected under conditions that mimic, as closely as possible, the expected conditions in IDF-East. However, available characterization data do not strongly support estimates of release rates over long periods of time, and alternate assumptions for the analysis had to be considered.

**Comparative Analysis:** In the *Draft TC & WM EIS*, the analysis was predicated on the assumptions that mass transfer of radionuclides and chemicals from the FBSR solids to the pore waters in IDF-East was limited by the rate of dissolution of the FBSR product; that the only constraint on that dissolution was the amount of available pore water; and that, consequently, the release rates of radionuclides and chemicals were governed by the stoichiometry of the assumed dissolution reaction and the rate of pore water movement through the waste form. For both Waste Management Alternatives 2 and 3, the resulting concentration versus time of key risk drivers in groundwater near IDF-East was dominated by releases from the FBSR product. Figures 15 and 16 are reproduced from the *Draft TC & WM EIS* and show the groundwater

concentrations versus time at the Core Zone Boundary and Columbia River nearshore for technetium-99 and iodine-99, respectively. The early concentration peaks (between CYs 2940 and 4940) are associated with releases from tank farm closure waste in the RPPDF and are not relevant to this discussion. The later peaks (between CYs 5940 and 11,940) are associated with waste disposed of in IDF-East and are dominated by contributions from the FBSR products, offsite waste, and secondary waste.

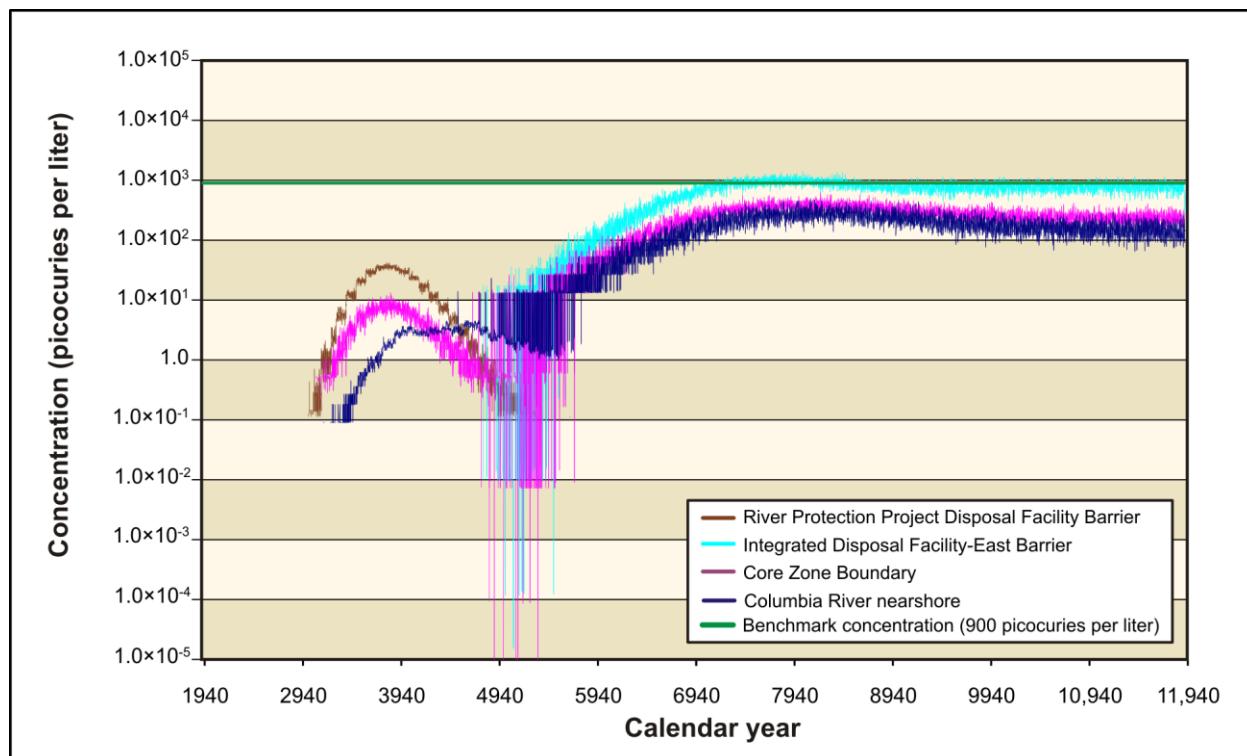


**Figure 15. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time (Results from *Draft TC & WM EIS*)**

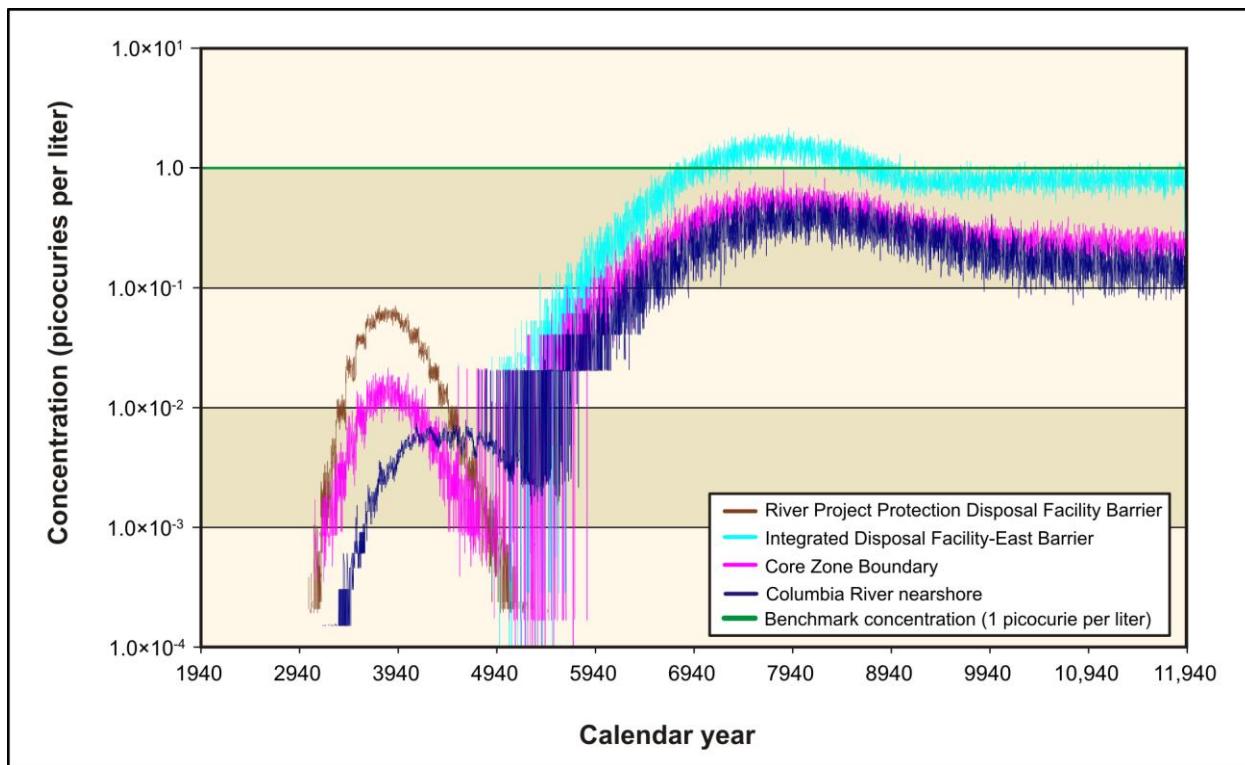


**Figure 16. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time (Results from *Draft TC & WM EIS*)**

The assumption that mass transfer of radionuclides and chemicals from the FBSR solids to the pore waters in IDF-East was limited by the rate of dissolution of the FBSR product was retained in the reanalysis. However, in addition to the amount of pore water available, a constraint was added to the reanalysis that the solubility products of the dissolved FBSR materials not exceed saturation for a stable-phase assemblage of primary and secondary minerals. Consequently, the release rates of radionuclides and chemicals in the reanalysis are governed by the solubility of the assumed primary- and secondary-mineral assemblages and by the rate of pore water movement through the waste form. Figures 17 and 18, from the reanalysis, show the groundwater concentrations versus time at the Core Zone Boundary and Columbia River nearshore for technetium-99 and iodine-99, respectively. (Figures 17 and 18 also show the groundwater concentrations versus time for the RPPDF and IDF-East barriers, which, although not presented in the *Draft TC & WM EIS*, were developed to provide additional insight to the evaluation of the assumption change.) Again, the early concentration peaks (between CYs 2940 and 4940) are associated with releases from tank farm closure waste in the RPPDF and are not relevant to this discussion. The later peaks (between CYs 5940 and 11,940) are associated with waste disposed of in IDF-East and are dominated by contributions from the FBSR products, offsite waste, and secondary waste.



**Figure 17. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time (Results from Reanalysis)**



**Figure 18. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time (Results from Reanalysis)**

**Discussion:** In the relevant timeframe of interest (between CYs 5940 and 11,940), concentrations associated with two risk-driving radionuclides, technetium-99 and iodine-129, are predicted to be approximately an order of magnitude lower at the Core Zone Boundary and the Columbia River nearshore in the reanalysis relative to the draft EIS, primarily as a result of the addition of solubility constraints to the groundwater model governing release from FSBR solids. However, conclusions from the reanalysis are the same as those from the draft EIS, i.e., that concentrations at the IDF-East barrier would exceed benchmark concentrations.

#### (10) Offsite waste inventory and waste acceptance criteria

**Description:** The *Draft TC & WM EIS* analysis showed that receipt of offsite waste streams containing specific amounts of certain risk-driving radionuclides, e.g., iodine-129 and technetium-99, could cause an exceedance of the benchmark concentrations for these radionuclides. As discussed in the draft EIS, one means of mitigating this impact would be for DOE to limit or restrict receipt of offsite waste containing iodine-129 or technetium-99 at Hanford (e.g., through waste acceptance criteria). In response to public comments on the draft EIS, DOE eliminated one waste stream with relatively high concentrations of technetium-99 and iodine-129 from the offsite waste inventory estimates in the reanalysis. The removal of this waste stream resulted in a significant reduction in the technetium-99 and iodine-129 offsite waste inventories.

**Comparative Analysis:** Based on the public's input and concerns about offsite-waste disposal at Hanford, DOE eliminated a waste stream from the estimated offsite waste inventory coming to Hanford. Specifically, DOE eliminated from the groundwater long-term analysis one offsite waste stream containing a significant inventory of iodine-129 and technetium-99, among other radionuclides. The results of this reanalysis illustrate the difference this action would make in potential groundwater impacts. This inventory reduction action is analyzed as part of the Waste

Management alternatives. The waste stream had a volume of 6,500 cubic meters (229,500 cubic feet). Tables 4 and 5 summarize the estimated radioactive and chemical COPC inventories, respectively, for this waste stream that were deleted and the percent of the total each represents.

**Table 4. Radioactive Constituents of Potential Concern Deleted (in curies) and Percent of Total Reduced**

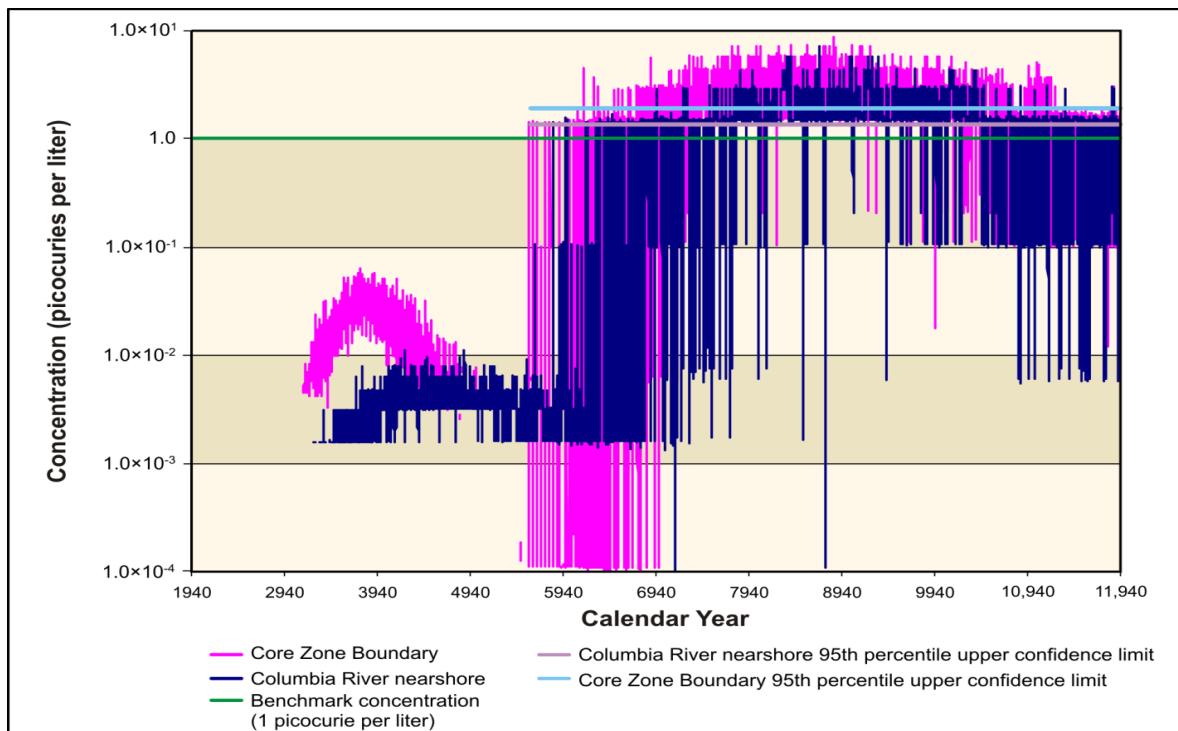
Iodine-129	Cesium-137	Carbon-14	Hydrogen-3	Plutonium-239, -240	Strontium-90	Technetium-99
$1.30 \times 10^1$	$1.30 \times 10^4$	$5.20 \times 10^3$	$3.25 \times 10^3$	$4.37 \times 10^1$	$4.88 \times 10^3$	$3.38 \times 10^2$
85.0%	2.0%	84.8%	5.5%	62.0%	0.7%	18.8%

**Table 5. Chemical Constituents of Potential Concern Deleted (in kilograms) and Percent of Total Reduced**

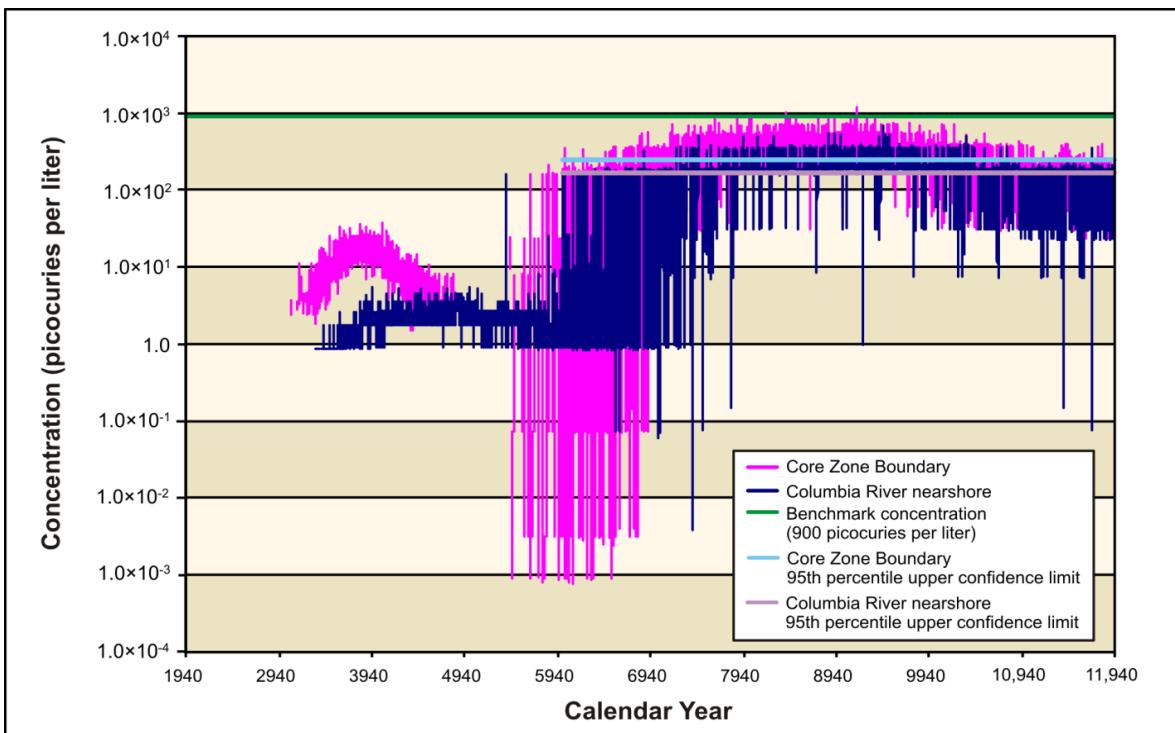
Arsenic	Cadmium	Chromium	Silver
2.99	$1.95 \times 10^{-2}$	$1.33 \times 10^1$	$4.10 \times 10^{-2}$
37.0%	0.0%	14.2%	0.2%

Note: To convert kilograms to pounds, multiply by 2.2046.

Figures 19 and 20 are reproduced from the *Draft TC & WM EIS*. They show the groundwater concentrations versus time at the Core Zone Boundary and Columbia River nearshore for iodine-99 and technetium-99, respectively. The early concentration peaks (between CYs 2940 and 4940) are associated with releases from tank farm closure waste in the RPPDF and are not relevant to this discussion. The later peaks (between CYs 5940 and 11,940) are associated with waste disposed of in IDF-East and are dominated by contributions from offsite waste and secondary waste.

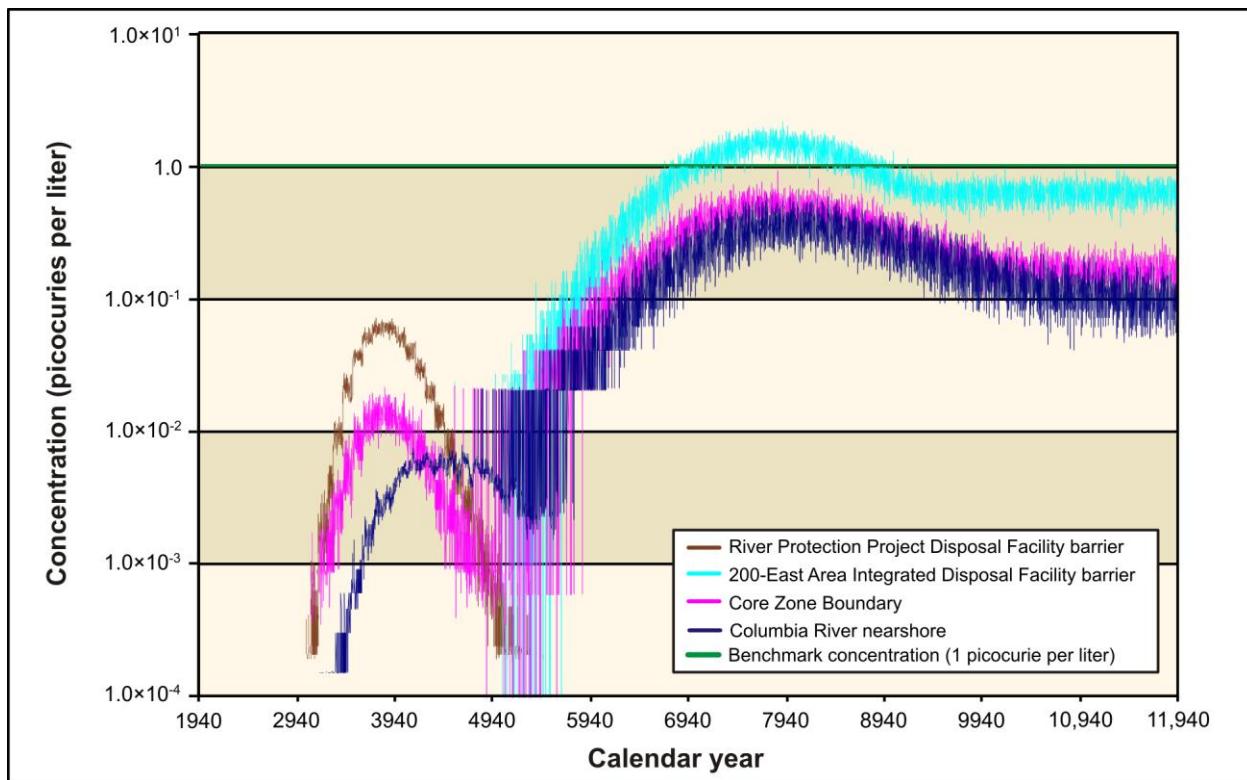


**Figure 19. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time (Results from *Draft TC & WM EIS*)**

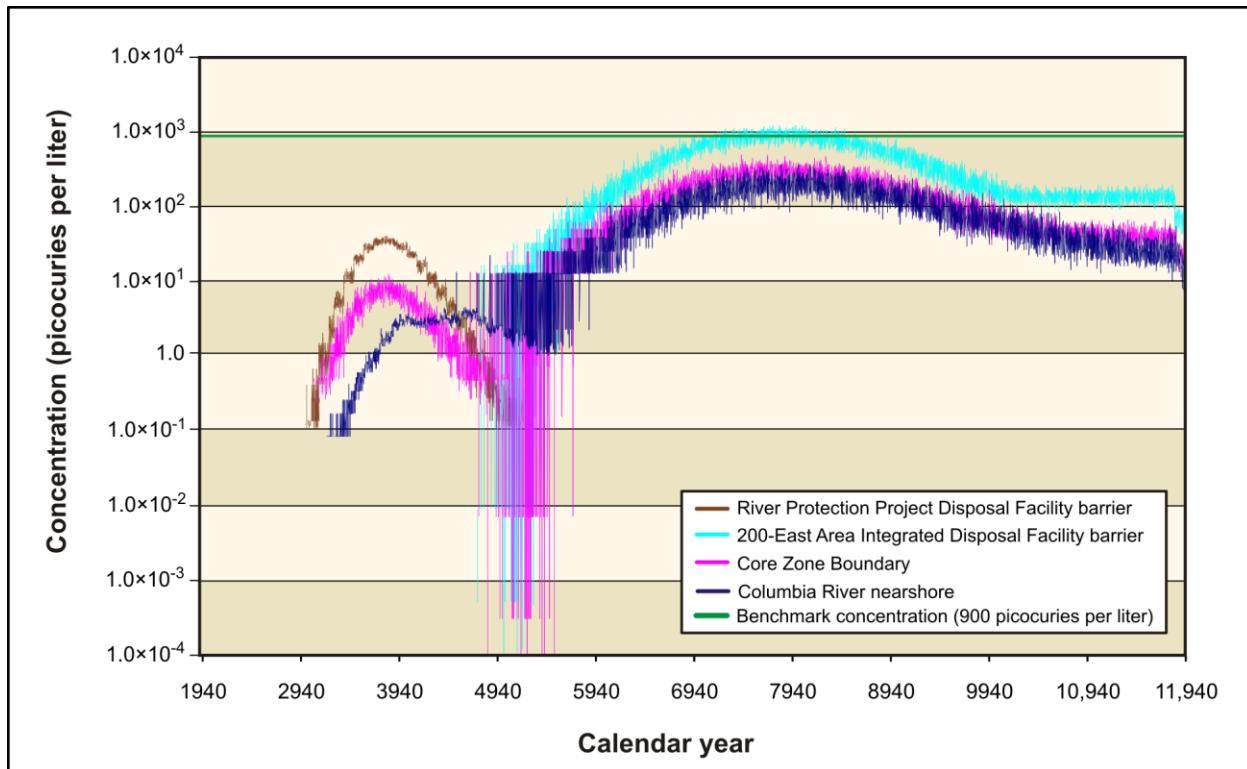


**Figure 20. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time (Results from *Draft TC & WM EIS*)**

Figures 21 and 22 show results from the reanalysis (i.e., without the one specific offsite waste stream). They show the groundwater concentrations versus time at the Core Zone Boundary and Columbia River nearshore for iodine-99 and technetium-99, respectively. The early concentration peaks (between CYs 2940 and 4940) are associated with releases from tank farm closure waste in the RPPDF and are not relevant to this discussion. The later peaks (between CYs 5940 and 11,940) are associated with waste disposed of in IDF-East and are dominated by contributions from offsite waste and secondary waste.



**Figure 21. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time (Results from Reanalysis)**



**Figure 22. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time (Results from Reanalysis)**

**Discussion:** In the relevant timeframe of interest (between CYs 5940 and 11,940), concentrations associated with two risk-driving radionuclides, technetium-99 and iodine-129, are slightly lower for technetium-99 and an order of magnitude lower for iodine-129 at the Core Zone Boundary and the Columbia River nearshore in the reanalysis relative to the *Draft TC & WM EIS*. However, results from the reanalysis indicate that iodine-129 concentrations at the IDF-East barrier would exceed benchmark concentrations.

The reanalysis confirms DOE's original conclusion that limiting the amount of offsite waste containing technetium-99 and iodine-129 would reduce the concentration of these radionuclides at the Core Zone Boundary and the Columbia River nearshore. However, the two sets of results are sufficiently close to the technetium-99 and iodine-129 benchmark concentrations that additional measures such as waste form performance improvements or applying waste acceptance criteria at IDF may be needed.<sup>6</sup>

#### **(11) Steam Reforming Facility iodine-129 air emissions**

**Description:** In the *Draft TC & WM EIS*, DOE assumed that each thermal supplemental treatment (LAW vitrification, bulk vitrification, and steam reforming) facility would include an iodine-129 abatement capability. This assumption was made due to the lack of a sufficiently mature design for two of the supplemental treatment processes, bulk vitrification and steam reforming. Currently available engineering data for the bulk vitrification process support this assumption; however, data for the steam reforming process do not. Therefore, for Tank Closure Alternative 3C, the previously assumed iodine-129 abatement capability for air releases from the two Steam Reforming Facilities has been eliminated. Specifically, in the *Draft TC & WM EIS*, it was assumed that air treatment technologies, i.e., iodine 129 abatement, would result in a reduction factor of 100 for iodine-129 air emissions from the Steam Reforming Facilities.

**Comparative Analysis:** DOE performed a sensitivity analysis to evaluate the difference in dose to the public that would result from this change. The results indicate that, over the 22 years of operation of the WTP and the 200-East and 200-West Area facilities, the dose to the public from the combined sources under Tank Closure Alternative 3C would be approximately 1,200 person-rem, with the dose due to WTP emissions representing approximately 30 percent of the total. The contributions from activities in the 200-East and 200-West Areas, where the Steam Reforming Facilities would be located, would be a dose to the public over the 22-year operational period of approximately 450 and 400 person-rem, respectively. Over the 22-year period, the dose to the maximally exposed individual (MEI) would be 15 millirem.

For comparison, in the *Draft TC & WM EIS*, the total dose to the public over the 22 years of operation of the WTP and the 200-East and 200-West Area facilities from the combined sources under Tank Closure Alternative 3C would be approximately 570 person-rem, with the dose to the public due to WTP emissions representing approximately 63 percent of the total. The contributions from activities in the 200-East and 200-West Areas, where the Steam Reforming Facilities would be located, would be a dose to the public over the 22-year operational period of approximately 100 and 100 person-rem, respectively. The dose to the MEI over the life of the project would be approximately 14 millirem.

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<sup>6</sup> On December 18, 2009, after the October 30, 2009, issuance of the *Draft TC & WM EIS*, DOE issued a Modification of Preferred Alternatives in the *Federal Register* (74 FR 67189). In this notice, DOE stated that it "would not send LLW and MLLW from other DOE sites to Hanford for disposal (with some limited specific exceptions) at least until the WTP is operational.... Off-site waste would be addressed after the WTP is operational subject to appropriate NEPA review." A deadline of 2022 for initial operations of the WTP was later settled (*State of Washington v. Chu*, Civil No. 2:08-cv-05085-FVS, October 25, 2010).

In both the draft EIS and the sensitivity analysis, the dose to the MEI would be 0.6 and 0.7 millirem per year, respectively, well below the annual dose limit to an individual member of the public of 10 millirem per year (40 CFR 61, Subpart H).

**Discussion:** Although there would be an increase in total dose to the public and the MEI over the 22-year operational period under Tank Closure Alternative 3C, due primarily to the increase in iodine-129 releases from the Steam Reforming Facilities, the increases correspond to a change in the lifetime risk of a latent cancer fatality, from  $8 \times 10^{-6}$  to  $3 \times 10^{-5}$  (0.03 percent increase). In DOE's comparative assessment of the Tank Closure alternatives, the potential environmental impacts of Tank Closure Alternative 3C are essentially unaltered. Specifically, the relative ranking of Tank Closure Alternative 3C to the maximum- and minimum-impact Tank Closure alternatives is unchanged.

## **(12) Groundwater B Barrier and Core Zone reporting**

**Description:** In the northeast part of the Core Zone Boundary (in the vicinity of the B/BX/BY SST farms and associated cribs and trenches [ditches]), the unconfined aquifer is thin relative to most other parts of central Hanford. The top-of-basalt surface rises going north toward Gable Mountain, and the water table is nearly flat in this area because of the high hydraulic conductivity of the aquifer materials. As a consequence, in some places, the top-of-basalt surface is known to rise above the water table and the aquifer is nonexistent (i.e., the vadose zone overlies an inactive portion of the aquifer). This feature poses issues for the groundwater modeling system; to ensure mass balance throughout the entire groundwater system, it is desirable for all of the vadose zone and radionuclide flux to be delivered to active portions of the aquifer. In all modeling systems that are constructed around the concept of individual vadose zone models of specific locations that are coupled across the water table to a regional flow model, some compromise must be made to address the nonexistence of the aquifer at such locations. An associated issue is the location of the tracking objects ("lines of analysis") in areas where the aquifer is nonexistent. For the reporting to be meaningful in terms of human health risk assessment, the exposure pathway from the source to the receptor location along the line of analysis should be complete; e.g., a future groundwater user cannot be exposed to contamination contained in groundwater in areas where the aquifer does not exist.

**Comparative Analysis:** In the *Draft TC & WM EIS*, the first issue was addressed by individually moving the modeled locations of some sources near the B/BX/BY tank farms to the south, away from the rise in the top of basalt and Gable Mountain. The distance each site was moved was the minimum necessary to ensure that the entire vadose zone model was located over active portions of the aquifer. The B Barrier and Core Zone Boundary were viewed as purely geographic entities and were not relocated in the modeling effort for the *Draft TC & WM EIS*. In the draft EIS, for Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C, the maximum concentrations of technetium-99 and iodine-129 were 144,196 and 187 picocuries per liter, respectively, at the B Barrier (both occurred in CY 1956).

In the reanalysis, a different representation was conducted for the sites located near the B/BX/BY tank farms to promote the value of preserving the spatial relationships of the different sites to each other and to the B Barrier and the Core Zone Boundary. The modeled locations of all sites in the area were collectively moved to the south; the distance was determined to be the minimum distance such that all of the vadose zone models in this area were over active portions of the aquifer. The B Barrier and parts of the Core Zone Boundary were also adjusted to preserve their spatial relationship to the relocated sites. As a result, in the reanalysis, for Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C, the maximum concentrations of technetium-99 and iodine-129 are projected to be 33,680 and 42 picocuries per liter,

respectively, at the B Barrier (again, both occurred in CY 1956). The difference in predicted peak concentrations, about a factor of 4, is similar for the other Tank Closure alternatives and, in all cases, is within the factor of 10 (order of magnitude) design specification adopted for the groundwater model system.

**Discussion:** The reanalysis and reporting do not change the relationship of the impacts of the considered actions with respect to benchmark concentrations; all of the Tank Closure alternatives continue to show exceedances (i.e., greater than two orders of magnitude) during the operational period, consistent with historical observations, as well as varying degrees and durations of exceedances for future times, consistent with expected outcomes for various retrieval and closure scenarios. Results from both the *Draft TC & WM EIS* and the reanalysis, as well as existing field data, indicate that concentrations at the B Barrier and Core Zone Boundary have exceeded benchmark concentrations.

**(13) Groundwater analytical methodology: aggregation of individual sources**

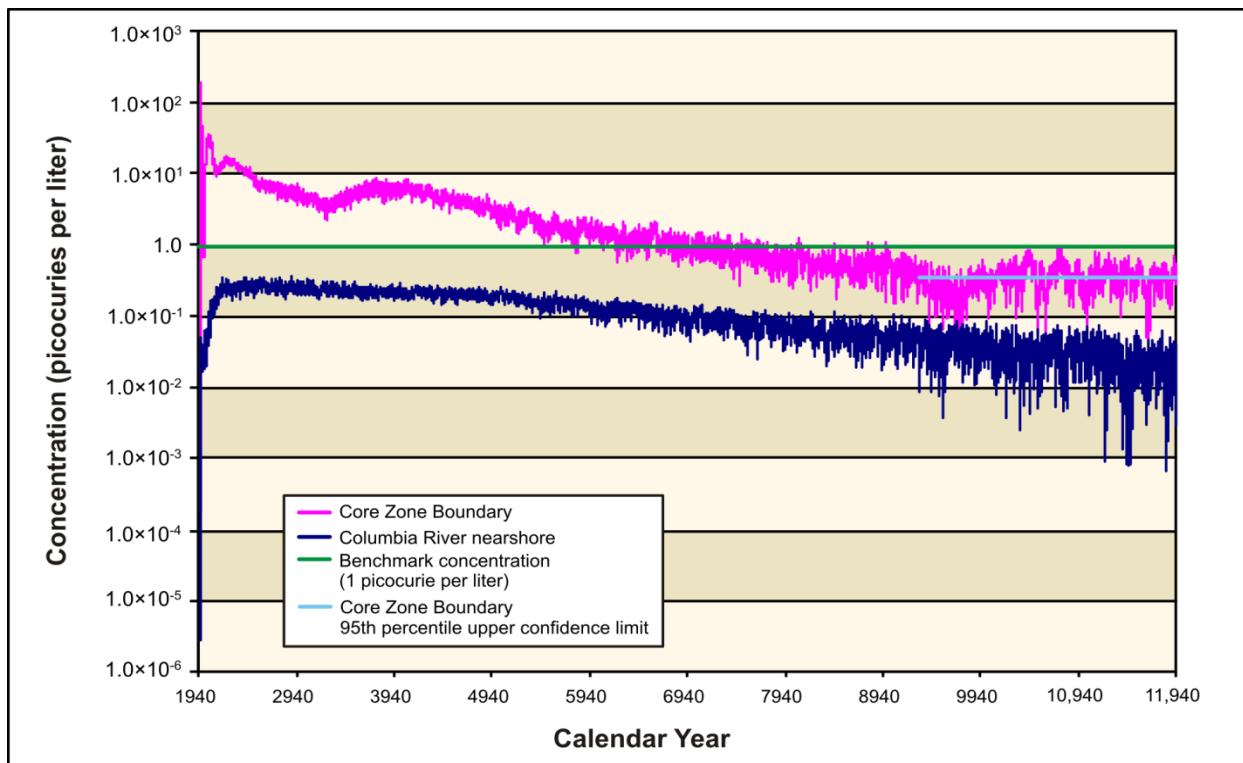
**Description:** In both the *Draft TC & WM EIS* and the reanalysis, prepared in response to public comments, groundwater analysis calculations of concentration versus time were made for individual sources, which were subsequently aggregated to produce results for entire alternatives. This methodology was selected primarily to provide information on individual sources (i.e., the Performance Objective in the *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* [DOE 2005]) and secondarily for computational efficiency.

In the *Draft TC & WM EIS*, tables of the maximum concentration as a function of time were produced for each source. The aggregation to produce results for the alternatives was a summation of the maximum concentrations for all sources, year by year. This approximation works well when the sources for an alternative are closely located and the individual contaminant plumes largely overlap (e.g., for Waste Management Alternative 2, when most of the sources are located at IDF-East). The approximation provides an overestimate when the individual sources are not closely located and the individual contaminant plumes do not overlap (e.g., for all Tank Closure alternatives and Waste Management Alternative 3, where the individual sources are distributed across the Core Zone). In the reanalysis, the aggregation method involves summation of the concentrations for each source at each time step at discrete locations across the model domain. The result is a more-accurate estimate of concentration versus time for Tank Closure alternatives and Waste Management Alternative 3, which includes both an IDF-East and an IDF-West.

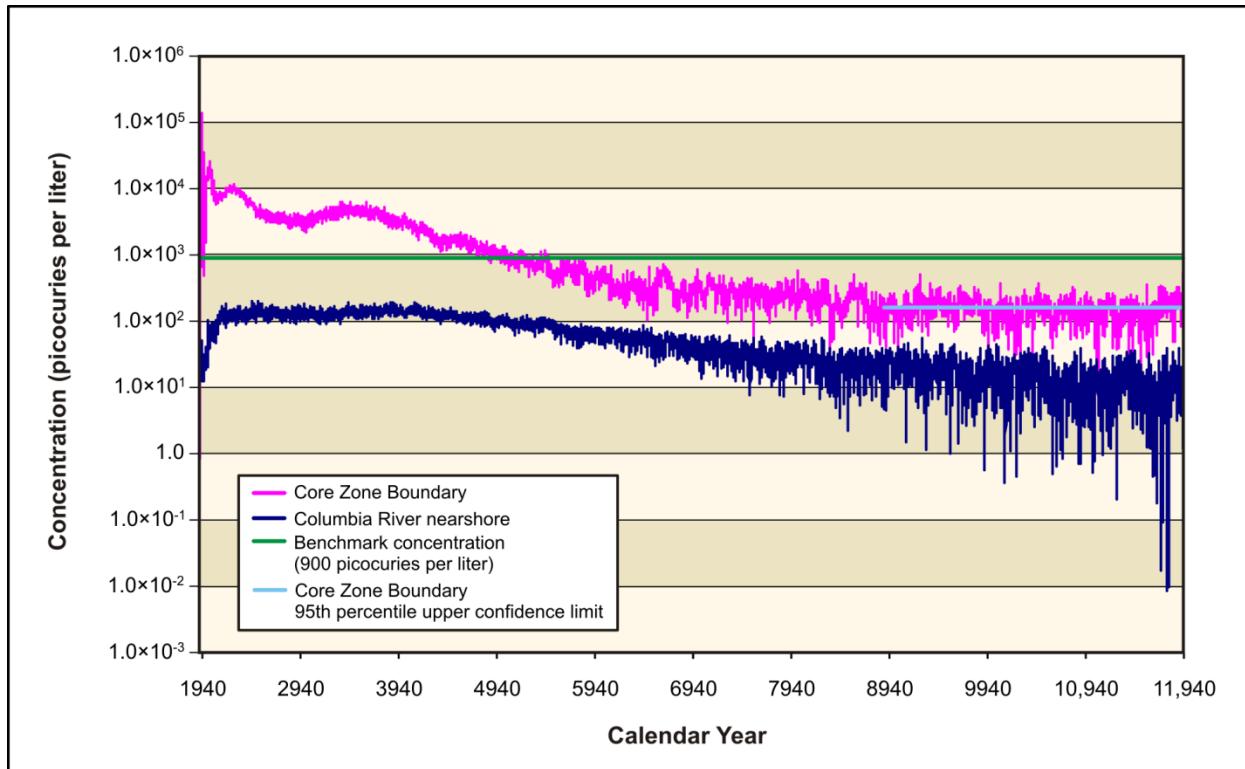
**Comparative Analysis:** In the *Draft TC & WM EIS* groundwater analysis, tables were produced containing maximum concentrations at the barriers, Core Zone Boundary, and Columbia River nearshore as a function of time for each individual source. This method overestimates impacts for situations where individual sources are not collocated and the individual contaminant plumes do not largely overlap (e.g., all Tank Closure alternatives and Waste Management Alternative 3, where the individual sources are distributed across the Core Zone). The aggregated concentration distribution can then be searched for the maximum value associated with the barriers, the Core Zone Boundary, and the Columbia River nearshore. This method still provides an accurate estimate for alternatives with closely located sources and improves the estimate for alternatives with sources distributed over a wide area.

In two earlier sections of this SA (see items (9) and (10) in Section 3.2), on steam reforming waste form performance and on offsite waste inventory and waste acceptance criteria, draft EIS and reanalysis projections of concentration versus time were compared for Waste Management Alternative 2. Some differences can be noted, but, as discussed, the differences are attributable

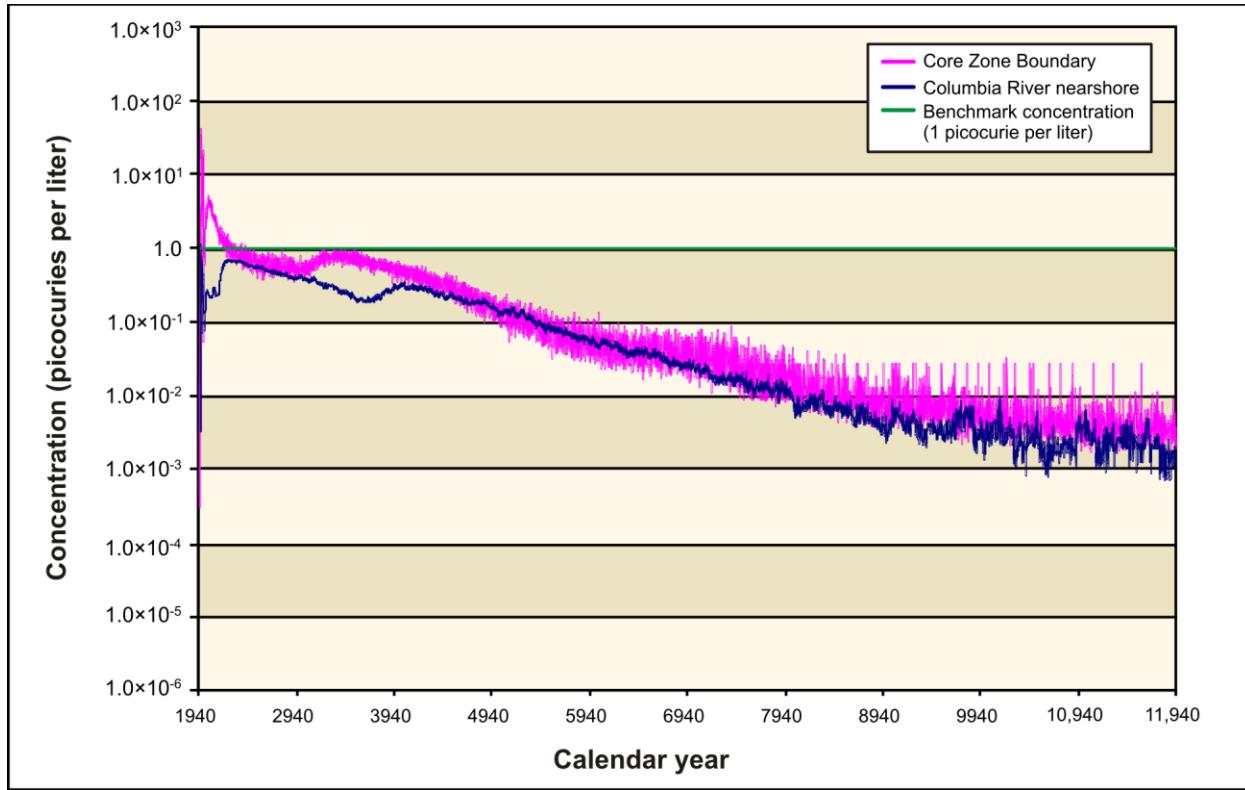
to changes in waste form performance and inventory rather than the method of aggregation. The figures below illustrate the comparison of draft EIS and reanalysis predictions of concentration versus time for Tank Closure Alternative 2B and Waste Management Alternative 3. Figures 23 and 24 show the concentration versus time for Tank Closure Alternative 2B from the draft EIS for iodine-129 and technetium-99, respectively (Chapter 5, Figures 5–80 and 5–81); the corresponding predictions from the reanalysis are provided in Figures 25 and 26. Note that the early structure of the curves (i.e., near the peak concentrations prior to CY 2100) is similar; the peak concentrations are dominated by releases from the B/BX/BY cribs and trenches (ditches), which are nearly collocated. Following this period, the dominance of any single group of closely located sources becomes smaller, and the contaminant plumes are widely distributed across the Core Zone. At these times, the method of aggregation becomes more important and the differences between the results become more apparent. A similar effect is noted for Waste Management Alternative 3, with sources at both IDF-East and IDF-West. Figures 27 and 28 show the concentration versus time from the draft EIS for iodine-129 and technetium-99, respectively; the corresponding predictions from the reanalysis are provided in Figures 29 and 30.



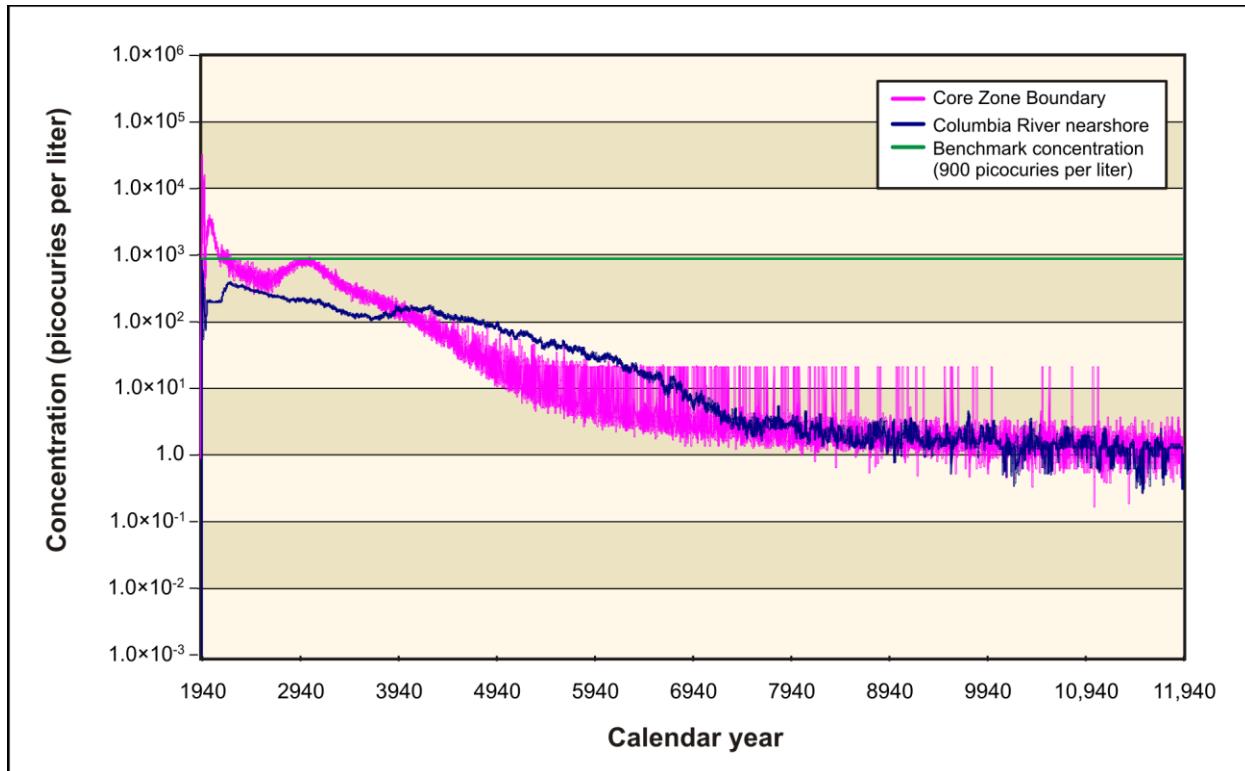
**Figure 23. Tank Closure Alternative 2B Iodine-129 Concentration Versus Time  
(Results from *Draft TC & WM EIS*)**



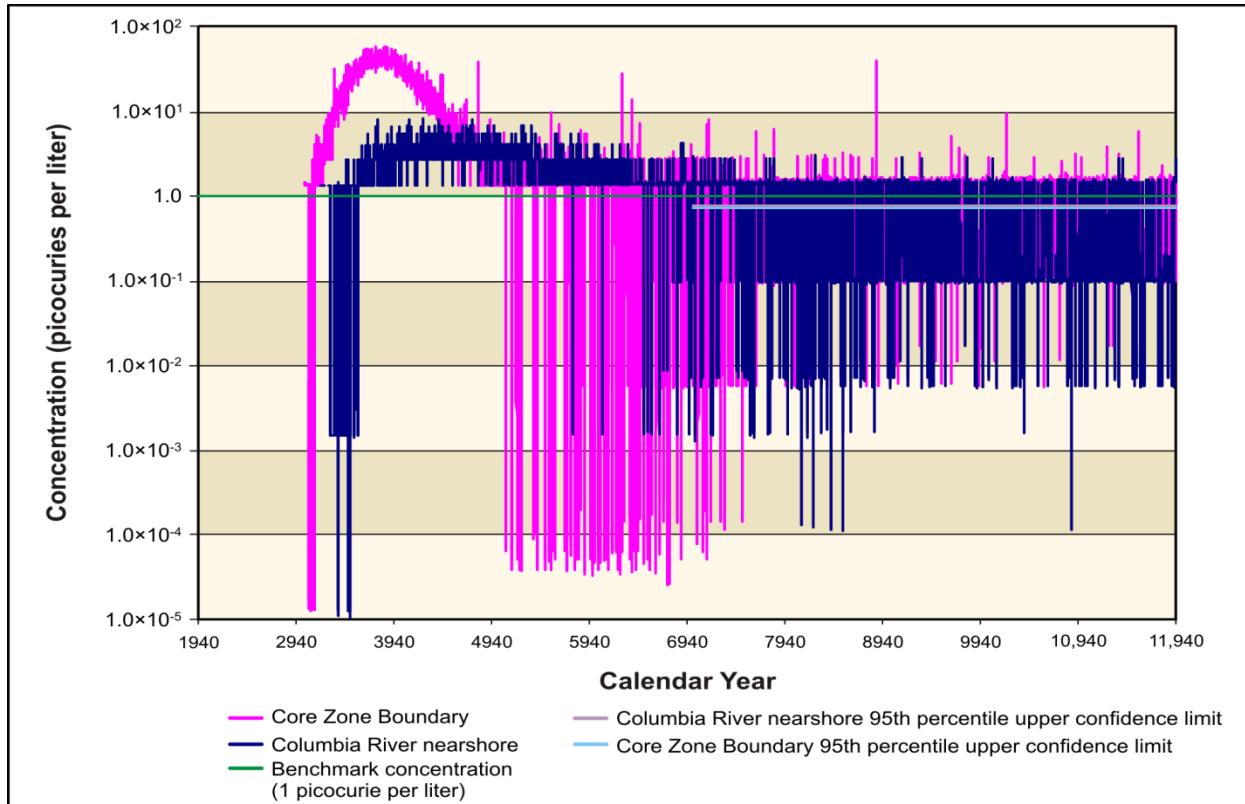
**Figure 24. Tank Closure Alternative 2B Technetium-99 Concentration Versus Time  
(Results from *Draft TC & WM EIS*)**



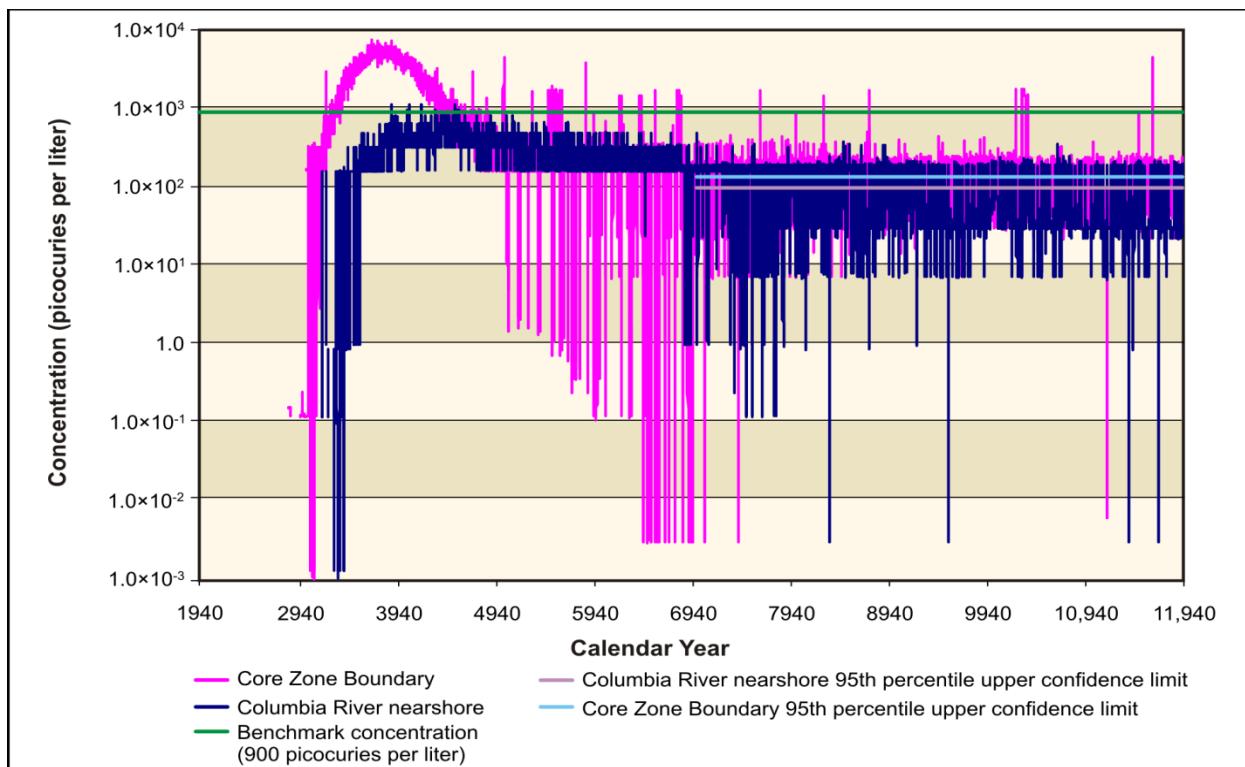
**Figure 25. Tank Closure Alternative 2B Iodine-129 Concentration Versus Time  
(Results from Reanalysis)**



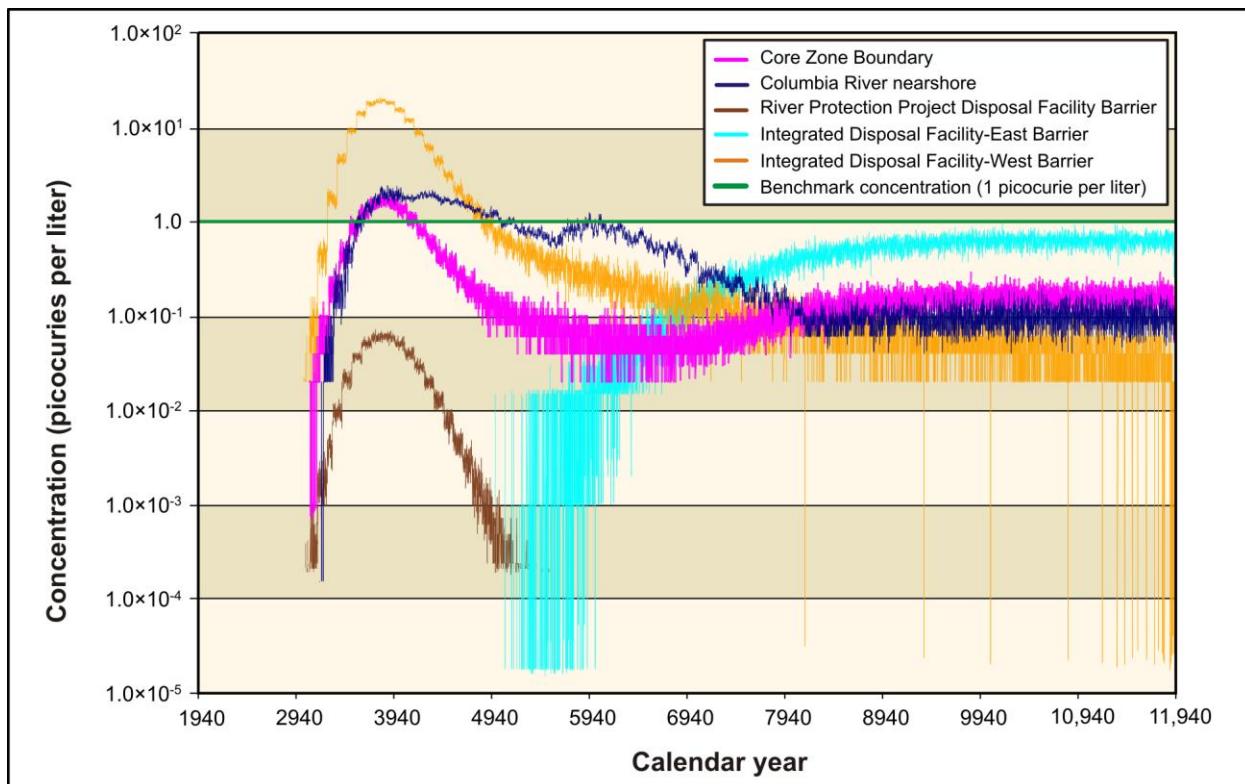
**Figure 26. Tank Closure Alternative 2B Technetium-99 Concentration Versus Time  
(Results from Reanalysis)**



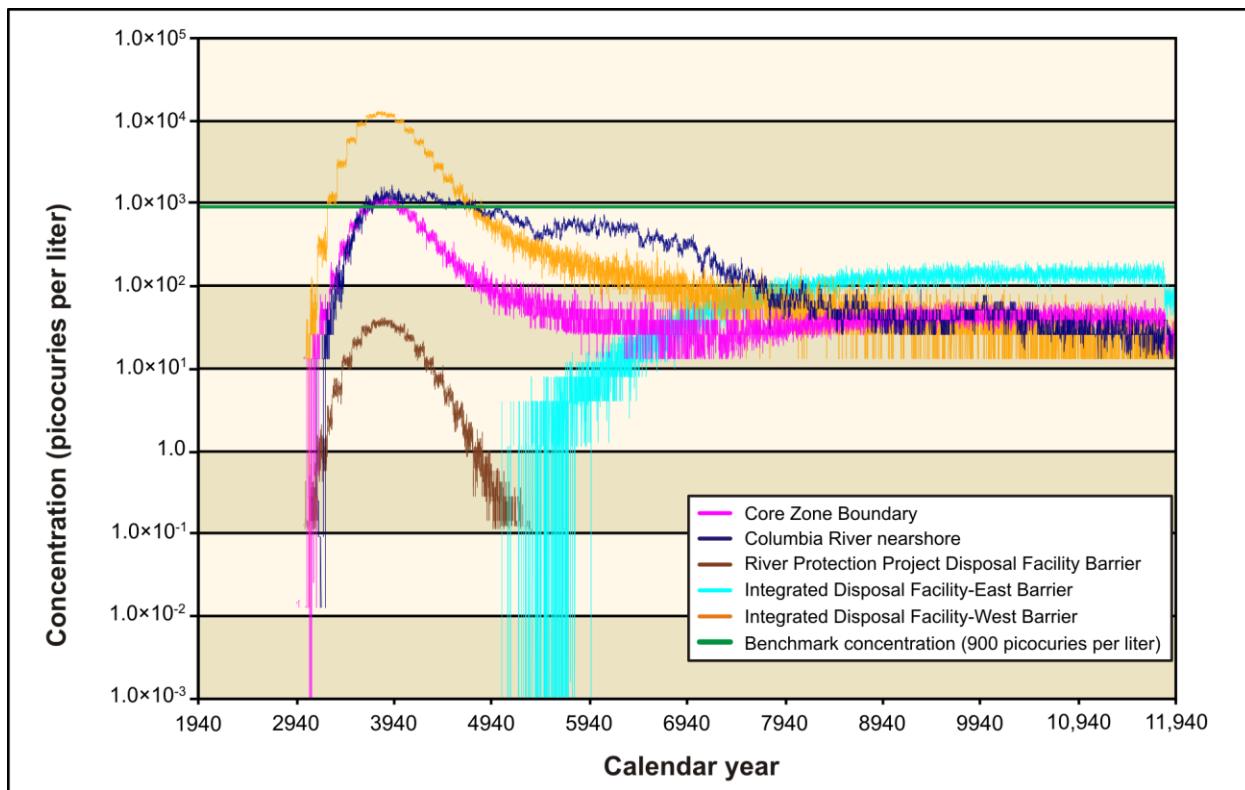
**Figure 27. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A,  
Iodine-129 Concentration Versus Time (Results from Draft TC & WM EIS)**



**Figure 28. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time (Results from *Draft TC & WM EIS*)**



**Figure 29. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time (Results from Reanalysis)**



**Figure 30. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time (Results from Reanalysis)**

**Discussion:** There are no changes to the proposed action(s). Results of the reanalysis do not change the relative comparison of the impacts of the proposed actions at the barriers, the Core Zone Boundary, or the Columbia River nearshore. In addition, the new information does not change the relationship of the impacts of the proposed actions with respect to benchmark concentrations; all of the Tank Closure alternatives continue to show exceedances (i.e., greater than two orders of magnitude) during the operational period, consistent with historical observations, as well as varying degrees and durations of exceedances for future times, consistent with expected outcomes for various retrieval and closure scenarios. //

#### (14) Revised assumed inhalation rate

**Description:** In the *Draft TC & WM EIS*, the air inhalation rate used for analyzing impacts on the public during normal operations due to atmospheric releases of radioactive materials for all the alternatives was assumed to be 20 cubic meters (706 cubic feet) per day. However, the inhalation rate assumed for the long-term impacts analysis in the draft EIS was 23 cubic meters (812 cubic feet) per day, or 8,400 cubic meters (296,646 cubic feet) per year. DOE has corrected this inconsistency, using the same air inhalation rate for both short- and long-term impact analyses, i.e., 23 cubic meters (812 cubic feet) per day (Beyeler et al. 1999) in the reanalysis for all the alternatives. This increase of 15 percent (from 20 to 23 cubic meters [706 to 812 cubic feet] per day) was applied across all the alternatives.

**Comparative Analysis:** As expected, a comparison of the air analysis results found that the differences in population doses and calculated latent cancer fatalities between the draft EIS and the reanalysis are linear to the 15 percent increase in inhalation rate and that the dose to the MEI in the year of maximum impact from the three emission source locations due to the increased assumed inhalation rate remains below the annual dose limit to an individual member of the public of 10 millirem per year (“National Emission Standards for Hazardous Air

Pollutants" [40 CFR 61, Subpart H]). The maximum dose to the MEI in the reanalysis due to the increased inhalation rate is estimated to be 2.0 millirem per year under Tank Closure Alternatives 2B and 6B, Base and Option Cases.

**Discussion:** Further review found that the relative conclusions about the alternatives are unchanged. While there is a change to the inhalation rate for estimating impacts on the general public and as a result of hypothetical accidents, the absolute changes to impacts would be minimal and the change to all *TC & WM EIS* alternatives is the same.

## **4.0 CONCLUSIONS**

In accordance with CEQ regulations (40 CFR 1502.9(c)) and DOE regulations (10 CFR 1021.314(c)), this SA evaluates information previously presented in the *Draft TC & WM EIS* that has been updated, modified, or expanded to determine whether a supplement to the draft EIS is warranted. Table 6 lists the 14 topical areas reviewed and provides a summary discussion of each topic.

Revisions include changes to contaminant inventories, corrections to estimates, updates to characterization data, and new information that was not available at the time of publication of the *Draft TC & WM EIS*. When reanalyzed, the modified inventories do not change the key environmental findings presented in the draft EIS. That is, they do not present significant new circumstances or information relevant to environmental concerns and bearing on the proposed action(s) and their impacts. Similarly, changes to some of the parameters used in the alternatives analysis (e.g., increases in the inhalation rate used for calculation, changes to barrier locations for human health risk reporting, and changes in assumptions used for analytical purposes) do not significantly affect the potential environmental impacts of the alternatives on an absolute or relative basis, whether the changes are considered individually or collectively. These are not substantial changes in the proposed action(s) that are relevant to environmental concerns.

**Table 6. Summary of Discussion by Review Topic**

Review Topic	Review Topic Number	Discussion	Supplement Analysis Section
<b>Cumulative Impacts Analysis Inventory</b>			
T Plant inventory correction	1	Corrections have no discernible effects on cumulative impacts analysis relevant to environmental concerns and bearing on the proposed action(s) or impacts.	3.1
Magnesium/mercury inventory corrections for Z Area cribs and trenches (ditches)	2	Corrections have no discernible effects on cumulative impacts analysis relevant to environmental concerns and bearing on the proposed action(s) or impacts.	3.1
Addition of inventories for GTCC LLW and GTCC-like LLW	3	Inclusion of GTCC LLW and GTCC-like LLW inventory has no discernible effects on cumulative impacts analysis relevant to environmental concerns and bearing on the proposed action(s) or impacts.	3.1
ERDF inventory update	4	ERDF, with the inventory corrections, remains an insignificant contributor to the estimated concentrations of technetium-99 and iodine-129 at the Core Zone Boundary and Columbia River nearshore. Corrections have no discernible effects on cumulative impacts analysis relevant to environmental concerns and bearing on the proposed action(s) or impacts.	3.1
Carbon tetrachloride inventory sensitivity analysis	5	The reanalysis, at DOE's planned level of 95 percent removal, results in a reduction in the concentration below the benchmark standard in less than 100 years following active treatment, which is consistent with the 200-ZP-1 Operable Unit ROD at both the Core Zone Boundary and the Columbia River nearshore. Carbon tetrachloride is not a COPC that is related to any of the action alternatives, and the results have no bearing on the comparative analysis of the EIS alternatives, either from a cumulative impacts standpoint or individually.	3.1
300 Area Process Trenches inventory corrections	6	Deletion of plutonium inventories for the three waste sites has no discernible effects on cumulative impacts analysis relevant to environmental concerns and bearing on the proposed action(s) or impacts.	3.1
<b>Changes to Alternatives Analyses</b>			
Unplanned-releases inventory modifications	7	Inventory changes resulted in a net decrease (except for hydrogen-3 [tritium] and mercury) and have no discernible effects on the alternatives analyses relevant to environmental concerns and bearing on the proposed action(s).	3.2
IHLW Interim Storage Facility	8	Minimal changes to required resources and short-term impacts; no changes to long-term or human health effects relative to the impacts in the draft EIS due to additional storage modules under Tank Closure Alternatives 2A, 2B, and 6C.	3.2
Steam Reforming Facility waste form performance	9	Groundwater concentration results are approximately an order of magnitude lower; however, conclusions remain the same in the reanalysis as in the <i>Draft TC &amp; WM EIS</i> ; estimated concentrations at the IDF-East barrier exceed benchmark concentrations, and additional mitigation measures may be necessary.	3.2

**Table 6. Summary of Discussion by Review Topic (*continued*)**

Review Topic	Review Topic Number	Discussion	Supplement Analysis Section
Offsite waste inventory and waste acceptance criteria	10	Exclusion of one offsite waste stream represents an example of how waste acceptance criteria could be applied at a disposal facility, but is not a change to the proposed action(s).	3.2
Steam Reforming Facility iodine-129 air emissions	11	Minor changes to one alternative (Tank Closure Alternative 3C) that result in increases in total dose to the public and the maximally exposed individual but only 0.03 percent increase in lifetime risk of a latent cancer fatality. The relative ranking of Tank Closure Alternative 3C with other Tank Closure alternatives is unchanged.	3.2
Groundwater B Barrier and Core Zone reporting	12	Reanalysis and reporting do not change relative to the ranking of impacts of alternatives at the B Barrier and Core Zone Boundary nor to the relationship of impacts of the alternatives with respect to benchmark concentrations. Results remain the same in the reanalysis as in the <i>Draft TC &amp; WM EIS</i> : estimated concentrations at the B Barrier and Core Zone Boundary have exceeded benchmark concentrations and additional mitigation measures may be necessary.	3.2
Groundwater analytical methodology: aggregation of individual sources	13	Information on long-term groundwater impacts is presented, with results more clearly differentiating outcomes. No changes to relative ranking of impacts for alternatives at the barriers or Columbia River nearshore, and no changes to relationship of impacts of the actions with respect to benchmark concentrations.	3.2
Revised assumed inhalation rate	14	Correction to short-term analysis inhalation rate has a minimal impact and is the same for all <i>TC &amp; WM EIS</i> alternatives. Conclusions concerning alternatives are unchanged relative to the draft EIS conclusions.	3.2

**Key:** COPC=constituent of potential concern; DOE=U.S. Department of Energy; EIS=environmental impact statement; ERDF=Environmental Restoration Disposal Facility; GTCC=greater-than-Class C; IDF-East=200-East Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; LLW=low-level radioactive waste; ROD=Record of Decision; *TC & WM EIS*=*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

## **5.0 DETERMINATION**

Based on the analyses in this SA, DOE concludes that the updated, modified, or expanded information developed subsequent to the publication of the *Draft TC & WM EIS* does not constitute significant new circumstances or information relevant to environmental concerns and bearing on the proposed action(s) in the *Draft TC & WM EIS* or their impacts. In addition, DOE has not made substantial changes in the proposed action(s) that are relevant to environmental concerns. Therefore, in accordance with CEQ regulations (40 CFR 1502.9(c)) and DOE regulations (10 CFR 1021.314(c)), I have determined that a supplemental or new *Draft TC & WM EIS* is not required.



David Huizenga Date: 2/8/12

David Huizenga  
Acting Assistant Secretary for  
Environmental Management (EM-1)

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