Protecting Health: Criteria for the Hanford Burial Grounds

COPHP Report

October 26, 2010

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The University of Washington's masters training program, Community-Oriented Public Health Practice, of the School of Public Health, is pleased to submit this report to the Hanford Advisory Board (HAB). As students at the University of Washington, it was our goal to provide the HAB an overview of our findings and to make recommendations for further action.

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Executive Summary

In the early part of October 2010, various stakeholders in the Hanford cleanup, including the U.S. Department of Energy and several advocacy groups, invited our group of University of Washington public health graduate students to join the current discussion around appropriate burial ground cleanup policies at Hanford. As public health workers, we are committed to delivering policy suggestions that ensure burial ground remediation will occur in a way that protects the health of communities.

Several key issues need to be addressed through burial ground remediation policies:

- Complex and interacting factors directly influence the risk of exposure to human populations:
  - Mobility of the waste through soil, groundwater, wind-blown dust or air vapors
  - Length of time waste remains harmful to human health
  - Amount and location of each waste material within the burial grounds
- Scientific information about these risk factors is often difficult for lay people to understand and not well publicized. We know several radioactive substances in the burial grounds are extremely dangerous to human health and have longevity of thousands of years. Further, many chemicals buried in the trenches at the burial grounds will threaten population health if they reach the groundwater or the Columbia River, remain in the soil, or become airborne.
- Many radiation protections and guidelines are based on protecting "Reference Man," a "hypothetical 20 to 30 year old Caucasian male" weighing 154 pounds.[18] The fatal cancer risk for women, however, is twice as high as that for men at the same radiation dose.[18] Standards need to consider different exposure scenarios, such as for traditional Native American land use, and acceptable levels of radiation for women and children.
- The Department of Energy has taken several steps to monitor the burial grounds for contaminates in the air and ground water. Again, information about both the monitoring process and contamination findings are not well publicized and often difficult for the public to understand.

Future remediation efforts will need to address the issues described above and reflect the shared values of community members, advocacy groups, contractors, and government agencies. We propose burial

ground remediation alternatives be evaluated as to whether the outcome they lead to is **comprehensive, protective, transparent** and **vigilant**. These criteria are intended to reflect the shared value of protecting health.

Introduction

Stakeholders in the Hanford cleanup have a common interest in protecting the environment, thoroughly cleaning up Hanford, preventing human exposure to dangerous radioactive materials and hazardous wastes, and engaging all entities in the decision process. The agencies responsible for the clean-up at Hanford, collectively known as the Tri-Party Agencies, include the United States Department of Energy (D0E), the Washington State Department of Ecology (Ecology), and the United States Environmental Protection Agency (EPA). Additional stakeholders include the Hanford community, Hanford workers, myriad advocacy groups, public health practitioners, taxpayers, and contractors. As students in the public health program at the University of Washington and members of the public health profession, our primary interest is in protecting the health and well-being of the people living and working around Hanford now and into the future.

In our effort to better understand the public health risks at Hanford, we often found conflicting information and differing perspectives on the history, current risks, and future cleanup plans of Hanford. We found ourselves struggling to identify accurate sources and to reconcile conflicting information. Others interested in learning about or participating in the decision-making process about cleaning up Hanford will likely encounter similar difficulties.

Rather than provide answers, the purpose of this report is to provide a framework for both understanding and formulating questions about contaminants of most concern to the environment and to the health of humans, appropriate limits on human exposure to radioactive and hazardous waste, and effective ways to monitor the cleanup process. Based on our research, we also propose criteria for a burial ground cleanup policy to protect the health of our communities.

Background

In Hanford's early years as a top-secret nuclear weapons facility, few people knew about the nature or purpose of work conducted at the site. This secrecy contributed to a culture that discouraged employees, citizens, and concerned organizations from asking questions about Hanford's products, health risks to humans, and potential environmental consequences. In the late 1980s, the mission of Hanford shifted from weapons production to cleanup of the highly contaminated site. Since the 1980s, agencies involved in the cleanup have worked to do away with the culture of secrecy and develop a plan that prioritizes the shared values of all stakeholders while championing transparency. Meeting these goals will lead Hanford into a new era of mutual trust.

A present issue of concern is the burial grounds in the Central Plateau (200 Area) that hold radioactive and toxic waste. As public health students, we are interested in the characterization of waste stored in these burial grounds and the potential threat these materials pose to surrounding communities and environments. From the mid-1940s until 1970, the DOE dumped all types of radioactive and contaminated materials into the unlined burial grounds.[1] In 1970, the Atomic Energy Commission

declared that high-level radioactive waste needed to be inventoried, packaged, and placed in lined trenches for retrieval at a later date.

In the Hanford Solid Waste Burial Grounds, the quantity and nature of buried radioactive and toxic waste is unknown. Of particular concern is the waste buried before 1970 for which dumping records are incomplete or missing. Early burials of waste were not expected to be retrieved or to comply with current environmental standards.[2] In addition to not having any records, sometimes the material found in the trenches does match the records that are available.[3] Because workers cannot fully predict the nature and radioactivity level of many buried materials, the process of digging up uncharacterized contaminants in burial grounds is necessarily slow and cautious.

Contaminants

While there are not complete inventories of the chemicals in the pre-1970 burial grounds, much has been learned from digging up burial grounds located along the river. The DOE has acknowledged the 200 Area trenches at issue now contain at least 363 kg of plutonium, 340 kg of uranium, solvents, many of which are carcinogenic, and acids as well as contaminated garments and equipment.[4] Where there is no clear record of what was disposed, a major concern is not only the hazards posed by individual toxic substances, but the results of the interaction between these hazardous chemicals.

From a public health standpoint, the concern is that the burial grounds do not properly prevent the movement of mass quantities of toxic waste; waste that includes chemicals known to be hazardous to human health and the environment. When assessing the options for burial ground remediation, it is important to understand the characteristics of these chemicals including their persistence, mobility, and effects on human health. Those accountable for public health should understand and report the potential for mobility, toxicity, and bioaccumulation of these chemicals prior to evaluating options for a successful remediation.

Persistence: While some radioactive substances decay or break down into harmless substances quickly, many in the burial grounds that will remain radioactive and toxic for millions of years. A way to measure persistence is to evaluate the half-lives of these substances. A half-life is the amount of time it takes for half of the atoms in any given radioactive isotope to decay. Uranium, with a half-life of 4.47 billion years, should be considered highly persistent.

Contaminant	Half-Life
Plutonium	24,100 years
Carbon-14	5,700 years
Tritium	12 years
Iodine-129	15 million years
Strontium	29 years
Technetium-99	210,000 years

These radioactive and toxic substances in the burial ground will persist for a long time.

Mobility: The radioactive and chemical wastes in the burial grounds are currently disposed in trenches beneath the soil. At least 40 miles of these trenches in the Central Plateau are unlined, meaning there is no barrier between the items in the trenches and the soil. Chemicals in these trenches have the

potential for moving through the soil laterally, vertically or escaping as vapor, while others may remain immobile. Mobile chemicals can move into the ground water and ultimately reach the Columbia River.

The mobility of a chemical is affected by interactions with other chemicals, climate, the pH, salt content and condition of the soil. As the contents of the burial grounds are unknown, predicting the movement becomes a challenge. We do know some things:

- Carbon tetrachloride has been found in soil 30 feet below one of the burial ground trenches.[5]
- Contaminants have been documented to move from burial grounds at Hanford when assisted by excess water such as direct liquid discharges, water line leaks, or meteoric sources (winter rain and snowmelt).[6]

In our research, we found that the point source of contaminants found in Hanford groundwater was commonly either unreported or not known. Whether from tank or burial ground waste, several chemicals that are suspected of being in the burial grounds have migrated into the groundwater, indicating they are mobile. Some of these chemicals include:[7]

Carbon tetrachloride	Technetium-99
Chromium	Tritium
Iodine-129	Uranium
Mercury	Strontium-90
Nitrates	Cesium

Mobility is also affected by human influence. During an excavation process, potentially contaminated soil could be released as particles into the air and carried to downwind locations.

Some chemicals in the burial grounds have the potential for migrating into the groundwater. Excavating poses the possibility of mobilizing contaminants into the air.

Bioaccumulation: Humans, plants and animals come into contact with chemicals as chemicals move through the environment via the water, soil, and air. Some chemicals are not easily broken down, and therefore can build up in plants and animals to levels that are much higher than the levels that exist in the soil or water. Bioaccumulation is the word used to describe this increase in concentration of a toxic substance in an organism over time.

Several chemicals suspected of being in the burial grounds are known to bioaccumulate:

- Mercury and chromium have been known to bioaccumulate in aquatic animals. Mercury has been found in fish at concentrations 10,000 times found in the water.[8]
- Tumbleweeds, with their long roots, reach the water table and have been known to suck up radioactive uranium prior to tumbling through Eastern Washington and Oregon.[9]
- Technetium does not bind to any rocks or soil, it is highly soluble and so is taken up quickly by plants. Sandy-soil conditions further facilitate uptake. Technetium bioaccumulates in plants, mammal and fish.[10]
- Cesium can pass from water to soil to grass to cows to milk, and finally to humans.[20]
- An independent study in 2005 found plutonium and other toxic chemicals in fish and shellfish retrieved from the Columbia River.[11]
- Strontium is known to act like calcium and is readily absorbed into human bones. If radioactive strontium is absorbed by the body, it can reside in the bones and is linked to bone cancer.[12]

Once in the environment, some contaminants will bioaccumulate to increasingly harmful levels.

Toxicity: Exposure to chemicals and radioactive substances can occur by inhalation, ingestion, or contact with contaminants. Whether the exposure will result in harm depends on the concentration, toxicity, and radioactivity of the chemical. In terms of radiation exposure, the closer you are, the more time you spend and the less shielding you have from a source of radiation, the greater your exposure. When exposed to chemicals such as those in the burial grounds, humans can be affected by the radiation emitted by the chemical or the toxic effect of the chemical itself.

Radiation can cause most types of cancer. Some tissues, such as breast tissue and the thyroid, are more sensitive to radiation than others. While cancer is the most commonly studied effect of radiation, radiation also affects the immune system, which manifests as autoimmune diseases. Radiation can also affect fetal development, both at a genetic level prior to conception and in the womb.

The toxic effects of chemicals vary greatly. They can range from relatively mild manifestations such as nose and eye irritation to more severe conditions such as immune disorders, kidney, liver and lung damage, cancer and at high enough doses, death. These examples of health problems associated with exposures to chemicals at and around Hanford serve as reminders of the potential for harm and the need for caution.

- Hanford workers have been diagnosed with specific conditions related directly to their chemical exposures. Chronic beryllium disease, a disease that primarily affects the lungs, has been diagnosed in 140 workers at Hanford. A family member of a beryllium worker who brings home beryllium dust on shoes or clothing also risks exposure.[13]
- A CDC birth cohort study found "a small increased risk of Hashimoto's thyroiditis for men who lived in the counties near the [Hanford] facility "[14] and were exposed to iodine-131 released into the air during the 1940's.

Human exposure to these contaminants increases the risk of poor health outcomes.

There remains uncertainty about the contents of the burial grounds and the potential for environmental contamination and harm to workers and the public. Careful consideration of the persistence, mobility and toxicity of all contaminants in the burial grounds will be crucial when evaluating the alternatives for remediation of this site.

Limits and Standards

Federal and state regulations set the contamination limits that govern Hanford cleanup.[a] The EPA emphasizes using risk (proportion of people who will develop cancer from radiation) rather than amount of radiation (measured in millirem or picocuries) to determine acceptable levels of contamination. The EPA has therefore said cleanup of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) sites should achieve a level of risk between the one additional cancer in 10,000 to 1 million similarly exposed individuals, based on the reasonable maximum exposure

[a] The literature about risk are unclear, alternating between lifetime risk of getting cancer and fatal cancer, as well as between men, women, and different age groups. The Tri-Party Agencies would better serve the public by clarifying these issues.

for an individual.[15] When cleanup at Hanford is complete, the cumulative radiation exposure from nuclear waste to individuals may not exceed 15 millirems per person per year above background.[16] This number, according to some estimates, could represent an increase in lifetime cancer risk of 3 in 10,000 individuals.[17] While the EPA asserts that this risk is "consistent with levels generally considered protective in other governmental actions," including EPA regulations and guidance, it is inconsistent with the CERCLA risk guidelines.[15]

To comply with the 15 millirem exposure limit in a particular area of contamination, regulators consider an "exposure scenario," that reflects how an area of land or a resource, such as water, is expected to be used in the future. Allowable contamination levels are based on the amount of contamination it would take for a person in the exposure scenario to be exposed to 15 millirems of radiation per year. For land that will remain industrial, the exposure scenario is based on exposure of workers to contaminants through industrial work activities. For land that will become residential, the exposure scenario is different: Residents will certainly drink the water, children will likely play in the dirt, people may plant gardens, etc. For residential areas, contamination levels must be low enough so that residents are not exposed to more than 15 millirems through expected activities of daily life.

The risk and exposure limits guiding Hanford cleanup raise important questions about how to manage burial ground waste safely over the long-term:

1. **Does the 15 millirem exposure limit adequately protect vulnerable groups?**
   Many radiation protections and guidelines are based on protecting "Reference Man," a "hypothetical 20 to 30 year old Caucasian male" weighing 154 pounds.[18] The fatal cancer risk for women, however, is twice as high as that for men at the same radiation dose, and for children, it is 3.7 to 4.5 times greater.[18] How would women, children, and other more biologically vulnerable groups fare living and/or working on land cleaned up to the 15 millirem level?

2. **Do the exposure scenarios accurately reflect future land use?**
   Hanford occupies land that is important to four local Native American tribes. Do the exposure scenarios used in setting contamination levels take into consideration tribes' use of the land, such as hunting and medicinal herbs?

   Some of the contaminants in Hanford's burial grounds will persist for millions of years. Do current land use predictions consider expected use over at least the next few hundred years? If land use changes, additional cleanup may be necessary to ensure the remedy is still protective.[15] Would more stringent regulations, even for areas expected to remain industrial, do a better job of protecting potential future users, and/or minimize future costs if land use changes?

3. **Is the DOE approach based on our best current understanding of radiation health effects?**
   In 2005, the National Academies (National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council) published the *Biological Effects of Ionizing Radiation* (BEIR VII) which concluded the "scientific research base shows that there is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial. The health risks–particularly the development of solid cancers in organs–rise proportionally with exposure. As the overall lifetime exposure increases, so does the risk."[19]

This is known as the Linear No Threshold (LNT) model. Despite the 2005 recommendation by the Academies, the DOE has never adopted LNT as a scientific principle to guide its policy decisions.

4. **What about the health risks of radioactive and toxic, non-radioactive chemicals in combination?**
   In addition to radioactive waste, the solid waste burial grounds contain toxic chemicals that can reach workers and members of the public through the air, soil, and groundwater. Individuals encounter toxins and radiation in combination, and exposure limits should be conservative and take into account the level of scientific uncertainty about how these interactions affect health.

As advocates for public health, we believe a critical understanding of exposure limits is necessary. Information about the science and decisions behind exposure limits is currently difficult for the public to access.

Monitoring

Regular monitoring of the environment, particularly of contaminants that may leach from the burial grounds is a necessary requirement of any cleanup plan. It is just as important to communicate any findings to all stakeholders in a manner that can be understood. Responsibility for communicating potential exposures to the public falls on the Tri-Party Agencies.

In addition to preserving and conserving the land around Hanford and along the Columbia River, one of the goals of the United States Fish and Wildlife Service includes creating additional space for public recreation (see Appendix A for map). The areas surrounding the Columbia River are open to the public and local native tribes for recreational use. The Hanford burial grounds are within 20 miles of public recreation areas. The Wahluke Unit of the Hanford Reach National Monument, has been open to recreational hunting and fishing for years. Strict, regular and wide-spread monitoring of water, fish, soil and crops along the Columbia River is crucial for ensuring members of the public who access these recreational areas are not exposed to harmful chemicals or radiation.

Currently the DOE has a directive to monitor both groundwater and air quality for harmful waste materials. The overall objective for monitoring is to ensure that the containment of contaminants in the burial grounds is in compliance with state and federal environmental laws. The quality of the air is measured routinely using samples taken from multiple locations within and outside the perimeter of the Hanford site. The air monitoring is summarized in the Hanford Site Annual Environmental Report.

Groundwater is sampled semiannually through a series of onsite wells. The samples are tested semi annually for pH, total organic carbon, and total organic halides and annually for uranium, technetium-99, tritium, Iodine-129, mercury and lead. These monitoring systems collect information on the total alpha emission, beta emission, tritium, iodine-129, and some trans-uranic isotopes. All groundwater data for the burial grounds is summarized and formally published annually in the Hanford site groundwater report.

It is apparent that the Tri-Party agencies are performing tests and addressing the movement of some contaminants. The reports are numerous and can be found (with some searching) on the Internet. The crux of the challenge was in deciphering the reports. There was a lack of comparable measurements between documents, it was challenging to comparing findings to regulatory standards, challenging to

determine which standards were appropriate, and difficult to understand the scope of what was tested. Conflicting information from outside sources contributed to confusion regarding the monitoring of the cleanup.

Criteria

A successful burial ground remediation process must protect public health. This paper raises many concerns to be considered in designing the remediation plan. Evaluating outcomes based on a specific set of criteria is a useful way to determine the acceptability of different remediation alternatives.

We propose four criteria to evaluate the outcomes of any alternative chosen for the remediation of the burial grounds:

Comprehensive: The burial grounds contain known contaminants that are persistent, mobile, bioaccumulate, and are toxic, in addition to unknown contents. A successful remediation plan must make known and address the contents and the characteristics of what is buried.

Protective: The remediation plan must ensure the health and safety of the public, those who work at Hanford, and of vulnerable populations who will come into contact with the area affected by the burial grounds. Hazardous contaminates must be cleaned up to a level that will not lead to adverse health effects.

Vigilant: The burial ground remediation process must include the monitoring of the movement of chemicals in the ground, air, and water. The monitoring plan must extend for as long as the chemical is harmful to people.

Accountable: It is essential for the burial ground remediation process to be transparent and accessible to the public. Transparency ensures the institutions responsible for remediation are accountable to the public. Accessibility ensures that the public will have access to clear information, be informed of the pros and cons, and engaged to advocate in their best interest.

There are additional criteria that are also important to a successful remediation plan, **such as efficiency**. However, the four above criteria are specific to ensuring the remediation process will protect public health.

Conclusion

The remediation of the burial grounds at Hanford presents a multitude of challenges, requiring the expertise and involvement of multiple stakeholders. Although stakeholders, including community members, advocacy groups, contractors and government agencies have different concerns, we all share the common interest of protecting public health. Employing our recommended criteria will ensure that the remediation efforts are comprehensive, protective, transparent and vigilant. Through working together and utilizing the criteria, the burial ground remediation process will protect human health and the environment and ultimately create a Hanford that everyone can safely enjoy.

Appendix A: Map of Hanford Reach National Monument

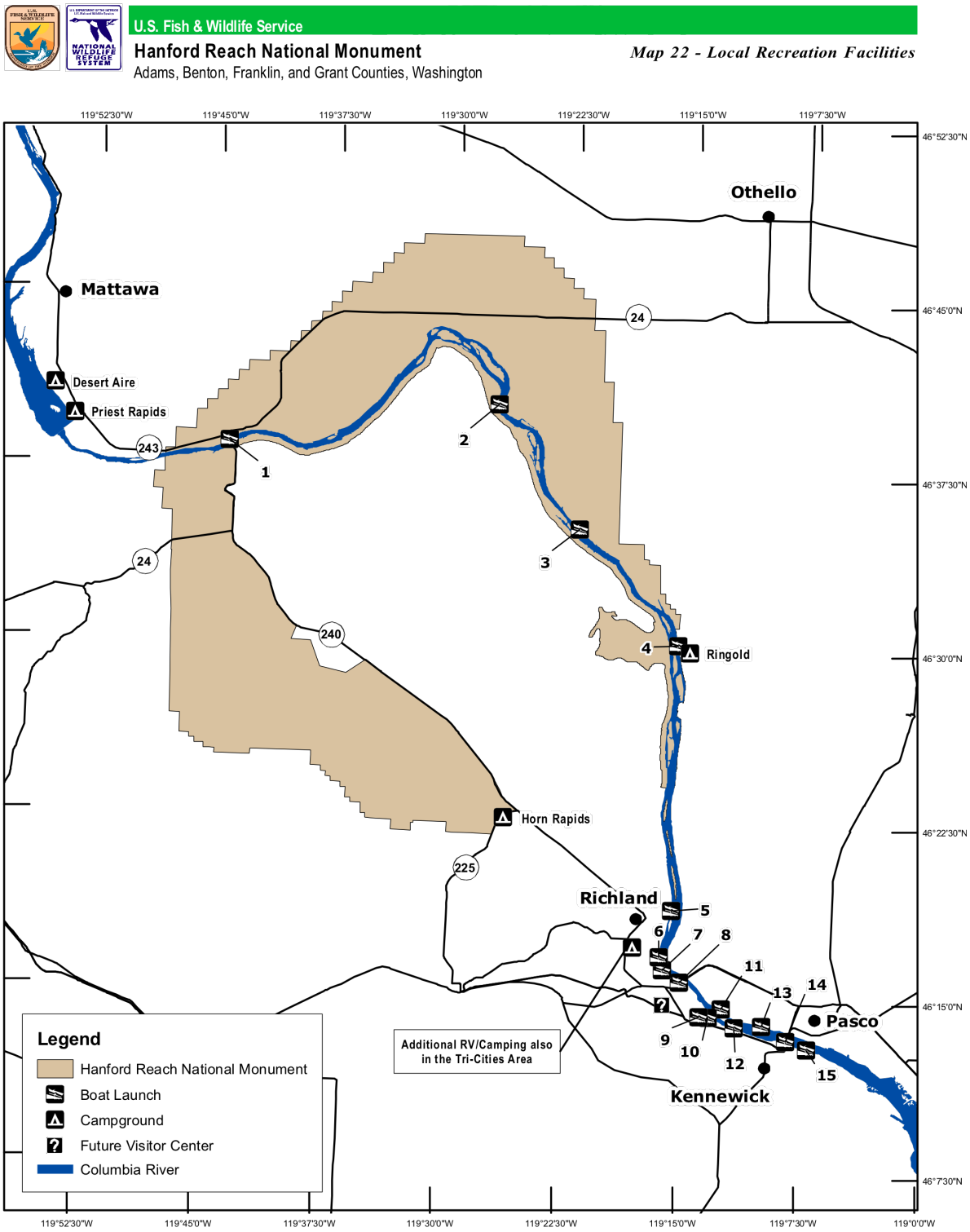

Figure 1 From http://www.fws.gov/hanfordreach/planning.html#finalccp

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