Hanford Radioactive Solid Waste Burial Ground Position Paper

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Purpose

This document is intended to provide guidance for the decision-making process concerning cleaning up the solid waste burial grounds in the 200 Area of the Hanford site. It was written by students in the University of Washington's Community-Oriented Public Health Practice MPH program. It based on our research, numerous interviews, a site tour, and presentations by representatives of Tri-Party Agencies and community advocates. It includes background information on the Hanford burial grounds, highlights the values that we believe should inform the decision-making process, and, after considering advantages and disadvantages of various solutions, our recommendations. We offer our analysis in the hopes of contributing to the Department of Energy and their partners' current process to consider different options for cleanup and prepare to make a final decision in 2017.

Summary

During WWII and throughout the Cold War, the United States Department of Energy (DOE) Hanford Site's main mission was to produce plutonium for atomic weapons. Nearly 70 years later, Hanford's new mission is to clean up the toxic contamination from that production process. A major site priority is the remediation of the solid waste burial grounds in the 200 Area, which contain a heterogeneous mix of radioactive and hazardous wastes. Although the Tri-Party Agreement provides legal directives for the process, jurisdictional, scientific, and political concerns complicate cleanup efforts. Cost-effective solutions that feasibly prevent contaminant mobility are preferred but may not yet be fully operational. Lead regulatory agencies will also have to gain community acceptance of their strategies. Today, the Tri-Party agencies are beginning a process to study various approaches to burial ground cleanup. After several years of further characterization by the DOE, the Washington State Department of Ecology will make a final decision.

After speaking with representatives of the Tri-Party agencies, advocacy groups, Native American Nations, and citizens, we identified four key values that are shared by all parties. We believe that using these values to guide the decision-making process will help to ensure a sound solution that all stakeholders can support. They are: minimize impacts on human and environmental health, conduct an effective and cost-efficient cleanup, protect worker safety, and guarantee public participation and transparency.

We applied these key values and five criteria commonly used to evaluate toxic waste cleanup to compare different cleanup strategies, including capping and remove-treat-dispose (RTD). Capping can be done relatively inexpensively with materials available onsite. However, it may require costly maintenance and may not last as long as some of the radioactivity in the trenches. A variety of cleanup strategies, including RTD, may provide a more thorough solution for the most contaminated trenches and help to ensure that toxic waste at Hanford has a minimal effect on the environment and future generations. Based on our analysis we recommend that the Tri-Party agencies prioritize extensive research about the burial ground contents and their behavior in the environment, consider multiple remediation strategies, and maintain attention to worker safety and transparency throughout the entire cleanup process.

Values

Burial ground cleanup activities and decision making should be guided by the shared values of community members, advocacy groups, Native American Nations and Tri-Party Agencies to protect the long-term health of the land and those who use it. Through an analysis of stakeholder perspectives, we have identified the following shared values:

Minimize impacts on human and environmental health

The overarching goal of all cleanup at Hanford is to mitigate the effects of plutonium production and waste storage on human health today and for the generations that will continue to use the Hanford site. Protecting the environment is a necessary corollary to protecting human health, as well as a worthy goal in and of itself. This goal is reflected in the seven “Goals for Cleanup” that the Tri-Party agencies laid out in the “Hanford Site Cleanup Completion Framework.”[iii] It is also a key goal of numerous advocacy groups, citizens, and Native American Nations who will be directly affected by the cleanup and have sought to add their voice to the decision making process.

Get it done right: Conduct an effective and cost-efficient cleanup

The Department of Energy, other Tri-Party agencies, and citizens all want the Hanford cleanup to be done well. Options that may be faster or less expensive initially need to be weighed against potential future expense for maintenance or further remediation. The nature of some of the nuclear waste at Hanford is that it will have the potential to emit damaging radiation for not only centuries, but millennia. It is imperative to take the long view in planning how to remediate such waste. While milestones and deadlines are critical methods to keep cleanup progress on track, getting the cleanup done on time cannot be substituted for getting it done effectively. Spending more time on a thorough cleanup now is a worthwhile investment if it will effectively prevent contamination from affecting people and the environment in the future and the need for expensive maintenance and additional remedies.

Conducting an effective and cost-effective cleanup also means gathering adequate data to inform cleanup choices. Without adequate data, various cleanup options cannot be compared and evaluated. Characterization should be planned and executed to provide information that will help decision makers evaluate all potential cleanup options, not just one. Without such characterization, it will be impossible to know if the right cleanup methods have been used and ultimately whether cleanup was done thoroughly.

Ensure worker safety

As in all aspects of cleanup at Hanford, worker safety should be a priority in cleaning up the burial grounds. Because they contain many varieties of toxic waste, including but not limited to radioactive waste, a variety of strategies must be used to protect workers from exposure during the characterization and remediation process. The rights of workers command our respect and need to be prioritized regardless of what technologies are employed in remediation. Protecting Hanford workers is worth taking the necessary time and expense.

Guarantee public participation and transparency

In the words of a U.S. Department of Energy (DOE) representative, to consider Hanford 'clean,' "we will all have to work together to agree it was done right." The DOE has set a precedent of inviting public input at multiple points in the decision making process. This input must be meaningfully considered, not tokenized or dismissed. In turn, the DOE can increase community buy-in to their proposed solutions if they provide accurate and understandable data to support their recommendations.

Background

During WWII and throughout the Cold War the DOE Hanford Site's main mission was to produce plutonium for atomic weapons. The eastern Washington area known as White Bluffs was selected as an ideal location because of low population density, proximity to the Columbia River, and available power from the Grand Coulee Dam. In the name of national security, the federal government forced Native American tribes and white settlers in nearby farming communities off their property to build the fabrication and processing center. Since plutonium production is extremely inefficient roughly 300,000 tons of raw uranium were needed to make 100 tons of plutonium.

Now, nearly 70 years later, Hanford's new mission is to clean up the toxic contamination from that production process. The 1989 Tri-Party Agreement provides a legal framework and milestones for the DOE, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) to clean up the Hanford site. Cleanup methods are hotly contested and the future and function of the facility continue to fuel regional and national debates. Jurisdictional, scientific, and political concerns complicate issues of occupational hazards, public exposures to radioactive materials, and community acceptance. According to the DOE, 11,000 employees work on clean up projects ranging from building a vitrification plant (turning liquid waste into glass), demolition, and treatment of contaminated soil and groundwater.

Hanford's Radioactive Solid Waste Burial Grounds

Over the years, the Hanford Site hosted many types of activities and also received waste from offsite. Practices, regulations, and record keeping pertaining to waste disposal changed over time, resulting in heterogeneous burial ground contents and differing levels of knowledge as to what each trench contains. Today, Hanford's solid waste burial grounds contain over 40 miles of trenches that hold approximately 450,000m^3 of radioactive solid waste.[i] The burial grounds are located in the northeastern and northwestern corners of the Inner Area of the Central Plateau, called the 200 East and 200 West Areas. The East and West areas are further divided into "operable units."

To guide cleanup prioritization the DOE has sorted the burial grounds in the 200 East and West areas into six main types based on their contents. Their initial field investigations have also helped characterize the contents of the burial grounds and the risks posed by each operable unit. Representatives from citizen groups and Ecology have called for more in-depth investigation beyond surface characterization. Of greatest concern are the 363kg of plutonium and 485,340kg of uranium that remain in the burial grounds.[ii]

Burial Ground Regulations

Waste disposal practices and regulations have changed many times since the 1940s. In Hanford's early years, plutonium that was too expensive or impossible to extract using current technologies was buried.[i] One of the most important changes regarding waste disposal resulted from a 1970 ruling from the Atomic Energy Commission (AEC). The AEC ruled that transuranic (TRU) waste (containing plutonium) had to be separated from other solid waste ("low-level waste") and placed in retrievable storage pending removal to a deep underground repository. This ruling established what is referred to as pre-1970 and post-1970 TRU waste. Pre-1970 waste is also referred to as "non-segregated" since it mixes highly radioactive substances with low-level waste. Regulatory changes in the 1980s included banning low-level liquid organic waste from land disposal, new Washington State legislation regulating hazardous waste disposal, and the conditions of the Tri-Party Agreement. The practice of burying waste in unlined trenches officially ended in 2004.[ii]

Changing policies have two important implications for cleaning up the burial grounds. First, operable units contain a variety of hazardous and radioactive wastes packaged using multiple methods and presenting significant levels of risk to workers and future generations. Second, the AEC's 1970 directive has created one of the most difficult burial ground cleanup issues. The result of the directive is that similar wastes might have completely different requirements governing their disposal depending on whether they were produced before or after 1970. These complicated policies and disposal practices mean that burial ground remediation will be a complex and potentially hazardous task.

Possible Solutions

The DOE has already identified several alternatives for burial ground remediation including: no action, in situ treatment, capping individual landfills without removing waste, and a comprehensive strategy called Remove-Treat-Dispose (RTD). DOE is responsible for suggesting solutions for Ecology to approve based on criteria laid out by federal and state legislation. First, the federal Comprehensive Environmental Response Compensation and Liability Act (CERCLA, also known as the Superfund Act), requires some characterization of burial grounds before remediation. Second, the Washington Model Toxics Control Act (MTCA) and the state's Hazardous Waste Management Act require the characterization of contaminant source and leakage before capping can take place. Both state laws and CERCLA "clearly identify removal and treatment as the preferred alternative for waste disposal."[iii] Because state acts prioritize a permanent cleanup solution, they must be used in conjunction with accompanying CERCLA guidelines.

Our research team used the following CERCLA balancing criteria to evaluate the merits of capping and RTD since these two strategies were mentioned frequently in our conversations with stakeholders and agency representatives. However, we emphasize that burial ground cleanup will likely include a combination of multiple cleanup strategies and should not be viewed as an exclusive choice between these two options.

CERCLA Criteria

1. Long-Term Effectiveness and Permanence
2. Reduction of Toxicity, Mobility, or Volume Through Treatment
3. Short-Term Effectiveness
4. Implementability/Feasibility
5. Cost
6. Community acceptance [iv]

1. Long-term Effectiveness and Permanence

a. Capping

Proponents of capping argue that the fifteen-foot thick Hanford Prototype Barrier has an estimated life of 1,000 yrs.[v] Concerns exist that natural settling of the land or a larger seismic event could lead to cracks in the cap that allow water in. An additional concern is that radioactive elements found in the trenches may have half-lives exceeding tens of thousands of years, much longer than the 1,000 that the caps are designed for.

However if capping is determined a possible response for certain trenches, an alternative technology, known as an evapotranspiration barrier (ET), could be effective. ET uses native grasses and shrubs to create an evaporation system that keeps deeper soil dry. It also has the ability to re-seal itself after natural movements in the earth.[vi]

Since pre-1970s waste was poorly catalogued throughout Hanford, proposals to cap the burial grounds will have to be supported by in-depth characterization of burial ground contents. During the past 20 years, workers have been surprised by accidental discoveries in other burial grounds at Hanford.[vi] Findings of unexpected and undocumented pieces of uranium fuel recently turned up near a burial ground, and in 2005 workers discovered a buried safe contaminated with plutonium residue. These findings point to limited knowledge of what substances exist in the trenches. Without a better understanding of the contaminants, Oregon's cleanup board explains, "it is not possible to accurately assess the risks of leaving the waste in place."[ii]

b. RTD

The DOE states that "inadequate fundamental understanding of waste form performance and contaminant release, transport, and transformation processes result in inadequate conceptual models potentially leading to selection and design of non-optimal remedial actions."[vii] Thorough characterization of the burial grounds will thus be the first step in any long-term remediation solution. Proceeding without a clear understanding of the hazardous waste located in the burial grounds could lead to an ineffective plan.

The decision about a long-term solution to the burial grounds needs to account for the very real implications of leaving hazardous waste in the ground at Hanford. Although capping may serve as a solution for some low-level waste in the burial grounds, it is important to thoroughly remediate as much high-level waste as possible. While not the only threat to human and environmental health, "plutonium-contaminated waste will pose one of the most serious risks to the human environment for years to come."[viii] Plutonium can cause cancer even in minute particles, and because isotopes may take 24,000 years to lose half of their radioactivity, it will likely last longer than cleanup measures.[ix]

The Hanford cleanup plan must comply with long-term standards for human and environmental exposure. Federal controls require that disposal of radioactive wastes at DOE sites must pose less than a 1 in 10,000 chance of exceeding EPA drinking water standards over a 10,000-year time frame.[xi] A recent estimate by the DOE found that "plutonium in groundwater from dump sites at Hanford could reach the near shore of the Columbia River in less than 1,000 years at concentrations 283 times greater than the federal drinking water standard."[xi] It is reasonable to expect that people will drink the groundwater near Hanford in the future and could be exposed to dangerously high levels of plutonium contamination. Ultimately, proper investigation of ground contents, characterization, and most importantly, the removal and treatment of highly hazardous material must occur before deciding on an effective long-term solution.

2. Reduction of toxicity, mobility, or volume through treatment

a. Capping

Capping would not change the nature or reduce the volume of waste in the burial grounds. While capping could reduce movement, it cannot immobilize hazardous and radioactive waste. Reports from the Washington Department of Health say contaminants like carbon tetrachloride will spread beyond the footprint of the trenches. Their Model Toxic Control Act (MCTA) investigation predicts that, if left in the trenches, uranium will eventually contaminate the groundwater.[x] Computerized modeling can help estimate future contamination but cannot completely predict how waste will move through the earth. Some cleanup advocates argue that models do not fully take into account the fact that water moves laterally at the Hanford site, not just vertically, dispersing the contaminant through the soil in ways caps cannot prevent.[vi] Toxicity experts admit that our limited understanding of dispersal means that there are no clear explanations for all contamination found at Hanford.[iv]

b. RTD

Recent reports show that there is more high-level hazardous waste in the burial grounds at Hanford than originally believed. Incomplete records restrict the government's ability to determine exactly how much plutonium poses a contamination hazard, but there is little doubt that the challenge is significant. [xii] For example, the amount of plutonium in Hanford high-level radioactive waste tanks is more than double the amount estimated in 1996[xi] and current estimates show that about 2.7 tons of plutonium in liquid and solid wastes were mostly discharged or buried in soil."[xi]

Scientists are unsure how plutonium in the burial grounds will behave in the future. Plutonium at Hanford has already been found to migrate at greater distances than models might predict. Although DOE models show that plutonium will bind to the soil and remain close to the trenches, plutonium has been found in groundwater and at a depth of 100 feet.[iv] According to S.S. Hecker, former Director of Los Alamos National Laboratory, it is "one of the most challenging applications of modern chemistry because of the inherent complexity of plutonium and the corresponding complexity of the natural environment."[xi]

Plutonium is not the only dangerous waste in the burial grounds. Due to scattered record keeping,[xi] it is still unclear what else is contained in the burial grounds. Units contain a combination of hazardous and radioactive waste, packaged using multiple methods or not packaged at all, that presents varying levels of risk to workers and future generations. It is possible that the risk of environmental contamination will be higher for waste buried in burlap sacks six decades ago than for recent waste. While it no one seems to know exactly what might happen if the contaminants are left in the ground, it is probable that capping will not reduce volume and toxicity of waste and that mobility of contaminants is still possible.

3. Short-term effectiveness

Harsh winters and variable weather conditions are a concern in Hanford's central plateau. In the short-term, caps could effectively prevent percolation of rainwater and debris into the contaminated area, lessening the speed of which contaminants move through the soil. However, capping could not definitively stop the spread of contaminants to the ground or river water and further contamination of those resources would likely occur. An additional consideration is that capping could make additional remediation difficult or impossible. For these reasons and others, the EPA and Ecology jointly recommend that "waste sites that do not attenuate within 100 years post-construction completion, reside in the shallow zone, and result in unacceptable exposure under any reasonably anticipated land use should be considered for RTD." [xi] Up to this point, surface characterization has raised further questions instead of providing clarity. Additional characterization will help establish which cleanup strategies will be most effective and eliminate the need for future remediation.

4. Implementability/Feasibility

With the exception of no action, capping is DOE's simplest solution. Prototype barriers have been designed and, in some cases, observed for years. Proponents say they can be built easily with standard equipment and readily available on-site material.[xii] Still, even the most low-maintenance cap would require indefinite monitoring and maintenance. Institutional controls such as record keeping, site surveillance, and sensor upkeep are imperfect measures that can and have failed at other nuclear sites.[xi] While highly feasible, this capping is at the bottom of the MTCA's cleanup priority list.

It is also feasible to dig up the majority of waste contained in the burial grounds. Although the burial grounds in the 200 Area are more hazardous and thus potentially more complicated than other Hanford sites, DOE has demonstrated success cleaning up other areas. DOE is currently finishing with the cleanup of the Hanford burial grounds located near the Columbia River. It may not be possible to remove deep subsurface concentrations of waste, but the "technology to remove the major preponderance of these wastes from near surface soil was successfully demonstrated at Hanford thirty years ago."[xi] Dr. Robert Alvarez of the Institute for Policy Studies has argued that cleanup at the Idaho National Laboratories sets a precedent that Hanford could follow in cleaning up pre-1970s mixed waste – especially because Hanford contains much higher concentrations of plutonium.

Although the costs will be high, he argues that the costs of leaving the waste in place are "incalculable."[xi]

At this point, no data available indicate that the deep vadose zone has received releases from the landfills. Only carbon tetrachloride has been confirmed to a depth of 30 feet at the 218-W-4C landfill. Generally speaking, 45-60 feet below ground surface is the maximum depth of practical excavation.[xi] This means that the vadose zone, the area between the ground surface and the water table, can be practically dug up. Worker safety would be a serious implementation concern in digging up hazardous waste. Caution and stringent safety measures could address this issue, as they have in other cleanup projects.

5. Cost

It is presumed that capping is a more affordable option than full excavation, treatment, and disposal of Hanford's solid burial ground waste.[xiii] However, an in-depth cost analysis of capping, including long-term site surveillance and management, would be necessary to compare with the more comprehensive RTD option as well as other options. Further characterization may be important to give a clear idea of what the relative costs will be for each option. Since caps do not remove contamination from the site, the remediation of continued chemical leakage to the groundwater and Columbia River will likely entail long-term expense. If natural or anthropogenic events make the caps ineffective, a more comprehensive removal and treatment plan might be required. This realistic possibility creates a choice to either 'pay now or pay *more* later.'

6. Community Acceptance

With so many stakeholders invested in the outcomes at Hanford the cleanup efforts will only be considered a success if we can all agree that it was done right. In order for the DOE to be able to stand shoulder to shoulder with community stakeholders and declare the cleanup complete, they will need to continue listening and responding to community voices and opinions. It is clear from our research that a majority of stakeholders see capping as the last option for remediation. At this point, deciding to adequately categorize, dig up, and properly contain as much of the existing waste as possible is regarded as an acceptable solution by the community. If the DOE decides that capping is the best possible cleanup strategy, obtaining buy-in from regulators, community members and advocates will necessitate supporting research that is thorough and convincing. It is difficult to put a price tag on cleaning up the burial grounds when money spent cleaning a waste site has longer-lasting societal value than money spent on putting barriers or caps into place.[vi] Our conversations with community members found support for RTD in the hope that it would benefit the surrounding region and create the possibility of future land use.

Recommendations

We believe that extensive research about burial ground contents and their behavior in the environment and consideration of multiple remediation strategies should be prioritized in burial ground cleanup planning. Capping may be appropriate in some instances, but it should all possible options, including RTD, should be evaluated. In addition to capping and removal, treatment, and disposal, other strategies such as vacuuming hazardous vapors, grouting mobile contaminants, or in situ vitrification may also be considered, based on what is found about the contents of various trenches.

We recommend:

- **Thorough characterization to provide the necessary information to evaluate all viable cleanup strategies, and ultimately to choose from among them.** Although we believe that characterization should be done thoroughly, it may not be possible to gather all potentially useful information. In the absence of complete information, it is safest to base plans on the highest level of risk to protect the health of workers, the public, and the environment as much as possible.. Past experience at Hanford has shown unpleasant surprises when other burial grounds close to the river have been excavated.[xi] It is reasonable to assume that currently unidentified contaminants may also exist in burial grounds in the 200 Area.

- **Worker safety be prioritized throughout the cleanup process**. Rather than dictating which remediation strategies should be implemented, this means allowing for the time and expense that effective worker protections require in any cleanup process. Any alternative will have to be executed safely using lessons from work that has already been done.

- **Information including data related to the burial grounds and potential remediation strategies continue to be provided to the public.** Efforts by the DOE can make sure such information is understandable. Input from community members, including Native American nations, will also be vital throughout the decision-making process.

- **Multiple remediation strategies be impartially evaluated for use in the burial grounds.** In particular, removal of pre-1970 transuranic waste should be prioritized. Decisions should be made based on assembling thorough data and a careful and complete consideration of all options. Landfill cleanup efforts at other sites, while not identical, offer examples of how burial grounds can be remediated using a variety of strategies. The waste zone, the vadose zone, and the groundwater can be monitored to establish levels of different contaminants. Some volatile waste that turns into vapors can be vacuumed out of the ground. In situ grouting can be used to keep other waste from changing into more volatile forms that could leach into the soil and groundwater. Enclosures can be built over segments of the landfill so that contaminants would not be dispersed through the air when they are removed. Workers can use special gloveboxes to separate transuranic waste from other pollutants. The costs may be high but the technology exists.

Conclusion

In this paper we offer our recommendations and perspectives, both as public health students at the University of Washington and as community members. We hope that it will contribute to the research and evaluation process the DOE is undergoing. We believe that as the DOE considers different options for cleanup of the burial ground, using key shared values can guide the decision-making process and lead to the development of a cleanup solution that all stakeholders can support. Based on our work, we recommend the cleanup process involve thorough research and characterization of burial ground contents and their behavior in the environment and consideration of multiple remediation strategies, with strong considerations for the long-term benefits of RTD.

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Citations

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[i] Tri-Party Agreement. Frequently Asked Questions about Hanford's Radioactive Solid Waste Burial Grounds. 2010.
[ii] U.S. Department of Energy. An Introduction to Hanford's Radioactive Solid Waste Burial Grounds. October 5, 2010 presentation to Hanford Advisory Board Committee of the Whole.
[iii] U.S. Department of Energy. Hanford Site Completion Framework. DOE/RL-2009-10, Rev. 0. July, 2010.
[i] Hanford Challenge. Dig it up or leave it there? The pre-1970s "TRU" Controversy. *Hanford Challenger*. 2010;3(2):1.
[ii] Tri-Party Agreement. An Introduction to the Hanford Site Radioactive Solid Waste Burial Grounds (200-SW-2 Operable Unit). 2010.
[iii] Oregon Hanford Cleanup Board. "Position Paper on Capping Waste Sites located on the Hanford Nuclear Site." *Oregon Hanford Cleanup Board.* July 2005. Web. 20 Oct. 2010.
[iv] EPA Superfund Record of Decision Amendment: EPA ID: WA3890090076 Available at: http://www.epa.gov/superfund/sites/rods/fulltext/a1000122.pdf
[v] Pacific Northwest National Laboratory Website. Project Summary Page. http://hanfordbarriers.pnl.gov/default.asp Web. October 19, 2010.
[vi] Knight, P. et al. *Position Paper on Capping Waste Sites Located on the Hanford Nuclear Site*. Salem, OR: Oregon Hanford Cleanup Board, July 2005.
[vii] Gilbertson, Mark. "Environmental Remediation Sciences Planning Meeting: Environmental Management Goals." Lecture. Environmental Remediation Sciences Planning Meeting. US Department of Energy, Office of Environmental Management. Web. 20 Oct. 2010. <http://esd.lbl.gov/research/projects/ersp/generalinfo/pi_meetings/April07/presentations/Monday/Gilbertson4.pdf>.
[viii] Alvarez, Robert. "Plutonium Wastes from the U. S. Nuclear Weapons Complex." *Institute for Policy Studies.* 7 July 2010. Web. 19 Oct. 2010. http://www.hanfordchallenge.org/wp-content/uploads/2010/05/2010-07.12-Alvarez-Plutonium-Wastes-report.pdf
[ix] Wald, Matthew L. Analysis Triples U.S. Plutonium Waste Figures. *The New York Times.* 10 July 2010. Web 20 Oct. 2010. http://www.nytimes.com/2010/07/11/science/earth/11plutonium.html?_r=3&scp=1&sq=robert+alvarez&st=nyt
[x] Goldstein, L. Comments on the Draft Interim Action for the Proposed Construction of the Lower Level of the Cover at the US Ecology Low-level Waste Disposal Site. Washington State Department of Ecology. May 11, 2010. Print
[xi] Considerations for Cleanup of the Hanford 200 Area National Priorities List Site. December 2007. Print.
[xii] Pacific Northwest National Laboratory Website. Project Summary Page. http://hanfordbarriers.pnl.gov/default.asp Web 19 Oct. 2010