River Without Waste

Recommendations for Protecting the Columbia River from Hanford Site Nuclear Waste

A Report from the Oregon Hanford Waste Board

December 2002

Oregon Hanford Waste Board

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Cover photo: N Reactor and the N-1 Crib at the Hanford Site

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Summary

The Columbia River carves the northern border of Oregon, providing economic stability to the region via transportation, electricity, recreational opportunities and other immeasurable benefits to thousands of Oregonians. This ancient river contains spawning grounds for salmon, and is home to many species of fish and other wildlife. This natural wonder flows by the largest nuclear waste site in North America – the Hanford Site.

Huge amounts of radioactive and chemically hazardous wastes – generated at Hanford during more than 40 years of plutonium production for America's nuclear weapons program – threaten the Columbia River. Some of these wastes are now entering the river. Cleaning up these wastes will take decades.

The Oregon Hanford Waste Board considers and advocates cleanup policies that protect Oregon's interests – including the Columbia River – from the hazards posed by Hanford's wastes. The Board devoted its 2002 meetings to better understanding Hanford's impacts on the Columbia River and how and whether cleanup work is addressing those impacts. This report contains the Board's findings and provides recommendations for protecting the Columbia River from Hanford's wastes now and in the future.

Introduction

The Columbia River is arguably the predominant and unifying natural feature of the Pacific Northwest. It drains a 259,000 square-mile basin, the Columbia Basin, that includes territory in seven states and one Canadian province. The river flows more than 1,200 miles from the Canadian Rockies in southeastern British Columbia to the Pacific Ocean. It carries ten times as much water as the Colorado River and two and a half times the volume of the Nile.

Two of the most dramatic events in geologic history created the Columbia Basin: the largest lava flow known on earth and the largest known ice-age floods. More than 6 million years ago, immense lava flows laid down a basalt floor as much as two miles deep across much of the Northwest. Then, about 2 million years ago, ice-age glaciers dammed the mouths of valleys and created enormous lakes. One such lake, Lake Missoula, was formed behind a 2,000-foot high ice dam. Lake Missoula covered nearly 3,000 square miles in present-day Idaho and Montana at depths up to 950 feet. Lake Missoula's ice-dam burst several times unleashing the greatest floods known on earth. The floods carved out more than 50 cubic miles of earth, piled 30 story high mountains of gravel, scattered 200-ton boulders from the Rocky Mountains to the Willamette Valley and created the magnificent Columbia River Gorge.

The Columbia River is the region's ecological and economic heart. The river provides habitat for salmon and other wildlife. It provides water for irrigation and is a popular recreation attraction. Dams along the river generate electric power and allow for barge transportation more than 300 miles inland from the mouth of the river. In 1855, the Cayuse, Umatilla and Walla Walla Tribes ceded 6.4 million acres in northeastern Oregon and southeastern Washington, including lands along the Columbia River that are now part of the Hanford Site, to the federal government. The Tribes reserved rights to fish, hunt, and gather traditional foods and medicines throughout the ceded lands. People across the region now recognize the spiritual and aesthetic importance of the river that Native Americans have known for generations.

The Columbia Basin is also home to the largest environmental cleanup in North America. The U.S. Department of Energy (DOE) produced plutonium for nuclear weapons for more than 40 years at the Hanford Site, along the Columbia near the confluences of the Yakima, Snake and Walla Walla rivers. The production processes generated enormous volumes of chemical as well as radioactive wastes in both solid and liquid form. The volume of liquid waste discharged to the porous soil at the site was so great (444 billion gallons) that it significantly altered the water table. Hanford's water table has only recently begun to recede to historical levels now that liquid waste discharges have largely stopped. The liquid wastes created 180 square miles of overlapping groundwater contamination plumes. Some of the contamination exceeds drinking water standards where it enters the river. However, the volume of the river reduces the levels to below drinking water standards in river water samples.

In 1987, the Oregon Legislature created the Oregon Hanford Waste Board. Much of the Board's early work focused on making sure that the state had a voice about Hanford activities most immediately affecting Oregonians: waste transportation and emergency preparedness. The Board also encouraged cleanup actions that protected the Columbia River. The Board and Oregon Office of Energy worked with regional partners to establish a system to safely transport radioactive waste to and from Hanford through Oregon. The Board helped secure Oregon's involvement in emergency response planning for the Hanford Site and the Columbia Generating Station, a nearby commercial nuclear power plant. Since the Board's inception, its meetings have provided Oregonians with a means for learning about Hanford issues and personally sharing concerns with federal and state policymakers.

Regional map showing the location of the Hanford Site

The Board recognizes and acknowledges the Columbia River's importance to the state and the region. Oregonians care deeply about the Columbia River and the river is one of the most direct routes for Hanford's contamination to impact Oregon. There is uncertainty about what will happen if Hanford's wastes continue to migrate towards and into the Columbia River. However, the Board believes that the Columbia River is too important a resource to the people of the Pacific Northwest and the nation to fail to act now because of that uncertainty. A proactive approach is essential. The Board offers the following recommendations related to Hanford cleanup, with the goal of protecting the Columbia River now and in the future.

Protect Salmon in the Hanford Reach

Background

The Hanford Reach is the last significant remaining spawning habitat for fall Chinook salmon in the main stem of the Columbia River. The region and the nation continue to devote significant resources to restoring Columbia River salmon. At the same time, contamination from the Hanford Site continues to enter the river near spawning areas in the Hanford Reach.

One of the contaminants entering the river from the Hanford Site is chromium. Chromium is a metallic element that can damage living organisms at low concentrations and tends to accumulate in the food chain. There are several different types of chromium. The type that is entering the Hanford Reach is hexavalent chromium. The full impact of the hexavalent chromium on the salmon and the spawning areas is unknown. Several studies, although inconclusive, suggest that hexavalent chromium harms young salmon.

During Hanford's production period, water from the Columbia River was pumped into Hanford's nuclear reactors to cool them. Chromium was added to the water to prevent corrosion in the reactors. After the water passed through the reactors, it was piped back into the Columbia River. This process carried chromium into the river. Other spills and discharges contaminated soils with chromium near the shoreline and the contamination continues to migrate into the groundwater. These spills and discharges created several plumes of chromium contamination in groundwater at Hanford. The chromium-contaminated groundwater has been seeping into the Hanford Reach since the early 1960s. Hexavalent chromium is also entering the Columbia River from springs at the bottom of the river bed. The level of hexavalent chromium entering the river is considered toxic to aquatic species.

Currently, DOE is working to clean up the hexavalent chromium contamination in the groundwater. There are two principle cleanup methods in use: pump and treat systems and a chemical barrier. The pump and treat systems draw water out of the ground, remove the contaminants at the surface and re-inject the clean water back into the ground. The chemical barrier is created by injecting a chemical into the ground where it reacts with naturally occurring materials in the soil. When the groundwater reaches this chemical barrier, the hexavalent chromium in the groundwater reacts with the barrier and is changed to a much less mobile, less toxic form. Both methods are designed to prevent the hexavalent chromium from entering the river. Neither method prevents hexavalent chromium in the soil from continuing to migrate into the groundwater nor completely removes hexavalent chromium from the groundwater before it reaches the chemical barrier.

Hanford Reach of the Columbia River

DOE is required to operate the pump and treat systems and the chemical barrier as a result of an interim regulatory decision to clean up the contamination. DOE is required to reduce the concentration of hexavalent chromium entering the Columbia River to no more than 20 micrograms per liter of chromium in groundwater at the point where the contaminated groundwater mixes with Columbia River water. A final cleanup standard has not yet been set.

Board Recommendations

Demonstrate Compliance

- DOE should demonstrate that existing containment systems are meeting the required performance standards. The 20 microgram per liter standard for hexavalent chromium must be met prior to any mixing or dilution of the contaminated groundwater plume by infiltrating river water. Dam releases and other factors cause the level of the Columbia River to rise and fall. The varying water level influences the amount of river water that is mixing with groundwater in some groundwater monitoring wells near the shore. DOE should use monitoring wells that are not influenced by high river water levels to demonstrate compliance. If there are no such wells, DOE should account for the influence of river water when demonstrating compliance by subtracting the infiltrating effects. If DOE is unable to demonstrate compliance conclusively, it must take additional, measurable cleanup actions to meet the compliance standard.
- DOE should demonstrate that the chemical barrier is effective. Stakeholders need assurance that contaminated groundwater is not flowing around or beneath the barrier. Performance monitoring of the system should include observation wells to demonstrate contaminated groundwater is not bypassing the treatment zone due to fast flow paths or through premature failure of the treatment area.

Better Determine Effects on Salmon and their Food Sources

- DOE should fund an additional study by a consortium of Northwest universities to determine whether the continued presence of hexavalent chromium from Hanford Site groundwater and in the Columbia River is measurably impacting the salmon and other anadromous fish. The study should examine potential exposures through the entire life cycle of the fish, not just one or two life stages as in the existing studies, and should analyze potential reproductive effects. The study should use a statistically significant sample of Columbia River salmon and replicate river water conditions.
- The U.S. Environmental Protection Agency, and its appropriate counterpart in the State of Washington, should pursue independent studies to determine whether the hexavalent chromium standard of 20 micrograms per liter is ecologically protective before establishing it as the final cleanup standard for Hanford's chromium groundwater contamination. This includes determining what impact chromium may have on organisms and insects that are food for the Hanford Reach's anadromous fish.

Monitor the Columbia River in Oregon for Hanford Contamination

Background

One of the most frequent questions Oregonians ask when discussing the Hanford Site is whether the Columbia River is monitored for the presence of radioactive materials. Oregonians consider monitoring one of the best assurances that the Hanford Site's radioactive wastes are not harming the river. However, there is no monitoring for radionuclides occurring along the Columbia River in Oregon today.

Monitoring for Radioactive Contaminants

Due to a lack of funding, the Oregon Health Division ceased monitoring the Columbia River in 1993. The Oregon Health Division conducted environmental sampling of the Columbia River from 1961 to 1993.[1] Samples were collected at 11 locations on the Columbia River from McNary Dam to Astoria. Sampling included water, river bottom sediment, aquatic vegetation and fish.

The Health Division detected peak concentrations of Hanford radioactivity in the Columbia River during the mid-1960s, when Hanford's nine reactors were operating. Despite the elevated levels, the Health Division did not limit public consumption of fish and edible seafood or restrict water use in Oregon. The measured levels of radioactive materials in the Oregon environment were below then-recommended federal and international standards.

Radioactivity levels in the river dropped dramatically following the shutdown in 1971 of the last of Hanford's single pass reactors. At that time, the Health Division noted "there was no Hanford radioactivity detectable in the Columbia River or Oregon seacoast."[2] However, the Health Division recommended continuing a monitoring program. "At Hanford, the management of high and low-level radioactive wastes, storage of irradiated fuel, and massive uranium, tritium, chromium and strontium-90 moving through the groundwater to the Columbia River, make it imperative that this surveillance activity be maintained."[3]

The Washington Department of Health currently monitors the Columbia River for radioactive materials. Most of its sampling is adjacent to the Hanford Site and the Tri-Cities, although it also annually samples sediments behind McNary Dam. Like the Oregon Health Division, the Washington Department of Health had previously sampled the Columbia River as far as Astoria. After several years of basically detecting background levels, the Washington Department of Health focused its sampling program closer to the Hanford Site. Pacific Northwest National Laboratory (PNNL) also monitors the river in the vicinity of the Hanford Site for DOE.

Monitoring for Chemical Contaminants

Hanford's groundwater is contaminated by several chemicals, including nitrate, chromium, and carbon tetrachloride. The Oregon Department of Environmental Quality (DEQ) samples portions of the Columbia River for chemicals and other contaminants, but not for radioactive materials. DEQ takes no samples farther east than Warrendale, just a few miles west of Cascade Locks, which is located 200 miles down river from the Hanford Site.

Board Recommendations

- Focused radiological and chemical monitoring of the Columbia River, downstream from the Washington border, should resume to ensure that contaminants from the Hanford Site do not reach Oregon undetected. The need for focused sampling will increase as tank waste treatment work proceeds and if sediment dredging occurs upstream from McNary Dam on the Columbia in the future. Although sampling programs near the Tri-Cities generally have found little detectable contamination attributable to the Hanford Site in recent years, the potential for larger releases to the Columbia River in the future remains a concern due to the continuing presence of radioactive and chemical wastes that have yet to be cleaned up. Water and sediment

[1] Environmental Radiological Surveillance Report on Oregon Surface Waters 1961-1993. Oregon Health Division, Radiation Protection Services, 1994.

[2] Id. at 1.

[3] Id. at 2.

samples should be collected and analyzed annually from the pools behind the McNary, John Day, The Dalles and Bonneville Dams.

Because the State of Washington has an environmental monitoring program in existence, the simplest and least expensive option may be for DOE – which funds Washington's environmental monitoring program – to provide additional funding to Washington to conduct this focused additional sampling and analysis.

Alternatively, staff from Oregon Public Health Services[4] – or perhaps even the Oregon Office of Energy – could collect the samples for analysis at Oregon State University's Radiation Center Laboratory. Oregon State University maintains radiological laboratory capabilities, in part, to provide analysis in the event of a nuclear incident that may impact Oregon. Analyzing water and sediment samples from the Columbia River would provide the laboratory with opportunities to maintain its readiness. Split samples should be offered to the Pacific Northwest National Laboratory for comparative analysis.

The Oregon Office of Energy should explore the best option for resuming this focused environmental sampling. The sampling should be coordinated with the Quality Assurance Task Force for the Pacific Northwest, a group formed by the Washington Department of Health to oversee and make recommendations regarding radiation monitoring programs in Washington.

- The Oregon Office of Energy should explore with DEQ opportunities to expand DEQ's chemical monitoring program of the Columbia River to include two locations in Oregon nearer to the Hanford Site. As with the radiological monitoring, annual sampling would be sufficient – unless or until contaminants are found.

[4] The Oregon Health Division changed its name to Oregon Public Health Services in 2001.

Provide Better Information to the Public

Background

Hanford was born in a time of secrecy, and secrecy was essential to its plutonium production mission during World War II and the Cold War. But Hanford's mission is now protection of human health and the environment through cleanup. Secrecy plays no part in such work. It is an obstacle to such work.

In 1986, the public began to learn details about Hanford's operating history and waste management practices. Since that time, there has been considerable public concern about what impact Hanford's operations and activities may have had and are having on the Columbia River. The absence of information, due in part to secrecy, has prevented the public from being an effective partner in helping DOE clean up the Hanford Site.

DOE, its regulators, the State of Oregon and others provide information to the public about various aspects of Hanford's operations. Many of these information materials focus on the Columbia River. However, feedback from public meetings indicates that basic information about groundwater contamination and the Hanford Site's impacts on the Columbia River is not being provided in an understandable form to the public. People want to know what Hanford contaminants are entering the river, in what quantities, and what the effects of those contaminants may be. Such information is critical for the public to understand, participate in and support decisions and actions to clean up the Hanford Site. Without public support, DOE will take longer and spend more money on cleanup.

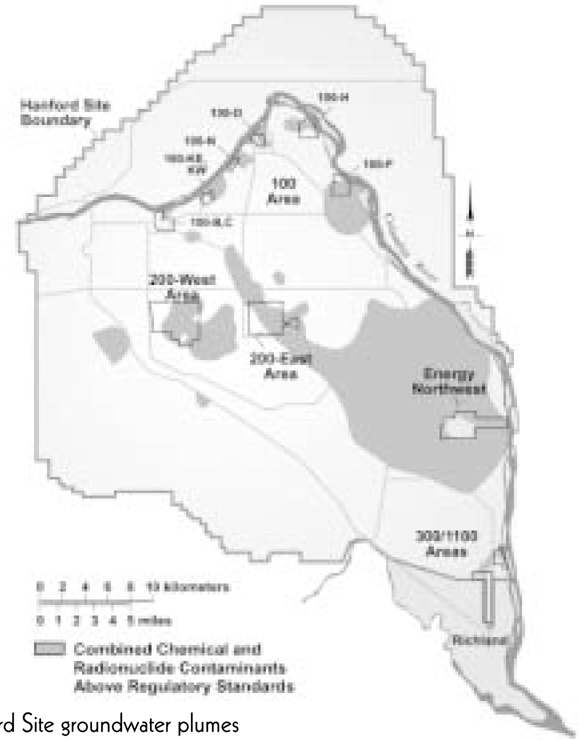
Board Recommendations

- ◆ DOE should formally recognize that secrecy obstructs cleanup. Secrecy prevents the public from understanding the cleanup challenges, providing ideas to promote cleanup and, ultimately, providing strong support for cleanup decisions.
- ◆ DOE should fund an independent effort to compile information about what contaminants are entering the Columbia River in what quantities, and their potential effects, in a concise and easily understood format.
- ◆ DOE should make the information readily available from a link on the Hanford Site web page, in written publications, public notices and mailings. DOE should update the information every six months and include an analysis of how contaminant amounts have changed in its annual progress reports.

Stop Further Vadose Zone and Groundwater Contamination

Background

The Department of Energy has failed to take some basic steps to prevent further contamination of the environment at the Hanford Site. Some of Hanford's waste sites are known to be major contributors to vadose zone (the area between the surface and groundwater) and groundwater contamination. These include burial grounds, cribs, injection wells, trenches and other disposal areas, where infiltration of surface water (rainwater and snowmelt) causes contaminants to move. Hanford's aging infrastructure adds to this problem of contaminant mobilization. Water pipes continue to leak water into the soil thereby mobilizing contaminants. Action to stop contaminant mobilization is essential to protect against further degradation of the environment. It also will simplify later cleanup efforts.



Hanford Site groundwater plumes

Board Recommendations

- ◆ DOE should prevent contaminant mobilization now by constructing temporary caps, soil barriers and channels to prevent water from entering burial grounds and other waste sites pending cleanup.
- ◆ DOE should repair or replace leaking water pipes and systems, especially those near burial grounds, and install monitoring systems to immediately identify future leaks so that they can be stopped quickly.
- ◆ DOE should review all liquid disposal practices at Hanford and verify they are not causing or contributing to contaminant mobilization.
- ◆ DOE should prioritize cleanup of burial grounds along the Columbia River to focus first on those sites that are known to be releasing contaminants into the vadose zone and groundwater.

Clean Up Vadose Zone and Groundwater Contamination in the River Corridor by 2012

Background

The Hanford 2012 Plan describes the Richland Operations Office's, one of the two U.S. Department of Energy management offices at the Hanford Site, cleanup priorities for the next ten years. The priorities focus on three outcomes: restoring the Columbia River corridor, transitioning the Central Plateau and preparing for future uses of the Hanford Site. The Columbia River corridor restoration portion of the plan does not include cleanup of contaminated groundwater. In fact, until recently, little priority was given to vadose zone and groundwater protection and cleanup at Hanford. The Tri-Party Agreement largely defers establishing plans and deadlines for cleaning up vadose zone and groundwater contamination.

Board Recommendations

- ◆ DOE should aggressively develop and implement a comprehensive vadose zone and groundwater cleanup plan.
- ◆ DOE should partner with the Washington Department of Ecology, Oregon Office of Energy, Tribal Nations and stakeholders to develop the plan.
- ◆ The plan should include specific actions that clean up vadose zone and groundwater contamination by 2012. The plan should also include a comprehensive vadose zone monitoring program (see next section) to detect contamination before it spreads to groundwater.
- ◆ The plan should include interim and final deadlines that are incorporated into the Tri-Party Agreement.

Develop and Implement a Comprehensive Groundwater Monitoring Program

Background

Despite many thousands of monitoring wells that have been drilled at Hanford during the past 60 years, there is much that DOE does not know about the location and quantities of contaminants in the vadose zone and groundwater. In addition, many of the older wells are no longer of use and provide potential pathways for contaminants to move in the subsurface. The geology underlying the Hanford Site consists of multiple basalt flows with layered sediments. The depth to groundwater ranges from a little over three feet near the Columbia River to over 300 feet in the center of the site.

Groundwater Monitoring

There are more than 1,000 active groundwater monitoring wells at Hanford. Each year, 600 to 700 of these are sampled. The Tri-Party Agreement requires DOE to install up to 50 new Resource Conservation and Recovery Act (RCRA) groundwater monitoring wells yearly until all land disposal units and single shell tanks have RCRA compliant monitoring systems.

Well Decommissioning

DOE has identified 2,150 wells that need to be removed or decommissioned because they are no longer useful. These wells provide a pathway for surface water to penetrate into the vadose zone and drive contaminants toward groundwater. Some pose a high risk of causing more contamination because they are located in or adjacent to waste sites. DOE proposes to decommission 380 high-risk and 70 unused wells on the Central Plateau by 2006.[5] (The Central Plateau includes the 200 West and 200 East Areas shown on the map on page 6.)

[5] Hanford Performance Management Plan, Rev. D, August 2002, at 56.

Installation of groundwater monitoring well at the Hanford Site

Board Recommendations

- ◆ DOE and the Washington Department of Ecology should develop a comprehensive assessment of groundwater monitoring needs. The assessment should demonstrate which wells are needed, which wells need to be deepened, which wells need maintenance and which wells should be decommissioned.
- ◆ DOE and the Washington Department of Ecology should elevate in priority the need for this comprehensive monitoring program within the Tri-Party Agreement. DOE should provide sufficient funding to move forward aggressively.
- ◆ The Washington Department of Ecology should establish points of compliance (where groundwater must meet a specified water quality level) that protect beneficial uses of groundwater. It should require installation of monitoring wells at any points of compliance where active monitoring wells are not already in place.
- ◆ DOE should decommission those wells that the assessment identifies as no longer needed. Any wells identified in the assessment that are not included in the Hanford Performance Management should be decommissioned by 2012. This is an important action to eliminate a potential rapid pathway for contamination to spread to the vadose zone and groundwater.

Keep Pump and Treat Systems Operating

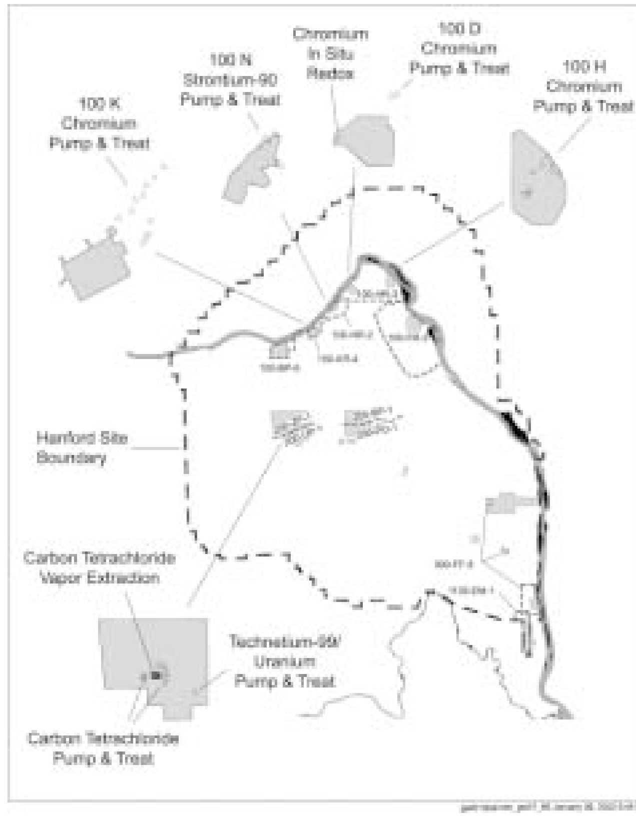
Background

Oregonians are amazed and appalled when they learn that groundwater is carrying contamination from the Hanford Site into the Columbia River. Eight major plumes contaminate over 180 square miles of groundwater at Hanford. The contamination levels in several of the plumes are more than 100 times the drinking water standard. DOE operates pump and treat systems that are helping to prevent the further spread of the plumes and limit the amount of contamination entering the Columbia River. (See map at right.)

The State of Oregon has long-standing concerns about the impacts of contaminants from Hanford's groundwater on the Columbia River. Oregon was a strong advocate for the initiation of pump and treat systems at the Hanford Site. The systems have succeeded as an interim measure in containing the size of Hanford's groundwater contamination plumes and reducing, although not eliminating, contamination entering the Columbia River.

Both DOE and the U.S. Environmental Protection Agency have questioned the need for some of these systems. The U.S. Environmental Protection Agency's most recent Five Year Review, a formal review of the effectiveness of remediation required by federal law, reported that some systems were insufficiently capturing plumes and removing concentrations.[6] Similarly, the Richland Operations Office's Performance Management Plan concludes that some systems are ineffective because they do not remove enough contamination or extend into all contaminated areas of an aquifer.[7]

However, the U.S. Environmental Protection Agency's Five Year Review acknowledges the value of these systems for containing contaminants that would otherwise flow into the Columbia River.[8] Also, in response to recommendations in the Five Year Review, DOE has taken actions that have improved the performance of the systems.



Pump and treat and other groundwater contamination containment systems at the Hanford Site

Board Recommendations

- DOE should continue operating the pump and treat systems. The measure of success of these systems is the degree that they prevent contamination from spreading and entering the Columbia River.
- The Tri-Parties should expedite a more aggressive research and development effort to field meaningful alternative methods to more efficiently and effectively protect the Columbia River from groundwater contamination.
- DOE should demonstrate effective remediation of the sources of contamination before discontinuing operation of pump and treat systems. This includes demonstrating that elimination of the contamination source or other remedial activities achieves equivalent protection as a particular pump and treat system.

[6] USDOE Hanford Site First Five Year Review Report, U.S. Environmental Protection Agency, Region 10, Hanford Project Office, 2001, at v.

[7]See Performance Management Plan at 59.

[8] Hanford Site First Five Year Review Report at 100-16.

Address Science and Technology Needs

Background

Hanford's scientists and engineers have helped advance cleanup by developing technologies that are reducing threats to public health and safety and the environment. The technologies have helped DOE move significant amounts of spent nuclear fuel away from the Columbia River. They have allowed DOE to investigate the condition of the huge underground waste storage tanks. There is a long list of technological accomplishments, but increased focus on addressing groundwater cleanup challenges is necessary.

The accomplishments result from expertise and resources applied to a particular problem. They also demonstrate, as Hanford's whole history does, that technological problems can be solved. The challenge is identifying and prioritizing problems, and funding work to solve them.

The Oregon Hanford Waste Board has long advocated scientific research and technology development to advance cleanup. We highlight the following two cleanup challenges and encourage scientific research and technology development to address them.

Tritium

Tritium is the most mobile and the most widely distributed groundwater contaminant at Hanford. It is a radionuclide that was generated as a byproduct and produced intentionally to boost the explosive power of nuclear weapons. It contaminates groundwater and is found in several burial grounds. The tritium contaminated groundwater is not contained or treated, and is entering the Columbia River. DOE documents indicate that groundwater contaminated with tritium has been entering the Columbia River since at least the 1960s.

Because current technology to clean up tritium is expensive, it is less toxic than other radionuclides at Hanford and tritium has a half life of 12.3 years, DOE does not plan any action to clean it up. Instead, DOE is relying on "natural attenuation" or the slow decaying away of the tritium for cleanup. It will take about 100 years for the tritium in the groundwater at Hanford to decay to a level below the drinking water standard. DOE is relying on the volume of the Columbia River to dilute concentrations that reach the river to below applicable drinking or water quality standards.

Carbon tetrachloride vapor extraction system

Carbon Tetrachloride

Carbon tetrachloride is a primary contaminant in the vadose zone and groundwater beneath Hanford's Central Plateau. It is a colorless liquid that is heavier than water and was used primarily as a solvent and degreaser. DOE dumped 2 million pounds of liquid carbon tetrachloride onto the ground at Hanford. It also buried some as solidified waste in barrels in various burial grounds. Some carbon tetrachloride evaporated into the air or became part of the soil column or groundwater. But DOE cannot account for about sixty-five percent, approximately 1.3 million pounds, of the carbon tetrachloride used. It is presumed to be contaminating the vadose zone and groundwater.

Unlike many radioactive contaminants, carbon tetrachloride does not radioactively decay or bind with soil and rock. Dissolved carbon tetrachloride moves with groundwater. It may also form a dense non-aqueous phase liquid or DNAPL, which is extremely difficult to remediate. DNAPLs do not mix with water and may sink to the bottom of an aquifer. On the bottom of an aquifer, they continually release low concentrations into the groundwater. Carbon tetrachloride has been shown to cause cancer in laboratory animals. The U.S. Environmental Protection Agency considers carbon tetrachloride a "probable human carcinogen."

DOE has been using a soil vapor extraction system and a pump and treat system to remove some of the carbon tetrachloride released to the environment. (See map on page 9.) These systems have removed about 186,573 pounds or about 9 percent of the volume disposed to the soil as of June 2002.

Board Recommendations

- DOE must make an effort to prevent tritium from entering the Columbia River. It is unacceptable to allow tritium to enter the Columbia River without any effort to contain or treat it. DOE should develop an effective remedial strategy that can be applied to tritium contaminated groundwater within a decade. DOE must also make an effort to identify and remediate the sources of tritium contamination and potential future contamination sources in burial grounds.
- DOE should expand its effort to develop methods to characterize and remediate carbon tetrachloride, especially in its DNAPL form, in Hanford's vadose zone and groundwater.
- DOE should fund scientific research and technology development now to enable remediation of burial grounds that have so far been bypassed for cleanup. These burial grounds present unique hazards and challenges. DOE should emphasize the development of technology to clean up burial grounds containing wastes contaminated with tritium. This includes developing robotic technology to perform cleanup while also protecting workers.
- DOE should fund the Science & Technology Roadmap, a multi-agency effort to understand how contaminants move in the environment. Such understanding is critical to develop methods to remediate contaminants so as to protect water sources.

Glossary

Anadromous Fish – is a fish or fish species that spends portions of its life cycle in both fresh and salt water, migrating from fresh water to salt water to mature and returning to fresh water to spawn; these include the anadromous forms of pacific trouts and salmon as well as smelts, lamprey, whitefish, and sturgeon.

Aquifer – is any saturated, permeable soil or rock formation that stores and transmits groundwater in sufficient quantity to supply wells.

Basalt – is a fine-grained volcanic rock formed by crystallization of lava. Basalts are common volcanic rocks in Oregon and Washington.

Burial Ground – is an area of land used for shallow disposal of radioactive, chemical, and/or hazardous wastes in solid form. There are a large number of identified burial grounds at Hanford. There may be some that have not been identified. The burial grounds are usually covered by soil and may or may not be lined to contain the material and monitored for leaks to the surrounding environment. The Department of Energy does not know for sure what all of Hanford's burial grounds contain. The existing information and investigations of some burial grounds indicate that they are so hazardous that technology does not currently exist to safely clean them up.

Carbon Tetrachloride – is a chlorinated organic solvent that was used at Hanford mainly in the plutonium extraction process. It is a probable human liver carcinogen via inhalation and ingestion. It also can damage the central nervous system. The maximum permissible contaminant level for carbon tetrachloride is 5 micrograms per liter. There is an approximately 4.2 square mile plume of carbon tetrachloride contamination reaching levels as high as 6,500 micrograms per liter at Hanford.

Central Plateau - is an approximately 75 square mile area near the middle of the Hanford Site. It is the most heavily contaminated and most hazardous area of the site. The Central Plateau contains a large number of facilities formerly used for spent nuclear fuel processing and plutonium metal production as well as 177 underground high-level radioactive waste storage tanks. It is the origin of much of the groundwater contamination at Hanford. The Department of Energy is slowly cleaning up this area. However, cleanup will not be completed until some time in the very distant future.

Chromium - is a metallic element that can damage living organisms at low concentrations and tends to accumulate in the food chain. The maximum permissible contaminant level for chromium is 100 micrograms per liter. However, the Washington ambient water quality standard, which is designed to protect aquatic organisms, is 10 micrograms per liter for chromium. Hexavalent chromium has been measured at levels as high as 4,750 micrograms per liter at Hanford.

Crib – is an underground structure designed to receive liquid waste that can percolate into the soil directly and/or after travelling through a connected tile field.

Curie – is a measure of radioactivity. Contamination levels are often expressed in picocuries or pCi.

Dense Non-Aqueous Phase Liquid – (DNAPL) is one of a group of organic substances that are relatively insoluble in water and more dense than water. DNAPLs tend to sink vertically through sand and gravel aquifers to the underlying layer. They are extremely difficult to clean up because they penetrate deep into soil and rock.

Double Shell Tank – is a reinforced concrete underground vessel with two inner steel liners to provide containment and backup containment of liquid plutonium processing wastes. Instruments between the two liners would detect leaks in the inner liner. There are 28 double shell tanks at Hanford. Their average size is 1 million gallons.

Five Year Review – is an on-going, periodic review of remedial actions that is required by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) if cleanup does not remove all hazardous substances, pollutants or contaminants at a site. CERCLA or Superfund is a federal law that requires cleanup of hazardous waste sites. The review is to ensure protection of human health and the environment. The U.S. Environmental Protection Agency completed the first Five Year Review for the Hanford Site in April 2001.

Half-life – is the time required for half the atoms in a sample of radioactive material to decay to another substance. Half-lives for different materials vary from small fractions of a second to billions of years.

Injection Well – is a well that is used to insert rather than withdraw material from the ground.

Isotopes - are forms of the same chemical element that differ in the number of neutrons in their nucleus.

Land Disposal Unit – is a regulatory term under federal law, the Resource Conservation and Recovery Act (RCRA), for places where hazardous waste is disposed. Examples of land disposal units include: landfills, waste piles, injection wells, land treatment facilities, salt formations and underground mines and caves.

Maximum Contaminant Level – is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

Nitrate – is a naturally occurring oxide of nitrogen. Nitrate is a nutrient as well as a major component of animal manure, human sewage waste and commercial fertilizers. The U.S. Environmental Protection Agency has set a maximum permissible contaminant level of 10 milligrams per liter for nitrate in public water supplies. Above that level, nitrate may present a serious health concern for infants and pregnant or nursing women. Nitrate is a byproduct of the plutonium separation process used at Hanford. There is an approximately 16 square mile plume of nitrate contamination at Hanford reaching levels as high as 1,700 milligrams per liter.

Office of River Protection – is one of the two managerial offices of the U.S. Department of Energy at the Hanford Site. Congress created the Office of River Protection (ORP) in 1998 to manage cleanup of Hanford's underground storage tank wastes.

Performance Management Plan – is an August 2002 description and schedule for six initiatives to accelerate Hanford cleanup released by the Richland Operations Office and the Office of River Protection. It is designed to save money over the long term by spending more money now to complete more cleanup sooner.

Plume – is a subsurface zone that contains contaminants originating from a source area. A plume can extend a considerable distance depending on groundwater flow and chemistry.

Plutonium – is a man-made radioactive element, which is twice as heavy as lead. Plutonium-239 is preferred for manufacturing nuclear weapons. It has a half life of about 24,000 years. Hanford produced and purified plutonium. Plutonium wastes have been disposed at Hanford in burial grounds, cribs and trenches.

Pump and Treat System – is a remediation system that draws water out of the ground, treats or removes the contaminants at the surface and reinjects the treated water back into the ground.

Resource Conservation and Recovery Act (RCRA) – is a federal law that creates a comprehensive system for managing the generation, transportation, treatment, storage and disposal of hazardous wastes to protect human health and the environment. The Washington Department of Ecology enforces RCRA at Hanford.

Radionuclide – is a radioactive form of a given element. For example, tritium and strontium-90 are radionuclides of the elements of hydrogen and strontium, respectively.

Richland Operations Office – is one of the two managerial offices of the U.S. Department of Energy at the Hanford Site. The Richland Operations Office is responsible for management and cleanup of the majority of the Hanford Site other than Hanford's underground tanks.

Single Shell Tank – is an underground storage vessel consisting of a single concrete shell lined with carbon steel. Hanford's single shell tanks contain high-level radioactive waste. There are 149 single shell tanks at Hanford that range in size from 55,000 to one million gallons. At least 67 of the tanks have leaked material to the surrounding soil and groundwater.

Single Pass Reactor – is a nuclear reactor in which heat is carried away by a cooling medium that passes through the reactor only once. At Hanford, Columbia River water was used as the cooling medium. Water was drawn from the river, treated with chemicals (for reasons such as preventing corrosion), passed through the reactor and then discharged into the river. Sometimes the water (which was both radioactive and thermally hot) was discharged directly into the river. Other times, the water was retained in cooling ponds for a period of time before it was discharged into the river. The first eight production reactors at Hanford were single pass reactors.

Soil Vapor Extraction System – is a remediation system that uses a vacuum to remove volatile and some semi-volatile organic carbon contaminants (VOCs and SVOCs) from the soil. A volatile or semi-volatile organic contaminant is a compound that evaporates readily at room temperature. Carbon tetrachloride is an example of a VOC. The vapor leaving the soil may be treated or destroyed, depending on local and state air discharge regulations.

Spent Nuclear Fuel – is fuel that has been withdrawn from a nuclear reactor following irradiation before the constituent elements have been separated by reprocessing.

Strontium-90 – is a radioactive isotope of the element strontium. Strontium is an element that is chemically similar to calcium. The isotope strontium-90 has a half-life of 28.6 years. It is a byproduct of the plutonium production process used at Hanford. The maximum permissible contaminant level for strontium-90 is 8 picocuries per liter. Levels of strontium-90 as high as 18,000 picocuries per liter have been measured in groundwater at Hanford.

Tritium – is a radionuclide that was generated as a byproduct and produced intentionally at Hanford for use in boosting the explosive power of nuclear weapons. It has a half-life of 12.3 years and there is a 70 square mile plume of tritium contamination at Hanford. The maximum permissible contaminant level for tritium is 20,000 picocuries per liter. Levels of tritium as high as 8,000,000 picocuries per liter have been measured at a burial ground near the Columbia River. The levels of tritium in at least one Central Plateau monitoring well increased from 2,500,000 picocuries per liter in Fiscal Year 2000 to 4,300,000 picocuries per liter in Fiscal Year 2001.

Tri-Party Agreement – is a 1989 consent decree that is the action plan for cleaning up the Hanford Site. It contains legally enforceable schedules and deadlines for performing cleanup.

Vadose Zone – is the zone between the ground surface and the water table. This porous soil zone contains air and water.

Uranium – is the basic material for nuclear technology. This element is naturally occurring and slightly radioactive. It can be refined into a heavy metal twice as dense as lead. The maximum permissible contaminant level for uranium is 30 micrograms per liter. Levels approaching 6,713 micrograms per liter of uranium have been measured in groundwater at Hanford.

Hanford Fast Facts

- 180 square miles of groundwater contamination above drinking water standards
- 177 underground tanks with 53 million gallons of radioactive and chemical waste
- Over a million gallons of radioactive and chemical waste have leaked from the tanks
- 1,300 tons of spent nuclear fuel in pools near the Columbia River
- 12 tons of plutonium in the form of spent fuel, separated metal, oxides and waste
- 25 million cubic feet of radioactive and chemical waste in 175 trenches
- More than 1,900 waste sites and 500 contaminated facilities

For more information, see www.energy.state.or.us/nucsafe/hwboard.htm or contact the Nuclear Safety Division of the Oregon Office of Energy, 625 Marion Street NE, Suite 1, Salem, OR 97301-3742, 800-221-8035 (toll free in Oregon) or 503-378-4040 (in Salem or outside Oregon).

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