The Aquifer and the INEEL

A 2002 INEEL Environmental Restoration Program Factsheet

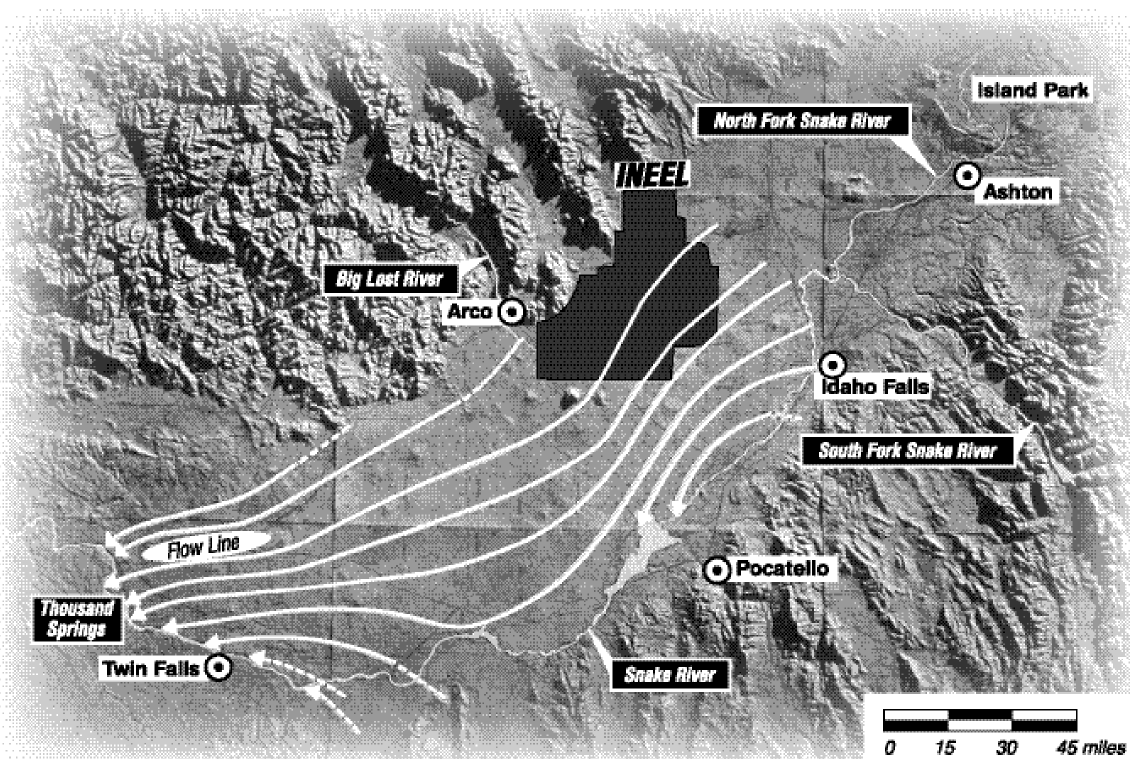
The eastern Snake River Plain Aquifer is the sole source of drinking water for most of the people in southeast Idaho. The aquifer has been studied since the 1950s by the U.S. Geological Survey (USGS) and other organizations. Estimated by the USGS to contain approximately 1 billion acre-feet of groundwater, the aquifer annually supplies approximately 40,000 ***acre-feet*** (about 642 billion gallons) of water for drinking and nearly 2 million acre-feet of water for irrigation and industry.

Most of this water is clean and requires no treatment to make it safe to drink.However, human activities, such as agriculture and industry, have contaminated portions of the ***aquifer***. The Idaho National Engineering and Environmental Laboratory (INEEL) is one source of contamination. Most of the groundwater beneath the INEEL is clean and all water consumed by workers and visitors is safe. However, contamination exists in isolated,defined areas beneath some facilities. None of the contamination is predicted to spread beyond the site's boundaries at levels that would pose a risk to human health and the environment.

When ***groundwater*** at the INEEL poses a potential threat to human health and the environment, federal and state laws require the U.S. Department of Energy (DOE) to address potential risk. Cleanup work is underway in known areas of contamination at individual facilities.

The groundwater in the eastern Snake River Plain Aquifer comes mostly from mountain snowmelt, a smaller amount from rain. The aquifer begins near Ashton, Idaho, and flows southwestward where it discharges at Thousand Springs, Idaho. Water entering the aquifer near Ashton requires 200 to 300 years to reach Thousand Springs and flows an average of five to ten feet per day, very fast compared to most aquifers.

The depth to the aquifer's ***water table*** is about 200 feet at the INEEL's northern border and increases gradually to about 900 feet at the INEEL's southern border. The aquifer is about 4,000 feet thick at the center of the Snake River Plain.



Groundwater in the eastern Snake River Plain Aquifer flows southwestward from Ashton, Idaho to Thousand Springs (near Hagerman, Idaho).

Studying Groundwater at the INEEL—
Monitoring and Modeling

Groundwater movement near a source of contamination results in areas known as ***contaminant plumes***. Most plumes at the INEEL consist of dilute contaminant concentrations only slightly above ***drinking water standards***, though some plumes have higher concentrations near the source of contamination. Identifying the location and extent of groundwater contamination requires careful placement of monitoring wells.

More than 200 ***monitoring wells*** are used to regularly collect groundwater samples at and around the INEEL. The samples provide data for evaluating the groundwater's quality, which indicates the effectiveness of cleanup efforts and helps scientists understand the nature of the aquifer.

Data from many wells are required to assess the aquifer. Though most wells are located near contaminant sources, others are located up- and downgradient of the INEEL. Some contaminated groundwater at the INEEL is in ***perched water*** zones or is moving downward through the ***vadose zone***, areas which are also monitored.

In addition to monitoring wells, scientists also use sophisticated computer models to study aquifers and evaluate various cleanup options. Based on a variety of assumptions, models can be used to estimate future contaminant concentrations to determine potential future risks to human health.

Models have a degree of uncertainty that result in conservative, and often more expensive, actions being taken. Improving the scientific understanding of how water and contaminants travel in different rock and soils will lead to improved modeling abilities and reduced costs.

Groundwater Contamination and Cleanup

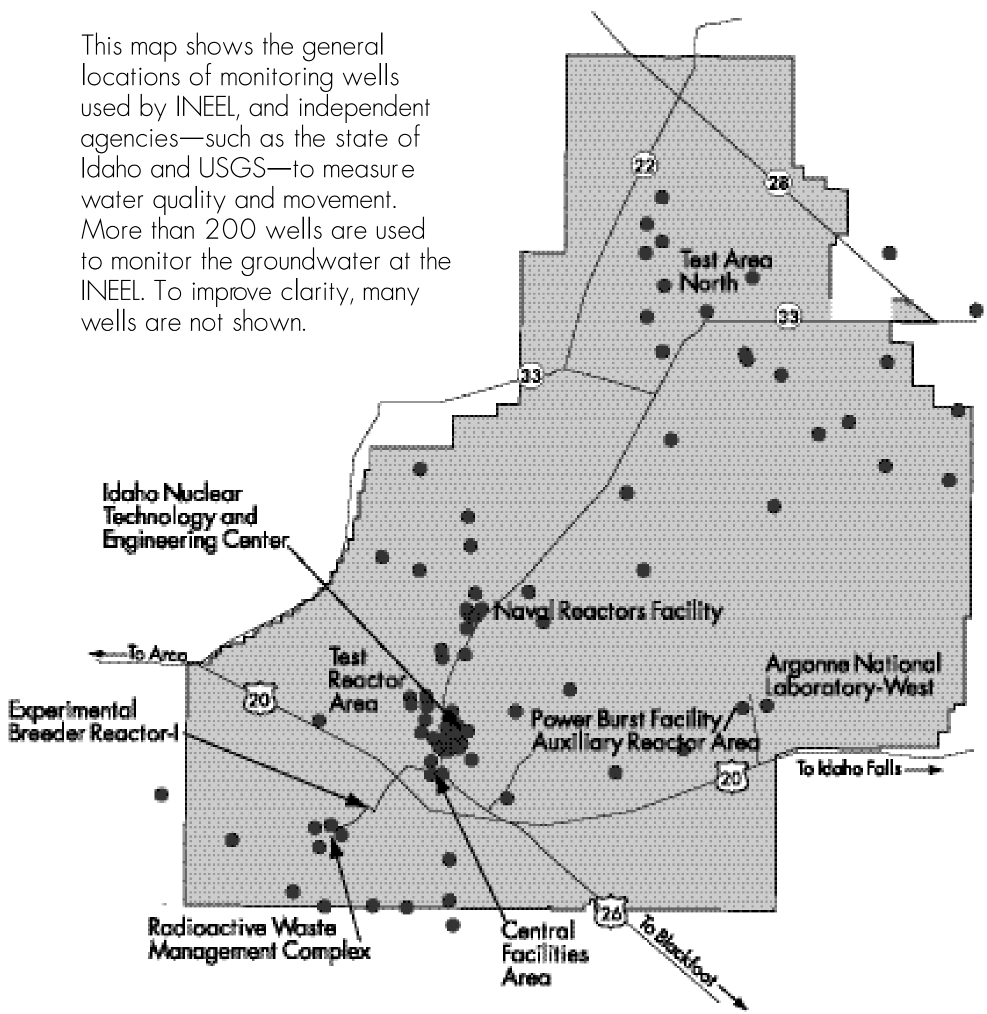
Practices at the INEEL today do not contribute to groundwater contamination. However, the use of injection wells, sewage drainfields and unlined disposal ponds in the past resulted in an estimated 27,500 acre-feet of contaminated groundwater that consistently exceeds the U.S. Environmental Protection Agency's (EPA) ***drinking water standards***. Most of this contaminated groundwater is very dilute, though there are small areas of concentrated contamination at Test Area North and Idaho Nuclear Technology and Engineering Center.

Cleanup actions are underway at several INEEL facility areas using existing technologies. These often consist of one or more processes—biological, physical or chemical.

Other steps have also been taken to protect the groundwater. Older disposal ponds have been replaced with lined evaporation ponds. Dikes and other controls are being used to reduce or eliminate water sources that can mobilize contaminants. Injection wells are no longer used and wastewater that is disposed of in sewage drainfields and disposal ponds no longer carries contaminants in concentrations that pose a risk.

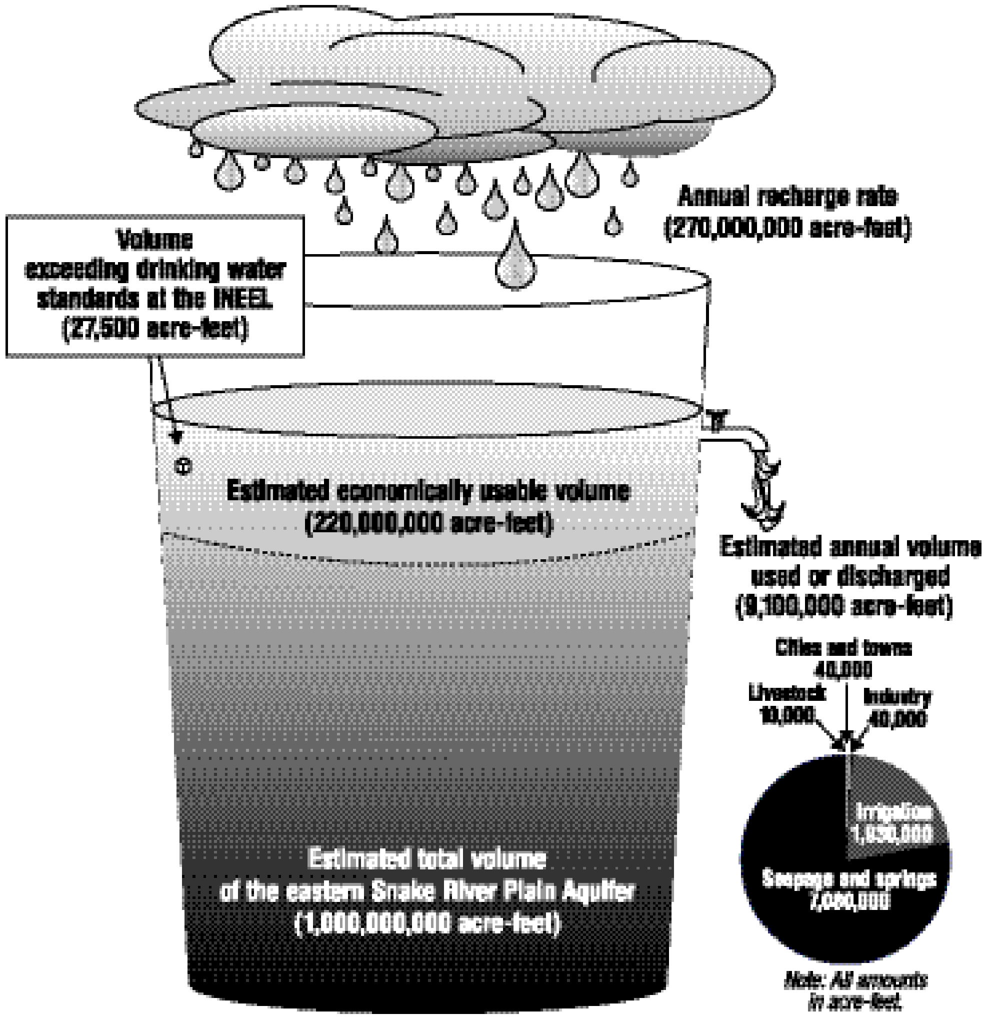
Groundwater cleanup is driven by potential risk. If monitoring and environmental reviews indicate that aquifer contaminant concentrations will exceed established risk standards beyond 100 years, cleanup actions must be undertaken. Monitoring and environmental reviews ensure that contaminant levels continue to diminish as expected.

The DOE, EPA, and state of Idaho Department of Environmental Quality (IDEQ) closely monitor wastewater to make sure new aquifer contamination does not occur.



This map shows the general locations of monitoring wells used by INEEL, and independent agencies—such as the state of Idaho and USGS—to measure water quality and movement. More than 200 wells are used to monitor the groundwater at the INEEL. To improve clarity, many wells are not shown.

Glossary of Words used when discussing Groundwater



Acre-feet

A volume of water. One acre-foot of water—equivalent to 325,850 gallons—can irrigate an acre of alfalfa in the arid west for ten days during the summer.

Aquifer

A layer of water-saturated rock or soil through which water flows in a quantity useful to people. The rate of flow depends upon porosity and permeability, and the slope of the water table. Groundwater in aquifers usually flows very slowly, only a few inches to a few feet per day.

Contaminant Plume

An area of groundwater contamination, which is three-dimensional and is usually elongated along the aquifer gradient. Contaminants that migrate into the aquifer generally remain in the upper portion of the aquifer, but more dense contaminants may sink more deeply.

Drinking Water Standards (MCLs)

The standards, also known as maximum contamination levels, that establish the maximum permissible levels of contaminants in water delivered to any user of a public water system. The EPA has the authority to control these standards to protect the nation's drinking water. Because groundwater and surface water are often used in the same public water systems, regulatory agencies use MCLs to define contaminant levels for groundwater.

Groundwater

Water that soaks into the ground and percolates downward through rock or soil pores until it is stopped by an impermeable layer. Natural sources are rainfall, snowmelt and water that seeps into the ground beneath streams, rivers and lakes. Other sources can include irrigated fields, canals, wastewater drainfields, injection wells, leaking pipes and industrial cooling ponds.

In Situ Bioremediation

A cleanup method that injects a nutrient (such as sodium lactate) below ground into a source area to stimulate naturally occurring bacteria to break down volatile organic compounds into other harmless compounds. This technology prevents any potential risk to workers and the environment.

Monitoring Wells

Wells—of various designs and at various depths—used for collecting groundwater samples. One type of well can sample only the top part of an aquifer; another can obtain a sample that averages a large portion of an aquifer.

Natural Attenuation

The physical, chemical and biological processes that act without human intervention to reduce the mass, toxicity, mobility, concentration or volume of contaminants in groundwater.

Perched Water

Groundwater that collects above a layer of relatively impermeable material, such as clay, and then slowly moves downward to the aquifer. Perched water zones are often present beneath reservoirs and industrial facilities, but disappear when the surface water source is eliminated.

Vadose Zone

The unsaturated layers of rock and soil extending from the ground surface down to the water table, or aquifer. Contaminants move at different rates through the vadose zone depending on how they react with the rock and sedimentary material.

Water Table

The top of a water-saturated area in an aquifer. Water tables often fluctuate.

A Summary of Areas with Groundwater Contamination

Central Facilities Area

Contaminants exceeding MCLs:

- Nitrate

There is nitrate contamination in the groundwater at the Central Facilities Area, most likely originating from the old Sewage Treatment Plant Drainfield, which is no longer used. Current studies indicate that this contamination will fall below regulatory limits by 2009.

Idaho Nuclear Technology and Engineering Center

Contaminants exceeding MCLs:

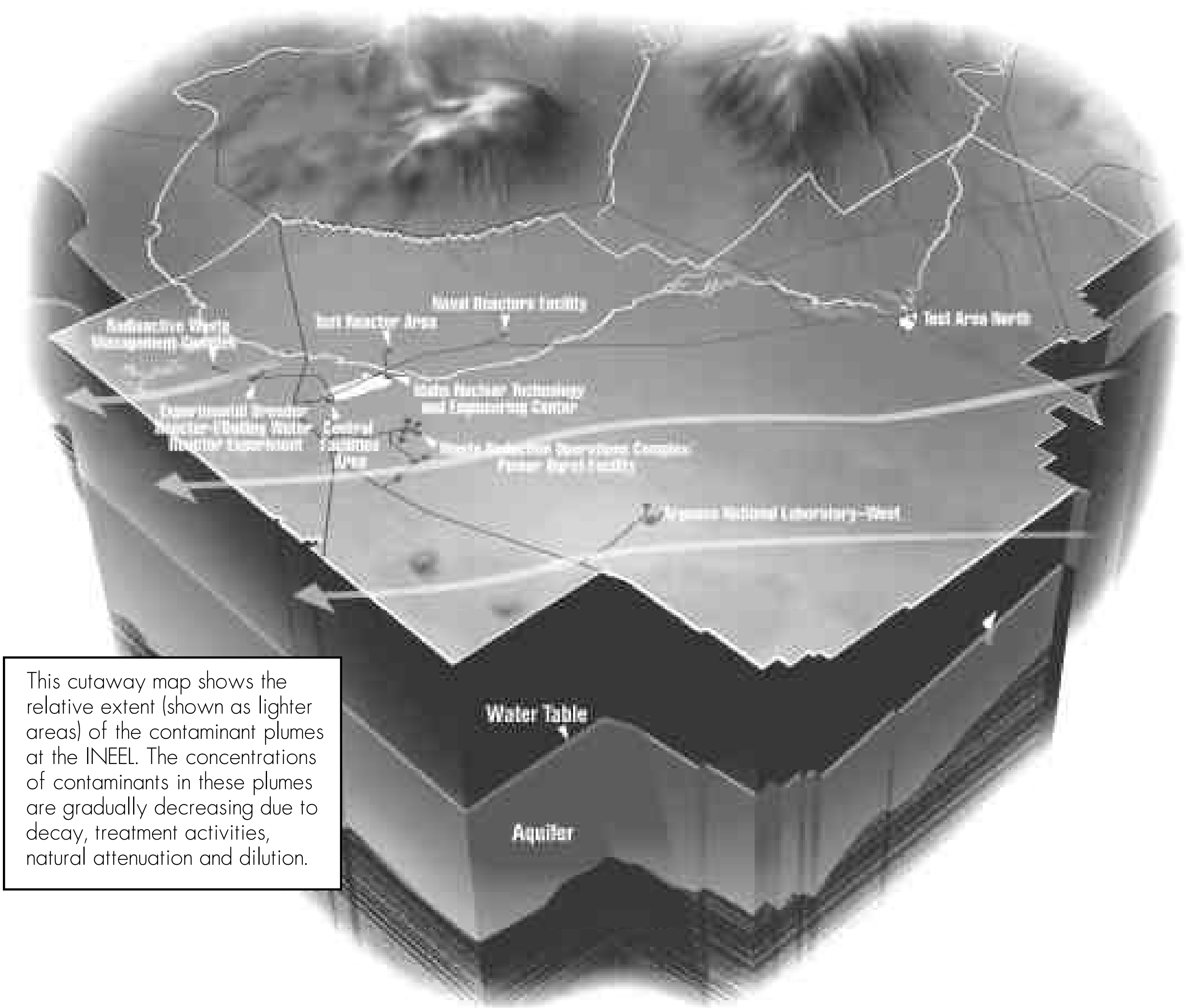
- Iodine-129
- Strontium-90
- Tritium

At the Idaho Nuclear Technology and Engineering Center, radionuclides have contaminated groundwater in the vadose and perched water zones and also the aquifer at concentrations exceeding EPA's drinking water standards. The primary sources are an injection well, which is no longer used, and contaminated soils at the Tank Farm.

Several cleanup measures have been taken to reduce the movement of contaminants in the soils and vadose zone. New percolation ponds have been constructed outside the area of contamination (nearly two miles from the original ponds). These are expected to be operational in 2002.

In addition, actions have been taken to sharply reduce the amount of water infiltrating into contaminated areas and areas near the perched water zones. Groundwater monitoring will continue to ensure these actions are effective.

It is expected that natural attenuation, dispersion and decay will reduce aquifer contamination to acceptable levels within 100 years. Some uncertainty will remain until ongoing monitoring can provide greater scientific understanding of the effectiveness of natural mechanisms and other proposed actions.



This cutaway map shows the relative extent (shown as lighter areas) of the contaminant plumes at the INEEL. The concentrations of contaminants in these plumes are gradually decreasing due to decay, treatment activities, natural attenuation and dilution.

Test Area North

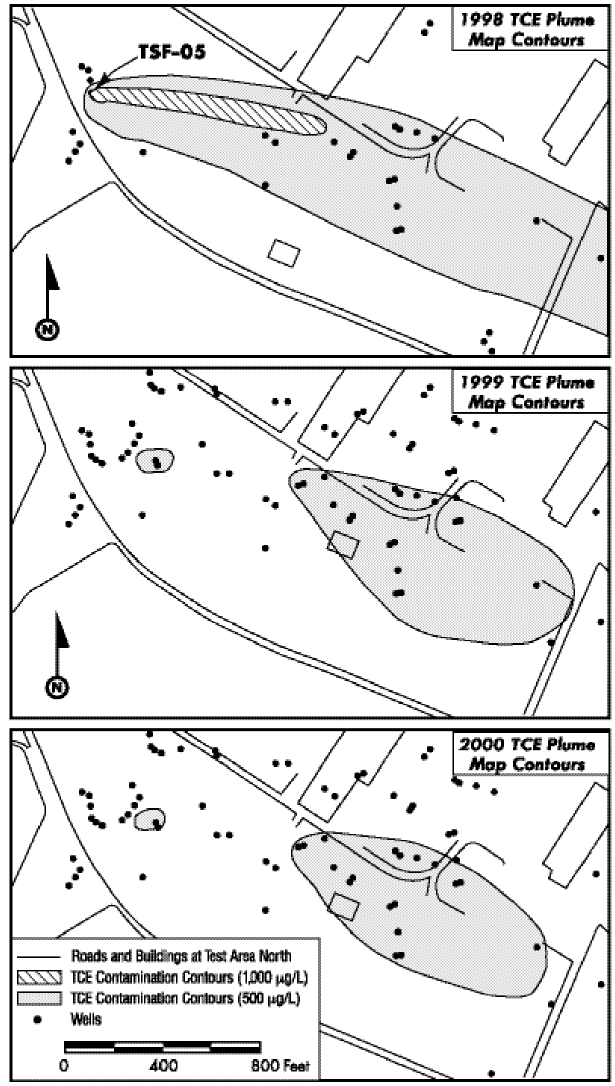
Contaminants exceeding MCLs:

- Trichloroethene (TCE)
- Tetrachloroethene (PCE)
- cis- and trans-1,2-dichloroethene (DCE)
- Cesium-137
- Tritium
- Strontium-90

The groundwater at Test Area North has been contaminated with several volatile organic compounds and radionuclides at levels exceeding safe drinking water standards. The contamination originated from an injection well into the aquifer that was used from 1953 to 1972. The extent of the ***contaminant plume*** is approximately 9,000 feet by 3,000 feet.

After reviewing the original remedy and newer technology, the DOE, EPA and state of Idaho agreed to change the remedy and selected a combination of three methods to clean up the contamination.

In situ bioremediation, which enhances natural biological activity to completely break down volatile organic compounds, is being used in the immediate vicinity of the injection well (the area of greatest contamination). To ensure that an appropriate decay rate meeting remediation goals is being achieved, this method will be combined with pump-and-treat technology, which is already in place, and monitored ***natural attenuation***. By combining the three methods, the overall time and cost of remediation will be reduced.



Plume maps at Test Area North show how combined cleanup technologies are reducing groundwater contamination.

Test Reactor Area

Contaminants exceeding MCLs:

- Chromium
- Tritium

Chromium and tritium contamination occurs in both shallow and deep perched water zones at the Test Reactor Area, and extends in plumes past the facility boundaries beneath the Idaho Nuclear Technology and Engineering Center and the Central Facilities Area.

This contamination primarily originated from water seeping into the ground from cooling ponds and from a wastewater injection well.

Contaminated water is no longer allowed to seep into the vadose zone, and the well ceased to be used for chromium injection in 1972.

The contaminant plumes are expected to decay and/or disperse to below safe drinking water standards within 100 years. During this time period, contaminant levels will continue to be monitored.

Radioactive Waste Management Complex

Contaminants exceeding MCLs:

- Carbon Tetrachloride
- Strontium-90

Both the aquifer and perched water zones at the Radioactive Waste Management Complex contain contaminants in concentrations exceeding EPA's drinking water standards. The contamination, consisting of an organic chemical and a radionuclide, originated primarily from buried waste at the Subsurface Disposal Area. Extensive groundwater and vadose zone monitoring is underway to learn more about contaminant migration.

The estimated 1.08 million pounds of carbon tetrachloride comprise approximately 75 percent of the volatile organic compounds disposed of at the Subsurface Disposal Area. The migration of these compounds cause drinking water standards (maximum contamination levels) to be exceeded. Since January 1996, more than 100,000 pounds of these volatile organic compounds have been vacuum extracted and destroyed to mitigate the contamination.

Some Facts About Inorganic and Organic Chemicals, and Radionuclides

Inorganic Chemicals

Inorganic chemicals include metals, and nitrates and nitrites. While many metals are essential to life, practically all are toxic in excessive quantities. Some metals, such as lead, are toxic in very small quantities.

Metals in the environment are commonly absorbed and concentrated by plants and animals. This can be dangerous for humans if they eat the plants and animals. However, after plants absorb metals from contaminated soils, the plants can be harvested and safely disposed of, removing the absorbed metals from the environment. This is a cleanup technology currently being used at the INEEL.

Nitrates and nitrites are simple compounds of oxygen and nitrogen. These compounds are a constituent of animal waste, a common fertilizer and byproducts of many industrial processes. Nitrates are also an end-breakdown product for many nitrogen-containing chemicals.

Organic Chemicals

Organic chemicals are chemicals containing carbon. All known life forms are based on organic chemicals. Common products containing organic chemicals include gasoline and alcohol.

Many organic chemicals are readily absorbed by internal body tissues. Because the liver is the human body's major site for chemical breakdown, some organic chemicals can cause serious liver damage and increase the likelihood of liver cancer.

Many organic chemicals are almost completely insoluble in water; they will either float or sink depending upon their density relative to water. For example, gasoline floats on the surface of water in a thin film; trichloroethene sinks.

Radionuclides

Radionuclides are radioactive forms of elements. For example, iodine-129 is a radioactive form of iodine. Tritium is a radioactive form of hydrogen that is usually found as a component of water. Radionuclides are a special case of inorganic chemicals and are easier to detect in minute quantities due to their radioactive properties.

Radionuclides decay (emit radioactivity) at predictable rates called half-lives. A half-life is the time it takes for one half of the atoms in a quantity of a radionuclide to decay. After the first half-life, 50 percent of the atoms have decayed; after the second, 75 percent have decayed; and so forth. After seven half-lives, less than 1 percent of the radionuclide remains in its original form. The decayed form that remains can be either another radionuclide or a non-radioactive substance.

Radionuclides, like all contaminants, can be inhaled as dust or ingested in food and water. Though some studies indicate low doses of radiation can have beneficial effects, radionuclides can damage the genetic material in cells and lead to cancer.

Water containing tritium is almost identical to ordinary water except that it is radioactive and slightly heavier. Though there is no practical cleanup method to separate tritium-containing water from ordinary water, a quantity of tritium-containing water will contain less than 1 percent of its original radioactivity after an 86-year period (seven half-lives).

The radionuclides cesium-137 and strontium-90 are often found in equal proportion close to sources of contamination at nuclear facilities. At the INEEL, cesium-137 binds strongly to the rock, while strontium-90 does not. So, as the distance increases from a source of contamination, the proportion at which the two radionuclides are found rapidly rises in favor of strontium-90. This characteristic is useful in determining a contamination source.

Ongoing subsurface science research uses secondary ion mass spectrometry (SIMS) instrumentation to analyze the mobility of plutonium and other radionuclides.

Why isn't plutonium listed as an aquifer contaminant at the INEEL?

The discussion in this factsheet focuses on those INEEL contaminants that consistently exceed drinking water standards, posing a reasonable threat to the aquifer.

Though there is a perception that plutonium is a groundwater contaminant at the INEEL, current research and modeling shows that plutonium is not a threat to the aquifer. There have been isolated and inconsistent trace detections of plutonium in sedimentary interbeds and in the aquifer. However, they are near the scientific limits of detection (360 times below the drinking water standard). These detections are inconsistent with current understanding of how plutonium moves in the environment.

Ongoing scientific research is examining plutonium's chemical nature and mobility in the subsurface. Based on current scientific understanding, plutonium poses no risk to aquifer quality in the present or the foreseeable future.

Subsurface Science Initiative Focuses on DOE's Most Challenging Problems

The INEEL established the Subsurface Science Initiative to help the DOE better understand and model the complex geological, geochemical, biological and hydrological processes of the subsurface.

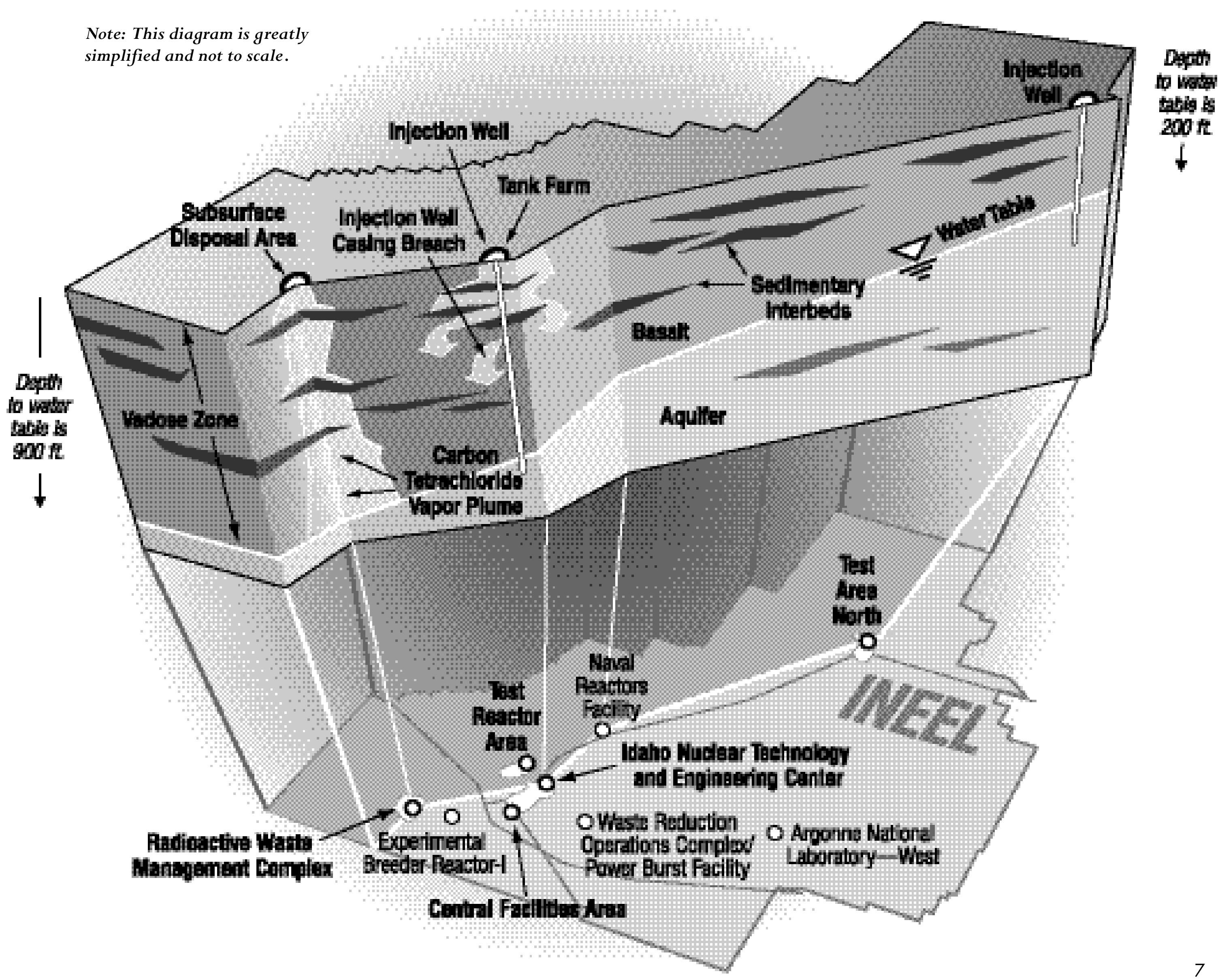
Not only are the majority of DOE's difficult cleanup issues related to subsurface contamination, but the proposed final resting place for most stabilized waste will be in subsurface repositories or disposal areas. Increasing our understanding of subsurface processes is a critical part of this cleanup effort.

The INEEL's Subsurface Science Initiative is a coordinated, multi-disciplinary, multi-institutional collaborative research program.The Initiative focus on wide-reaching research campaigns, and also on building the technical and experimental infrastructure—such as the planned Subsurface Geosciences Laboratory—needed to advance subsurface science.

The INEEL Subsurface Science Initiative is focusing collaborative research efforts on the most challenging subsurface science problems facing DOE.The objectives are to substantially enhance the scientific basis of environmental remediation programs at the INEEL and across the DOE complex, and to provide better options for monitoring and long-term stewardship of contaminated sites.

This cross-section of the INEEL shows the basic geology of the aquifer and most of the sources of groundwater contamination. Facilities with groundwater contamination are shown in boldface.

Note: This diagram is greatly simplified and not to scale.



Information

- For information on specific documents, speakers, briefings, tours, public meetings,and comment periods, call (800) 708-2680.

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- For information on environmental topics, call (208) 526-0075 (Idaho Falls) or (208) 334-9572 (Boise)
- INEEL home page: **http://www.inel.gov**
- INEEL Environmental Management page: **http://www.inel.gov/environment**

www.inel.gov/environment

- The INEEL Administrative Record (documents and source materials) is available at **http://ar.inel.gov/home.html** and at the following locations:

INEEL Technical Library
DOE Public Reading Room
1776 Science Center Drive
Idaho Falls, ID 83415
208-526-1185

Albertsons Library
Boise State University
1910 University Drive
Boise, ID 83725
208-385-1621

University of Idaho Library
University of Idaho Campus
434 2nd Street
Moscow, ID 83843
208-885-6344

References

- *Groundwater at the INEEL*, a more extensive fact sheet available for download at **http://www.inel.gov/environment**
- The U.S. Geological Service (USGS), Water Resources Division, Idaho District, **http://idaho.usgs.gov/**
- The U.S. Environmental Protection Agency (EPA) Office of Groundwater and Drinking Water, at (800) 490-9198, **http://www.epa.gov**
- The INEEL Oversight Program, which monitors water quality of the Snake River Plain Aquifer, at (800) 232-INEL.

Publications

- *Summary of the Snake River Plain Regional Aquifer-System Analysis in Idaho and Eastern Oregon.* G. F. Lindholm, U.S. Geological Survey (USGS) Open-File Report 91–98, 1993, Boise, Idaho.
- *Upper Snake River Basin Study*, 1997. Idaho Department of Water Resources, 1301 N. Orchard Street, Boise, Idaho, 83720.
- *Risk Assessment in Superfund:A Primer*, an EPA guide to risk assessment, available in Binder 300 of the Information Repositories, or by calling the EPA at (206) 553-6901.

INEEL
INEEL Environmental Restoration Program
MS 3206
P.O. Box 1625
Idaho Falls,ID 83415-3206

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