Tritium at 800 pCi/L in the Snake River Plain Aquifer in the Magic Valley at Kimama: Why This Matters

Environmental Defense Institute
Special Report

By Tami Thatcher
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Brief Summary: The truth about the migration of waste water contaminants in the Snake River Plain Aquifer from historical operations at what is now called the Idaho National Laboratory has long been hidden. This report will show why the contamination is not primarily from nuclear weapons fallout, globally or from the Nevada Test Site. By examination of the radionuclide and chemical constituents deep in the aquifer at the Kimama well, it can be shown that the contamination is in fact primarily from INL waste water practices. Weapons testing did shower Idaho and the rest of the country with elevated levels of tritium and other fallout. However, there are various contaminants in the aquifer from INL operations that would not result from weapons testing.

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Executive Summary

At the Idaho National Laboratory (then called the National Reactor Testing Station) extensive waste water disposal commenced in 1952 from nuclear reactor operations, spent nuclear fuel reprocessing and other nuclear fuel separations processes. These operations introduced enormous quantities of radiological and chemical contaminants into the Snake River Plain aquifer. Wastes were also buried over the aquifer.

Despite US Geological Survey monitoring of the aquifer since 1949, the view that the aquifer was a economical disposal solution, the evolving regulatory standards in the early years, and the secrecy surrounding nuclear research especially as related to nuclear weapons production had created a system that intermittently monitored contaminants, sometimes decades after the waste was introduced. And even when contaminants were monitored, the public was not told the truth about the spread of the aquifer contamination downgradient from the INL site.

Groundwater monitoring showing contamination offsite was and still is being withheld from the public. The USGS often ceased to monitor wells that showed contamination, creating "no discernible trend" by design. Even though detection capability has evolved, at times it would appear that less than adequate detection capability has been used to argue contaminants were not present, especially with regard to tell-tale chromium, tritium and other chemical contamination from the INL. And the variable contamination found from intermittent groundwater monitoring was argued to mean that the source and extent of the contamination appeared uncertain.

There has been more spin than science when it comes to what the public has been told about the extensive contamination of the aquifer that flows rapidly downgradient to the Magic Valley. The excuses that the well monitoring results were not repeatable had much to do not only with sample detection capability but also with the inadequate understanding of contamination stratification in deep wells and the highly variable rates of injection of various wastes.

The depth of the aquifer varies: deeper in the central areas and shallower as the aquifer approaches the Snake River to the south of the monitored Magic Valley region. The contamination is then much closer to the surface as the aquifer becomes shallower near the Snake River from Rupert to Hagerman.

The prevailing excuse that weapons fallout was the source of the aquifer contamination can be examined and refuted by review of aquifer upgradient groundwater sources such as the Big Lost River and Birch creek sources, and by examining various INL waste water contaminants in the aquifer that are not contained in weapons fallout.

The extent of chemical and radiological contaminants from INL waste water injection wells and percolation ponds is examined. Historical groundwater monitoring records — those that were located — are reviewed. Evolving radiological health protection standards are highlighted. And modern federal drinking water standards are presented, as are the reasons that maximum contaminant levels (MCLs) do not necessarily assure adequately safe drinking water.

The contaminated aquifer water found in the Magic Valley in deep borehole sampling contained elevated levels of radionuclides exceeding concentrations that the US Geological Survey has been reporting for many years in the Magic Valley. The US Geological Survey has failed to discuss where the elevated radiological contamination at the Kimama well monitoring came from—consistent with its decades of covering up nuclear weapons and INL radiological airborne and groundwater contamination. The USGS has been and largely continues to be an organization dedicated to facilitating the Department of Energy's cover-ups and to that purpose, they have functioned effectively as "forever contamination sites" were created at INL and as the population downgradient was being fed a toxic soup of contaminants in their water.

It was tritium and a whole lot more that was in INL waste water: uranium, thorium, americium-241, strontium-90, cesium-37, iodine-129, a host of organic chemical solvents used in fuel separations and purification of weapons material, and a huge quantity of hexavalent chromium. It was also many less toxic but tell-tale constituents like sodium, chloride, nitrate, barium and others that were used in fuel reprocessing and separations.

It matters that the public understand the truth about the rapid and significant flow of contamination to the Magic Valley from historical INL waste water because the illness and death from the toxic soup of radiological and chemical contamination is continuing.

About the Author

Tami Thatcher is an Idahoan with roots in the Little Lost Valley. Her grandparent's ranch was located at the boundary of the INL between INTEC and Test Area North. There were radiation monitoring films hung on grandma's white picket fence — and she died of cancer. So understanding historical radioactive contamination, both airborne and in groundwater, has become a deeply personal interest. She has a Bachelor of Science degree in Mechanical Engineering from the University of Idaho and worked as a nuclear safety analyst at the Idaho National Laboratory. She is not most qualified person to write this — she just happens to be one of the few not compelled to hide the truth in order to preserve their career in the nuclear industry.

Tritium at 800 pCi/L in the Snake River Plain Aquifer in the Magic Valley at Kimama: Why This Matters

When the deep well monitoring performed by the US Geological Survey discovered elevated levels of tritium, about 10 times higher than had reported for over two decades in the Magic Valley groundwater monitoring, the USGS did not try to identify the source of the contamination. [1] Nor did it get news coverage.

There are dozens of reports from 1989 on all stating tritium concentrations in groundwater in the Magic Valley are less than 150 picocurie/liter (pCi/L), and are often far less (see references at the end of this report). Monitoring in the Magic Valley actually began in the 1950s, although the data from this monitoring has been hidden away. See Figure 2 below for some of the monitoring wells south of the INL.

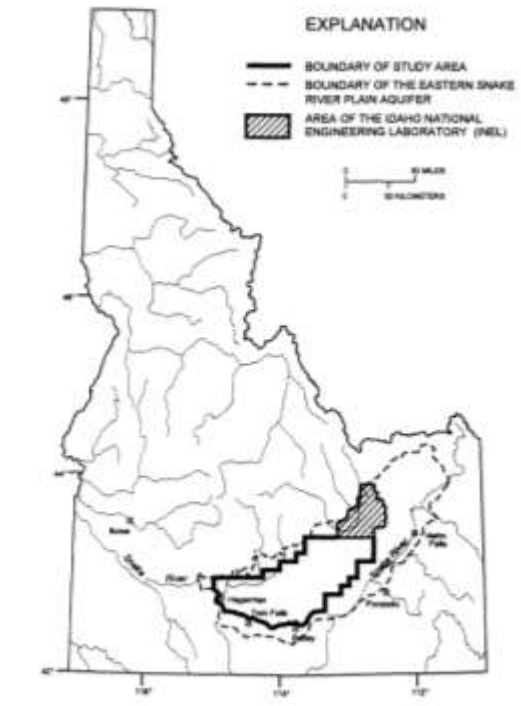

Figure 1. Location of the study area, between the Idaho National Engineering Laboratory and Hagerman, Idaho.

Kimama is located in Lincoln County roughly 60 miles southwest of the INL, about 20 miles northwest of Acequia and north of Rupert in Minidoka County. Finding tritium at 810 pCi/L deep in the aquifer at Kimama, after at least two decades of USGS monitoring that found only tritium levels below 134 pCi/L is big deal. It should warrant discussion of the source of the tritium.

Even though the drinking water maximum contaminant level (MCL) for tritium in water is an industry-friendly 20,000 pCi/L, people concerned with humans having healthy babies consider 100 pCi/L to be about the maximum that pregnant women should be drinking because of the damage to DNA and concern for birth defects, as California public health goals attest. Figure 1 to the left is from USGS report 97-4007.

[1] USGS "Geophysical Logs and Water Quality Data for Boreholes Kimama-1A and -1B, and a Kimama Water Supply Well near Kimama, Idaho," Data Series 622,DOE/ID-22215, 2011.

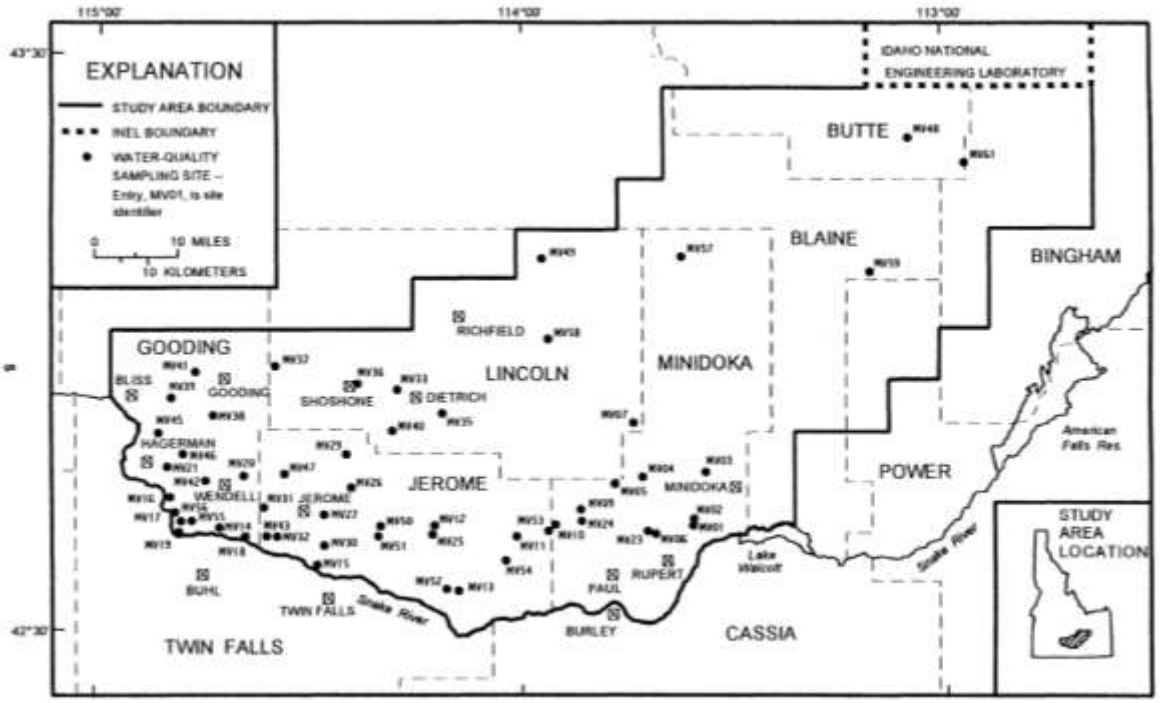

Figure 2.—Location of selected water-quality sampling sites on the eastern Snake River Plain.

Figure 2. Figure is from US Geological Survey Report 97-4007 (DOE/ID-22133) from https://pubs.usgs.gov/wri/1997/4007/report.pdf

The INL's naval and research spent nuclear fuel reprocessing plant and test reactor area had wells near those facilities that for years were exceeding tritium concentrations of 250,000 pCi/L. Once the tritium or any other contaminant is in the aquifer, it travels downgradient to the Magic Valley and then the Snake River. The degree to which the contamination fanned out depends on the volumes of waste water being injected, fractures in the aquifer basalt, and aquifer pumping.

While it is true that global weapons testing radiological fallout and local weapons testing fallout from the Nevada Test Site did spread vast amounts of tritium and other fallout over Idaho and much of the US, a close examination of the INL waste water contaminants and the differences between INL waste water and weapons fallout will prove that the aquifer contamination downgradient from the INL is from historical INL waste water and perhaps from buried waste.

Mountainous areas do receive more radioactive fallout from airborne sources such as nuclear weapons testing because there is more precipitation there than in the drier desert regions. Tritium, cesium-137, strontion-90, and a host of other radionuclides were in the fallout. Tritium is among the most mobile of radionuclides and least likely to be bound-up to soil.
But the groundwater monitoring downgradient from those mountainous areas does not show levels of tritium or other contaminants that would explain the elevated levels of contaminants at Kimama.

There are numerous reports, mainly by the USGS, that say the monitoring of the wells south of the INL in the Magic Valley, found tritium levels, all below 134 pCi/L since 1989 — and usually considerably less than 100 pCi/L. Background tritium levels are usually stated by the USGS as below 40 pCi/L generally and below 150 pCi/L at the INL. The median value of tritium in the aquifer at the INL has been stated to be 34 pCi/L in a 2016 report by the USGS. [2]

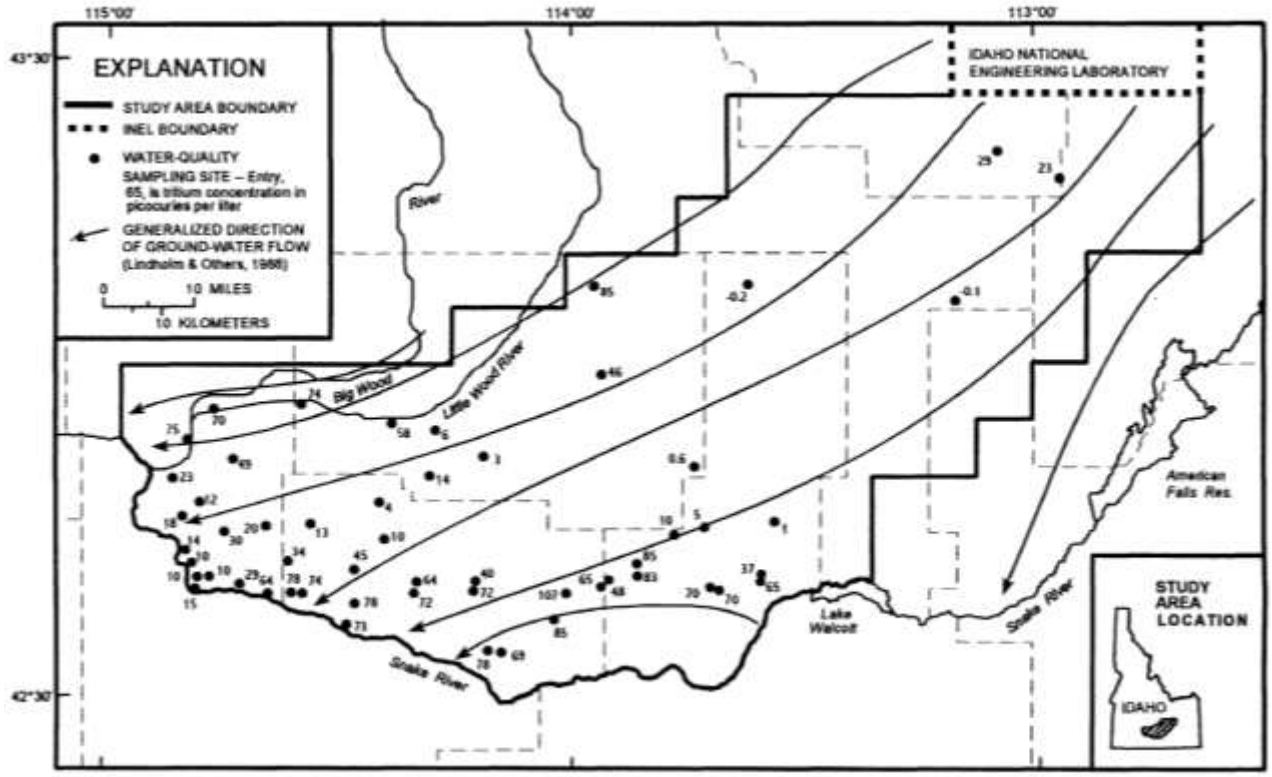

Figure 3. --Map of 1990-92 tritium concentrations with location of selected water-quality sampling sites on the eastern Snake River Plain

Figure 3. Map of 1990-92 tritium concentrations in the Magic Valley from USGS report 97-4009 (DOE/ID-22133) from https://pubs.usgs.gov/wri/1997/4007/report.pdf.

By 1999, the levels of tritium in the Magic Valley were generally less than 65 pCi/L as reported by the USGS. And a USGS 2003 study found 38.1 pCi/L to be the maximum tritium concentration in the Magic Valley. [3] So, why isn't it news when the tritium concentration far

[2] Bartholomay, R.C., and Hall, L.F., "Evaluation of background concentrations of selected chemical and radiochemical constituents in water from the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho: U.S. Geological Survey Scientific Investigations Report 2016-5056 (DOE/ID-22237), 2016. http://dx.doi.org/10.3133/

[3] Rattray, G.W. and Wehnke, A.J., "Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Laboratory to the Hagerman Area, Idaho, 2003.," US Geological Survey Report 2005-1125 version2, 2005.

south of the INL is found in a deep borehole to exceed 800 pCi/L? And why doesn't the USGS even attempt to explain it?

The USGS has typically addressed the elevated levels of tritium and other radionuclides and contaminants by emphasizing that tritium is natural (which is true but only accounts for very tiny amounts of tritium in the environment) and that large amounts were released from nuclear weapons testing — which is also true. But many USGS reports on the Magic Valley omitted adequate description of the waste waster contaminants at the INL and omitted significant historical monitoring data that existed prior to 1989.

Some USGS reports use the reasoning that the EPA monitoring of the Snake River at one location, Buhl, Idaho, where elevated levels of tritium were found in the Snake River likely explained the Magic Valley tritium levels. They express that irrigation using the Snake River was the likely source of elevated concentrations of tritium — when the reverse is the case — the aquifer was contaminating the Snake River. Where the contamination is clearly far north of the Snake River, people seem to have been told that the source was from mountain groundwater contaminated by weapons fallout.

The figure below shows darker shading in the portion of the Snake River Plain Aquifer having greater depth. As the aquifer flows from deeper to shallower sections, in the general southwesterly downgradient flow, the frequently unmeasured levels of higher contamination

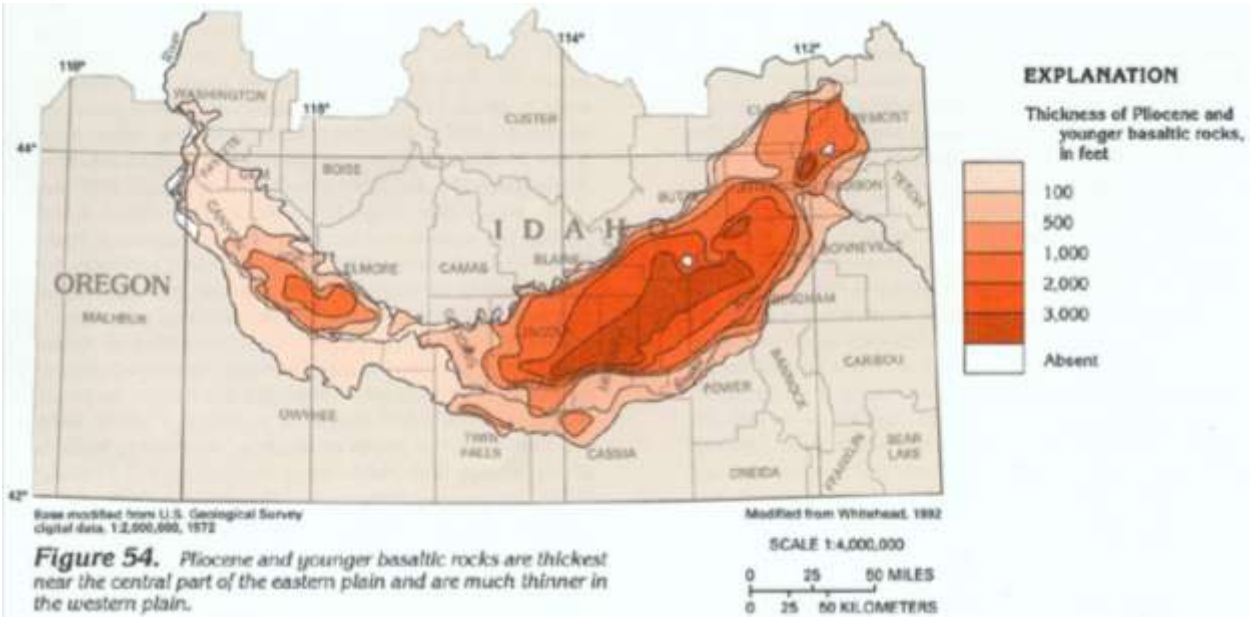

Figure 4. Snake River Aquifer thickness from USGS.gov website at http://pubs.usgs.gov/ha/ha730/ch_h/jpeg/H054.jpeg

deep in the aquifer then mix with shallower levels. This may explain why contamination levels often bump up in the regions where the aquifer is more shallow.

The global and region nuclear weapons testing fallout do not account for the elevated tritium reading over 800 pCi/L in 2016 in the deep well at Kimama. The fact that INL contamination tends to migrate deeper in the aquifer as it flows downstream from INL, deeper than was historically sampled by the USGS, [4] and the fact that enormous levels of tritium were disposed of into the Snake River Plain aquifer by the INL does provide a reasonable explanation for the elevated levels of tritium contamination.

The US Geological Survey has never made any serious attempt to explain the weapons fallout effects in terms of timing, yield, weather patterns, etc. from weapons tests versus INL releases and the effect on aquifer contamination such as tritium levels. Weapons testing information has largely been declassified since 1994. It is interesting to note the very large number of "accidental" releases of radioactivity by the US underground weapons testing after the 1963 partial test ban. [5] [6]

Chemicals and More in INL Waste Water

The Idaho National Laboratory released airborne tritium in reactor operations, nuclear fuel reprocessing operations, and in reactor fuel melt experiments and accidents. The INL also released tritium to ground water from reactor operations and fuel reprocessing — and in huge amounts.

Waste water from nuclear fuel reprocessing, other fuel separations processes and reactor operations from the historical operations at the Idaho National Laboratory included 31,000 curies of tritium between 1952 and 1990. The waste water contained are large variety of other tell-tale constituents such as elevated sodium, chloride, nitrate, chromium, and organic solvents — all of which seem to go hand in hand with wells in the Magic Valley that are the most contaminated with radionuclides.

These tell-tale constituents like sodium, chloride, nitrate and hexavalent chromium were not released in weapons fallout. The only explanation really is that the elevated levels of

[4] US Geological Survey website link: http://id.water.usgs.gov/projects/INL and INL bibliography at http://id.water.usgs.gov/INL/Pubs/INL_Bibliography.pdf . Select individual wells at the USGS mapper at http://maps.waterdata.usgs.gov/mapper/index.html **US Geological Survey Mapper Data**: See well data at http://maps.waterdata.usgs.gov/mapper/index.html.

[5] Bergkvist, N., Ferm, R., Defence Research Establishment and Stockholm International Peace Research Institute, "Nuclear Explosions 1945 – 1998," July 2000. http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/31/060/31060372.pdf

[6] US Department of Energy, "US Nuclear Tests: July 1945 through September 1992," DOE/NV-209 (Rev. 14), 1994. See https://fas.org/nuke/guide/usa/nuclear/usnuctests.htm

radionuclides and other contaminants is that the source, all along, has been the INL, originally the NRTS.

Along with radiological contaminants, historical operations at the INL disposed of a multitude of chemical contaminants into the aquifer. The chemical wastes were often used in nuclear fuel reprocessing or other separations processes, then disposed of via deep injection wells, ponds or pits at Idaho Nuclear Technology and Engineering Center (INTEC), ATR Complex (formerly the Test Reactor Area), the Naval Reactors Facility (NRF), [7] and Test Area North (TAN). Chemical contaminants have also reached the aquifer from burial of wastes at the Radioactive Waste Management Complex (RWMC).

Not only tritium was disposed of into the Snake River Plain Aquifer from the INL historical operations: iodine-129, neptunium-237, technetium-99, chlorine-36, carbon-12 and other less mobile radionuclides such as uranium, strontium-90, and cesium-137 were also injected into the aquifer at INL's INTEC, the chemical spent fuel separations facility to recover highly enriched uranium from government reactors. A uniquely important study by the USGS that sampled and analyzed aquifer contamination around INTEC was never reported in a USGS or DOE report. It was not made part of the USGS aquifer bibliography until my request that the study, hidden in a closed-access journal, be added to the USGS bibliography. [8]

Despite over two decades of remediation activities including vapor extraction at the RWMC and TAN for CERCLA cleanup, the levels of chemical contamination in the aquifer at both locations have been increasing. Carbon tetrachloride levels continue to increase at RWMC; 821,000,000 grams disposed of there between 1952 and 1978. Trichloroethylene (TCE) was disposed of via injection well at TAN but the quantity is unknown — but it may have been as much as 35,000 gal. [9] [10]

Tetrachloroethylene, PCE, was disposed of at TAN but the amount is unknown. PCE was also disposed of at RWMC and NRF. Recent detections of PCE north of RWMC are being investigated by the US Geological Survey.

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[7] Department of Energy, "Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report," INEEL/EXT—03-01169, Rev. 2, September 2003. p. 3-70, 3-71: S1W Tile Drainfield (1953-55) which "plugged up," S1W leaching pit (1955-60), and S1W temporary leach pit (1956) were all used for "low-level radioactive waste" which means anything goes, and the downgradient well monitoring reflects that.

[8] T. M. Beasley, P. R. Dixon, and L. J. Mann, "^{99}Tc, ^{236}U, and ^{237}Np in the Snake River Plain Aquifer at the Idaho National Engineering and Environmental Laboratory," Environmental Science & Technology, 2:3875-3881, 1998.

[9] Department of Energy, "Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report," INEEL/EXT—03-01169, Rev. 2, September 2003. p. 4-2, 4-23 to 4-26.

[10] Department of Energy Idaho Operations Office, *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory Site,* Fiscal Years 2010-2014, DOE/ID-11513, December 2015.

The Advanced Test Reactor Complex, formerly called the Test Reactor Area disposed of unknown levels of contaminants that the CERCLA cleanup has never attempted to investigate. Primarily, this is because the materials involved nuclear fuels and ***weapons material*** separations. But we do know that over 31,000 lb of hexavalent chromium, widely known to cause cancer, was injected into the aquifer.

Hexavalent chromium concentration although unstated by the USGS should be below 1 ug/L in the aquifer. Monitoring of groundwater in wells at the southern boundary or south of the INL has found hexavalent chromium at 1 ug/L or higher in wells USGS 90 at 9 ug/L, USGS 108 at 8 ug/L, USGS 11 at 3 ug/L, USGS 14 (also called MV-60/61) at 5 ug/L in report USGS 93-126. [11]

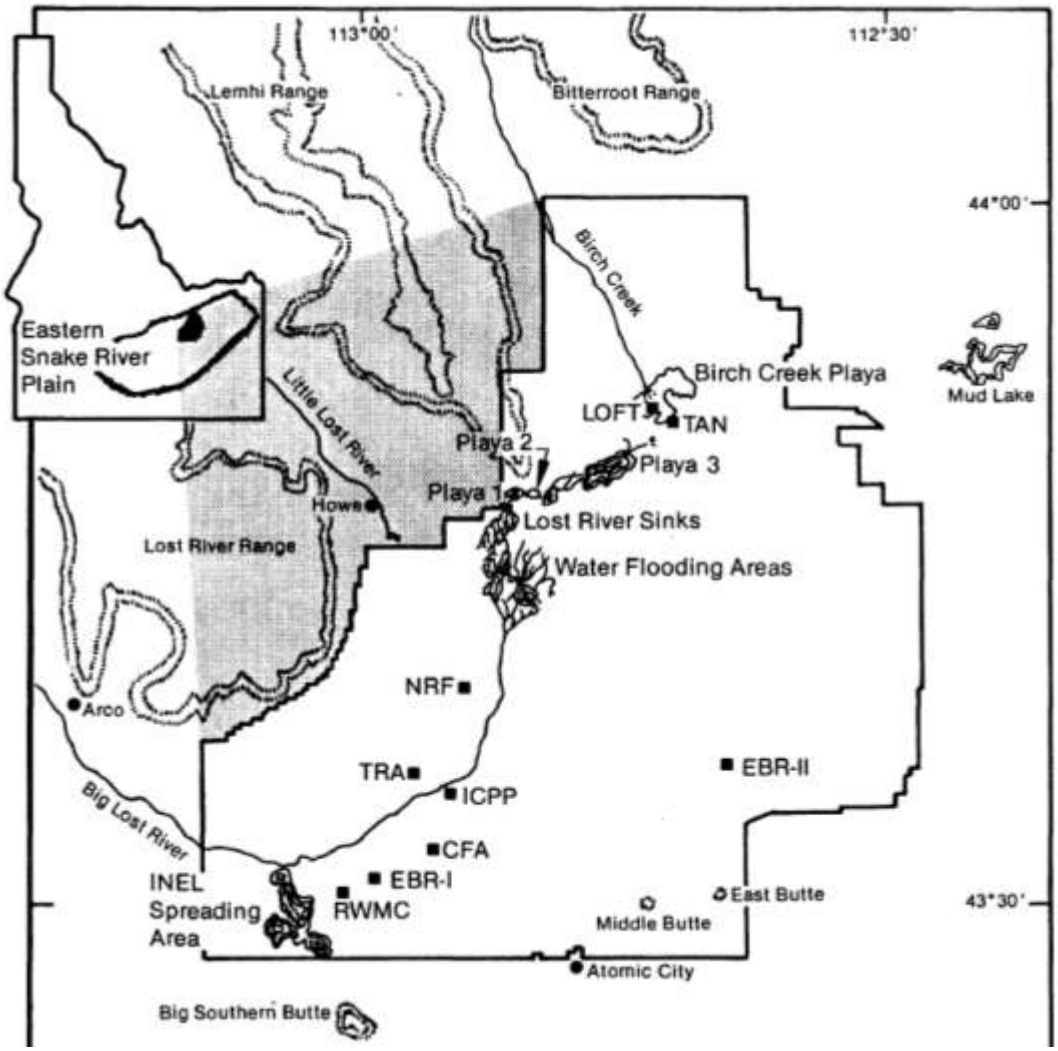

Figure 5. Idaho National Laboratory facilities.

[11] Liszewski, M.J. and Mann, L.J., "Concentrations of 23 Trace Elements in Ground Water and Surface Water at and near the Idaho National Engineering Laboratory, Idaho, 1988-91," US Geological Survey Report 93-126, 1993.

In a summary report for an INL contractor for years 1989 to 1991, hexavalent chromium detections south of INL were summarized as MV-48 at 1 ug/L, MV-49 at 1 ug/L, and MV-59 at 4 ug/L. [12]

You might not be surprised at the amount of chemicals from the INTEC, the chemical processing plant for spent nuclear fuel reprocessing — but actually the Naval Reactors Facility disposed of almost as many chemicals as INTEC. Both INTEC and NRF are upgradient of the recently found PCE contamination. See Figure 5 for the location of various INL facilities.

Once a contaminant is in the aquifer, it flows downgradient, generally to the southwest of the INL. So even if a well at the INL shows a decrease in contamination concentrations, that's not the big picture unless the half life of the material has significantly reduced what flows in the aquifer downgradient. Also, soil may slow the migration of contaminants buried in waste or in percolation ponds — but once that contamination is in the aquifer, it flows downgradient, generally flowing deeper as it flows from the source of the contamination.

Despite the chemical disposal via injection wells, percolation ponds and waste burial, commencing in the early 1950s, the US Geological Survey did not monitor **chemical contamination** until the late 1980s. In the reports that the US Geological Survey issued, the public was always assured that they were keeping a watchful eye, rigorously monitoring the aquifer. They were monitoring the aquifer but in ways meant to keep the Department of Energy, formerly the Atomic Energy Commission, able to keep polluting and keeping the public from understanding what was actually happening.

The USGS was intimately involved in hiding information pertaining to nuclear weapons fallout, weapons material separation techniques, and various chemical and radionuclide contamination. Instead of comprehensive disclosure, the USGS choose to discuss tritium and a few other radioisotopes with relatively short half life. The USGS choose to avoid discussing radionuclide contamination of longer-lived contamination. And the USGS choose to word its reports in ways to hide the fact that workers at INL were drinking highly contaminated water for decades.

The chemical soup from INL waste water disposal has been flowing downgradient for decades. Let's take a look at some of these chemicals and what facilities they came from — then the detection of various chemicals downgradient will take on a whole new meaning that the USGS has downplayed. Because so many reports present only a fragmented look at the chemical contaminants, a list of chemical contaminants most prevalent at the INL from various CERLCA cleanup, USGS and other reports is provided in Table 1. [13] [14] [15] [16] [17] [18]

[12] Golder Associates, for EG&G Idaho, "Assessment of Trends in Groundwater Quality at the Idaho National Engineering Laboratory," 933-1151, October 29, 1993..

[13] Department of Energy, "Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report," INEEL/EXT—03-01169, Rev. 2, September 2003. p. 4-2, 4-23 to 4-26.

Table 1. Facilities that disposed of chemical contaminants at the Idaho National Laboratory that have been **found in the aquifer in significant concentrations**.[a]

Chemical	RWMC	TAN[d]	INTEC	TRA[b]	NRF[c]
Carbon tetrachloride	G				
Chloroform	G		G		G
Dichloro-difluoromethane	G	G			
Methylene chloride	G		G		x
1,1,-Dichloroethane		G	G		
Cis-1,2-Dichloroethene		G			
Trans-1,2,-Dichloroethene		G			
Tetrachloroethylene, PCE	G	G			G
Trichloroethylene, TCE	G	G	G		G
1,1,1-Trichloroethane	G	G	G	G	G
Toluene	G	G	G	G	G
Hexavalent chromium	Note e	Note e	Note e	G	Note e

Table notes:

a. The facilities are the Radioactive Waste Management Complex (RWMC), Test Area North (TAN) and vicinity, Idaho Nuclear Technology and Engineering Center (INTEC) — formerly the Chemical Processing Plant and vicinity including Central Facilities Area that received contaminated drinking water from INTEC, Test Reactor Area, now called the Advanced Test Reactor Complex, and the Naval Reactors Facility (NRF).

b. Acrylonitrile was found in soil and waste water disposal entrances at TRA. The Department of Energy patents acrylonitrile in 1989, see http://www.aquafoam.com/patents/CA4832881.pdf . The "reporting level" for acrylonitrile has been set at a very high level, for years 20 ug/L when other chemicals were at reporting threshold levels of 0.2 ug/L. The reason for this is unknown.

c. Aroclor-1254, Aroclor-1260, Bis-2-Ethylhexl-phthalate, Din-Octylphalate, Di-n-Octylphalate and benzene were found is disposal ditch soil at NRF. The "reporting level" for Acrolein compounds (which include Aroclor) is set at 20 ug/L when other chemicals were at reporting threshold levels of 0.2 ug/L. The reason for this is unknown.

d. At Test Area North, Trans-1,2,Dichloroethene levels of 22,000 microgram per liter (ug/L) and Trichloroethylene of 35,000 ug/L were measured in 1987. Typical limits for drinking water are 5 ug/L. Source USGS report: 87-766.

e. USGS Report 93-126 found elevated hexavalent chromium at TAN and NRF and the TRA hexavalent chromium plume has spread to INTEC and RWMC as well as south of INL.

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[14] Greene, M.R., Tucker, B.J., "Purgeable Organic Compounds in water at or near the Idaho National Engineeing Laboratory, Idaho, 1992-95," US Geological Survey Report 98-51, June 1998.

[15] Liszewski, M.J. and Mann, L.J., Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho – 1990 and 1991," US Geological Survey Report 92-174 (DOE/ID-22104), 1992.

[16] Mann, L.J.and Knobel, L.L., "Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho ," US Geological Survey Report 87-766, December 1987. https://pubs.usgs.gov/of/1987/0766/report.pdf

[17] See the Naval Reactor Facility final environmental impact statement at www.ecfrecapitalization.us and the summary at http://www.ecfrecapitalization.us/EIS-0453-FEIS_Summary.pdf See Chapter 3.

[18] Till, J.E. et al., Radiological Assessment Corporation, for the Centers for Disease Control, "Final Report – The Feasibility of Performing a Chemical Dose Reconstruction Study at the INEEL," RAC Report No. 4-CDC-Task Order 1-1999-Final, September 1999. https://www.cdc.gov/nceh/radiation/ineel/taskorder1report.pdf

In fact, even as chemical contamination exceeds drinking water standards at the waste burial ground, now called the Radioactive Waste Management Complex and at Test Area North, and the aquifer in these areas is growing increasingly contaminated despite years of vapor vacuum extraction of the organic solvents, the USGS is discontinuing monitoring of total organic carbon.[19]

For a few years starting in 1987, the USGS performed analyses of numerous chemical constituents in many wells. The problem, however, is that inexplicably high reporting levels are used for some chemicals like Acrolein and Acrylonitrile that may have been used extensively at TRA and NRF for fuels separations. There is no explanation of very high levels of organic carbon. Toluene and xylene found in limited monitoring prior to 1987 appear to be a rough cut at identifying the chemical contaminations and may not be fully representative of chemicals in the aquifer.

The State of Idaho public drinking water monitoring program that began in the late 1980s was still not mature in the early 1990s. But it is quite interesting that the groundwater monitoring by the Idaho Department of Environmental Quality drinking water monitoring program for the City of Minidoka in 1993 found chloroform at 8.3 ug/L, carbon tetrachloride at 0.32 ug/L and other chemical contaminants.

Regarding elevated chemical contaminants in the Kimama well, the USGS attributes most of the chemical abnormalities in the Kimama deep levels to possible well drilling contaminants. Shouldn't the USGS have at least attempted to understand their well drilling contaminants, given that most of these contaminants include key INL waste water non-radiological constituents?

[19] See DOE/ID-22232, page 8.

"Tritium Units" Don't Equal PicoCuries/Liter

The US Geological Survey often excuses INL waste water tritium when not immediately near injection sources at INL as being from weapons fallout. This report 1989 report of tritium deposition in the US [20] gives a rough estimate of annual tritium deposition based on regional precipitation for 1953 to 1983. The resulting Tritium-units (TU), however, seem to often be confused with being equal to picocuries per liter. Actually, 1 TU is equal to 3.22 pCi/L.

In any event, the tritium-laden precipitation would mix with existing surface and ground water, reducing the tritium concentration from the precipitation.

The tritium levels in precipitation in the Michel report for 1953-1983 have been said to have given Idaho about 4000 pCi/L during the peak year in 1963. I believe that this should actually be 4000 TU in 1963, so the level is pCi/L would be 3.22 times higher, at over 12,000 pCi/L. The radioactive half life of tritium is 12.3 years. Be that as it may, the USGS has stated that by 1992, the average concentrations in surface water would be only about 65 pCi/L. [21] [22] But concentrations of tritium disposed of via injection wells, pits and percolation ponds at INL began in 1952 and were reported at 340,000 pCi/L in 1968 in the drinking water at INL. So even with the 12.3 year half life of tritium, the INL tritium disposal easily accounts for the elevated tritium at Kimama.

I may have it wrong. But what I do see is that almost 50 years after much of the nuclear weapons testing, the Department of Energy and its service organizations like the US Geological Survey are still keeping secrets so the American public will not understand the extent of US weapons testing contamination and the true extent that this may have caused damaged DNA and illness.

[20] Michel, R.L., "Tritium deposition in the continental United States, 1953-83: US Geological Survey Water-Resources Investigation Report 89-4072," 1989.

[21] Mann, L.J., and Walton, H.L., "Tritium, Stable Isotopes, and Nitrogen in Flow from Selected Springs that Discharge to the Snake River, Twin Falls-Hagerman Area, Idaho, 1990-93," US Geological Survey Report 94-4247, 1994. p. 5 and 6.

[22] Michel, R.L., "Tritium deposition in the continental United States, 1953-83: US Geological Survey Water-Resources Investigation Report 89-4072," 1989.

Elevated Radionuclide Levels at Kimama — Why It's Not Weapons Fallout

The presentations for the Idaho National Laboratory are always emphasizing that plutonium, americium, cesium and strontium bind to the soil. They argue, therefore, that these contaminants won't migrate from buried waste sites to the aquifer any time soon. Here is a discussion of important radionuclides in INL waste water other than tritium.

To give a very basic concept of the aquifer flow from the INL, Figure 6 below shows generalized aquifer flow lines for a radionuclide contaminant from INTEC. Flow is affected by pumping and injection; this can cause pluming to the east and west rather than strictly flowing in a southwest direction.

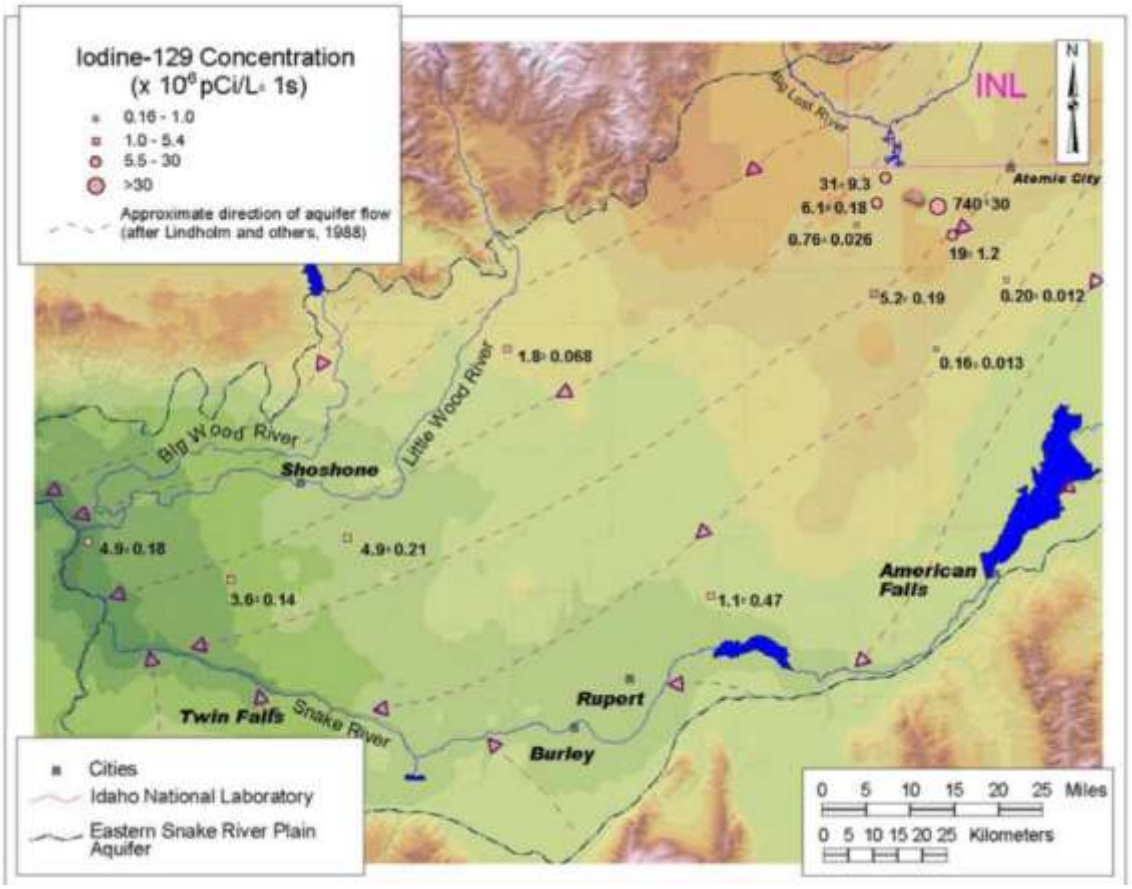

Figure 6. Aquifer flow gradient from the Idaho National Laboratory to the Magic Valley with depiction of iodine-127 levels from F. Hall's 1997-98 report.[23]

[23] Hall, Flint, "Concentrations of Selected Trace Metals, Common Ions, Nutrients and Radiological Analytes in Ground Water," Idaho Department of Environmental Quality, OP-06-03, 2005. http://www.deq.idaho.gov/media/553383-selected_trace_metals.pdf

The USGS doesn't attempt to discuss the source of the radionuclide contamination in the Kimama well. The radionuclide sampling results from the Kimama well is provided in Table 2.

The Kimama well sampling revealed americium-241, plutonium-239+240, and cesium-137 levels that were higher than typical for drinking water and Magic Valley monitoring. ***It is not only the level of these contaminants, but the ratio of these contaminants that give important clues.*** The ratio of americium-241 to plutonium-239 at Kimama, at a ratio of 1.0, is too high to have been from global or regional weapons fallout. Weapons testing fallout would not be so high in americium-241 relative to plutonium-239+240; global fallout ratio of Am-241 to Pu-239+240 would be less than 0.01. The excessive americium-241 levels in relation to plutonium-239 (plus Pu-240) at Kimama are too high to be from global or regional fallout.

Table 2. Radionuclide levels monitored in 2010 at Kimama, pCi/L. [a]

Constituent	300 ft supply well	830 ft	460 ft borehole	830 ft borehole
Tritium	50	810	240	70
Strontium-90	0.5	1.5	0.3	NA
Cesium-137	15	8	12	NA
Gross alpha	0	18	-1	NA
Gross beta	3.8	14.4	4.3	NA
Americium-241	-0.01	0.003	0.006	NA
Plutonium-238	-0.005	-0.003	0.006	NA
Plutonium-239+240	-0.005	0.003	0.009	NA

Units: pCi/L = picocuries/liter.

Table notes:

a. USGS Data Series 622, DOE/ID-22215, 2011.

b. Uncertainties not listed here are in Table 4 of the DOE/ID-22215 report.

Enrichment in Am-241 relative to Pu-239+240 can occur due to plutonium purification processes that removed the americium-241 contamination from weapons material, concentrating the Am-241 in waste water or burial at INL's RWMC. Some of the Am-241 blowing in the wind from RWMC is known to be at a higher ratio to Pu-239+240 than fallout. Excessive levels of americium are also found in the aquifer at INL from NRF and TRA plutonium purification chemical separations processes. The fact is that the elevated levels of americium-241 relative to the plutonium levels found in the Kimama well indicates that the source of the contamination is not global or NTS nuclear weapons testing fallout.

The cesium-137 ratio to plutonium-239+240 in the Kimama well, over 2500, is also higher than would be expected from global or regional fallout. Weapons fallout should not exceed a ratio of 38. At Kimama, the cesium-137 ratio to plutonium-239+240, where it can be calculated, indicates a much higher value, more consistent with INL fallout or waste water. [24]

Nuclear weapons testing was conducted by the US and other countries. Global fallout includes US testing outside of the US and testing by the former USSR, China, France and other countries. Regional fallout is from US testing, primarily at the Nevada Test Site. Table 3-1 provides an overview of annual relative magnitude of global and regional (NTS) weapons testing fallout from 1951 to 2000.

Table 3-1. Annual global and regional Nevada Test Site fallout: 1951 to 2000. [a]

	Global Fallout		NTS Fallout	
Year	Collective Dose (10^3 person-Gy)	Population-weighted Dose (mGy)	Collective Dose (10^3 person-Gy)	Population-weighted Dose (mGy)
1951			6.5	0.039
1952			15	0.093
1953	1.1	0.007	19	0.12
1954	2.8	0.017	0.2	0.001
1955	1	0.006	12	0.072
1956	4.1	0.025	0.1	0.001
1957	4.9	0.03	20	0.12
1958	6.8	0.042	0.8	0.005
1959	7.7	0.047		
1960	1.6	0.01		
1961	3.3	0.02		
1962	14.5	0.089	4.7 (Test Sedan)	0.029
1963	12.6	0.077		
1964	5.9	0.036		
1965	3.7	0.023		
1966	3.0	0.019		
1967	2.4	0.015		
1968	2.3	0.014		
1969	2.1	0.013		
1970	2	0.012		
1971	1.8	0.011		
1972	1.8	0.011		
1973-2000	34.4	0.211	0.33 (1963-2000)	0.0028
Total	119.8	0.74	79	~0.5

Gy = Gray, 1 Gray = 100 rad. a. Table data from CDC feasibility study, p. 64, at https://www.cdc.gov/nceh/radiation/fallout/feasibilitystudy/technical_vol_1_chapter_3.pdf

[24] Beasley, T.M. et al., "Heavy Element Radionuclides (Pu, Np, U) and Cs-137 in Soils Collected from the Idaho National Engineering and Environmental Laboratory and Other Sites in Idaho, Montana, and Wyoming," Environmental Measurements Laboratory, EML-599, October 1998. p. 37, 45.

Regional fallout in Table 3-1, however, does not appear to include the roughly 30 or more known cases of iodine-131 being released from the NTS underground tests after the partial test ban at the end of 1963. The partial test ban allowed underground tests but not atmospheric tests or underwater tests. [25] The 1993 UNSCEAR report lists atmospheric releases of iodine-131 from leakage of underground weapons tests at the Nevada Test site. [26] Iodine-131 was identified because of the significant health effect as I-131 is ingested via cows or goats milk but tritium and other radionuclides were probably also released. But the UNSCEAR report does not mention the Plowshares program weapons testing—some of which was conducted underground—but some tests were above ground.

A compilation of known underground tests that released radioactivity and additional tests from the Plowshares above ground tests is provided in Table 3-2. Plowshares research was to promote atomic bombs for excavation of soil, but it didn't prove to be useful. The underground test iodine-131 release data is from the UNSCEAR 93 report. [27] The Plowshares tests that were after the 1963 partial test ban and were "crater" type are from FAS.org website compilation of Department of Energy report DOE/NV-209.

Table 3-2. Atmospheric releases of iodine-131 to the atmosphere from underground tests and above ground Plowshare program tests carried out at the Nevada test site before and after the 1963 partial testing ban.

Name of test	Year of test	Yield, kT	Iodine-131 released	
			TBq	Ci
Antler	9/151961	2.6	0.2	5.4
Feather	12/22/1961	150	0.04	1.08
Pampas	03/01/1962	9.5	0.0004	0.01
Platte	04/14/1962	1.85	0.4	10.8
Eel	06/19/1962	4.5	0.4	10.8
Des Moines	**06/13/1962**	**2.9**	**1200**	**32,400**
Sedan, Plowshare	07/06/1962	104	?	?
Bandicoot	**10/19/1962**	**12.5**	**330**	**8,910**
Yuba	06/05/1963	3.1	0.0008	0.0216
Eagle	12/12/1963	5.3	0.08	2.16
Pike	**03/13/1964**	**<20**	**13**	**351**
Alva	08/19/1964	4.4	0.001	0.027

[25] Pravalie, R. (2014). Nuclear Weapons Tests and Environmental Consequences: A Global Perspective. *Ambio*, *43*(6), 729–744. http://doi.org/10.1007/s13280-014-0491-1.

[26] UNSCEAR, Report to the general assembly, United Nations, "Annex B: Exposures from man-made sources of radiation," 1993. http://www.unscear.org/unscear/en/publications/1993.html See Table 13, p. 130 for atmospheric released of iodine-131 from underground tests at the Nevada test site.

[27] Federation of American Scientists, website containing United States Nuclear Tests July 1945 through September 1992, (DOE/NV-209 Rev. 14, December 1994) , https://fas.org/nuke/guide/usa/nuclear/usnuctests.htm United States Nuclear Tests by Date include date, yield, purpose, i.e., Plowshare, and type, i.e. crater, tower, or shaft.

Drill	12/05/1964	<23.4	0.5	13.5
Parrot	02/12/1964	1.3	0.2	5.4
Alpaca	02/12/1965	0.33	0.0009	0.0243
Palanquine, Plowshare	04/14/1965	4.3	?	?
Tee	05/07/1965	7	0.06	1.62
Diluted Waters	06/16/1965	<20	0.7	18.9
Red Hot	**03/05/1966**	**<20**	**7**	**189**
Pin Stripe	**04/25/1966**	**<20**	**7**	**189**
Double Play	**06/15/1966**	**<20**	**4**	**108**
Derringer	09/12/1966	7.8	0.009	0.243
Nash	01/19/1967	39	0.5	13.5
Midi Mist	06/26/1967	<20	0.01	0.27
Hupmobile	**01/18/1968**	**7.4**	**4**	**108**
Cabriolet, Plowshare	01/26/1968	2.3	?	?
Buggy, Plowshare	03/12/1968	5.4	?	?
Schooner, Plowshare	12/08/68	30	?	?
Pod	10/29/1969	16.7	0.03	0.81
Scuttle	11/13/1969	1.7	0.0001	0.0027
Snubber	04/21/1970	12.7	0.2	5.4
Mint Leaf	05/05/1970	<20	3	81
Carpetbag ?	**12/17/70**	**220**	**?**	**?**
Baneberry	**12/18/1970**	**10**	**3000**	**81,000**
Diagonal Line	11/24/1971	<20	0.05	1.35
Rio Blanco, Plowshare in Rifle, Colorado	05/17/1973	99	?	?
Riola	09/25/1980	1.07	0.02	0.54

Units: TBq = Tera (10^{12}) Becquerel, 1 Ci = 1 curie = 3.7E10 disintegrations/second = 3.7E10 Bq

kT = kilotons, The only Plowshare tests listed were "crater" type. Carpetbag test on 12/17/70 added to table but not officially noted as causing an offsite release. The iodine-131 release for 12/18/70 Baneberry test seems disproportionately high for its yield.

Sources: http://www.unscear.org/unscear/en/publications/1993.html and FAS.org summary of DOE/NV-209.

Now that more than 50 years have passed since the bulk of the US weapons testing took place, health studies are still not complete, the data for regional US weapons testing are scattered around and currently cannot be accessed on Department of Energy websites. The need to hide the fact that the US was still releasing fallout after the 1963 partial test ban—accidentally they claimed on numerous occasions—radionuclides from weapons testing at the NTS meant that the Idaho Operations Office and the US Geological Survey were not to put too fine a point on any environmental monitoring that might disclose US DOE weapons fallout or INL fallout.
The same folks that put a film badge on my grandmother's white picket fence in the 1950s chose to act like they were not able to provide enough coherent environmental monitoring of air, water or milk through the 1980s to explain INL releases versus NTS releases or global fallout. The lapses, omissions, destroyed samples, lost data, general fuzziness, etc. appear to be deliberate.

There may have been correlations between weapons testing and aquifer monitoring particularly for tritium and especially when the well was not located near or downgradient from disposal wells injecting large amounts of tritium into the aquifer. Wells that were fed from surface water and mountain runoff were not necessarily monitored for radionuclides—or at least, the data does not appear to have been made public.

Radionuclide monitoring in the aquifer at the INL and downgradient been conducted by the USGS. However, it is difficult to find coherent data. A well may be monitored for a few chemical constituents but no radionuclides. It may be monitored for chemicals but only one time in 30 years. Radionuclides may be detected at elevated levels, but the well is not sampled again. The set of radionuclides sampled may be extremely minimal.

Radionuclide sampling took place in the 1960s but rarely included uranium and thorium sampling along with tritium and other radionuclides. It becomes challenging to discern what normal background levels are, and trending is difficult or impossible, by design.

The importance of the under-reported uranium and thorium fuel separations waste from INL into the aquifer is that the INL is the likely source of much of the elevated gross alpha contamination in downgradient community drinking wells in the Magic Valley.

Uranium consists of uranium-238, uranium-235 and uranium-234. Important decay chain products for Uranium-238 include thorium-234, thorium-230, radium-226, radon-222, lead-214, -210 and -206. Important uranium-235 decay chain products include thorium-231, thorium-227, radium-223, radon-219, and lead-211 and lead-207.

Natural thorium-232 was also disposed of at the INL. Important decay chain products of thorium-232 include radium-228, actinium-228, radium-224, radon-220, and thallium-208, lead-212, and -208.

Thorium-232 was used to breed fissile weapons material uranium-233. There were many U-233 programs at the Idaho site at the Naval Reactors Facility, Test Reactor Area (now the ATR Complex), ANL-W (now the Materials and Fuels Complex), and the Radioactive Waste Management Complex. Uranium-233, analogous to fissile weapons material plutonium-239, is bred from thorium fuel combined with highly enriched uranium-235 seed fuel. The Department of Energy dumped anything and everything into the Snake River Plain aquifer in the 1950s through 1970s. Direct disposal to the aquifer of thorium and uranium materials following examination, separations or reprocessing operations at the INL resulted in largely unmonitored or under-monitored contamination of the aquifer until drinking water programs began in the late 1980s and early 1990s in the State of Idaho.

Many radioactive and chemical wastes resulting from DOE facilities at the Idaho National Laboratory were not identified by the USGS aquifer monitoring when CERCLA cleanup investigations commenced —see the CERCLA cleanup report and others at the administrative record. [28] Along with plutonium and many uranium isotopes, the INL CERLCA cleanup found contaminants of concern, meaning that the quantities involved were significant to human health, that included thorium isotopes, uranium-233 fissile material bred from thorium, and europium-152, a contaminant of U-233 production. Many of these contaminants were rarely if ever reported by the USGS as having been disposed of at INL prior to CERCLA cleanup investigations.

The high levels of gross alpha from uranium and thorium radioactive wastes, along with hexavalent chromium, have long reached Idaho's Magic Valley. [29] They not only reached the Magic Valley, the contaminants have adversely affected the health of people drinking the water.

Comparison of Background Levels of Constituents in the Aquifer to Historical Highs near INL Facilities

The US Geological Survey has been monitoring various chemical properties and constituents in the Snake River Plain aquifer since 1949. The waste water disposal commenced in the early 1950s at the National Reactor Testing Station now called the Idaho National Laboratory. Various reports have provided background levels of constituents; however, many of these reports muddy the water, so to speak, because while they exclude the most highly contaminated wells at INL,

[28] See INL CERCLA Cleanup Administrative Record at https://ar.icp.doe.gov and See one report for an idea of contaminants in Department of Energy Idaho Operations Office, "Final Removal Action Report for CPP-601, CPP-602, CPP-627, CPP-630, and CPP-640," DOE/ID-11453, February 2012. See Table 3, p. 19 and 20. *https://ar.icp.doe.gov/images/pdf/201202/2012022800768BRU.pdf*

[29] Department of Energy, Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report, INEEL/EXT-03-01169, Rev. 2, September 2003. p. 4-2. at https://inldigitallibrary.inl.gov/sti/3562854.pdf

they tend to include numerous contaminated wells, thus inflating what they term background levels of contaminants from what is natural or is flowing in from aquifer source water from northern and western mountain ranges.

It is essential to know the background levels of various aquifer constituents. However, a recent US Geological Survey report of background levels, the report issued by the USGS in 2016, lacks a comprehensive set of constituents — and it has inflated the background levels by averaging in so many wells influenced by INL waste water [30] as can be seen in Table 4.

The constituents and properties compiled in Table 4 show a small set of background levels for comparison. The constituents and properties include specific conductance, chloride, sodium, nitrate, sulfate, chromium, hexavalent chromium, bicarbonate, organic compounds, barium and tritium. These constituents (or properties) were selected because they tend to be increased at least several fold by INL waste water practices and because they are more prevalently reported. The primary references for Tables 4 through 6 are Robertson (1974),[31] Orr (1991), [32] Bagby (1985), [33] Knobel (1992), [34] Knobel (1999), [35] and Bartholomy (2015), [36] Bartholomay (2016), [37] and the

[30] Bartholomay, R.C., and Hall, L.F., "Evaluation of background concentrations of selected chemical and radiochemical constituents in water from the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho: U.S. Geological Survey Scientific Investigations Report 2016-5056 (DOE/ID-22237), 2016. http://dx.doi.org/10.3133/

[31] Robertson, J.B. et al, "The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970," US Geological Survey, IDO-22053, UC-70, February 1974. https://pubs.er.usgs.gov/publication/ofr73238

[32] Orr, .R., Cecil, L.D., and Knobel, L.L., US Geological Survey, "Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical Constituents in Ground Water in the Vicinity of the Idaho National Engineering Laboratory: US Geological Survey Water Resources Investigations Report 91-4015, DOE/ID-22094, 1991.

[33] Bagby, J.C. et al., US Geological Survey, "Water-Quality Data for Selected Wells On or Near the Idaho National Engineering Laboratory, 1949 through 1982., Open-File Report 84-714, 1985.

[34] Knobel, L.L. et al., US Geological Survey, "Chemical Constituents in the Dissolved and Suspended Fractions of Ground Water From Selected Sites, Idaho National Engineering Laboratory and Vicinity, Idaho, 1989," Report 92-51, March 1992. See Table 19 for USGS well 14 contamination including thorium-232 decay products lead-212 and radium-228. They were mystified by the variations in monitored contaminant levels in the same well. But the variations likely resulted from the stratified contamination levels and variation in mixing the stratified levels during well sampling. http://pubs.er.usgs.gov/usgspubs/ofr/ofr925

[35] Knobel, L.L. et al., "Chemical constituents in ground water from 39 selected sites with an evaluation of quality assurance data, Idaho National Engineering and Environmental laboratory and vicinity, Idaho: US Geological Survey Open-file Report 99-246, DOE/ID-22159, 1999.

[36] Bartholomay, R.C., Hopkins, C.B., Maimer, N.V., US Geological Survey, "Chemical Constituents in Groundwater from Multiple Zones in the Eastern Snake River Plain Aquifer, Idaho National Laboratory, Idaho, 2009-13," Scientific Investigations Report 2015-5002, DOE/ID-22232, 2015.

[37] Bartholomay, R.C., and Hall, L.F., "Evaluation of background concentrations of selected chemical and radiochemical constituents in water from the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho: U.S. Geological Survey Scientific Investigations Report 2016-5056 (DOE/ID-22237), 2016. http://dx.doi.org/10.3133/

NRF Final EIS. [38] Many other contaminants were also influenced by INL waste water practices such as zinc, iron, aluminum etc. are not addressed here.

Table 4. A compilation of key non-radiological background levels of various aquifer constituents from various reports and tritium.

Constituent	Robertson, 1974 [b]	Orr, 1991	Knobel, 1992	Knobel, 1999 [c]	Bartholomay, 2016 [d]
Specific conductance	225	ns	ns	ns	ns
Chloride, mg/L	6.6	ns	14	7.4	11.8
Sodium, mg/L	7	ns	ns	6.5	8.3
Nitrate (NO3)[a]	0.5	0-1.4	ns	0.32	0.655
Sulfate, SO4, mg/L	21	ns	30.5	12	21.4
Chromium, ug/L	ns	2-3	ns	1	4
Hexavalent chromium, ug/L	ns	ns	ns	ns	ns
Bicarbonate HCO3, mg/L	81	ns	157	ns	176
Organic compounds, ug/L	ns	<0.2	ns	100	ns
Barium, ug/L	ns	50 - 70	<100 [e]	<70 as indicated by USGS 8	ns
Tritium, pCi/L	ns	75 to 150	38	70	34

Units: Specific conductance in units of mircosiemens per centimeter at 25 degrees Celsius as (uS/cm).
mg/L = milligram per liter; ug/L = microgram per liter; pCi/L = picocurie per liter.
Table notes:
a. Nitrate is often reported as "Nitrite plus Nitrate" but the nitrite contribution is small.
b. The data from Robertson, 1974 are from Table III for USGS 17, a well located upgradient of TRA, NRF and INTEC and relatively distant from TAN.
c. The data from Knobel, 1999 are from Table 8, well USGS 17.
d. The data from Bartholomay, 2016, Report 2016-5056 (DOE/ID-22237) from Table 1, the median value for the western tributary.
e. Data from Knobel, 1992, Report 92-51 indicate a barium concentration of less than 100 ug/L in well 98, an elevated value because the well is downgradient from NRF. Wells downgradient from RWMC are reported to have barium concentrations less than 51 ug/L in Table 7. In Report 88-332, the USGS reports elevated barium levels, often above 130 ug/L downgradient from INTEC, TRA and NRF.

[38] Recapitalization of Infrastructure Supporting Naval Spent Nuclear Fuel Handling, DOE/EIS-0453-F, 2016, Chapter 3.

The two important points to recognize from Table 4: (1) the table gives a relative order of magnitude for expected background levels, and (2) the so called "background" data published in 2016 tend to inflate what natural background levels should be because they include so many somewhat contaminated wells at INL.

Background levels for source water to the aquifer are provided in Table 5. This table gives some basis for understanding that the elevated chloride, tritium and others are not due to source water inflow to the aquifer north or west of the INL. Other than tritium, the other constituents are not found in global or regional weapons testing fallout.

Table 5. A compilation of key non-radiological background levels of various aquifer constituents of Big Lost and Birch Creek source water compared to 2016 INL background levels, and tritium.

Constituent	Birch Creek, 2015 [b]	Big Lost, 1974 [c]	Big Lost, 2015 [d]	INL Background Levels [e]
Specific conductance	ns	333	ns	ns
Chloride, mg/L	8.2	3.5	6.4	11.8
Sodium, mg/L	9.0	6.9	5.7	8.3
Nitrate (NO3)[a]	0.53	0.5	0.71	0.655
Sulfate, SO4, mg/L	29	18	20	21.4
Chromium, ug/L	ns (<1.9 in 2003 report [f])	ns	ns	4
Hexavalent chromium, ug/L	ns	ns	ns	(<1, see Note g)
Bicarbonate HCO3, mg/L	162	192	222	176
Organic compounds, ug/L	ns	ns	na	ns
Tritium, pCi/L	6.4	ns	35.2	34

Units: Specific conductance in units of mircosiemens per centimeter at 25 degrees Celsius as (uS/cm).
mg/L = milligram per liter; ug/L = microgram per liter; pCi/L = picocurie per liter.
Table notes:
a. Nitrate is often reported as "Nitrite plus Nitrate" but the nitrite contribution is small.
b. The data from Bartholomay, 2015, are from Appendix A and for the source water Birch creek underflow.
c. The data from Robertson, 1974 are from Table IV for the Big Lost River, 1963 data.
d. The Big Lost river data are cited in Bartholomay, 2015 (DOE/ID-22232) Appendix A from a 2001 citation.
e. The background values are selected from Bartholomay, 2016, are from Table 1, the median value for the western tributary.

f. Chromium was sampled in the Birch creek area in USGS 2003-4272, off INL site levels below 1.9 ug/L.
g. Review of USGS report 93-126 indicates that background levels of hexavalent chromium levels should be <1 ug/L. The 1972 USGS Robertson report, IDO-22053, using detection capability of 5 ug/L stated that neither chromium nor hexavalent chromium were detectable where there was not INL contamination. The report also noted that 10 percent of hexavalent chromium may convert to chromium-III; therefore, they used chromium monitoring as an indicator of hexavalent chromium.

Now a description of some revealing historical maximums of various constituents in INL waste water in Table 6. These noted maximum values give some perspective of the contaminant or constituent levels at or near various INL facilities from various wells at or downgradient the facility for the set of constituents noted above.

Groundwater monitoring data after 1952 near the Test Reactor Area (now the ATR Complex), Naval Reactors Facility (NRF), and chemical processing plant (now INTEC) is typically influenced by waste water practices. The enormous water volumes involved with TRA and INTEC increased the plume spread of the contaminants. Waste water practices at Test Area North (TAN) involved multiple disposal wells but involved lower total water volumes. Leaching of waste from the burial ground (now the RWMC) is indicated by higher downgradient contamination south of RWMC. But contaminants from TRA, NRF and INTEC also influence RWMC contamination as well as contamination south of these facilities at Central Facilities Area, the south boundary of INL and also south of the INL flowing to the Magic Valley. The disposal of waste water was not steady and constant; it was sporadic and variable.

Table 6. A compilation of key non-radiological historical aquifer maximums from various reports near INL facilities and INL background levels and tritium. [b]

Constituent	RWMC	TAN	INTEC	TRA	NRF	INL Back-ground 2016 [d]	Suggested INL Back-ground
Specific conductance	>400, 1220	440	623	3880	711	ns	~300
Chloride, mg/L	82	69	341	81	120	11.8	<10
Sodium, mg/L	88	97	39	136	47	8.3	<7
Nitrate (NO3)[a]	1.8	4.4	7	9	1.7	0.655	0.5
Sulfate, SO4, mg/L	88	4088	3540	150	39	21.4	21
Chromium, ug/L	9	10	80	414	43	4	2-3
Hexavalent chromium, [c] ug/L	38	8	46	160	9	ns	0
Bicarbonate HCO3, mg/L	340	522	200	190	343	176	81
Organic compounds, ug/L	ns	ns	ns	ns	ns	ns	<0.2
Barium, ug/L [c]	29	140	190	71	130	ns	<70
Tritium, pCi/L	300 to 26,000	2000	260,000	663,000	6800 Since 2010 <150	34	<35

Units: Specific conductance in units of mircosiemens per centimeter at 25 degrees Celsius as (uS/cm).
mg/L = milligram per liter; ug/L = microgram per liter; pCi/L = picocurie per liter; ns = not sampled.

Table notes

a. Nitrate is often reported as "Nitrite plus Nitrate" but the nitrite contribution is small.

b.Bagby 1985 is an over 800 page report covering 1949 to 1982 and peak values of various constituents were searched for in the report to give some idea of the higher values at or near INL facilities. Both Knobel 1992 and 1999 reports and the NRF Final EIS (2016) were also reviewed. The background data are from Bartholomay, 2016.c. Mann, L.J. and Knobel, L.L., "Concentrations of Nine Trace Metals in Ground Water at the Idaho National Engineering Laboratory, Idaho," US Geological Survey, Report 88-332, May 1988. Table 2 in this report shows wells near RWMC as less than 29, at the TAN disposal well of 140 ug/L, at INTEC USGS 113 of 190 ug/L, at TRA USGS 58 of 71 ug/L, and at NRF USGS 97 and NRF wells of 130 ug/L.

c. USGS report 93-126 monitoring of hexavalent chromium 1989 to 1991 indicates elevated levels at TAN, NRF, CPP, RWMC as well extensive contamination at TRA.

Background concentration levels have been presented in Table 6 from a 2016 USGS report and a suggested background level is provided.

The historical values in Table 6 are for the aquifer rather than perched water which may have been higher, sometimes much higher, at INL facilities. The historical contaminant concentrations noted in Table 6 are peaks or maximums from various reports and are not exhaustively searched but illustrate that these constituents reached many times normal INL background.

Specific conductance, sodium, chloride, sulfate and tritium were greatly increased where fuel reprocessing or fuel separations operations were conducted near INTEC, TRA and NRF. The sulfate level was increased over 2000 fold at TAN and INTEC above background levels. Nitrate was increased roughly 10 fold at INTEC due to nitric acid process water. Nitric acid is used for dissolved spent nuclear fuel. Other steps in fuel reprocessing involve other chemical contaminants.

The Test Reactor Area (TRA) was the main source of hexavalent chromium contamination but other facilities including NRF and INTEC likely disposed of hexavalent chromium also.

Tritium is included in the Tables 4 through 6 to give a perspective into the radionuclide contamination in INL waste water. This is not to imply that tritium was the only radionuclide in waste water contamination at INL. But tritium is highly mobile in water and was the most often monitored radionuclide after its monitoring began about 1961.

Key chemical contaminant markers for INL waste water contaminants include sodium, chloride, sulfate, organic carbon and others that the USGS has marked with an asterisk in the Kimama report's Table 5 are designated as "probably affected" by well drilling gel solution. [39]

Radionuclides from INL waste water contamination went largely unmonitored or incompletely monitored for many years. Even when a radionuclide was a known contaminant, it may have been monitored only years after injection, and only spottily monitored if at all. The key point, though, is that source water to the INL has low tritium levels, in recent years far below 100 pCi/L. Source water from global or regional nuclear weapons testing fallout, then cannot be the source of elevated levels of tritium, above 800 pCi/L measured in 2010 at Kimama. This is further underscored by the lack of elevated non-radiological constituents in source water from mountain ranges.

But the non-radiological constituents from INL waste water have long been elevated and have been found south of the INL. In fact, the USGS frequent monitoring and the huge number of

[39] USGS "Geophysical Logs and Water Quality Data for Boreholes Kimama-1A and -1B, and a Kimama Water Supply Well near Kimama, Idaho," Data Series 622,DOE/ID-22215, 2011.

wells they dug, show trends of increasing levels of chloride, sodium, and nitrate by the 1960s. The USGS obviously knew these constituents were indicating the front of the tide of contaminants from INL waste water.

Nothing but a Few Atoms of Contamination from INL prior to 1989? Look at the Facts

The Atomic Energy Commission (AEC) that ran the National Reactor Testing Station, or the INL, issued reports that stated that they were rigorously monitoring the groundwater both at the INL and south of the INL in the 1950s and 1960s. Tritium was not monitored routinely prior to about 1960, but monitoring of water characteristics, gross alpha and gross beta contamination was being conducted.

The results were summarized without well identifiers or specific well monitoring results. However, maximum reading and group average gross alpha and beta results for the INL on-site and INL offsite south of INL were given. The criteria for concentrations of the radionulicdes in groundwater (drinking water) were looser then and the analytical capabilities for water analysis more primitive. The extensive monitoring of the Magic Valley in the 1950s and 1960s reveals the understanding by the USGS that the contamination would be expected there. And during many years of monitoring, they were not claiming that there was no effect on the Magic Valley from INL operations.

Those were in the golden years prior to 1963 — before citizens began to realize that weapons testing was putting strontium in their children's teeth, for example. As people became more aware that radioactive contamination might be affecting their health, the AEC became even less forthcoming about its activities and more inclined to deny that any contamination from INL was detected offsite.

The practice of avoiding discussion of a complete set of INL contaminants including a complete set of radionuclides of significance has been prevalent. In the early years, only gross alpha and gross beta were monitored and then, only averages given out. Now, while the Idaho Department of Environmental Quality still uses gross alpha and gross beta, the INL does not even provide a background level for them.

Various long-lived radioisotopes were deliberately not discussed by the USGS including, for many years, chloride-36, neptunium-237, iodine-129, various uranium and thorium isotopes and their decay progeny. The AEC, now the Department of Energy, wanted to avoid letting the public know that very long-lived radioisotopes were being dumped into the aquifer for the relatively quick ride down to the Magic Valley.

The USGS might now give excuses that groundwater monitoring prior to the 1980s was primitive and unreliable. But that's only if a monitoring result appears high. They seem to stand behind any and all measurements that indicate that the contaminant concentrations were low.

The USGS often indicate in their reports that the sample result was not requested, or the sample was lost, or the sample was destroyed, etc. . And often quite contaminated wells are simply not "selected" for inclusion in the report. Sometimes very high uncertainties where involved and so the USGS could effectively hide contamination by saying they could not be confident of detection, thus the contamination was "below the reporting limit." And then there is the continued practice of resampling if the sample concentration for the constituent is high so the next sample can show a low, which could easily be a diluted sample. There is no such treatment if the initial sample indicates that the concentration is low.

Interesting Tritium Spikes in the 1960s

One report with monitoring of the Snake River aquifer beneath the INL and vicinity, including Mud Lake and also south of the INL was published by the USGS spanning 1949 through 1982. [40] This report does have some apparent mistakes; however, it contains a great deal of useful data. But the reader must note that in addition to primitive radionuclide sampling results, the results are typically given in picocuries/milliliter (pCi/ml) and must be multiplied by 1000 to obtain pCi/L.

The INL then called the National Reactor Testing Station would dispose of over 30,000 curies of tritium into the Snake River Plain Aquifer in the 1950s, but aquifer monitoring of tritium did not begin until the 1960s. The largest tritium releases were known to occur from INL facilities such as INTEC, formerly the chemical processing plant, and the ATR Complex, formerly the Test Reactor Area (TRA). And even after the US Geological Survey began monitoring tritium, its monitoring was sporadic.

Beyond the disposal wells and ponds at these facilities putting tritium into the aquifer that did flow downgradient, there were two important sources of airborne tritium that potentially affected groundwater monitoring: (1) global and regional nuclear weapons testing and (2) INL fallout from reactor operations and particularly, from open-air large scale destructive reactor fuel testing.

Table 7 and 8 below show tritium data with an emphasis on finding 1960s tritium data in USGS Bagby report 84-714.

[40] Bagby, J.C. et al., US Geological Survey, "Water-Quality Data for Selected Wells On or Near the Idaho National Engineering Laboratory, 1949 through 1982., Open-File Report 84-714, 1985.

What the data from tritium monitoring show is that there are definitely wells both downgradient of these INL facilities and also wells that were NOT downgradient from large tritium waste water sources from the INL that have spikes in tritium concentrations exceeding 4000 pCi/L in the 1960s. The question then is whether this is from weapons testing fallout or INL fallout. And whichever one it is, was the ground water contaminated or could perhaps the laboratory monitoring the tritium be contaminated from the airborne contamination? Two notable spikes that produce high tritium concentrations in wells including wells not downgradient of INL injection wells occur in mid-1965 and fall of 1966. Those spikes are bolded in the tables below. The Department of Energy's radiological releases continuing from the Nevada Test Site that were for years unreported, following 1963, may likely be the cause of elevated tritium levels if INL radiological releases were not the cause.

The USGS parameter code of 07005 was the only code used by the USGS for tritium in the Bagby report. In the Bagby report, uncertainty values were sometimes entered under parameter code 07006. Years later, a different parameter code would be used for tritium, 07000, with 07001 the code for uncertainty value.

Where the data appear to have obviously been incorrectly entered in the 84-714 report —for example, data appearing to be 1000 times too high— I have entered data as I believe was a correction. Other data that seem impossible are marked with two question marks.

I suspect that where the data are entered several times as 2.00 or 4.00 pCi/ml and with no uncertainty value, it looks suspiciously like they were economizing on effort to the extent that the data may or may not be monitored. **However, when the tritium data spikes high and the associated uncertainty value was entered and is correspondingly high, this appears to be a valid entry.**

It is telling that tritium concentrations approaching or exceeding 20,000 pCi/L off the INL site were not cause for USGS to communicate this to the public or to discuss it in their reports, then or later on as more restrictive tritium concentrations for drinking water were enacted. The USGS practice appears to be to avoid discussing these measurements and now to dismiss these readings historical readings as unreliable—but we are expected to believe the low readings.

What is most telling is the lack of any commentary or public notification of the exceedingly high tritium levels in offsite wells, or any explanation of why the data should not be considered valid representation of aquifer tritium concentrations. Much of this data has simply been "disappeared" by the USGS.

Table 7. Tritium data prior to 1982 as available on INL excluding key aquifer injection sites.

Downgradient from injection sites of INTEC or TRA		Not downgradient from injection sites of INTEC or TRA	
Well name	Date and tritium level (pCi/L)	Well name	Date and tritium level (pCi/L)
EOCR (southeast of INTEC, north of Atomic City)	06/62 4000 09/62 4000 11/62 1200 12/62 2400 10/64 4000 12/64 4500 +/- 800 03/65 2000 **06/65 7000 +/- 1000** 09/65 2000 12/65 2000 02/66 2000 **10/66 70 ??** **10/66 28,000 +/- 9000** 04/67 2000 10/67 5000 +/- 2000 12/67 0 +/- 700 01/68 through 4/73 equal 2000 08/73 7000 +/- 2000 10/73 1000 01/74 1000 04/74 1000 10/74 1000	Arbor Test (Near EBR-II, ANL-W now the Materials and Fuels Complex)	07/60 35000 06/62 4000 09/62 4000 12/64 6200 03/65 2000 **07/65 7000** 09/65 2000 12/65 2000 03/66 2000 09/77 200
O.M.R.E (southeast of INTEC, north of Atomic City)	10/61 8600 10/61 4000 10/61 3900 10/61 3900 10/61 4000 10/61 3200 11/61 3600 **01/65 84000 +/- 800 ??** 03/65 5000 +/- 1000 **06/65 10000 +/- 1000** **09/65 7000 +/- 1000** **12/65 6000 +/- 1000** **03/66 8000 +/- 1000** 07/66 3000 +/-1000 **10/66 9000 +/- 1000** 04/67 3000 +/- 1000 10/67 10000 +/- 2000 05 68 4000 +/- 1000 10/68 8000 +/- 2000 04/69 5000 +/- 2000 10/69 5000 +/- 2000 04/70 4000 +/- 2000	Area II (southwest of EBR-II, ANL-W now the Materials and Fuels Complex) EBR II 1 (ANL-W, now the Materials and Fuels Complex)	06/62 4000 09/62 4000 12/64 2900 03/65 5000 **07/65 9000** 09/65 2000 12/65 2000 03/66 2000 04/77 (0) 09/77 0.0 08/69 11,000 01/63 1600 03/65 2000 06/65 2000 **06/65 8000 +/-1000** equal 2000 through 1968 09/77 200 +/-200

	10/70 8000 +/- 2000 04/71 5000 +/- 2000 01/72 9000 +/- 2000 04/72 8000 +/- 2000 07/72 2000 10/72 4000 +/- 2000 01/73 4000 +/- 2000 04/73 6000 +/- 2000 08/73 2000 10/73 8000 +/- 2000 01/74 6000 +/- 1000 04/74 6000 +/- 2000 07/74 6000 +/- 1000 10/75 5600 +/- 200 04/76 5600 +/- 400 10/76 5800 +/- 500 04/77 5600 +/- 400 09/77 4300 +/- 200 04/78 5900 +/- 500 07/78 6100 +/- 500 10/78 5600 +/- 400 04/79 4900 +/- 400 10/79 4900 +/- 400 04/80 4100 +/- 400 10/80 4700 +/- 200 04/82 4300 +/- 200 10/82 3400 +/- 200	SPERT 1 (located west of EBR-II and east of INTEC)	10/61 4000 10/61 2200 06/62 4000 09/62 40,000 09/64 4000 12/64 4800 +/-800 *12/64 48,000 ?? +/-800 **03/65 13,000 +/-1000** 06/65 6000 +/-1000 09/65 3000 +/-1000 09/65 4000 01/66 2000 03/66 2000 07/66 60 10/66 2000 Equal 2000 or less through 04/72
USGS 83	1962 4000 monitored 5 times 08/62 4500 01/63 2400 02/63 4700 03/63 1400 03/63 4000 05/63 4000 05/63 2700 06/63 4000 07/63 10,000 08/63 4000 09/63 3000 09/63 4000 10/63 4000 12/63 1400 01/64 4000 03/64 2300 03/64 4000 04/64 4000 05/64 1700 05/64 6000 05/64 3500 05/64 3500	USGS 15 (south of Howe, north of NRF)	11/62 2300 06/64 3100 01/65 6600 **07/65 9000** 12/65 2000 03/66 2000 09/77 0.0

	05/64 4000 07/64 4000 08/64 4000 09/64 4000 01/65 5500 03/65 2000 06/65 2000 Equal or below 2000 except * 05/68 9,000 * 10/71 13,000		
USGS 9	10/61 4000 03/62 4000 04/62 5000 +/- 2000 06/62 7200 +/- 1900 12/62 2300 03/63 9500 +/- 2000 12/63 4000 03/64 4000 05/64 3900 +/- 700 07/64 4000 09/64 4000 12/64 4200 +/- 800 01/65 5200 +/- 800 03/65 2000 **05/65 11000 +/- 1000** **06/65 9000 +/- 1000** 09/65 2000 12/65 2000 03/66 2000 07/66 1310 **11/66 40 +/- 13000??** 07/67 2000 12/67 30 +/- 12000?? 5/68 – 4/73 2000 10/73 1000 07/74 1000 10/74 1000 05/75 60 +/- 120 10/75 200 +/- 200 04/76 400 +/- 200 07/77 0 +/- 200 09/77 0 +/- 200 04/78 400 +/- 200 10/78 200 +/- 200 03/79 +/- 200 10/79 0 +/- 200 04/81 0 +/- 200 10/81 200 +/- 200 04/82 200 +/- 200	USGS 19 (South of Howe, north of NRF)	12/62 3600 03/63 4000 06/64 3900 01/65 4900 **06/65 7000** 12/65 2000 **07/66 70 ??** **11/66 0.0 +/- 9000 ??** 04/67 2000 12/67 0.0 +/- 700 05/68 2000 10/68 2000 04/69 2000 10/69 2000 04/70 2000 11/70 2000 04/71 2000 10/71 2000 04/72 2000 10/72 2000 04/73 2000 10/73 1000 04/74 1000 10/74 1000 04/75 140 +/- 120 Less than or equal 200 through 10/82

	08/82 140 (assumed) 10/82 200 +/- 200		
USGS 104	10/80 400 +/- 200 11/80 200 +/- 200 12/80 600 +/- 200 12/80 800 +/- 200 12/80 1000 +/- 200 12/80 800 +/- 200 12/80 1200 +/- 200 12/80 800 +/- 200 12/80 1000 +/- 200 12/80 1000 +/- 200 12/80 800 +/- 200 12/80 800 +/- 200 04/81 1000 +/- 200 07/81 400 +/- 200 10/81 800 +/- 200 04/82 1100 +/- 200 07/82 200 +/- 200 10/82 800 +/- 200	USGS 17 (Northeast of NRF)	04/62 4500 03/63 4000 06/64 5600 01/65 4000 06/65 2000 **06/65 8000** 12/65 2000 09/77 0.0
		USGS 29 (near Test Area North, south of Mud Lake on east INL boundary)	07/61 4000 06/62 4100 09/62 4000 01/65 4200 **07/65 9000** 12/65 2000 09/77 0.0

Units: pCi/L = picocuries/liter. Source: USGS Report 84-714.

Table 8. Tritium data prior to 1982 as available, wells in INL vicinity offsite.

Wells downgradient from INTEC/TRA South of INL		Wells not downgradient from INTEC/TRA outside INL	
Well name	Date and tritium level (pCi/L)	Well name	Date and tritium level (pCi/L)
Cerro Grande (INL southern boundary)	12/62 2300 05/63 1400 06/63 1500 +/- 720 12/63 1800 +/- 720 05/64 4800 +/- 700 12/64 8600 +/- 800 03/65 2000 **06/65 6000 +/-1000** 09/65 2000 12/65 2000 03/30 2000 **10/66 50 ??** 04/67 2000 12/67 0.0 +/- 300 equal or less than 2000 to 1982	Mud Lake (discrepancy in well identification, probably near the Mud Lake surface water, however)	11/61 4000 12/62 2300 04/63 1700 03/64 1400 05/64 1400 06/64 1800 +/- 800 07/64 1400 04/65 2000 05/65 3000 +/-1000 **05/65 12000 +/-1000** **07/65 10000 +/-1000** **08/65 18000 +/-2000** 09/65 2000 04/66 2000 05/66 2000 06/66 2000 **10/66 93000 +/-9000** 03/67 800 +/- 40 03/67 2000 06/67 2000 03/68 2000 06/68 2000 08/68 2000 04/69 2000 09/69 2000 through 4/73 2000 04/74 1000 10/74 1000 04/75 180 +/- 120 10/75 200 +/-200 less than or equal 400 through 10/82
Leo Roger 1 (INL southern boundary)	04/67 2000 07/67 2000 07/70 17,000 +/- 2000 06/71 7000 +/- 2000 04/72 2000 10/72 2000 07/73 2000 05/75 0 +/- 100 04/77 200 +/- 200 06/78 480 (assumed) 07/80 0 +/- 200 07/81 200 +/- 200		
Atomic City	11/62 1200		

(INL southern boundary)	12/62 2300 06/63 1400 12/63 1400 12/63 4000 05/64 1600 +/- 720 05/64 3900 +/- 700 01/65 7600 +/- 800 06/65 2000 **06/65 11000 +/- 1000** 08/65 2000 12/65 2000 03/66 2000 (no data for fall 1966) 12/67 2100 +/- 300 Equal 2000 through 4/73 10/73 1000 Equal or less than 1000 to 1982		
USGS 8 (west of RWMC)	12/65 thru 4/72 2000 09/77 200 06/80 200 04/82 0 10/82 0		
USGS 11 (south of RWMC)	08/60 9600 06/65 3000 +/- 1000 **06/65 9000 +/- 1000** 09/65 2000 12/65 2000 03/66 2000 05/71 2000 04/72 2000 09/77 0 +/- 200 12/78 200 +/- 200 03/79 0 +/- 200 10/79 400 +/- 200 04/80 800 +/- 200 06/80 200 +/- 200 10/80 200 +/- 200 04/81 200 +/- 200 10/81 200 +/- 200 04/82 0 +/- 200 08/82 0 +/- 200 10/82 0 +/- 200		
USGS 13 (west of RWMC)	07/65 2000 06/80 200 +/- 200 04/82 200 +/- 200		
USGS 14 (south of Atomic City)	03/65 2000 06/65 2000 **06/65 9000 +/- 1000**		

	09/65 2000 12/65 2000 03/66 2000 04/71 2000 04/72 2000 09/77 0 +/- 200 12/78 0 +/- 200 03/79 0 +/- 200 10/79 0 +/- 200 04/80 200 +/- 200 10/80 200 +/- 200 04/81 0 +/- 200 10/81 400 +/- 200 04/82 0 +/- 200 08/82 0 +/- 200 10/82 0 +/- 200		
USGS 16 (south of USGS 14)	07/60 26,000 06/65 2000 **06/65 8000 +/- 1000**		
Wheatgrass (south of USGS 14, north of USGS 16)	05/78 480 pCi/L assumed unit error in report. 04/80 0 pCi/L		
Simplot (near Tabor, south of INL and west of Blackfoot)	No tritium data. But the limited 1970s data suggest bicarbonate (HCO3), nitrate (NO3), and sodium elevated from INL contamination.		

Units: pCi/L = picocuries/liter. Source: USGS Report 84-714.

The tritium concentrations from tables 7 and 8 show that elevated tritium levels miles from disposal facilities were not uncommon. The USGS has chosen to ignore most of their own data saying that it was "spurious" or "unreliable" or due to global weapons testing. By their omitting these data from their reports they have neglected to explain the data. The number of elevated values is too great to have been simply a spurious analytical result. And the magnitude of the tritium measurements reveal anything but a trivial problem during the 1960s. If the tritium levels in the aquifer were elevated because of global weapons testing fallout, the magnitude of the measurements should have been similar as the contamination blew in from many hundreds of miles away. But the highest spikes of tritium in the aquifer occur near INL facilities, even those with little waste water disposal and at locations upgradient from INL facilities that had extensive waste water disposal. The USGS has never attempted to do more than tap dance around as they have sought to hide the extent of INL and NTS weapons testing airborne radiological releases as well as waste water disposal to the aquifer.

There is an absence of groundwater monitoring in 1963 as various tests were planned near EBR-II. The northern portion of the INL is rarely monitored from 1965 into the mid-70s perhaps because of the extensive contamination from the SNAPTRAN destructive nuclear reactor tests.

I shall also point out that in reviewing USGS mapper data for wells located south of INL, I noted several entries for the 1960 tritium concentration that are incorrect entries. For example, an entry for tritium concentration in 1960 was entered as 21 pCi/L. The entry of anything less than 2000 pCi/L is not possible in 1960 because that refinement of detection capability did not exist. Either the value is either supposed to be 1000 times higher, 21,000 pCi/L or it is a completely erroneous entry. The errant tritium data used parameter code 07000 rather than 07005 that was commonly used in 1960. The accuracy of tritium monitoring was no better than roughly plus or minus 200 pCi/L even into 1977. The errant data occur in off-site well 425019113474101 for 1960 which says the tritium concentration is 21 pCi/L. It occurs another well south of INL, 430626113391001, which says the tritium concentration for 1960 was 32 pCi/L. And for 425909113444101, which says the tritium concentration is 40 pCi/L in 1960. No uncertainty entries and not even the parameter code for tritium uncertainty was in the quality records. These wells had only tritium concentrations or very limited monitoring data. The fact that the USGS had sampled tritium in 1960 — even if it is reported incorrectly is interesting, Why wasn't this data reported by the USGS in later reports of Magic Valley contamination monitoring?

Uranium and Thorium Radioactive Waste Dumping at INL

The acceptance of direct dumping of thorium and uranium related material following separations or examinations processes at the Department of Energy's Hanford facility gives important insight into the dumping practices at Idaho's Department of Energy site, now called the Idaho National Laboratory. There were many U-233 programs at the Idaho site at the Naval Reactors Facility, Test Reactor Area (now the ATR Complex), ANL-W (now the Materials and Fuels Complex), and the Radioactive Waste Management Complex.

In fact, the thorium and uranium in the Snake River Plain aquifer found by various US Geological Survey reports is not naturally occurring but is there because of radioactive waste disposal into the aquifer by the Department of Energy. [41] For an idea of the radioactive and

[41] LeRoy L. Knobel et al., US Geological Survey, "Chemical Constituents in the Dissolved and Suspended Fractions of Ground Water From Selected Sites, Idaho National Engineering Laboratory and Vicinity, Idaho, 1989," Report 92-51, March 1992. See Table 19 for USGS well 14 contamination including thorium-232 decay products lead-212 and radium-228. They were mystified by the variations in monitored contaminant levels in the same well. But the variations likely resulted from the stratified contamination levels and variation in mixing the stratified levels during well sampling. http://pubs.er.usgs.gov/usgspubs/ofr/ofr925

chemical waste resulting from one DOE facility at the Idaho National Laboratory, see this CERCLA cleanup report and others at the administrative record. [42]

The high levels of gross alpha from uranium and thorium radioactive wastes, along with hexavalent chromium, have long reached Idaho's Magic Valley. The state's drinking water monitoring program has done what is can to pretend this isn't from INL. Experts attending the INL Citizens Advisory Board continue to claim that only a few molecules of contamination can be found south of the INL. This frequently repeated falsehood along with inadequate state oversight ignores the elevated cancers in counties downgradient from the Idaho National Laboratory that are probably because of the chemical and radioactive contaminants in the aquifer from the INL.

One of the contaminants particular to U-233 production that does not occur otherwise in reactors is the production of contaminant europium-152. While reactors that use fuel highly enriched in U-235 produce europium-154, they do not produce Eu-152. INL cleanup contaminant-of-concern lists include Europium-152, thorium and uranium from INL waste disposal. A surface soil report for the Department of Energy also reported Europium-152 in Arco Idaho. [43] An Idaho National Laboratory summary of contaminants of concern, though incomplete, lists Eu-152 for TRA and INTEC as well as thorium and uranium-233 for TRA and RWMC. [44]

The 1982 USGS report [45] summarizing well monitoring data from 1949 to 1982 shows that twenty wells at or near the INL were monitored at least once for uranium or thorium, or their decay products. Although it was not routine and only took place during 1978 to 1982, the USGS for some wells in those years provided analytical results for uranium and its decay products lead-214 (Pb-214) and bismuth-214. They also provided analytical results for thorium and its decay products lead-212 (Pb-212), actinium-228 and thallium-208 for some wells. The USGS has the ability to determine what radionuclides are present when the sample has radioactivity — so the monitoring data for various radionuclides for some wells indicates they determined that the radionuclide was there by gamma spectroscopy. This means that wells that were not sampled for

[42] See INL CERCLA Cleanup Administrative Record at https://ar.icp.doe.gov and See one report for an idea of contaminants in Department of Energy Idaho Operations Office, "Final Removal Action Report for CPP-601, CPP-602, CPP-627, CPP-630, and CPP-640," DOE/ID-11453, February 2012. See Table 3, p. 19 and 20. *https://ar.icp.doe.gov/images/pdf/201202/20120228007688RU.pdf*

[43] S. M. Rood et al., "Background Dose Equivalent Rates and Surficial Soil Meal and Radionuclide Concentrations for the Idaho National Engineering Laboratory," INEL-94/0250, Rev 1, August 1996, Lockheed Martin for the Department of Energy Idaho Operations Office. See page A-3, europium-152 contamination found in city of Arco December 1982 and Monteview in 1982 (p. A-19). Radium-228 also associated with thorium cycle is found at Atomic City in 1978 (p. A-6) and other locations.

[44] Department of Energy, Environmental Management under DOE-ID, INEEL Subregional Conceptual Model Report, INEEL/EXT-03-01169, Rev. 2, September 2003. p. 4-2. at https://inldigitallibrary.inl.gov/sti/3562854.pdf

[45] Bagby, J.C. et al., US Geological Survey, "Water-Quality Data for Selected Wells On or Near the Idaho National Engineering Laboratory, 1949 through 1982., Open-File Report 84-714, 1985.

lead, actinium, bismuth, and thallium likely didn't have significant quantities of these radionuclides. If these were naturally occurring, then they occur in wells other than those in prominent INL waste water plumes. Well monitoring of wells near NRF, TRA, CPP, RWMC and TAN all show both uranium and thorium or their decay products, at levels not naturally occurring in the aquifer.

Wells near INTEC show both uranium and thorium decay product contamination. One well, USGS 47, showed very high Pb-214, a U-238 decay product, of 320 pCi/L and high Pb-212, a Th-232 decay product, of 140 pCi/L. Wells near the burial ground, the RWMC, also had high levels of both Pb-214 and Pb-212. Well USGS 90 reported 160 pCi/L of Pb-214, and 70 pCi/L of Pb-212. One northern INL well at Test Area North, the IET well had elevated Pb-214 (a U-238 decay product) and Ac-228 (a Th-232 decay product).

One well at NRF, NRF 1, reported only a single measurement of dissolved uranium. It was sampled in 1955 and showed 2.1 mg/L of dissolved uranium. No other uranium or thorium monitoring was performed but the reason may be due to secrecy rather than the non-detection of uranium or thorium decay products.

At the Test Reactor Area, aquifer well USGS 65 showed a very high level of Pb-214 (a uranium decay product) of 230 pCi/L and measurements of actinium-228 (Ac-228) and thallium-208 (Tl-208), both decay products of Th-232 were elevated near TRA.

Not surprisingly then, downgradient wells near the southern boundary of INL also had elevated levels of these radioisotopes. The Leo Roger 1 well had Pb-214 (a uranium-238 decay product) of 130 pCi/L. USGS 9 south of RWMC was monitored for Pb-212, at 160 pCi/L. USGS 11 had Pb-214 at 90 pCi/L and Pb-212 (a Th-232 decay product) of 110 pCi/L. USGS 14 south of INL had Pb-214 levels of 90 pCi/L in 1980.

USGS report 92-51 sampled many wells, including USGS 11 and USGS 14. [46] This report shows significant levels of both uranium and thorium contamination in both USGS 11 and 14, despite destroyed samples and a very odd use of a new code "not present." The table from 92-51 is rearranged and presented here in Table 9. To understand the data, it should be noted that the decay chain of U-238 includes decay products of Th-234 and Ra-226 and Radon-222; and the decay chain of Th-232, used for thorium fuel cycles to develop weapons material U-233, includes decay products Pb-212, Ra-228, Ra-224. [47]

[46] Knobel, L.L. et al., US Geological Survey, "Chemical Constituents in the Dissolved and Suspended Fractions of Ground Water From Selected Sites, Idaho National Engineering Laboratory and Vicinity, Idaho, 1989," Report 92-51, March 1992. See Table 19 for USGS well 14 contamination including thorium-232 decay products lead-212 and radium-228.. http://pubs.er.usgs.gov/usgspubs/ofr/ofr925

[47] See our factsheet with uranium and thorium decay series in "Radionuclides in Groundwater Fact Sheet" at www.environmental-defense-institute.org

Table 9. USGS 11 and 14 well data from the 1989 USGS 92-51 report. [a, b]

Radionuclide	USGS 11 (downgradient from RWMC)	USGS 14 (downgradient from INTEC/TRA)	USGS 14 (QA)	USGS 14 (QA)
Total Uranium and Uranium-238 decay series				
Total Uranium, ug/L	2.54	5.75	2.97	2.06
Th-234, pCi/L	NP	NP	3.38	DS
Ra-226, pCi/L	NP 0.058	0.39 0.085	NP 0.096	DS 0.082
Thorium-232 decay series				
Ra-228, pCi/L	NP 0.245	NP 0.616	0.393 -0.116	DS 0.218
Ra-224, pCi/L	0.86	0.91	0.284	DS
Pb-212, pCi/L	0.74	NP	NP	DS
Other radionuclides				
Gross alpha, ug/L	1.93	10.25	-	-
as suspended solid, ug/L	0.087	0.148	-	-
Gross alpha, as if Th-230, pCi/L	2.12	11.2	-	-
as suspended solid, pCi/L	0.085	0.145	-	-
Gross beta, as Sr-90/Y-90, pCi/L	3.76	3.96	-	-
as suspended solid, pCi/L	0.357	0.357	-	-
Co-60, pCi/L	NP	0.31	NP	DS
Radon-222, pCi/L	7	5	-	-
Sr-90, pCi/L	<0	<0	-	-
Cs-137, pCi/L	<0	<0		
Tritium, pCi/L	38 (NWQL) 20 (RESL)	19 (NWQL) 60 (RESL)	-	-
Pu-238, pCi/L	0.006	0.01	-	-
Pu-239, pCi/L	<0	0.005	-	-
Am-241, pCi/L	<0	0.16	-	-

Units: ug/L = micrograms/liter; pCi/L = picocuries/liter.

Table notes:

a. Data from USGS 1989 data, Report 92-51. Data presented to highlight these two wells south of INL. Uncertainty entries have been omitted for simplification. Highest values have been selected if multiple measurements cited.

b. These deep wells may have been shallowly sampled. If contamination is stratified, this may under represent the contamination deeper in the well. It may also explain the inconsistent results from sampling well USGS 14 several times.

The somewhat high levels of both uranium and thorium decay products in these two wells south of INL but in the northern portion of the Magic Valley well monitoring area should cause one to question the statements by USGS that the southern Magic Valley wells must have thorium and uranium rock to explain their elevated levels.

The USGS long ago knew that the levels of uranium and thorium from natural rock were so low that there was no need to subtract the natural levels from the measured levels. The measured levels of uranium and thorium and their decay products as measured are not natural but are from INL waste water. Although the USGS does not appear to have any uranium or thorium well monitoring data prior to 1989, USGS report 97-4007 does include uranium and thorium well monitoring data. [48]

The USGS report 97-4007 used gamma spectrometry to identify radionuclides in Magic Valley groundwater samples. On p. 11, they state that the detection of cobalt-60, americium-241, cesium-137, uranium-238 and its decay products thorium-234, radon-226, lead-214, and bismuth-214, uranium-235 but no associated U-235 decay products, and thorium decay products of lead-212 and bismuth-212 but no t-horium-232. The study cites inconsistency and lack of reproducibility of results and doesn't even report many of these radionuclides or the wells they were found in. But these radionuclides have been found in groundwater south of the INL and reported in other reports — so dismissal of the detections was inappropriate. At the least, more rigorous monitoring was called for — but instead the monitoring was reduced.

How Fast Does Contamination Flow Downgradient?

In 1960, the Atomic Energy Commission (AEC) annual environmental monitoring report highlights the finding that underground water "flows in a south to south-westerly direction at an approximate rate of 35 feet a day." [49] The estimated rate of groundwater flow given in later reports is usually less than 10 feet per day. A 1974 report by Robertson [50] states the following:

"Average flow rates in the aquifer are difficult to assess. Tracer studies at the NRTS indicate natural flow rates in the range of 5 to 20 feet per day with an average near 10 feet per day. However, these local measurements are not necessarily representative of velocities throughout the aquifer. Indirect estimates of general flow rates were made by assuming certain properties of

[48] Bartholomay, R.C. et al., "Evaluation of radionuclides, inorganic constituents, organic compound data from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1989 through 1992: US Geological Survey," Report 97-4007, DOE/ID-22133, 1997.

[49] US Atomic Energy Commission, Idaho Operations Office, "Health and Safety Division Environmental Monitoring Data Annual Summary for the National Reactor Testing Station, 1960," IDO-12082, 1961.

[50] Robertson, J.B. et al, "The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970," US Geological Survey, IDO-22053, UC-70, February 1974. https://pubs.er.usgs.gov/publication/ofr73238 p. 13, 151-153.

the aquifer. . . .it appears that the average velocity is on the order of 5 to 10 feet per day. Using a different approach, flow rates of 10 to 20 feet per day were calculated. . .”

The Robertson report also states that “the first **significant** [emphasis added] waste chloride from the ICPP arrived at the CFA-1 well in about 1958. It therefore traveled a horizontal distance of about 35,000 feet in about 2,000 days, for an approximate velocity of 7 feet per day. . ..The 1958 arrivals of tritium and chloride are first arrivals rather than average arrivals; for this reason the arrival time may indicate a velocity faster than the average. The leading edge of the contamination front travels faster than the average flow as the front disperses longitudinally.”

Although the Robertson report is calling the 1958 arrival of waste water from ICPP a “first arrival,” aquifer monitoring data of the sparse data for the 1950s show that in the neighboring CFA-2 well, that the level of sodium, chloride level and specific conductivity is starting to bump up from the ICPP waste water in 1956. Thus, it appears that the first detectable signs of contamination came at a velocity of roughly 24 feet per day, lateral to main flow path and with injection well and downgradient pumping well.

Aquifer flow velocity is affected by rock porosity, gradient, and also whether the flow is on the most direct path or laterally spread out from the most direct path from the contamination source, the injection well velocity, and pumping of water from the aquifer which draws aquifer water toward the pumps. Conceptually, I picture the aquifer rock like sponge, but a sponge that is solid in some parts and more porous in others, and it is as though a wire has been poked through in some places, creating a tube for a fast path, in some places.

“Fast paths” can transmit contaminants rapidly, as a 2000 report explains: “Groundwater flow is usually focused into preferential flow pathways in fractured or highly heterogeneous aquifers. . .these “fast paths” pose a critical problem, because they can transmit contaminants rapidly yet may arise from subtle or hidden natural features such as zones of increased fracture density or connectivity.” [51]

The point I want to make is that the USGS and the AEC became aware of the need to hint that it would take a long time for wastes to move in the aquifer off of the INL site so the public would not worry. There appears to be more spin than science in various discussions of the rate of groundwater velocity — and little to no data presented from the extensive groundwater monitoring that took place in the 1950s and 1960s to back up the USGS/AEC assertions.

[51] Thomas M. Johnson et al., *Geology*, “Groundwater “fast paths” in the Snake River Plain aquifer; Radiogenic isotope ratios as natural groundwater tracers,” October 2000; v. 28; no. 10; 871-874.

The USGS study of radioactive Chlorine-36 discusses waste water reaching USGS 14 "at least by 1984." [52] But a more detailed report on this topic concludes that analysis of archived samples for Cl-36 showed the waste water had reached USGS 14 south of the INL and east of the Big Southern Butte by the 1970s. [53] Let me emphasize: "by the 1970s" means that the waste was likely there years earlier. This has big implications for the travel time of INTEC disposal injection well arrival times south of the INL.

It also means that the INTEC plume of aquifer contamination that was driven by the large injection volume of water reached Atomic City by the 1970s. And the aquifer there still has elevated tritium levels and other contaminants along with elevated chromium, sodium and nitrate, all markers of the INTEC plume. The contaminated drinking water at the INL's Central Facilities Area receives the INTEC plume and the contamination will head south for years to come. The tritium levels at the Central Facilities area south of INTEC remain high despite the decades of decay for the 12.3 year half life isotope.

The travel time of contaminants in the aquifer is affected by the specific location they enter the aquifer and by whether the contaminants were injected directly into the aquifer with a large liquid waste volume or seeped to the aquifer from percolation ponds. Buried waste with only precipitation as the driver will be slower and the contaminants have to first migrate through soil to reach the aquifer.

The Department of Energy, since the 1980s, is no longer using injection wells. Percolation ponds and pits were then used and pipe leakage from the tank farm and other leakages have continued. Waste was buried at the INL starting in the 1950s and has continued to be buried at INL although burial of transuranic waste from Rocky Flats did cease in the 1970s. The waste is still there above ground waiting to be shipped to the struggling to reopen WIPP underground salt facility in New Mexico. Keep in mind that the Department of Energy is planning to bury more waste at INL at the new replacement for the Radioactive Waste Management Complex. [54] And very little of the buried waste at the Radioactive Waste Management Complex is actually being removed –

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[52] U.S. Geological Survey, "Evaluation of archived water samples using chlorine isotopic data, Idaho National Engineering and Environmental Laboratory, Idaho 1966-93," DOE/ID-22147, Report 98-4008, 1998. http://pubs.er.usgs.gov/usgspubs/wri/wri984008

[53] L. DeWayne Cecil, "Origin of Chlorine-36 in the Eastern Snake River Plain Aquifer, Idaho: Implications for Describing Ground Water Contamination Near a Nuclear Facility. A thesis presented to the University of Waterloo in fulfillment of the thesis requirement for the degree of Doctor of Philosophy In Earth Sciences Waterloo, Ontario, Canada, 2000. http://www.collectionscanada.gc.ca/obj/s4/f2/dsk3/ftp04/NQ60526.pdf

[54] US Department of Energy, "Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site," Final, DOE/EA-1793, December 2011. http://energy.gov/sites/prod/files/EA-1793-FEA-2011.pdf and see EDI's report "Unwarranted Confidence in DOE's Low-Level Waste Facility Performance Assessment – The INL Replacement Facility Will Contaminate Our Aquifer for Thousands of Years" at http://www.environmental-defense-institute.org/publications/rhllwFINALwithFigs4.pdf

most of the buried waste will remain buried despite the retrieval, at great expense, of targeted waste that leaves most of the plutonium and americium and all of the other radioactive waste buried above the aquifer. [55] [56]

Detailed trending of aquifer contamination has shown the bump ups in contamination downgradient very shortly after the increase in contamination upgradient. The fractures in the rock in the aquifer can allow very rapid transit times for a portion of the water. The crest of the contamination will take much longer to reach areas miles downgradient; however, the contamination can be detected miles downgradient, in fact, very rapidly.

If the aquifer didn't move much faster than the supposed 70 to 350 years stated in a USGS brochure, [57] then we would not have had the elevated levels of chromium, including hexavalent chromium in groundwater in the Magic Valley. Both the USGS and the Idaho Department of Environmental Quality drinking water programs have inexcusably ignored the elevated chromium that came from INL waste water and then they went a step further by selecting very coarse detection standards for known INL waste water contaminant hexavalent chromium to "less than 50 ug/L or "less than 15 ug/L." This may have helped cover up the hexavalent chromium contamination from the INL, but it did not make it any less toxic to people ingesting it.

One can observe a high degree of correlation of elevated tritium levels with elevated levels of specific conductivity, sodium, chloride, nitrate as nitrogen and barium. Data prior to 1952 are sparse but tend to support the fact that INL waste water practices made rather immediate and measureable effects on the groundwater in the Magic Valley. One just needs to remember that the monitoring of deeper wells in the northern portion of the Magic Valley, over 450 ft deep, tended to miss much of the contamination.

In the next section, groundwater monitoring data from the 1960s are presented that indicate first arrival of contamination had already arrived in the Magic Valley by 1960.

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[55] U.S. Department of Energy, 2008. Composite Analysis for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site. DOE/NE-ID-11244. Idaho National Laboratory, Idaho Falls, ID and U.S. Department of Energy, 2007. Performance Assessment for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site. DOE/NE-ID-11243. Idaho National Laboratory, Idaho Falls, ID. Available at INL's DOE-ID Public Reading room electronic collection. See https://www.inl.gov/about-inl/general-information/doe-public-reading-room/

[56] See that the publically available administrative record for RWMC cleanup does not contain the assessment of radionclide migration and radioactive doses after 10,000 years. The pre-10,000 year contaminant migration is artificially suppressed for the first 10,000 years and then rapidly escalates and stays elevated for hundreds of thousands of years. See the Administrative Record at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documents for documents associated with this cleanup action, including "Record of Decision" documents and EPA mandated Five-year Reviews at http://ar.inel.gov or http://ar.icp.doe.gov

[57] Bartholomay, R.C., US Geological Survey Fact Sheet FS-052-98, "Effect of Activities at the Idaho National Engineering and Environmental Laboratory on the Water Quality of the Snake River Plain Aquifer in the Magic Valley Study," 1998.

A Closer Look at the 1960s and the Influence of INL Operations on the Magic Valley

The USGS began monitoring the groundwater wells in the Magic Valley in the 1950s. The Atomic Energy Commission Idaho Operations office started limited reporting both onsite and offsite groundwater monitoring in 1959. The offsite wells were not identified but were depicted on maps. The AEC environmental monitoring reports provided gross alpha, gross beta and sometimes tritium concentration.

The reported data for the offsite wells in the Magic Valley south of the Idaho National Laboratory and for INL onsite drinking water wells is presented in Tables 10, 11, and 12. The low radiological concentrations of 1959 are not seen again. The level of gross alpha, below 3 pCi/L reported in 1959 would be consistent with normal aquifer background levels; the elevated levels so often reported from 1960 on are above normal background aquifer levels.

In the late 1980s, when the public called for more investigation of the groundwater in the Magic Valley, there would be wild fluctuations in gross alpha concentrations. For example, gross alpha concentrations in groundwater in the Magic Valley measured in 1989 often exceed 3 pCi/L, exceed 10 pCi/L and even exceed 18 pCi/L. [58]

A USGS report by Robertson [59] says it covers the influence of liquid waste at the National Reactor Testing Station, now the INL, from 1952 to 1970. The report, however, says nothing of any radionuclide monitoring offsite in the Magic Valley despite years of monitoring gross alpha, gross beta and sometimes, at least, tritium concentrations.

Nor does the Robertson report mention gross alpha or gross beta monitoring onsite. It does discuss that INL waste water included tritium, cobalt, and strontium — but this left out many other radionuclides. Some radionuclides were not discovered until later years, like iodine-129 and chlorine-36, but why was gross alpha omitted when it had been monitored since 1959?

The Robertson report contains important information about the INL waste water disposal but why does it leave out so much of the data that was collected? The Robertson report also leaves out groundwater monitoring at the Test Area North and the burial grounds at the Radioactive Waste Management Complex out completely. TAN and RWMC would become known in the

[58] Bartholomay, R.C. et al., "Evaluation of radionuclides, inorganic constituents, organic compound data from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1989 through 1992: US Geological Survey," Report 97-4007, DOE/ID-22133, 1997. See Table 4.

[59] Robertson, J.B. et al, "The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970," US Geological Survey, IDO-22053, UC-70, February 1974. https://pubs.er.usgs.gov/publication/ofr73238

Table 10. Increasing levels of gross alpha radiological contamination in onsite and offsite wells downgradient from the INL during the 1960s based on Atomic Energy Commission environmental monitoring reports, units of pCi/L. [a]

	Maximum	Average	Radioactivity Concentration Guide	Detection Limit
Gross Alpha — Offsite south of INL in the Magic Valley				
1959	below 3	below 3	?	(3?)
1960	5	3.1	?	(3?)
1961	6.6	4	10	4
1962	3	3	10	3
1963	5	4	10	3
1964	9	4	10	3
1965	4	4	100	3
1966	3	3	100	3
1967	5	3	100	3
1968	5.3	3.2	100	3
1969	4	3.1	30	3
Gross Alpha — Onsite Drinking Water Wells				
1959	below 3	below 3	100	(3?)
1960	10	3.1	100	?
1961	11	3.5	100	4
1962	4	3.1	100	3
1963	10	4	100	3
1964	7	4	100	3
1965	7	3	100	3
1966	6	4	3000	3
1967	9	3	3000	3
1968	9	3.1	3000	3
1969	6.3	3.2	30	3

Units: pCi/L = picocurie/liter.
Table notes: Natural background concentration of gross alpha in groundwater said to be 0 to 5 pCi/L, Orr 1991 but this appears to be inflated by nuclear weapons testing and INL operations.

late 1980s to be huge aquifer contamination sites with radionuclide and chemical contamination. The chemical contamination was ignored almost entirely by the USGS from1949 to the late 1980s.

Uranium monitoring was conducted in the 1950s in the Magic Valley but never included in the Robertson report. And if the elevated concentrations in groundwater were due to weapons fallout, there should have been no reason to single out the aquifer down-gradient from the INL in the Magic Valley for monitoring in the 1950s and 60s.

Table 11. Increasing levels of gross beta radiological contamination in onsite and offsite wells downgradient from the INL during the 1960s based on Atomic Energy Commission environmental monitoring reports, units of pCi/L. [a]

	Maximum	Average	Radioactivity Concentration Guide	Detection Limit
Gross Beta – Offsite south of INL in the Magic Valley				
1959	below150	below 150	?	150
1960	below 150	below 150	3000	?
1961	220	200	3000	200
1962	150	150	100	50
1963	120	30	100	6
1964	20	10	100	6
1965	17	8	100	6
1966	7	7	100	6
1967	15	7	100	6
1968	6.8	5.2	100	5
1969	5	5	100	5
Gross Beta – Onsite Drinking Water wells				
1959	3900 due to Ru-106	300	?	?
1960	450	150	30,000	?
1961	430	200	30,000	200
1962	430	150	3000	50
1963	80	20	3000	6
1964	100	20	3000	6
1965	52	8	3000	6
1966	125	8	3000	6
1967	36	7	3000	6
1968	36	6	3000	5
1969	113	6.6	100	5

Units: pCi/L = picocurie/liter.
Table notes: Natural background concentration of gross beta in groundwater are said to be 0 to 8 pCi/L, Orr 1991 but this appears to be inflated by nuclear weapons testing and INL operations.

Table 12. Increasing levels of tritium radiological contamination in onsite and offsite wells downgradient from the INL during the 1960s based on Atomic Energy Commission environmental monitoring reports, units of pCi/L. [a]

	Maximum	Average	Radioactivity Concentration Guide	Detection Limit
Tritium – Offsite south of INL in the Magic Valley				
1959	not sampled	not sampled	no limit	-
1960	not reported if sampled	not reported if sampled	no limit	not reported if sampled
1961	6000	below 6000	1,000,000	4000
1962	4000	4000	3,000,000	4000
1963	5000	4000	3,000,000	4000
1964	not reported	not reported	3,000,000	
1965	not reported	not reported	3,000,000	
1966	not reported	not reported	3,000,000	
1967	not reported	not reported	3,000,000	
1968	below 2000	below 2000	3,000,000	2000
1969	below 2000	below 2000	3,000,000	2000
Tritium – Onsite Drinking Water wells				
1959	not sampled	not sampled	no limit	not sampled
1960	not reported	not reported	30,000,000	?
1961	62,000	below 5000	30,000,000	4000
1962*	63,000	6000	30,000,000	4000
1963	94,000	7000	30,000,000	4000
1964	not reported	not reported	100,000,000	
1965	not reported	not reported	100,000,000	
1966	not reported	not reported	100,000,000	
1967	not reported	not reported	100,000,000	
1968	340,000	10,900	100,000,000	2000
1969	85,000	8288	3,000,000	2000

Units: pCi/L = picocurie/liter.

Table notes: Natural background concentration of tritium would be less than 30 pCi/L but nuclear weapons testing did put high levels of tritium in the atmosphere, which rained out onto surface water. Orr, 1991 states tritium levels generally range from 75 to 150 pCi/L. What is known in the 1960s in the Snake River Plain aquifer is that with a detection level of 2000 pCi/L and many wells monitored yielding 2000 pCi/L, background levels certainly were less than 2000 pCi/L in the 1960s.

The Atomic Energy Commission Idaho Operations Office was assuring the public that they were carefully monitoring waste water disposal at the INL and that groundwater used for drinking was below Radiation Concentration Guides. What the AEC didn't necessarily mention was which specific wells, what the results for each well were or even what the Radiation Concentration Guide was. A maximum measured concentration and the average for the monitored wells in a group was given, however, for each year through the 1960s. Regulatory guidelines for radioactivity in groundwater through the 1960s are presented in Table 13 and the allowable concentration levels change wildly — up and down by several orders of magnitude.

Table 13. Wild fluctuations in **allowable** radioactivity concentrations in water during the 1960s at the Idaho National Laboratory site for the offsite public and onsite drinking water wells based on Atomic Energy Commission environmental monitoring reports, units of pCi/L. [a]

Year	Gross Alpha offsite	Gross Alpha onsite	Gross Beta offsite	Gross Beta onsite	Tritium offsite	Tritium onsite
1950s	no limit	no limit	no limit	no limit	no limit	no limit
1961	10	100	3000	30,000	1,000,000	30,000,000
1963	10	100	3000	30,000	3,000,000	30,000,000
1965	100	3000	100	3000	3,000,000	30,000,000
1966	100	3000	100	3000	3,000,000	?
1968	100	3000	100	3000	3,000,000	100,000,000
1969 1st half	30	400	100	3000	3,000,000	100,000,000
1969 2nd half	30	30	100	100	3,000,000	3,000,000
2015	15	15	4 mrem/yr (8 pCi/L Sr-90, or 200 pCi/L Cs-137)	4 mrem/yr (8 pCi/L Sr-90, or 200 pCi/L Cs-137)	20,000	20,000

a. Units: pCi/L = picocurie/liter (pCi/L); mrem = millirem, a unit of radiation that includes biological effectiveness. Sources: Atomic Energy Commission (AEC) environmental monitoring reports: First annual environmental monitoring summary report issued in 1958 (IDO-12012) although radioactivity releasing begins by 1952. Cognizance of maximum permissible concentrations for beta emitters is expressed in the 1959 annual environmental report (IDO-12014). At times the environmental monitoring reports only express radioactivity concentrations as a percentage of derived radioactivity concentration guide but then don't state what that level is. Annual summary reports not issued for many years and when issues, the titles changed frequently to deliberately make it difficult for the public to locate reports. The 1960 report says water monitored "radiation protection guide" but don't say what those levels are. Twice a year reports of the IDO-12019 series likely were not available to the public prior to the Human Radiation Experiments collection development. The IDO-12019 series of environmental monitoring data, reports 9 through 25 cover 1961 to 1969 and contain monitored onsite and offsite drinking water for gross alpha, gross beta and sometimes tritium. The U.S. Department of Health, Education, and Welfare, Public Health Service also issued reports that contained environmental monitoring information from the National Reactor Testing Station.

Many of these reports are available online at the INLdigitallibrary in the Public Reading Room section at https://inldigitallibrary.inl.gov/SitePages/INL%20Research%20Library%20Digital%20Repository.aspx

As can be seen in Table 13, offsite levels were typically more restrictive than onsite levels by a factor of 10. But onsite levels wells that were being reported were the drinking water wells. The AEC deemed it quite acceptable to allow everyone onsite to drink more contaminated water than would be allowed offsite. Onsite workers included radiation workers as well as the pregnant office secretary and everyone working at the site who drank the water (or the coffee) .

There were no clearly defined regulatory limits for radiation protection standards for the public from 1952 to 1960. [60] The AEC Idaho Operations Office announced a public radiation standard in December of 1961. Radiation protection standards for the public do not apply to accidents and the most limiting standard for the public was based on an estimated average dose to the population. An annual dose of 170 millirem (mrem) whole body, gonads or bone marrow was allowed, and 500 mrem was allowed to other organs. For workers, much higher radiation exposures were allowed, ranging from 15,000 to the later accepted 5,000 mrem/yr. Radiation exposure comes from airborne emissions, direct radiation from shipping casks, and contaminated food or water. It might seem that the current allowable annual radiation limit for drinking water is 4 mrem — but that is only for total beta emitters excluding tritium. As typically applied, the standards allow 4 mrem for mixed gross beta, another 4 mrem for tritium, 15 pCi/L of mixed alpha emitters without uranium or radium-226/-228, 30 ug/L of uranium, whether naturally in the water or not, and 5 pCi/L of combined radium-226/-228. The actual dose will depend on the particular radionuclides in the water. The current limits are not necessarily protective of health especially for pregnant women, children and long-term use. But certainly the limits today are many times more restrictive for drinking water than in the 1960s.

During the 1960s, as shown in Table 13, allowable radioactivity concentrations for gross alpha contamination in groundwater offsite ranged from from 10 to 100 pCi/L, with onsite personnel allowed 3000 pCi/L during some years. Natural background levels in the Snake River Plain aquifer should be less than 3 pCi/L and close to zero. Allowable radioactivity concentrations for gross beta particle contamination in water offsite ranged from 100 to 3000 pCi/L, with onsite personnel allowed 30,000 pCi/L during some years. Natural background levels of manmade strontium-90 and cesium-137 is zero. Today's gross beta concentration limit is based on 4 mrem/yr, and if based on strontium-90 would be 8 pCi/L or if based on cesium-137 would be 200 pCi/L. The public health goal for these contaminants is zero.

And, also shown in Table 13, allowable radioactivity concentrations for tritium were as high as 3,000,000 pCi/L offsite and 100,000,000 pCi/L onsite. Today's tritium federal maximum

[60] US Department of Energy Idaho Operations Office, "Idaho National Engineering Laboratory Historical Dose Evaluation," DOE-ID-12119, August 1991. Volumes 1 and 2 can be found at https://www.iaea.org/inis/inis-collection/index.html p. 40

contaminant level is 20,000 pCi/L and California's public health goal for tritium is 100 pCi/L. Natural background levels of tritium should be very low, less than 30 pCi/L.

The 1974 USGS report by Robertson [61] provides another glimpse into the lack of understanding of the harm of radionuclide ingestion by this table of 1968 maximum permissible concentrations of radioisotopes in drinking water, shown in Table 14. Current EPA limits are much lower.

Table 14. US AEC maximum permissible concentrations of radioisotopes in drinking water onsite compared to average ICPP disposal well effluent in pCi/L. (Source: IDO-22053).

Isotope	"Average long-term concentration in ICPP effluent"	1974 AEC limit	Current EPA drinking water standard [b]
Cerium-144 (284.9 day)	4500	10,000	30 pCi/L, beta
Cesium-137 (30.2 yr)	2400	20,000	200 pCi/L, beta
Cobalt-60 (5.3 yr)	-	50,000	100 pCi/L, beta
Tritium (H-3) (12.3 yr)	526,000	3,000,000	20,000 pCi/L tritium beta
Ruthenium-106 (373.59 day)	1,100	10,000	30 pCi/L, beta
Strontium-89, (50 day)	390	3000	20 pCi/L, beta
Strontium-90, (28.8 yr)	2400	300	8 pCi/L, beta
Zirconium-95 (64 day)	3000	60,000	200 pCi/L, beta

Source, Table X, p.122 of IDO-22053. Original units in pCi/ml. pCi/L = picocurie/liter; yr = year.
Table notes:
Original note a "U.S. Public Health Service (1962) placed a maximum allowable limit of 0.01 pCi/ml for Sr-90 in public drinking water. Of the above listed isotopes, Sr-90 is the only one specifically restricted by US Public Health Service." There is no discussion in IDO-22053 of any limit on gross alpha, gross beta, uranium, thorium, transuranic such as plutonium, or iodine-129 in drinking water.
b. Combined beta emitters except tritium not to exceed 4 mrem/yr. For a listing of beta emitter limits in pCi/L that equal 4 mrem/yr for an individual radionuclide occurring alone, see this table: http://www.iem-inc.com/information/tools/maximum-contaminant-levels-for-water . Tritium, although a beta emitter, is considered separately with MCL 20,000 pCi/L. Note also that federal drinking water also limits gross alpha to 15 pCi/L, excluding uranium and radium, Uranium is limited to 30 micrograms/L, and combined Radium-226/-228 is limited to 5 pCi/L.

[61] Robertson, J.B. et al, "The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970," US Geological Survey, IDO-22053, UC-70, February 1974. https://pubs.er.usgs.gov/publication/ofr73238

If there was no contamination from INL downgradient in Magic Valley groundwater wells, then why was the 1950s and 1960s data omitted from later USGS reports investigating the groundwater in the Magic Valley?

If you look at the number of wells monitored at one point or another in the Magic Valley on the USGS mapper online, you see a very high concentration of wells. Most are monitored for only a few years, some only one time. Then the monitoring ceases and new wells were dug.

Well data are provided in Table 15 as an example in the southern part of Blaine County, near the City of Rupert in Minidoka County. The well was monitored twice in 1953, again in 1954 and for the last time in 1957. There is no data provided prior to INL operations which began disposing of radioactively and chemically contaminated waste water in 1952. But all of the levels are above normal background levels except perhaps the stated uranium level, which is low. Data for another well in SE Blaine County is provided in Table 16.

The data for these two wells could be consistent with seeing first arrival INL waste water contamination. Why was monitoring of these well discontinued in 1956 after only one sample for radionuclides? There is no chemical monitoring data for the wells. And why hasn't the USGS published the gross alpha, gross beta, tritium, or uranium monitoring results prior to 1970?

Could it be that monitoring, reporting and trending the data since 1949 in a coherent fashion would have made it too obvious the effect INL operations were having on the water in the Magic Valley?

Table 15. Southern Blaine county well monitoring data for well monitored from 1953 to 1957, well number 424310113184301.

Analyte	06/03/1953	10/02/1953	05/18/1954	08/05/1957	Background level
Specific Cond. (us/cm)	468	465	480	475	~300
Bicarbonate mg/L	178	182	180	179	81
Chloride mg/L	28	27	30	26	<10
Sodium mg/L	22	25	21	23	<7
Sulfate mg/L	49	48	52	48	21
Nitrate as N mg/L	0.678	0.949	0.407	0.881	0.5
Uranium, ug/L	not sampled	not sampled	not sampled	1.1 (< 1 pCi/L)	< 3 ug/L [a] (<2 pCi/L)
Gross beta, pCi/L	not sampled	not sampled	not sampled	<17 pCi/L	0 to 8 pCi/L Orr, 1991

Units: Specific conductance in units of mircosiemens per centimeter at 25 degrees Celsius as (uS/cm).

mg/L = milligram per liter; ug/L = microgram per liter; pCi/L = picocurie per liter.

Table notes:

USGS parameter codes used are as follows: Specific conductivity, 00095; bicarbonate, 00440; chloride, 00940; sodium, 00930; nitrate as N, 00620; uranium, 22703; gross beta, 03501. See the USGS.gov mapper online at https://maps.waterdata.usgs.gov/mapper/index.html

Table notes:

a. Uranium background level estimated from USGS report 2016-5056 (DOE/ID-22237) Table 1 values for western tributary, median values for U-234, U-235, and U-238 in picocuries/liter, converted to micrograms/liter by dividing by 0.67 pCi/ug.

Table 16. Southeast Blaine county data for well monitored 1917 to 1956, well number 424258113105101.

Analyte	1934	1953	1953	1954	1956	Background level
Specific Cond. (us/cm)	NS	523	515	525	522	~300
Bicarbonate mg/L	89	198	202	202	204	81
Chloride mg/L	10	33	32	32	30	<10
Sodium mg/L	12.8	23.0	29.0	16.0	26.0	<7
Sulfate mg/L	57.4	59	58	62	57	21
Nitrate as N mg/L	NS	0.52	0.542	0.587	0.565	0.5
Uranium, ug/L	NS	NS	NS	NS	<1.3 (<1 pCi/L)	< 3 ug/L [a] (<2 pCi/L)
Gross beta, pCi/L	NS	NS	NS	NS	<17	0 to 8 pCi/L Orr, 1991

Units: Specific conductance in units of mircosiemens per centimeter at 25 degrees Celsius as (uS/cm).
mg/L = milligram per liter; ug/L = microgram per liter; pCi/L = picocurie per liter.
Table notes:
USGS parameter codes used are as follows: Specific conductivity, 00095; bicarbonate, 00440; chloride, 00940; sodium, 00930; nitrate as N, 00620; uranium, 22703; gross beta, 03501. See the USGS.gov mapper online at https://maps.waterdata.usgs.gov/mapper/index.html (NS for analyte not sampled.) An approximation for pCi/L for natural uranium in ug/L is to multiply by 0.67 pCi/ug.
Table notes:
a. Uranium background level estimated from USGS report 2016-5056 (DOE/ID-22237) Table 1 values for western tributary, median values for U-234, U-235, and U-238 in picocuries/liter, converted to micrograms/liter by dividing by 0.67 pCi/ug.

Current Maximum Contaminant Levels for Drinking Water

A table of federal drinking water maximum contamination levels (MCLs) is given in Table 17, with emphasis more on long-lived radionuclides. It is important to recognize that staying just below the MCLs will probably not protect human health. Public health goals are typically 0 for radionuclides. For a listing of beta emitter limits in pCi/L to equal 4 mrem/yr for an individual radionuclide, see this table: http://www.iem-inc.com/information/tools/maximum-contaminant-levels-for-water . Tritium, although a beta emitter, is considered separately with MCL 20,000 pCi/L. Gross alpha is limited to 15 pCi/L, excluding uranium, Uranium is limited to 30 micrograms/L, and combined Radium-226/-228 is limited to 5 pCi/L. Non-radiological contaminants are also included in the table.

Table 17. Typical aquifer contaminants of concern at the Idaho National Laboratory.

Constituent	Regulatory maximum contaminant level[1]	Natural background level	Location of Primary Interest[2]
Radionuclide (half-life, main decay mode)			
Tritium (12.3 year, beta)	20,000 pCi/L	0 to 150 pCi/L	INTEC, ATRC, RWMC, TAN, NRF, other areas
Carbon-14 (5730 year, beta)	2,000 pCi/L	0	RWMC
Chlorine-36 (301,000 year, beta)	700 pCi/L	0	RWMC, INTEC
Iodine-129 [3] (17,000,000 year, beta and gamma)	1 pCi/L	0 to 0.0000054 pCi/L (DOE/ID-22225, 2013)	RWMC, INTEC
Technetium-99 (213,000 year, beta)	900 pCi/L	0	RWMC, INTEC 2,200 pCi/L and increasing trend.
Neptunium-237 (2,144,000 year, alpha)	15 pCi/L	0	RWMC
Cesium-137 (30.2 year, beta)	200 pCi/L (previously 160 pCi/L)	0	RWMC, INTEC, ATRC, TAN, MFC
Strontium-90 (29.1 year, beta)	8 pCi/L	0	RWMC, INTEC, ATRC, TAN
Uranium-238 (4,470,000,000 year, mixed, alpha)	10 pCi/L	0	RWMC, TAN, INTEC
Total uranium	(30 ug/L)	<3 pCi/L or < 2 ug/L [7]	RWMC, TAN, INTEC, TRA, NRF
Uranium-234, pCi/L	(Note: 8)	1.36 pCi/L [7]	see total uranium
Uranium-235, pCi/L	(Note: 8)	0.025 pCi/L [7]	see total uranium
Uranium-238, pCi/L	(Note: 8)	0.541 pCi/L [7]	see total uranium
Uranium-233, pCi/L	(Note: 8) from thorium cycle	0	see total uranium

Uranium-236, pCi/L	(Note: 8) from neutron capture in a nuclear reactor	0	see total uranium
Gross alpha [4]	15 pCi/L		
Gross beta/gamma [5]	4 mrem/yr (8 pCi/L derived from 4 mrem/yr based on Sr-90)	7 pCi/L (DOE/ID-11492, 2013)	
Organic Compounds			
Carbon tetrachloride (CCl_4)	5 u/L	0	RWMC, INTEC
Methylene chloride	5 u/L	0	RWMC
Tetrachloroethylene (PCE)	5 u/L	0	RWMC, TAN
Trichloroethylene (TCE)	5 u/L	0	RWMC, TAN 1350 ug/L
Inorganic Analytes			
Nitrate	10 mg/L	0.655 mg/L from USGS 2016 [9]	INTEC, RWMC, MFC
Chromium	100 ug/L	<1.9 ug/L [10] Hexavalent chromium should be 0	Primarily TRA now ATRC. Also RWMC, TAN, INTEC, PBF, NRF
Sodium	(an indicator of nuclear process waste)	8.3 ug/L from USGS 2016 [9]	1.5 million lb/yr discharged by INL during 1989-1991 at INTEC, ATRC, NRF, CFA, MFC

Units: pCi/L = picocurie/liter; mg/L = milligram/liter; ug/L = microgram/liter; mrem/yr = millirem/yr; lb= pound.
Table Source: Department of Energy, *Operable Unit 7-13/14 Five-Year Monitoring Report for Fiscal Years 2010-2014*, DOE/ID-11507, August 2014, and Idaho Cleanup Project, *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory*, DOE/NE-ID-11201, Revision 3, February 2007.
Table Notes:
1. Maximum contaminant level from US Environmental Protection Agency for drinking water, 10 CRF 141.
2. Some monitored locations indicated here may apply to perched water rather than the aquifer. RWMC soil sampling is also included.
3. "I-129 is monitored for indirectly by analyzing for Tc-99" at the RWMC superfund site; USGS tends to report I-129 but not Tc-99. USGS monitoring of Tc-99 reported in journal articles rather than accessible USGS reports.
4. Gross alpha includes radium-226 but excludes radon and uranium. The activity of uranium having a natural composition can be estimated from mass in microgram/Liter by multiplying by 0.67 pCi/microgram.
5. Gross beta excludes naturally occurring potassium-40.Gross beta given here is based on strontium-90.
6. Facilities are Advanced Test Reactor Complex (ATRC) formerly the Test Reactor Area and Reactor Technology Complex; Central Facilities Area (CFA); Idaho Nuclear Technology and Engineering Center (INTEC), formerly the Idaho Chemical Processing Plant; Materials and Fuels Complex (MFC) formerly Argonne National Laboratory – West; Naval Reactors Facility (NRF); Power Burst Facility (PBF);Radioactive Waste Management Complex (RWMC); Test Area North (TAN).
7. Uranium background level estimated from USGS report 2016-5056 (DOE/ID-22237) Table 1 values for western tributary, median values for U-234, U-235, and U-238 in picocuries/liter, converted to micrograms/liter by dividing by 0.67 pCi/ug.
8. The uranium limit is for total uranium, the sum of each uranium isotope after converting reported activity (pCi/L) to mass uits (ug/L).
9. Chromium was sampled in the Birch creek area in USGS 2003-4272, off INL site levels below 1.9 ug/L.

10. Nitrate and sodium background level from USGS report 2016-5056 (DOE/ID-22237) Table 1 values for western tributary, median values for U-234, U-235, and U-238 in picocuries/liter, converted to micrograms/liter by dividing by 0.67 pCi/ug.

The federal limit for tritium in drinking water is 20,000 pCi/L (picoCurie/liter). But is it safe to drink even 100 pCi/L? The answer to this question is no it is not safe and don't believe the NRC, the DOE or the Health Physics Society. The reason is that the total energy imparted by tritium is not as important at the fact that the hydrogen in tritium is incorporated into the body's DNA. The damage caused by the radioactive decay is not randomly dispersed as is cosmic radiation to the body during an airplane ride. While powerful industry interests lobby to keep federal limits for tritium high, **the State of California declared a drinking water goal for tritium of less than 100 pCi/L.**

A 1990 USGS report states that an increased allowable maximum contaminant level for tritium was coming and that implied that no one should be concerned about exceeding the current MCL. [62] MCLs change and so the USGS should not be focused on telling people not to worry because the monitoring did not consistently exceed the current MCL. The USGS has curiously avoided, for many decades of INL monitoring, what normal background levels should be, because that would have put on display the elevated levels. Rather than commenting on potential future changes to MCLs, the USGS should have been more carefully selecting adequate detection levels for tritium and hexavalent chromium because the better capability was often available then they used.

After seeing the adverse health effects of hexavalent chromium, also called chromium-6, the state of California has not only reduced the regulatory limit for hexavalent chromium from the EPA's 100 micrograms/liter to 10 micrograms/liter, **California also created a public health goal to limit hexavalent chromium to 0.02 micrograms/liter.** [63]

California regulators say that 0.02 ug/L yields a 1 in a million risk of cancer. So drinking water with hexavalent chromium at 100 ug/l is a cancer risk of 1 in 200, for a person drinking it for 70 years. It should be noted for perspective that 31,130 lb of hexavalent chromium admittedly dumped into the aquifer would require almost the entire aquifer to dilute to the public health goal of 0.02 ug/L. Of course, the plumes of hexavalent chromium are not diluted over the

[62] USGS Report 90-4090, L.J. Mann and L.D. Cecil, "Tritium in Ground Water at the Idaho National Engineering Laboratory, Idaho," June 1990. p. 32 and 34. http://pubs.usgs.gov/wri/1990/4090/report.pdf

[63] California state resources board for chromium-6 (hexavalent chromium) at http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chromium6.shtml

entire aquifer as they flow downgradient to the Magic Valley.[64] The EPA continues to investigate chromium but has not changed the federal MCL. [65]

Selected Magic Valley References

Most of the references in this report are contained in footnotes on the page discussed. But this list of US Geological Survey reports (and one Idaho Department of Environmental Quality report) was too long to include in a footnote and so is included here.

Mann, L.J., "Tritium concentrations in flow from selected springs that discharge to the Snake River, Twin Falls-Hagerman area, Idaho, US Geological Survey Water-Resources Investigations Report 89-4156, DOE/ID-22084), 1989. Note: The measurement accuracy for tritium in this investigation is poor with detection of 500 pCi/L in 1988 improved to 200 pCi/L in 1989. The EPA tritium data for the Snake River at Buhl Idaho for 7/1974 to 10/1988 is provided in Table 3 on p. 20.

Wegner, S.J., and Campbell, L.J., "Radionuclides, Chemical Constituents, and Organic Compounds in Water From Designated Wells and Springs From the Southern Boundary of the Idaho National Engineering Laboratory to the Hagerman Area, Idaho, 1989," USGS Report 91-232, 1991. Note: p. 18, Tritium measurements did not exceed 134.4 pCi/L. This report sampled 55 wells south of the INL. The tritium levels were reported to be between 45 and 106 pCi/L. The report notes that higher tritium concentrations are typically found in the regions closer to the Snake River. They reason that it is because of Snake River contamination — but it is entirely possible that the upgradient levels of contamination have been underreported because shallow well sampling in deep portions of the aquifer can miss the higher levels of contamination that lie deeper underground. Then the more shallow wells that happen to be closer to the Snake river are receiving the upgradient aquifer contaminants both shallow and deep levels of the aquifer are now mixing as the aquifer closer to the Snake River is less thick.

Mann, L.J., and Knobel, L.L., "Radionuclides, metals, and organic compounds in water, eastern part of A&B Irrigation District, Minidoka County, Idaho: US Geological Survey Open-File Report 90-191, DOE/ID-22087, 1990.

Bartholomay, R.C., et al., "Radionuclides, inorganic constituents, organic compounds, and bacteria in water from selected wells and springs from the southern boundary of the Idaho

[64] The Snake River aquifer is roughly 2.44E+15 liters. Contamination is not diluted by the entire aquifer but spreads in unevenly diluted amounts of contamination as the contaminated waste water in the aquifer flows in fast paths and in slow paths downgradient, fanning out and spreading south, southeast and southwest from the source of contamination. For perspective only, to dilute 31,130 lb of hexavalent chromium to 0.02 micrograms/Liter would take 7E+14 Liters.

[65] American Water Worker Association, Chromium in Drinking Water: A Technical Information Primer at http://www.awwa.org/Portals/0/files/legreg/documents/UpdatedChromiumInDrinkingWaterSummaryFinal.pdf

National Engineering Laboratory to the Hagerman area, Idaho, 1990: US Geological Survey Open-File Report 92-91, DOE/ID-22102, 1992. This report samples 19 of the original 55 wells.

Bartholomay, R.C., et al., "Radionuclides, inorganic constituents, organic compounds, and bacteria in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1991: US Geological Survey Open-File Report 93-102, DOE/ID-22108, 1993. This report samples another 18 of the original 55 wells.

Bartholomay, R.C., and Edwards, D.D., "Radionuclides, inorganic constituents, organic compounds, and bacteria in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1992: US Geological Survey," Report 94-76, DOE/ID-22114, 1994. This report samples another 18 of the original 55 wells. The tritium levels measured from 1.00 to 70.4 pCi/L. It points out that background concentrations of tritium range from 75 to 150 pCi/L based on Orr and others, 1991.

Golder Associates, for EG&G Idaho, "Assessment of Trends in Groundwater Quality at the Idaho National Engineering Laboratory," 933-1151, October 29, 1993. Located at the https://inldigitallibrary.inl.gov, identifier 94548. Tables 1 through 6 address northern Magic Valley wells MV-48, -49, -57, -59 and -60. Note that it compiles various USGS reports and cleanup investigation information available at that time.

Bartholomay, R.C. et al., "Radionuclides, stable isotopes, inorganic constituents, and organic compounds in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1993: US Geological Survey," Report 94-503, DOE/ID-22117, 1994.

Bartholomay, R.C. et al., "Radionuclides, stable isotopes, inorganic constituents, and organic compounds in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1994: US Geological Survey," Report 95-718, DOE/ID-22124, 1995.

Mann, L.J. et al., "Tritium, stable isotopes, and nitrogen in flow from selected springs that discharge to the Snake River, Twin Falls-Hagerman area, Idaho, 1990-93: US Geological Survey," Report 94-4247, DOE/ID-22119, 1994. p. 12, for 1990 through 1993, tritium in springs when detected is from 9.2 to 78.4 pCi/L.

Bartholomay, R.C. et al., "Radionuclides, stable isotopes, inorganic constituents, and organic compounds in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1995: US Geological Survey," Report 96-196, DOE/ID-22130, 1996.

Bartholomay, R.C. et al., "Evaluation of radionuclides, inorganic constituents, organic compound data from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1989 through 1992: US Geological Survey," Report 97-4007, DOE/ID-22133, 1997. See tritium p. 8 of 65 samples, only 3 exceed 100 pCi/L, the highest being 134 pCi/L.

Bartholomay, R.C. et al., "Radiochemical and chemical constituents in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1996: US Geological Survey," Report 97-360, DOE/ID-22141, 1997. Tritium levels reported on p. 13 are between 2.6 and 71 pCi/L. Background tritium levels should be from 0 to 40 pCi/L based on Knobel, 1992, it states.

Bartholomay, R.C. and Twining, B.V., "Wells and Springs from Southern Boundary of the Idaho National Engineering and Environmental Laboratory to the Hagerman Area, Idaho, 1998," US Geological Survey Report 99-473, DOE/ID-22133, 1999. Summary of tritium measurements on p. 9 using ISU-EML enrichment technique ranged from 17 to 89 pCi/L. They point out that tritium in ground water in Idaho is generally from 0 to 40 pCi/L based on Knobel and others, 1992.)

Bartholomay, R.C. and Twining, B.V., "Radiochemical and chemical constituents in water from selected wells and springs from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho, 1999" US Geological Survey Report 00-399, DOE/ID-unknown, 2000. p 7, tritium samples range from 1.6 to 60 pCi/L.

Bartholomay, R.C. et al., "Radiochemical and chemical constituents in water from selected wells south of the Idaho National Engineering Laboratory, Idaho," US Geological Survey Report 01-138, DOE/ID-22175, Undated, cerca 1999. p. 10 tritium samples from 1994 to 1995 range from 6.5 to 65 pCi/L.

Twining, B.V., "Tritium in flow from selected springs that discharge to the Snake River, Twin Falls-Hagerman area, Idaho, 1994-99," US Geological Survey, Report 02-185, DOE/ID-unknown, 2002. p. 6 tritium samples range from 1.6 to 16.7 pCi/L.

Hall, Flint, "Concentrations of Selected Trace Metals, Common Ions, Nutrients and Radiological Analytes in Ground Water," Idaho Department of Environmental Quality, OP-06-03, 2005. http://www.deq.idaho.gov/media/553383-selected_trace_metals.pdf Tritium measurements offsite are less than 100 pCi/L except from some late 1988 and perhaps 1999 samples that even "blanks" come back with tritium measurements over 200 pCi/L. This has informally been attributed to a tritium release at the ISU laboratory which was eventually discovered. I have not been able to get information about this yet despite a few queries to ISU and the NRC.

Various INL Environmental Monitoring Documentation Sources

AEC Environmental Monitoring Reports for 1958 to 1970:

IDO-12012, 1958 Health and Safety Division Annual Report.

IDO-12014, Annual Report of Health and Safety Division, 1959

IDO-12019, Annual Report of Health and Safety Division, 1960

IDO-12021, Health and Safety Division Annual Report (1961)

IDO-12033, Annual Progress Report, 1962 Health and Safety Division

IDO-12037, Annual Progress Report, 1963, Health and Safety Division

IDO-12073, Annual Report, 1969 Health Services Laboratory - 1960-1969 (Persons exposed to external radiation)

IDO-12075, 1970 Annual Report of the Health Services Laboratory (persons exposed to external radiation)

IDO-12082 (Early years not always labeled as such) AEC Environmental Monitoring data calendar year and quarterly reports for 1959, 1960, 1961, 1962, 1963 (Report No. 12 and 13), 1964 (Report No. 14 and 15), 1965 (Report No. 16 and 17), 1966 (Report No. 18 and 19), 1967 (Report No. 20 and 21), 1968 (Report No. 22 and 23), 1969 (Report No. 24 and 25), 1970 (Report No. 26 and IDO-12082).

See also US Department of Health and Welfare, Radiological Health Data reports, issued 1960 to 1970 that cover NRTS 1960 through 1968.

Environmental Monitoring Reports for 1971 to 1989:

IDO-12082, Atomic Energy Commission becomes ERDA in 1974, ERDA becomes the Department of Energy in 1977, National Reactor Testing Station becomes the Idaho National Engineering Laboratory in 1974.

The INL digital library contains many of these earlier documents at https://inldigitallibrary.inl.gov/SitePages/INL%20Research%20Library%20Digital%20Repository.aspx . Some documents that are listed say no document was loaded; others have a few pages loaded but do not contain the report. Others contain most of the report but lack the appendices. Some reports are entered twice and are loaded in one location but not the other.

For some years. www.ostigov/scitech contains a limited set, mainly DOE/ID-12082 series reports from the 1990s. There are offsite monitoring reports like the ESRF- series reports and contractor onsite reports (EG&G, LMITCO, ICP, BEA etc.) that fed into the DOE/ID-12082 series reports. Keep in mind the Naval Reactors Facility at the Idaho site are sometimes folded into Idaho environmental surveillance reports and sometimes (1996 and later) reported separately. NRF reports appear on osti.gov for 1997 to 2003.

Oddly inconsistently, osti.gov/scitech contains some of the DOE/ID-12082 series documents but not all. (1989, 1992, 1993, 1994, 1995, 1997, 1998 some are loaded, some are not.). The folks have osti.gov have kindly stated that if a report is not there, they may or may not load it — they admit that they may take weeks or months or simply not load a requested report at all.

The cleanup administrative record at https://ar.icp.doe.gov contains some environmental annual reports, 1988 through 1996, but not 1991, which is also missing on osti.gov.

The Stoller environmental reports are online at http://www.idahoeser.com/ for 1995 on, for annual and quarterly reports.

Idaho Department of Environmental Quality has used tax payer money to create reports since about 1987 but only posts online reports from 2010 and newer. IDEQ also has drinking water data posted online, but not INL radionuclide data for INL drinking water. The IDEQ drinking water data is rather unreliable in that zero may be entered for seriously non-zero analytes – so any data reading as zero needs to be confirmed with other monitoring information. Also, the investigation of sources of elevated contamination is virtually nil in the IDEQ drinking water reports.