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Are the elevated cancer rates in Bonneville County and other counties near the Idaho National Laboratory due to INL radiological releases?

Radiological monitoring for the Idaho National Laboratory may provide answers about the elevated cancer rates in the counties surrounding the INL. Of course, the narrative of nearly every environmental monitoring report since the 1950s has always been that they just don't know if the detections of radionuclides were from the INL. And the reports always emphasize that the detected radionuclides are just a fraction of the Department of Energy's "Derived Concentration Guidelines." [1]

The Department of Energy's "Derived Concentration Guidelines" would allow about 100 mrem/yr to every adult and child and for internal radionuclides and this level is known to increase cancer rates. But we are seeing elevated cancer rates in Bonneville county and other counties surrounding the INL despite the levels detected being far below the DOE's Derived Concentration Guidelines for radioactivity in air, water and food.

The ever-present americium-241, plutonium-238, plutonium-239 or -240, strontium-90 and cesium-137 are radionuclides from nuclear weapons testing fallout as well as main-stays of Idaho National Laboratory operations. These radionuclides are commonly detected in air filters. Strontium-90 is commonly detected in wheat and lettuce.

Nuclear weapons testing in the 1950s and 1960s, and continuing to about 1980, did spread a host of radionuclides over southeast Idaho as well as other parts of Idaho, Utah, Nevada, Montana and across the United States. [2]

The INL's releases were extremely high during the 1950s and 1960s and so were the releases from regional nuclear weapons testing from the Nevada Test Site.

Perhaps the elevated thyroid cancer rates in Bonneville county are due to the double whammy of nuclear weapons testing at the Nevada Test Site and also from the Idaho National Laboratory and people were exposed prior to the early 1960s. This is probably partly right. But people on the western part of Idaho that were exposed to both Nevada weapons testing fallout

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[1] Department of Energy's environmental monitoring reports, see idahoeser.com and inldigitallibrary.inl.gov.

[2] National Cancer Institute, *Estimated Exposures and Thyroid Doses Received by the American People from Iodine-131 in Fallout Following Nevada Atmospheric Nuclear Bomb Tests*, October 1997.

and to the radiological releases blowing in from the Department of Energy's Hanford site. But only Bonneville County is still suffering from elevated thyroid cancer rates, elevated childhood cancer rates and elevated rates of certain cancers. [3]

The news headline read that "cancer trends for Idaho are stable." [4] That is what citizens were supposed to take away from the 2017 cancer rate study in Idaho. Why were citizens not told about the counties exceeding state average cancer rates?

Bonneville County, where Idaho Falls is located, has double the thyroid cancer rate compared to the rest of Idaho, based on the Cancer Data Registry of Idaho (CDRI) for the year 2017. [5] See Table 1.

Table 1. Bonneville County thyroid cancer incidence rate compared to the rest of Idaho, 2017.

Cancer type	Sex	Rate in Bonneville County	Adjusted Rate in Bonneville County	Rate for remainder of Idaho
Thyroid	Total	28.2	30.7	14.2
	Male	16.0	17.8	7.4
	Female	40.3	43.5	21.0

Table notes: Rates are expressed as the number of cases per 100,000 persons per year (person-years). Rates are expressed as the number of cases per 100,000 persons per year (person-years). Adjusted rates are age and sex-adjusted incidence rates for the county using the remainder of the state as standard. Data from Factsheet for the Cancer Data Registry of Idaho, Idaho Hospital Association. Bonneville County Cancer Profile. Cancer Incidence 2013-2017. https://www.idcancer.org/ContentFiles/special/CountyProfiles/BONNEVILLE.pdf

Digging into the Radiological Soil Contamination Levels in counties around the Idaho National Laboratory

Because it is spring, I decided to dig into the soil data. The soil gets contaminated from radioactive air emissions. The most recent radiological soil contamination levels available are from 2018 from idahoeser.com and I've found radionuclide concentration monitoring data in soil going back to 1970. Soil samples taken biennially, usually in the third quarter of the year, and from about twelve counties around the INL.

As I searched historical environmental monitoring reports for answers, I am alarmed by the growing disparity of the narrative and what the environmental monitoring data actually reveal.

Starting off with the tame results, here's what cesium-137 and strontium-90 trending looks like from 1975 to 2018, shown in the figures below for radionuclide concentrations in soil off of

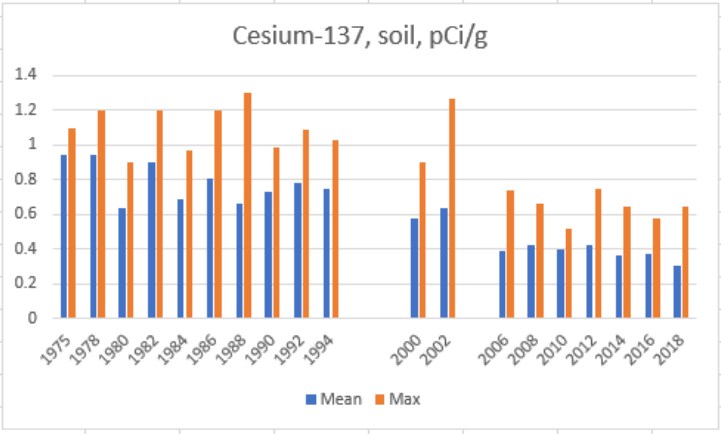
[3] Environmental Defense Institute February/March 2020 newsletter article "Rate of cancer in Idaho continues to increase, according to Cancer Data Registry of Idaho."

[4] Brennen Kauffman, *The Idaho Falls Post Register*, "New cancer report on 2017 shows stable cancer trends for Idaho," December 13, 2018.

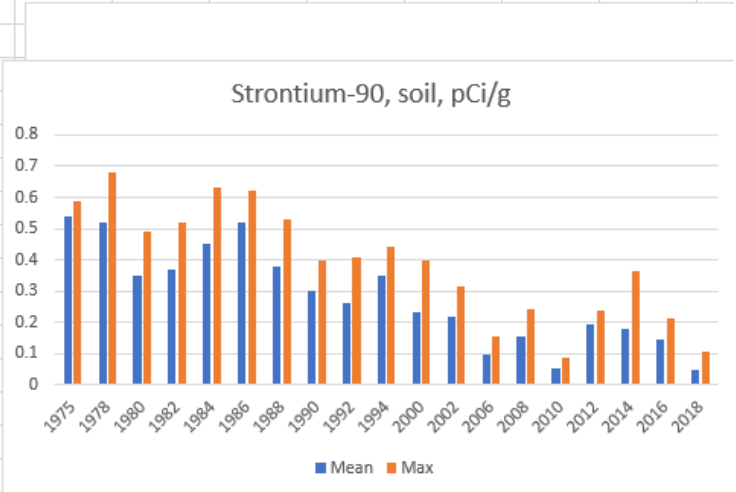
[5] C. J. Johnson, B. M. Morawski, R. K., Rycroft, Cancer Data Registry of Idaho (CDRI), Boise Idaho, Annual Report of the Cancer Data Registry of Idaho, *Cancer in Idaho – 2017*, December 2019. https://www.idcancer.org/ContentFiles/AnnualReports/Cancer%20in%20Idaho%202017.pdf

the INL site. The concentrations of cesium-137 and strontium-90 from 2000 to 2018 generally are lower than the concentrations detected offsite between 1970 and 1999.

Year	Mean	Max
1975	0.94	1.1
1978	0.94	1.2
1980	0.64	0.9
1982	0.9	1.2
1984	0.69	0.97
1986	0.81	1.2
1988	0.66	1.3
1990	0.73	0.99
1992	0.78	1.09
1994	0.75	1.03
2000	0.58	0.9
2002	0.64	1.27
2006	0.386	0.735
2008	0.421	0.664
2010	0.395	0.519
2012	0.42	0.746
2014	0.361	0.641
2016	0.375	0.579
2018	0.308	0.642

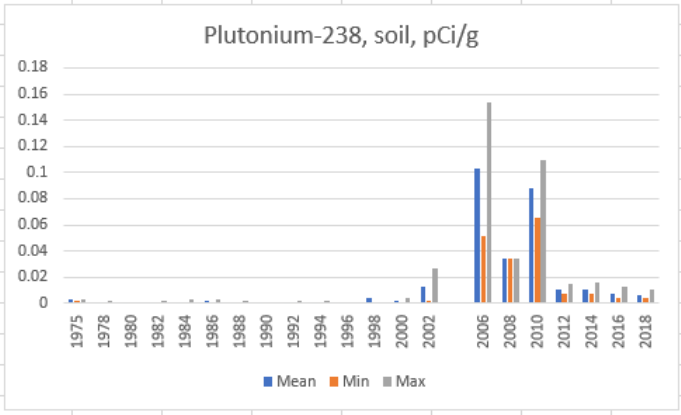


Year	Mean	Max
1975	0.54	0.59
1978	0.52	0.68
1980	0.35	0.49
1982	0.37	0.52
1984	0.45	0.63
1986	0.52	0.62
1988	0.38	0.53
1990	0.3	0.4
1992	0.26	0.41
1994	0.35	0.44
2000	0.23	0.4
2002	0.218	0.313
2006	0.096	0.154
2008	0.155	0.241
2010	0.051	0.0844
2012	0.194	0.238
2014	0.181	0.364
2016	0.144	0.214
2018	0.045	0.105



Now, let's look at some far more interesting trends. Looking at the soil trending for plutonium-238 from 1975 to 2018, plutonium-238 concentrations in offsite soil have skyrocketed since 2002. Pay attention to the maximum values found at offsite locations.

Year	Mean	Min	Max
1975	0.0028	0.0023	0.0034
1978	0.001	0.0005	0.002
1980	0.0007	0.0005	0.0009
1982	0.0011	0.0007	0.0017
1984	0.0015	0.0008	0.0027
1986	0.0021	0.001	0.0027
1988	0.0014	0.0009	0.0024
1990	0.0006	0.0003	0.0012
1992	0.0013	0.0009	0.0019
1994	0.0013	0.0009	0.0019
1996	0.0011		
1998	0.004		
2000	0.0016	0.0005	0.004
2002	0.0129	0.002	0.027
2006	0.103	0.052	0.154
2008	0.034	0.034	0.034
2010	0.0878	0.0657	0.11
2012	0.0107	0.0075	0.0147
2014	0.0111	0.0074	0.0156
2016	0.0073	0.0041	0.013
2018	0.0067	0.004	0.0109



The average and maximum soil concentrations for plutonium-238 before 2002 were typically below 0.003 pCi/g. But the maximum soil concentrations for plutonium-238 from 2006 to 2018 have exceeded 0.01 pCi/g and for 2006 and 2010, exceeded 0.1 pCi/g.

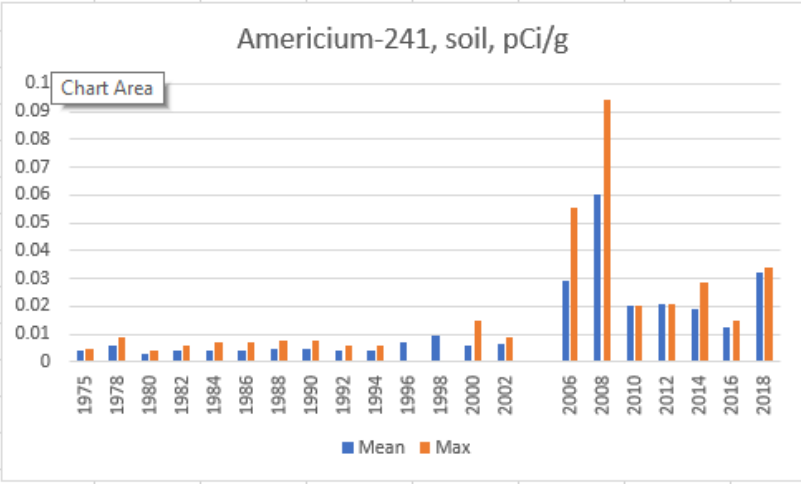
For the average soil concentration values, I use in the figures, I excluded results with poor radioactive decay counting statistics. So, unlike some of the DOE's environmental monitoring, I don't toss out high "outliers" and then average in oddly low or negative results which may lower the average annual radionuclide concentrations of the soil.

While the DOE's environmental monitoring has sometimes trended average radionuclide concentrations in soil values, they have not trended minimums or maximum radionuclide soil concentrations since 1994. With the soil averages, it isn't clear how they have arrived at average values when the average values have been tabulated (and also sometimes converted using unique and unstated multipliers for each sample, to convert the picocurie/gram concentrations to aerial nanocurie/square-meter contamination levels).

Decreasing minimum radionuclide soil concentration values would make sense as weapons fallout decays away. But I am noticing markedly higher maximum values of radionuclides in the soil. And this suggests to me the contamination is recently released from the INL. (I'll provide even more compelling evidence using yellow-bellied marmot data.)

Let's look at the offsite americium-241 soil concentrations from 1975 to 2018.

Year	Mean	Max
1975	0.004	0.005
1978	0.006	0.009
1980	0.003	0.004
1982	0.004	0.006
1984	0.004	0.007
1986	0.004	0.007
1988	0.005	0.008
1990	0.005	0.008
1992	0.004	0.006
1994	0.004	0.006
1996	0.007	
1998	0.0097	
2000	0.006	0.015
2002	0.0064	0.009
2006	**0.029**	**0.0556**
2008	**0.06**	**0.094**
2010	0.02	0.02
2012	0.021	0.021
2014	**0.0188**	**0.0287**
2016	**0.0126**	**0.0148**
2018	**0.0323**	**0.034**

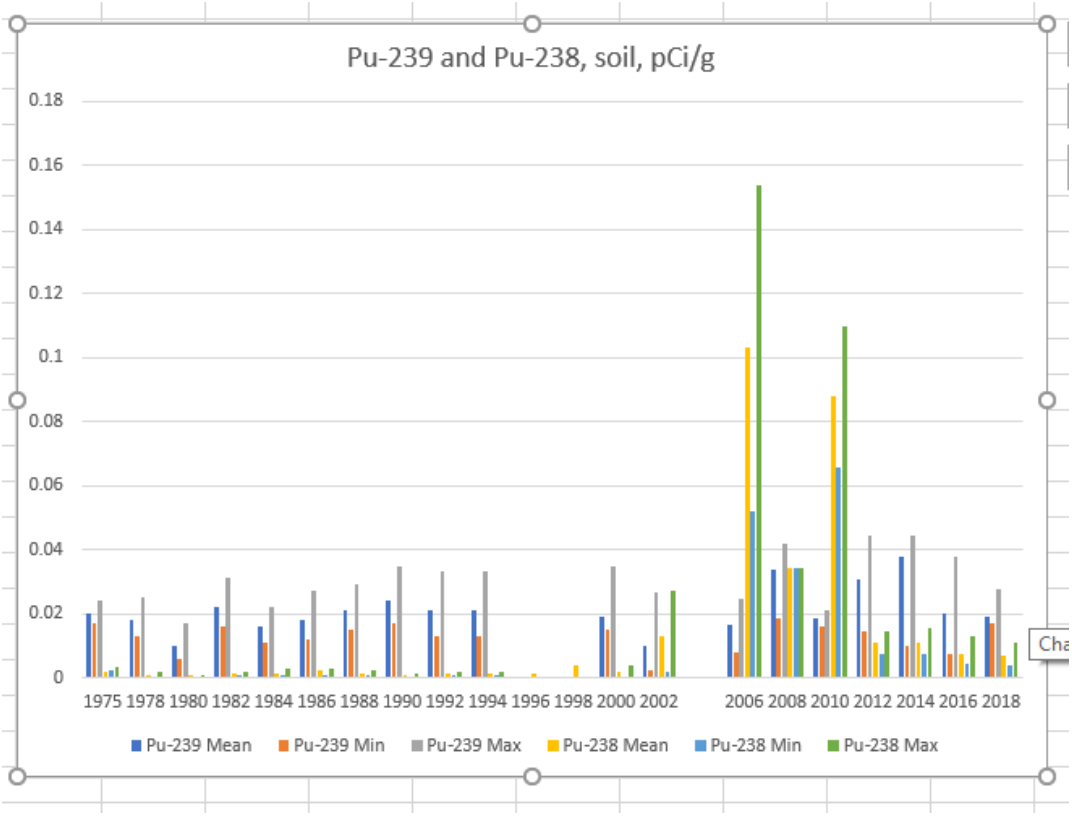


Clearly, the maximum soil concentrations for the americium-241 from 2006 to 2018, peaking at 0.094 pCi/g in 2008, roughly ten times higher than historical soil concentrations that had maximums typically below 0.008 pCi/g. The DOE's environmental monitoring narrative is doubling-down on asserting that the source of the plutonium-238 and americium-241 contamination is from historical weapons testing and not the INL.

It is important to understand that the radioactive fallout from nuclear weapons testing in southeast Idaho was extensive. But weapons testing fallout was very high in combined

plutonium-239 (and plutonium-240) and low in plutonium-238. The activity ratio of Pu-238 to Pu-239/240 from weapons fallout has been estimated as less than 0.05. [6]

The INL, however, has various facilities that may release far more plutonium-238 than plutonium-239/240. Let's look at a trend graphic for both Pu-239 and Pu-238 for 1975 to 2018.



Not only is the maximum plutonium-239 in soil off of the INL site (offsite) higher in 2008 than the previous three decades, but the maximum concentrations of plutonium-238 in offsite soil have skyrocketed. The ratio of plutonium-238 to plutonium-239/240 is greater than 1 in several years, not resembling the ratio from weapons testing fallout. And the high concentrations have very good 3-sigma statistics that solidly support the high value of the radionuclide concentrations. [7]

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[6] T. M. Beasley et. al, Environmental Measurements Laboratory, *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*, EML-599, October 1998.

[7] One standard deviation, or one sigma (or 1-sigma), would define 68 percent of all data points; two sigma (or 2-sigma) would include about 95 percent of the data; and three sigma (or 3-sigma) would include 99.7 percent, of in our case, the radionuclide decay counting statistics for a sample. When the sample result is greater than 3-sigma, the sample result is higher than the standard deviation multiplied by 3. It corresponds to a high confidence that there was a positive detection of an analyte. But 2-sigma results, when a sample result is greater than the

Again, you don't need to accept my tabulated average (or mean) values. Just look at the maximums, and you can see off-the-charts elevated levels which are not due to typical statistical fluctuations in counting radioactive decays in soil samples.

Back in the 1990s, a study was conducted that surveyed soil contamination data from a variety of soil monitoring studies between the 1970s to the early 1990s, both on- and off of the INL site. The study was conducted so that "background" levels of contaminants could be defined so that new contamination or excessive contamination levels could be identified. These so-called background levels are elevated by INL releases as well as nuclear weapons testing fallout, yet the data excluded the most highly contaminated onsite areas. Summary statistics from the soil study by Rood et al., 1996 [8] are shown in Table 2.

Table 2. Summary statistics for background concentrations of selected radionuclides for onsite cobalt-60 and for several offsite radionuclides from the soil study by S. M. Rood et al. (1996).

Radionuclide	Number of samples	Mean (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Standard deviation (pCi/g)	Standard error
Cs-137	126	0.44	0.0099	0.955	0.2	0.018
Sr-90	22	0.26	0.01	0.46	0.10	0.02
Am-241	18	0.005	0.0019	0.0114	0.0026	0.0006
Pu-238	18	0.0014	-4.6E-05	0.0056	0.0014	0.0003
Pu-239/240	20	0.024	-0.0046	0.1358	0.0316	0.007
Co-60 (onsite only)	55	0.44	0.012	4.1	0.80	0.11

Table notes. Source S. M. Rood et al., *Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory*, INEL-94/0250, August 1996. Table 6 for onsite cobalt-60 and Table 23 "Summary statistics for the radionuclide combined data set (offsite). Rood (1996) included soil data from 1970 through the early 1990s.

The soil study by Rood et al., (1996) included data for cobalt-60 detections found onsite and the study did not find cobalt-60 offsite. Cobalt-60 detections offsite are contamination since the 1996 Rood study of soil data collected prior to 1992.

Furthermore, the soil study by Rood et al., (1996) found only 1 detection of cesium-134, and two detections each for europium-152 and europium-155 and recommended that any detection of these or of uranium-235 (with 3 detections) should be considered contamination.

The Rood soil study took a rather interesting and short-sighted view of short-lived radionuclides and removed some of the data that had been collected. Soil contamination levels for short-lived actinium-228, lead-212, lead-214, thallium-208, bismuth-212, bismuth-214, manganese-54, cerium-144, beryllium-7, zirconium-95 and niobium-95 were not just excluded from soil background statistics, but also zeroed-out from raw data tables so that the

standard deviation multiplied by 2 are still strong indication of detection of the analyte and the result is not a false positive. Sample results above 3-sigma are unlikely to be "false positives." Sample results below 3-sigma may have the additional problem, however, of up to a 50 percent probability of being a "false negative."

[8] S. M. Rood et al., Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory, INEL-94/0250, August 1996.

concentrations detected historically could not be reviewed despite the first six of these being referred to as "naturally-occurring" and the rest being frequent and continued contaminants both on and off the INL site.

In Table 3 below, radionuclide soil concentrations considered to be background levels in the soil study by Rood (1996) are compared to more recent radionuclide soil concentrations. While the cesium-137 and strontium-90 concentrations are below the estimated background level from the soil study by Rood (1996), the soil concentrations for americium-241, plutonium-238 and plutonium-239/240 are often above the background level. Cobalt-60 was also detected offsite in 2002, 2006, and 2008 and would be from the INL. The complete soil data compilation is provided in Table 4.

Various years of quarterly reports listed on the idahoeser.com website dead-ended in 404 error messages for years before 1999, and in 2000 there were no data reports issued, although the 2000 soil data have been included in soil trending in 2008. Average values for soil could sometimes be obtained from summary graphics. In many cases, no average value for soil radionuclide concentrations were available and so I used the strongest data to estimate average soil concentration values. My estimated average values can be disputed. But the minimum and maximum values are pretty straight-forward and important to pay attention to.

As shown in Table 3, the cesium-137 and strontium-90 concentrations in soil do not exceed the INL's soil contamination summary statistics from the S. M. Rood et al. 1996 report. **But the americium-241 and plutonium-238 average values and maximums do exceed the Rood 1996 soil summary statistic values. And the plutonium-238 to plutonium-239/240 ratio is far too high in plutonium-238 to be from historical weapons testing.** The average plutonium-239/240 soil concentrations, based on my average estimates, have also been exceeding the Rood 1996 soil summary statistic values. But the maximum plutonium-239/240 soil sample detection from the Rood 1996 soil study of 0.1358 pCi/g has not been exceeded.

Cobalt-60 from weapons testing would not be detectable but it is released by the INL. The Rood 1996 soil study included onsite soil detections of cobalt-60 but no offsite detections. Detection of cobalt-60 offsite should be considered INL contamination. I provide addition information discussion of cobalt-60 following Table 4.

Table 3. Comparison of offsite 2008 and 2018 soil concentrations to the "background" concentrations estimated in a soil study by S. M. Rood et al. (1996).

Radionuclide	Number of samples[a]	Mean (pCi/g)	Min (pCi/g)	Max (pCi/g)	Mean above background?	Max above background?
Cs-137						
Background (pre-1996)	126	0.44	0.0099	0.955		
2008	13 >3-sigma	0.42	0.0698	0.664	No	No
2018	12 >3-sigma	0.30	0.192	0.642	No	No
Sr-90						
Background (pre-1996)	22	0.26	0.01	0.46		
2008	9 >3-sigma	0.155	0.056	0.241	No	No
2018	1 >3-sigma	0.0446	0.077	0.105	No	No
Am-241						
Background (pre-1996)	18	0.005	0.0019	0.0114		
2008	2 ~2-sigma	0.06	0.027	0.094	Yes	Yes
2018	3 >3-sigma	0.032	0.031	0.034	Yes	Yes
Pu-238						
Background (pre-1996)	18	0.0014	-4.6E-05	0.0056		
2008	1 ~2-sigma	(0.034)	(0.034)	0.034	(Yes)	Yes
2018	4 >3-sigma	0.0067	0.004	0.0109	Yes	Yes
Pu-239/240						
Background (pre-1996)	20	0.024	-0.0046	0.1358		
2008	3 ~2-sigma	0.0336	0.0183	0.0417	Yes	No
2012	11 >3-sigma	0.0306	0.0144	0.0444	Yes	No
2014	6 <3-sigma	0.038	0.0269	0.0442	Yes	No
2018	4 >3-sigma	0.0189	0.0109	0.0279	No	No
Co-60						
Background (pre-1996)	55	0.44	0.012	4.1		
2008	1 ~2-sigma	0.003	?	?	No ? [d]	
2012	7 onsite [b]	0.05	0.03	0.2	Onsite, No	Onsite, No

Table notes. Source S. M. Rood et al., *Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory*, INEL-94/0250, August 1996. Table 6 for onsite cobalt-60 and Table 23 "Summary statistics for the radionuclide combined data set (offsite). Rood (1996) included soil data from 1970 through the early 1990s. a. Three-sigma detections are sample results larger than 3 times the standard deviation. b. The cobalt-60 detections in 2012 were from Table 7-2 in-situ gamma scan results for soil. There were offsite cobalt-60 detections noted in 2002, 2006, and 2008. Troublingly poor counting statistics such as 0.004 ± 0.548 pCi/g suggest "hot blanks" or flipped sample and background blank used in counting radioactive decays. This would mean that the cobalt-60 contamination levels are higher than reflected in environmental monitoring reports.

Table 4. Average cesium-137, strontium-90, americium-241, plutonium-238 and plutonium-239/240 concentrations in offsite soils, 0-5 cm depth, from 1970 to 2018, in counties near the Idaho National Laboratory.

Radionuclide	Year	Mean[a] pCi/g	Minimum[b] pCi/g	Maximum pCi/g	MDC pCi/g	Estimated soil background concentrations, pCi/g [c]
Cs-137	1970-75	0.94	0.78	1.1	0.01	0.005
	1978	0.94	0.72	1.2		
	1980	0.64	0.46	0.90		
	1982	0.90	0.64	1.2		
	1984	0.69	0.49	0.97		
	1986	0.81	0.54	1.2		
	1988	0.66	0.34	1.3		
	1990	0.73	0.54	0.99		
	1992	0.78	0.56	1.09		
	1994	0.75	0.55	1.03		
	1996					
	1998					
	2000 [d]	0.58	0.27	0.9		
	2002	0.64	0.370	1.27		
	2004	Not published	Not published	Not published		
	2006	0.386	0.0752	0.735		
	2008	0.421	0.0698	0.664		
	2010	0.395	0.186	0.519		
	2012	0.420	0.052	0.746		
	2014	0.361	0.167	0.641		
	2016	0.375	0.181	0.579		
	2018	0.308	0.192	0.642		
Cesium-137 soil concentrations were markedly elevated in 1986 and 1988 and also in 2002. This suggests releases not only from the 1986 Chernobyl nuclear disaster but also from INL operations. Note that minimums are getting lower but maximums are staying high and this is also a sign of continuing INL releases and not simply the residual contamination from past nuclear weapons testing. The spike in 2002 was shown in graphic of soil averages, offsite, from 1975 to 2012.						
Sr-90	1970-75	0.54	0.43	0.59	0.09	
	1978	0.52	0.40	0.68		

Radionuclide	Year	Mean[a] pCi/g	Minimum[b] pCi/g	Maximum pCi/g	MDC pCi/g	Estimated soil background concentrations, pCi/g [c]
	1980	0.35	0.25	0.49		
	1982	0.37	0.26	0.52		
	1984	0.45	0.32	0.63		
	1986	0.52	0.43	0.62		
	1988	0.38	0.28	0.53		
	1990	0.30	0.22	0.40		
	1992	0.26	0.17	0.41		
	1994	0.35	0.27	0.44		
	1996					
	1998					
	2000 [d]	0.23	0.075	0.4		
	2002	>0.213 Only 1 onsite statistic approaching 3s	?0.213	?0.313 or closer to 0.700 ? 55.7 ± 700 for a sample isn't reasonable. They may be using "hot blanks" or not counting nearly long enough for reasonable statistics		
	2004	Not published	Not published	Not published		
	2006	0.096 All 13 offsite soil samples greater than 3s.	0.03	0.154		
	2008	0.155	0.056	0.241		

Radionuclide	Year	Mean[a] pCi/g	Minimum[b] pCi/g	Maximum pCi/g	MDC pCi/g	Estimated soil background concentrations, pCi/g [c]
	2010	0.0506	0.0417	0.0844		
	2012	0.194	0.141	0.238		
	2014	0.181	0.125	0.364		
	2016	0.144	0.068	0.214		
	2018	0.0446	0.0177 (using ~ 2s results)	0.105		
Strontium-90 concentration maximums were down to 0.4 pCi/g in 1990, yet the maximum offsite soil value in 2014 is nearly that high at 0.36 pCi/g. This is following ESER data in 2010 that found the maximum soil concentration of Sr-90 of 0.08 pCi/g. The behavior of the minimum and maximum trends seems to be ignored by ESER. And ESER has not performed soil trending for Sr-90 since 2012, where only average values were trended.						
Am-241	1970-1975	0.004	0.003	0.005	0.003	0.005
	1978	0.006	0.004	0.009		
	1980	0.003	0.002	0.004		
	1982	0.004	0.003	0.006		
	1984	0.004	0.002	0.007		
	1986	0.004	0.002	0.007		
	1988	0.005	0.004	0.008		
	1990	0.005	0.003	0.008		
	1992	0.004	0.002	0.006		
	1994	0.004	0.002	0.006		
	1996 [f]	0.007	?	?		
	1998 [f]	0.0097	?			
	2000 [d]	0.0066	0.001	0.015		
	2002	0.0064	0.0033	0.009		
	2004	Not published	Not published	Not published		
	2006	**0.029**	**0.016**	**0.0556**		
	2008	**0.060**	**0.027**	**0.094**		
	2010	~0.02	~0.02	~0.02		
	2012	~0.021	~0.021	~0.021		
	2014	**0.0188**	**0.0133**	**0.0287**		

Radionuclide	Year	Mean[a] pCi/g	Minimum[b] pCi/g	Maximum pCi/g	MDC pCi/g	Estimated soil background concentrations, pCi/g [c]
	2016	**0.0126**	**0.0094**	**0.0148**		
	2018	**0.0323**	**0.031 (>3s)**	**0.034**		
Americium-241 levels were a maximum of 0.004 pCi/g in 1980. Yet valid detections, including 3-sigma detections, are nearly ten times that that since 2006. The maximum value in 2018 was 0.034 pCi/g, with 3-sigma statistics. ESER is declaring americium-241 that the levels are attributed to historical weapons testing fallout. The fact is that the INL has long been releasing americium-241 to our region and 1990s CERCLA cleanup investigations show this.						
Pu-238	1970-1975	0.0028	0.0023	0.0034	0.002	0.0014
	1978	0.001	0.0005	0.002		
	1980	0.0007	0.0005	0.0009		
	1982	0.0011	0.0007	0.0017		
	1984	0.0015	0.0008	0.0027		
	1986	0.0021	0.001	0.0027		
	1988	0.0014	0.0009	0.0024		
	1990	0.0006	0.0003	0.0012		
	1992	0.0013	0.0009	0.0019		
	1994	0.0013	0.0009	0.0019		
	1996 [f]	0.0011	?	?		
	1998 [f]	0.004	?	?		
	2000 [d]	0.0016	0.0005	0.004		
	2002	0.0129	0.002	0.027		
	2004	Not published	Not published	Not published		
	2006	0.103	0.052	0.154		
	2008 [e]	0.034	0.034	0.034		
	2010	0.0878	0.0657	0.110		
	2012	0.0107	0.0075	0.0147		
	2014	0.0111	0.0074	0.0156		
	2016	0.0073	0.0041	0.0130		
	2018	0.0067	0.004	0.0109		
Plutonuim-238 is rising because of INL releases. By averaging in unreliable data or just not averaging the data and not trending the results, the problem has been hidden. But valid and high detections show how at least some locations offsite are more contaminated than in the past. Stunningly, some offsite						

Radionuclide	Year	Mean[a] pCi/g	Minimum[b] pCi/g	Maximum pCi/g	MDC pCi/g	Estimated soil background concentrations, pCi/g [c]
areas are more contaminated with Pu-238 for the last 20 years than in the 1970s!						
Pu-239/240	1970-1975	0.020	0.017	0.024	0.002	0.024
	1978	0.018	0.013	0.025		
	1980	0.010	0.006	0.017		
	1982	0.022	0.016	0.031		
	1984	0.016	0.011	0.022		
	1986	0.018	0.012	0.027		
	1988	0.021	0.015	0.029		
	1990	0.024	0.017	0.035		
	1992	0.021	0.013	0.033		
	1994	0.021	0.013	0.033		
	1996					
	1998					
	2000 [d]	0.019	0.015	0.035		
	2002	0.0098	0.0023	0.0268		
	2004	Not published	Not published	Not published		
	2006	0.0166	0.00798	0.0248		
	2008	0.0336	0.0183	0.0417		
	2010	0.0185	0.0162	0.0209		
	2012	0.0306	0.0144	0.0444		
	2014	0.038	0.0269 (>3s) 0.0099 (~2s)	0.0442		
	2016	0.020	0.0075	0.0377		
	2018	0.0189	0.0169	0.0279		
Plutonium-239 and plutonium-240, combined, should not be exceeding 0.024 pCi/g. Yet, the peak and average 2008, 2012 and 2014 contamination levels exceeded levels from the early 1970s. Though they are trying to explain this away, as simply from historical weapons testing, the fact is that INL releases are causing the elevated contamination of Pu-239/240. And the plutonium-240 levels decay to radium-228 that is increasing detected in drinking water in concentrations far above naturally occurring levels.						

Table notes: a. The mean is as estimated by ESER reports unless no tabulated mean was available. In that event, when greater the 3-sigma estimates were plentiful, only the 3-s data were used. When a location had more than one result, the highest result was used and the lower, usually "duplicate" value was ignored. b. Where there were few or no 3-s estimates, the data from near 2-sigma estimates and above were used to determine the mean and the minimum value. Maximum concentrations usually had greater than 3-s uncertainty statistics. The 1994 ESER report 95% confidence interval values were used as minimum and maximum values in this table. c. Estimated background radionuclide concentrations in soil are taken from Table 23 summary statistics for soil from S. M. Rood et al., Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory, INEL-94/0250, August 1996. It should be noted that the summary statistics for soil from the Rood study are inflated by decades of INL releases; however, these data are for offsite soils and avoided the most contaminated INL onsite areas. d. For 2000, quarterly reports were not coming up on the ESER database. The 2000 data were roughly estimated from Figure 3-3 in the annual report. e. Plutonium-238 data for 2008 had either used "hot blanks" or inadequate counting time. Only the data for a single location approached 2-s, with 0.03364 pCi/g ± 0.01684 pCi/g. Data like "-0.02614 pCi/g ± 0.0088 pCi/g" show serious problems in the counting methods. f. For 1996 and 1998, the ESER tables would not display, so mean values from Figure 7-3 from the 2002 report were converted rather roughly from aerial nC/m2 to pCi/g by eyeballing the figure and interpolation.

The cobalt-60 contamination in soil should be undetectable from nuclear weapons testing. The Rood soil report summary concentrations provided no offsite background contamination concentration for Co-60, so any detection should be considered INL contamination. The Rood soil report did include data from an onsite study that did include Co-60.

Detections of cobalt-60 in the offsite soil monitoring program have been noted in 2002, 2006, 2008, 2010, and 2012. Yet, none of the results are above 2-sigma detections. But the sample counting results are troubling. Results range from 0.0002 ± 0.00667 pCi/g to -0.00446 ± 0.407 pCi/g.

If you understand the counting statistics and the subtraction of a "blank" considered to be a background soil sample, it is as though they reversed the hot soil sample and the blank, to arrive at the oddly high standard deviation, about 100 times higher than the supposed sample result. It is not at all clear what the average, minimum or maximum results are for Co-60; but any detected Co-60 would not be from weapons testing and is from the INL. Cobalt-60 soil monitoring data are provided in Table 5. And this will be relevant to the look at radionuclides in Marmots, later on in the newsletter.

Table 5. Cobalt-60 concentrations in soil, pCi/g, both onsite and offsite.

Radionuclide	Year	Mean[a] pCi/g	Minimum[b] pCi/g	Maximum pCi/g	MDC pCi/g	Estimated soil background concentrations, pCi/g [c]
Cobalt-60	1992 or before	0.44 onsite	0.012 onsite	0.44 onsite	0.01 to 0.2	0.012 minimum onsite value Offsite value should be below 0.012
Cobalt-60	2002	~0.006	?	?	?	Poor counting statistics, but the results appear to be near 0.006 pCi/g
Cobalt-60	2006	0.002	?	?	?	Poor counting statistics with wildly high standard deviations.
Cobalt-60	2008	0.003	?	?	?	Poor counting statistics with wildly high standard deviations.
Cobalt-60 - onsite in-situ scans	2012	0.05 for 7 onsite detections	0.03 onsite	0.2 onsite	?	0.03 minimum onsite value in 2012.

Table notes: a. The mean is as estimated by ESER reports unless no tabulated mean was available. In that event, when greater the 3-sigma estimates were plentiful, only the 3-s data were used. When a location had more than one result, the highest result was used and the lower, usually "duplicate" value was ignored. b. Where there were few or no 3-s estimates, the data from near 2-sigma estimates and above were used to determine the mean and the minimum value. Maximum concentrations usually had greater than 3-s uncertainty statistics. c. Estimated background radionuclide concentrations in soil are taken from Table 6 (Table 23 summary statistics did not include cobalt-60) for soil from S. M. Rood et al., Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory, INEL-94/0250, August 1996. It should be noted that the summary statistics for soil from the Rood study are inflated by decades of INL releases; however, these data are for offsite soils and avoided the most contaminated INL onsite areas. Basically cobalt-60 from nuclear weapons testing should not be detectable because of its 5.27 year half-life and weapons testing largely ended by 1963 and certainly ended by 1980.

Strontium-90 not decreasing like it should in garden lettuce and wheat near the Idaho National Laboratory

The strontium-90 concentrations in garden lettuce from 1995 to 2018 are provided in Table 6. For 1995 to 1999, Sr-90 concentrations in lettuce are generally decreasing. But concentrations for 2000 and 2002 are high, but have rather poor statistics with less than 3-sigma. But note how the strontium-90 concentrations for on-site lettuce for 2004 to 2018 vary greatly. The lettuce is known to pick up strontium-90 from airborne deposition, soil and water.

The high onsite values of strontium-90 coupled with large fluctuations in Sr-90 concentrations in lettuce from 2004 to 2018 strontium-90 data illustrate the airborne variations in strontium-90 levels and how they are reflected in garden lettuce.

Table 6. Strontium-90 concentrations in garden lettuce (1995-2018) in pCi/kg.

Year	1995	1996	1997	1998	1999
Arco	140 ± 50	200 ± 200	70 ± 70	200 ± 100	120 ± 40
Atomic City	300 ± 120	120 ± 100	160 ± 60	100 ± 70	90 ± 40
Blackfoot	740 ± 200	270 ± 240	90 ± 70	100 ± 80	130 ± 60
Carey	-50 ± 180	LOST	70 ± 50	200 ± 50	120 ± 80
Howe	No sample	100 ± 160	80 ± 80	100 ± 90	60 ± 70
Idaho Falls	60 ± 30	LOST	50 ± 30	70 ± 40	60 ± 40
Monteview	100 ± 90	LOST	90 ± 40	100 ± 50	225 ± 200
Mud Lake	80 ± 40	160 ± 360	170 ± 80	100 ± 80	160 ± 80
Pocatello	No sample	LOST	No sample	No sample	No sample
Maximum offsite 1995-1999	***740***	***270***	***170***	***200***	***225***
Year	2000	2002	2004	2006	2008
Arco	81 ± 41	92.9 ± 45	No sample	No sample	22 ± 7
Atomic City	No sample	No sample	150 ± 30	**30 ± 10**	**90 ± 15**
Blackfoot	80 ± 30	116 ± 160	-20 ± 40	**30 ± 10**	**22 ± 4**
Carey	295 ± 140	283 ± 160	40 ± 20	No sample	**18 ± 4**
Howe	88 ± 48	64.8 ± 56	30 ± 50	No sample	**45 ± 5**
Idaho Falls	61 ± 50	40.60 ± 50	-30 ± 40	**70 ± 10**	18 ± 6
FAA Tower	No sample	No sample	No sample	20 ± 10	**70 ± 11**
Monteview	No sample	85.40 ± 44	No sample	**40 ± 10**	-5 ± 4
Mud Lake	51 ± 51	109 ± 52	-120 ± 110	No sample	No sample

Pocatello	89 ± 60	No sample	140 ± 110	No sample	No sample
EFS-onsite	No sample	No sample	230 ± 90	**50 ± 10**	17 ± 28
Maximum offsite 2000-2008	***295***	***283***	***150***	***70***	***90***
Year	2010	2012	2014	2016	2018
Arco	13.7 ± 11.5	**126 ± 29.8**	**38.8 ± 5.17**	No sample	No sample
Atomic City	**41.1 ± 11.8**	65.1 ± 24.1	**35.6 ± 4.95**	**103 ± 6.47**	33.3 ± 19.4
Blackfoot	-8.7 ± 5.9	**94.6 ± 26.5**	**18.4 ± 3.26**	**29.8 ± 3.33**	54.3 ± 84.8
Carey	1.4 ± 9.9	**148 ± 32**	**58 ± 7.27**	No sample	No sample
Howe	-15.1 ± 7.6	41.9 ± 20.6	No sample	**94.2 ± 6.77**	30.9 ± 19.4
Idaho Falls	5.65 ± 8.15	59.6 ± 23.6	No sample	**37.6 ± 3.45**	55.6 ± 20
FAA Tower	**73.5 ± 12.5**	70.3 ± 24.9	**33.7 ± 5.01**	**103 ± 4.95**	44.7 ± 20
Monteview	30.4 ± 13.9	**104 ± 27.4**	**46 ± 6.2**	**38.3 ± 3.31**	0.89 ± 17.5
Mud Lake	No sample	No sample	No sample	No sample	No sample
Pocatello	No sample	No sample	No sample	No sample	No sample
EFS-onsite	12 ± 13.1	**164 ± 34.6**	**(35.6 ± 5.08)**	**(241 ± 7.4)**	**(154 ± 23.5)**
Maximum Offsite 2010-2018	***73***	***148***	***58***	***103***	***56***

Table notes: Source is Department of Energy's environmental monitoring reports, see idahoeser.com. When duplicates were presented, only the maximum value is presented in this table. Apparent unit errors in idahoeser.com were assumed; either that of some of the lettuce is 1000 times hotter than I show in this table. Data for Basalt and for Rigby were provided for only a single year and were similar to other communities and so were not included in the table. Values for locations shown in Bold were delineated as greater than 3-sigma results. A greater than 3-signa detection has a low probability of being a false positive result.

Strontium-90 concentrations in wheat samples are provided in Table 7. **In wheat, the concentration of strontium-90 averaged about 7 pCi/kg from 1995 to 2000. Yet, in 2010, wheat in Mud Lake sampled at higher than historical maximums, at 19.9 ± 3.56. In 2014, wheat in Arco sampled at the maximum of 11.3 ± 1.97, and in 2018, wheat in Roberts sampled at the maximum of 53.9 ± 19.9 pCi/kg.** Why aren't the strontium-90 maximum concentrations in wheat decreasing? Crops pick up strontium-90 from the air more so than from the soil. These peak strontium-90 concentrations resemble the late 1960s more than the 1990s. The continuing source of strontium-90 in southeast Idaho is the Idaho National Laboratory.

Table 7. Strontium-90 concentrations in wheat grown in counties near the INL, pCi/kg.

Year	1963	1964	1965	1966	1967
Maximum	170	30	37	14	17
Average	Unknown	11	26	10	8
Year	1995	1996	1997	1998	1999
Maximum	12	16	14	9	8
Average	7	8	7	6	6
Year	2000	2004	2010	2014	2018
Maximum	6	65.3 ± 27	19.9 ± 3.56	11.3 ± 1.97	53.9 ± 19.9
Average	4	Not tabulated	Not tabulated	Not tabulated	Not tabulated

Table notes: pCi/kg is picocurie/kilogram or 1E-12 curie/1000 grams. Source Idahoeser.com.

Prominent nuclear activation products at the Idaho National Laboratory, can be spread far and wide - and are often not recognized as INL contamination

The U.S. Geological Survey was chartered with monitoring groundwater near the Idaho National Laboratory since the inception of the laboratory in 1949. It would be more accurate to say that the U.S. Geological Survey was helping the Department of Energy, then the Atomic Energy Agency (AEC), to economically dispose of radionuclides into the Snake River Plain Aquifer and then cover up the extent of the contamination.

When the U.S. Geological Survey determined that several activation products should be monitored in groundwater at the Idaho National Laboratory, they added several activation products to be monitored. But while these activation products would have provided evidence of INL groundwater contamination, largely the data from these activation products is very limited. And activation products such as cobalt-58 and chromium-51 are only recorded as being monitored once. The USGS groundwater monitoring data for cobalt-60, iron-59, zinc-65, manganese-54, and antimony-125 are very limited. These radionuclides could not have been attributed to nuclear weapons testing fallout.

In a 1957 publication, the activation products in aluminum-clad fuel at the INL, the Borax-III reactor, were listed. [9] The activation products in reactor cooling water were noted as sodium-24, chromium-51, iron-59, zinc-65 and others. Activation products are formed by the neutron addition or neutron capture of the nuclear fuel cladding, fuel matrix or fuel coolant.

Table 8. Selected activation products in Idaho National Laboratory radiological releases and wastes.

Element	Probable formation	Half-life	Comment
Sodium-24 (Na-24)	Na-23 (n, gamma); or Al-27 (n, gamma)	15.0 hour Decays to stable Magnesium-24	Aluminum-clad fuel at the INL's MTR, ETR and ATR
Chromium-51 (Cr-51)	Cr-50 (n, gamma)	27 days Decays to stable vanadium-51	Chromium alloy in aluminum-clad fuel
Iron-59 (Fe-59)	Fe-58 (n, gamma)	46 days Decays to stable cobalt-59	Iron alloy in aluminum-clad fuel
Zinc-65 (Zn-65)	Zn-64 (n, gamma)	250 days Decays to stable copper-65	Aluminum-clad fuel
Manganese-54 (Mn-54)	Cr-54 (p, n); Fe-54 (n, p)	312 days Decays to stable chromium-54	Prevalent in zirconium allow fuels
Cesium-134 (Cs-134)	Cs-133 (n, gamma)	2.06 years Decays to stable barium-134	Activation product from nuclear reactors and is not produced by nuclear weapons testing
Europium-152 (Eu-152)	Eu-151 (n, gamma)	13.5 year Decays to stable samarium-152 or cerium-140	Europium alloy in target. A fission product and an activation product
Cobalt-60 (Co-60)	Co-59 (n, gamma); or Ni-60 (n, p)	5.27 year Decays to stable nickel-60	Nickel or cobalt in targets
Nickel-63 (Ni-63)	Ni-62 (n, gamma)	98.7 years	Nickel in targets

[9] American Nuclear Society, *The Journal of the American Nuclear Society*, "Nuclear Science and Engineering," Volume 2, Number 2, Academic Press Inc., April 1957. P. 139, Table II "Radioactivities Observed in Reactor Water and Filter."

Element	Probable formation	Half-life	Comment
		Decays to stable copper-63	
Antimony-125 (Sb-125)	Tin-124 (Sn-124) (n, gamma), to Sn-125, then beta decay to Sb-125	2.77 years Decays to stable tellurium-125	Fission product and zirconium cladding activation product. Tin is an alloy material in zirconium and other alloys. Tin activation of Sn-124 to Sn-125 then beta decays to antimony-125.
Zirconium-95/niobium-95		64 days/35 days	Fission product and a zirconium cladding activation product
Niobium-94		20,000 year	Fission product and a zirconium cladding activation product

Table notes: Primary sources: 1957 ANS journal and Merril Eisenbud, *Environmental Radioactivity*, Academic Press, 1987. Decay products from https://periodictable.com. See also "Chart of 211 Radioactive Poisons in 10-Year Old CANDU Spent Fuel" at http://www.ccnr.org/hlw_chart.html for a listing of fission products, activation products and actinides.

These various activation products result from neutron capture to cladding material, fuel matrix or to fission products or their decay products. These activation products are often present in far greater concentrations than would occur from regional or global weapons testing.

When manganese-54 was detected in wheat samples in 1964, excuses were made and the contamination was attributed to past weapons testing rather than nuclear fuel reprocessing or calcining of liquid high-level waste and the stack and any other airborne releases from the Idaho National Laboratory. The fact is that the stack releases from nuclear fuel reprocessing blew cladding activation product manganese-54 for more than 50 miles in every direction from the INL, contaminating growing wheat by the airborne release of manganese-54. [10] The key point is that the Department of Energy denied that the Idaho National Laboratory, then the National Reactor Testing Station, was the source of the contamination. And without actually having a scientific basis, the Department of Energy, then the Atomic Energy Agency, assumed that there wasn't any health concern.

The U.S. Geological Survey created monitoring entries for chromium-51 and antimony-125 but provided only one data entry for each. Other activation products including cobalt-60, iron-59, zinc-65, and manganese-54 were monitored by the USGS, yet were rarely reported. It appears

[10] See the May 2020 Environmental Defense Institute Newsletter article "Radioactive Manganese-54 and why it was in wheat samples near the Idaho National Laboratory in 1963 and 1964."

that monitoring data of these activation of products was deleted when scrutiny of drinking water contamination at the INL began. Yet, not all of this monitoring data was deleted. And it is important data particularly due to the short half-lives of these activation products.

While the USGS has elaborated on chromium-36 which is very difficult to detect, the agency largely has ignored all of the monitoring that it did conduct on activation products. Many of the detections are solid detections of quite elevated concentrations that have resulted from radioactive waste water deepwell injection at the INL. These activation products entered the aquifer via percolation ponds more slowly and via deepwell injection. The monitoring of these relatively short-lived radionuclides and their movement from deepwell injection sources, primarily the spent fuel reprocessing facility now called the Idaho Nuclear Technology Engineering Center (INTEC) show movement of the flushed radionuclides that is far more rapid than the USGS likes to pretend.

For airborne emissions, the manganese-54, cobalt-60, cesium-134 and antimony-125 have all been detected in soil miles from the INTEC stack. The antimony-125 was so blatantly due to INL's fuel reprocessing that they had to admit that the antimony-125 (or Sb-125) being detected in 1987 had to be from the INL. Detection of Sb-125 greatly increased when the fuel reprocessing using the Fluorinel (or FAST) process began in 1986. In 1987, Sb-125 was detected in air monitoring in nearly every air sampling station on the INL site and off of the INL site during the first three quarters of the year. Antimony-125 was detected at two-thirds of the onsite stations in the fourth quarter. The FAST facility did not reprocess fuel from mid-October to mid-December. The maximum detection onsite was 229 E-15 microcuries/milliliter with typical values less than 50 E-15 microcuries/milliliter, and the maximum value offsite values occurred at Howe (7.2 E-15 microcuries/milliliter) and Arco (5.2 E-15 microcuries/milliliter). [11]

Air monitoring of antimony-125 in 1987 is shown in Table 2. All of the offsite results are shown, for Blackfoot, Craters of the Moon, Idaho Falls, Rexburg, Arco, Atomic City, FAA Tower (on the east edge of the INL), Howe, Monteview, and Reno Ranch. But only a portion of the onsite stations monitored have been included in the table.

When the uncertainty value is one-third of the detection value or less, such as for Howe in the second quarter, 7.2 +/- 2.2 or Central Facilities Area (CFA) in the third quarter, 12.9 +/- 2.8, the detection is solid and exceeds 3-sigma. It is considered very unlikely to be a false positive. The third quarter detection for Howe is 5.5 +/- 2.4. This is a 2-sigma detection but not a 3-sigma detection. The negative values are used by the environmental monitoring programs to calculate the average value for the year.

Table 9. Antimony-125 activity in air in 1987 from the INL's FAST facility.

Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Blackfoot	1.3 +/- 2.6	-1.5 +/- 2.2	-1.4 +/- 2.6	0.2 +/- 2.6

[11] Department of Energy, Environmental Monitoring, DOE/ID-12082(87), 1988. Table B-4 "Antimony-125 Activity in Air (1987).

Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Craters of the Moon	2.3 +/- 0.6	3.3 +/- 2.4	2.2+/- 2.4	1.0 +/- 2.6
Idaho Falls	1.0 +/- 4.2	0.1 +/- 1.4	0.1 +/1 2.6	2.6 +/- 3.2
Rexburg	-0.3 +/- 1.2	-0.1 +/- 2.2	0.0 +/0 2.2	-0.6 +/- 1.2
Arco	5.2 +/- 2.6	1.9 +/- 2.4	1.5 +/- 1.6	1.6 +/- 2.4
Atomic City	2.7 +/- 1.8	3.0 +/- 4.0	1.8 +/0 2.4	1.1 +/- 2.0
FAA Tower	-1.2 +/- 2.0	0.8 +/0 2.2	0.0 +/- 2.2	1.3 +/- 2.0
Howe	3.0 +/0 2.0	7.2 +/- 2.2	5.5 +/- 2.4	3.5 +/- 2.0
Monteview	Invalid	2.8 +/- 2.4	0.0 +/- 2.2	-0.3 +/- 2.2
Mud Lake	0.9 +/- 2.2	3.5 +/- 2.4	1.9 +/- 2.2	3.4 +/- 2.0
Reno Ranch	3.2 +/- 1.6	3.2 +/- 1.8	1.4 +/- 2.2	-0.4 +/- 1.8
ANL-W	2.8 +/- 2.2	1.4 +/- 2.2	2.6 +/- 2.6	2.9 +/- 2.0
CFA	47 +/- 4	6.9 +/- 2.6	12.9 +/- 2.8	1.0 +/- 1.6
ICPP (INTEC)	42 +/- 6	95 +/- 8	229 +/- 12	21 +/- 4
TRA	27 +/- 6	8.5 +/- 2.8	30 +/- 4	3.2 +/- 2.6

Source: DOE/ID-12082(87).

The onsite detections shown for CFA, INTEC and TRA are all very strong detections of antimony-125 during the first three quarters. The data in Table 3 for the offsite locations show lower concentrations of antimony-125 but still provide an indication of how far and wide the radionuclides from a single stack at the INL could fly in 1987. And it should be mentioned that in the earlier decades, less air monitoring and air filtering technology was available.

Was the antimony-125 released by INL in 1986 and 1987 significant to estimated radiation dose? The environmental monitoring reports estimated that in in 1986, 78 percent and in 1987, 96 percent of the estimated dose came from antimony-125. And in addition to the antimony-125, the INL also released iodine-129 in those years. The last fuel reprocessing campaign was in 1988 and significant antimony-125 detections seem to have ended then.

In the 1987 environmental monitoring report, air monitoring also detected the activation products cesium-134, manganese-54 and fission product and also activation product zirconium-95. The Department of Energy environmental monitoring report (DOE/ID-12082(87) stated the following: “Although investigations did not reveal any particular source, these may be due to Site operations.” Further on in DOE/ID-12082(87), they decide that the detections of Cs-134 and Zr-95 are not detections, are infrequent, and “the statistical differences are not attributable to Site operations.” Somehow, the fact that Zr-95 had long been known to be in the waste water from fuel reprocessing had escaped them.

In the 1989 environmental monitoring report, air monitoring detected cerium-141, manganese-54, ruthenium-106, antimony-125 and zirconium-95, "but no reason for their presence on the filters has been determined."

In the 1994 environmental monitoring report, air monitoring detected cerium-141, cerium-144, manganese-54, niobium-94, zinc-65, silver-110m, as well as strontium-90, plutonium-238 and americium-241.

In later years, and continued detections of Cs-134 resulting from INL operations, I don't think they try to deny that Cs-134 is from INL operations. **In 2012, soil monitoring detected Cs-134 at nine INL facilities during in-situ gamma monitoring of soil.** The maximum soil concentration occurred at the ATR Complex, but due to the magic of the averaging and an unusually low minimum reported minimum value, the average value for Cs-134 in soil for the ATR Complex blended in with other INL facility averages.

The last fuel reprocessing campaign at the INL's INTEC was in 1988, and calcining of liquid high-level waste from fuel reprocessing ended in May 2000. Reprocessing rinse-outs may have been conducted after 1988 and the decision to end fuel reprocessing was made in 1993 when reprocessing was officially ended.

Yet, various operations at the INL, including INTEC's high-level waste evaporator and high-level waste tank farm, various radioactive waste percolation or evaporation ponds, and the Advanced Test Reactor, the Radioactive Waste Management Complex, and the Materials and Fuels Complex, have continued to not only be the mainstays of cesium-137, strontium-90, plutonium-238, plutonium-239/240 and americium-241, operations continue to release cesium-134, cobalt-60, europium-152 as well as uranium-238 according to 2012 onsite soil samples from the INL environmental monitoring programs.

Detections of various short-lived fission products and activation products such as manganese-54, zinc-65 and others that are prevalently released by the INL and are not released by any other nuclear waste dumps or nuclear operations in or near Idaho are not being attributed to the INL, but they should be. The reader is cautioned that some short-lived radionuclides are the decay progeny of long-lived radionuclides and must not be dismissed due to their short radioactive half-life. That said, the short radioactive half-life of various neutron activation products must be freshly produced in a nuclear reactor. Waste packages taken to the INL's Radioactive Waste Management Complex may include these short-lived radionuclides from reactor operations. But why are many of these same short-lived radionuclides, fresh from reactor operations, detected in yellow-bellied marmots living in Pocatello?

What yellow-bellied marmots have to tell us about radiological releases from the Idaho National Laboratory

As I was digging through historical radionuclide soil contamination data for counties near the Idaho National Laboratory, I came upon analysis of sacrificed yellow-bellied marmots.

And because I had been studying the short-decay half-lives of various neutron activation products from INL operations, I recognized the source of the radioactivity in the marmot tissues.

In 2002, marmot tissues were analyzed for radionuclide content. The marmots were taken from the Idaho National Laboratory near the Radioactive Waste Management Complex and from near the Pocatello zoo. There was also marmot data from 1998 also detecting cobalt-60, zinc-65, niobium-95, cesium-134, cerium-141 and also strontium-90, cesium-137 and plutonium-238.

Now you might expect the INL's marmots to have higher concentrations of radionuclides and you might expect that the marmots from Pocatello would only have radionuclides from weapons testing fallout. Well, yes, the INL's marmots did sometimes have higher concentrations of radionuclides. But the marmots from INL and from Pocatello had short-lived neutron activation products that would not be at concentrations this high from weapons testing fallout.

Nor would these activation products be from uranium refining processes such as the waste from Formerly Utilized Sites Remedial Action Program (FUSRAP), radioactive soil that is shipped, often by railway through Pocatello, to the US Ecology disposal site at Grandview on the Boise-side of the state.

Both the INL's RWMC and the Pocatello marmots had the mainstays: strontium-90 and cesium-137 in their tissues. And in 2002, both the INL's and the Pocatello marmots had these short-lived neutron activation products that can only be from the INL: cerium-141, cobalt-58 and cobalt-60, chromium-51, hafnium-181, manganese-54, niobium-95, zinc-65, and the fission product ruthenium (either Ru-103 or Ru-106, both of which are short-lived). See Table 10.

I found this data shocking, particularly since neither fuel reprocessing or calcining were being conducted at INL's INTEC. The Department of Energy's environmental monitoring narrative was simply to say that eating a marmot wouldn't be that harmful.

Table 10. Man-made radionuclides in marmots from Pocatello and from one INL sample from the 2002 environmental monitoring report data, selected results.

Location and Collect Date	Analyte	Result ± 2s uncertainty (pCi/g)	Result ± 2s uncertainty (pCi/g)
Pocatello zoo area, March 1, 2002, analyzed June 5, 2002.			
	Americium	0.60 ± 0.90	1.60 ± 1.90
	Cerium-141	59.20 ± 45.00	42.40 ± 45.00
	Cesium-137	2.40 ± 3.50	-0.80 ± 2.60

Location and Collect Date	Analyte	Result ± 2s uncertainty (pCi/g)	Result ± 2s uncertainty (pCi/g)
	Cobalt-58	1.00 ± 10.00	-4.80 ± 9.20
	Cobalt-60	2.80 ± 4.00	2.40 ± 3.10
	Chromium-51	-22.00 ± 450.00	13.20 ± 460.00
	Hafnium-181	-11.10 ± 21.00	-13.30 ± 21.00
	Manganese (Mn-54)	5.70 ± 4.40	1.20 ± 3.60
	Niobium-95	8.00 ± 35.00	29.4 ± 34.00
	Plutonium-238	0.00 ± 0.80	0.00 ± 1.30
	Plutonium-239/240	0.30 ± 0.70	-0.30 ± 0.50
	Ruthenium (radioactive, unspecified nuclide)	6.50 ± 23.00	-12.50 ± 23.00
	Zinc-65	-16.70 ± 11.00	-13.70 ± 9.20
	Zirconium (radioactive, unspecified)	-15.40 ± 21.00	-9.80 ± 18.00
	Strontium-90	12.00 ± 21.00	8.40 ± 8.30
Idaho National Laboratory, March 17, 2002, analyzed May 17, 2002			
	Americium	4.3 ± 3.00	1.10 ± 1.30
	Cerium-141	12.20 ± 63.00	28.00 ± 96.00
	Cesium-137	-1.10 ± 2.80	4.20 ± 3.80
	Cobalt-58	-9.40 ± 11.00	-0.60 ± 15.0
	Cobalt-60	1.60 ± 3.50	1.50 ± 4.50
	Chromium-51	168.00 ± 670.00	-298.00 ± 1000.00
	Hafnium-181	4.30 ± 26.00	-33.20 ± 38.00
	Manganese (Mn-54)	-0.20 ± 3.90	5.00 ± 5.20
	Niobium-95	36.70 ± 46.00	41.50 ± 66.00
	Plutonium-238	-0.20 ± 0.40	0.00 ± 1.40
	Plutonium-239/240	0.70 ± 1.00	1.10 ± 1.60
	Ruthenium (radioactive, unspecified nuclide)	-24.9 ± 29.00	-45.90 ± 42.00
	Zinc-65	-13.00 ± 10.00	-3.90 ± 14.00
	Zirconium (radioactive, unspecified)	4.10 ± 22.00	-17.10 ± 30.00
	Strontium-90	13.20 ± 15.00	2640.00 ± 540.00

Source: idahoeser.com, 2002.

It is important to note that in the early years of environmental monitoring, Pocatello was included. But in later years, usually Pocatello was excluded from the environmental monitoring program because it was deemed too far away from the INL. For many years, the wind isopleths were unscientifically loped off everything south of Blackfoot even though elevated concentration lines extended south of the Blackfoot. Wind isopleths would imply that the marmots in Pocatello would have minimal, if any, influence from the INL airborne contamination. And yet, the marmots in Pocatello had internal contamination levels near the levels of the INL RWMC marmots.

The environmental monitoring program narrative has been to avoid admitting when the radionuclides detected in environmental monitoring are due to INL releases. Vague denials of INL being the source of the radionuclide contamination have been common. And placing the blame on past weapons testing has been overused through the years. Then I came across data on radionuclide discharges to the open-air evaporation pond at the Advanced Test Reactor Complex. While alpha emitters were largely excluded, many of the short-lived radionuclides found in marmots are released by the INL, see Table 11. Americium-241 is an alpha emitter, but was included in the INL's table as it is also a gamma emitting radionuclide.

Table 11. Gamma-emitting radionuclides discharged to the ATR Complex Evaporation Pond from August 13, 1993 to January 20, 2012, estimated total decay-corrected activity (millicuries).

Analytes	Activity released (millicuries/year)	Analytes	Activity released (millicuries/year)
Silver-110m	1.76	Iodine-131	0.23
Americium-241	22.20	Iodine-133	0.02
Barium-140	0.27	**Manganese-54**	11.77
Cerium-141	0.96	Molybdenum-99	1.49
Cerium-144	54.37	Sodium-24	38.98
Cobalt-58	11.30	**Niobium-95**	0.57
Cobalt-60	4176.58	Neptunium-239	0.20
Chromium-51	1105.34	Rhenium-188	4.34
Cesium-134	12.99	**Ruthenium/Rh-106**	3.17
Cesium-137	6630.04	Antimony-122	0.04
Europium-152	135.94	Antimony-124	1.15
Europium-154	118.37	Scandium-46	1.23
Europium-155	23.10	Tantalum-182	2.04
Iron-59	1.20	Tungsten-187	0.06
Hafnium-175	1.80	**Zinc-65**	24.77
Hafnium-181	29.81	**Zirconium-95**	1.65

Analytes	Activity released (millicuries/year)	Analytes	Activity released (millicuries/year)
		Strontium-90 (beta)	396
		Tritium (weak beta)	124,500

Analytes in **bold** were detected in marmot tissue samples in 2002. Beta emitters such as strontium and tritium are not gamma emitters, but have been added to this table. The INL data excluded many known alpha emitters from the table such as plutonium-238, plutonium-239 and curium-244. Table source is *Technical Basis for Environmental Monitoring and Surveillance at the Idaho National Laboratory Site*, DOE/ID-11485, February 2014.

These marmot tissue samples did not address the elevated levels of tritium in air, precipitation and water and did not include thyroid tissue samples. But if the grass eating and air breathing marmots have these radionuclides in their bodies, what about people?

Summary of key points in this month's newsletter

(1) Cancer rates in the counties surrounding the Idaho National Laboratory are elevated. In particular, the thyroid cancers remain elevated in Bonneville county and are about twice the rate of the remainder of the counties in Idaho.

(2) Soil contamination is usually from airborne releases of radionuclides. It can also be from irrigation with contaminated water.

(3) Looking at the radionuclide contamination in soil off of the INL site, the cesium-137 and strontium-90 levels do seem lower since 2006 than from the 1970s and 1980s. But the level of strontium-90 in garden lettuce and wheat does not seem to be trending downward and this could be due to continued releases from the INL.

(4) The level of plutonium-238 in soil in southeast Idaho is rising. The proportion of plutonium-238 to plutonium-239/240 is much higher than would be the case for contamination from past nuclear weapons testing. The significant rise in plutonium-238 contamination is due to the INL, despite no official admittance of this fact.

(5) The level of americium-241 in soil in southeast Idaho is rising. The rise in americium-241 contamination is not due to historical weapons testing and is due to the INL, despite no official admittance of this fact.

(6) The trending of average concentrations of plutonium-239 in soil is less clear, but the maximum contamination levels found in some biennial soil samples in recent years is often higher than the maximums found from 1970 to 1994.

(7) Some of the radionuclides released from the INL are called nuclear activation products. These radionuclides may have relatively short radioactive decay half-lives. This means that these radionuclides are not from historical weapons testing. And it allows the determination of the source of the contamination. Several important activation products typical of INL releases are listed in Table 8 and include chromium-51, iron-59, zinc-65, manganese-54, cobalt-60, zirconium-95 and niobium-95. Fission products cerium-141 and 144 also have short radioactive half-lives.

(8) When the tissue from yellow-bellied marmots in Pocatello, Idaho, have numerous nuclear activation products, formed by neutron capture reactions in a nuclear reactor, as found in 2002 and these activation products or fission products have short radioactive decay half-lives, it calls for admitting that the source of these radionuclides is the INL. That the source is the INL and that the source is not being admitted should concern everyone living within 50 miles of the INL.

Articles by Tami Thatcher for June 2020.