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Seventy-four years after the Trinity Test in New Mexico, National Cancer Institute nears completion of a radioactive fallout study

On July 16, 1945, the first nuclear weapons test in the U.S. was conducted in New Mexico near Alamogordo. The secret test of a plutonium nuclear weapon like the one that would be dropped on Nagasaki later in August was named "Trinity" by the theoretical physicist, J. Robert Oppenheimer who led part of the Manhattan Project at the Los Alamos laboratory in New Mexico to design and build nuclear weapons.

There were two nuclear weapons designs: the plutonium bomb, called "Fat Man" dropped on the Japan city of Nagasaki on August 9, 1945, and the uranium-235 bomb, called "Little Boy" dropped on Hiroshima on August 6, 1945. The plutonium bomb had roughly 21 kilotons, the equivalent to 21,000 tons of TNT, and the uranium bomb had roughly 15 kilotons explosive power. [1] The two bombs dropped on Japan killed 42,000 people in Nagasaki and 70,000 people at Hiroshima. The enriched uranium came from the Oak Ridge laboratory in Tennessee and the plutonium came from production reactors at the Hanford laboratory in Washington. Development of both designs had proceeded in parallel.

The study of injuries to survivors in Japan from the bombing began five years after the bombing and continued to be documented for decades. [2] The "Life Span Studies" of the people who survived the bombings in Japan are considered by the nuclear industry to provide "the gold standard" for radiation leukemia and cancer rates. Some of the problems with the assumptions used in the "Life Span Studies" that cause the underestimation of harm are explained by John W. Gofman, M.D., Ph.D., in his book *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*. [3]

The harm and even the existence of radioactive fallout was denied in both cities in Japan and in New Mexico where the Trinity test took place.

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[1] Howard G. Wilshire, Jane E. Nielson, and Richard W. Hazlett, *The American West at Risk – Science, Myths, and Politics of Land Abuse and Recover*, Oxford University Press, ISBN 978-0-19-514205-1, 2008.

[2] James N. Yamazaki with Louis B. Fleming, *Children of the Atomic Bomb – An American Physician's Memoir of Nagasaki, Hiroshima, and the Marshall Islands*, Duke University Press, Durban and London, 1995.

[3] John W. Gofman, *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*, Committee for Nuclear Responsibility, 1990.

Oppenheimer would later express regret for the atomic bombs dropped and give less enthusiasm for larger nuclear weapons and nuclear aircraft than the military found pleasing. [4] This attitude resulted in the loss of his security clearance and ultimately cost him his role with the U.S. Atomic Energy Commission.

A sharp rise in infant mortality following the 1945 Trinity test can be seen in infant mortality rates, writes Kitty Tucker and Robert Alvarez. [5]

The radioactive fallout that spread over New Mexico in 1945 is now being studied by the National Cancer Institute to model the dispersion and dose reconstruction for possible exposure to fallout from the Trinity nuclear weapons test.

The past thyroid studies by the National Cancer Institute of radioactive iodine-131 exposure from later nuclear weapons testing at the Nevada Test Site, initiated years after the exposures, were released years after the studies were completed. The National Cancer Institute also omitted consideration of exposure to all other fission products, uranium and transuranic radionuclides that downwinders were also exposed to.

In addition to the Trinity nuclear weapons test in New Mexico and the years of nuclear weapons testing at the Nevada Test Site are the nuclear weapons tests conducted by the United States in the Pacific Islands at Bikini, Eniwetok and the Marshall Islands. Radioactive fallout harmed people near these nuclear weapons tests and compensation programs belatedly have been extended to some downwinders of the Nevada Test Site and Pacific Island weapons tests.

People in New Mexico suffered radioactive fallout from the Trinity Test and later from the Nevada Test Site, yet no compensation program has applied to them.

In addition to the radioactive contamination from nuclear weapons test fallout and from the major sites of enriched uranium and plutonium production and chemical separations are a multitude of sites across the United States that are contaminated from uranium mining and milling, uranium conversion, fuel fabrication and other sites contaminated by manufacture of materials for nuclear weapons and nuclear fuel. [6] [7]

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[4] Nuel Pharr Davis, *Lawrence & Oppenheimer*, Simon and Schuster, New York, Library of Congress Catalog Card Number: 68-19940., Copyright 1968.

[5] Kathleen M. Tucker, Robert Alvarez, *Bulletin of the Atomic Scientists*, "Trinity: "The most significant hazard of the entire Manhattan Project," July 15, 2019. https://thebulletin.org/2019/07/trinity-the-most-significant-hazard-of-the-entire-manhattan-project/

[6] Raymond L. Murray, *Understanding Radioactive Waste*, Fourth Edition, Battelle Press, 1994. The book provides useful history and explanation. Yet the easy-breezy attitude in this book displays the ever-optimistic view that the waste problems will easily be solved, despite little progress since the book was written 30 years ago, all while virtually ignoring the vast environmental damage and human suffering throughout nuclear weapons and nuclear energy development.

[7] Editors: Arjun Makhijani, Howard Hu, and Katherine Yin, *Nuclear Wastelands – A Global Guide to Nuclear Weapons Production and its Health and Environmental Effects*, By a Special Commission of International Physicians for the Prevention of Nuclear War and The Institute for Energy and Environmental Research, The MIT Press, 1995. This book describes many of the nuclear waste sites that we continue to struggle with today.

New Special Exposure Cohort (SEC) Added for the Idaho National Laboratory for INTEC Workers between 1963 and 1970

As of July 21, 2019, an additional class of employees has been added for the Idaho National Laboratory employees who worked at the Idaho Chemical Processing Plant (CPP), now known as the Idaho Nuclear Technology and Engineering Center (INTEC), between January 1, 1963 and February 28, 1970. [8] Employees with a diagnosed cancer qualifying for radiation compensation, who worked during that time frame, are eligible for compensation without performing a radiation dose assessment because of inadequate radiation monitoring or record keeping.

With each new added Special Exposure Cohort (SEC) under the Energy Employee Occupational Illness Exposure Compensation Act, [9] [10] a few more workers that have previously been denied compensation on the basis of the official estimate of radiation exposure based on inadequate radiation exposure monitoring or recording, may now quality for illness compensation.

This latest SEC states: "All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Idaho National Laboratory (INL) in Scoville, Idaho, and who were monitored for external radiation at the Idaho Chemical Processing Plant (CPP) (e.g., at least one film badge or TLD dosimeter from CPP) between January 1, 1963, and February 28, 1970, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort." [11]

The Idaho Chemical Processing Plant now called INTEC conducted chemical separations of research reactor fuel and spent fuel from Naval submarines. This nuclear fuel reprocessing resulted in wide-spread release of air-borne effluents as well as deepwell injection, percolation pond usage and tank farm leakage that contaminated the Snake River Plain aquifer.

The extent of the human and environmental cost of nuclear weapons and nuclear energy development is not ignored in this independent work.

[8] Center for Disease Control (CDC), National Institute for Occupational Safety and Health (NIOSH), Update page at https://www.cdc.gov/niosh/ocas/update.html

[9] 42 USC 7384, The Act--Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA), as Amended and see the website for the Center for Disease Control, National Institute of Occupational Safety and Health, Division of Compensation Analysis and Support at http://www.cdc.gov/niosh/ocas/ and U.S. Department of Labor, Office of Workers' Compensation Programs, EEIOCPA Program Statistics, http://www.dol.gov/owcp/energy/regs/compliance/weeklystats.htm

[10] See the NIOSH Radiation Dose Reconstruction Program at http://www.cdc.gov/niosh/ocas. See the Idaho National Laboratory status at http://www.cdc.gov/niosh/ocas/ineel.html and see the portion of INL formerly ANL-W at http://www.cdc.gov/niosh/ocas/anlw.html

[11] CDC, NIOSH, Idaho National Laboratory Radiation Dose Reconstruction page at https://www.cdc.gov/niosh/ocas/ineel.html#pet219

In recent years, previously added Special Exposure Cohorts (SEC) for Idaho National Laboratory workers who were monitored for external radiation are:

- All INL workers between March 1, 1970 and December 31, 1974.
- CPP workers who worked between January 1, 1975 and December 31, 1980. [12]
- Argonne National Laboratory-West workers from April 10, 1951 through December 31, 1957. [13]

NIOSH investigations of other years of exposure and of other INL facilities, such as the burial grounds, now known as the Radioactive Waste Management Complex, the Test Reactor Area, now known as the ATR Complex, and Test Area North are continuing and should eventually result in many more Special Exposure Cohorts. But for many workers, the years of delays may mean that compensation will only benefit survivors and not the worker who was made ill despite promises of adequate radiation protection.

The Energy Employee Occupational Illness Compensation Program (EEOICP) provides compensation for radiation-induced illnesses under Part B of the program. Chemically-induced illnesses under Part E of the program are administered by the Department of Labor. The wide-spread use of many chemicals at the sites where Energy Employees worked is generally known especially now after various cleanup investigations of water and soil contamination have been conducted. But the inadequate monitoring of chemical exposures continues to cause Part E chemical exposure compensation claim denials to continue. The Part E chemical exposure compensation claims process includes a complicated appeals process that is time-sensitive. Many people just give up without appealing their Part E denial.

EEOICP Part E compensation is applicable to an illness from toxic exposure to chemicals, solvents, acids, metals, and radiation. Part E provides medical benefits and compensation for impairment and/or wage loss related to an accepted illness, $10,000-$15,000 per year to the employee and a $125,000 lump sum to the survivors.

David Manuta explained some of the challenges for Part E claims at recent Critical Nurse Staffing luncheons held in Idaho Falls. Importantly, if new medical information is obtained since the claim was denied, the claim may be re-opened.

The Department of Labor uses a "Site Exposure Matrix" [14] that according to Terrie Barrie, three outside reviews have found inadequate. [15] [16]

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[12] CDC, NIOSH, Idaho National Laboratory Radiation Dose Reconstruction page at https://www.cdc.gov/niosh/ocas/ineel.html#pet219

[13] CDC, NIOSH, Argonne National Laboratory-West Radiation Dose Reconstruction page at https://www.cdc.gov/niosh/ocas/anlw.html

[14] Energy Employees Claimant Assistance Project, DOL Training Manual and Handbooks. This non-profit organization has assembled some very helpful information to help EEOICPA claimants. https://www.eecap.org/DOL_Manuals.htm

[15] Blog by Terrie Barrie, Alliance of Nuclear Worker Advocacy Groups, 970-824-2260, "Three other independent entities – Econometrica in 2005, Government Accountability Office (GAO) in 2010 and the Institute of Medicine

NIOSH investigations of the Portsmouth Gaseous Diffusion Plant document all the usual problems in worker radiation dose estimation

Energy Employee Occupational Illness Compensation for all Department of Energy gaseous diffusion plants, including the Portsmouth Gaseous Diffusion Plant in Ohio, the Paducah plant in Kentucky, and the K-25 plant at Oak Ridge, Tennessee include the Special Exposure Cohort (SEC) for employees employed before February 1, 1992. Claims compensated under the SEC do not have to go through the radiation dose reconstruction process. The worker's illness must be one of the 22 specified cancers and the workers must have worked for a specified time period at the SEC site.

Compensation can still be granted for workers after 1992 not included in the SEC class on the basis of radiation monitoring records for a radiation dose reconstruction.

The problems of radiation dose reconstruction at the Portsmouth plant include:

- Radiation badges worn above the waist, while handling canisters and other work involving higher radiation exposure below the waist;
- Ignoring transuranic radionuclides that were present in addition to the uranium;
- Ignoring the technetium-99 low energy beta exposure, prevalent at the plant in some areas, that was not detected by radiation badges;
- Ignoring or underestimating neutron dose;
- Inadequate surveys and inadequate radiation/contamination area posting;
- Subtraction of elevated background levels from badges in ways that could be inconsistent and could erase too much of the recorded radiation exposure;
- Lowering the recorded radiation dose for an individual if it was high;
- Destruction of radiation records;
- Failure to obtain bioassay from all potentially exposed workers;
- Ignoring the radiation monitoring, protection and over-exposure of security guards who entered all areas of the plant and were required to guard special nuclear materials and all areas of the facility;
- Treatment of abnormal releases as routine events that were then not typically documented as abnormal events.

(IOM) in 2013 – have reviewed the Site Exposure Matrix (SEM) and found it inadequate." https://jkmhoffman.tumblr.com/post/58521504283/niosh-bad-behavior/amp

[16] National Academies Press, Review of the Department of Labor's Site Exposure Matrix Database, 2012, at https://www.ncbi.nlm.nih.gov/books/NBK202492/ and the DOL's Site Exposure Matrix (SEM) database at www.sem.dol.gov and U.S. Department of Labor (DOL) Procedure Manual https://www.dol.gov/owcp/energy/regs/compliance/PolicyandProcedures/procedure_manual_3.1-2019.05.pdf

Along with the inadequate radiation monitoring and inadequate chemical exposure monitoring were the usual repeated assurances that the worker was safe. [17] According to the 2008 Portsmouth document, chemical hazards included fluorine, trichloroethylene (TCE), tri-butyl phosphate (TBP), Freon, nitric acid, hydrofluoric acid, verasole, beryllium, asbestos, arsenic and mercury.

In addition to uranium hexafluoride (UF6) and slightly oxidized forms of uranium, the gaseous diffusion plants handled recycled or reprocessed uranium fuels. The reprocessed uranium contained transuranic radionuclides, primarily neptunium-237 and plutonium-239 and the fission product technetium-99. Reprocessed uranium would also include uranium-236. [18] Uranium decay progeny include thorium and protactinium.

Various chemical forms of uranium were present at the gaseous diffusion plants. High-fired forms can be slower to clear from the body. The chemical form as well as particle size would affect how much health harm is actually caused.

Independent researchers have documented the experience with inhalation of depleted uranium associated with burned up military tanks in the Gulf War which has indicated high retention of small uranium particles and more health harm from uranium exposed to high temperatures than natural forms of uranium.

Fire at Portsmouth Gaseous Diffusion Plant in 1998 involved methane generated from aluminum carbide

The 1998 fire at the Portsmouth Gaseous Diffusion plant near Piketon, Ohio, operated by US Enrichment Corp (USEC) and previously operated by the Department of Energy involved aluminum compressor parts overheating, and uranium hexafluoride, moisture, and formation of aluminum carbide, which subsequently off-gassed methane.

While this incident was different from the beryllium carbide and subsequent methane generation at the Idaho Cleanup Project that resulted in the rapid overpressurization of four drums, ejection of drum contents and smoldering transuranic waste, the USEC fire involved unexpected chemical reactions involving carbides.

David Manuta investigated the causes of the 1998 fire at the Portsmouth Gaseous Diffusion Plant, which are summarized in two articles. [19] [20]

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[17] SC&A interviews of 46 current and former employees of the Portsmouth Gaseous Diffusion Plant, Attachment 1: Summary of Site Expert Interviews, SCA-TR-TASK1-0020, April 18, 2008, Pages 89 to 120 at https://www.cdc.gov/niosh/ocas/pdfs/abrwh/scarpts/sca-siteexintvw-r0.pdf

[18] ORAU Team Dose Reconstruction Project for NIOSH, "K-25 Gaseous Diffusion Plant – Occupational Internal Dose," ORAUT-TKBS-0009-5, October 4, 2006. https://www.cdc.gov/niosh/ocas/pdfs/tbd/k25-5r1p1.pdf

[19] David M. Manuta, Ph.D., FAIC, *The Chemist*, "The Chemistry of an Industrial Aluminum Fire," March/April 2000, pp. 21-24.

[20] David M. Manuta, Ph.D., FAIC, *The Chemist*, "A Chemical/Thermodynamic Study of Aluminum Compounds," September/October 2000, pp.19-24.

The series of chemical reactions at the uranium-hexafluoride plant produced aluminum fluoride, and effectively created the "fluorine-analog" of the Thermite reaction. [21] Aluminum carbide, Al_4C_3, had been formed in the very high temperature environment. The in-leakage of moist air allowed the aluminum carbide to create aluminum oxide, Al_2O_3, and methane, CH_4.

$$Al_4C_3(s) + 6\ H_2O(g) \rightarrow 2\ Al_2O_3(s) + 3\ CH_4(g)$$

The formation of aluminum oxide was exothermic, generating enough heat for the methane to ignite. The methane flames were visible and memorable to workers who witnessed them.

Respiratory Protection Basics: Don't Use a PAPR When You Should Be Wearing SCBA

During routine radiological work, the concentration of airborne radioactive alpha contamination can be assessed and the appropriate mask and respiratory protection equipment selected. During an accident, it is important to know if airborne radioactive alpha contamination may be present. With the Constant Air Monitors not alarming following the exposure of drums at the Idaho Cleanup Project, emergency responders did not know the level of airborne alpha radiation. [22] The low penetrating radiation field marked on the first contact-handled transuranic waste drum that spewed its contents April 11, 2018 did not offer any information about the level of airborne radioactive alpha contamination or the level of toxic metal fumes or chemical vapors.

The protection provided by a filter or atmosphere-supplying respirator depends on the leakage of the face mask, and the design and the type of respiratory protection. The higher the Protection Factor, PF, the higher the protection from airborne contamination.

A Powered Air Purifying Respirator (PAPR), has at best a Protection Factor (PF) of 1000 while the blower is running to prevent inward leakage of the contaminated atmosphere around the facepiece seal. A PAPR only filters particulate and provides no protection regarding volatile organic compounds or other fumes. Without the positive pressure air feature, a purifying air filter mask would have a PF of 100 or less.

There are two types of atmosphere-supplying respirators: airline respirators and self-contained breathing apparatuses (SCBAs). SCBAs are typically used by emergency responders. A self-contained breathing apparatus requires carrying compressed air in a tank. The tanks typically only hold enough oxygen for a limited time, such as 30 minutes, depending on the rating and on the users breathing rate. The PF for an SCBA can be as high as 10,000 for a

[21] David M. Manuta, Ph.D., FAIC, Adventures in 'Real World' Chemistry – Manuta Chemical Consulting, www.dmanuta.com/AdvRealWorldChemistry.ppt

[22] Idaho Cleanup Project Core, "Formal Cause Analysis for the ARP V (WFM-1617) Drum Event at the RWMC," October 2018. https://fluor-idaho.com/Portals/0/Documents/04_%20Community/8283498_RPT-1659.pdf

"pressure demand" SCBA or as low as a regular face mask (PF of 100) if there is negative mask pressure, and subsequent mask leakage, during inhalation. [23]

During an emergency, the specific radionuclides or mixture may not be known and the concentration of airborne radionuclides may not be known. Guidance can be found that suggest that at contamination levels of 10,000 disintegrations/cubic meter or alpha reading for a 60 cm2 probe above 1,000,000 counts per minute, the emergency responder should select a full-face mask, Pressure Demand SCBA. (See Department of Defense, DOD 51 00.52-M, chapter 6.)

When the contaminated air concentration and respiratory protection system Protection Factor (PF) are known, the concentration of contaminants inhaled can be determined from:

$$\text{Concentration Inhaled} = \frac{\text{Contaminated Air Concentration}}{\text{Protection Factor}}$$

When the breathing rate estimated and the time of exposure, the curie level of the contaminants inhaled can be estimated, for a specific concentration of inhaled contaminants.

The Concentration Inhaled can be compared to the "derived air concentration" (DAC) level, specific to the radionuclides or mixture involved, DAC = Contaminated Air / PF.

The "derived air concentration" or DAC is based on the airborne contamination level of an occupational exposure of 2000 hours per year, with 1.2 cubic meters of air breathed per hour, that would yield a 5-rem annual dose for one specific radionuclide.

In an emergency, highly contaminated air can exceed the Protection Factor for the respiratory system and result in a high intake in a short time even with the use of respiratory protection.

If the contaminated air concentration were 1,000,000 disintegrations per minute/cubic meter and the Protection Factor 10,000, the concentration of radionuclides inhaled would be 100 disintegrations per minute/cubic meter or DPM/m^3.

$$\text{Concentration of inhaled radionuclides} = \frac{1{,}000{,}000 \text{ dpm}/m^3}{10{,}000} = 100 \text{ dpm}/m^3$$

DPM inhaled = 100 dpm/m^3 * breathing time 0.5 hr * 1.2 m^3/hr air breathed = 60 DPM

The conversion from disintegrations per minute, DPM, to curies is made knowing that

1 curie = 3.7E10 disintegrations per second or 2.22E12 disintegrations per minute.

Therefore, 1E-6 curie or 1 uCi is equal to 2.22E6 DPM.

If the Protection Factor used was only 100, rather than 10,000, for the same breathing time of 0.5 hours, and 1.2 m^3 of air breathed per hour, the curies inhaled would be 6000 DPM or 2.7E-3 microcuries (uCi).

6000 dpm /(2.22E6 dpm/uCi) = 2.7E-3 uCi

[23] 10 CFR Appendix A, "Assigned Protection Factors for Respirators" https://www.law.cornell.edu/cfr/text/10/appendix-A_to_part_20

For uranium-238 with an Allowable Limit on Intake (ALI) of 4E-2 uCi, this would still remain below the 5 rem annual dose limit. See Table 1 below for ALI annual limits and DAC values for 2000 hours of exposure. The chemical form of the radionuclide can affect how the material is or isn't cleared from the body.

Table 1. Occupational derived air concentrations (DAC) and public exposure air effluent concentrations for selected radionuclides from 10 CFR 20.

	Occupational Exposure (2000 hours per year)		Public Exposure
Radionuclide	Inhalation Allowed Limit on Intake (ALI) (uCi)	Inhalation DAC (uCi/ml)	Effluent Concentrations, Air (uCi/ml)
Americium-241	6E-3 (W class, bone surface)	3E-12 (W class)	2E-14 (W class)
Iodine-129	9.0 (D class, thyroid)	4E-9 (D class)	4E-11 (D class)
Technetium-99	7E+2 (W class)	3E-7 (W class)	9E-10 (W class)
Plutonium-238	7E-3 (W class, Bone surface) 2E-2 (Y class)	3E-12 (W class) 8E-12 (Y class)	- 2E-14 (Y class)
Plutonium-239	6E-3 (W class, bone surface) 2E-2 (Y class, bone surface)	3E-12 (W class) 7E-12 (Y class)	2E-14 (W class) 2E-14 (Y class)
Neptunium-237	4E-3 (W class, bone surface)	2E-12 (W class)	1E-14 (W class)
Cesium-137	2E+2 (Class D)	6E-8 (Class D)	2E-10 (Class D)
Strontium-90	2E+1 (Class D, bone Surface) 4E+0 (Class Y)	8E-9 (Class D) 2E-9 (Class Y)	3E-11 (Class D) 6E-12 (Class Y)
Radium-226	6E-1 (Class W)	3E-10 (Class W)	6E-8 (Class W)
Radium-228	1E+0 (Class W)	5E-10 (Class W)	6E-8 (Class W)
Radon-222	1E+4 (with daughters removed) 1E+2 (with daughters present)	4E-6 (with daughters removed) 3E-8 (with daughters present)	1E-8 (with daughters removed) 1E-10 (with daughters present)
Uranium-230	3E-1 (Class Y, UO2, U3O8)	1E-10 (Class Y)	4E-13 (Class Y)
Uranium-232	8E-3 (Class Y)	3E-12 (Class Y)	1E-14 (Class Y)
Uranium-234	4E-2 (Class Y)	2E-11 (Class Y)	5E-14 (Class Y)
Uranium-235	4E-2 (Class Y)	2E-11 (Class Y)	6E-14 (Class Y)
Uranium-236	4E-2 (Class Y)	2E-11 (Class Y)	6E-14 (Class Y)
Uranium-238	4E-2 (Class Y)	2E-11 (Class Y)	6E-14 (Class Y)
Uranium-natural	5E-2 (Class Y)	2E-11 (Class Y)	9E-14 (Class Y)
Thorium-230	6E-3 (Class W, bone surface) 2E-2 (Class Y, bone surface)	3E-12 (Class W) 6E-12 (Class Y)	2E-14 (Class W) 3E-14 (Class Y)
Thorium-232	1E-3 (Class W, bone surface) 3E-3 (Class Y, bone	5E-13 (Class W) 1E-12 (Class Y)	4E-15 (Class W) 6E-15 (Class Y)

Radionuclide	Occupational Exposure (2000 hours per year)		Public Exposure
	Inhalation Allowed Limit on Intake (ALI) (uCi)	Inhalation DAC (uCi/ml)	Effluent Concentrations, Air (uCi/ml)
	surface)		
Thorium-234	2E+2 (Class W, lower large intestine wall) 2E+2 (Class Y)	8E-8 (Class W) 6E-8 (Class Y)	3E-10 (Class W) 2E-10 (Class Y)

Table notes: See 10 Code of Federal Regulations, Part 20 for definitions and more details. A readable alphabetical listing of radionuclides for 10 CFR 20 Appendix B tables is available from the U.S. Nuclear Regulatory Commission website at https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/appb/ The unit of "uCi" means micro-curie or 1.0E-6 curie. The unit of "ml" means milli-liter or 1.0E-3 liter. Class D, W, and Y pertain to estimated biological clearance times of days, weeks or years. Only selected radionuclides and selected clearance classes were included in the table.

The relationship between the DAC and the ALI is given by:

DAC = ALI (in uCi)/(2000 hours per working year * 60 minutes/hour * 2E4 ml per minute)

Where 2E4 ml per minute is the assumed volume of air breathed per minute by under working conditions of "light work."

= ALI (in uCi) / 2.4E9

Immediately following the 2018 explosion of four transuranic waste drums at the Idaho Cleanup Project, with the plugged up Constant Air Monitors and lack of monitoring of airborne contaminant concentrations where emergency responders were present, with no particle sizes, with undocumented radionuclides, undocumented chemical forms of the radionuclides, and this was coupled with losing the initial nasal smears, [24] **I have to wonder, exactly how did Fluor Idaho conclude, prior to any lung count assessment, that conducting the lung counts was only "a precaution…to confirm no internal uptake"?** [25]

And since lung counts do not determine chemical exposure and there were burning metals and chemical vapors from volatile organic compounds released by the burning drum as well as beryllium and polychlorinated bisphenols (PCBs), how did Fluor Idaho determine there were no significant chemical exposures?

At least one emergency responder wore only a PAPR respirator that only filters particles and has a relatively low mask Protection Factor. Other responders wore no respiratory protection in the building's vestibule and they reported smelling smoke. Amazing that the INL knew so

[24] Idaho Cleanup Project Core, "Formal Cause Analysis for the ARP V (WFM-1617) Drum Event at the RWMC," October 2018. https://fluor-idaho.com/Portals/0/Documents/04_%20Community/8283498_RPT-1659.pdf See page C-53: "Initial nasal smears were lost."

[25] Fluor Idaho Press Release, April 12, 2018 4:05 p.m. "No Injuries or External Contamination Detected from Incident at DOE-Idaho Site." This Press Release maintains the falsehood of only a single drum being involved in the incident. See all Press Releases at https://fluoridaho.com/Home/Newsroom#press_releases

quickly that no leakage of the respiratory protective face masks had occurred, and no health harm had occurred given the lack of monitoring of radionuclide concentrations, metal fumes or chemical gases emergency responders were exposed to.

The Department of Energy, after encouraging Fluor Idaho to proceed with short cuts to treat the drums, issued a letter to Fluor Idaho after the accident stating that Fluor's compliance with Federal laws will be investigated. [26]

Largest Fire in Idaho National Laboratory's History Started July 23 by Lightning Strike

The "Sheep Fire" burned 112,107 acres on the U.S. Department of Energy's Idaho National Laboratory. [27] [28] The fire started July 22 and was contained by July 26. The fire started near the Materials and Fuels Complex on the eastern side of the site but spread westward through the middle of the site, to the edges of major nuclear facilities, including the Naval Reactors Facilities, ATR Complex and the Idaho Nuclear Technologies and Engineering Center (INTEC).

No facilities were damaged; however, power lines were burned. Nonessential personnel at the DOE nuclear facilities were evacuated July 23.

Outdoor storage of radioactive waste at the Materials and Fuels Complex and other facilities, fortunately, was not affected by the fire. The fire did not burn close to the Radioactive Waste Management Complex and its outdoor storage of radioactive waste and fabric enclosures.

With the fire out, the problems have not ended. The burning of the grass cover and sage will mean loose powdery dirt, and periodic brown-out conditions when the wind blows toward the highway. The air-filter clogging, blinding blowing dirt condition will be accompanied by higher than usual levels of radioactivity, from burning the heartland of the INL exposed to decades of INL radiological fallout from routine and accident events.

One hopes that bright reflector signs will be placed along the highway before too many accidents occur during the inevitable driving visibility brown-outs that are to come. And in addition to low visibility, you and your car are going to wish you had respiratory protection.

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[26] "Notice of Intent to Investigate" from Department of Energy Office of Enforcement, Kevin L. Dressman, Acting Director to Fred Hughes, Program Manager, Fluor Idaho, LLC, March 13, 2019 notifying Fluor Idaho of DOE's "decision to conduct an investigation into the facts and circumstances associated with the Radioactive Waste Management Complex drum over-pressurization event and response at the Idaho Cleanup Project on April 11, 2018." https://www.energy.gov/sites/prod/files/2019/03/f60/Fluor%20Drum%20Event%20NOI.pdf

[27] Nathan Brown, *The Idaho Falls Post Register*, "INL facilities closed by 133-square-mile wildfire," July 24, 2019.

[28] Nathan Brown, *The Idaho Falls Post Register*, "Sheep Fire biggest in INL history," July 31, 2019.

Idaho Gutting Radiological Contamination Protection from Environmental Clean Air Law

I stumbled upon this 2019 law change, effective spring of 2019 after the adjournment of the Idaho Legislature, to IDAPA 58 – Department of Environmental Quality, 58.01.01 – Rules for the Control of Air Pollution in Idaho, Docket No. 58-0101-1801. [29]

The law had included since 1995 a provision for radionuclides. But this section of the clean air law has now deleted the following text:

> *xvi. Radionuclides, a quantity of emissions, from source categories regulated by 40 CFR Part 61,Subpart H, that have been determined in accordance with 40 CFR Part 61, Appendix D and by Department approved methods, that would cause any member of the public to receive an annual effective dose equivalent of at least one tenth (0.1) mrem per year, if total facility-wide emissions contribute an effective dose equivalent of less than three (3)mrem per year; or any radionuclide emission rate, if total facility-wide radionuclide emissions contribute an effective dose equivalent of greater than or equal to three (3) mrem per year.(5-1-95)*

Given the increasing levels of airborne radiological contamination occurring on the lower west Boise-side and the lower east Idaho National Engineering-side of Idaho, this law change certainly is not about protecting human health and the environment.

The source of increasing radioactive contamination on the Boise side of the state is not being investigated by the Idaho Department of Environmental Quality. The ongoing importation of radioactive waste from around the country to the US Ecology Idaho Grandview site appears to have a role in the increasing airborne radiological contamination. Some of this radioactive waste is from Formerly Utilized Sites Remedial Action Program (FUSRAP) sites around the United States contaminated from the early years of nuclear weapons production and the atomic energy program.

The last 20 plus years the gyrating levels of gross alpha and gross beta (when sampled) in Boise area drinking water, from Kuna to Boise, and Murphy to Marsing, are not from naturally occurring uranium and thorium in the soil. [30] The report "Isotopic and Geochemical Investigation into the Source of Elevated Uranium Concentrations in the Treasure Valley Aquifer, Idaho," in 2011 [31] does look at the issue — but does not identify the source of the elevated radioactivity.

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[29] Office of the Administrative Rules Coordinator, Department of Administration, Pending Rules, Committee Rules Review Book, Submitted for Review Before House Environment, Energy & Technology Committee, 65th Idaho Legislature, First Regular Session – 2019. January 2019 at https://adminrules.idaho.gov/legislative_books/2019/pending/19H_EnvEnergyTech.pdf

[30] Environmental Defense Institute newsletter article for October 2018, "Idaho DEQ Reports Concerning the Elevated Radioactivity in Drinking Water in the Boise Area Don't Identify the Source of the Radioactivity."

[31] Brian Hanson, Dr. Shawn Benner, Dr. Mark Schmitz, Dr. Spencer Wood, Department of Geosciences, Boise State University., "Isotopic and Geochemical Investigation into the Source of Elevated Uranium Concentrations in the Treasure Valley Aquifer, Idaho," Submitted to the Idaho Department of Environmental Quality, April 2011.

The report confirms the widespread occurrence of sometimes very high uranium concentrations, up to 100 micrograms/liter.

DOE Refuses to State How Much Radioactive Waste Will Remain Buried After the "Cleanup" of RWMC's Buried Waste

The Department of Energy has refused to state, for even one radionuclide, americium-241, the curies that will remain buried at the Radioactive Waste Management Complex's burial ground after buried waste exhumation ends.

I submitted a question to the Idaho Cleanup Project Citizens Advisory Board meeting asking how many curies of americium-241 would remain buried after the final exhumation of the Accelerated Retrieval Projects end. There are many other radionuclides that will remain buried, but I wanted to make the question manageable. The Department of Energy responded with stunning obfuscation.

> ***Question submitted to ICP CAB***: Now that the Idaho Cleanup (Project) is on the last Accelerated Retrieval Project (ARP IX) to exhume buried waste, how many curies of Americium-241 are remaining buried at the Subsurface Disposal Area (SDA)?
>
> ***Answer from the Department of Energy****: The performance objective for targeted waste retrieval was established in a record of decision agreed to by the regulators that states: "Completion of targeted waste retrieval will be measured by the volume of targeted waste retrieved. A minimum volume of targeted waste of 6,238 m^3 will be retrieved from a minimum of 5.69 acres…, with the need for additional retrievals, if necessary, determined pursuant to CERCLA." Therefore, the performance objective is based on the volume of targeted waste removed, not the removal of Am-241 curies from the SDA. (*DOE's response are posted on the CAB website: https://www.energy.gov/em/icpcab/recently-asked-questions)

The actual answer is, according to DOE's own documents, 215,000 curies of americium-241 will remain buried over the Snake River Plain Aquifer. This would take 6 Snake River Plain aquifers to dilute to drinking water standards, assuming 2.44E15 liters in the aquifer and the federal drinking water standard of 15 picocuries/liter.

In fact, over 90 percent of the americium-241 is remaining buried, of 230,000 curies of americium-241, after completing buried waste exhumation, an estimated 215,000 curies will remain buried according to composite analysis calculations. [32] [33] [34] The buried americium-241 is

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http://www.deq.idaho.gov/media/563327-uranium_treasure_valley_0411.pdf listed at http://www.deq.idaho.gov/regional-offices-issues/boise/water-quality-plans-reports/

[32] See the July 2017 EDI newsletter for a timeline for the burial ground at the Radioactive Waste Management Complex and other cleanup information at http://www.environmental-defense-institute.org/publications/News.17.July.pdf

not the only radionuclide that contributes to contaminant migration, but it was the dominant contributor according to the buried waste performance assessment. A partial inventory of the radionuclides in the buried waste at the Radioactive Waste Management Complex, what will be buried at its replacement facility, in high-level calcine and liquid sodium-bearing waste from reprocessing stored at the INL is provided in Table 2.

Table 2. Calcine bin set and Sodium-Bearing waste radionuclide partial inventory comparison to the waste that will remain buried at RWMC and at the replacement for RWMC.

Radionuclide (half-life)	Calcine Inventory (curies)	Sodium-Bearing Waste Inventory (curies)	Buried (existing) RWMC Inventory (curies)	Buried (future) Replacement RH-LLW Inventory (curies)
Carbon-14 (5730 year)	0.038	5.7E-4	731	432
Chlorine-36 (301,000 year)	0	?	1.66	260
Iodine-129 (17,000,000 year)	**1.6**	0.01	0.188	0.133
Technetium-99 (213,000 year)	**4600**	94.6	42.3	16.7
Neptunium-237 (2,144,000 year)	**470**	1.74	0.141	0.003
Uranium-232 (68.9 year)	1.6	?	10.6	0.00036
Uranium-233 (159,000 year) Product bred from U-235 and thorium, also decay of Np-237	0.057	0.036	2.12	0.0001
Uranium-234 (245,500 year) Pu-238 decay product	**130**	5.33	63.9	0.0012
Uranium-235 (703,800,000 year)	**3.2**	0.127	4.92	0.005
Uranium-236 (23,400,000 year) Pu-240 decay product	**11**	2.23E-5	1.45	0.0001
Uranium-237 (0.0185 year to Np-	**1.5**		-	-

[33] 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. (Newly released because of Environmental Defense Institute's Freedom of Information Act request.) See https://www.inl.gov/about-inl/general-information/doe-public-reading-room/

[34] See the CERCLA administrative record at www.ar.icp.doe.gov (previously at ar.inel.gov) and see also Parsons, Alva M., James M. McCarthy, M. Kay Adler Flitton, Renee Y. Bowser, and Dale A. Cresap, Annual Performance Assessment and Composite Analysis Review for the Active Low-Level Waste Disposal Facility at the RWMC FY 2013, RPT-1267, 2014, Idaho Cleanup Project. And see Prepared for Department of Energy Idaho Operations Office, Phase 1 Interim Remedial Action Report for Operable Unit 7-13/14 Targeted Waste Retrievals, DOE/ID-11396, Revision 3, October 2014 https://ar.inl.gov/images/pdf/201411/20141103009 60BRU.pdf

237)				
Uranium-238 (4,470,000,000 year)	3.1	0.125	148	16.2
Thorium-228 (1.92 year to radium-224) Natural thorium decay and Pu-240 decay product	1.6	?	10.5	-
Americium-241 (423 y decays to Np-237)	12,000	316	**215,000**	0.38
Plutonium-238 (87.7 year)	**110,000**	3900	2080	-
Plutonum-239 (24,000 year)	**48,000**	410	64,100	-
Curium-244	?	1.36	?	?

* Calcine inventory from DOE/EIS-0287; RWMC buried waste inventory from DOE/NE-ID-11243/11244 (figures cited may not be the latest estimates) and RPT-1267; replacement remote-handled facility INL-EXT-11-23102.
****Bold** highlighting of calcine inventory indicates a similar or larger inventory than the buried RWMC waste. The RWMC buried waste is estimated by the DOE to yield 100 mrem/yr doses in drinking water for millennia unless a perfect soil cap limits the estimated doses to be 30 mrem/yr. Importantly, the inevitable spikes in contamination due to flooding have not been accounted for despite RWMC flooding in 1963 and 1969. The dose estimates are not conservative. The assumed dilution factors are not consistent with past INL aquifer contamination migration. Calcine migration Kd coefficients may be different than used for RWMC and may worsen the effect of calcine in the soil.
*** Sodium-Bearing Waste inventory decayed to 2012 from Sandia National Laboratories, "Evaluation of Options for Permanent Geologic Disposal of Used Nuclear Fuel and High-Level Radioactive Waste Inventory in Support of a Comprehensive National Nuclear Fuel Cycle Strategy," FCRD-UFD-2013-000371, SAND2014-0187P; SAND2014-0189P. Revision 1. 2014. For Sodium-Bearing Waste radionuclides not listed in FCRD-UFD-2013-000371, EDF-6495 values from 2007 are provided for C-14, Tc-99, and I-129. Other radionuclides in the Sodium-Bearing Waste, typically of shorter half-life, are not listed in this table.

In addition to this refusal to state the amount of radioactive waste that is remaining buried is the promotion of untrue claims at the April 25, 2019 Idaho Cleanup Project Citizens Advisory Board meeting in Twin Falls by the Department of Energy and the U.S. Geological Survey that the inter-sedimentary beds of soil beneath the buried waste will stop the contaminants from entering the aquifer. This simply is not true, or why would the aquifer already have exceeded the federal drinking water standard for carbon tetrachloride?

It is also important to note that the buried waste is heavily laden with chemical solvents of various types and this decreases the sorbing properties of radionuclides like plutonium. [35] The ability of radionuclides such as plutonium-239 to sorb to soil rather than migrate to the aquifer is already overly optimistically modeled in DOE's estimates of contaminant migration, but does not assume the waste is stopped from reaching the aquifer by inter-sedimentary beds.

[35] Editors: Arjun Makhijani, Howard Hu, and Katherine Yin, *Nuclear Wastelands – A Global Guide to Nuclear Weapons Production and its Health and Environmental Effects*, By a Special Commission of International Physicians for the Prevention of Nuclear War and The Institute for Energy and Environmental Research, The MIT Press, 1995. P. 253 Scientists found the migration of plutonium at the Savannah River Site had migrated to groundwater within 20 years, not the predicted migration time of hundreds of thousands of years. The presence of solvents is thought to have contributed to the rapid migration of contaminants.

NuScale Small Modular Reactors Completes Phase 2 and 3 of U.S. Nuclear Regulatory Review

The U.S. Nuclear Regulatory Commission has completed the second and third phases of its review of the NuScale small modular reactor design. [36] The review is now in phase 4 and is expected to be completed in 2020. [37]

The press release stated that: "Phase 2 involves publication of the safety evaluation report (SER) with open items, while Phase 3 consists of the Advisory Committee on Reactor Safeguards (ACRS) review of both the staff's SER with open items and NuScale's DCA. The ACRS is an independent advisor to the NRC. The entire review is now in Phase 4."

"As the company nears deployment of its pioneering SMR in the U.S., NuScale has already signed MOUs to explore the deployment of its technology in Canada, Jordan, and Romania, and similar agreements are being discussed with various other potential customers."

The Utah Associated Municipal Power Systems (UAMPS) board of directors passed a resolution recognizing the needed minimum of 150 megawatts of buy-in on the NuScale project slated for construction at the Idaho National Laboratory. [38] UAMPS includes cities in Utah and also Idaho Falls.

The project has faced serious hurdles over seismic design vulnerabilities and now apparently is slated to be built in the flood plain of the Big Lost River, should the MacKay dam fail. The aquifer below the proposed facility is radiologically and chemically contaminated. The workers at the proposed commercial nuclear power plant will be at the INL but will not be eligible for Energy Employee Occupational Illness Compensation for their radiation exposures. The commercial nuclear energy industry does not provide radiation illness compensation to its full-time or part-time employees despite certain jobs entailing significant radiation exposure in order to operate, maintain and decommission the facilities. And we continue to learn that worker illness actually increases at doses of about 400 mrem annually, while the annual dose limit is 5,000 mrem annually. [39]

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[36] Post Register, *The Idaho Falls Post Register*, "NuScale reactors clear regulatory review phase," July 23, 2019.

[37] NuScale Press Release, "NuScale's SMR Design Clears Phases 2 and 3 of Nuclear Regulatory Commission's Review Process," July 22, 2019. https://newsroom.nuscalepower.com/press-release/company/nuscales-smr-design-clears-phases-2-and-3-nuclear-regulatory-commissions-revie

[38] Nathan Brown, *The Idaho Falls Post Register*, "UAMPS announces 150 megawatts of buy-in for reactor project," July 19, 2019.

[39] Richardson, David B., et al., "Risk of cancer from occupational exposure to ionizing radiation: retrospective cohort study of workers in France, the United Kingdom, and the United States (INWORKS), BMJ, v. 351 (October 15, 2015), at http://www.bmj.com/content/351/bmj.h5359 Richardson et al 2015 . This epidemiology study that included a cohort of over 300,000 nuclear industry workers has found clear evidence of solid cancer risk increases despite the average exposure to workers being about 2 rem and the median exposure was just 410 millirem. Also see December 2015 EDI newsletter.

NuScale's power plant design can house up to 12 individual power modules which can be installed while some of its power modules are operating. This poses load handling risks adjacent to operating nuclear reactor modules. The majority investor in NuScale is Fluor Corporation, a global engineering, procurement, and construction company with a 60-year history in commercial nuclear power. And here in Idaho Fluor has a growing reputation for allowing nuclear facility accidents such as unsafely packaging significant amounts of oxidizing pyrophoric uranium and beryllium carbide in transuranic waste drums that spewed their smoldering contents at the Fluor-managed facility at the Idaho National Laboratory on April 11, 2018.

Last fall we learned from Department of Energy cleanup contractor Fluor Idaho's report [40] on the causes of the explosion of the four waste drums that the DOE had **not conducted the required nuclear safety analysis**, required by 10 CFR 830 nor had it conducted the required chemical compatibility analysis — all while refusing to heed knowledge about the waste and failing to properly characterize the constituents in the waste and packaging the waste without compliance with Waste Isolation Pilot Plant Waste Acceptance Criteria.

Articles by Tami Thatcher for August 2019.

[40] Idaho Cleanup Project Core, "Formal Cause Analysis for the ARP V (WFM-1617) Drum Event at the RWMC," October 2018. https://fluor-idaho.com/Portals/0/Documents/04_%20Community/8283498_RPT-1659.pdf