A Collaborative Effort to Address the Distribution of Plutonium-Contaminated Sludge in Livermore, California

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Abstract

For over a half-century, the U.S. Department of Energy nuclear weapons laboratory in Livermore, California has worked with plutonium in the course of its mission to research and develop nuclear weapons. Plutonium releases via the Laboratory's sewer system resulted in the contamination of sewage sludge that was distributed and used widely as soil conditioner in parks, landscaping around public buildings, and in home lawns and gardens. The amount of sludge distributed and the concentration of the radioactivity in the sludge are uncertain.

In 1999, research was undertaken to investigate the historic distribution of sewage sludge (1958-1976) in Livermore. Navigating the uncertainties surrounding the sludge distribution more than forty years after it began presented an enormous ethical challenge. Community members who received the sludge at no cost were not told that the sludge they received may have been contaminated with plutonium, and the log-book that had recorded the names and addresses of sludge recipients had disappeared. The half-life of weapons-grade plutonium is about 24,000 years. Therefore, former, current, and future Livermore residents are at potential increased risk of cancer and other health impacts from their largely unrecognized and therefore unavoidable exposure to radioactive sludge.

Two research models to address the potential public health impacts of plutonium-contaminated sludge distribution were undertaken. One model was a collaborative approach that emphasized gathering and incorporating local knowledge into the scientific analysis and fostering the growth of mutually respectful relationships between scientists, governmental, and non-governmental collaborators. This model sought an ethical research framework that would maximize the benefits to community health while minimizing the potential for unwarranted fears, or stigmatization of individuals, households, or the entire community. Principles of community right-to-know and the precautionary principle were incorporated into the science. This investigation concluded that the distribution of sewage sludge posed an indeterminate health hazard due to a lack of data and recommended a process be implemented to inform and solicit further information from residents who may have obtained sludge, sample known areas of sludge disposition in order to gain a better understanding of the potential health risk, establish criteria for sampling residences and interpreting results, and provide a mechanism for sampling and, if necessary, removing plutonium-contaminated sludge. An outcome of the research was the convening of the Alameda County Plutonium Action Taskforce (ACPAT), a transparent, locally-based, participatory process for scientific-decision making to address the large uncertainties surrounding the distribution of sludge. Since 2003, ACPAT members have conducted educational and other activities to carry out a work plan that they developed to implement the research recommendations.

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The second research model undertaken was a dose-assessment approach, that utilized existing data to estimate radiological doses from exposure to plutonium contaminated sewage sludge and compared the estimated doses with those that have caused sickness or death. The investigation acknowledged the population-based implications of the sludge exposure, finding that many Livermore residents could have been exposed to plutonium-contaminated soil and that exposure may still be occurring. However, it did not make a quantitative estimate of the number of people potentially exposed to contaminated sludge over the lifetime of the plutonium, and translate those doses to risk. The investigators received many public comments strongly objecting to specific assumptions and methods it incorporated into its dose assessment. This research concluded that there was no public health hazard stemming from the distribution of contaminated sewage sludge.

Identifying and implementing a collaborative model to address the large scientific uncertainties associated with the sludge distribution involved many hurdles including: (1) lack of trust, unequal power, and different perspectives among collaborators; (2) lack of data; (3) opposition to the ACPAT process by Lawrence Livermore National Laboratory; (4) inconsistent Alameda County leadership in the ACPAT process; and (5) lack of funding to carry out the ACPAT process. Key limitations are that neither of the two investigations nor the ACPAT process address issues of intergenerational equity and primary prevention of exposure. In November 2005 the U.S. Department of Energy decided to double the plutonium storage limit at Livermore National Laboratory to more than 3,000 pounds—enough plutonium for about 300 nuclear bombs. Worldwide, there are 3.7 million pounds of this man-made substance. The wide dispersal of a radioactive substance having a lifetime of virtually forever, guarantees that the majority of Livermore's plutonium will still be waiting for the generations who follow. Therefore, prevention efforts undertaken today must also speak to the health of future generations. This will involve looking upstream of the plutonium and working towards sustainable solutions to security that do not involve the public health threats embedded in the global embrace of nuclear weapons.

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When they had dried this speck of matter God had not welcomed at the Creation they simply snipped off the sides of the platinum dish, covered the sample with a layer of protective Duco Cement, glued the dish to a piece of cardboard labeled Sample A and set is aside until it decayed completely to 94^{239}… Not until 1942 would they officially propose a name for the new element that fissioned like U235 but could be chemically separated from Uranium. But Seaborg already knew what he would call it … Seaborg would name the element 94 for Pluto, the ninth planet outward from the sun, discovered in 1930 and named for the Greek god of the underworld, a god of earth's fertility but also the god of the dead: plutonium.[1]

Part I: Plutonium, Sewers, and Sludge: A Half-Century of Livermore's History

The aftermath of World War II brought indelible change to Livermore, California. In 1952, Edward Teller won a second nuclear weapons laboratory in the southeast corner of the Livermore Valley, about 50 miles east of San Francisco, in Alameda County.[2] From its beginning, Teller's Livermore Radiation Laboratory, was operated for the Atomic Energy Commission and later for the U.S. Department of Energy (DOE) by the University of California. For more than half a century, Livermore's National Laboratory has worked with plutonium in the course of its mission to research and develop nuclear weapons. The essential ingredients of every nuclear weapon are fissile materials compressed into a "supercritical mass" so that the number of fissions will escalate very rapidly and create a nuclear explosion.[3] Plutonium is one of the two principle fissile materials used to make nuclear weapons explode.

Plutonium both routinely and unintentionally left Livermore Laboratory via the sewer system. The laboratory's sewage effluent and the plutonium it carried was destined for the Livermore Water Reclamation Plant (LWRP). The end result of waste treatment at the LWRP is "sludge." Between 1958 and 1975, the LWRP's four sludge drying beds covered an area approximately the size of five football fields. The drying beds were filled yearly, up to four inches high, with sludge. Liquids flowed out of the sludge into an underlying layer of sand, and were carried off into tile drains. Workers hammer milled and ground the dry sludge, while treated liquid effluents were placed in oxidation ponds, which covered approximately 37 acres, and then discharged to the Arroyo Seco and Arroyo Las Positas.[4] In 1958 the Livermore Radiation Laboratory was renamed the E.O. Lawrence Radiation Laboratory, to honor the nuclear physicist Ernest O. Lawrence,[5] and the LWRP began to offer its sludge to Livermore's 13,000 residents, for free, for use as a soil amendment.

In 1960, two years after the LWRP began distributing sludge to the public, the State of California, Department of Public Health, Bureau of Radiologic Health, began conducting monthly monitoring of radiation in LWRP's effluent and digester sludge. Plutonium gives off radiation in the form of alpha particles. In 1964, routine monitoring by the State at the LWRP revealed relatively higher alpha activity in dried digester sludge, signaling a large release of plutonium to the sewer.[4] The State Health Department did not monitor radiation levels in the "end-of-the-pipe" sludge given to the public.

By the mid-1960s Livermore was growing, and so grew the LWRP. Between 1965-1967, in order to meet the needs of Livermore's 30,000 residents, "phase II" expansion was underway at the LWRP. Two sludge lagoons were added. The LWRP now had a capacity to hold five to

seven years of Livermore's waste. The oxidation ponds were shortened and liquid effluents were disposed of at the airport, and discharged into the arroyos. The construction activities at the LWRP brought the distribution of sludge to the public to a temporary halt. The sludge remained in the drying beds for about one year before it was mixed and given out again.

In the spring of 1967 the laboratory inadvertently released a larger-than-usual quantity of plutonium to the city's sanitary sewer. Since "low-level" radioactivity was routinely released to the sewer from the laboratory the source of these "extra" releases was never definitively established. [6] The 21 day-long discharge of plutonium left the sewage sludge at the LWRP contaminated, but no one knew by how much.

At the time of the incident, laboratory employees tried to estimate the amount of plutonium released into the sewer. But they faced a dilemma: the laboratory's radiation monitor was inoperative for five of the 21 days, so release data were available for only 16 days. Laboratory workers inferred the data for the missing five days, and estimated that the laboratory discharged approximately 32 millicuries of Plutonium-239-Americium-241 to the sewer.[6] During this time, high levels of alpha activity were also detected in dried digester sludge by the State Department of Health.[4]

One year after the 1967 non-routine plutonium release, and after phase II construction activities had been completed, the LWRP resumed giving sludge to the public and local agencies. Residents who picked up sludge were asked to sign their names and addresses in a log book. Sludge was also hauled by LWRP workers to the Altamont/Vasco Road landfill, stockpiled at the airport, and disposed of at a 200 acre ranch adjacent to LWRP. Golf courses and arroyos began receiving liquid effluents from LWRP.

In June 1968, Janis Turner and her husband moved into their newly-built Livermore home. Janis was starting her teaching career in the Livermore School District and her husband was employed in the Computations Division at LLNL. Beginning in July 1968, Janis and her husband began the year-long effort to landscape their recently purchased Livermore home. They were delighted to read an announcement in a local newspaper about free processed sludge, and ferried truckloads of sludge from the LWRP to their new home in her dad's old yellow pick-up truck. "Our LWRP sludge-fertilized garden has been growing for 35 years, feeding family, neighbors and friends organic produce harvested from my 12 fruit trees and vegetable garden," Janis relates today with pride.

Sometime between 1968 and 1971, a young Livermore father came home from work with news that free sludge was available at the LWRP. Martha Priebat recalls that her husband liked the idea of getting free sludge to use in several planting beds in their large back yard in Livermore. At least one LWRP worker recalls putting the sludge to use in his garden at the time.

And so the cycle continued: plutonium from Livermore Radiation Laboratory, through the sewer system, to the LWRP, to the sludge, to the public. The population of Livermore was now 41,000. No one had yet measured the amount of plutonium in the sludge given to the ever-growing public. About this time, the University of California removed the word "radiation" from the Livermore laboratory's name, and re-named it Lawrence Livermore National Laboratory (LLNL).[5]

In 1973, 15 years after sludge was first distributed to the public, Livermore Laboratory monitored plutonium in processed LWRP sewer sludge for the first time. LWRP employees read about the presence of detectable levels of plutonium in the sludge drying beds in the laboratory's annual report. LWRP employees stopped giving the sludge away to the public. Sludge was still given

out to local agencies, and also to a half-acre worm farm on Buena Vista Avenue, an LWRP employee's yard, and to the rose garden at Great Livermore Junction/Portola Road.

In 1975, in view of what the laboratory described as the "widespread use of the sludge as a soil conditioner in parks, landscaping around public buildings, and in home lawns and gardens," Livermore Laboratory planted a garden to study how much plutonium a person would inhale and ingest if they used LWRP sludge to grow their food.[7] The LLNL study reported plutonium levels in processed sewage sludge as high as 4.4 picocuries per gram (pCi/g). Notably, this concentration exceeds the 2.59 piC/g level used by the U.S. Environmental Protection Agency (USEPA) in setting goals for plutonium clean-up activities for residential areas.[8] The laboratory's 1975 garden study concluded that the radiation dose associated with use of the sludge would be 0.04 percent of the annual permissible dose. A year later, the LWRP stopped distributing sewage sludge to local agencies.

Although all sludge distribution by LWRP had stopped by 1976, plutonium discharges from LLNL to the Livermore sanitary sewer system had not. On May 12, 1988, in a meeting between LLNL and LWRP personnel, Laboratory' employees disclosed that elevated levels of plutonium were released to the City's sanitary system beginning in May 1987. The Assistant Director of Public Works at the time, John C. Hines, was apparently not pleased by this news, writing that LLNL's treatment of the release as a "non-incident" does not give consideration to the public's health concerns. [9] He was particularly concerned that LWRP workers were unprotected for possible radiation exposures, and were totally dependent on LLNL to advise them of potential health risks in a timely manner. Hines proposed that LWRP conduct their own monitoring to insure the protection of the health of LWRP workers and the public, and that the cost be charged to LLNL. More than a decade later, community members would seek the same remedy—independent monitoring paid for by LLNL—when they found out about the possibility of plutonium in their sludge.

Part II: Research Ethics in Assessing the Public Health Impacts of Plutonium-Contaminated Sludge

Setting the Research Agenda

In 1987 LLNL was listed as a Superfund site. Ten years later, and almost 40 years after the sludge was first distributed, the Agency for Toxic Substances and Disease Registry (ATSDR) initiated a scientific investigation of the potential human health impacts of LLNL activities. The health assessment was undertaken because ATSDR is required by law to conduct a Public Health Assessment at Superfund clean-up sites. Community members and advocates did not initiate, and some did not welcome, ATSDR's research. On the basis of reports from other communities living near DOE nuclear weapons facilities, [10,11] some community-health advocates feared that the ATSDR public health assessment process would involve a superficial look at limited data, yet lead to sweeping conclusions that exposures are "below levels of health concern."

ATSDR conducted part of its LLNL research under a cooperative agreement with the California Department of Health Services' Environmental Health Investigations Branch (CDHS). CDHS researchers initiated a public participation process, called the "Site Team," to help guide the state and federal agencies' research efforts. The Site Team consisted of approximately 25 members, including representatives of the DOE, LLNL, city, county, and state government, environmental, peace, and anti-nuclear organizations, a small-business owner, a school nurse, and a Bay-Area community member who had previously grown up in another nuclear weapons-

impacted community, the Hanford Reservation in Washington state, home to what the DOE describes as the "world's largest environmental cleanup project."[12]

CDHS researchers attempted to incorporate meaningful public participation into their health investigation. One way CDHS researchers translated this ethic into the scientific process was by creating the opportunity for the public to suggest topics to be investigated. As Executive Director of Western States Legal Foundation, Jacqueline Cabasso had been closely tracking the environmental record of LLNL for over 15 years, along with Marylia Kelley, her counterpart at Tri-Valley Communities Against a Radioactive Environment. Together, these organizations had decades of experience uncovering and disclosing the environmental impacts of LLNL. During an early Site Team meeting, Jackie held up a newspaper article discussing the results of LLNL's "plutonium garden," [13] and asked, "This has always troubled me, why did LLNL plant a plutonium garden to assure us growing food in plutonium is safe? What happened to the sludge? How much plutonium was in the sludge?" Jackie suggested that CDHS researchers "look into the sludge issue," and they did. By 1999 the health agencies' preliminary investigation established that historic releases of plutonium from LLNL resulted in radioactive contamination of sludge at the LWRP. In May 1999, state and federal health agencies jointly recommended that the historic distribution of sewage sludge be investigated.[14]

Research into the distribution of plutonium laden sludge was sparked by a single question posed in a public meeting almost four decades after the sludge was first distributed. However, the kindling had long been in place, as the investigation was just one thread in an interconnected web of events related to the release of radioactive materials from LLNL (Table 1). For example, the sludge investigation took place in the context of community concerns about more widespread community contamination stemming from recent disclosure of plutonium contamination of three Livermore parks. The parks that had been sampled to obtain "background" levels of plutonium in community soil, as part of on-site LLNL plutonium remediation activities. All three parks showed elevated levels of plutonium, with the highest concentration found in Big Trees Park about one-half mile west of LLNL. Moreover, inseparable from the scientific uncertainty as to the potential health risks associated with the releases illustrated in Table 1 was the longstanding and vast public relations effort by LLNL to minimize public concerns.

Table 1. Timeline of Plutonium Sludge (1952 to 2005) and Some of the Known Unintentional Releases of Radioactive Material from Lawrence Livermore National Laboratory (1960-2005)

1952	Livermore Radiation Laboratory established.
1958	Livermore Water Reclamation Plant (LWRP) begins to distribute sludge to the public, for free.
1960	State of California, Department of Public Health begins monthly monitoring of radiation in LWRP effluent and digester sludge.
November 8, 1960	Curium fire in Building 251, may also involve plutonium-238.
March 26, 1963	Criticality accident in Building 261 triggers explosion, followed by 15 kilograms of weapons grade uranium burning uncontrollably.
1964	Routine monitoring by the State of California at LWRP reveals relatively higher alpha activity in dried digester sludge, signaling a large release of plutonium to the sewer.
January 20, 1965	350,000 curies of tritium goes up the stacks in Building 331.
September 13, 1965	Plutonium fire in Building 332 involves about 100 grams of plutonium.
April 20, 1967	Plutonium spill outside Building 332 spreads due to rain.
May 25 to June 15, 1967	Plutonium is released to sewer system.
August 6, 1970	Tritium accident in Building 331 releases 300,000 curies, elevated levels of tritium related to accident found by LLNL 150 miles away, in Fresno.
1973	Unknown quantities of plutonium released to soil during transfer of solid materials from "solar evaporators."
1973	Livermore Laboratory monitors plutonium in processed sewer sludge for the first time.
1973	LWRP stops distributing sludge to the public.
1975	Livermore Laboratory plants a garden to study how much plutonium a person would inhale and ingest if using LWRP sludge to grow food.
June 16, 1975	Contaminated liquids sprayed throughout a room in Building 332.
1976	LWRP stops distributing sludge to local agencies.
April 8, 1980	Burst plutonium "glove box" outside Building 332.
April 16, 1980	Flash fire in plutonium "glove box" causes pressure to blow the window out, Building 332.
March 1983	Plutonium, curium and americium spilled from waste drums in Building 612.
June 8, 1984	5,000 curies of tritium released from Building 331.
January 25, 1985	1,000 curies of tritium released from Building 331.
February 1986	Plutonium "glove box" leak due to degradation of the gloves.
December 15, 1986	Failed pump and cryogenic vessel releases 125 curies of tritium.
May 1987	Plutonium released to sewer system.
April 14, 1987	Equipment failure releases 198 curies of tritium.
1987	Lawrence Livermore National Laboratory declared a Superfund site. The USEPA places LLNL on the National Priorities List of hazardous waste sites due to groundwater contamination.
May 15, 1988	Unexpected presence of tritium in gases being vented, 653 curies released.
August 22, 1989	Container pressure relief fails, 329 curies of tritium released.
1989	Livermore Valley wines sampled by LLNL are found to contain four times the tritium of other CA wines.
1990	U.S. Department of Energy investigative team finds elevated levels of plutonium in off-site air monitor east of LLNL.
April 2, 1991	Improper preparation of reservoir releases 144 curies of tritium.
July 9, 1991	Increase in plutonium discharge found in sewer.
October 24, 1991	Torn bag results in plutonium powder spread on floor.
1994	USEPA soil samples find elevated levels of plutonium in three city parks; highest levels are found in Big Trees Park west of LLNL.

March 1994	Rainwater at LLNL is found to contain tritium at concentrations 7 times higher than state and federal maximum limits; equipment from Building 331 "off-gassing" is thought to be the cause.
1995	Additional soil sampling in Big Trees Park undertaken jointly by USEPA, LLNL and the State of California reveals concentrations of plutonium up to 1.02 pCi/g in the top two inches of dirt.
February 7, 1996	Inventory reveals 12 pounds of plutonium at LLNL unaccounted for.
February 7, 1997	HEPA filter failure in Building 321 releases uranium-238.
February 1997	Plutonium-contaminated tissue cut out of worker's body.
March 1997	Uranium filings catch fire.
July 2, 1997	Curium contamination during filter shredding operation.
1997	The Agency for Toxic Substances and Disease Registry (ATSDR) initiates a Public Health Assessment of the potential human health impacts of Livermore Laboratory's activities.
1998	LLNL conducts a third round of sampling to investigate plutonium in Big Trees Park. Elevated levels of plutonium found at numerous sites in the Park, near (but not in) the nearby creek, along the baseball field that borders the elementary school and by a little grassy hill between the park and the sidewalk. Slightly elevated levels of plutonium also found behind an apartment complex between LLNL and Big Trees Park.
May 1999	The California Department of Health Services (CDHS) and ATSDR jointly recommend the historic distribution of sewage sludge be investigated.
November 2002	CDHS concludes, "sludge at LWRP was contaminated by routine and unintentional releases of plutonium from LLNL … [and] the historic distribution (1958-1976) of sewage sludge from the LWRP poses an indeterminate health hazard due to a lack of data." CDHS recommends that "LLNL/DOE [should] provide funding to Alameda County Department of Health Services to implement a process to address the historic distribution of sludge from LWRP."
August 2003	ATSDR concludes, "the historic distribution of Pu-contaminated sewage sludge is determined to be no apparent public health hazard."
October 2003	Plutonium "glove box" leaks due to missing seal, emergency generator, alarm system and negative air flow system fail simultaneously.
May to August 2004	LLNL cited for "chronic airborne radiation levels" of plutonium over a 4-month period due to continual use of faulty equipment in waste packaging operations.
March 2005	LLNL cited for storing plutonium in paint cans and food tins.
April 22, 2005	Radioactive spill at LLNL tracked off-site; spill area left unsecured for several days.
November 2005	U.S. Department of Energy issues decision to double the amount of plutonium that can be kept at Livermore National Laboratory having determined its review showed no adverse environmental impacts associated with the weapons research even if more plutonium is made available.

Research Methods

Although the recommendation to investigate the sludge distribution was made jointly by CDHS and ATSDR, the federal and state researchers completely diverged in their methods of inquiry. Two research models to address the potential public health impacts of plutonium-contaminated sludge distribution emerged: (1) A collaborative approach, undertaken by CDHS; and (2) a dose-assessment approach pursued by ATSDR.

A collaborative approach

Key characteristics of the CDHS research method were: (1) gathering and incorporating of local knowledge into the scientific analysis; and (2) fostering the growth of mutually respectful relationships between scientists, governmental, and non-governmental collaborators by including them in all aspects of the research.

Absent a complete and accurate written record about the sludge, and by virtue of their commitment to a transparent, collaborative process, CDHS researchers recognized that input from workers and community members would be essential to their investigation. However, in

1999, over the protests of community-based members of the Site Team, ATSDR unexpectedly withdrew its funding to CDHS to convene the Site Team—leaving CDHS without a functional mechanism to gather the historical knowledge about the sludge. In May 2000, the CDHS convened an informal group, called the "Sludge Working Group," as a way to ensure the necessary collaboration. ATSDR continued to convene the Site Team intermittently as a mechanism to complete other components of its Public Health Assessment.

CDHS invited all members of the Site Team to participate in the Sludge Working Group. Site Team members who self-selected to join the Sludge Working Group included community members, representatives of three non-governmental organizations (San Francisco-Bay Area Physicians for Social Responsibility, Tri-Valley Communities Against a Radioactive Environment and Western States Legal Foundation), state and local health officials, and a representative of the City of Livermore. Neither DOE nor LLNL representatives chose to participate in the Sludge Working Group.

Working together, the Sludge Working Group identified and interviewed retired LWRP workers who provided researchers with invaluable, and otherwise undocumented, data. The working group members also tried to locate the log book that had the names and addresses of the households that received the sludge. Despite making Freedom of Information Act requests to LLNL, and searching the files at the LWRP, the location of log book remains a mystery to this day.

For Sludge Working Group members, navigating the uncertainties surrounding the sludge distribution presented an enormous ethical challenge. Historically, the ethical implications of distributing plutonium-contaminated sludge had been virtually ignored or obfuscated. Community members who received the sludge at no cost were not told that the sludge they received may have been contaminated with plutonium. During the years that the sludge was distributed to the public, over 11,000 homes had been built in Livermore. As the century that ushered in the nuclear age came to a close, the population of Livermore had grown to over 76,000, and it continues to rise. This translates into ever larger numbers of people at risk of exposure to the plutonium.

Sludge Working Group members grappled with how to engage the community about the potential health hazard without knowing who took the sludge, where it went, and how much plutonium it contained. What was known was that the half-life of weapons-grade plutonium is about 24,000 years. Therefore, former, current, and future Livermore residents are at potential increased risk of cancer and other health impacts from their largely unrecognized and therefore unavoidable exposure to radioactive sludge. Sludge Working Group members tried to find an ethical research framework that would maximize the benefits to community health while minimizing the potential for unwarranted fears, or stigmatization of individuals, households, or the entire community.

Community members had differing experiences with the sludge and expressed their feelings about how to proceed in the face of uncertainties about the sludge in many ways, for example:

> *Some knew they had obtained and used LWRP sludge and were concerned about the implications for their family:*
>
> "It is frustrating to remember the hundreds of hours my son and I worked our soil with shovel, hoe, and rotatiller. My son is now ready to start his own family. I will NOT allow my future grandchildren to play in my soil as long as I suspect plutonium is present. I am requesting a thorough soil test." *Janis Turner*

Others didn't know for sure they had contaminated their property, but were concerned that they may have transferred the risk to others:

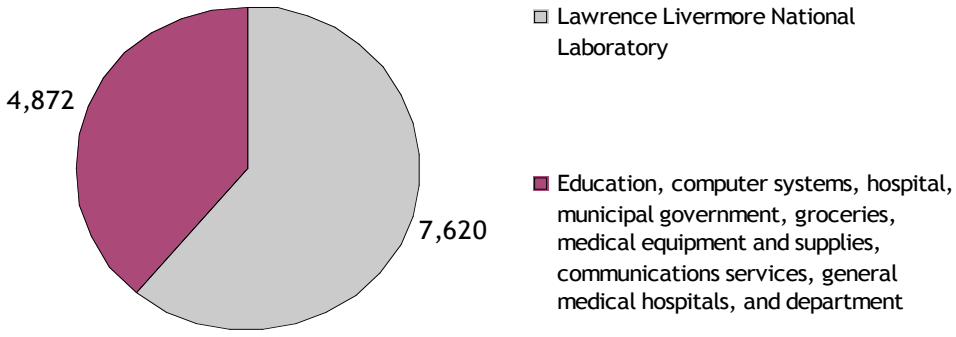
"… We sold the house in 1972. I do not know for sure that we used any sludge and, of course, do not know if it contained plutonium. However, I am concerned that the grounds at my old house may be contaminated with plutonium. The present owner would have no way of knowing about the possible radioactivity in their yard. Taking action about my concerns is the only way I have of remediating my unwitting contamination of that home." *Martha Priebat*

And some have gardened extensively in Livermore soil and have no way of knowing if plutonium was part of their exposure:

"As a person who works with the soil, I have been angry and disappointed that, despite the passage of years, location and removal of radioactive sludge once distributed to Livermore's gardeners, has not been completed. The health implications of contact with even small amounts of affected soil are severe and many of us may have been affected. It's time to address this problem." *Mary Perner*

However, the extent to which these feelings are representative of Livermore's residents is not known. LLNL is by far the largest employer in Livermore (Figure 1). Other residents have expressed concerns about jobs; others support the laboratory and its mission; and others have expressed fear of social or work-related retaliation if they were to publicly express their questions about the plutonium.

Figure 1. Top Ten Non-Manufacturing Employers in Livermore (N=12,492 jobs)



Source: Economic Development Alliance for Business. City of Livermore
http://www.edab.org/index.html?BODY=cities/livermore.html Accessed February 29, 2005

It became clear that none of the people at the table could decide for the community what to do about the sludge. A shared understanding of the problem as one of science *and* ethics developed over time. The Sludge Working Group members felt that more information was needed and that members of the community should be provided information ("community right-to-know")[15] about historic sludge contamination. The right-to-know approach is based on the fact that community members were not made aware of the potential for plutonium contamination when, or after, they received the sludge**.** Since the nature and extent of the potential health hazard remains uncertain, members also supported a process that approached these issues in a proactive manner and would be based on the "precautionary principle."[16] A key component of the precautionary principle is to take precaution in the face of scientific uncertainty. By integrating community right-to-know and the precautionary principle into the science, the research led to the process proposed in the CDHS report.

The CDHS collaborative approach led to the November 2002 release of the CDHS report titled, *Proposed Process to Address the Historic Distribution of Sewage Sludge Containing Plutonium Released from the Lawrence Livermore National Laboratory.*[4] The CDHS report compiled what was currently known about the sludge and concluded that "sludge at LWRP was contaminated by routine and unintentional releases of plutonium from LLNL … [and] the historic distribution (1958-1976) of sewage sludge from the LWRP poses an indeterminate health hazard due to a lack of data." CDHS recommended that "LLNL/DOE [should] provide funding to Alameda County Department of Health Services to implement a process to address the historic distribution of sludge from LWRP."

The objectives of the proposed process were to inform and solicit further information from residents who may have obtained sludge, sample known areas of sludge disposition in order to gain a better understanding of the potential health risk, establish criteria for sampling residences and interpreting results, and provide a mechanism for sampling and, if necessary, removing plutonium-contaminated sludge. ATSDR refused to sign off on the CDHS report, and CDHS released the report independent of the federal agency.

A dose-assessment approach

ATSDR's approach utilized "existing data to estimate radiological doses from exposure to plutonium contaminated sewage sludge and compared the estimated doses with those that have caused sickness or death." [17] ATSDR was explicit in its development and incorporation of a "chronic minimal risk level" for ionizing radiation which ATSDR considered to be "protective for both cancer and non-cancer health effects." The National Academy of Sciences, Nuclear and Radiation Studies Board, has observed that ATSDR's use of a threshold for evaluating the potential health impacts of chronic exposure to ionizing radiation is inconsistent with its claim to be incorporating health protective assumptions in its Public Health Assessments.[18]

ATSDR was also explicit that its method "was not designed to evaluate the *risks* associated with radiological releases, … but does address the radiological *doses* created by exposures to the Pu [plutonium]-contaminated sludge and whether those doses are at levels likely to create any adverse health effects*"* (emphasis added).

The ATSDR dose assessment made assumptions about the sufficiency of the available data and about exposure conditions or scenarios that would lead to the highest doses or worst-case exposure conditions for an exposed individual. Based on this methodology, ATSDR concluded that "the historic distribution of Pu-contaminated sewage sludge is determined to be no apparent public health hazard."

ATSDR acknowledged the population-based implications of the sludge exposure, stating that "many Livermore residents could have been exposed to Pu 239-contaminated soil," and "exposure may have occurred, or may still be occurring." However, ATSDR did not make a quantitative estimate of the number of people potentially exposed to contaminated sludge over the lifetime of the plutonium, and translate those doses to risk. As undertaken by ATSDR, its dose assessment methodology discounted a basic epidemiological principle of preventive medicine that large numbers of people exposed to "small" risks can lead to a large public health impact. [19]

When its report was released in 2003, ATSDR received many public comments strongly objecting to specific assumptions and methods it incorporated into its dose assessment. [20] However, even assuming that a scientifically-competent dose assessment had been performed by ATSDR, the divergent methods underlying the CDHS and ATSDR approaches are likely to account for much of the difference between the agencies' conclusions.

On August 11, 2004, the three community-based organizations and the individual community members of the ATSDR Site Team resigned en masse from the ATSDR Site Team. In their 5-page letter, the community representatives stated in part: "We have participated in good faith in the process for eight years, attempting always to mend the flaws in the ATSDR's public health assessment process. We have used our individual and organizational in-house scientific expertise and have also hired independent scientists to offer needed comment and criticism on the individual "health consults" and studies undertaken by ATSDR [of which the plutonium-contaminated sludge was but one]… For eight years, ATSDR has disregarded our individual and collective scientific and community expertise. … [T]he site team process is being used by ATSDR to imply community participation and acceptance… Therefore, we take the only ethical action available to us -- to tender our resignations…"

Part III: Formalization and Expansion of the Community-Government Partnership as an Ethical Model for Participatory and Equitable Decision-Making

Alameda County Plutonium Action Taskforce (ACPAT)

The outcome of the CDHS collaborative research process was a report that proposed a transparent, locally-based, participatory process for scientific-decision making to address the large uncertainties surrounding the distribution of sludge. The Alameda County Environmental Health Department convened an expanded working group in July 2003, named the Alameda County Plutonium Action Taskforce (ACPAT), to address the historical distribution of plutonium-contaminated sewage sludge.

The ACPAT began with approximately 25 members, including an expanded community member contingent along with Sludge Working Group members. The ACPAT process was designed to inform the public of plutonium contamination to sewage sludge from historical releases from LLNL to the LWRP, to increase public participation in environmental decision making, to provide environmental sampling and analysis to affected and interested residents, and to provide a mechanism for implementing appropriate follow-up action. Alameda County actively solicited community members' involvement in the process at public meetings, followed-up by letters and phone calls.

Under the leadership of Pamela Evans of the Alameda County Environmental Health Department, ACPAT set up a regular, local meeting schedule with agendas that aimed to carry out a work plan that they developed to implement the CDHS report recommendations, and to accommodate the interests and concerns of community members. For example, newer members wanted information about property owners'

contamination disclosure responsibilities, health effects of plutonium, construction activities at contaminated sites, and appropriate sampling protocols for contaminated residential gardens.

Sludge Working Group and later ACPAT members collaborated on grant proposals, trainings for community members and scientists, and educational materials. To date, the results of this collaborative model have been:

- 1998-99 Submitted USEPA grant proposals for funding to conduct independent monitoring for radiation; conducted community and government "Radiation and Risk" workshops to strengthen the capacity of community members impacted by the historic distribution of sludge to make informed decisions about their health, and for state and local officials to respond to community concerns.
- 2002 Conducted government and community organization workshop on evaluating and communicating radiation risk; released CDHS Report and held community meeting.
- 2003 Developed work plan and grant proposal to Syracuse University to fund *Short Courses for Environmental Research Ethics, Case Study and Trainings for the Ethical Decision-Making for Widespread Distribution of Plutonium-Contaminated Sewage Sludge;* initiated ACPAT meetings which are on-going.
- 2004 Conducted government and community workshops on health risks.
- 2006 Developed and posted plutonium-sludge related fact sheets on the Alameda County Environmental Health web-site.[21]

Hurdles: Some Overcome, Some Persistent

Lack of trust, unequal power, different perspectives, lack of data

What began in 1997 as what could be viewed as "unwilling but cooperative" participation on the part of the community organizations when ATSDR initiated the public health assessment process, developed over ten years into a truly collaborative process to address an uncertain environmental exposure. Although many factors may have contributed to this outcome, the participatory research framework nurtured by CDHS scientists was essential. The CDHS-led investigation served to equalize power among the scientists and community members and valued the contribution of all points of view, including a CDHS health physicist, city, county, and state government representatives, and community-based environmental and peace activists.

Members of the Sludge Working Group came to the table with very different perspectives but all shared a commitment to protecting the public health. All participants were experienced at, and committed to, providing their respective constituencies with only the most scientifically-accurate information. All participants appeared familiar and comfortable with not having the answer, and therefore with grappling with scientific uncertainty.

Although ATSDR and LLNL took the position that no public health risk exists due to the contaminated sludge, CDHS and county health officials gave more weight to the evidence that there were substantial data gaps. This led state and local agencies to determine that risk to residents living at properties where sludge may have come to rest is not established, and cannot be, based on the available information.

Opposition to the ACPAT process by Lawrence Livermore National Laboratory
LLNL refused the county's request to provide funding for a process to address the sludge issue and sent a letter to USEPA, essentially opposing the county's and other stakeholders' USEPA grant application. As previously noted, LLNL's extensive public relations efforts promote its message that the plutonium-sludge distribution and other LLNL releases carry no health risk to the community.

Inconsistent Alameda County leadership in the ACPAT process
Although representatives of Alameda County attended meetings of the Site Team convened by CDHS in 1997 to guide the public health assessment process, the county's commitment to interact with non-governmental organizations in a collaborative process to address radioactive exposures in the County was actually prompted by the 1998 and 1999 findings of the Alameda Grand Jury recommendations to the Alameda County Board of Supervisors.[22] The Grand Jury recommended that the county collaborate with governmental and non-governmental organizations to assure public safety from radioactive and other hazardous contaminants from LLNL and other sites in the county, mandate monitoring of radioactive contaminants, seek and allocate funding for independent monitoring, and disseminate information regarding radioactive contaminants. [23,24]

In January 2004, the county suddenly reversed itself when it refused to accept its first successful grant to support the ACPAT process, and it abandoned project leadership. Some of the grant funds (from Syracuse University) were redirected to Tri-Valley Communities Against a Radioactive Environment and Western States Legal Foundation. This enabled the nonprofit groups to move forward with the work. However, the loss of the funding to the county did impede ACPAT's efforts to implement the work plan, and caused the county's credibility to suffer among its community-based partners. Despite this setback, the ACPAT has continued to meet, to address community members' questions and issues, to plan for workshops, to develop fact sheets, and to strategize alternative approaches to implement the work plan.

Lack of funding to carry out the ACPAT process
As described above, LLNL/DOE have refused to fund the sludge follow-up process, and the county was not successful in its two grant requests to USEPA. The process has moved forward through the in-kind contributions of all the collaborators, and limited funding from Syracuse University for trainings and case-study development. In 2005, ACPAT members met with elected officials at both the county and federal levels to present their concerns and to identify other funding sources to implement the work plan. In March 2005, the County Board of Supervisors voted to request a federal appropriation for this purpose.

Limitations: Intergeneration equity and primary prevention
This case study has described the development of a process to address the issue of plutonium-contaminated sludge distribution in the Livermore Valley. At best, if implemented, the process developed will permit community members who may have received the sludge to get the necessary information, training, and environmental testing to make informed decisions about the health of themselves and their families. Key limitations are that the process does not address issues of intergenerational equity and primary prevention of exposure. The ACPAT process is happening against a backdrop of the DOE's November 2005 decision to double the plutonium storage limit at LLNL to more than 3,000 pounds,[25] enough plutonium for about 300 nuclear bombs. Worldwide, there are 3.7 million pounds of this man-made substance.[26] The wide dispersal of a radioactive substance having a lifetime of virtually forever, guarantees that the majority of Livermore's plutonium will still be waiting for the generations who follow. Therefore, prevention efforts undertaken today must also speak to the health of future generations. This

will involve looking upstream of the plutonium and working towards sustainable solutions to security that do not involve the public health threats embedded in the global embrace of nuclear weapons.[27]

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[15] **Community Right-to-Know**: Title III of Superfund law: In 1986 Superfund law was amended with a provision added to help increase the public's knowledge and access to information on the presence of

hazardous chemicals in their communities and releases of chemicals into the environment. (USEPA Superfund: www.epa.gov/oerrpage/superfund/programs/er/comunity/rt2know.htm)

[16] Precautionary Principle: When information about potential risks is incomplete, basing decisions about the best ways to manage or reduce risks on a preference for avoiding unnecessary health risks instead of on unnecessary economic expenditures. USEPA Terms of the Environment: http://www.epa.gov/OCEPAterms/pterms.html

Precautionary Principle: When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically. Science and Environmental Health Network. Fact Sheet: The Precautionary Principle: A Common Sense Way to Protect Public Health and the Environment: http://www.sehn.org/precaution.html

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[22] On April 14, 1998, the grand jury issued a report that found, “Contaminants such as plutonium, tritium, and volatile organic compounds (VOCs) are present in several Alameda County facilities. The largest of these facilities is Lawrence Livermore National Laboratory (LLNL) where there have been releases of plutonium which have appeared on a nearby City of Livermore park and on citizens’ lawns.”

[23] Alameda County Grand Jury. 14 April 1998. Letter from Neil B. Goodhue, Foreman, 1997-1998, Alameda County Grand Jury to Supervisor Scott Haggerty.

[24] Alameda County Grand Jury. 26 July 1999. Letter from Levi M. Poe, Foreman, 1998-1999, Alameda County Grand Jury to Ms. Susan Muranishi, County Administrator.

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