2001

Playing with Poison: Plutonium Use at Lawrence Livermore National Laboratory

Peter M. Strauss

Tri-Valley Communities Against A Radioactive Environment

Playing With Poison:
Plutonium Use at Lawrence Livermore National Laboratory

Prepared by
Peter M. Strauss
PM Strauss & Associates

For
Tri-Valley CAREs

Introduction

Plutonium is a human-made radioactive substance and a potent poison when inhaled or ingested. It is made in nuclear reactors, and one isotope is the primary explosive material in modern nuclear weapons. This is one of the most toxic radionuclides that Lawrence Livermore National Laboratory (LLNL) works with, and when it is introduced to the environment, it is poisonous in very small doses. It has been used at LLNL to design and fabricate nuclear weapons. Even with the cessation of the "Cold War" in the 1990's, LLNL continues to use plutonium for designing, testing and dismantling nuclear weapons.

LLNL, managed and operated by the University of California, was created in 1950 by the U.S. Atomic Energy Commission (AEC) on an 800-acre parcel just east of the City of Livermore, California. AEC is a predecessor federal agency of the U.S. Department of Energy. The land was federally owned and formally used as a naval aviation training station. LLNL is approximately 50 miles east of San Francisco. The population of the San Francisco Bay area is approximately 6.0 million.

Although LLNL is a multi-purpose national laboratory, its primary mission is nuclear weapons research and development. This research mission includes nuclear weapons design, military application, nuclear testing and weaponization. Although the weapons are tested at another site (i.e., the Nevada Test Site or NTS), work at LLNL involves working with radioactive substances and other materials that make up nuclear warheads. These radioactive substances are extremely hazardous under certain circumstances, and are extremely toxic.

The following report is about plutonium use at LLNL, past and present. This report describes the major hazards of plutonium experiments at LLNL and the known releases and potential releases to the environment.

The report is divided into five chapters:

- Plutonium and Bombs
- LLNL's Mission and Its Experiments With Plutonium
- Potential Releases to the Environment
- Future Expansion of Activities
- Conclusions and Recommendations

Attached as **Appendix 1** is a glossary of terms and acronyms used throughout these reports. Attached as **Appendix 2** are some basic scientific facts about radionuclides and scientific notation and metric conversion. **Appendix 3** contains a description of properties of plutonium that make it attractive for nuclear weapons. **Appendix 4** contains a detailed description of the surplus plutonium disposition program, which LLNL has a role in. **Appendix 5** is a detailed review of transportation requirements for shipping plutonium from Rocky Flats to LLNL.

This report was funded by Tri-Valley CAREs (TVC) in its effort to better inform the community about one of the most dangerous activities that takes place at LLNL. It is based on an extensive search of the literature. In large part, most of the documentation was assembled by Tri-Valley CAREs through a series of Freedom of Information Act (FOIA) requests, without which this report would not have been possible.

I personally want to thank the staff and members of TVC who have helped craft this document.

Chapter 1

Plutonium and Bombs

Plutonium (Pu) is a man-made radioactive element that emits alpha particles.[1] There are eighteen isotopes of plutonium[2]. Pu^{239} is the primary isotope used in nuclear weapons devices. It is created by bombarding uranium (U^{238}) with neutrons. The capture of a neutron in U^{238} produces U^{239}. By undergoing two successive beta decays, it transforms into Pu^{239}. It is created in military and civilian nuclear reactors. If developed for weapons, uranium fuel is irradiated for only a few weeks, so as not to create the less fissile Pu^{240}. It is then separated from the uranium fuel rod.

Bomb designers use Pu^{239} for its ability to rapidly create a chain reaction, which is caused by the release and adsorption of neutrons. This makes it an ideal component of a nuclear weapon, and was first used in the Nagasaki atomic bomb.

A modern nuclear warhead "pit" contains molded shapes of plutonium, surrounded by a high explosive layer.[3] When the explosive is detonated, it compresses the pit uniformly and rapidly, so that the plutonium implodes to supercritical mass. This causes the fission chain reaction that is known as an atomic bomb. If the pit contains the lighter elements of tritium and deuterium gas, the radiation and temperature from the fission reaction causes the atomic matter to fuse, resulting in a thermonuclear explosion. This is often called the hydrogen bomb.

Both the U.S. and Russia have produced weapons-grade plutonium on a massive scale since the development of nuclear weapons. In the U.S alone, from 1944 to September 1994, the U.S. Government produced and acquired a total of 111.4 metric tons (MT) [4] of plutonium. There has been a continuing dialogue between the two nations since the early 1990's to reduce the existing nuclear arsenal.

Since its discovery and emergence with the Nagasaki bomb, plutonium has altered the course of history due to the fear of a nuclear attack, and the consequent build-up of technology and armaments to protect against such an event. Additionally, because of its long hazardous life and the potential to enter the environment, its production and its eventual disposition have caused an enormous drain on intellectual and economic resources.

---

1 Radioactive substances emit alpha, beta or gamma rays. Alpha rays or particles are ejected spontaneously at high speed in certain radioactive transformation. Alpha particles are more damaging than the same dose of the other particles, but because of their high mass, they do not travel very far and will not penetrate a sheet of paper. See Glossary.

2 Elements are assigned one or two letter abbreviations. The abbreviation for plutonium is Pu. When a number is associated it indicates the mass number of the element. Pu^{239} represents plutonium with a mass number of 239.

3 Designing the shape of the plutonium in a bomb is secretive and highly classified.

4 Throughout this report metric tons (MT), kilograms (kg), and grams are used as the measure of the amounts of plutonium. One metric ton is 2,205 pounds, and one kilogram is approximately 2.2 pounds. One gram is therefore 0.0022 pounds. See metric conversion chart attached to this report.

Because plutonium is a man-made substance, and there is no natural background.[5] However, there are global background levels of plutonium resulting from fallout from aboveground nuclear testing. Worldwide, it is estimated that background levels range from 0.01 to 0.001 picoCuries/gram (pCi/g) of soil. Most of the contamination resides in the upper layer of soil. [6]

Hazards

In general, ionizing radiation as emitted by plutonium has been shown to be carcinogenic, mutagenic, and teratogenic. Radiation can induce cancer in nearly every tissue or organ of the human body. Cancer induction is a delayed response, and is well documented from research on Japanese bomb survivors, uranium workers, radium dial painters and medical patients. By 1950, scientists discarded the concept of a maximum permissible exposure, recognizing that any exposure could be dangerous. It has been long held in the scientific community that although humans are exposed to naturally occurring and induced radiation (e.g., medical exams), there is essentially no safe level of radiation. The severity of the radiation dose depends primarily on the quantity of radiation taken into the body and on the route by which it enters the body.

There is controversy about the effects of low doses of radiation over long periods. Most estimates of illness are based on people who received large doses of radiation over a very short period of time (such as the Japanese bomb survivors). In 1990, studies of this group suggested that cancer risks might be higher than previously thought.[7] Within acute, high dose populations, there is a linear relationship between dose and cancer rate: that is, each incremental dose causes an increase in risk. What is uncertain is whether this same dose relationship exists to populations exposed to low doses accumulating over time. John Gofman, a well-known health physicist argues that a linear extrapolation understates the low dose/cancer risk by at least two times.[8] The National Academy of Sciences began publishing a report on the Biological Effects of Ionizing Radiation (BEIR) in 1972. Each successive report has increased the fatal cancer risk/ low dose relationship. The BEIR V report in 1990 asserted that radiation is almost nine times as dangerous than had been estimated by the BEIR I Report.

Pu^{239} has a half-life of 24,000 years, longer than recorded history.[9] Pu^{239} retired from weapons "will remain around for the closest thing to eternity on earth" (American Physical Society spokesperson). In order to approximate the hazardous life of a radionuclide, a general rule of thumb that is used is that a radionuclide's hazardous life is

---

5 There is evidence from a uranium deposit in southern Africa that plutonium has occurred naturally the uranium deposit underwent a small chain reaction leaving a small amount of plutonium.

6 The regulatory limit for soil agreed to by Regional EPA and LLNL for plutonium is 2.5 pCi/g in residential areas and 10 pCi/g in industrial areas.

7 Geiger, Rush et al, Dead Reckoning: A Critical Review of the Department of Energy's Epidemiologic Research, Physicians For Social Responsibility, 1992, p. 30

8 From Geiger, Rush et al, Dead Reckoning: A Critical Review of the Department of Energy's Epidemiologic Research, Physicians For Social Responsibility, 1992, p. 30, citing Gofman, "Radiation-Induced Cancer from Low-Dose Exposure", San Francisco: CNR Book Division, 1990.

9 A half-life is a measure of time it takes for half the radioactive material to radiate energetic particles and rays and transform to new material. For example the half live of $cesium_{137}$ is 30 years, during which half of it decays to a stable non-radioactive stable nuclide ($barium_{137}$). See attached **Glossary**.

ten times its half-life. So the Pu^{239} in existence today will be hazardous for 240,000 years.

Pu^{239} primarily emits alpha particles. However, it is associated with Americium 241 (Am^{241}), which primarily emits gamma radiation. Plutonium metal is pyrophoric. That is it ignites in the presence of air. Small particles and shavings from machine work are pyrophoric and create a fire hazard. However, large metal pieces form an oxide coating on the outside, and no longer ignite on contact. In general, inhaled plutonium is far more hazardous than plutonium that is ingested. Tiny particles can lodge in the lung, where they can remain for a period of 500 days. Of material absorbed into the deep lung, approximately 15% goes to the lymph nodes and eventually to the bloodstream. If deposited in the bone through the bloodstream, it can remain there for up to 200 years.[10]

Glenn Seaborg, a renowned nuclear physicist,[11] stated that plutonium is one of the most dangerous poisons that man must learn to handle. Various groups have estimated the health effects of plutonium:

- The International Physicians for the Prevention of Nuclear War estimate that 27 micrograms (μg) deposited in the lung would cause cancer in an adult. [12]
- A Los Angeles Times editorial estimates that "One ten-thousandth of a gram [i.e., 100 μg], inhaled, can cause cancer. A few ounces in an urban water reservoir could cause hundreds of thousands of deaths." [13]
- LLNL scientists have written that only high doses are required to produce acute effects. [14] They calculate that ingestion of about 500,000 μg (i.e., 1/2 gram) of plutonium would be necessary to deliver an acutely lethal dose and inhalation of about 20,000 μg of plutonium dust of optimal size would be necessary to cause death within roughly a month. A person inhaling less than acutely lethal quantities of plutonium will still have an increased probability of getting cancer. Many think this is a gross understatement.

See **Appendix 3** for more details on the properties of plutonium.

---

10 Plutonium Health Physics, Los Alamos National Laboratory, HSE-10-10-01, 3/89. Based on a calculation of allowable rem per year, the maximum permissible amount for the lung and bone are 0.016 μCi and 0.04 μCi, respectively. For the bone, this would translate to 0.65 μg of Pu.

11 See Gray, L. W., From Separations to Reconstitution - A Short History of Plutonium in the US and Russia, UCRL-JC-133802, April 15, 1999.

12 Plutonium: Deadly Gold of the Nuclear Age, International Physicians Press, 1992, p. 148.

13 The Los Angeles Times, August 19, 1994, Editorial, "The New Threat That Must Unite the World".

14 A Perspective on the Dangers of Plutonium, W. G. Sutcliffe, R. H. Condit, W. G. Mansfield, D. S. Myers, D. W. Layton, and P. W. Murphy, Lawrence Livermore National Laboratory, April 14, 1995

Chapter 2

LLNL's Mission and Its Use of Plutonium

During World War II and the ensuing cold war, the U.S. developed a massive complex to develop and test nuclear weapons. Weapons parts were fabricated at Colorado, Florida, Missouri, Tennessee and Ohio. Final assembly took place in Texas. Vast areas of land in Nevada and Idaho were used to test and research nuclear weapons. Two national nuclear weapons design laboratories, Los Alamos and Lawrence Livermore, in New Mexico and California respectively, were created to design and develop new generations of nuclear weapons after the atomic bomb had been developed at Los Alamos.

Mission

LLNL is a Department of Energy (DOE) research facility operated by the University of California. The site was established by Edward Teller and E.O. Lawrence to develop the hydrogen bomb. In 1942, the Navy first used the area as an aircraft maintenance facility. In 1950, the property was transferred to the Atomic Energy Commission (AEC), a predecessor of the DOE. Around 1951, the Atomic Energy Commission (AEC) began construction of the Lawrence Livermore National Laboratory (LLNL) site. Historically, the site is known for the designing, fabricating, developing, and testing of new weapons at the Nevada Test Site (NTS). The site was created in large part because it was believed that two independent weapons design programs, working in competition with each other, would be better able to develop nuclear weapons that could be added to the nuclear stockpile.

A test site was acquired by LLNL in 1955 for the development and testing of high explosive materials and components of nuclear weapons. These tests simulate nuclear weapons explosions using all of the same materials that are in a nuclear bomb, except that surrogate materials are substituted for fissile materials. This site, known as Site 300, was necessary to acquire in order for LLNL to compete effectively with LANL for work.

The laboratory's mission has evolved, but its primary focus continues to be in support of nuclear defense programs. Since the mid-nineties, the mission has shifted somewhat because of the cessation of weapons testing. It now supports DOE defense programs through (1) researching techniques related to surplus plutonium disposition, (2) assembling and disassembling weapons, (3) research pit reuse, (4) testing pits returned from stockpile, (5) conducting basic research on plutonium, (6) developing pyrochemical processing methods, and (7) developing plutonium coating and fabrication techniques.[15]

LLNL is currently involved in the re-design of several warheads, specifically, the W87 to increase its accuracy and in one of three new design options for the W76 and W88 submarine-launched nuclear weapons. LLNL has also been named the lead laboratory for two new "modifications" of the W80, a nuclear warhead that sits atop cruise missiles. LLNL supported the work of LANL in adding earth-penetrating capability to the B61 nuclear bomb in 1996. LLNL is studying the possibility of developing a new deep earth-penetrating mini-nuclear weapon and various other new weapons concepts.

15 Defense & Nuclear Technologies Directorate, Safety Analysis Report, p. 2.7, Volume 1, January 1995

The Superblock and Support Buildings

Within the main site is a heavily guarded facility known as the Superblock. The Superblock is so named because it is encircled by two security fence, overlooked by a guard tower, has restricted access, some of the structures are reinforced in case of an earthquake, and there are systems built into the facility that provide protection from natural disaster, fire and loss of power. LLNL claims that the Superblock is governed by rules and regulations that are "similar to those used by the Nuclear Regulatory Commission for nuclear reactors". [16] The entire LLNL complex in Livermore has approximately 150 security personnel. Of these, approximately 50 have received SWAT-like training. Security personnel are not trained to deal with bomb threats; they rely on Alameda County Bomb Unit for support. They are also not trained to for radiological accidents.

The Superblock complex consists of several buildings for storing, handling, packaging and machining radioactive materials and metals, including tritium, uranium (U), plutonium (Pu), curium (Cm), and americium (Am). Plutonium is used or stored at the Plutonium Facility and Central Vault (Building 332). Several support buildings outside of the Superblock also handle plutonium. These support buildings do not have the same degree of protection as the Superblock. Below is a description of the Plutonium Facility and its support buildings.

- <u>B-332, Plutonium Metallurgy Facility and Central Vault.</u> B-332 is the location of most of the plutonium research at LLNL. B-332 is made up of four parts or "Increments". Increment 1 is the largest section and is two stories high. It contains a storage vault and plutonium laboratories. The laboratories are relatively small rooms containing gloveboxes and workstations. Activities at the laboratories include casting, plutonium recovery (from solid and liquid waste), physical testing, and machining and materials management. Individual room hood and glovebox exhaust ventilation ducts are routed through high-efficiency particulate air (HEPA) filters and connect to a separate Plenum Equipment Building. Increment 2 contains a nonradioactive materials laboratory. Increment 3 contains laboratories that focus on pyrochemical processes such as oxide reduction, molten salt extraction to remove americium, vacuum melting and casting, and hydriding to separate plutonium from other metal substrates. Increment 3 stores and processes most fissile materials. Increment 3 is connected to Increment 1 by an airlock. It contains ventilation equipment, emergency water supplies, and emergency power equipment. Increment 4 provides office space and a protective services station. The Plenum Equipment Building houses dual plenum chambers each provided with water spray devices, two stage HEPA filters, exhaust fans and motors.

The Plutonium Facility began operation in 1961 after construction of Increment 1. Its original mission was to support the nuclear weapons program through research into the physical and chemical properties of plutonium. With the addition of Increment 3 in 1977, the mission expanded to include the fabrication, testing and assembly of plutonium device parts to support LLNL's nuclear testing program. Increment 1 conducts basic research such as developing alloys, determining properties such as density and heat capacity, and inspecting plutonium and uranium bearing components. Increment 3 is more involved with machining, developing welding techniques, and pressure testing.

---

[16] <u>Science and Technology Review</u>, "Inside the Superblock", LLNL, March 2001.

Because manufacturing warhead "pits" has ceased at Rocky Flats, LLNL is also experimenting with alternative approaches to manufacture the pits. The casting method that is envisioned by LLNL reduces extensive machining required by the old process and reduces waste generation.

There are several processes used for research on the properties of plutonium. The HYDOX and HYDEC processes convert plutonium metal to plutonium oxide or into unclassified shapes. These processes are described late in the report. Other processes include molten salt extraction used to separate Am from plutonium, electro-refining, used to obtain high purity plutonium, melting/casting, tilt-pour furnace, glass formation, parts declassification, button/part breaking, crucible cleanup/oxidation, and weapons pit bisection/disassembly.[17]

A single workstation has a mass limit of 2.6-kg (5.7 lbs.) of plutonium in solid form. In certain cases this quantity can be raised to 4.0 kg (8.8 lbs.). A single laboratory has a plutonium limit of 20-kg (44 lbs.). Plutonium contaminated solid wastes are sealed in metal drums, which then are transported to the waste management facilities. Liquid wastes are dried and become a solid waste. Wastewater is transported to a central collection system consisting of two 1,000-gallon retention tanks. Radioactivity is monitored and an alarm sounds if levels are twice background radiation levels. All water below permitted levels (4×10^{-7} μCi/ml) is discharged to the City of Livermore's sanitary sewer. All water exceeding discharge requirements is transferred via tank truck to the waste management facility.

- B-251, Heavy Metal Facility. This is a support building that includes basic research of heavy elements, including Pu^{239}. Solid wastes generated by glove box operations or hot cell operations are sealed in metal drums, which then are transported to the waste management facilities. Liquid waste is processed in this building. Most is dried and becomes a solid waste. Wastewater is transported to a central collection system consisting of two 1,000-gallon retention tanks. Radioactivity is monitored and an alarm sounds if levels are twice background radiation levels. All water below permitted levels (4×10^{-7} μCi/ml) is discharged to the sanitary sewer. All water exceeding discharge requirements is transferred via tank truck to the waste management facility.

- B-231, Controlled Materials Vault. This support facility serves as a shipping, receiving and storage area for controlled materials. The vault is contained in a concrete structure. Two HEPA filters filter the exhaust air.

- Building 514, 612, Waste Management Facilities. Operations at these support facilities include treatment, packaging and disposal of transuranic wastes (TRU), mixed wasted and low-level radioactive waste (LLRW). Any radionuclide handled at LLNL can be handled in this building. After the material is analyzed, it can either be taken to B-514 (liquid waste treatment facility) or to B-612 (Solid Waste Treatment Facility). Principal treatment technology for wastewater is chemical precipitation and vacuum filtration. This creates a filter cake that is collected in drums and sent to B-612. Treated water is discharged to Livermore's sanitary sewer. B-612 operations generally compact

[17] This list is from LLNL Operational Safety Procedure 332.75-3, extracted copy. An extracted copy censors some of the information and thus this is not a full list.

the solid waste to reduce the volume. Objects that are not compacted are packaged in specially designed containers and shipped to the NTS.

Losses and Storage

The 1992 Environmental Impact Statement set the administrative limit for the amount of plutonium on site at 700 kg, or 1540 lbs.[18] In 1993, as part of Secretary Hazel O'Leary's Openness Initiative, it was reported that LLNL possessed 400 kilograms or 880 pounds of plutonium. This was a snapshot in time and should not be confused with the maximum amount that could be possessed by LLNL.[19] This includes Pu^{238}, Pu^{239}, and $Americium^{241}$, which are typically found in weapons grade plutonium. This enough for approximately 140 Hiroshima sized atomic bombs. In 1996, DOE reported that LLNL lost 5.5 kilograms (12 pounds) of Pu^{239}, accounted for either by measurement and reporting differences, or losses due to spills and releases to air, water and sewer.

Plutonium is dangerous to store. Plutonium is primarily found in two forms at LLNL: metal or plutonium oxide. There is also ash and residues that contain plutonium, as well as liquid plutonium nitride. Of primary concern is storing it so as not to exceed a critical mass in any one location, whereby there would be enough neutron activity to start a fissionable event (i.e., criticality accident). This why there are strict mass limits for any one workstation. Second, there are always radiation hazards associated with plutonium. Plutonium in solution (e.g., plutonium nitride) is the most difficult form of plutonium to store. Plutonium from scrap and residues is reactive and corrosive. Plutonium metal and oxide generally present fewer problems, although plutonium oxide is a fine dust and is easily dispersed and inhaled.

Most plutonium is stored in double containers. Plutonium metal reacts with oxygen to form plutonium oxides. Release of heat and expansion of volume, which may cause failure of the primary storage container, accompany this reaction.[20] To keep the inner surface of the outer container free of contamination, the first can is often wrapped in plastic bags. As has been theorized, a breach of the inner container can cause the plastic to deteriorate, creating corrosive by-products. In another scenario, the plutonium is in direct contact with the plastic bag. Hydrogen in the container reacts with plutonium, which in turn embrittles the plastic. When the bag is pulled from the can for use of the plutonium, the plastic breaks. The plutonium-hydrogen (hydride) reacts with oxygen, and disperses oxide powder. See **Figure 1** and **Figure 2** for diagrams of these scenarios.[21]

---

[18] Personal conversations with Dawn Wechsler and John Bellaurdo, U.S. DOE, 5/24/01 and 12/3/01, respectively. The administrative limit is set by the facility, considering factors such as human health and safety, and the size and characteristics of the facility. It is not a regulatory limit per se, but is used by audit teams to make sure that the site does not exceed its limits.

[19] In the 1994 Plutonium Vulnerability Assessment[19] it was reported that the quantity of plutonium at LLNL at any one time is 400 kilograms (kg), or 880 pounds (lbs.). This amount has been repeated throughout several important documents including the 1995 Safety Analysis Report for LLNL.

[20] U.S. DOE, "Assessment of Plutonium Storage Safety Issues at Department of Energy Facilities, " DOE/DP-0123T

[21] See "Vulnerabilities and Disposition of Plutonium", Bret Leslie, IEER, 1994

In 1994 eight cans of ash residues were found pressurized. A 1998 Report[22] indicated that the entire inventory of 114 cans of ash residue was vented to mitigate this problem. The

[22] DOE, An Implementation Plan for the Remediation of Nuclear Materials in the Defense Nuclear Facilities Complex (Rev. 1), 12/98, p. 5-72.

Figure 1: Plutonium Storage Scenario 1

Figure 2: Plutonium Storage Scenario 2

ash was to be washed with water or a weak acid solution and then thermally stabilized in a calcination furnace prior to repackaging. The material that met WIPP disposal criteria was to be shipped to WIPP, and the remainder was to be stored on-site. The report also identified 91 storage containers of plutonium metal and 92 containers of plutonium oxide that are "excess inventory not required by Defense Programs". This material was to packaged in accordance with DOE specifications by May 2002, and retained on-site until further notice. It also noted that LLNL was negotiating with Oak Ridge for that site's small inventory of plutonium metal and oxide, which is approximately 708 grams. All of these materials will be processed through a new Plutonium Stabilization and Packaging System that would meet DOE's plutonium packaging and storage standard (DOE-STD-3013).

Chapter 3

Releases to the Environment

Potential Release Mechanisms

There are numerous potential release mechanisms that could allow plutonium to escape to the environment. These include the following:[23]

- Earthquake, causing a breach in containment facilities.
- High winds, causing a breach in containment facilities.
- Internal fire, spreading plutonium inside and outside LLNL*
- Loss of power, that could cause certain safety features to fail, thus causing a release.
- External chemical spills, or release of toxic gas, which in turn could cause personnel to lose capacity to protect themselves or the public.
- Spill of plutonium powder or liquid. *
- Internal flood, causing a washout of contaminants to the environment.
- Corrosion of piping/ducting, leading to a release to the air inside or outside the facility.
- Foundry accident where water is mixed with molten plutonium, leading to a steam or hydrogen explosion.
- Disposing of plutonium liquids or wastes on-site, and allowing environmental factors such as wind and rain to have it migrate to the air or water. *
- Solvent explosion in glove box, leading to an internal or external release. *
- Internal/external transportation accident
- Over/under pressurization of gloveboxes, leading to release through the ventilation system. *
- Break in, or loss of glove, exposing worker to radiation, and changing pressure in glove box. *
- Degradation of glovebox seals.
- Failure to use approved procedures. *
- Failure of storage containers, leading to internal and external releases. *
- Release of fine particles to LLNL sewer system, which discharges to Livermore's Municipal Wastewater Treatment Facility. *
- Break in the sewer line leading to contamination of soil, groundwater or surface water. *
- Leakage from HEPA filters. *
- Degradation of HEPA filter seals, leading to external emissions.
- Ignition of pyrophoric plutonium, associated with machine turnings, metal castings and the plutonium "skulls". In 1969, a major fire occurred at Rocky Flats when a briquette of machine turnings was stored on combustible shielding material. LLNL deals with all of these types of materials on a smaller scale than Rocky Flats.

[23] This list was compiled based on the following criteria: 1) It was identified in DOE's Vulnerability Analysis of LLNL as having a greater than one in one million chance of occurring in any single year or is a scenario for which security officers are trained; 2) it has occurred at LLNL; or, 3) it has occurred at another DOE facility. Those marked with an asterisk (*) are release mechanisms that have occurred at LLNL.

- Inadvertent mixing of ignitable compounds with plutonium. In 1964, a major explosion at Rocky Flats occurred when an operator mistakenly thought that carbon tetrachloride would be an extinguishing agent for burning plutonium machine turnings.
- Criticality accident, which is the worst case release mechanism. A criticality accident is a runaway nuclear chain reaction, beginning with an intense flash and followed by a release of radiation. Plutonium bombs are designed in such a way that when triggered by a small explosive charge, the plutonium pit reaches a critical mass and begins a chain reaction that results in explosion. *
- Terrorist activity, including biological weapons attack, truck bomb, or an improvised nuclear device using material at LLNL.[24]

Throughout LLNL's operating history there have been releases of plutonium that have exposed workers and the public. **Table 1** is a list of releases that were reported at LLNL. These include both internal and external releases. **Table 2** is a summary of management mistakes, human errors, violations of procedures, and potential problems that could have led to releases. The two tables represent all of the occurrences and possible occurrences that were documented and available to the public.

[24] Terrorist activities are those identified by the Security Police Officers Association union as main threats to the complex.

Table 1
Accidental Releases at LLNL

- 11/8/60 - A curium (Cm^{242}) fire occurred in B-251, releasing several Curies. Some Pu^{238} may have been present.[25]
- 1953 - 1962 - Radioactive liquid wastes, including plutonium, were disposed of in unlined pits in the Taxi Strip area (presently where Trailer 5475 is located).
- 1962 - 1976 - Radioactive liquid wastes, including plutonium, were treated in solar evaporation trays at the south end of the Taxi Strip, near B-531 and Trailer 5475.
- 3/26/63 - An explosion and fire involving enriched uranium resulted from a criticality accident at B-261. The explosion was equivalent to approximately 5.19 pounds of TNT. About 15 kg of uranium burned, and another 10 kg melted and was distributed on the floor. [26] No person received more than 120 mrem.[27] Release of radioactivity was detected in two buildings that are 350 meters away. Approximately 900 Ci were released.[28]
- 9/13/65 - A plutonium fire in B-332 started, involving about 100 grams of wet plutonium in the form of thin plating. A plastic bag containing the plutonium was left over the weekend and it ignited when the bag was handled on Monday. Alpha contamination in room was $>10^6$ dpm. Contamination in corridor was 10,000 dpm. It reportedly all contained within building. It took 2 1/2 months to cleanup.[29]
- 4/20/67 - A spill of radioactive liquid containing plutonium outside B-332 in an outside storage area, resulting in levels between 10,000 and 160,000 dpm. A leaking transfer container caused the spill. It began to rain soon afterwards and there were problems containing the plutonium. After the incident, LLNL changed procedures so that TRU waste no longer stored outside B-332.[30]
- 5/25/67 - 6/15/67 - Release of 32 mCi to sewer. In late May, monitors detected a permissible release to the sewer although it was 30 to 100 times normal. By early-June, LLNL increased monitoring frequency. On June 6, levels were approximately 1 to 2 thousand times normal. [31] It was estimated that sludge would contain 2-3 pCi/g of plutonium. In 1975, tests indicated that sludge contained 2.8 pCi/g of Pu^{239}.
- 1973 - Unknown quantity of plutonium may have been released to soil during a 1973 transfer of dry materials from "solar evaporator". LLNL modified evaporation method to reduce wind dispersal.

---

25 Draft EIR for the University of California Contract with the Department of Energy for Operation and Management of LLNL, p. B-2, 12/22/86.

26 Kathren, Day, Denham, Brown, "Health Physics Following Nuclear Excursion: the LRL Incident of 26 March 1963", Health Physics, pp. 183-192, Vol. 10, 1964

27 A mrem is a unit of measurement for radiation, adjusted for biologic affects. There is some controversy about using this measurement, as there are many assumptions about the biological affects. See Glossary under Roentgen Equivalent Man.

28 Draft EIR for the University of California Contract with the Department of Energy for Operation and Management of LLNL, p. B-2, 12/22/86.

29 Defense & Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-1, May 13, 1994.

30 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-2, May 13, 1994.

31 D. C. Sewell, Associate Director of LLNL, documented the event in1967. Although it was known at the time that the plutonium and Am would be deposited in the sludge, no action was taken to prevent its distribution.

- 1974 - LLNL samples around solar evaporation trays confirms that there were releases to the environment.
- 6/16/75 - An exothermic reaction sprayed contaminated liquids throughout a room in B-332. It was caused by improper addition of reactive chemicals. Decontamination took 3 weeks.[32]
- 4/8/80 - Burst glove box released 3 μgm (0.26 μCi) outside B-332 because of "improperly installed HEPA filters." [33] Operations at B-332 stopped until similar glove boxes are inspected. Release not detected in offsite air monitors.
- 4/16/80 - Flash fire in glove box caused pressure to blow the window out. Plutonium escaped to room in B-332. Release was not detected in stack monitors. Caused by leaving ethanol in glovebox, which when heated volatized in the box and finally exploded.[34]
- 9/82 - 1983 - Pits at Taxi strip are excavated. 1500 cubic yards of radioactively contaminated soil is removed and disposed at Beatty Nevada. During excavation, rainfall was abnormally high, suggesting that some contaminated soil particles may have been carried away or dissolved and mixed with groundwater.
- 3/83 - Routine handling of drums at B-612 containing curium, americium, and plutonium spilled on to ground and contaminated at least one worker. Event was discovered day after it occurred because contaminated employee wore the same clothes to work that he had worn previous day. This suggests that some contamination was tracked off site by at least one employee (three were working on the drums when the spill occurred). Event involved a sequence of procedural and human errors. First, in 1980, the drums were mislabeled, which consequently resulted in their being placed outdoors for three years. Second, in 1983 workers mishandled the drums, which was a violation of safety procedures (i.e., the appearance of leakage did not cause employees to monitor what was leaking). Third, there was a violation of procedures preventing egress from the waste storage area. [35]
- 2/86 - Two workers received internal dose of 1-rem each because of breach in glovebox. This dose was the "allowable" dose over a 50-year period. No respirators were worn. Caused by degradation of gloves.[36]
- 5/87 - LLNL releases approximately 1 mCi of Pu^{239} to sanitary sewer.
- 1990 - DOE inspection team states that LLNL had not investigated or evaluated the cause of measurable off-site plutonium contamination as determined by high-volume air particulate samples collected during 1988. Since there was no detectable plutonium in the stack monitors, the source was unknown, but could have been due to wind-blown soil contamination originating from on-site source area.
- 6/28/91 - X-ray exposure to worker's hand when worker intentionally bypassed safety interlocks in order to x-ray plutonium part. Exposure of 233 mrem.[37]
- 7/9/91 - Monitoring indicates statistically significant increase in plutonium discharge too sanitary sewer. Average went from 0.21 μCi per month during first 7 months of 1990 to

---

32 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-2, May 13, 1994.

33 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-3, May 13, 1994.

34 Memorandum, From J. Hauber, LLL Investigating Committee to San Investigating Committee, May 5, 1980.

35 Incident Analysis Report, April 5, 1983, Number 0301.

36 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-4, May 13, 1994.

37 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-5, May 13, 1994.

1.25 μCi per month from 8/90 through 5/91. Later report indicates that this increase was probably due to sewer cleaning activities.[38]

- 10/24/91 - Double bag of plutonium powder tore and was spread on floor. Worker received small amount in nasal passage.[39]
- 10/5/92 - While working in glovebox at B-251, worker punctures glove and thumb with curium-244 contaminated material. Receives estimated dose of no greater than 10 rem. [40]
- 10/29/92 - Two workers contaminated after can of plutonium oxide is placed in bag. No inhalation occurred.
- In 1994, EPA discovers plutonium in three city parks that are above background. The highest levels occur in Big Trees Park, which is adjacent to Arroyo Seco Elementary School. This park is approximately one-half mile from the LLNL boundary.
- 2/7/96 - DOE reported that LLNL couldn't account for 5.5 kilograms (12 pounds) of plutonium in its stockpile. This could be attributed to releases to the environment, quantities that remain bound in the ventilation and sewer systems, theft, or incorrect weighing of the plutonium. There has been no further explanation.
- 8/5/96 - Several basement ducts reported contaminated.
- 12/26/96 - Worker's hand is contaminated with radioactive material.
- 2/3/97 - Worker's hand is punctured during glovebox operation.
- 2/7/97 - Complete HEPA filter failure at B-321, releasing depleted uranium.
- 7/2/97 - Personnel contaminated after shredding a HEPA filter at B-513. The HEPA filter was contaminated with over 500 times the limit of curium. Five workers were exposed to doses 3 to 5 times regulatory limits. The DOE issued a Notice of Violation to LLNL, describing "numerous failures by your organization to implement established radiological protection requirements and quality controls necessary to protect workers. These failures occurred multiple times…" [41]
- 12/11/97 - Some HEPA filters show leak rate of 0.04% as opposed to the standard of 0.03%. Filter gaskets could also be source of leaks.

---

38 Occurrence Report, OAK-LLNL-LLNL-1991-1024.
39 Occurrence Report, OAK-LLNL-LLNL-1991-1051.
40 Occurrence Report, OAK-LLNL-LLNL-1992-0090.
41 Preliminary Notice of Violation, NTS-SAN-LLNL-LLNL-1997-0001, March 9, 1998.

Table 2
Reported Incidents and Vulnerabilities at LLNL That Could Have Led to Releases

- 3/11/79 - LLNL mistakenly sends 21 "sacks" of Am containing 43 microCi (μCi) to Alameda County Landfill. Material is recovered.
- 4/16/79 - During inspection of B-332 HEPA filters, six failed test, six others too active (i.e., contaminated) to conduct test. All twelve filters replaced.
- 1/10/80 - -Safety report notes the risk due to fire. It posits scenario where fire in glovebox breaches glovebox, fuel of some sort is left around, fire suppression doesn't work, and there is 4.5 kg of plutonium in glovebox. 0.05% becomes suspended (2.25 grams) goes through one filter (99.97% removal) so 675 micrograms are released. Off-site person would inhale $1x10^{-4}$ or $1x10^{-5}$ microcuries or about 5 millirem. This would increase cancer risk by $1x10^{-7}$.
- 1/24/80 - 1/26/80 - Earthquakes on Greenville-Diablo fault (5.9 and 6.3 Richter scale) left small damage to walls of increment 1. No releases occurred. Some walls were seismically strengthened.[42]
- 8/29/80 - Failure of downdraft HEPA filter. Recommendation to re-evaluate changeout schedule "because of significant amount of plutonium in this system" (i.e., filters and duct system).
- 2/6/81 - Report that stack-sampling system is inadequate, there are inadequate seismic tiedowns, and HEPA filters get plugged with dust.
- 9/11/81 - Memo states that there are many old filters (10-15 years old) in use at LLNL, noting that tests don't test age related stress/material factors. Report also notes that "Bldg. 332 appears to be one of the only facilities in the world where factors such as dust loading and contamination levels do not necessitate a relatively frequent filter changeout schedule."[43] Attached memo of 1/15/81 states "the system is out of balance", that in August of 1980 staff were informed of the need to change downdraft filters as soon as possible, but this was not done. The report also indicated that one of the rooms "has a significant problem due to low flow", that square hoods "for the most part, have unacceptable flows", and "stack sampling systems on all exhaust points of the building should be reviewed on an annual basis".
- 4/30/83 - Report that glovebox HEPA filters have leaking housing.
- 6/1/83 - Report found small plutonium particles in the gloveboxes and the ventilation system that could be dispersed if the filters were not in good shape.
- 6/30/88 - Power outage in B-332 resulting from LLNL electric system failure. Emergency diesel generator (EDG) maintained power. No releases or corrective actions.[44]
- 7/29/88 - EIS accident analysis reports a 4.5-kg max-credible release. States that it would have far less off-site effects then release at B-251.
- 10/3/89 - LLNL employee files a complaint that glovebox in B-332 is too old to safely conduct experiments. While LLNL investigative team establishes that there is no immediate threat to health, it recommends decommissioning the glovebox, and

---

42 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-3, May 13, 1994.

43 Memorandum to Michael Schwab from Industrial Hygiene Group and Safety Science Group, Re: Old HEPA Filters in Bldg. 332, 9/11/81

44 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-5, May 13, 1994.

immediately stop using it. The evaluation also states that "[I]n the past, local contamination has been found in the area."[45]

- 3/9/90 - Report describes how older filters will be destroyed by fire protection (i.e., water spray). At Rocky Flats, a 1980 plutonium incinerator fire caused adhesion on the HEPA filters to degrade and steel supports on frames to warp, and water blew them out of housings. Filter bank housing was in poor shape and did not meet criteria for nuclear grade. There were also possible leaks from gaskets, filters, ball valves, test ports, boot seals, and caulking.
- 3/27/90 - An inspection report discloses that 17 of 22 HEPA filters in one batch, and 4 of 26 in another were discovered torn or cracked.
- 6/6/90 - Internal memo, referring to HEPA filters, states that "I hope it doesn't take a release like we had in late 1979 - early 1980 to spring money necessary to resolve the problems."
- 7/20/91 - Emergency diesel generator (EDG) failure. No releases occurred.[46]
- 1/27/92 - Report that HEPA filters are 100% efficient for particles > 0.1 to 0.3 microns. Only 1 % of plutonium particles are less than that.
- 1/30/92 - HEPA filter degradation on glovebox exhaust discovered during annual surveillance testing. Filters tested at 99.90 and 99.95% removal instead of 99.97 %. Filters were replaced.[47]
- 7/15/92 - EDG test failure.[48] Same EDG as 7/20/91.
- 9/28/92 - Accidental puncturing in B-332 fire water supply line. Fire department corrected this right after it occurred.[49]
- 10/17/92 - Inspection showed degradation of room exhaust air ducts and in glove box ducts. No radioactive contamination. Repaired cracked ducts and sections were seismically secured.[50] After further inspection, evidence of corrosion was found in another exhaust duct. Cracking was due to intergranular stress corrosion cracking in weld heat affected areas.
- 10/28/92 - Failure of glovebox exhaust pressure line. Due to material degradation. [51]
- 12/1/92 Report states that monitoring gauges not calibrated.
- 12/13/93 - Failure of EDG during monthly maintenance test. Repairs were made.[52]
- 5/94 - Defense System/Nuclear Design Directorate requires that all glove boxes be triply filtered. Requires that they should be able to be exposed to 180 degrees F, and have 99.97% removal of particles over 3 microns. Filters should be marked with the flow rate, flow direction, and serial number.
- 6/17/94 - Worker in storage vault observed two bulged cans containing plutonium ash accumulated from incineration activities. The double can was bulging at both ends. All cans in the vault are bagged.
- 6/21/94 - Radiographs indicate that several inner cans are bulging.

---

45 Complaint Investigation Report, October 1989, related to LLNL Hazard Evaluation Request (LL 4638), 6/1/89

46 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-6, May 13, 1994.

47 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-6, May 13, 1994.

48 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-6, May 13, 1994.

49 Occurrence Report, OAK-LLNL-LLNL-1992-0013.

50 Occurrence Report, OAK-LLNL-LLNL-1992-0098.

51 Occurrence Report, OAK-LLNL-LLNL-1992-0100.

52 Defense Nuclear Technologies Directorate, Basis for Interim Operations, p. 3-7, May 13, 1994.

- 6/21/94 - Failure of glovebox exhaust fan is discovered.
- 7/94 - A DOE inspection team discovered another 7 bulging cans of plutonium oxide. This could be the result of hydrogen pressure from moisture in the can, or the breakdown of the plastic bags that are sealed in the cans. X-ray analysis determined that the inner cans had peeled back in two containers.
- 7/29/94 - Report that HEPA filters for B-332 were unqualified. "This public disclosure [of Westinghouse employee] has increased the urgency to resolve the problem before others discover the problem and force the laboratory to shut down affected operations of B-332." States that specifications for the HEPA filters were prepared in 1962 and that no certification facility could test the equipment because of shape and size.
- 8/94 - A second DOE inspection revealed another bloated can, and an analysis of gasses from the cans. A mixture of hydrogen, oxygen, and hydrocarbons was found. DOE re-classified the risk of explosion from low to high.
- 8/4/94 - Plutonium Working Group Assessment Team Report identifies the following vulnerabilities at LLNL[53]. At B-332, vulnerabilities are to workers who receive increased exposure due to storage of excess material, obsolete packages and the lack of specific knowledge of packaging, and inadequate design basis for internal structures during an earthquake. For B-251, vulnerability results from insufficient information to characterize quantities of materials. For B-231, vulnerability includes excess sources leading to increased exposure.
- 9/30/94 - Plutonium Working Group[54] identifies LLNL B-332 as one of the 14 most vulnerable sites in the DOE complex. Identifies 282 plutonium containers that contain "uncharacterized materials and unknown package configurations". 108 packages contain plutonium ash that is generating hydrogen gas. Eight cans bulged due to pressurization, creating a hazard for workers. Also identifies the lack of supports for the fire suppression system, which could fail in an earthquake. Some interior walls were not made of reinforced masonry so that they could collapse in an earthquake and damage gloveboxes and plutonium contents.
- 12/12/94 - Vulnerability Assessment indicates that sprinkler system in Increment 1 and HEPA filters housed in Plenum Building could fail under a design basis earthquake. LLNL reinforced piping system.[55]
- 2/16/95 - Presentation to LLNL states that HEPA filters can fail when exposed to high temperature, high air flows, shock waves, moisture, and heavy particle deposits.
- 2/16/95 - Report on HEPA filters states that filters may fail under accident conditions; there are many old filters with no guidance for disposal; filters are not qualified for nuclear applications; DOE has standards developed by the army; LLNL has functioning filters with 32 years of service. They have failed at DOE facilities and had 0% efficiency in accidents and off-normal conditions.
- 4/95 - The Defense Nuclear Facilities Safety Board requires shutdown of plutonium Building after important safety measures were missed in April. Shutdown lasts until October, and ventilation system and emergency generator were added.

---

[53] Vulnerabilities that were identified were given a qualitative ranking of low or high likelihood and low or high consequence. Only those that were given a high likelihood or consequence are included here.

[54] Plutonium Working Group Report "Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage, US DOE, September 1994, DOE/EH-0415.

[55] Occurrence Report, OAK-LLNL-LLNL-1994-0078.

- 5/23/95 - Failure of EDG.
- 1996 - B-332 HEPA Test database identifies inventory of 277 HEPA filters. Of these, 17 reported removed, and 28 inactive. Of the 232 remaining filters, 48 were installed in 1975, 59 were installed before 1987 (20 years old), and only 31 were less than 5 years old.
- 1/24/96 - Glovebox pressure is lower than normal and required personnel to leave the area.
- 6/24/96 - HEPA filters in Increment 1 failed test.
- 7/18/96 - LLNL is required by DOE to repackage approximately 400 pounds of excess plutonium. New canisters will have to be certified for up to 50 years. LLNL plans to begin repackaging its 300 to 400 canisters in late 1997. New canisters will not have plastic liner. One stainless-steel can will be vacuum sealed, welded shut and placed inside another can, also vacuum sealed and welded shut.
- 8/23/96 - Potential overmass of dispersible plutonium mass limit.
- 9/9/96 - HEPA filter report states that abnormal conditions such as fire, high wind, earthquake "may affect the HEPA filters" HEPA filters over 15 years old routinely failed when exposed to over-pressure situations. "Within B-332 there are many filters older that 5 years which have been in service from greater than 10 years."
- 10/30/96 - Report states that QA tests show vendor testing not adequate, failure rates of 5-10 %. The report noted that accidents within the DOE complex have "challenged HEPA filters" (1957, 1969, 1980). For example, after 15-19 years, the filter strength was degraded by 50 %. DOE facilities have filters in service for 10-20 years; LLNL had filters in-service for as long as 31 years. Additionally, the report pointed out that filters degrade from radiation absorption and that the fiberglass medium and metal borders may be weakened due to water. Testing of the sprinkler system could cause the fiberglass to degrade and the filter boxes made of plywood to warp. Leak tests at the facilities are done to assure proper installation and age-related problems, but do not indicate filter efficiency. Leak tests are done to assure proper installation and age related problems. Not indicative of filter efficiency. Beginning in 1992, over 5%of filters were rejected by QA (through 95). The report also stated that "DOE facilities routinely handled the oxide form of fissionable materials such as plutonium in respirable size particles. Our facility ventilation ducts contain plutonium in significant quantities."
- Between 5/20/97 and 7/15/97, a workstation violated criticality controls at least 12 times. In October 1997, criticality safety controls were violated 12 times during activities relating to materials storage vaults. During December another criticality control was violated during re-packaging. In the course of investigating the cause of these violations, it was learned that 18 other infractions had been discovered. In general, operational procedures are designed to keep an activity sub-critical with an adequate margin of safety. In these cases, inadequate procedures and training were the major factors, as well as inadequate supervision.[56] As a result of these safety infractions, the DOE placed B-332 on standby in October 1997. It resumed operation in April 1998. The record of violations reveals systematic deficiencies in management and worker understanding and attitudes.
- 7/23/97 - Empty vials found to contain radioactive samples.

---

[56] Investigation Summary Report, Materials Overmass and Repackaging Concerns at Lawrence Livermore National Laboratory, Plutonium Facility Building 332, US DOE, May 21, 1998

- 10/30/97 - Violation of criticality controls after two containers had been placed in storage locations with lower mass limits than in previous location.[57]
- 12/97 - Violation of criticality controls while performing re-packaging at B-332.
- 5/21/98 - Investigation Report identifies that the 1997 criticality events were "symptomatic of ongoing poor work processes and practices in B-332, rather than an example of planned willful noncompliance with safety measures."[58] It concluded that the repeated violations were in the areas of "personnel training and qualification, procedure compliance, and quality improvement." In an earlier letter from the Defense Nuclear Facilities Safety Board, the Chairman stated that the number of criticality infractions "raise questions as to whether DOE-OAK is staffed with the technical capabilities necessary to provide guidance" and "neither DOE-OAK nor LLNL management appears to recognize or fully appreciate all of the problems of hazardous work control".[59]
- 8/7/98 - LLNL report to DOE confirms safety violation (administrative, personnel) occurred. Mass quantity of plutonium in glovebox is over limit (220 grams). 268 grams were stored in one glovebox
- 3/12/99 - Memo from Argonne National Laboratory indicates that B-332 HEPA filters are "not" immune to the type of events that occurred at Rocky Flats. Recommends replacing all HEPA filters at B-332.
- 5/99 - LLNL In-place leak test for HEPA filters indicates that there are no regulations regarding service life of HEPA filters. A standard was established that replaces any filter that becomes wet; replace any filter that could be exposed to water five years from date of manufacture; and replace all filters within 10 years.
- 7/15/99 - Glovebox fire damper failed during routine maintenance.
- 7/20/99 - Combustible loading exceeded in laboratory room.
- 2/00 - LLNL received a bomb threat via phone against the plutonium processing facility at LLNL. The building was not evacuated per procedure. None of the security officers had either the training or the equipment to deal with a bomb threat.
- 1/02 - There is an allegation by security officers at LLNL that security officers are not trained for radiological emergencies and that they are ill-equipped and do not receive the same type of external radiation monitoring as do other LLNL employees. The security officers spent at least 20% (the minimum percentage to warrant monitoring of radiation exposure) of their time in the Radioactive Materials Areas (RMA), yet are not provided high quality dosimeters and not all are provided respiratory protection.

---

57 Occurrence Report, SAN-LLNL-LLNL-1997-0065.

58 Investigation Summary Report, Materials Overmass and Repackaging Concerns at Lawrence Livermore National Laboratory, Plutonium Facility Building 332, US DOE, May 21, 1998

59 Letter from John T. Conway, Chairman of DNFSB to Frederico Pena, Secretary of Energy, December 31, 1997.

LLNL's Protection Strategy

LLNL has three tiers system to protect against releases of plutonium to the environment. The first are confinement barriers that protect workers from contamination. These include the metal cans for storing plutonium, glovebox enclosures, and glovebox exhaust/filtration systems. All gloveboxes are operated under negative pressure so that under normal operations contaminants flows through the ventilation system. The second tier of confinement refers to the room where the primary confinement system is located. Fire rated doors and barrier walls are constructed to withstand a design basis accident.[60] Typically, each room's exhaust is first filtered by a single HEPA filter and is then conducted to a two stage HEPA system. Room pressure is positive but is lower than corridor pressure. The third tier of confinement refers to the building structure, the airlock between Increment1 and 3, and two separate ventilation systems.

Accidental releases or releases from normal operations

There been problems with carrying out this strategy. Each of the three tiers of protection has either failed or there have been inspection reports identifying the potential for failure. In 1995, EPA confirmed that 0.005 pCi/g was background for the Bay Area. Some studies of background levels of plutonium suggest there are small recurring or non-recurring emissions from LLNL operation. One study reported the background value as 0.0026 pCi/g, based on 200 samples. Another study reported the background value as 0.0032 pCi/g to 0.0054 pCi/g, depending on whether the sample was upwind or downwind of LLNL.[61] This last result is important in that it suggests that 0.001 to 0.002 pCi/g of the Pu^{239} is the result of LLNL operations. Also, the California Department of Health Services (CDHS) conducted a study in 1980 showing that the mean concentration of $Pu^{239/240}$ levels one-half mile downwind (i.e., east) of LLNL was 0.068 pCi/g, as opposed to the mean concentrations on the west side (Big Trees Park) of 0.017 pCi/g.[62] This suggests that an increment of 0.05 pCi/g is associated with air deposition (ten times as much as expected from fall-out). [63] Releases to specific media are described below. [64]

Releases to Air

From 1975 and 1985, LLNL routine releases of all radioactivity to the atmosphere were approximately 4,000 Curies (Ci) per year.[65] In 1990, the Department of Energy (DOE) had an inspection team that evaluated each of the facilities Environmental Health and

---

[60] See **Glossary** for Definition of Design Basis Accident

[61] See Health Consultation, Lawrence Livermore National Laboratory, Big Tree Park 1998 Sampling, Agency for Toxic Substances and Disease Registry, September 2, 1999, page 6, citing Gallegos, G. (1995) "Surveillance Monitoring of Soils for Radioactivity: Lawrence Livermore National Laboratory 1976 to 1992". Health Physics 69:487-493.

[62] Health Consultation, Lawrence Livermore National Laboratory, Big Tree Park 1998 Sampling, Agency for Toxic Substances and Disease Registry, September 2, 1999, pp. 8-9.

[63] Lawrence Livermore National Laboratory (LLNL) reported in1993 that background for Livermore Valley soils was 0.005 pCi/g.

[64] The PRG for residential soil is 2.5 pCi/g and 10 pCi/g for industrial soil. Plutonium was detected at 11.5 pCi/g.

[65] See University of California, Draft Environmental Impact Report for the University of California Contract with the DOE for Operation and Management of LLNL, p. B-4, 12/22/86, SCH-85112611. LLNL states that these releases are "insignificant" relative to "established standards and those that result from natural background radiation."

Safety programs. This inspection team was known as the "Tiger Team". At LLNL, it found that there was "measurable offsite plutonium contamination that was found in high-volume air particulate sampling collected during 1988." This could have resulted from wind-blown particulates from on-site soils, stack emissions, or wind-blown particulates from off-site soils.

Exhaust stacks are also monitored to detect plutonium if it passes through the filters. Facilities using plutonium send exhaust through at least two sets of HEPA filters before exhaust air is emitted to the environment. In1980, plutonium was detected leaving the stacks. HEPA filters are employed to capture fine particles in the exhaust of gloveboxes, from room ventilation systems and from air stacks. They are "the last barrier of protection against the release of particulate radioactivity to the environment at our nuclear facilities". The potential failure of the HEPA filters is of serious concern to Tri-Valley CAREs. Aside from failure of the filters due to degradation, there is concern that two filters in series are not sufficient to capture particles that are in the range of 0.1 micron in size.

The HEPA filter was developed in the 1950's to minimize the release of hazardous quantities of radionuclides, and look similar to common furnace filters, except that they are larger. It consists of a fiberglass membrane that has a minimum thickness of 0.015 inch. The filters are folded in an accordion-like fashion around aluminum separators, and are placed in a metal or fire-resistant plywood frame. A neoprene or gel gasket seals the filter box to its mounting in the ventilation system. See **Figure 2** for a diagram of a typical HEPA filter and filter box.

Failures or potential failures of HEPA filters have been documented by numerous inspections indicating them to be in poor shape and not protective in case of an accident. HEPA filters came under increased scrutiny after it was learned that they did not meet performance criteria, and that neither DOE nor the vendors it acquired them from had a quality control method for testing the filters. Not only were many filters rejected by a late-to-establish quality assurance program, the filters and ventilation system reportedly contain a significant amount of plutonium.[66] Additionally, in 1999 LLNL acknowledged that there were no regulations regarding the service life of HEPA filters. A standard was established that filters would be replaced for the following reasons: if it becomes wet; if it could be exposed to water five years from date of manufacture; and replace all within 10 years. In 1999, Argonne National Laboratory recommended that LLNL replace all HEPA filters at B-332.

Releases to Water

Discharge from the sanitary sewer at LLNL flows to the Livermore Water Reclamation Plant (LWRP). LLNL is the largest user, contributing approximately 30 million liters per month. [67] Most storm sewers are also routed to the LWRP, although some are discharged

[66] Plutonium that resides in the filters and the ventilation system is called "holdup". In the case of a catastrophic accident, such as a fire, significant amount of the holdup would be released.

[67] Balke, Brian, Plutonium Discharges to the Sanitary Sewer: Health Impacts of the Livermore Water Reclamation Plant, 4/6/93, UCRL-ID-113548 in which it is estimated that this comprises 7% of LWRP volume. In the January 11, 2002 edition of Newsline, a publication for employees of LLNL, it was reported that the Livermore site discharges makes up approximately 3.9% of the flow to the system.

Figure 2
Separator Filter and Filter Box

to a holding pond and to a Arroyo De Seco. Data indicates that plutonium has been released both acutely and chronically. Although most of the plutonium in the sewage is precipitated with sludge, the remaining liquid is discharged to San Francisco Bay. There are no estimates on how much plutonium was released to the Bay. Even if it is a very small amount, there should be some concern about it.

The largest known release of plutonium to the sewer occurred in 1967. LLNL estimates that it released 32 mCi, although the source was never definitively established. It has been speculated that some of the release was from holdup in the old sewer lines, and that construction activities caused the release. In late May 1967 monitors detected a permissible release to the sewer although it was 30 to 100 times normal. By early-June, LLNL increased monitoring frequency. On June 6, levels were approximately 1 to 2 thousand times normal.

Permitted releases of plutonium continue to this day. **Figure 3** provides a historical trend of plutonium in LLNL sewage from 1973 through 1997. This is given in picoCuries per milliliter. LLNL estimated that the 32 mCi released in 1967 translated to 2 pCi/ml.

Between 1973 and 1992, LLNL reported data for effluent from the sewer lines. Although monitoring has indicated that discharges are within DOE limits, the effluent is only checked once per month. On two occasions, levels reached almost 1000 μCi of plutonium, and on seven other occasions, measurements indicated that over 100 μCi of plutonium were discharged. Discharges of between 1 μCi and100 μCi per month were common between January1973 and January 1981. Between 1981 and 1992 levels have more frequently fallen between 0.1 μCi and 1.0 μCi per month. LLNL reports however that plutonium released from LLNL sewage is "roughly" 1 μCi per month. All told, between January 1973 and January 1992, LLNL released approximately 8,000 μCi to the sewer system.[68]

Additionally, the sewer line emanating at LLNL was reported broken under Arroyo Seco for an indeterminate number of years. This could have washed contaminated water through the arroyo. Arroyo Seco Elementary School is approximately one-half mile from LLNL and is adjacent to the arroyo.

Releases to Sludge and Soil

There have been releases of plutonium that have contaminated soils inside and outside of the boundaries of LLNL. Samples taken in 1993 from three public parks in Livermore revealed higher than expected concentrations of plutonium in soil. These locations were selected because it was assumed that they would be a good indicator to determine background levels. One location was Big Trees Park, which is one-half mile west of LLNL's boundary. The average level detected at Big Trees Park was 0.164 pCi/g, which is approximately 33 times the highest predicted background level from the largest weapons-testing fallout (0.005 pCi/g). In Big Trees Park, they found one sample of 1.0 pCi/g, almost 200 times what should be expected. At Sycamore Grove and Sunflower

68 Monthly Plutonium Discharges from LLNL: January 1973- January 1992, unknown source.

Figure 3: Permitted Releases of Plutonium to the Sewer System

State Park also showed higher than expected levels of plutonium in soil. Soil within LLNL fence line also indicated plutonium concentrations up to 11.5 pCi/g.

Soil contamination outside the boundary of the site probably is the result of one or more of the following release mechanisms: air deposition as discussed above, distribution of sewage sludge as a soil amendment; or wind-borne particulates originating from on-site waste-disposal practices.

Distribution of Sewage Sludge

Following completion of the Livermore Water Reclamation Plant (LWRP) in 1958 until 1967, there is no information about whether sludge was distributed as a soil amendment. From 1967 through 1976, sludge was distributed freely to residents and the City of Livermore for public works projects. From 1976 through 1980, sludge may have been disposed of at property adjacent to the reclamation plant. A logbook identifying people who took sludge was kept, but unfortunately, investigations have failed to locate it. It was estimated that sludge from this episode would contain 2-3 pCi/g of plutonium. D. C. Sewell, Associate Director of LLNL, documented the event in 1967.[69]

Although it was known at the time that the plutonium and americium would be deposited in the sludge, no action was taken to prevent its distribution. The California Department of Health Service (CDHS) reported in 1998 that alpha activity in sewage sludge as high as 297 pCi/g was documented in 1964.[70] In 1975, tests indicated that sewage sludge contained 2.8 pCi/g of Pu^{239}.[71]

From 1976 through 1980, sludge may have been disposed of at property adjacent to the reclamation plant. Sludge was sampled in 1973, 1974, 1975 and 1990. Average activity in pCi/g from plutonium for each year respectively was 2.6, 1.83, 3.3, 0.23.

In 1973, LLNL sampled the yards of three employees who reported using sludge. In the first yard, activity of $Pu^{239/240}$ was 0.324 pCi/g at one centimeter (cm) and 0.004 at 25 cm. In the second yard, activity was 1.84 pCi/g at one cm, and 0.797 at 25 cm. The third yard was only slightly above background.[72] This confirms that there is a wide variation of contamination at properties that have used sludge, probably due to a variety of factors. One of the samples taken from the original Big Trees park study had a concentration of 1.0 pCi/g. LLNL attributes this to sludge.

Soils were sampled at the LWRP in 1971, 1976, 1987, 1988 and 1989. Average activity in pCi/g from plutonium for each year respectively was 0.27, 0.22, 0.34, 0.20, and 0.02. A 1998 report indicates that several soil samples from the LWRP exceeded 1 pCi/g and on at least one occasion, the soil was above the EPA residential standard of 2.5 pCi/g.

On-site Waste Disposal

---

[69] Letter to E.C. Shute, Manager, San Francisco Operations, U.S.AEC for D.C. Sewell, Associate Director, LRL: Subject Summary Hazards Analysis - Pu-Am Release to Sanitary Sewer, August 22, 1967.

[70] CDHS/EHIB (Environmental Health Investigations Branch) Comments on the Livermore Big Trees Soil Sampling Plan, p.3, June 10, 1998, and Health Consultation, Lawrence Livermore National Laboratory, Plutonium in Big Trees Park, Agency for Toxic Substances and Disease Registry, May 17, 1999, page 20

[71] In 1987 EPA proposed guidance for unrestricted use of soils containing plutonium was 0.2 μCi per square meter. This concentration represents approximately 15 pCi/g.

[72] Health Consultation, Lawrence Livermore National Laboratory, Big Tree Park 1998 Sampling, Agency for Toxic Substances and Disease Registry, September 2, 1999, page 15.

From 1953 through 1962, radioactive liquid wastes, including plutonium were disposed of in unlined pits in the former Taxi Strip area (presently where Trailer 5475 is located). Waste was collected from the buildings in glass 5-gallon carboys. In 1959, waste was being generated at a rate of 1 - 3 carboys per week.[73] Records indicate that in 1959, 1500 carboys were stored at the northern end of the taxi strip. Samples from 200 carboys indicated some high specific activities.[74] According to Buerer, there were no records describing the disposal pits in this area, nor is there an exact indication of where they were situated.

In 1962, LLNL built an unknown quantity of solar evaporation trays at the south end of the Taxi Strip. These trays were 10' x 20' and one foot deep. They were made of concrete and lined with plastic. The concrete was coated with an epoxy paint to restrict seepage through the concrete. They were intended to reduce volume of liquid radioactive waste by permitting evaporation of liquids. As liquids dried, sludge was rolled up in the plastic liner and placed in 55-gallon drums. Samples from the trays indicated up to 16,716 pCi/g for Am^{241}, up to 15,932 pCi/g for other transuranics, 19,977 pCi/g for U^{235}. [75]

In 1973 it was confirmed that an "unknown" quantity of plutonium had been released to soil during a transfer of dry materials from the evaporator. LLNL modified the evaporation method to reduce wind-born dispersal of contaminants. The evaporators were taken out of service in 1976.

In 1982, the old Taxi Strip was surveyed to find surface or near-surface contamination. Apparently, similar surveys took place in 1978 and 1981 after the Taxi Strip was demolished and during the construction of Building 543. Buerer stated that "[T]he existence of buried contamination was unknown at the beginning of the present survey..".[76]The survey took twenty-eight 9-inch soil cores. The survey was expanded to include sampling soil for radioactivity at 4 to 10 foot depths at the proposed location of a sewer line. One of these test holes found buried waste indicated by broken glass, solvent odor and elevated radioactivity. After discovery of this first pit (Pit #1), LLNL began a search for other pits. Three other pits were found, the last covering an area 40' by 20', and having a depth of 6 feet. This area contained low-level radioactive soil, and was situated where an evaporation tray was once located. Contamination was "presumed to have been caused by leakage from the tray."[77]

In 1991, LLNL collected surface soil samples from LLNL property. This collection was based on the assumption that airborne plutonium detected in 1988 highlighted by the Tiger Team was due to soil contamination in the southwestern portion of LLNL caused

---

73 A. L. Buerer, Assessment and Clean-up of the Taxi Strip Waste Storage Area and Lawrence Livermore National Laboratory, January 26, 1983, UCID-20869.

74 90 % contained less than $1x10^4$ dpm/liter gross alpha; 80 % contained between $1x10^3$ and $1x10^6$ dpm/liter gross beta; and 10 % contained between $1x10^7$ and $1x10^8$ dpm/liter gross beta.

75 The Taxi Strip area was also a disposal site for chlorinated compounds that are listed as hazardous. As such, some mixed wastes were disposed as radioactive wastes. This waste was sent to Beatty, NV, which in 1992 was a privately operated low-level radioactive waste disposal facility. In 2001, groundwater beneath this site is being cleaned up under Superfund.

76 A. L. Buerer, Assessment and Clean-up of the Taxi Strip Waste Storage Area and Lawrence Livermore National Laboratory, January 26, 1983, UCID-20869, p. 3.

77 A. L. Buerer, Assessment and Clean-up of the Taxi Strip Waste Storage Area and Lawrence Livermore National Laboratory, January 26, 1983, UCID-20869, p. 9.

by "historical activities". Levels of plutonium in shallow soil exceeded the EPA's Preliminary Remediation Goal (PRG).

Figure 4 is a diagram of the location of the pits and the approximate location of Trailer 5475. Trailer 5475 is important because in 1993, after the area was supposedly cleaned up, it was the one location where plutonium 239 exceeded industrial standards and required further removal. Still unknown are the locations of all the pits and evaporator trays.

Studies assessing health effects and off-site contamination

There have been a series of studies addressing off-site contamination of plutonium and health effects. These are briefly described below. Many of the studies involving off-site contamination were instigated as a result of the 1990 "Tiger Team" report referred to earlier. These studies are summarized below.

1. 1991 LLNL Sampling.[78]

LLNL collected 195 surface soil samples from on-site locations in the Southeast quadrant of LLNL property. These samples were evenly spaced at approximately 250 feet apart. All of them were taken at 5 centimeters (cm). Some of these samples showed plutonium approaching EPA's PRG.

2. 1994 National Air and Radiation Environmental Laboratory (NAREL) Report.[79]

The National Air and Radiation Environmental Laboratory (NAREL) of EPA followed up the 1991 study with a sampling program to detect plutonium around the Southeast Quadrant of LLNL (near the former Taxi Strip). The objective was to confirm the results of the LLNL study. Samples were collected from 17 locations where the 1991 LLNL samples had detected plutonium. In addition, soil samples were collected from three offsite background locations that were presumed to be unaffected by operations from LLNL. Samples were taken at depths of 1 cm and 5-cm (approximately 2 inches). The study made two significant findings: samples at Trailer 5475 were found to contain 11.5 pCi/g, approximately 15 times the level found by LLNL in 1991; and, samples in off-site areas contained higher than expected levels of Pu^{239}. These locations were Big Trees Park, Sycamore Grove Park and Sunflower Park. The NAREL study recommended that soil near Trailer 5475 be removed, and that further sampling be done at Big Trees Park, which had the highest levels of the off-site locations.

3. 1995 Joint Big Trees Park Sampling Study.[80]

In 1995, a sampling team comprised of LLNL staff, EPA and the State of California Department of Health Services (CDHS) collected 19 samples in and around Big Trees

78 U.S. DOE, Environmental Report for 1991 LLNL, UCRL-50027-91, UC-702, 1991

79 See NAREL, Confirmatory Sampling of Plutonium in Soil From the Southeast Quadrant of LLNL, August 15, 1994

80 See UCRL-ID-121045, July 1995

Figure 4: Taxi Strip Removal Action

Park. 13 of 16 samples were consistent with background levels. Four samples collected near a previous EPA sample indicated a concentration of 1.0 pCi/g.

4. 1998 -1999 ATSDR reports.

In 1996 the Agency for Toxic Substances Disease Registry (ATSDR) and the California Department of Health Services (CDHS) began a review of existing data that could shed light on the health impacts resulting from LLNL activities. As part of this effort, the agencies reviewed the plutonium contamination in Big Trees Park. A series of draft Health Consultations were prepared, spanning from 1998 - 1999. In 1999, ATSDR and CDHS completed the final Health Consultation that evaluated the health impacts to residents because of plutonium found in Big Trees Park. It used as its basis data from the previous reports. While Sycamore Grove and Big Trees had levels above the expected concentrations attributable to fallout from atmospheric weapons testing, Pu^{239} levels increased with depth around the base of trees.

The highest sample concentration at Big Trees Park was 1.02 pCi/g, 200 times background. However, this level is only 50 % of EPA's residential standard for Pu^{239}. Both EPA and ATSDR concluded that these levels do not pose an unacceptable risk to local residents. However, this analysis is based on a basic health risk assumption that there is a "safe" level of incremental radiation. Most scientists studying the health effects of radiation do not support this assumption.

ATSDR inferred from the data at Big Trees Park (i.e., increase of concentration with depth) that the most plausible theory for explaining how the plutonium was deposited in the parks was through use of sewage sludge from the LWRP. It discounted air as a major contributor, and did not think that sediment from the re-channeling of Arroyo Seco, which runs by Big Trees Park, was likely. However, there seemed to be little attention paid to the contribution of airborne plutonium emanating from B-332. As HEPA filters from that facility generally do not capture very fine particles in the 0.1-micron in size, there is little way to ascertain the contribution from airborne releases resulting from "normal" operations.

ATSDR recommended that it evaluate distribution of contaminated sludge throughout the Livermore Valley. If locations are found where sludge was used, it recommended assessing the feasibility of approaches to characterize potential problems in those areas.

5. Cancer Incidence Report.

In 1995, the CDHS prepared a study on "Cancer Incidence Among Children in Livermore California 1960-1991". It was designed to test the hypothesis of increased incidence of leukemia and non-Hodgkins' lymphoma on persons under the age of 25. This hypothesis was confirmed for a nuclear facility that processed plutonium in Great Britain (i.e., Sellafield). The study did not find this correlation at Livermore. However, the study did indicate a higher than expected incidence of malignant melanoma in young residents (two-times expected levels), and among those born in Livermore (six-times expected levels). There was a higher rate of brain cancer during the 1960's (three times higher than the remainder of Alameda County), but there was no indication of excess brain cancers since 1969. The melanoma cancer is significant in that an earlier study of all residents, including employees, found excess malignant melanoma in Livermore.

6. Melanoma Studies.

Since 1972, there has been a statistically significant (three-fold) increase in diagnosed malignant melanoma among LLNL employees, relative to the surrounding community.

7. 1998 DOE Health Effects Study.

The Nashville Tennessean conducted an investigative report to determine if there had been increased illnesses in people living near DOE's weapons plants. The study was not chemical specific or a pure epidemiological study, and much of it was based on self-reporting and anecdotal information. However, the stories of health impairment were very prevalent. Four hundred and ten people from around 13 facilities were interviewed. People told of ailments including immune system deficiencies, tremors, memory loss, fatigue, breathing problems, muscular problems, reproductive problems, as well as cancers. According to DOE, there are no plans for broader study of disease affecting those who live around the plants.[81]

8. Ongoing investigation.

There is an ongoing investigation by CDHS to determine what can be done concerning plutonium contaminated sludge that has been used by Livermore residents as a soil amendment.

Cleanup and Monitoring

Plutonium that was found near Trailer 5475 was cleaned up to industrial standards set by EPA (i.e., 10 pCi/g). Approximately 3,000 cubic yards of contaminated soil was excavated and disposed of at either the Nevada Test Site or one of the Class 1 landfills in California (Casmalia or Kettleman Hills). However, during excavation rainfall was abnormally high, suggesting the possibility that contaminated soil particles were carried away by surface run-off to either drainage ditches or were dissolved and made their way into the groundwater. The regulatory agencies did not require LLNL to clean up contamination in Big Trees Park or other off-site areas.

Prior to 1971, all monitoring of environmental media (air, soil, and water) was done for general radioactivity (i.e., alpha, beta, and gamma emissions).[82] In 1971, specific elements were monitored. Since 1979, LLNL has routinely sampled air from three remote locations in or near Livermore. These locations include the Tracy Fire Station, the LWRP, and the VA Hospital. Each location showed elevated levels of Pu^{239} and Pu^{240} in each year between 1979 and 1983, after which the levels flattened out. LLNL believes that the decrease is most likely due to improvements in analytical testing, rather than decreases in actual emissions.[83]

---

81 "Illnesses Found Around Livermore Lab, Other Weapons Sites", Tri-Valley CAREs Citizen's Watch, October 1998

82 Lindeken et al, Environmental Levels of Radioactivity in Livermore Valley Soils, URCL-74424, 4/16/73.

83 Balke, Brian, Plutonium Discharges to the Sanitary Sewer: Health Impacts of the Livermore Water Reclamation Plant, 4/6/93, UCRL-ID-113548.

Chapter 4

Future Expansion of Activities Involving Plutonium

For the most part DOE plans to continue plutonium research as previously described. That is, it supports DOE defense programs through (1) development of plutonium processing technologies, (2) development of plutonium pit safety features (3) testing of pits returned from stockpile, (4) reduction of LLNL's excess fissionable materials. The traditional role is not merely one of pure research, as this summary suggests. For example, the National Nuclear Security Administration (NNSA) of DOE has assigned responsibility to LLNL to refurbish the W80 warhead, which is carried by a cruise missile.

In addition to continuation of its traditional role, LLNL has a part in two relatively new DOE programs: the Stockpile Stewardship Program and the Plutonium Disposition Program. Future decisions about the extent of LLNL's role in these two programs will determine if additional stocks of plutonium are going to be transported to and from LLNL.

These programs and LLNL's role are described below.

Stockpile Stewardship Program[84]

The Stockpile Stewardship Program is managed by the National Nuclear Security Administration (NNSA) of DOE. It was originally proposed in the early 1990's to be a substitute for nuclear testing. It includes operations associated with manufacturing, maintaining, refurbishing, monitoring and dismantling the nuclear weapons stockpile; the activities associated with the research, design, development, simulation, modeling, and non-nuclear testing of nuclear weapons; and, the planning, assessment and certification of safety and reliability[85]. One of the more complex tasks is understanding the behavior of plutonium after it is placed in a nuclear device. LLNL, along with some other parts of the weapons complex, are charged with specific research tasks to study the effects of aging on Pu^{239}.

Along with LLNL's continued role in weapons research, it LLNL will have a critical role in this program. Stockpile Stewardship programs at LLNL include: an Annual

---

[84] Tri-Valley CAREs has published an excellent description of the stockpile stewardship program. See Civiak, R., Managing the U.S. Nuclear Weapons Stockpile, Appendix A, July 2000.

[85] The U.S. Department of Energy (DOE) is spending over $4.5 billion dollars a year on the "Stockpile Stewardship" program, more than was spent on average during the Cold War on directly comparable activities. These involve new and more advanced nuclear weapons research and production facilities, including:

← The National Ignition Facility (NIF) at LLNL. The NIF is an array of lasers the size of a football stadium, designed to create brief, contained fusion. It has a wide range of applications from training weapons designers to nuclear weapons effects testing.

← The Dual Axis Radiographic Hydrotest Facility (DARHT), near completion at the Los Alamos National Laboratory in New Mexico. This facility will join several already existing facilities where mockups of primaries, the first stage of a thermonuclear weapon, are imploded while very fast photographic or x-ray images are generated.

← Pulsed power technologies. Further experiments exploring the extreme conditions created in a nuclear weapon explosion are studied using various types of "pulsed power," in which a large amount of energy is stored and then released very quickly in a small space. Pulsed power facilities are used to explore nuclear weapons function and effects and directed energy weapons concepts.

Certification of certain weapons in the stockpile, operating of the National Ignition Facility (NIF), operating the Controlled Firing Facility, operating the Terascale Simulation Facility, and its contribution to the Accelerated Strategic Computing Initiative (ASCI). The two weapons design laboratories (LLNL and LANL) perform the Annual Certification of the nuclear stockpile with assistance from Sandia National Laboratory. LLNL is primarily responsible for evaluating the status of weapons it has developed that remain in the stockpile. [86]Additionally, LLNL will continue to receive and test warhead pits containing plutonium and return these to the stockpile.

The Stockpile Stewardship program and LLNL's role is controversial and TVC has many concerns. The program integrates data from a variety of testing techniques, providing weapons designers with data so that they can modify nuclear weapons. For example, the B61-11 gravity bomb already has already been modified and deployed without underground testing. Also, it is reported that "[U]nder the rubric of exercising Stockpile Stewardship capabilities, the weapons laboratories also are developing replacement warhead designs for submarine launched ballistic missiles".[87]

The NIF is DOE's largest construction project. It is intended to produce conditions of matter close to those that exist at the center of stars and in detonating nuclear weapons. To accomplish this, the NIF will have the largest array of lasers in the world, focusing 192 laser beams on a tiny capsule of nuclear fuel. If NIF achieves its ultimate goal, the lasers will compress the nuclear fuel unit until it "ignites" to release about fifteen times more energy than was added. These experiments, in conjunction with LLNL's supercomputers will enable US weapons designers to upgrade the nuclear weapons codes, the complex software at the heart of designing new and more sophisticated nuclear weaponry.

It has not been determined whether the NIF will use plutonium. DOE has stated that it will make a final decision on the use of plutonium at NIF by January 1, 2004.[88] However, a report by the General Accounting Office (GAO) suggested that DOE is inclined to use it at NIF. It stated:[89]

> *Los Alamos National Laboratory officials believe that using plutonium in NIF and achieving robust (repeatable) thermonuclear ignition are key to NIF's value in the area of studying weapons primaries. However, NIF has not been approved for using plutonium, and the achievement of ignition is not guaranteed.*

U.S. program for disposing of excess plutonium

In 1993, the US established a policy to seek to eliminate, where possible, accumulation of stockpiles of weapons-grade material. These include both highly enriched uranium (HEU) and plutonium. The DOE strategy for surplus plutonium has two facets. First, it will reduce the number of sites where plutonium is stored. This will require upgrading the storage facilities at the Savannah River Site (SRS) in South Carolina, and the Pantex

---

86 LLNL-designed weapons in the stockpile include: the W62 warhead used surface to surface missiles; B83-0/1 bomb; the W87 warhead used surface to surface missiles; and the W84 cruise missile warhead.

87 Andrew Lichterman and Jacqueline Cabasso, "Faustian Bargain 2000: Why 'Stockpile Stewardship is Fundamentally Incompatible with the Process of Nuclear Disarmament", Western States Legal Foundation, May 2000

88 Supplemental EIS National Ignition Facility, response to comments.

89 GAO-01-677R Follow-up Review of DOE's National Ignition Facility, June 1, 2001

facility in Texas, which will become two major storage sites. Plutonium now stored at the Rocky Flats Environmental Technology Site (RFETS) in Colorado will be moved to one of these two sites while going through LLNL and Los Alamos National Laboratory (LANL) for processing. Surplus plutonium currently stored at Hanford in Washington, Idaho National Engineering and Environmental Laboratory (INEEL), and LANL in New Mexico will remain at those sites.[90]

In 1996, Secretary of Energy Hazel O'Leary memorialized the second facet of the DOE strategy by establishing a dual-track strategy to irreversibly dispose of the nation's surplus plutonium.[91] Fifty metric tons (MT) of plutonium were declared surplus. The first track of the strategy plans to turn approximately 33 MT into plutonium oxide that will be blended with uranium oxide to produce a mixed oxide (MOX) fuel for use in nuclear reactors. The spent fuel from these reactors will be disposed of in a geologic repository, much the same as is planned for spent fuel from commercial reactors. The second track consists of immobilizing the approximately 17 MT of plutonium that is not suitable for use in MOX fuel without extensive purification. This will be done by incorporating plutonium oxide into ceramic disks, and assembling it in such a way that it is suitable for disposal in a geologic repository. How either or both options are implemented will be determined by the results of technology demonstrations, additional environmental reviews and detailed cost proposals. This strategy is described in more detail in **Appendix 4**.

LLNL has been charged to take on several additional research roles with respect to the disposing of excess plutonium.[92] LLNL is the lead on the technical effort for the development phase of ceramic immobilization. This technology was proven at LLNL, but due to budget constraints, it is no longer an active project. Furthermore, LLNL was tasked with separating the plutonium from some of the excess parts at RFETS. The plutonium would be converted to plutonium oxide that will be used as feedstock to the MOX fuel program.

The transfer of plutonium parts to LLNL from RFETS and the subsequent transfer of treated parts and waste is one of the more controversial issues for the community. This issue is described below, and in more detail in **Appendix 5**.

<u>Rocky Flats Parts</u>

In 1997, DOE decided to phase out storage of all weapons-usable plutonium at Rocky Flats Environmental site (RFETS). Rocky Flats has 875 Classified Parts that must be processed and stored before DOE can close the site. The plan established in 1999 is for SRS to process 206 items, for Rocky Flats to process 245 items, for LLNL to process 89 plutonium/metal shells, and for LANL or SRS to process 335 items.

A Memorandum of Understanding among Rocky Flats, LLNL, LANL and SRS dated February 8, 2000 sets the basic parameters for the transfer of parts from RFETS to LLNL. The parts are composite shells consisting of Pu^{239} and a non-plutonium substrate

---

90 The current plutonium at LLNL is not included because it is not considered "surplus".

91 DOE Press Release: R-97-001 January 14, 1997

92 As described previously, plutonium is authorized for use in LLNL's Superblock. The allowable stock of plutonium at LLNL (i.e., 1,540 pounds) is for weapons research and development. It is not considered surplus to government needs. Consequently, none of the existing plutonium stored at LLNL falls within the scope of the disposition program for surplus plutonium.

(i.e., beryllium, vanadium, tantalum and depleted uranium). LLNL agreed to take the parts as "part of its research and development activities, in support of the Department's Pit Disassembly and Conversion Facility Program." [93] After treatment to separate the plutonium from non-fissile material, the plutonium will be packaged and sent to the SRS. Non-fissile materials will be sanitized (i.e., demilitarized/declassified), stored in 3-4 drums and sent to the Waste Isolation Pilot Project (WIPP) in New Mexico as TRU waste. DOE claims that although SRS is capable of separating the plutonium from its substrate, LLNL is the only DOE site capable of recovering the plutonium and declassifying the metal substrate so that it can be disposed of as TRU.

Because of administrative limits for the amount of plutonium at LLNL (i.e., 1,540 pounds), shipments must be handled in such a way that limits are not exceeded at any given time. One of the concerns raised by DOE Defense Programs (DP) is that taking on the extra material compromises LLNL's ability to serve its mission in defense programs. A recent memo stated that LLNL is "near the administrative limit for plutonium storage". In a declassified memo, it was stated that "We must be pretty careful about making commitments about using DP [Defense Programs] inventory space for other work. This is particularly crucial because LANL's TA-55 is shutdown/in standby...Any urgent work from DP will need to be performed at B-332." [94] Therefore, prior to receiving a shipment from Rocky Flats, LLNL must ship an equivalent amount to SRS. Essentially 270 kgs (approximately 600 pounds) of plutonium will be shipped from LLNL to SRS in 65 containers.

An agreement signed between Oakland Operations Office, Rocky Flats, and SRS determined that LLNL would receive its first shipment on November 2000, a second shipment in December 2000, and the balance will depend on LLNL's ability to ship plutonium to SRS to make room for the new plutonium. LLNL was supposed to work to receive final shipment by September 2002. However, no shipments had taken place due to a number of variables, the most important being obtaining approval to use the Drum Type-22 (DT-22) shipping container for transporting the classified parts to LLNL[95]. The problem is that the DT-22 shipping container is not authorized for use for most of the parts because "[T]he designers of the DT-22 have indicated that it will not meet the 10 CFR 71 requirements if subjected to the dynamic crush test".[96] DOE has been well aware of this fact for several years.

Instead of designing a container that would safely meet Nuclear Regulatory Commission (NRC) standards, DOE has requested a "National Security Exemption" to use these containers so that closure of RFETS will not be delayed. Although there is a suggestion that the closure of RFETS is linked to national security[97], this link is tenuous at best.

---

93 Memorandum of Agreement to Ship 89 Composite Parts from the Rocky Flats Environmental Technology Site to Lawrence Livermore National Laboratory, EM-33, D. Brown, February 8, 2000

94 Memo from Dawn Wechsler to Phil Wong and Phil Duarte, 8/30/2000

95 The Drum-Type (DT) 22 is a Type B fissile class 1 or II package that was designed to transport up to 10 kg of uranium metal, 5 kg of plutonium contaminated uranium metal, or 2.016 kg of plutonium. It is a 55-gallon drum with a secured lid.

96 See July 19, 2000 memo from F. Shepard to Marylyn Creedon, Deputy Administrator of Defense Programs. Also see Memo to Distribution from Weapons Surety Division (WSD) Re: Compliance issues with proposed shipments in Model FL and the DT-22 shipping containers, October 5, 1999.

97 See Memo to Carolyn Huntoon, Assistant Secretary for Environmental Management (EM) from Paul Golan. April 20, 2000. This memo requests an NSE for shipping special nuclear materials (SNM) in the DT-22

First, it is not clear that timely closure of RFETS is a national security issue. Second, LLNL plans to treat the treatment of the plutonium parts from RFETS a research project, not as a weapons project. Third, although the parts are shaped in a classified form, RFETS can either declassify them or if it cannot, store them while a proper container can be developed. Fourth, shipping plutonium in unqualified containers raises a myriad of security issues.

In addition to having the parts shipped from RFETS to LLNL, LLNL must obtain enough 9975 container for shipment of plutonium to SRS and determine the specifications and packaging requirements for material that will go into these containers. The plutonium oxide or metal will be packed in Type 3013 storage cans with a 9975 container as an overpack. The storage cans of plutonium dioxide or metal are made of stainless steel. The cans would be welded shut and leak tested to ensure that the weld was sound. If a can were to fail the leak test, it would be reopened and re-welded. [98]

The plutonium from RFETS will be declassified at LLNL. The plutonium will either be made into an oxide or be casted into a metal puck, using the Hydride-Oxidation (HYDOX) and Hydride-Dehydride-Casting (HYDEC) technologies, respectively. In the HYDOX process, plutonium metal reacts with hydrogen, nitrogen, and oxygen at controlled temperatures and pressures in a pressure vessel to produce plutonium dioxide. When the metal is first reacted with hydrogen gas to form a hydride, it separates from the metal substrate (e.g., beryllium, depleted uranium). Then the vessel is then purged of the hydrogen and the plutonium hydride reacts with nitrogen gas to form a plutonium nitride. The nitrogen is then purged and replaced with oxygen for the final reaction forming plutonium dioxide. If the plutonium is to be used for MOX, impurities such as gallium must be removed.

Alternatively plutonium components can be reconstituted in unclassified metal form using the HYDEC process. In this three-step process, plutonium is first hydrided to separate it from the substrate. It is then dehydrided, and finally is melted and casted. [99]

When plutonium is converted to an oxide, it is stable, and no longer pyrophoric in the presence of oxygen. However, oxide powder is more respirable and accidental releases would have greater potential health effects. An advantage of the HYDOX process is that it reportedly creates no solid or liquid waste.

LLNL will receive surplus plutonium from other parts of the weapons complex to expand upon related work. For example, LLNL reported that it will conduct the following activities in the future[100]:

---

shipping container. An attachment lays out the reasoning for granting the National Security Exemption (NSE): 1) a majority of parts at RFETS are weapons components in various stages of fabrication; 2) many parts have Secret/Restricted data; 3) RFETS cannot declassify the parts (i.e., take them out of weapon shape); 4) expediting removal of parts reduces classification issues at RFETS, 5) closure of protected area at RFETS reduces security posture at the site 6) an NSE exemption is consistent with National Security Goals "supporting DOE SNM consolidation and storage, non-proliferation, and international safeguards."

[98] Based on handwritten notes from the Workshop on Removal of Special Nuclear Materials and Radioactive Waste to Allow the Rocky Flats Environmental Technology Site Closure held on October 14, 1999, SRS has experienced a welded can failure and will be investigating welding procedures.

[99] Y. Zundelevich, M. Bronson, Hydride/Oxidation (Hydox) Process for Conversion of Plutonium Metal to Oxide, June 1998, UCRL-JC- 128029

- *Use existing HYDOX unit to explore cyclic process adaptability for various feed materials and determine which (if any) feed types need to be processed in separate steps.*
- *Examine alternate gallium removal technologies and incorporate gallium removal into the second stage of the two-reactor HYDOX system. LLNL intends to take full advantage of this development by designing the system to be capable of processing pits in support of the Pit Disassembly and Conversion Program.*
- *Develop automated control and remote handling in the HYDOX operation for high activity material.*

See **Figure 5** for a detailed drawing of the HYDOX crucible.

[100] Y. Zundelevich, M. Bronson, Hydride/Oxidation (Hydox) Process for Conversion of Plutonium Metal to Oxide, June 1998, UCRL-JC- 128029

Figure 5: HYDOX Process

Chapter 5

Recommendations

This chapter makes recommendations that address issues pertaining to past releases and future activities. It also makes some overarching recommendations that pertain to LLNL's experimenting with plutonium.

Overarching Recommendations

- Given the history of poor management practices involving the use of plutonium, evaluate whether LLNL's activities experimenting with this substance should be halted or severely restricted. A 1998 investigation report indicated that the 1997 criticality events were "symptomatic of ongoing poor work processes and practices in B-332, rather than an example of planned willful noncompliance with safety measures."[101] Repeated violations existed in the areas of "personnel training and qualification, procedure compliance, and quality improvement." The Chairman of the Defense Nuclear Facilities Safety Board further stated that the number of criticality infractions "raise questions as to whether DOE-OAK is staffed with the technical capabilities necessary to provide guidance" and "neither DOE-OAK nor LLNL management appears to recognize or fully appreciate all of the problems of hazardous work control".[102] Based on the experience of LLNL's plutonium management, experiments should be halted or severely restricted. [103]

- Evaluate whether plutonium research at LLNL is in the national interest. LLNL is one of two weapons design laboratories (LANL being the other) that experiments with plutonium, and it is not clear that this research needs to take place at both locations. The Laboratories were set up so that weapons designers could compete against one another in America's pursuit to develop the "best" nuclear weapons. With the demise of the cold war, this competition is no longer important, if ever it was.

  Maintaining two weapons design laboratories that experiment with extremely hazardous substances is not only an extraordinary expense, but it also increases security and proliferation risks substantially. In 1993, the U.S. established a policy seeking to eliminate, where possible, accumulation of stockpiles of weapons-grade material. The DOE strategy articulated at that time was to reduce the number of sites where plutonium is stored. Taken together with the historical mismanagement of plutonium at LLNL, strong consideration should be given to phasing out LLNL's experiments with plutonium as a matter of national interest.

- Implement a detailed employee and community health database and uniform radiation data collection system. This recommendation was first made by the

---

101 Investigation Summary Report, Materials Overmass and Repackaging Concerns at Lawrence Livermore National Laboratory, Plutonium Facility Building 332, US DOE, May 21, 1998

102 Letter from John T. Conway, Chairman of DNFSB to Frederico Pena, Secretary of Energy, December 31, 1997.

103 Based on experience with the civilian nuclear power industry, I have little doubt that had these types of infractions occurred at a reactor, regulatory treatment would have been harsh, including heavy civil penalties, increased regulatory oversight and possible shutdown until the agency (in this case the Nuclear Regulatory Commission) was satisfied that the plant, operating personnel, management, and procedures were all up to the task.

Physicians for Social Responsibility[104] concerning employee health, radiation exposure and its links to disease. This report reiterates this recommendation, and has added a community component. It is unclear whether LLNL has compiled a database on employee health and relates that to radiation exposure. As some community members have also been exposed, it would be prudent to compile a database to help establish potential links between disease and radiation for the surrounding community.

- Thoroughly review the Quality Assurance program regarding all aspects of plutonium use at LLNL. Throughout the time period for which there is documentation about the HEPA filter program at LLNL, one of the most egregious findings is the lack of a good quality assurance program. A quality assurance (QA) program is the hallmark for any program dealing with nuclear materials. A quality assurance program comprises:

  > All those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. [105]

  In the nuclear industry, QA is often referred to as the final element for the "defense in depth" strategy for protecting public health and safety. A tenant of QA in the nuclear industry is that the user of a product made by vendors must check any certification of the product. The government should be held to these same standards. The fact that a good QA program for the HEPA filters did not exist within the DOE complex until a vendor came forward in 1994 is indicative of a serious problem.

Past Releases

- Reiterate recommendations Tri-Valley CAREs made in a letter to Marilyn Underwood of the CDHS[106]. These recommendations include: 1) implement a search for the logbook containing a record of who took LWRP sludge; 2) publicize potential problems with past use of sludge; 3) provide free testing of soil and soil replacements to Livermore residents; 4) where plutonium is discovered, remove and store it at LLNL's main site; 5) investigate and evaluate the efficacy of monitoring LLNL waste streams that could potentially enter the sewage; and, 6) investigate ways in which health testing be made available to the public. Furthermore, should anyone in the community be adversely affected by plutonium, they or their survivors should be compensated.

- Reiterate recommendations by ATSDR regarding additional sampling of Big Trees Park and Arroyo Seco Creek. These samples were to determine the vertical extent of contamination, addressed in the 1998 sampling event and subject of a later Health Consultation.[107] ATDSR also recommended investigating potential contaminant releases from sewer line ruptures.

---

104 Geiger, Rush et al, Dead Reckoning: A Critical Review of the Department of Energy's Epidemiologic Research, Physicians For Social Responsibility, 1992, p.13

105 NRC Regulations regarding nuclear power plants: 10 CFR, Part 50, Appendix B, Introduction.

106 April 15, 1998

107 U.S. Department of Health and Human Services, Agency for Toxic Substance and Disease Registry, Health Consultation: Plutonium Contamination in Big Trees Park, May 17, 1999, Executive Summary.

- Continue studies of plutonium contamination stretching over a broader area. ATDSR also recommended that the distribution of contaminated sludge throughout the Livermore Valley be evaluated.[108] If locations are found where sludge was used, ATDSR recommended assessing the feasibility of approaches to characterize potential problems in those areas. Notable are the results of 1973 LLNL testing the backyards of three of its employees where sludge was used. Because one surface sample was close to the EPA action level, this alone would warrant a further and broader search. If any sites are identified as warranting cleanup, LLNL should do so.

- Increase monitoring stations to measure off-site releases to the atmosphere. Only three off-site air monitors are situated in or nearby Livermore. One is in Tracy, over twelve miles away. With only two points somewhat near the site, it is uncertain that all air releases of plutonium emanating from LLNL would be detected.

- Increase monitoring of sewage. Tri-Valley CAREs recommended evaluating and monitoring the sources of contamination. This should also include increasing the frequency of monitoring sewage at the LWRP, sewage sludge, and effluent. The sludge lagoons and drying fields should also be monitored as they may a source of wind blown particulates.

- Determine how much plutonium was discharged to San Francisco Bay. After removal of solids at the LWRP, wastewater was discharged to San Francisco Bay. This wastewater most likely contained very small particles of plutonium that were not precipitated. Over the years, there could have been a buildup of plutonium at the point of discharge, which can make its way into the ecosystem. Discharges should be back calculated and disposition studies should be done to determine if plutonium in the wastewater poses a risk to the estuarine environment.

- Assess the Taxi Strip Area for any remaining radioactive wastes. From 1953 to 1976 the Taxi Strip area received an unknown soup of radioactive materials, placed in unlined pits and evaporator trays. The Superfund cleanup at LLNL is treating groundwater contaminated with solvents and tritium found below the Taxi Strip in the area near Trailer 5475. Much of the area near the Taxi Strip was also used as a dump site, most recently exhibited by the discovery of over 100 capacitors containing PCBs that were found during the foundation excavation for the NIF. Although the Taxi Strip was cleaned up in 1983, it would be prudent to go back and identify the location of all pits and trays, and excavate and dispose of material as required. New sensors for detecting low levels of radiation have most likely been developed since this area was last cleaned up.

- Determine who should pay for off-site cleanup and monitoring. If possible endangerment to health and the environment exists, there should be no question that DOE/LLNL should pay the large part of any off-site cleanup and additional health and environmental monitoring. If the risks are associated with releases from the LWRP, then some cost sharing proposal may have to be negotiated. However, in no case should cleanup action be delayed while negotiations take place.

---

[108] U.S. Department of Health and Human Services, Agency for Toxic Substance and Disease Registry, Health Consultation: Plutonium Contamination in Big Trees Park, May 17, 1999, Executive Summary.

- Review scientific information concerning vertical migration of plutonium. If it were shown that plutonium and other radionuclides migrate faster than expected, both the deposition theory for Big Trees Park and the remediation strategy for the Trailer 5475 area should be re-evaluated. Until recently most scientists believed that plutonium, once in the environment, remains more or less in place. However, two recent studies have questioned the conventional wisdom. First, in 1995, a scientist working at Rocky Flats found significant migration of plutonium in the soil. Second, in 1997, other researchers discovered major plutonium migration in soil at the Nevada Test Site and at Hanford. However, at this time we do not understand the cause or rate of migration.[109] Also, early studies by LLNL indicated that "radionuclides have migrated to considerable depths". [110] They found radionuclides at 25 cm (approximately 10 inches). In addition, in 1998, at the Nevada Test Site, plutonium was discovered in well water almost one-mile south of a 1968 underground nuclear test. Conventional wisdom had assumed that the plutonium would immobilize within the nuclear blast's crater, trapped by the molten rock.[111]

- Review policies that allowed LLNL not to prevent or warn about distributing contaminated sludge from the LWRP. The large release of plutonium to the sanitary sewer in 1967 gained the attention of LLNL senior management when it occurred. An Associate Director of LLNL documented it. It would have been logical for LLNL to take steps at that time to restrict the distribution of contaminated sludge to the community. Community right-to-know policies should be reviewed, developed and/or rewritten to take into account of unanticipated releases of dangerous materials to the air, water or soil. For example, assuming that LLNL continues handling plutonium, it would be prudent to develop contingency strategies for any type of off-site release.

- Re-evaluate disposition theory in light of new information concerning plutonium migration and other factors. ATSDR was unequivocal in its September 1999 Health Consultation that sewage sludge was the pathway for plutonium in Big Trees Park. Based on a review of the data, there is ample evidence to indicate that some plutonium had been released through either wind-born soil blowing from the old waste pits, or from other mechanisms that released plutonium directly or indirectly to the air. We encourage regulatory agencies to re-evaluate the ATDSR findings. For example, in part ATSDR discounted air releases as the source based on the fact that there were higher concentrations of plutonium in the soil downwind from LLNL.[112] Air releases over the years, in all probability would have had a greater effect on downwind sites. However, releases could very well have contributed to upwind sites, as the wind does not blow in one direction all of the time, and there may have been episodic releases when the wind was not blowing west to east.

---

109 Daily Camera, "Migration of Plutonium in Soil at Rocky Flats", LeRoy Moore, August 1, 1998.

110 Lindeken et al, Environmental Levels of Radioactivity in Livermore Valley Soils, p.6, April 16, 1973, UCRL-74424

111 It is thought that the plutonium attached itself to tiny particles called colloids, which made their way to the groundwater. See Nature, "Colloidal Culprits in Contamination", Volume 397, January 7, 1999.

112 U.S. Department of Health and Human Services, Agency for Toxic Substance and Disease Registry, Health Consultation: Plutonium Contamination in Big Trees Park 1998 Sampling, 9/2/99, pp. 8-9.

- Review whether all corrective actions that were recommended by various inspection reports were done. These include:
  - Re-evaluating changeout schedule for HEPA filters due to significant amount of plutonium in the gloveboxes and ventilation system.
  - Replacing all HEPA filters, checking that each HEPA filter is marked with flow rate, flow direction and serial number.
  - Re-evaluating stack monitoring system.
  - Replacing exhaust ducts that showed signs of intergranular stress corrosion.
  - Fixing seismic problems with B-332, including sprinkler system in Increment 1 that could fail during design basis earthquake.
  - Ensuring that additional high-volume air particulate sampling, as planned in the 1990 Environmental Report for LLNL has taken place.[113]

The Future

- The policy of transporting surplus plutonium to different parts of the weapons complex should be re-evaluated. LLNL will receive and process RFETS plutonium parts and send the resulting plutonium oxide to SRS. The transport to LLNL, the processing at LLNL, the handling of plutonium at LLNL and SRS, and the storage and processing at SRS all increase the risk of accidental release to the environment. Security risks are increased with each change of hands.

  Transportation risks are obvious, from serious accidents that breach the transportation cask or engulf it in flames with a release of radioactivity. At this time, we know that the shipping container proposed for use from Rocky Flats to LLNL will not meet the crush test as required by NRC regulations. Any increase in transportation activity increase this probability.[114] This is also true for loading and unloading activities. Processing also presents dangers. Hydrogen used in the HYDOX unit is highly explosive. The combination of an explosive gas mixed with a pyrophoric element (i.e., plutonium) under heat and pressure presents an accident risk that has not been evaluated at LLNL.[115] Storage is also a problem as was indicated by the storage problems that have already occurred at LLNL. At RFETS, plastic jars that held plutonium nitrate have become embrittled, and there have been safety concerns about them at SRS.

- Require that the shipment and processing of RFETS plutonium parts be subject to a site-specific NEPA review. There does not seem to be a site-specific environmental

[113] NAREL, Confirmatory Sampling of Plutonium in Soil From the Southeast Quadrant of LLNL, August 15, 1994. p. 2-1

[114] DOE assessed the environmental effects, including accidents, of transportation in the Programmatic EIS on Storage and Disposition of Weapons Useable Fissile Materials, DOE/EIS-0229, 12/96 and the SPD EIS, DOE/EIS-0283D, 7/98. There appears to not be an evaluation of the specific additional impacts of shipments or processing at Livermore.

[115] An accident in 1957 at the Chelyabinsk-40 plutonium facility in the former Soviet Union was the result of a reaction of some of the same chemicals: hydrogen gas, nitric acid and plutonium. This was the largest known accident in a military production facility, releasing 2 million curies into the atmosphere and surrounding environment. This accident occurred at an early time in the Soviet's development of plutonium, and admittedly, LLNL has only a fraction of the plutonium that was involved.

review of LLNL's acceptance and processing of RFETS parts. A summary of a meeting at RFETS stated that there "were no NEPA requirements identified for this campaign [i.e., shipments to LLNL] since it should be covered under Research and Development."[116] Although this summary is not a legal document, there does not seem to be a basis for excluding research projects from NEPA reviews. Included in this review would be the subject of the shipping containers to and from LLNL.

- LLNL should not be authorized to use plutonium at NIF. It is unclear if and how plutonium would be used. As stated in the previously, LANL officials believe that using plutonium in NIF and achieving thermonuclear ignition are key to NIF's value in the area of studying weapons primaries. NIF, however, is not qualified to use plutonium. If DOE decides to use it, security requirements and operational procedures similar to those used at B-332 must be put in place. These include criticality controls, handling procedures, storage and packaging procedures, and around the clock security protection. This would be expensive, and surely increase the NIF operational budget substantially.

- NIF should be re-evaluated. Controversy centers around four factors: 1) whether the NIF will actually contribute to safety and reliability of the nuclear weapons stockpile that will not be dismantled; 2) whether its operations will violate the letter and spirit of the Comprehensive Test Ban Treaty; 3) whether the NIF will contribute to new weapons development activities; and, 4) whether the cost of the NIF, still in construction, will be so large relative to its contribution as to make it a waste of taxpayer money and a drain on funds for crucial activities.[117] We have already seen drastic budget cuts in the plutonium immobilization program.

  Because of the timing of planned stockpile refurbishment, NIF will not make any contribution to the refurbishment of several bombs in the stockpile. There is a lack of complete consensus among LANL, LLNL, and Sandia National Laboratory on NIF's research contribution. All three of the weapons laboratories agree that NIF is one of several important facilities needed to successfully support weapons science research. However, Sandia officials believe that NIF will not contribute to certifying whether weapons can survive hostile environments (those where radiation is present), and intend to rely instead on existing research facilities and computer simulations.

---

116 Summary of the Special Nuclear Material Shipping Meeting, August 17, 2000 at the Rocky Flats Site.

117 Tri-Valley CAREs has recently published a study investigating cost overruns by the Department of Energy in constructing NIF. See Civiak, Robert, Soaring Costs, Shrinking Performance, for Tri-Valley CAREs, May 2001. Dr. Civiak concludes that over the life of the facility, expenditures will exceed $30 billion. This includes approximately $5 billion in construction and operational costs of $440 million.