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NEW MEXICO ENVIRONMENT DEPARTMENT
ENVIRONMENTAL REVIEW COMMENT FORM

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NMED FILE NO.: 957ER **SAI NO.:** N/A

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(3) A response to the following question: Do the anticipated accomplishments of the proposal justify the requested funding level? (If "no" please explain in your review);

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DOE/EA-1059

Predecisional Draft Environmental Assessment

Radioactive Source Recovery Program

United States Department of Energy
Los Alamos Area Office
Los Alamos, New Mexico

Date Prepared:
October 30, 1995

Prepared For:
Office of Environmental Restoration and Waste Management
U.S. Department of Energy

EXECUTIVE SUMMARY

In a response to potential risks to public health and safety, the U.S. Department of Energy (DOE) is evaluating the recovery of sealed neutron sources under the Radioactive Source Recovery Program (RSRP). This proposed program would enhance the DOE's and the U.S. Nuclear Regulatory Commission's (NRC's) joint capabilities in the safe management of commercially held radioactive source materials. Currently there are no federal or commercial options for the recovery, storage, or disposal of sealed neutron sources.

This Environmental Assessment (EA) analyzes the potential environmental impacts that would be expected to occur if the DOE were to implement a program for the receipt and recovery at the Los Alamos National Laboratory (LANL), Los Alamos, New Mexico, of unwanted and excess plutonium-beryllium (^{238}Pu-Be) and americium-beryllium (^{241}Am-Be) sealed neutron sources. About 1 kg (2.2 lb) plutonium and 3 kg (6.6 lb) americium would be recovered over a 15-year project.

Personnel at LANL would receive neutron sources from companies, universities, source brokers, and government agencies across the country. These neutron sources would be temporarily stored in floor holes at the CMR Hot Cell Facility. Recovery reduces the neutron emissions from the source material and refers to a process by which: 1) the stainless steel cladding is removed from the neutron source material, 2) the mixture of the radioactive material (Pu-238 or Am-241) and beryllium that constitutes the neutron source material is chemically separated (recovered), and 3) the recovered Pu-238 or Am-241 is converted to an oxide form ($^{238}PuO_2$ or $^{241}AmO_2$). The proposed action would include placing the $^{238}PuO_2$ or $^{241}AmO_2$ in interim storage in a special nuclear material vault at the LANL Plutonium Facility.

Alternatives to the proposed action considered, but eliminated from further analysis in this EA, include: 1) recovery at alternate facilities at LANL, 2) recovery at other DOE facilities, 3) recovery at a commercial facility, and 4) long term storage without recovery at a DOE facility. The use of other LANL and DOE facilities were eliminated because DOE surveys indicated that these facilities could not handle the source material, or were committed to other programs, or would require considerable time and funds to bring them to an operational readiness level. The use of commercial facilities was eliminated from consideration because it was preferable that the recovery of the material be performed in a DOE facility. Long term storage without recovery was eliminated from consideration because DOE studies found that substantial time and funding would be required for planning, siting, construction (or retrofitting), and operation of an appropriate storage facility. More importantly, the personnel who would operate and monitor such a storage facility would receive 10 times the radiation exposure from the radioactive material in an unrecovered neutron source than they would receive from the same quantity of recovered material. The no-action alternative of not recovering unneeded and surplus ^{238}Pu-Be and ^{241}Am-Be neutron sources was analyzed to provide a baseline for comparison with the proposed action.

Potentially affected resources identified for the proposed action are water quality, land use for waste management, worker health effects, and air quality.

Water quality: The proposed action would generate liquid waste. It is anticipated that 1,600 gallons of liquid Low-Level Radioactive Waste (LLW) would be generated per year in addition to the 5.3 million gallons generated and treated at LANL annually.

Land use: The proposed action would require the disposal of solid LLW and transuranic (TRU) waste. It is anticipated that 4.2 cubic feet (about half a 55-gallon drum) of solid LLW would be generated by this program per year. Less than one 55 gallon drum of TRU waste would be generated over the entire 15 year lifetime of the project.

Worker health effects: The proposed action could result in radiation doses to workers on this project. Doses to individual workers are not expected to exceed 230 mrem (0.230 rem) per year.

Air quality: The proposed action would result in emission of exhaust fumes from approximately 500 miles driven per year to move neutron sources and recovered materials onsite, in addition to the 7.7 million miles driven within the LANL boundaries annually. Accidents could release some particulate Pu-238 or Am-241 to the air. Under normal operations, no radioactive emissions are expected.

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PREDECISIONAL DRAFT ENVIRONMENTAL ASSESSMENT

RADIOACTIVE SOURCE RECOVERY PROGRAM

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

1.0 PURPOSE AND NEED

1.1 Background

Within the last several years, various governmental and other agencies such as the Department of Energy, (DOE), the Nuclear Regulatory Commission (NRC), and the Conference of Radiation Control Program Directors (CRCPD) have voiced their concerns about the potential risks to the public health and safety from aging radioactive sources held by private companies, universities, and government entities. The aging of these sources, coupled with the increasing complexity of the licensing of nuclear materials has made radioactive source ownership more burdensome and costly, but source owners who want to get rid of their excess or unwanted sources have no options for doing so. This situation, potentially leading to mishandling or mismanagement of radioactive sources, causes a risk to public health and safety. If these sources are mishandled, members of the public could be exposed to radioactive emissions. If a source ruptures, members of the public could inhale or ingest radioactive material. DOE has already addressed some public health and safety concerns by reactivating a program to accept and manage plutonium-239 sealed radioactive neutron sources, and is now considering an additional program (the Radioactive Source Recovery Program) to protect public health and safety by accepting and managing other aging, unwanted, and excess radioactive sources.

Radioactive sources have been owned by the public beginning in the early 1950s. Since the passage of the Atomic Energy Act of 1954, qualified public and private organizations have been licensed to possess and use nuclear materials for a wide variety of applications. Literally tens of thousands of radioactive sources containing materials such as cobalt-60, cesium-137, americium-241 (Am-241) and plutonium-239 and -238 (Pu-239 and Pu-238) were manufactured and distributed. In most cases, the radioactive material was produced and provided by the Atomic Energy Commission (AEC). Most of these sources are still held under state and federal government possession and use licenses. In this past era of intensive radioactive source manufacture and use, future disposal mechanisms were not well-defined. Although the manufacture of radioactive sources continues today (albeit on a reduced scale), there are still no federal or commercial programs to recover or store excess or unwanted radioactive sources. In addition, unwanted radioactive sources cannot be disposed as waste because of restrictions in the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Title I of Public Law 99-240); no disposal facilities for these radioactive sources exist in the United States. The inability of owners to get rid of unwanted radioactive sources puts both economic and legal pressures on them. Owners must continue to license and manage the unwanted radioactive sources. Alternatives such as illegal storage or disposal could lead to the risks to public health and safety.

The Reorganization Act of 1974 dissolved the AEC and partitioned its responsibilities to the newly created NRC and Energy Research and Development Administration (ERDA, later DOE). NRC is responsible for licensing and regulating the use of radioactive materials in the commercial sector. DOE maintains the facilities and expertise to manage radioactive material.

In its capacity as a regulatory organization, the NRC has expressed a particular concern with regard to radioactive sealed neutron sources. Radioactive sealed neutron sources (neutron sources) are typically made from long-lived materials such as Pu-239, Am-241, or Pu-238 mixed with a low atomic weight non-radioactive material and encased in a small metal container. Typically, for the Am-241 and the Pu-238 neutron sources, the radioactive material is in the form of an oxide ($^{241}AmO_2$ or $^{238}PuO_2$) that is blended with either beryllium metal (Be) or beryllium oxide (BeO). The metal container surrounding the material blend is sealed inside an outer stainless steel jacket so that the radioactive material is protected by two layers of cladding. The shorthand notation ^{241}Am-Be or ^{238}Pu-Be refers to sources containing Am-241 or Pu-238 mixed with Be or BeO. Neutron sources can be used for many purposes, e.g., verifying compaction of materials for road and building construction, measuring rock densities for well drilling, and conducting research projects. Assuming no physical damage, the expected useful life of a sealed neutron source is approximately 20 years. This is based on the design-life of the metal cylinders and jackets and their associated welds.

Of particular concern to the NRC are those neutron sources in the well-logging industry, due to the economic downturn in the industry and the harsh physical demands of field use. These sources mostly contain ^{241}Am-Be. Also of concern are sources surplused by the shrinking of the military complex associated with the Department of Defense, mostly containing ^{238}Pu-Be. Licensees throughout the United States currently hold an estimated 1,000 ^{241}Am-Be and ^{238}Pu-Be sources that are old or no longer licensed for use.

The Atomic Energy Act of 1954, as amended, including the Reorganization Act of 1974 makes the NRC and the DOE jointly responsible for the recall or recovery, from the public domain, of nuclear material that may present a threat to public health and safety. DOE cooperates with the NRC on an as- needed basis to recover nuclear material when a potential risk was identified.

Since the 1990s, the DOE has been encountering increased costs and inefficiencies associated with a case by case response to managing unwanted sources. DOE now is evaluating a formal program to manage unwanted neutron sources containing ^{241}Am-Be and ^{238}Pu-Be beyond their emergency response basis. It is this program that is the subject of the proposed action.

1.2 Purpose and Need for Agency Action

Both public, private, and government owners have expressed the need to immediately turn over large numbers of ^{241}Am-Be and ^{238}Pu-Be neutron-emitting sealed sources to the federal government for safe management. This is because many of these sources are at or beyond the end of their useful life. DOE is the only government agency with the authority and the existing technical capability to safely manage these materials. The DOE now needs to extend its capability beyond an emergency response basis to receive and safely manage excess and unwanted ^{241}Am-Be and ^{238}Pu-Be neutron sealed sources and assure that these sources are no longer a risk to the public health and safety.

2.0 PROPOSED ACTION

The DOE considered several options for safely managing this material. These options are discussed in detail in this section. The proposed action includes receipt of neutron sources, short term storage, recovery of neutron source material, and storage of this recovered material. DOE needs to receive the neutron sources to protect the pubic health and safety. DOE needs short term storage for receipt of sufficient numbers of neutron sources to protect the public health and safety and for efficiency in recovery. DOE needs to recover the neutron source material to protect the health and safety of workers and to prepare the material for future uses consistent with DOE's missions (such as research and development and space applications). Then, DOE needs to store the recovered material until it is used.

2.1 Description of Proposed Action

The DOE proposes to establish a program to accept and recover surplus ^{241}Am-Be and ^{238}Pu-Be sealed neutron sources (hereafter referred to as neutron sources) in facilities at Los Alamos National Laboratory (LANL), located in the Southwestern part of the United States at Los Alamos, New Mexico (see Figure 1[1]). Neutron sources would be received from companies, universities, source brokers, and government agencies across the country. The current neutron source holders and brokers would ship them to LANL where their identities would be verified, their outer shells of stainless steel would be breached, and their neutron-producing source material recovered by the chemical separation of the $^{241}AmO_2$ or $^{238}PuO_2$ from the Be or BeO. Recovered material would be placed in interim storage at LANL. It is anticipated that this program would have a duration of 15 years and would involve the recovery of less that 3 kilograms (kg [6.6 lb]) of Am-241 and less than 1 kg (2.2 lb) of Pu-238.

DOE proposes this recovery process in order to reduce the neutron emissions from the material. Figure 2 shows a comparison of neutron emissions from neutron sources as compared to recovered material. As an added benefit, the amount of storage space needed for recovered Am-241 or Pu-238 nuclear material is less than that required for the same amount of material in a neutron source. Recovered Am-241 requires approximately 1/700 of the storage space as the same quantity of Am-241 contained in a neutron source (see Figure 3); recovered Pu-238 requires approximately 1/8,000 of the storage space as the same quantity of Pu-238 contained in a neutron source (see Figure 4). With recovered material, less shielding is needed to protect workers from exposure to direct radiation.

The proposed activities would take place at a number of LANL facilities and areas as shown in Figure 5. Neutron sources would be initially received at the SM-30 Shipping and Receiving area and transferred to either the Wing-9 Hot Cell Facility of the Chemical and Metallurgy Research Building (CMR) or the Plutonium Facility Building 4 (PF-4). These two recovery facilities are needed to address personnel safety issues, storage issues, and to separate the process of recovery of sources initially by material type (Pu-238 versus Am-241) and then by source neutron emission levels (high versus low). Hot cells are required to protect workers from exposure to high levels of neutron emissions from large sources and the Hot Cell Facility has abundant available short-term storage for sources; PF-4 maintains an existing capability to recover specific types of neutron sources, but does not have hot cells or adequate storage space for large numbers of sources. The smaller ^{241}Am-Be neutron sources (containing <40 Curies [Ci] of material per neutron source) could be transferred directly from SM-30 to PF-4 for recovery. All other ^{241}Am-Be and all ^{238}Pu-Be neutron sources would be transferred from SM-30 to the Wing-9 Hot Cell Facility for short-term storage or recovery. Some of the stored ^{241}Am-Be neutron sources could eventually be transferred from the Wing-9 Hot Cell Facility to PF-4 for recovery. The largest ^{241}Am-Be neutron sources and all ^{238}Pu-Be neutron sources would be recovered in the Wing-9 hot cells. All recovered Am-241 and Pu-238 would be transferred to the Special Nuclear Material (SNM) vaults at TA-55 and placed in the LANL inventory pending disposition. Figure 6 summarizes the proposed material transport and recovery plan. Support facilities needed for this program include the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF), and the TA-54, Area G Low Level Radioactive Waste (LLW) disposal and transuranic (TRU)

[1] Figures are located at the end of this document

waste storage facilities. Each of these facilities currently manages radioactive materials in compliance with DOE orders and other federal and state permit requirements.

The reasons that LANL is identified as the site of the proposed action include:

- co-located hot cells and neutron source storage areas,
- available facilities, including experienced personnel, and
- most of the neutron sources of immediate concern to the NRC are held by licensees in the southwestern U.S.

2.1.1 Facilities and Facility Preparation

Facilities that would be involved in the proposed action are listed in Table 1 below.

Table 1. Facilities that Would be Involved with Neutron Source Recovery

Facility Name	Designation	Location and TA	Operation
Receiving Facility	SM-30	South Mesa, TA-3	Receive shipped sources
Chemistry and Metallurgy Research Building	CMR	South Mesa, TA-3	Short-term storage, recovery of Pu-238 and Am-241
Plutonium Facility Building 4	PF-4	Mesita del Buey, TA-55	Recovery of Am-241, interim storage of recovered material
Nuclear Material Storage Facility	PF-41, NMSF	Mesita del Buey, TA-55	Interim storage of recovered material
Radioactive Liquid Waste Treatment Facility	RLWTF	Mesita del Buey, TA-50	Treat radioactive wastewater
Low Level Radioactive Waste Disposal Area	Area G	Mesita del Buey, TA-54	Burial area for LLW
Transuranic Waste Storage Area	Area G	Mesita del Buey, TA-54	Storage area for containers of TRU waste

Minor equipment procurement and installation would be required in CMR to accommodate the proposed action. Equipment, including liners for the hot cells (alpha boxes for contamination control), security monitors, and various radiation detectors, would be purchased from commercial vendors. Minor equipment procurement and installation would also be required at PF-4. Glove boxes would be procured

from commercial sources. All equipment would be removable and so would not constitute a modification to the Hot Cell Facility or to PF-4.

2.1.2 Shipment of Neutron Sources to LANL

Organizations with unwanted or excess neutron sources would be responsible for shipping their neutron sources to LANL. These organizations would be provided with a schedule for shipping their neutron source and detailed instructions to ensure that LANL's receiving requirements would be met. All sources should be packaged and shipped in accordance with U.S. Department of Transportation (DOT), federal, and state regulations governing the shipment of sealed radioactive materials. The neutron sources would be transported via commercial carriers to a central receiving area at LANL, SM-30. To protect the public health and safety all scheduled neutron sources would be accepted. DOE will accept ownership of the neutron source after its serial number is verified. Personnel at LANL would continue to receive emergency sources.

2.1.3 Neutron Source Receipt, Movement, and Short-Term Storage at LANL

Neutron sources would be moved in the same DOT shipping container in which they were received from SM-30 to Wing-9 of the CMR Building or to TA-55. Neutron sources received at CMR would be held in temporary storage awaiting recovery at CMR or awaiting transportation to recovery at PF-4. Transportation of neutron sources from CMR to TA-55 would take place either in DOT approved containers or via LANL standard nuclear material transportation protocols. Figure 5 shows the locations of SM-30, the CMR Building and TA-55 within the LANL site.

The combined short-term storage areas of the CMR Building and the Plutonium Facility at TA-55 could accommodate approximately 1,100 neutron sources. This provides the capacity to respond to emergency situations and to build a backlog of material for efficient batch recovery. There is adequate storage space at each facility for material from the proposed action as well as for existing inventories.

Up to 1,100 neutron sources could be received at SM-30 in the first year of this project. The Wing-9 Hot Cell Facility could accept up to 1,000 of these sources in the first year of this project; receipt in subsequent years would depend on the number of floor holes vacated as sources are recovered at CMR and at TA-55. TA-55 could accept up to 100 sources initially and additional sources as these 100 are recovered. These neutron sources would come directly from SM-30 and/or from the backlog at CMR.

At Wing 9 of the CMR Building, the ^{238}Pu-Be and the ^{241}Am-Be neutron sources would be received into the hot cell corridor and their serial numbers identified and verified either within the corridor or in a hot cell. The sources would then be transferred, using remote-manipulators whenever necessary, to a shielded container and placed in floor-hole storage in Wing 9 adjacent to the source recovery hot cells. Other holding and temporary storage areas at CMR include the hot cells and the CMR vault. Figure 7 illustrates the location of the floor-hole storage area in relation to other facilities within Wing 9. Figure 8 illustrates the configuration of a floor-hole.

At TA-55, neutron sources would be received and verified at the PF-4 Nuclear Material receipt area and temporarily placed in a working vault pending recovery. Alternatively, sources could be received at the PF-4 Nuclear Material receipt area and moved directly to the recovery line.

2.1.4 Neutron Source Recovery

Sealed neutron sources are typically small cylinders consisting of inner and outer stainless steel capsules which contain the source material. Figure 9 illustrates the basic dimensions and typical configurations of neutron sources likely to be encountered during the proposed action.

The recovery process consists of five distinct phases: decladding, dissolution, separation, precipitation, and calcination. A recovery process diagram is shown in Figure 10. Illustrated steps are summarized below.

A remotely operated decladding cutter, which is similar to a conventional pipe cutter, would be used to remove the stainless steel outer and inner capsules from the neutron source material. The declad material

would be mixed with concentrated hydrochloric acid (HCl), forming dissolved chloride compounds. Once the material dissolves, neutron emissions drop significantly. The steel capsules would then be rinsed with HCl and discarded as low level radioactive waste (LLW). The step for the separation of the Pu-238 or Am-241 from the beryllium would use an anion exchange resin column or repetitive base precipitations. This step yields two chemical streams, a Be-rich stream, and an actinide- (Pu-238 or Am-241) rich stream. The Be-rich stream would be treated with repetitive hydroxide base precipitations to remove residual Pu-238 or Am-241 until the actinide levels in the supernatant (the liquid left after precipitation) are below the established RLWTF acceptance limits for Am-241 or Pu-238 (18,500 disintegrations/second/liter or 70,000 disintegrations/second/gal). This supernatant stream, which contains water, low concentrations of the chemicals used in the recovery process, such as HCl and bases, and residual neutron source materials, including Pu-238, Am-241 and beryllium, would be discarded in the acid drain lines to the RLWTF for treatment. The precipitated residual Pu-238 or Am-241 would be calcined to a stable oxide ($^{238}PuO_2$ or $^{241}AmO_2$). The original actinide-rich stream would be precipitated and calcined to a stable oxide. The supernatant from the actinide-rich stream would also be discharged to the RLWTF.

Hot cells are required to protect workers from exposure to high neutron emissions from some sources. The CMR Hot Cell Facility would dedicate two of its sixteen hot cells to this project. The recovery process would be performed inside two interconnected hot cells protected by polymer-lined boxes that guard against contamination (alpha boxes). Hot Cell Facility design features include 0.8 m (32 in) mineral oil-filled leaded-glass windows. Additionally, the walls of the Hot Cell Facility, which are composed of reinforced concrete that includes magnetite (a natural iron oxide compound), are 0.7 m (28 in) thick. Use of the Hot Cell Facility allows personnel to remotely identify, monitor, store, and process these highly radioactive sources with little or no radiation dose.

Some ^{241}Am-Be neutron sources would be recovered in gloveboxes in PF-4. Sources that could be recovered in PF-4 would be limited to the smaller ^{241}Am-Be neutron sources because the gloveboxes do not offer the same level of shielding protection to the operator as do hot cells. Sources would be recovered at PF-4 using the same protocol as described above for CMR operations.

It is estimated that a maximum of 3,600 Ci of ^{238}Pu-Be neutron sources could be recovered in a single year at CMR. This amounts to less than 250 grams (slightly more than 0.5 lb) of $^{238}PuO_2$ powder. ^{241}Am-Be neutron sources would be recovered at CMR after ^{238}Pu-Be source recovery is completed. It is estimated that a maximum of 500 Ci ^{241}Am-Be neutron sources could be recovered in a single year at CMR. This amounts to approximately 150 g (~0.33 lb) of $^{241}AmO_2$ powder. The maximum annual recovery of $^{241}AmO_2$ powder at TA-55 is expected to be 1,000 Ci (300 g, ~0.66 lb).

It is anticipated that this fifteen-year program would involve the processing of less than 50,000 Ci of material total at both CMR and TA-55.

2.1.5 Interim Storage of Recovered Isotopes

The actinide oxides recovered from the neutron sources in the CMR Hot Cell Facility would be collected inside the processing hot cell and placed in shielded receptacles; these would subsequently be packaged according to applicable radioactive material requirements, for removal to the Plutonium Facility at TA-55. The material would be moved via truck either in a DOT-approved container or using LANL standard nuclear material transportation protocols from the CMR Building to the SNM storage vaults at the Plutonium Facility at TA-55 for interim storage. Materials recovered at PF-4 would be moved directly to the SNM storage vaults at TA-55. A maximum of 1 kg (2.2 lb) $^{238}PuO_2$ and 3 kg (6.6 lb) of $^{241}AmO_2$ would be added to the LANL inventory over the 15-year project. Material would be placed in the TA-55 inventory pending disposition. Disposition of inventory material made as part of LANL's ongoing operations would be addressed under existing NEPA analysis. New or different uses for the inventory material would be the subject of further NEPA analysis.

2.1.6 Waste Management

LANL has the infrastructure in place to process and treat all waste generated from the proposed action. Aqueous waste generated during chemical processing operations at CMR and PF-4 would be directly sent through existing waste lines to the TA-50 RLWTF for treatment. A total of 6,200 liters is expected per year as a result of this proposed action. Solid LLW and TRU waste generated during recovery operations at CMR and at PF-4 would be certified in accordance with applicable waste acceptance criteria. Solid LLW will be disposed of at TA-54, Area G. A total of less than 38 kg (84 lb) of LLW is expected per year as a result of this action. TRU waste would be held in long-term storage at TA-54, Area G. Less than one 55 gallon drum of TRU waste is expected over the entire lifetime of this proposed action. The total waste produced by the proposed project at TA-55 would not exceed that already described for the facility (DOE 1979).

2.1.7 Decontamination

This program is expected to last for 15 years. After this time, chemical equipment, glove boxes, and monitors used in the program could mostly be recycled into other programs. Alpha boxes from the Hot Cell Facility would have to be decontaminated, size-reduced and disposed of as LLW. Materials used in the decontamination process may be TRU waste.

2.2 No-Action Alternative

The no-action alternative would maintain the current level of effort and cooperation between the DOE and the NRC in the receipt of neutron sources. This typically would not go beyond receipt of neutron sources on emergency basis. Actions would be initiated to remove these sources from their licensees, or in the case of abandonment, from local governmental agencies when they are deemed to represent a potential hazard to public health and safety by the NRC. The number of removal actions and frequency of source abandonment is expected to increase as more neutron sources reach the end of their useful life and as more companies consider sources to be a liability rather than an asset.

At LANL, the no-action alternative would include the emergency receipt of neutron sources, and recovery of the ^{241}Am-Be sources that are received. Four emergency ^{241}Am-Be sources have been received at SM-30 and transferred to TA-55, where they were recovered, in the last two years. It is not anticipated under this alternative that recovery of emergency ^{238}Pu-Be sources would be performed at LANL.

This alternative does not meet the Purpose and Need requirements of protecting the public health and safety by receipt of large numbers of excess or unwanted Am-241 and Pu-238 neutron sources from private and government owners, but is being analyzed in order to form a baseline for comparison of potential actions.

2.3 Alternatives Considered but Eliminated from Detailed Analysis

2.3.1 Recovery at Alternative LANL Facilities

Although there are other hot cells at LANL (TA-48 in Building RC-1 and at TA-53), none of them can currently handle plutonium. No TRU isotopes are currently permitted in the hot cells at TA-48; these hot cells are committed to another program for the indefinite future. The hot cells at TA-53 are committed to target experiments for the foreseeable future. Additionally, current facility limitations state that plutonium is not allowed at TA-53. The Purpose and Need for receipt and management of ^{241}Am-Be and ^{238}Pu-Be neutron sources would not be met at these facilities.

New hot cells or glove boxes could be built at the Plutonium Facility at TA-55; however, the cost for construction would be prohibitive and this facility would not be available as quickly as the Hot Cell Facility in CMR Building. Additionally, without the floor-hole storage capacity of Wing 9 of the CMR Building, the projected inventory of neutron sources could not be accommodated for short-term storage. Table 2 lists criteria used to evaluate alternate LANL facilities for the neutron source recovery program.

The Purpose and Need for timely receipt of large numbers of ^{241}Am-Be sources and ^{238}Pu-Be sources would not be met by building this new facility.

Table 2. Criteria for Evaluation of Alternative LANL Facilities

Criterion	Reason	Results
Near other plutonium research and facilities equipped for plutonium activities	Close functional ties - shared equipment - shared trained personnel	Limits facilities to CMR, RC-1, and PF-4 Plutonium Facility
In limited security area	Security measures needed due to quantity of plutonium Access limited to - LANL personnel - those with prior authorization	Includes CMR, RC-1, and PF-4 Plutonium Facility
Specific laboratory qualities: - hot cells for plutonium and beryllium tests - glove boxes for other tests - operating plutonium recovery line	Worker protection - atmospheric protection - personnel monitors Availability of - storage vault - radioactive waste management	Limits available laboratory areas to: - hot cells in CMR - vaults in CMR and TA-55 - plutonium recovery line in PF-4
Gamma streaming tests performed on hot cells; and neutron streaming tests to be performed on hot cells	Reduces potential worker radiation exposure, ALARA (as low as reasonably achievable) concept	Limits available laboratory areas to hot cells in CMR

2.3.2 Recovery at Alternative DOE Sites

Other DOE facilities, such as Oak Ridge National Laboratory (ORNL) and Idaho National Engineering Laboratory (INEL) have facilities that could be used to perform the recovery of neutron sources. These facilities, however, may require a considerable investment in time and funds to bring them to an operational readiness level. A survey of DOE facilities for this purpose was conducted and documented in "Radioactive Source Recovery Program: Management Options Summary" (DOE 1995a). The results of the analysis of alternative DOE facilities are presented below.

Personnel at the Test Reactor Area (TRA) at INEL have completed a review of their facilities to determine what, if any, role they could perform in the neutron source recovery program. The analysis concluded that the facility did not have the space to provide long-term storage, but would be able to perform receipt and processing of neutron sources provided that such activity would not interfere with operations already relying on the TRA hot cell facilities. Personnel working on reactor programs at TRA are willing to support the recovery program but would restrict their participation to support activities that are in the bounds of currently approved safety documentation for the facility (INEL 1995). In addition, there is no storage space for the backlogging of large numbers of neutron sources. The Purpose and Need for timely acceptance of large numbers of neutron sources would not be met at this facility.

The Radiochemical Engineering Development Center (REDC) at ORNL is being evaluated for the feasibility of Pu-238 production. Staff from the REDC indicated that they could not recover neutron sources until the completion of Pu-238 production, potentially several years hence. Personnel at REDC may be able to recover small numbers of ^{238}Pu-Be sources in the future. The Purpose and Need for timely receipt and management of ^{241}Am-Be and ^{238}Pu-Be neutron sources would not be met at this facility.

Other DOE facilities such as Savannah River Site and Sandia National Laboratories were considered, but were dismissed as potential sites. Implementation of this project at Savannah River Site would require the re-opening of one of the processing facilities. A Savannah River Site processing facility is much larger than is required for this scale of work. This project could not be accomplished in a timely or economical fashion. Sandia National Laboratories does not have the radiochemical recovery facilities or the radiological waste management facilities needed for this program. The Purpose and Need for timely receipt and management of ^{241}Am-Be and ^{238}Pu-Be neutron sources would not be met at these facilities.

2.3.3 Recovery in Commercial Facilities

There are commercial facilities that are potentially available with capabilities to perform neutron source recovery. An example would be Amersham Corporation, a commercial manufacturer of neutron sources. However, institutional problems exist for the transfer of radioactive materials from governmental entities, such as the DOD, that have potentially large inventories of sources to be recovered, to non-governmental organizations. Additionally, it is uncertain whether these commercial facilities are capable of receiving large numbers of neutron sources (Evans, 1994). Also, the final transfer of the recovered materials to a DOE storage facility would likely entail increases in the public transportation of radioactive materials as compared to the recovery of the neutron sources by the DOE. These increases, due to additional shipments required to place the recovered materials at another facility for interim storage, would increase the risk to the public from radioactive materials transportation and would also increase worker exposure.

This alternative does not meet the Purpose and Need requirements of protecting the public health and safety by receipt of large numbers of Am-241 and Pu-238 neutron sources from both private and government owners.

2.3.4 Long-term Storage without Planned Recovery

DOE could accept and store neutron sources at DOE facilities without recovery until an appropriate disposition option has been identified.

Most DOE operational facilities currently store sealed radioactive sources, both neutron and non-neutron, incidental to the facilities' mission. However, there is no storage facility available within the DOE complex equipped to house the anticipated inventory of sources needing to be accepted from the private sector. Interim radioactive source storage would require substantial funding for planning, permitting, siting, construction (or retrofitting), and compliant operation of a storage facility. The completion of this facility would require a lengthy period of time, during which the DOE would maintain its current as-needed response capability. Once stored, the source inventory would require continual monitoring and inspection. As the sources age, there is no guarantee of capsule-weld integrity. The long-term storage of these sources would require the accommodation of the potential for failure of the capsules and contamination associated with capsule failure. There would be no recovery of the material in the neutron sources to reduce their neutron emissions, thus resulting in higher worker exposures and greater required storage space.

This alternative does not meet the Purpose and Need requirements of safe management of unwanted ^{241}Am-Be or ^{238}Pu-Be neutron sources. Radiation doses to storage facility workers would be higher than those resulting from a chemical separation and recovery alternative. This does not comply with DOE's policy to maintain doses to workers as low as reasonably achievable (ALARA).

2.4 Related and Future Actions

Plutonium and americium storage and recovery at PF-4, TA-55 was addressed in the LANL Site-Wide Environmental Impact Statement (SWEIS) (DOE, 1979).

Materials similar to those contained in the ^{238}Pu-Be and ^{241}Am-Be sources, which are currently stored in the CMR Building, could be introduced into the recovery line in order to minimize interim storage requirements, reduce associated personnel radiation doses, and to remove radioactive materials stored within the CMR Building. This action is not currently being proposed. If the DOE decides to pursue this action at a later date, it would be evaluated in future separate NEPA analysis.

Additionally, the DOE is considering an expanded radioactive source recovery program, beyond the scope of the recovery of the ^{238}Pu-Be and ^{241}Am-Be neutron sources discussed in this proposed action. This program could accommodate a larger number of ^{238}Pu and ^{241}Am neutron sources and perhaps unwanted single isotope sources, including TRU heat and power sources (Pu-238), Am-241 gamma radiation sources, and other licensed, sealed sources containing isotopes such as curium, californium, and cesium-137. Such a program may be evaluated as part of the LANL Site Wide Environmental Impact Statement (SWEIS) or other NEPA analysis, however, this action is not currently ripe for decision.

An EA is currently in process to evaluate upgrades to the CMR building. Analyses for the Radioactive Source Recovery Program are based on current facility configurations; potential future upgrades to the Wing-9 Hot Cell portion of the CMR building would not change or prejudice the environmental analysis for the Radioactive Source Recovery Program.

2.5 Background Regulatory Information

- NESHAP — CMR compliant under Federal Facilities Compliance Agreement (National Emission Standards for Hazardous Air Pollutants)
- NPDES — TA-50 RLWTF discharges under an existing NPDES permit (National Pollutant Discharge Elimination System)
- LLWPA — TA-54 must meet requirements of DOE Order 5820.2a for waste reduction, segregation, minimization, and characterization.

3.0 AFFECTED ENVIRONMENT

3.1 Regional Setting

The annual surveillance reports prepared by the LANL Environmental Protection Group in the Environment Safety and Health Division describe the LANL environment, including archaeology, geology, seismology, geographic setting, land use, hydrology, climatology, meteorology and population distribution of Los Alamos and surrounding areas (LANL 1994a). The general location of LANL within the county and New Mexico is shown in Figure 1. The sites for the proposed action are within developed areas with many similar activities and within the same ecological environment. These sites include SM-30 and CMR on South Mesa and TA-50, TA-54, and TA-55 on Mesita del Buey, as shown in Figure 5. Detailed descriptions of LANL environs, climatology, meteorology, hydrology, flood plains, wetlands, cultural resources and habitat suitable for threatened and endangered species are presented in several documents, which are incorporated by reference (DOE 1979, LANL 1990b, LANL 1994a).

3.2 Current Conditions

3.2.1 Site Description and Affected Population

LANL is a DOE facility located on 111 km^2 (43 mi^2) of land in Los Alamos County in north-central New Mexico, approximately 100 km (60 mi) north-northwest of Albuquerque. LANL is on the Pajarito Plateau, a series of mesas and canyons, at an elevation of about 2,200 m (7,200 ft) above sea level. Los Alamos has a semiarid, temperate mountain climate with about 0.45 m (18 in) of annual precipitation (LANL 1994a). Relevant information is summarized below.

Los Alamos County has an estimated population of approximately 18,115 (U.S. Census, 1990, projected to 1995); the Los Alamos town site has an estimated population of 11,400 and White Rock has an estimated population of 6,800. There is a small, privately owned residential area, Royal Crest Trailer Park, surrounded by LANL Property. Royal Crest Trailer Park is situated approximately 3.2 km (2 mi) northeast of the proposed project area and has an estimated population of 500 (Morris 1994). The principal population centers located within an 80 km (50 mi) radius of LANL are Santa Fe, Española, and the Pojoaque Valley. They have a total approximate population of 214,727 people. Fourteen pueblos and Native American reservations are located within a 80 km (50 mi) radius of LANL. The populations of the four closest pueblos are as follows: the San Ildefonso Pueblo (15 km [8 mi] to the east) has a population of 1,499; the Santa Clara Pueblo (37 km [23 mi] to the northeast) has a population of about 3,000; the Cochiti Pueblo(34 km [19 mi] to the west) has 1,342 people; and the Jemez Pueblo (43 km [27 mi] to the west) has 1,750 people (Commerce 1991). LANL employs approximately 12,250 people, (DOE 1995c) principally living within 80 km (50 mi) of LANL.

3.2.2 Air Quality

LANL and Los Alamos County are remote from major metropolitan areas and major sources of industrial pollution. In 1992, air quality at LANL was much better than ambient air quality standards set by the U.S. Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) (LANL 1994a). Information on nonradioactive air emissions is summarized in the annual Environmental Surveillance Report and the 1990 Non- Radioactive Air Emissions Inventory (LANL 1990a). Normal operations at LANL produce radioactive and nonradioactive air emissions in compliance with the Clean Air Act and the New Mexico Air Quality Control Act. An assessment of these emissions is also available in LANL Environmental Surveillance Reports (LANL 1994a).

3.2.3 Water Quality - Hydrology and Effluents

There are no naturally occurring permanent surface waters at LANL. The nearest source of permanent water is the Rio Grande, which flows through White Rock Canyon, 10.4 km (6.4 mi) to the southeast. All surface-flows within LANL originate from storm water runoff or from NPDES permitted outfalls from

LANL facilities. Intermittent flows (storm water runoff and ephemeral springs) infiltrate the alluvium of the canyon bottoms until the downward movement is impeded by less permeable tuff and volcanic sediment. This results in shallow alluvial ground-water bodies. LANL water discharges to the land surface are covered by its NPDES permit.

The main aquifer lies approximately 300 m (1,000 ft) below the surface. It is separated from alluvial and perched waters by 110 to 190 m (350 to 620 ft) of dry tuff and volcanic sediments (LANL 1994a). Water withdrawn from the main aquifer meets all current federal and state drinking water standards.

3.2.4 Waste Management

3.2.4.1 Radioactive Liquid Waste

Liquid waste containing radioactive and chemical materials is collected in the radioactive liquid waste drain lines, also called the acid or industrial waste lines, and conveyed to RLWTF at TA-50. The aqueous wastes are treated by ferric chloride precipitation (LANL 1993). Solids are filtered, dewatered, and collected in drums. The drums are moved to Area G, TA-54, for disposal as LLW. The treated effluent is discharged into Mortandad Canyon under a NPDES permit. The discharged water infiltrates surface sediments. Surface flow in this canyon is not known to have passed beyond the LANL boundary since the plant began operating in 1963 (LANL 1994a).

In 1992, the RLWTF treated about 20 million liters (5.3 million gallons) of waste water. The overall removal factor for materials dissolved and suspended in the water was 99.4 percent. For Pu-238, the removal factor was 99.97 percent; 0.000033 Ci was discharged. For Am-241, the removal factor was 87.3 percent; 0.000089 Ci was discharged (LANL 1992). Beryllium discharges were not reported. Most of the discharged radionuclides in the effluent are physically bound to the sediments in the channel (LANL 1994a).

To ensure that sediment carrying radionuclides is not carried beyond LANL boundaries during major run-off events, a series of three canyon sediment traps was installed in the early 1970s (LANL 1994a). These traps are 2.3 km (1.4 mi) upstream from the LANL boundary. In 1992, following thunderstorms in 1991 which filled the sediment traps, they were excavated to restore the original retention volumes.

3.2.4.2 Radioactive Solid Waste

LLW

LANL personnel operate an on-site radioactive disposal site at TA-54, Area G. Waste is placed in containers that are arrayed in pits that have been excavated in volcanic tuff. The present annual LLW waste disposal volume is 4,500 cubic meters (160,000 cubic feet).

TRU

Many operations at LANL generate TRU wastes. Personnel place these materials in containers such as 55-gallon drums. The containers are sealed and certified to Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (DOE 1991b). Containers are then transported to TA-54, Area G, where they are currently placed on asphalt pads in air-supported structures. The stacking array allows drums to be individually inspected and the storage areas are monitored. TRU wastes are being stored pending DOE decision to dispose at WIPP or another location. In 1994, LANL operations generated 77.2 cubic meters (386 cubic feet) of TRU waste. This amounted to a substantial decrease from the 200 cubic meters (7,080 cubic feet) generated in 1990.

3.2.5 Human Health Effects

A comprehensive explanation of exposures, doses and dose calculation methods, health effects due to radiation, and LANL's radiological program can be found in the annual environmental surveillance report (LANL 1994a). Background radiation is ionizing radiation from sources other than LANL. This background may include cosmic radiation, external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air (including radon gas) and water, and internal radiation from naturally

occurring radioactive elements in the human body. Background radiation does not include medical and dental x-rays.

Although most actinide isotopes are alpha-particle emitters, the nature of the working environment, i.e. hot cells, glove boxes, other protective enclosures, ventilation systems, and personnel protective measures, prevents internal (or "inside the body") exposure to the alpha particles. Internal exposures are extremely rare in laboratories or process areas designed to process or work with actinides. The predominant source of personnel radiation exposure in these facilities is external radiation exposure, such as X-rays, gamma rays and/or neutrons that accompany the alpha- or beta-particles emitted by the actinide isotopes. External radiation exposure is also "penetrating radiation" because, unlike alpha or beta particles, the radiation penetrates clothing and skin and reaches the internal organs, where the actual "exposure" takes place.

Exposure to penetrating radiation, routinely measured by personal dosimetry badges, is reported as the effective dose equivalent (EDE) in units of rems for the period during which the dosimeter was worn. Penetrating exposure is used in this EA as the unit of comparison for human impacts of routine and accident events for the proposed action.

Exposure to radiation may increase an individual's chance of developing fatal cancer. DOE has adopted the NRC's recommended risk conversion factors that express radiation doses in terms of risk of excess cancer fatalities. These risk factors are 400 cancer fatalities per million person-roentgen equivalent man (person-rem) for workers and 500 cancer fatalities per million person-rem for the general population (NRC 1991). The EDE to individuals in the general public, also referred to as doses, from natural background sources have been estimated in order to provide a basis of comparison with doses resulting from LANL operations. The background radiation dose to an average individual resident is 340 mrem/year in Los Alamos and 327 mrem/year in White Rock (LANL 1994a).

Members of the public living near LANL can potentially receive doses due to radioactive emissions from LANL. EPA limits doses received by members of the public through airborne releases to 10 mrem annually (EPA 1992). The DOE limits doses received by members of the public, taking all exposure pathways into consideration, to 100 mrem annually (DOE 1993). These constitute a committed effective dose equivalent (CEDE) because some radioactive material could be retained within the body. The dose is calculated as occurring entirely in the year of exposure. The calculated dose from inhalation due to LANL operations to the average resident in Los Alamos in 1992 was 0.12 mrem. The dose to a White Rock citizen was 0.11 mrem. The dose calculated for the hypothetical maximally exposed member of the public in 1992 was 6.1 mrem (LANL 1994a). The individual is located at East Gate. East Gate is located where Highway 502 crosses the eastern boundary of Los Alamos County (see Figure 1). The maximally exposed individual with respect to CMR operations is northeast of CMR is at approximately 11 km (7 mi) distant. The modeled dose at this location is 5.6×10^{-6} mrem/year (DOE 1995b). The largest source of radiation that contributed to this hypothetical dose was short-lived (less than 20 minutes) air activation products produced by Los Alamos Meson Physics Facility (LAMPF) at TA-53.

By way of comparison, cancer fatalities occur in about 20 percent of the U.S. population. These cancer fatalities are attributed to smoking, air pollution and many other factors. The dose of 6.1 mrem, calculated to be received by the maximally exposed individual due to LANL operations, would increase the risk of excess fatal cancer by 3×10^{-6} or 1 in 300,000. This fraction of an increase in fatal cancer risk to a Los Alamos resident is much smaller than the risk associated with doses from natural background radiation.

LANL protects the radiation worker under DOE Order 5480.11 ensuring that DOE facilities are operated in a manner such that the occupational radiation exposure to workers is maintained within acceptable limits, 2 rem/year, and as far below these limits as reasonably achievable (DOE 1992a). These regulations address recommendations generated by authoritative organizations, e.g., National Council on Radiation Protection and Measurements (NCRP), and International Commission on Radiological Protection (ICRP). They provide nuclear safety requirements that will, if violated, provide a basis for the assessment of civil and criminal penalty under the Price Anderson Amendments Act (PAAA) of 1988.

LANL personnel who may be exposed to radiation are included in the health physics monitoring program. Whole-body doses to all individuals working in DOE facilities are limited according to the ALARA concept and within the 2 rem/year administrative control level specified by DOE (DOE 1994). The maximum annual whole-body occupational dose is 5 rem; maximum annual dose to the extremities (hands) is 50 rem (DOE 1994). In order to further reduce occupational doses, LANL places more restrictive administrative controls on worker radiation exposure (LANL 1995). LANL administrative approval is required for whole-body doses that exceed 1.0 rem/year and annual doses to the extremities that exceed 20 rem/year. Additionally the laboratory standards supplement the LANL Radiological Control Manual by encouraging further reduction of the administrative control levels for personnel exposures during operations at LANL to below 0.5 rem/year (LANL 1994b, LANL 1995). Personnel wear appropriate anti-contamination clothing, including smocks, booties and rubber gloves as needed when working with radioactive material. Appropriate monitors will be used to measure personnel exposures. Personnel are notified of any occupational doses they receive.

3.2.6 Transportation

In 1990, government vehicles at LANL were driven approximately 12.3 million km (7.7 million mi) (LANL 1994a). The majority of these were driven on the LANL site. In addition, several roads within LANL boundaries are used by members of the public. The New Mexico Highway and Transportation Department estimated that in 1993, 293 million km (183 million mi) were driven within Los Alamos County (NM 1994). There were 287 vehicular accidents, of which 212 resulted in property damage and 75 in personal injury. There were no deaths.

3.3 Environmental Justice Considerations

Federal agencies are required to consider whether proposed actions would have a disproportionately adverse effect on minority and low income populations (EO 1994). Within a 16-km (10 mi) radius of TA-3, only 14% of the 18,115 persons are minority including Hispanics and Native Americans. The principal population centers located within an 80 km (50 mi) radius of LANL are Santa Fe, Española, and the Pojoaque Valley. These areas have an approximate total population of 214,727 people. Minority individuals account for 65 percent of the general population of 133,028 living 16 to 48 km (10 to 30 mi) from TA-3. Within 80 km (50 mi) radius of TA-3, minority individuals account for 54% of the population of 214,727. Low-income households increase sharply beyond the 16 km (10 mi) radius of the TA-3. Low income is defined as a household income of less than $15,000 in 1990. In the 16 to 49 km (10 to 30 mi) radius of TA-3, 23 percent (12,995 households) of the general population were low-income households. A total of 24 percent of the general population were below low-income households with the 80 km (50 mi) radius of TA-3.

Fourteen pueblos and Native American reservations are located within a 80 km (50 mi) radius of LANL. The populations of the four closest pueblos are as follows: the San Ildefonso pueblo has a population of 1,499; the Santa Clara pueblo has a population of about 3,000; the Cochiti pueblo has 1,342 people; and the Jemez pueblo has 1,750 people (Commerce 1991).

No disproportional adverse impacts to minority and low-income populations would be expected if DOE were to implement the proposed action.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Environmental Resources Not Affected

Because the activities encompassed by the proposed action would be performed in existing buildings, a number of environmental resources would not be affected by this action. These resources include recreational, agricultural and archaeological or cultural resources, historic sites, and the nesting/foraging habitat of migratory birds, and endangered and threatened species.

4.2 Environmental Consequences of the Proposed Action

The environmental consequences associated with the proposed action are limited to effects from storage and recovery operations and transportation. These effects include: (1) liquid effluents as byproducts of the chemical process performed to separate the TRU materials from beryllium during recovery operations, (2) solid radioactive waste from laboratory equipment and removed source capsules, (3) radiological dose and human health effects to LANL personnel, transportation crews and the general public, (4) exhaust fumes from onsite transportation of the neutron sources, and (5) potential emissions (related to accidents) of airborne TRU materials (Pu-238 and Am-241), beryllium, and acid vapors from neutron source recovery. Numerous administrative and engineering barriers to these potential effects are integrated into the proposed action to eliminate or mitigate these consequences. The following sections describe these consequences for normal operations and abnormal events potentially associated with the proposed action.

An existing capability to recover specific types of neutron sources is maintained at PF-4. This PF-4 capability has environmental protection controls comparable with the process being analyzed at CMR. The environmental consequences of plutonium and americium residue recovery for the Plutonium Facility were included in the operations analyzed in LANL SWEIS (DOE 1979). If the operation of ^{241}Am-Be source recovery and the waste streams from this activity were to be added to current operations and waste streams at TA-55, the total level of activity and waste generation for TA-55 would still be well below that analyzed for all Plutonium Facility operations in the LANL SWEIS (DOE 1979). The recovery of neutron sources proposed in this project at PF-4 would not constitute an increase in the throughput or waste generation described in this document. There would be no additional environmental effects that need to be considered as a result of the proposed ^{241}Am-Be neutron source recovery at TA-55, PF-4.

4.2.1 Waste Management Effects

The following sections describe waste management activities associated with the proposed action. These activities include liquid effluent and solid radioactive waste management.

4.2.1.1 Liquid Effluents

Aqueous LLW would drain directly from CMR and PF-4 into an industrial waste line, also known as an acid drain line. The acid drain line ties into a main line that exits from the southwest corner of the basement of the CMR Building and discharges to the RLWTF at the TA-50. It is estimated that the processing of 100 average activity ^{238}Pu-Be or ^{241}Am-Be neutron sources per year would result in an additional 6,200 liters (1,600 gallons) of aqueous LLW from the CMR Building per year. This volume represents an increase of less than 0.032 percent of the 20 million liters (5.3 million gallons) of radioactive liquid waste treated at the RLWTF at LANL annually (DOE 1995b). The small amounts of Pu-238 and Am-241 in the water discharged from the RLWTF would be expected to remain on-site in the sediment traps located in Mortandad Canyon. Discharged beryllium compounds in solution would also be treated at the RLWTF.

4.2.1.2 Solid Waste

Recovery of the neutron sources would also produce solid LLW and TRU waste. Waste containing TRU materials with half lives greater than 20 years and a specific activity of less than 100 nCi/gm from

alpha particle emission is defined as LLW. However, TRU waste contains TRU materials with half lives greater than 20 years and greater than 100 nCi/gm from alpha particle emission at the time of assay. LLW waste would typically be composed of laboratory equipment, such as plastic, glass, lead-lined gloves, and process residuals, including stainless steel and tantalum source capsules. TRU waste would be expected to be limited to hydroxide cake residues from precipitation reactions containing residual amounts of Pu-238 and Am-241 and used high-efficiency-particulate air (HEPA) filters. LANL collects, stores, processes and disposes of routinely generated solid wastes under established procedures in compliance with all applicable laws and regulations. LLW produced at LANL is disposed of at TA-54, Area G; TRU waste produced at LANL is held at TA-54 Area G, pending DOE decision to dispose of at WIPP or another location.

Estimates of the amounts of solid LLW resulting from the processing of 100 average activity ^{238}Pu-Be and/or ^{241}Am-Be neutron sources per year based on similar LANL operations are shown in Table 3. Total LLW waste generated corresponds to 0.12 cubic meters (4.2 cubic feet) per year. It is anticipated that less than one drum of TRU waste would be generated during the entire proposed action.

Table 3. Solid Waste Estimates

Waste Material	Generation Rate Per 100 Average Sources Per Year (kg/year)
Metal	25
Plastic	4.3
Glass	8.7
Total	38 (0.12 cubic meters per year)

4.2.2 Routine Radiological Effects

The radiological effects from routine operations and transportation associated with the proposed action could include radiation doses to LANL personnel and transportation crew.

Dose contributions resulting from the receipt, unpacking, and interim storage of neutron sources are considered to be extremely small. Receipt of each source would be performed within the hot cell corridor with the capability of remote operations. Loading into the floor holes for interim storage would be performed using a shielded floor hole loading container. The two layers of cladding around the source material makes an accident where the cladding is ruptured extremely unlikely.

No mechanisms were identified for inhalation or ingestion of radioactive materials during routine operations associated with the recovery of neutron sources. An estimate of the collective worker population whole-body dose to Hot Cell Facility operators during receiving, interim storage, transfer, recovery, and waste management activities is 2.3 mrem per average neutron source recovered. This dose rate corresponds to an annual dose of 230 mrem/year, which is less than one half of the LANL annual administrative limit for radiation workers and is comparable to the 12-year average group whole-body dose (calculated from 1982 to 1993) of 225 mrem/year for the Wing 9 Hot Cell Facility. This estimate is based upon experience with related source recovery operations using glove box isolation in LANL facilities and dose reduction factors from the shielding provided by separation distance and leaded-glass windows, available during shielded and remote operations in the Hot Cell Facility. Doses to workers in PF-4 associated with this project would not exceed limits of 5 rem per year established by DOE (DOE 1994). As with all operations at LANL, radiation doses are limited by administrative controls and an effective ALARA program that includes anti-contamination clothing and constant monitoring of worker

radiation exposure. Other workers in Wing 9 or adjacent facilities in the CMR Building are not predicted to receive doses from the recovery of neutron sources in the Hot Cell Facility. Workers on the neutron source recovery project may work on other projects and may receive doses from other projects.

Dose contributions resulting from the transportation of solid LLW from the CMR Building to TA-54, Area G for disposal are considered to be extremely small. The transportation of TRU waste as part of waste management activities on site at LANL have been previously evaluated (Rhyne 1994). Because all TRU waste transported over onsite roads at LANL must meet the same requirements as ongoing waste management activities, the previous analyses are applicable to this assessment. Current work practices for the transportation of TRU waste on site at LANL are described below. Waste drums are carried by forklift outside of the building and placed on a flatbed trailer. The waste drums are then moved to TA-54, Area G while the roads along the route are temporarily closed. The waste drums are then delivered for interim storage. Radiation to the general public and other LANL employees is eliminated by the road closure. The transportation crew's doses are also expected to be extremely small due to: (1) the short duration of the transfer, (2) the limited amount of TRU materials present in the waste, (3) shielding provided by separation distance from the waste drums, self-shielding and shields placed around the waste drums as needed to limit doses from higher activity waste drums and (4) the fact that less than one drum of TRU waste is generated during the entire proposed action.

4.2.3 Transportation

Exhaust fumes would result from the transportation of the neutron sources, recovered materials, and wastes among SM-30, the CMR Building, PF-4, and the waste management areas at TA-54. The contribution of the additional exhaust fumes resulting from the proposed action as compared to that produced from other transportation activities throughout the country, New Mexico and Los Alamos County would be extremely small. This project would increase onsite transportation by approximately 500 mi/ year (800 km/ year).

4.2.4 Air Emissions

Wing 9 of the CMR Building is equipped with an atmospheric protection system which employs a HEPA filter bank. As previously described, the recovery of the neutron sources would be performed remotely within alpha boxes in the Hot Cell Facility, which are also equipped with a HEPA filters. In addition to the two sets of HEPA filters, there is a pre-filter at the stack through which the Hot Cell Facility and general Wing 9 exhaust air flows. The HEPA filters have an efficiency rating of 99.97 percent for particles greater than 0.3 mm in diameter and the pre-filter has an efficiency of approximately 65 percent.

Under normal conditions, no airborne emission of Pu-238 and Am-241 particulates resulting from recovery operations in the Hot Cell Facility are expected. The removal of the neutron source outer capsules would be performed within the Hot Cell Facility using a remotely operated pipe cutting tool. This procedure does not result in the generation of metal shavings or fines as would a rotating saw. Additionally, the source matrix is typically a solid ceramic material that would not generate particulates unless crushed or energetically deformed. Given that many of the sources to be recovered are 20 or more years old and have been used under a variety of conditions, the solid form of the source material cannot be guaranteed and some of the source material may be in the form of a powder in the inner capsule. However, if this powder were to become airborne during cutting or through normal movement of the source prior to dissolution in the acid bath, it is unlikely that it would result in a measurable airborne concentration. Airborne Pu-238 and Am-241 emissions from TA-3, measured in 1992, were each less than 0.1 percent of the DOE derived air concentration guidelines (DCG) limit (LANL 1994a). Given the multiple air filtration systems in the Hot Cell Facility and Wing 9, the proposed action, under normal operating conditions, would not produce a measurable increase in the airborne Pu-238 and Am-241 emissions to the environment.

No non-radioactive airborne emissions resulting from recovery operations in the Hot Cell Facility are expected. Other than $^{238}PuO_2$ and $^{241}AmO_2$, the primary constituent of the neutron source material is either beryllium (Be) or beryllium oxide (BeO). As with the radioactive materials described above, it is unlikely that Be or BeO would become airborne during recovery operations. However, if this does occur, this material would be stopped by the multiple filters in the Hot Cell Facility and Wing 9 air systems. Source tests of similar neutron source recovery operations in the Plutonium Facility at TA-55 have resulted in no detectable beryllium air emissions. Beryllium would not be machined as a part of the proposed action; no beryllium permit would be needed.

There is also a potential that acid vapors may be produced during the dissolution of the neutron source material. These vapors would be neutralized by passing them through a base bubbler. No measurable acid vapors would be released to the environment.

Radioactive and nonradioactive air emissions from PF-4 would not exceed those already evaluated (DOE 1979).

4.2.5 Accidents

This section describes the potential consequences of accidents that could occur during the proposed action. These accidents include abnormal events that may occur during chemical processing, as a result of natural phenomena events and transportation.

4.2.5.1 Accidents Identified but Dismissed

The potential of a criticality accident was considered, but was dismissed. Material quantities handled will be well below criticality limits. In addition, Pu-238 is incapable of becoming critical.

Also, the potential release of radioactive materials during an onsite transportation accident involving neutron sources was dismissed. Sources are doubly clad in stainless steel and would be shipped on-site either in a DOT approved shipping container or via road closure minimizing the potential of an accident severe enough to cause a release. Likewise, the potential release of radioactive materials due to an accident during neutron source receipt and interim storage was dismissed. The likelihood of a handling accident severe enough to rupture two layers of stainless steel cladding to expose the radioactive material is slight.

Consequences of an accident involving Am-241 in PF-4 would be bounded by a comparable accident involving Pu-238 in the CMR Building because Pu-238 is the more radiotoxic material.

Dose contributions resulting from accidents associated with the transportation of solid LLW from the CMR Building or PF-4 to TA-54, Area G for disposal are considered extremely small. The assessment of accidents resulting from the transportation of TRU waste at LANL was based on previous evaluations (Rhyne 1994). This evaluation included numerous potential accident scenarios that would result in the release of TRU waste materials into the environment. An assessment of the annual frequency of these postulated accidents during road closure transfer of TRU waste to TA-54, Area G indicated that none had a frequency of occurrence greater than one in one million. Therefore, none were seen as credible events. If one of the postulated accidents were to occur, the resulting EDE to the maximally exposed member of the public would be below 0.5 rem (Rhyne 1994).

4.2.5.2 Accidents Analyzed

The consequences associated with potential accidents during neutron source recovery within the Hot Cell Facility were evaluated. The potential accidents identified ranged from a spill of source material as a powder during decladding to a hydrogen explosion resulting from the ignition of gases evolved during dissolution. Each scenario was evaluated and the resulting doses to a co-located worker and the nearest member of the public were calculated. A co-located worker is presumed to be within the Hot Cell Facility; the nearest member of the public is presumed to be located at the fence boundary of the CMR building. Totavi is located approximately 9 miles east of the CMR building on Highway 502. The assumptions and methodology used in these calculations, as well as the results for all potential accident scenarios, are

documented in Appendix A. Based on dose, the bounding event was an exothermic reaction causing a fire in an ion exchange resin column. The maximum doses and Latent Cancer Fatality (LCF) associated with this accident scenario are shown in Table 4. The involved worker receives no dose because the hot cell remains intact. The doses associated with the release of Am-241 are not listed because they are bounded by the Pu-238 doses due to its higher radiotoxicity.

Table 4. Radiological Consequences of the Bounding Source Recovery Accident While Processing a ^{238}Pu-Be Neutron Source

Receptor	Dose (rem)	Risk (latent cancer fatalities)
Involved Worker	none	none
Co-located Worker	0.013	7.6×10^{-5}; 1 in 13,000
Nearest Member of the Public	0.011	6.4×10^{-5}; 1 in 15,000

The consequences of accidents initiated by potential natural phenomena during neutron source recovery operations in the Hot Cell Facility were examined. The results indicated that the only natural phenomena event capable of initiating accidents within the Hot Cell Facility was a seismic event (Coats and Murray 1984). Wing 9 of the CMR Building was constructed in 1959 according to the 1960 Uniform Building Codes for Seismic Zone II and would be expected to maintain structural integrity in an earthquake with a peak horizontal acceleration of 0.2g or less. Earthquakes with higher peak ground accelerations may cause severe structural damage, up to and including building collapse.

Two accident scenarios initiated by seismic events were analyzed. The first was an earthquake with peak ground acceleration below design-basis. This seismic event was postulated to cause suspension of recovered $^{238}PuO_2$ or $^{241}AmO_2$ powder with release into the environment via the Wing 9 ventilation system due to vibration of an open storage container in the Hot Cell Facility. The second was a beyond design-basis earthquake that resulted in the collapse of Wing 9 and the CMR Building. The individual hot cells within the Hot Cell Facility are designed to fall intact into the basement of Wing 9 during this type of seismic event. However, for this analysis, it was conservatively assumed that the hot cells did not survive intact after collapsing into the basement and that all available radioactive materials were subject to resuspension and release into the environment. The annual probability of an earthquake with peak ground accelerations of 0.2g or higher at LANL is 0.0014 (Coats and Murray 1984).

The results of the analyses performed for both of these scenarios are presented in Tables 5 and 6, respectively. The beyond design-basis seismic event scenario presents data for a one hour, ground level release of radioactive material. As before, the bounding doses and LCF are represented by releases of Pu-238; therefore, values for Am-241 are not shown. For the earthquake with peak ground acceleration below design basis, the hot cells remain intact and the involved worker would receive no dose. For the earthquake with peak ground acceleration beyond design basis, the involved worker and any other workers in CMR would be killed in the building collapse. The nearest co-located worker to survive would be outside CMR and would receive the same dose as the nearest member of the public. Consequences for the beyond design-basis earthquake are also reported for receptors at San Ildefonso/Totavi and the Los Alamos townsite.

4.4 Cumulative Impacts

Cumulative impacts to the environment are those from the proposed action added to those already occurring because of operations taking place at LANL. The no-action alternative would not increase environmental impacts at or near LANL above those associated with LANL operations.

The proposed action would produce radioactive liquid effluents, solid wastes, some radioactive exposure to involved workers, and some increase in onsite transportation. The annual expected effects, compared with those from LANL operations, are summarized in Table 7. The impacts from the proposed action would occur annually, over the 15-year life of the project.

Table 7. Cumulative Impacts from the Proposed Action and Ongoing LANL Operations (Annual)

Factor	Proposed Action	LANL Operations[a]	Cumulative Impacts
Radioactive Liquid Effluents	6,200 liters	20 million liters	20 million liters
Solid LLW	0.12 cubic meter	4,500 cubic meters	4,500 cubic meters
TRU Waste	0.03 cubic meter	77[b] to 200[c] cubic meters	77 cubic meters
Worker dose (Hot Cell Facility)	230 mrem	225 mrem[d]	≤2,000 mrem[e]
Transportation	500 miles	7.7 million miles	7.7. million miles

[a]For 1992 (outflow characteristics). (LANL 1994a)
[b]1994 waste management data
[c]LANL 1991
[d]Average for Hot Cell Facility workers 1982-1993
[e]Administrative control limit

5.0 AGENCIES AND PERSONS CONTACTED

No agencies external to DOE were contacted in preparing this EA.

6.0 REFERENCES

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7.0 GLOSSARY, ABBREVIATIONS, ACRONYMS AND LIST OF TERMS

Glossary

Actinide: Any of a series of chemically similar, mostly radioactive elements with atomic numbers ranging from 89 (actinium) through 103 (lawrencium). In this document, used to mean either Pu-238 or Am-241.

Alpha Box: a steel liner placed into a hot cell to protect the hot cell from contamination.

As low as reasonably achievable (ALARA): An approach to radiological control to manage and control doses (individual and collective) received by the work force and the general public at levels as low as is reasonable, taking into account social technical, economic, practical and public considerations. As normally used in this document, ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable.

Background radiation: Radiation arising from radioactive material naturally occurring in the environment and from cosmic rays.

Calcination: A chemical process in which a substance is heated to a high temperature below its melting point causing oxidation.

Committed Dose Equivalent: The dose equivalent to organs or tissues of reference that would be received from an intake of radioactive material by a person during the 50-year period following the intake.

Committed Effective Dose Equivalent: The sum of the products of the weighting factors applicable to each of the organs of the body or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Curie: A unit of radioactivity, equal to 3.7×10^{10} disintegrations per second.

Dose: The amount of energy deposited in body tissue due to exposure to ionizing radiation.

Dose Equivalent: Some types of radiation, such as neutron and alpha, deposit their energy more densely in affected tissue than gamma radiation and, thereby, cause more damage to tissue. The term dose equivalent is used to take into account this difference in tissue damage and is defined as the product of the absorbed dose in tissue, a quality factor, and all other necessary modifying factors at the location of interest.

Effective Dose Equivalent: The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

Gamma radiation: Short wavelength electromagnetic radiation of nuclear origin with a range of wave lengths from about 10^{-8} to 10^{-11} centimeters, emitted from the nucleus of the atom.

Low Level Waste: LLW is solid waste that is not classified as high-level waste, transuranic (TRU) waste, or spent nuclear fuel as defined in DOE order 5820.2 (Radioactive Waste Management). LLW has a curie content greater than or equal to 10 nanocuries/gram.

mrem: milli-rem; 1000 mrem equals 1 rem.

Neutron source: A sealed radioactive source which predominantly produces neutron radiation.

Oxidation: The chemical combination of a substance with oxygen.

Precipitation: A chemical process that causes a solid substance to be separated from a solution.

Radiation: The emission and propagation of energy through space or through a material in the form of waves; for instance, the emission and propagation of electromagnetic waves.

Rem: The amount of ionizing radiation required to produce the same biological effect as one roentgen of high-penetration x-ray; a unit of dose equivalent for a single individual, used in the field of radiation dosimetry.

Roentgen: a unit of radiation exposure equal to the quantity of ionizing radiation that will produce one electrostatic unit of electricity in a cubic centimeter of dry air at zero degrees centigrade and standard atmosphere pressure.

Roentgen Equivalent Man: Rem

Special Nuclear Materials: Plutonium, uranium-233, uranium enriched in uranium-233 or in uranium-235, or any material artificially enriched in any of the foregoing (but does not include source material) and any other material that, pursuant to the provisions of Section 51 of the Atomic Energy Act of 1954, as amended, has been determined to be special nuclear material.

TRU: Transuranic - those elements with higher atomic numbers than uranium

TRU Waste: Radioactive waste that contains more than 100 nanocuries/gram of alpha emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years. (Except for U-233 and naturally occurring uranium)

Abbreviations and Acronyms

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ALO	DOE Albuquerque Operations Office
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
CMR	Chemistry and Metallurgy Research (Building), Los Alamos National Laboratory
CRCPD	Conference of Radiation Control Program Directors
DCG	derived air concentration guidelines
DOE	United States Department of Energy
DOT	United States Department of Transportation
DP	DOE Office of Defense Programs
EA	Environmental Assessment
EDE	effective dose equivalent
EO	Executive Order
EPA	United States Environmental Protection Agency
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilation and air conditioning
ICRP	International Council on Radiation Protection

INEL	Idaho National Engineering Laboratory
LAAO	DOE Los Alamos Area Office
LAMPF	Clinton P. Anderson Meson Physics Facility (Los Alamos Meson Physics Facility)
LANL	Los Alamos National Laboratory
LCF	Latent Cancer Fatality
LLW	low-level radioactive waste
MEI	maximally exposed individual
mrem	millirem (1000 mrem = 1 rem)
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMED	New Mexico Environment Division
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PAAA	Price Anderson Amendments Act
PF-4	Plutonium Facility Building 4
REDC	Radiochemical Engineering Development Center, Oak Ridge National Laboratory
rem	roentgen equivalent man
RLWTF	Radioactive Liquid Waste Treatment Facility, Los Alamos National Laboratory
RSRP	Radioactive Source Recovery Program
SNM	special nuclear materials
SWEIS	Site-Wide Environmental Impact Statement
TA	Technical Area
TRA	Test Reactor Area, Idaho National Engineering Laboratory
TRU	transuranic

Chemical Compounds and Radionuclides

Pu-238	plutonium-238
^{238}Pu-Be	plutonium-238 beryllium
$^{238}PuO_2$	plutonium-238 oxide
Am-241	americium-241
^{241}Am-Be	americium-241 beryllium
$^{241}AmO_2$	americium-241 oxide
BeO	beryllium oxide
HCl	hydrochloric acid

Unit Abbreviations

Ci	curie
ft	foot
g	gravity, unit equaling the acceleration of gravity
gm	gram
hr	hour
in	inch
L	liter
m	meter
mi	mile
rem	roentgen equivalent man

System of International Prefixes

Exponent	Prefix	Symbol
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n

Nomenclature

Some numbers are expressed in an exponential shorthand as follows: 5.2E-03 represents 5.2×10^{-3}, which can also be written as 0.0052

APPENDIX A

SOURCE TERM CALCULATIONS

A.1 INTRODUCTION

The following section provides a detailed description of the source terms developed for the non-transportation accident scenarios postulated for the Radioactive Source Recovery Program. The transportation-based accident scenarios are described in Appendix B. The accident scenarios evaluated varied from accidents associated with the recovery of ^{238}PuBe and ^{241}AmBe neutron source material to accidents initiated by seismic events. Once the source term was determined for each scenario, radiological doses to personnel and the general public were calculated.

A.2 SOURCE TERM CALCULATIONS

The scenarios chosen for analysis were determined by evaluation of the proposed action and the activities necessary for its completion. Several scenarios were identified which could potentially cause the release of radioactive materials outside the controlled environment of the Hot Cell Facility planned for use in the proposed action. Each of these scenarios were evaluated by assessing the radioactive material available via the inhalation pathway. The airborne source term is calculated by using the following formula as recommended by the DOE handbook for airborne release fractions/rates and respirable fractions for nonreactor nuclear facilities (DOE 1994).

$$\text{Source Term} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF}$$

where:

MAR	=	Material-at-Risk
DR	=	Damage Ratio
ARF	=	Airborne Release Fraction (or Airborne Release Rate [ARR] for continuous release)
RF	=	Respirable Fraction, and
LF	=	Leakpath Factor.

The MAR is the amount of radionuclides (in grams or curies of activity) available to be acted upon by a given physical stress. In the case of the proposed action, MAR represents the maximum quantity of ^{238}Pu or ^{241}Am available for each accident scenario. This amount varies dependent upon the conditions of each scenario. The DR is the fraction of the MAR actually impacted by the accident-generated conditions. In the accident scenarios evaluated for the proposed action, the DR is conservatively assumed to be 1, e.g. all the MAR is acted upon and available during the accident. The ARF is the coefficient used to estimate the amount of radioactive material suspended in air as an aerosol and thus available for transport. In the case of ARR, this is a rate release. The ARFs and ARRs, if applicable, vary for each scenario depending upon the physical form of the MAR and the conditions during the accident. The RF represents the fraction of airborne radionuclides as particles that can be transported through air and inhaled into the human respiratory system. As with the ARFs, the RFs vary for each scenario depending upon the physical form of the MAR and the conditions during the accident. The ARF and RF fractions used for these calculations were determined by the recommended values from the DOE handbook (DOE 1994). The LF is the fraction of radionuclides in the aerosol transported

through some confinement layer or otherwise reduced by other filtration mechanisms. The LF used for all the accidents evaluated for the proposed action, excluding the beyond design-basis seismic event, was 0.001. This LF represents the one stage high-efficiency particulate air filters (HEPA) at the Wing 9 stack. The Hot Cell Facility HEPA filter bank was ignored for these calculations in order to provide conservatively bounding airborne source terms. The LF for the beyond design-basis seismic event was 1.0 representing the assumption that no HEPA filtration was available due to collapse of the Wing 9 Hot Cell Facility and its surrounding structure.

The basic assumptions regarding the determination of these factors for each of the accident scenarios evaluated are listed below.

Maximum single source size	30 gm ^{238}Pu
Average source size	1 gm ^{238}Pu
Maximum number of sources in storage	1000
Maximum number sources recovered per year	100
Maximum amount of activity in the hot cell at any given time	200 gm ^{238}Pu or ^{241}Am
Average particle size (Activity Median Aerodynamic Diameter [AMAD])	1 µm
Lung Retention Class ($^{238}PuO_2$, $^{241}AmO_2$)	Y

The AMAD used in these calculations was assumed to be 1 µm due to the lack of definitive information regarding the condition of the sources likely to be encountered during the proposed action. This assumption represents a conservative approximation. Because the sources were predominately manufactured as oxide ceramics, it is unlikely that many of the neutron sources would contain powder.

The following are summaries of the determination of the source term for each scenario evaluated. The individual source term components are shown along with the total source term calculated.

Scenario 1: Spill of Radioactive Material in Hot Cell During Source Decladding

Material at Risk (MAR) =		30 gm ^{238}Pu or ^{241}Am (maximum)
Damage Ratio (DR) =		1.0 Assumption
Airborne Release Fraction (ARF) =		0.002 (DOE 1994, p. 4-9)
Respirable Fraction (RF) =		0.3 (DOE 1994, p. 4-9)
Leakpath Factor (LF) =	0.001	One Stage HEPA Filters at Stack

Source Term = MAR*DR*ARF*RF*LF = 1.8E-05 gm ^{238}Pu or ^{241}Am (maximum)

Scenario 2: **Spill of Recovered Radioactive Inventory in Hot Cell Before Shipment to the SNM Vault at TA-55**

Material at Risk (MAR) =	200 gm ^{238}Pu or ^{241}Am (maximum)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Fraction (ARF) =	0.002	(DOE 1994, p. 4-9)
Respirable Fraction (RF) =	0.3	(DOE 1994, p. 4-9)
Leakpath Factor (LF) =	0.001	One Stage HEPA Filters at Stack

Source Term = MAR*DR*ARF*RF*LF = 1.2E-04 gm ^{238}Pu or ^{241}Am (maximum)

Scenario 3: **Venting of Radioactive Material in Hot Cell During Source Decladding Due to Pressurized Source Capsule**

Material at Risk (MAR) =	30 gm ^{238}Pu or ^{241}Am (maximum)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Fraction (ARF) =	0.005	(DOE 1994, p. 4-8)
Respirable Fraction (RF) =	0.4	(DOE 1994, p. 4-8)
Leakpath Factor (LF) =	0.001	One Stage HEPA Filters at Stack

Source Term = MAR*DR*ARF*RF*LF = 6.0E-05 gm ^{238}Pu or ^{241}Am (maximum)

Scenario 4: **Suspension of Recovered Radioactive Inventory in Hot Cell Due to Vibration Resulting from a Below Design-Basis Seismic Event**

Material at Risk (MAR) =	200 gm ^{238}Pu or ^{241}Am (maximum)	
Damage Ratio (DR) =	1.0	(DOE 1994, p. 4-9)
Airborne Release Fraction (ARF) =	0.001	(DOE 1994, p. 4-9)
Respirable Fraction (RF) =	0.1	(DOE 1994, p. 4-9)
Leakpath Factor (LF) =	0.001	One Stage HEPA Filters at Stack

Source Term = MAR*DR*ARF*RF*LF = 2.0E-05 gm ^{238}Pu or ^{241}Am (maximum)

Scenario 5: **Aerodynamic Entrainment and Resuspension of Radioactive Material from Structural Collapse of the CMR Building Resulting from a Beyond Design-Basis Seismic Event**

Material at Risk (MAR) =	200 gm ^{238}Pu or ^{241}Am (maximum)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Rate (ARR) =	4.0E-06	(DOE 1994, p. 4-10)
Respirable Fraction (RF) =	1.0	(DOE 1994, p. 4-10)
Leakpath Factor (LF) =	1.0	No HEPA Filters

Source Term = MAR*DR*ARF*RF*LF = 8.0E-04 gm/hr ^{238}Pu or ^{241}Am (maximum)

Scenario 6: Potential Processing Accidents in the Hot Cell

Scenario 6a: Oxide dissolution - liquid spill

Material at Risk (MAR) =	30 gm ^{238}Pu or ^{241}Am (max single source)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Rate (ARR) =	2.0E-05	(DOE 1994, p. 7-15)[1]
Respirable Fraction (RF) =	1.0	(DOE 1994, p. 7-15)[1]
Leakpath Factor (LF) =	0.001	One stage HEPA Filters at stack

Source Term = MAR*DR*ARF*RF*LF = 6.0E-07 gm ^{238}Pu or ^{241}Am (maximum)

[1] free fall spill of a heavy metal solution

Scenario 6b: Oxide dissolution - boiling liquid

Material at Risk (MAR) =	30 gm ^{238}Pu or ^{241}Am (max single source)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Rate (ARR) =	2.0E-03	(DOE 1994, p. 7-16)[2]
Respirable Fraction (RF) =	1.0	(DOE 1994, p. 7-16)[2]
Leakpath Factor (LF) =	0.001	One stage HEPA Filters at stack

Source Term = MAR*DR*ARF*RF*LF = 6.0E-05 gm ^{238}Pu or ^{241}Am (maximum)

[2] continuous boiling liquid

Scenario 6c: Residue dissolution - dissolver eructation

Material at Risk (MAR) =	30 gm ^{238}Pu or ^{241}Am (max single source)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Rate (ARR) =	5.0E-05	(DOE 1994, p. 7-20)[3]
Respirable Fraction (RF) =	0.8	(DOE 1994, p. 7-20)[3]
Leakpath Factor (LF) =	0.001	One stage HEPA Filters at stack

Source Term = MAR*DR*ARF*RF*LF = 1.2E-06 gm ^{238}Pu or ^{241}Am (maximum)

[3] depressurization of liquid containment

Scenario 6d: Metal dissolution - liquid spray

Material at Risk (MAR) = 30 gm ^{238}Pu or ^{241}Am (max single source)
Damage Ratio (DR) = 1.0 Assumption
Airborne Release Rate (ARR) = 1.0E-04 (DOE 1994, p. 7-22)[4]
Respirable Fraction (RF) = 1.0 (DOE 1994, p. 7-22)[4]
Leakpath Factor (LF) = 0.001 One stage HEPA Filters at stack

Source Term = MAR*DR*ARF*RF*LF = 3.0E-06 gm ^{238}Pu or ^{241}Am (maximum)

[4] liquid spray through commercial nozzles

Scenario 6e: Metal dissolution - hydrogen explosion

Material in Dissolver

Material at Risk (MAR) = 30 gm ^{238}Pu or ^{241}Am (max single source)
Damage Ratio (DR) = 1.0 Assumption
Airborne Release Rate (ARR) = 4.0E-04 (DOE 1994, p. 7-24)[5]
Respirable Fraction (RF) = 1.0 (DOE 1994, p. 7-24)[5]
Leakpath Factor (LF) = 0.001 One stage HEPA Filters at stack

Dissolver inventory:

Source Term = MAR*DR*ARF*RF*LF = 1.2E-05 gm ^{238}Pu or ^{241}Am (maximum)

Recovered material stored in cell

Material at Risk (MAR) = 170 gm ^{238}Pu or ^{241}Am (max storage)
Damage Ratio (DR) = 1.0 Assumption
Airborne Release Rate (ARR) = 5.0E-03 (DOE 1994, p. 4-8)[6]
Respirable Fraction (RF) = 0.3 (DOE 1994, p. 4-8)[6]
Leakpath Factor (LF) = 0.001 One stage HEPA Filters at stack

Recovered material inventory:

Source Term = MAR*DR*ARF*RF*LF = 2.6E-04 gm ^{238}Pu or ^{241}Am (maximum)

Total Source Term = Dissolver + Stored = 2.7E-04 gm ^{238}Pu or ^{241}Am (maximum)

[5] detonation in dissolver chamber
[6] blast effects

Scenario 6f: Ion Exchange - resin exothermic reaction

Material at Risk (MAR) =	45 gm ^{238}Pu or ^{241}Am[7]	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Rate (ARR) =	1.0E-02	(DOE 1994, p. 7-42)[8]
Respirable Fraction (RF) =	1.0	(DOE 1994, p. 7-42)[8]
Leakpath Factor (LF) =	0.001	One stage HEPA Filters at stack

Source Term = MAR*DR*ARF*RF*LF = 4.5E-04 gm ^{238}Pu or ^{241}Am (maximum)

[7] maximum single source plus 10% residue from previous five batches
[8] burning resin

Scenario 6g: calcination - large room fire spread to hot cell

Material at Risk (MAR) =	200 gm ^{238}Pu or ^{241}Am (max recovered and stored in cell)	
Damage Ratio (DR) =	1.0	Assumption
Airborne Release Rate (ARR) =	6.0E-03	(DOE 1994, p. 7-50)[9]
Respirable Fraction (RF) =	0.01	(DOE 1994, p. 7-50)[9]
Leakpath Factor (LF) =	0.001	One stage HEPA Filters at stack

Source Term = MAR*DR*ARF*RF*LF = 1.2E-05 gm ^{238}Pu or ^{241}Am (maximum)

[9] heating of oxide powders

A.3 DOSE CALCULATIONS

The source terms calculated for each accident scenario were used to determine the worst-case dose consequences to various receptors. Several computer codes were employed to complete the dose calculations. For puff releases (instantaneous releases from the Wing 9 exhaust stack), excluding the Los Alamos population runs, the PUFF86 computer code was used. For ground releases, excluding the Los Alamos population runs, the HOTSPOT7 computer code was used. The source term for Scenario 5, the beyond design-basis seismic event, was assumed to be released at ground level due to the collapse of the CMR Building. For the Los Alamos population runs, the GENII-S computer code was used. Population data for 1993 was used in these calculations. The receptors were an occupational worker, a person outside the fence of the CMR Building, the nearest member of the public, and the maximally exposed individual (MEI). Because of the layout of the CMR Building, the occupational worker and a person outside the CMR Building fence were assumed to be at the same location. The doses calculated were limited to those associated with the release of ^{238}Pu because they represented the bounding doses based on higher radiotoxicity as compared to ^{241}Am. Additional assumptions used in these calculations are listed below.

- The ^{238}Pu specific activity: 17.3 Ci/g
- Meteorological:
  - Wind speed: 2 m/s
  - Stability class: D
  - Wind direction: down wind
- Emission parameters:
  - Stack height: 21.5 m (excluding Scenario 5)

Stack diameter	1.63 m (excluding Scenario 5)
Release duration	instantaneous (excluding Scenario 5)

The results of the dose calculations for each scenario are summarized below.

Scenario	Receptor	Distance (m)	Dose (rem)	Calculation Type
1	Occupational Worker/fence line[10]	650	5.1E-3	Puff release
	Nearest member of the public[11]	993	4.3E-3	Puff release
	MEI[12]	6430	3.8E-4	Puff release
2	Occupational Worker/fence line	650	3.5E-2	Puff release
	Nearest member of the public	993	2.9E-2	Puff release
	MEI	6430	2.6E-3	Puff release
3	Occupational Worker/fence line	650	1.8E-2	Puff release
	Nearest member of the public	993	1.5E-2	Puff release
	MEI	6430	1.4E-3	Puff release
4	Occupational Worker/fence line	650	5.8E-3	Puff release
	Nearest member of the public	993	4.9E-3	Puff release
	MEI	6430	4.3E-4	Puff release
5	Occupational Worker/fence line	< 100[13]	> 4.6[14]	1 hr ground release
	Nearest member of the public	993	5.9E-2	1 hr ground release
	MEI	6430	2.7E-3	1 hr ground release
6a	Occupational Worker/fence line	650	1.8E-4	Puff release
	Nearest member of the public	993	1.5E-4	Puff release
	MEI	6430	1.4E-5	Puff release
6b	Occupational Worker/fence line	650	1.8E-2	Puff release
	Nearest member of the public	993	1.5E-2	Puff release
	MEI	6430	1.4E-3	Puff release
6c	Occupational Worker/fence line	650	3.5E-4	Puff release
	Nearest member of the public	993	2.9E-4	Puff release
	MEI	6430	2.6E-5	Puff release
6d	Occupational Worker/fence line	650	8.6E-4	Puff release
	Nearest member of the public	993	7.2E-4	Puff release
	MEI	6430	6.4E-5	Puff release
6e	Occupational Worker/fence line	650	7.7E-2	Puff release
	Nearest member of the public	993	6.5E-2	Puff release
	MEI	6430	5.8E-3	Puff release
6f	Occupational Worker/fence line	650	1.3E-1	Puff release
	Nearest member of the public	993	1.1E-1	Puff release
	MEI	6430	9.5E-3	Puff release
6g	Occupational Worker/fence line	650	3.5E-3	Puff release
	Nearest member of the public	993	2.9E-3	Puff release
	MEI	6430	2.6E-4	Puff release

[10] The distance, 650 meters, is the location of the maximum dose to any individual.

[11] The nearest member of the public is taken from the publication "Final Report of Support Provided to Los Alamos National Laboratory's Radionuclide Air Emissions Management Program, Volume 4, Dispersion Modeling Input Parameters."

[12] The MEI is the maximally exposed individual from LANL emissions. This person is presently determined by the emissions from the Los Alamos Meson Physics Facility (LAMPF).

[13] The actual location of maximum dose is closer than 100 m to the facility. However, the code used will not calculate doses within this distance. A higher value would be appropriate because the fence line is located approximately 40 meters from the facility.

[14] The actual dose would be greater than the given value. The doses given for Scenario 5 are rates in rem/hr.

Additional dose calculations were performed for comparison. These included 1 Ci emissions of ^{241}Am and ^{241}Am and ^{238}Pu doses to additional receptors at San Ildefonso/Totavi and the Los Alamos townsite population. The distance to Totavi was estimated from map measurements. The additional calculations are summarized below.

Scenario	Emission (Ci)	Receptor	Distance (m)	Dose	Calculation Type
N/A	1.0 ^{241}Am	Occupational worker/fence line	650	2.9E+01 rem	Puff stack release
		Nearest member of the public	993	2.4E+01 rem	Puff stack release
		MEI	6430	2.1E+01 rem	Puff stack release
		Person at San Ildefonso/Totavi	10,000	1.1E+00 rem	Puff stack release
		Los Alamos Population	N/A	1.3E+04 person-rem	Puff stack release
5	1.0 ^{241}Am	Occupational worker/fence line	<100	>3.7E+02 rem/hr	1 hr ground release
		Nearest member of the public	993	4.8E+00 rem/hr	1 hr ground release
		MEI	6430	2.2E-01 rem/hr	1 hr ground release
		Person at San Ildefonso/Totavi	10,000	1.1E-01 rem/hr	1 hr ground release
		Los Alamos Population	N/A	9.7E+03 person-rem/hr	1 hr ground release
6f	7.8E-03 ^{238}Pu	Person at San Ildefonso/Totavi	10,000	4.8E+03 rem/hr	Puff stack release
		Los Alamos Population	N/A	6.6E+01 person-rem/hr	Puff stack release
5	1.4E-02 ^{238}Pu	Person at San Ildefonso/Totavi	10,000	1.4E-03 rem/hr	1 hr ground release
		Los Alamos Population	N/A	8.9E+01 person-rem/hr	1 hr ground release

A.3 REFERENCES

DOE 1994: U.S. Department of Energy, DOE Handbook, "Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, Volume I - Analysis of Experimental Data," DOE-HNBK-3010-YR, Washington, D.C., October 1994.

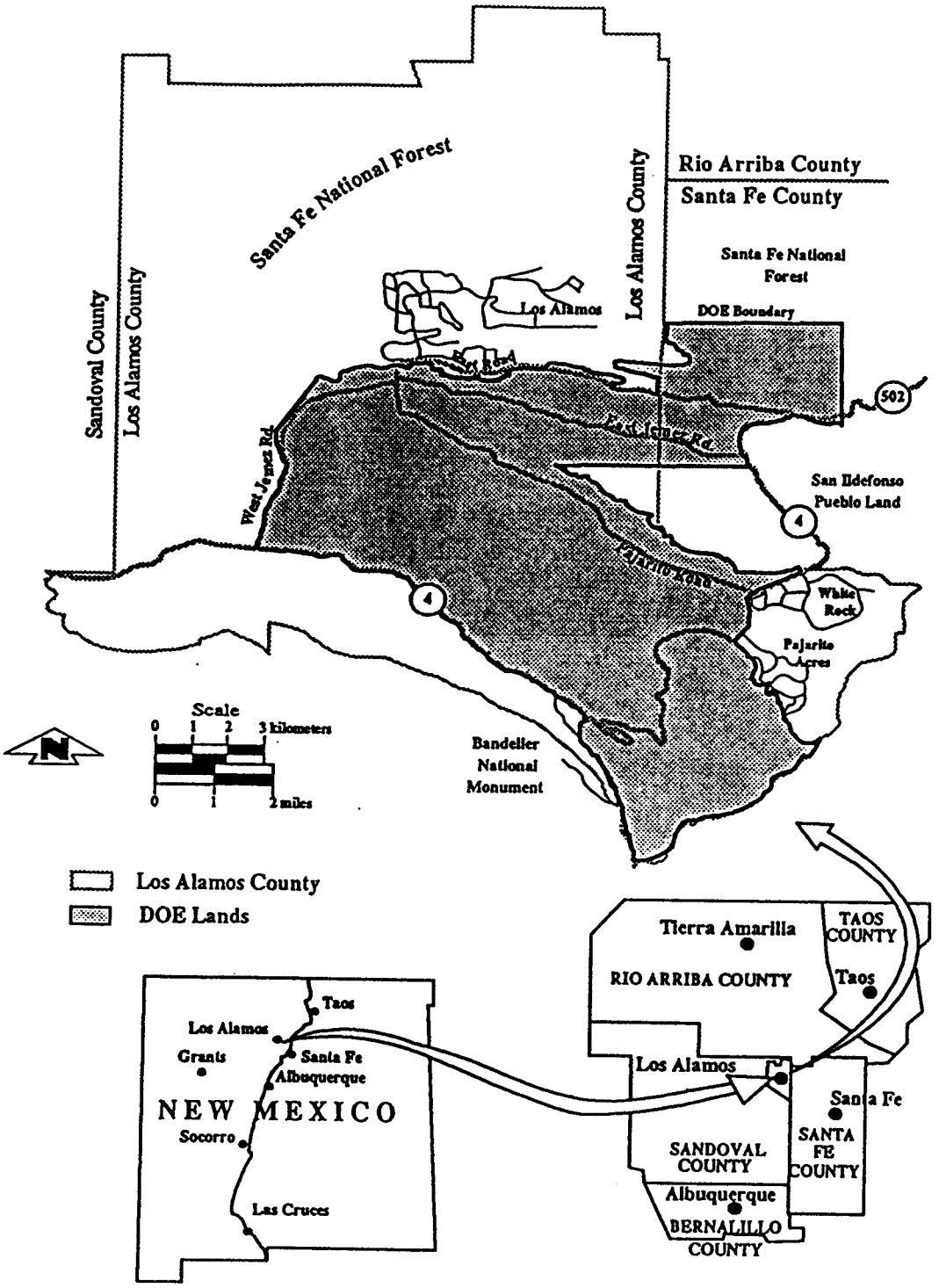


Figure 1. Location of Los Alamos National Laboratory

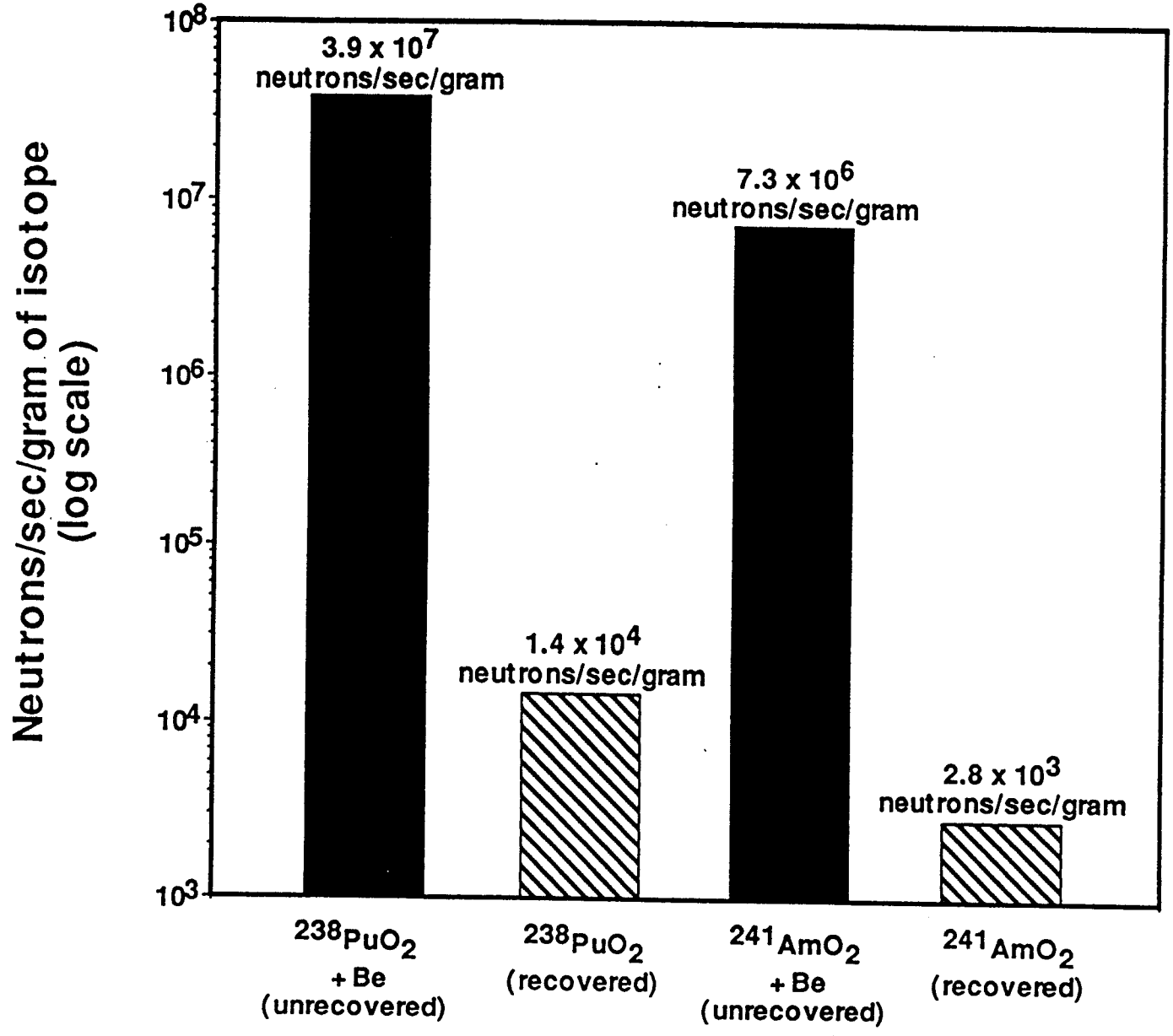
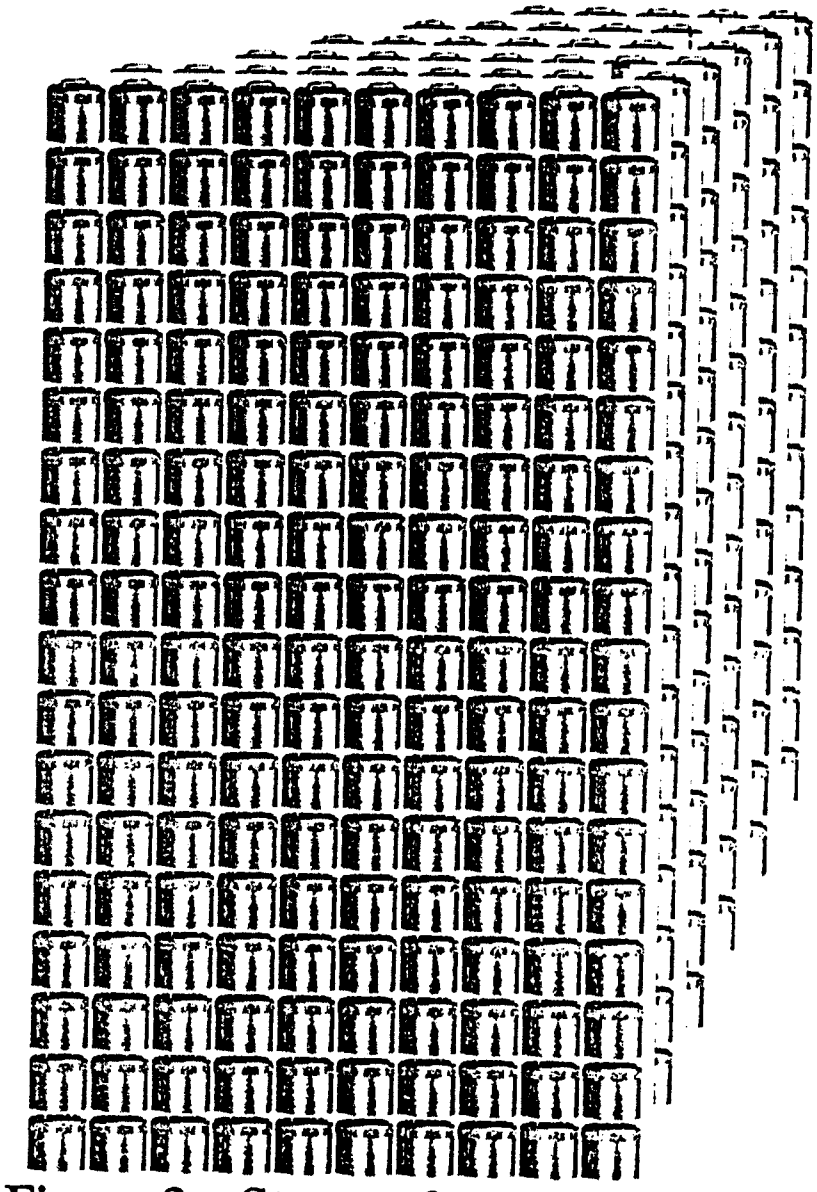
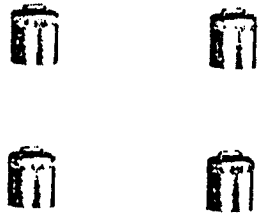


Figure 2. Comparision of neutron yields for unrecovered sources and recovered material.



Four 250 gram Water-Cooled cans of stable $^{241}AmO_2$



Shielded 1 Curie ^{241}Am-Be neutron sources

Figure 3. Storage for 1 Kilogram of 1 Curie ^{241}Am-Be Neutron Sources is 694 Times Greater than for Safe and Stable $^{241}PuO_2$ (2,778 Cans to 4 Cans)

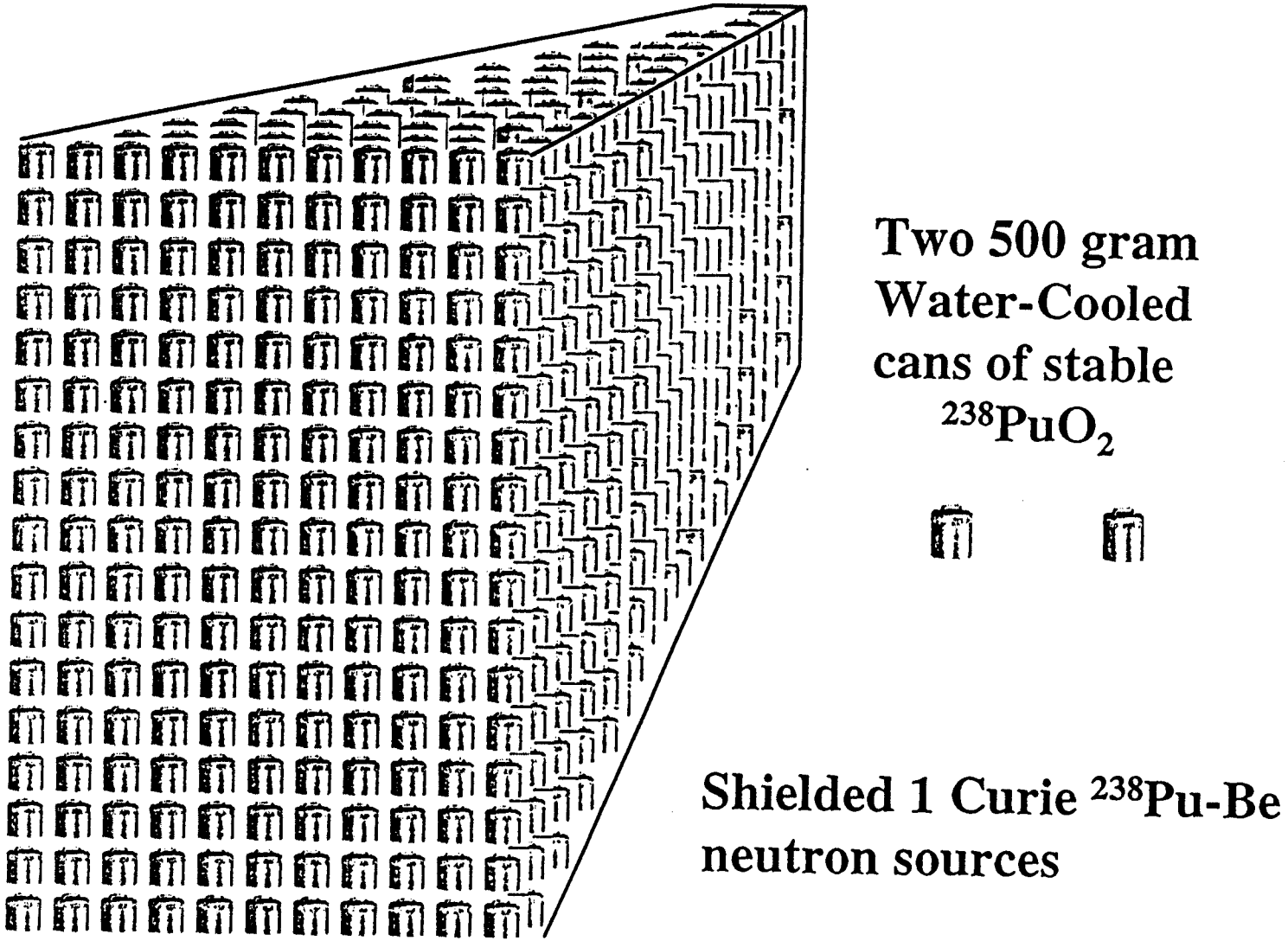


Figure 4. Storage for 1 Kilogram of 1 Curie ^{238}Pu-Be Neutron Sources is 8333 Times Greater than for Safe and Stable $^{238}PuO_2$ (16,667 Cans to 2 Cans)

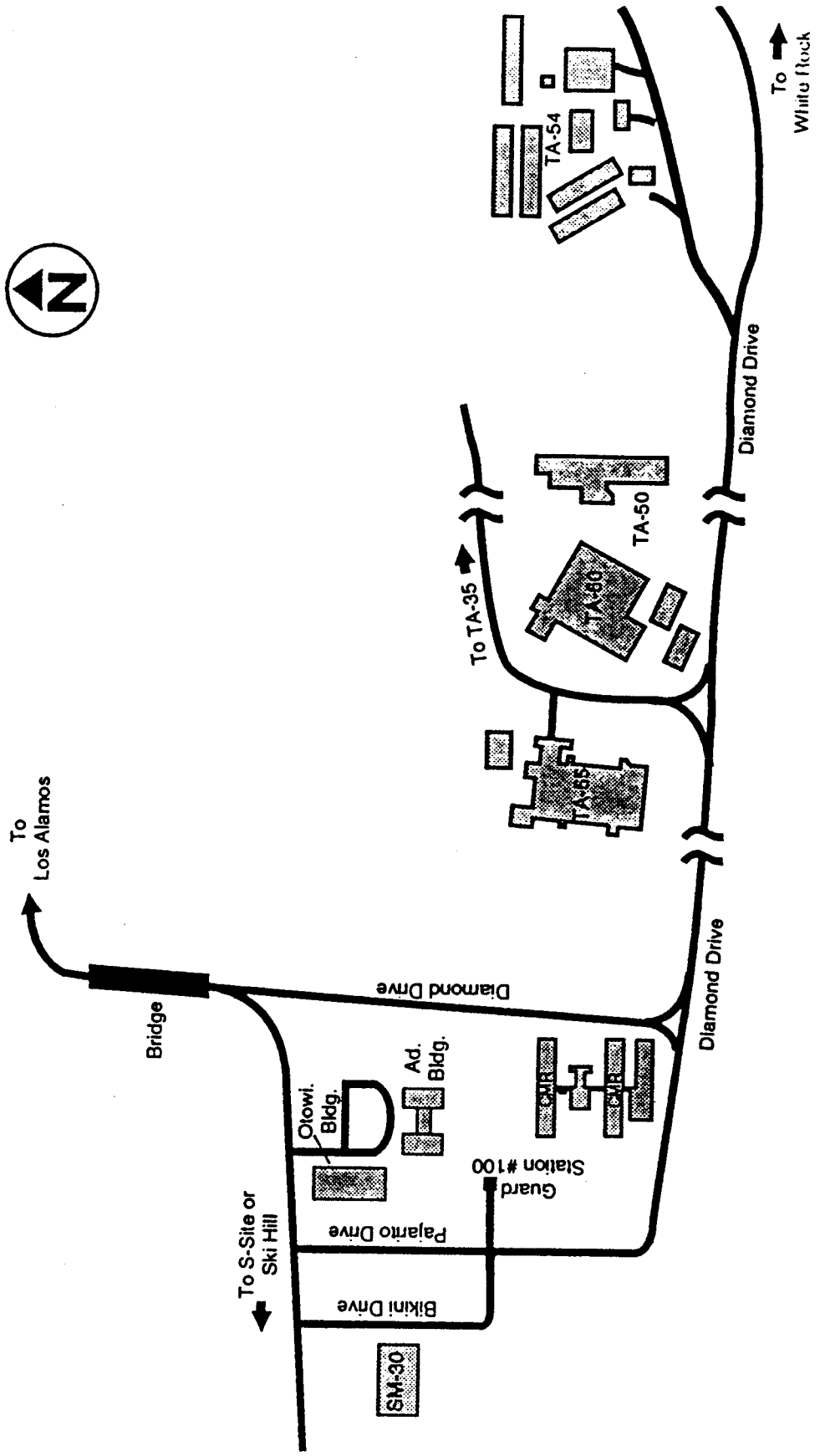


Figure 5. Locations of SM-30, CMR, TA-55, and TA-54 within the LANL Site

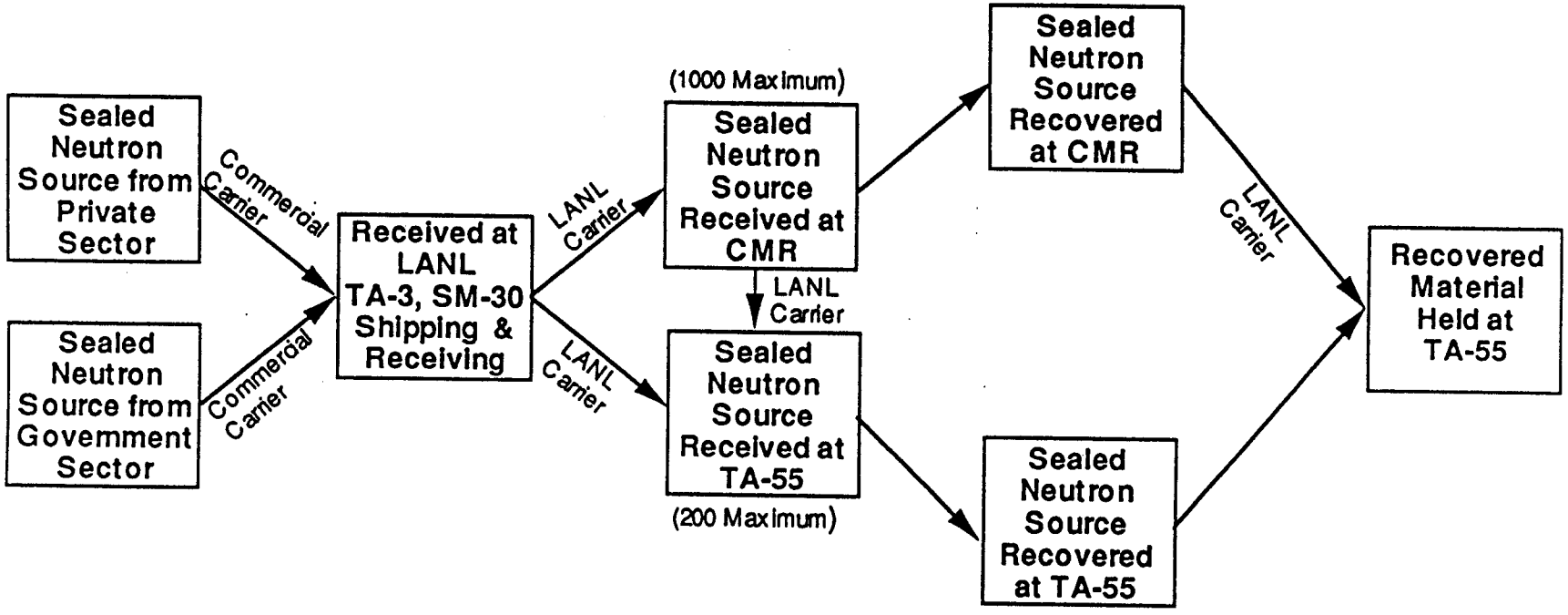


Figure 6. Neutron Source Movement and Recovery, including the maximum number of neutron sources that could be received in a single year. Neutron sources received in later years would depend on the number removed from temporary storage and recovered.

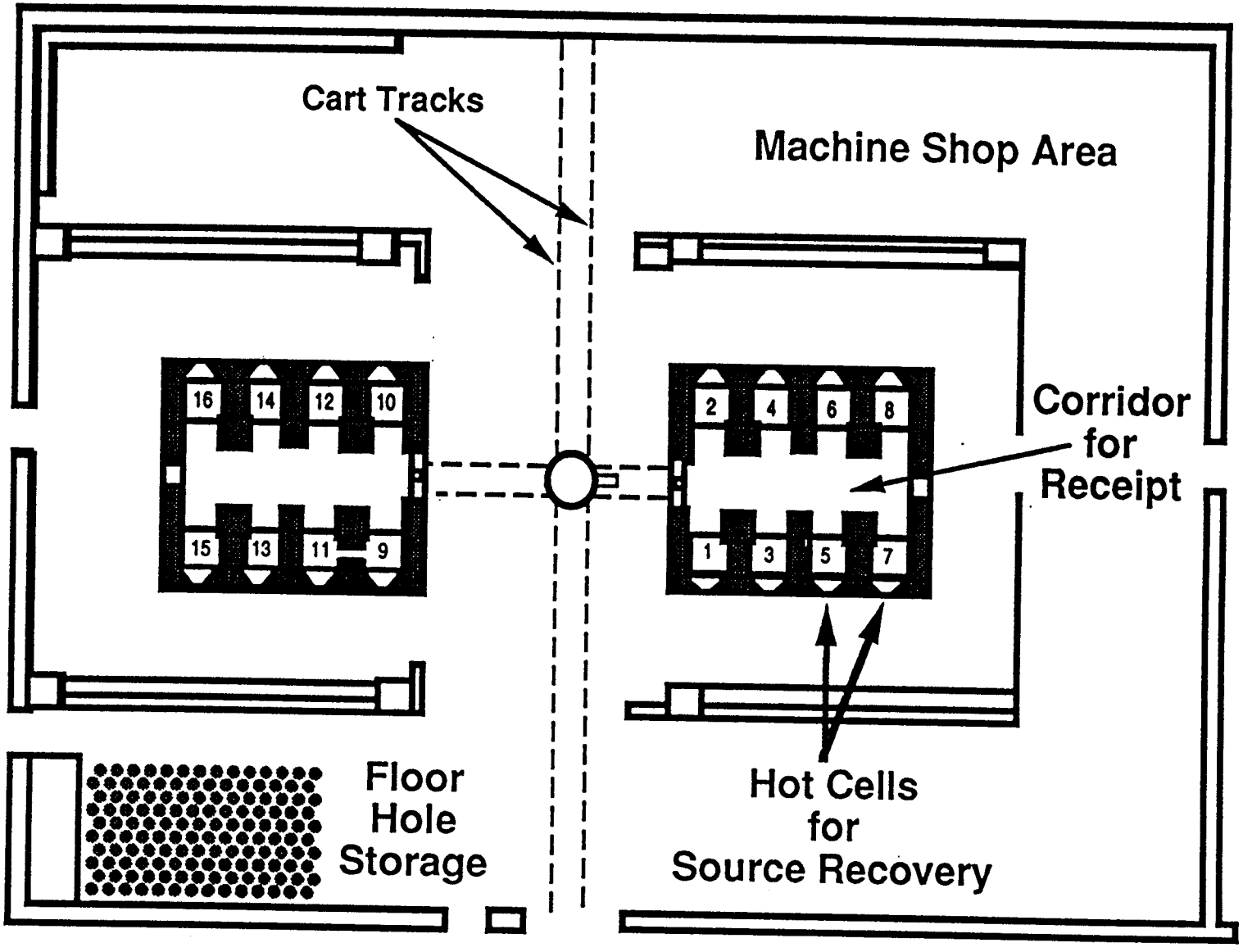


Figure 7. Location of Floor Hole Storage within the Wing-9 Hot Cell Facility

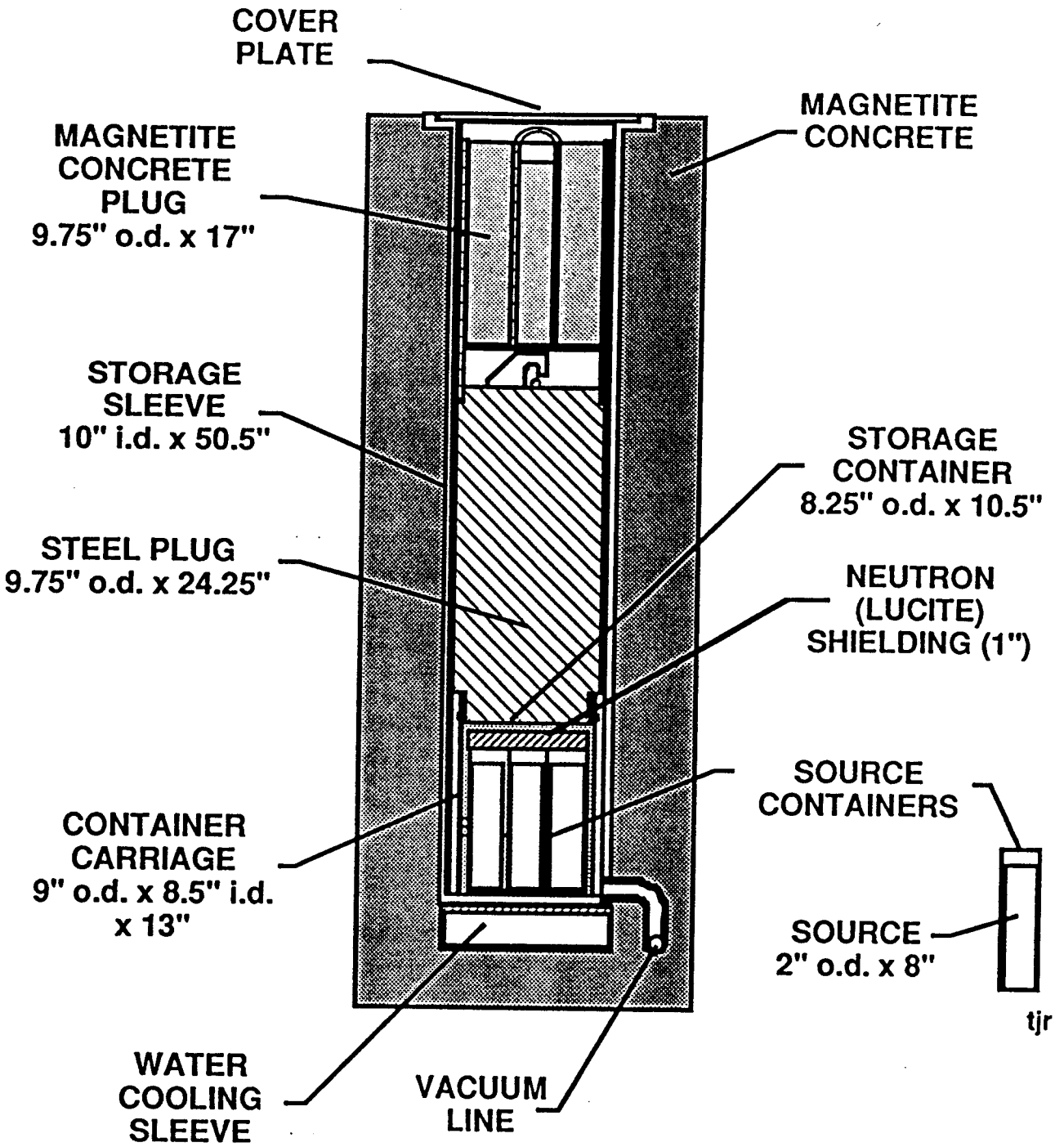


Figure 8. Diagram of Storage Area Within a Floor Hole

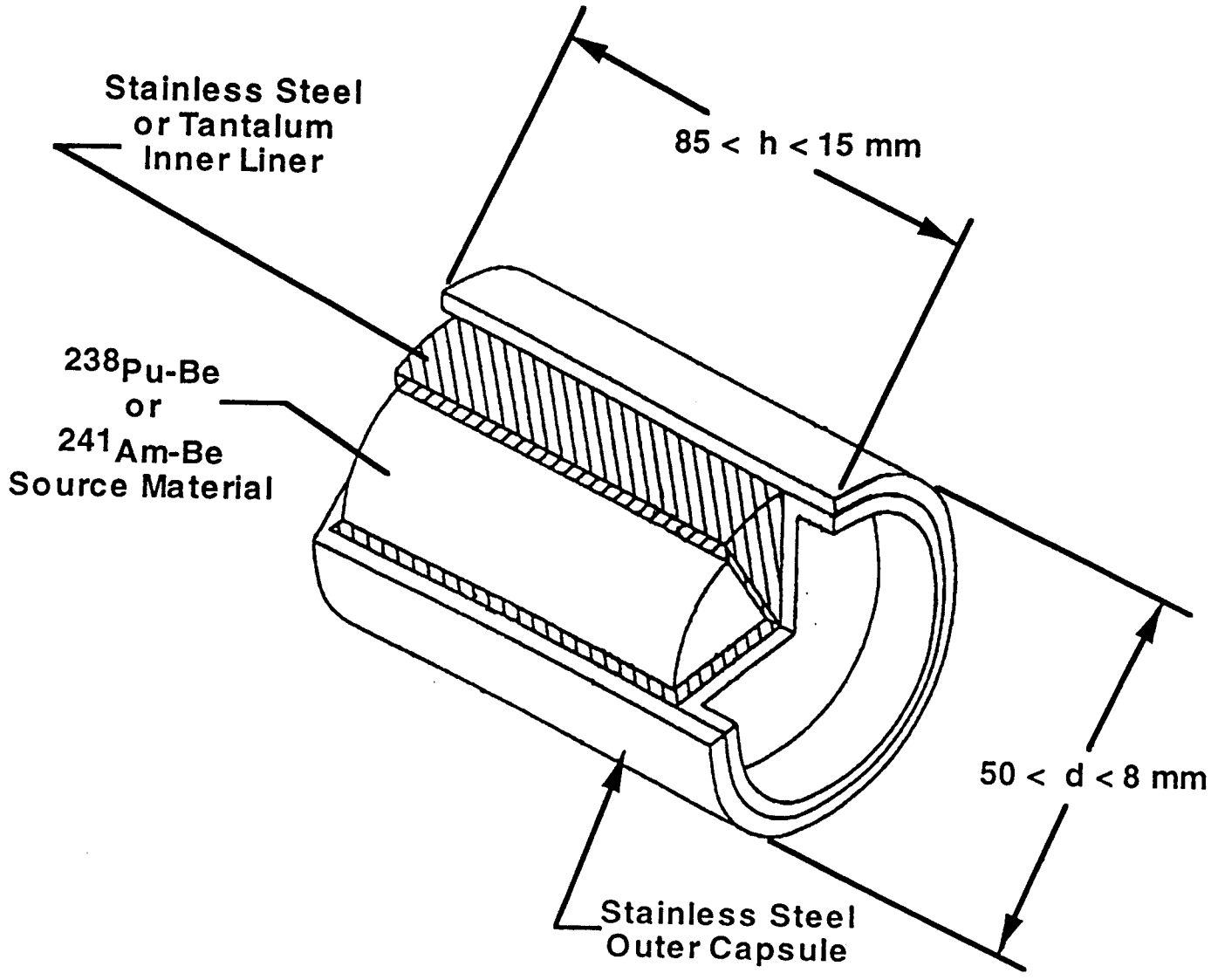


Figure 9. Typical Neutron Source Configuration.

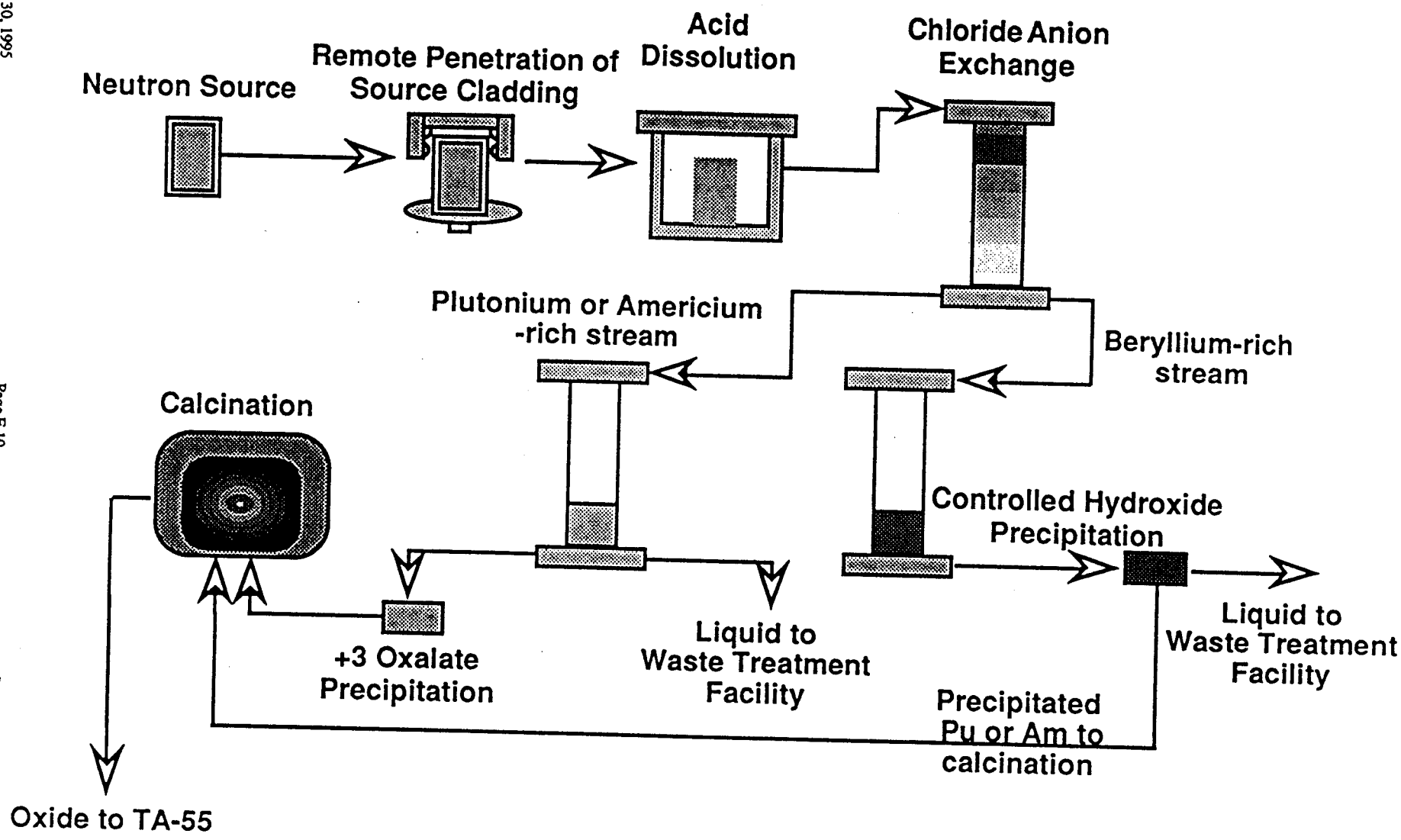


Figure 10. Flow Diagram for Source Recovery.