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SUPPLEMENT ANALYSIS

TRANSPORT AND STORAGE OF HIGH-ACTIVITY SEALED SOURCES FROM URUGUAY AND OTHER LOCATIONS

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National Nuclear Security Administration

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ACRONYMS AND ABBREVIATIONS

CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
CoC	Certificates of Compliance
Co-60	cobalt-60
Cs-137	cesium-137
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	environmental assessment
EIS	environmental impact statement
FR	*Federal Register*
FRR SNF EIS	*Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel*
GTRI	Global Threat Reduction Initiative
HEPA	high-efficiency particulate air
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
LANL	Los Alamos National Laboratory
LANL SWEIS	*Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico*
LCF	latent cancer fatality
LLW	low-level radioactive waste
MACCS2	MELCOR Accident Consequence Code System, Revision 2, Version 1.13.1
MCMIS	Motor Carrier Management Information System
MEI	maximally exposed individual
MeV	megaelectron-volt
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NRC	U.S. Nuclear Regulatory Commission
OSRP	Off-Site Source Recovery Project
Ra-226	radium-226
RAMQC	Radioactive Materials in Quantities of Concern
SA	Supplement Analysis
Sr-90	strontium-90
SwRI	Southwest Research Institute
TI	transportation index
UMTRI	University of Michigan Transportation Research Institute
WMD	Weapon of mass destruction

1.0 Introduction

This supplement analysis (SA) was prepared to assess whether there are substantial changes, or significant new circumstances or information, relevant to environmental concerns associated with continuing the National Nuclear Security Administration's (NNSA's) activities to recover and manage high-activity beta/gamma sealed sources relative to analysis in the *Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico* (*LANL SWEIS*) (**DOE 2008**) and other relevant National Environmental Policy Act (NEPA) reviews. This SA analyzes an aspect of the Off-Site Source Recovery Project (OSRP) that was not addressed in the *LANL SWEIS* (i.e., transportation of sealed sources recovered from foreign countries to the United States through the global commons[1] via commercial cargo aircraft) and examines the role of a commercial facility in managing these sealed sources.

The analysis in this SA uses a current proposed action to recover and manage sealed sources from Uruguay as a representative case to illustrate the potential environmental impacts associated with ongoing NNSA activities that could involve the recovery and management of similar high-activity beta/gamma sealed sources from approximately 20 locations (primarily domestic, but some foreign) annually. The sealed sources come from medical devices that are no longer in use and could contain cobalt-60 (Co-60), cesium-137 (Cs-137), radium-226 (Ra-226), or strontium-90 (Sr-90). Regardless of the current location of a source, the management activities are essentially the same, i.e., packaging, transportation, examination, storage, and disposal. As discussed below, the principal difference affecting potential environmental impacts is the distance that sources must be transported. For example, the transportation distance for transferring sources from Uruguay to the United States is approximately 4,400 miles (7,100 kilometers). Shipments from Mumbai, India to the United States would be a distance of approximately 8,500 miles (14,000 kilometers) so the impacts of a similar shipment of sealed sources from Mumbai to the United States would be expected to be roughly double that of the estimated impacts associated with the representative shipment from Uruguay. In any case, the potential environmental impacts principally would be worker exposures, which would be a small fraction of levels established in applicable regulations.

The Council on Environmental Quality (CEQ) regulations at 40 *Code of Federal Regulations* (CFR) 1502.9(c) require Federal agencies to prepare a supplement to an environmental impact statement (EIS) when the agency makes substantial changes in the Proposed Action or there are significant new circumstances or information relevant to environmental concerns. The U.S. Department of Energy (DOE) regulations at 10 CFR 1021.314(c) direct that when it is unclear whether a supplement to an EIS is required, that an SA be prepared to assist in making that determination.

1.1 Background

The NNSA's Global Threat Reduction Initiative (GTRI) is a vital part of the United States national security strategy of preventing the acquisition of nuclear and radiological materials for use in weapons of mass destruction (WMDs) and other acts of terrorism. The GTRI mission includes the effort to reduce and protect vulnerable nuclear and radiological materials located at civilian sites worldwide. GTRI has the goals of: (1) converting reactors from using WMD-usable highly enriched uranium to low-enriched uranium, (2) removing or disposing of WMD-usable excess nuclear and radiological materials, and (3) protecting at-risk WMD-usable nuclear and radiological materials from theft and sabotage. An element of the GTRI mission is the OSRP, an ongoing effort (since 1979) that involves the recovery,

[1] *Global commons refers to areas that are outside the jurisdiction of any nation (e.g., the oceans or Antarctica).*

storage, and, when appropriate, disposition of disused (excess, unwanted)[2] radiological sources that present potential public health and safety or national security concerns. GTRI (through the OSRP), in coordination with the Conference of Radiation Control Program Directors (representing state regulatory agencies), encourages and facilitates the recycle and reuse of disused radioactive sealed sources. If opportunities for recycle or reuse are not identified, DOE/NNSA may take title to sources recovered by the OSRP and store them pending transfer to another DOE program for use in DOE research applications or disposal.

Following the events of September 11, 2001, the U.S. Nuclear Regulatory Commission (NRC) conducted a risk-based evaluation of potential terrorist threats and concluded that disused radiological sealed sources constitute a potential vulnerability. In response, OSRP expanded its efforts to recover radiological sealed sources. Internationally, NNSA works with other United States, foreign, and international agencies to identify, condition,[3] and, when possible, repatriate (i.e., return to the country of origin) disused radioactive sealed sources. For example, the U.S. Department of State and the International Atomic Energy Agency (IAEA) have established a Latin American Regional Partnership that, along with NNSA, is coordinating the proposed recovery of disused sealed sources from Uruguay.

In implementing the OSRP, the NNSA uses the Southwest Research Institute (SwRI), a facility licensed by the State of Texas, Department of State Health Services, to support management of certain high-activity sealed sources. SwRI receives, stores, and transfers (to authorized recipients) beta/gamma sources (**TDSHS 2009a, 2009b**). SwRI has sufficient capacity for these sources in its existing facilities and experienced hot cell operators with extensive working knowledge of a wide variety of high-activity source-containing devices such as irradiators and teletherapy equipment.

1.2 Purpose and Need

As part of its ongoing mission, NNSA needs to recover and safely manage disused sealed sources to minimize or eliminate risks to national security or public health and safety. This includes the recovery of high-activity beta/gamma sources containing Co-60, Cs-137, Ra-226, or Sr-90 from domestic or foreign locations that could be used either individually or in aggregate in radiological dispersal devices commonly referred to as "dirty bombs." As an example, the radiological materials in 28 sealed sources from medical devices (teletherapy units) in Uruguay that are no longer in use and that pose a threat to public health and safety or national security need to be secured to ensure their proper disposition. The Government of Uruguay does not possess the capability to safely dispose of this material.

1.3 Related National Environmental Policy Act Documents

Ground Transportation and Management of Sealed Sources—In August 2000, DOE prepared the *Supplement Analysis, Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Modification of Management Methods for Certain Unwanted Radioactive Sealed Sources at Los Alamos National Laboratory* (**DOE 2000**). The SA evaluated changes in the approach to the management of sealed sources (primarily plutonium-238, plutonium-239, and americium-241 sources) from those analyzed in the Site-Wide EIS prepared for the Los Alamos National Laboratory (LANL) in 1999 (**DOE 1999**). In addition to an anticipated increase in the number of sources to be received, the

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[2] The term "disused" in this context refers to the source's current status. A source not being used by its current holder may have other uses.

[3] Conditioning includes the preparation of sources for long-term storage or disposal, i.e., physical removal of sources from devices for packaging or packaging of the entire device (without removing the source first). Conditioning can also refer to placing devices into containers (e.g., 55-gallon drums) and then filling the containers with concrete. IAEA endorses the latter method; however, NNSA generally does not accept sources conditioned in concrete.

proposed change was to not process the sources for actinide recovery but to focus on safe storage until the sources could be provided to new users or disposed of.

The 2008 *LANL SWEIS* (**DOE 2008**) analyzed the potential environmental impacts of continued management of sealed sources at LANL. It also evaluated the potential environmental impacts associated with an expansion of the types and quantities of sealed sources to be managed at LANL. The *LANL SWEIS* states that the OSRP "would continue to use commercial or other Federal organizations and facilities where appropriate, and LANL facilities would be used when these organizations and facilities were not appropriate to fulfill the national security mission of the Off-Site Source Recovery Project." The *LANL SWEIS* also analyzed the potential impacts of ground transportation of sealed sources, including transportation of Co-60 and Cs-137 sources, and Sr-90, explaining that "Because the locations of the sealed sources that would be transported to LANL have not been identified, the analysis used a bounding distant location (Bangor, Maine)." In the record of decision for the *LANL SWEIS*, NNSA announced that it was "broadening the types and quantities of radioactive sealed sources (Co-60, Ir-192 [iridium-192], Cf-252 [californium-252], Ra-226 [radium-226]) that LANL can manage and store prior to their disposal" (73 *Federal Register* [FR] 55833).

International Shipment of Radiological Materials—Potential environmental impacts associated with the air transport of radiological materials have been analyzed in other NEPA documents including the *Environmental Assessment for the Transportation of Unirradiated Uranium in Research Reactor Fuel from Argentina, Belgium, Japan, and the Republic of Korea to the Y-12 National Security Complex (Unirradiated Reactor Fuel Transport EA)* (**DOE 2005**) and the *Supplement Analysis* [to the 2001 Y-12 Site-Wide EIS] *for the Air and Ocean Transport of Enriched Uranium between Foreign Nations and the United States* (**DOE 2006**). These analyses evaluated the potential environmental impacts of air transport of unirradiated uranium between foreign nations and the United States. The *Unirradiated Reactor Fuel Transport EA* analyzed a shipment of unirradiated reactor fuel from four locations around the world (one in South America, two in Asia, and one in Europe) to Miami International Airport under the auspices of GTRI. The Environmental Assessment (EA) resulted in DOE determining that the proposed shipments were not major Federal actions significantly affecting the quality of the human environment; the SA resulted in a determination that NNSA did not need to supplement the *Site-Wide Environmental Impact Statement for the Y-12 National Security Complex* (**DOE 2001**) to evaluate transport from foreign nations.

The potential impacts from direct exposure to gamma-emitting radioactive materials following the breaching of transportation casks were evaluated in the *Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (FRR SNF EIS)* (**DOE 1996a**). The potential impacts from the breach of a spent nuclear fuel cask and the breach of a package containing sealed sources would be similar in that they represent external radiation exposure risks.

Disposal of Sealed Sources—Transportation to and disposal of low-level radioactive waste (LLW) that meets applicable waste acceptance criteria at the Nevada National Security Site (NNSS), formerly the Nevada Test Site, were analyzed in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (**DOE 1996b**). That EIS resulted in a Record of Decision that states that NNSS is available to DOE sites for disposal of LLW that meets the NNSS waste acceptance criteria (61 FR 65551; December 13, 1996). Certain sealed sources meet the NNSS LLW waste acceptance criteria and have been disposed at the NNSS. NNSA currently is updating the site-wide EIS for NNSS (DOE/EIS-0426); a notice of intent to prepare the new site-wide EIS was published on July 24, 2009 (74 FR 36691).

1.4 Proposed Action

NNSA proposes to recover and manage high-activity beta/gamma sources from about 20 locations (domestic or foreign) annually as part of ongoing OSRP activities. Sources being transferred from foreign nations would be transported by commercial aircraft to a U.S. airport. From the receiving airport, or from other domestic locations, sources would be transported by commercial truck to SwRI where they would be placed in storage pending reuse or disposal. The Proposed Action could also involve repatriation of sealed sources to another country (that is truck and/or air transport from SwRI to a foreign country).

As an example, the NNSA proposal to transport 1 Cs-137 and 27 Co-60 sealed sources to the United States from Uruguay for storage at a state-licensed facility pending their final disposition would be typical of the activities taken under the Proposed Action.

The sealed sources from Uruguay would be transported to Miami International Airport by commercial cargo aircraft, transported from Miami to San Antonio by truck or commercial cargo aircraft, and placed into storage at SwRI. Some of the sealed sources are of Canadian or Indian origin and may eventually be repatriated to Canada or India. Sources not repatriated to Canada or India could be disposed of at NNSS, provided that the sources meet NNSS waste acceptance criteria. Therefore, this SA also analyzes air transportation to India and ground transportation to a Canadian entry location (assumed to be near Alexandria Bay, New York) and to NNSS. The activities and environmental impacts associated with the shipments from Uruguay are representative of the types of activities and impacts that would be associated with any of the high-activity beta/gamma sealed source recovery operations undertaken through OSRP.

1.4.1 Characteristics of Sealed Sources from Uruguay

The characteristics of the sealed sources from Uruguay are shown in **Table 1–1**. The sources have been conditioned and containerized in Uruguay to meet the requirements of a special form radioactive material (49 CFR Part 173).[4] Three Type B packages (Model 9215/B(U)) would be used to transport the sources to the United States: one for the Cs-137 source, one for the 15 Co-60 sources from India, and one for the other 12 Co-60 sources. Type B packaging is designed and tested to withstand the conditions of normal transport as well as accident conditions.[5]

Table 1–1 Sealed Sources from Uruguay

Source	*Country of Origin*	*Isotope*	*Quantity*	*Original Activity (curies)*	*Current Activity (curies)*
Caesatron	Canada	Cesium-137	1	1,500	479
Eldorado 6	Canada	Cobalt-60	1	4,980	505
Eldorado 6	Canada	Cobalt-60	1	689	61
T-780	Canada	Cobalt-60	1	200	70
T-80	Canada	Cobalt-60	1	2,507	413
Theratron Jr	Canada	Cobalt-60	1	293	26

[4] *Special form radioactive material is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule; the piece or capsule has at least one dimension not less than 5 mm (0 2 in), and must meet testing requirements for impact, percussion, bending, heat, and leaching (10 CFR Part 71).*

[5] *Normal transport conditions, which may result in a package being subjected to heat, cold, vibration, changes in pressure, or other possible occurrences (e g., being dropped, compressed under a weight, sprayed with water, or struck by objects), must not result in loss of function (e.g , containment, shielding, continuance of subcriticality). There must be no substantial loss of function of the package even after being subject to a series of tests that are conducted sequentially to simulate accident conditions. These tests include being dropped from 9 meters (30 feet) onto an unyielding surface; being crushed; being punctured; being exposed to a high heat (a temperature of at least 800 °C or 1,475 °F), as from a fire, for 30 minutes; and, for fissile material packages, immersion in water. Also, an undamaged package must pass a 15-meter (50-foot) water immersion test (10 CFR Part 71)*

Source	***Country of Origin***	***Isotope***	***Quantity***	***Original Activity (curies)***	***Current Activity (curies)***
Theratron Jr	Canada	Cobalt-60	1	1,268	134
Theratron Jr	Canada	Cobalt-60	1	430	142
Theratron Jr	Canada	Cobalt-60	1	620	272
C-1000	United States	Cobalt-60	1	81	7
C-1000	United States	Cobalt-60	1	1,163	76
C-1000	United States	Cobalt-60	1	378	125
C8M80	United States	Cobalt-60	1	6,305	755
GC4000A	India	Cobalt-60	15	3,345	17

By comparison, sealed sources containing Ra-226 or Sr-90 expected to be recovered under the OSRP would be much smaller in size with the maximum amount of radioactive material on the order of 1 curie per sealed source and the average amount being on the order of 0.03 and 0.05 curies per sealed source, respectively. Approximately 150 sealed sources containing a total of approximately 4.5 curies of Ra-226, and 200 sealed sources containing a total of approximately 10 curies of Sr-90 are currently registered[6] with the OSRP.

1.4.2 Description of Transportation and Storage Activities

The description below regarding the recovery of sources from Uruguay would be generally applicable[7] to the recovery of sources from other locations. The IAEA would arrange for the sources to be transported from Uruguay to the United States. An agreement between IAEA and DOE would provide for transfer of ownership of the sealed sources to DOE/NNSA after receipt in the United States. Transport of the sealed sources from Uruguay or from any other potential sealed source location would occur in accordance with applicable national and international requirements for safety and safeguards. These standards include IAEA Safety Standard Series Number TS-R-1, *Regulations for the Safe Transport of Radioactive Material* (**IAEA 2005**), 10 CFR Part 71, NRC regulations for *Packaging and Transportation of Radioactive Material*, and 49 CFR Part 171 Subpart C, Department of Transportation (DOT) *Authorization and Requirements for the Use of International Transport Standards and Regulations.*

The IAEA would be responsible for preparing the sources and securing arrangements for transport from the foreign country to the United States. The IAEA would ensure the sealed sources are containerized as special form radioactive materials and placed in transportation packages that meet U.S. and international standards for Type B packages. The IAEA would be responsible for coordinating with local and national officials in foreign countries, obtaining the necessary export approvals, making any needed transit arrangements with countries through whose airspace the aircraft carrying the sealed sources may pass, arranging for customs clearance in the United States, and other international transportation activities.

At the airport of departure, the shipping packages would be loaded and safely secured in the aircraft's cargo bay for transport to the United States. The airport of entry for the shipments from Uruguay would be Miami International Airport, Miami, Florida, but any international airport in the United States could potentially receive such shipments from overseas. At the receiving airport, the packages would be unloaded and transferred to the shipper's warehouse adjacent to the airport. International packages would be placed in a low-traffic portion of the warehouse designated for hazardous (including radioactive) materials where they would remain for two to three days awaiting customs clearance. These warehouses are locked and access is limited to authorized personnel. Guards and video surveillance provide

[6] *As part of the OSRP effort to recover disused radioactive sealed sources that pose a potential risk to public health and safety or national security, OSRP established a sealed source registration system whereby organizations may voluntarily register their sources with the OSRP.*
[7] *IAEA would not be involved in the recovery of sources from locations within the United States.*

additional security. After clearing customs, the packages would be transferred to a commercial truck or cargo aircraft for transport to SwRI for storage.

At SwRI, the packages would be placed in a hot cell where the sealed sources would be removed from the shipping packages, inspected, and placed in secure storage configurations. Storage of the sealed sources at SwRI would continue pending final disposition. If no other domestic uses are identified, final disposition of the U.S.-origin sources would be disposal at NNSS as LLW if it is determined that the materials meet the NNSS waste acceptance criteria.[8] With regard to the shipment from Uruguay, GTRI would attempt to repatriate the Canadian-origin and Indian-origin sources to Canada and India, respectively. If Canada or India does not accept the sources, and no other domestic uses for these sources are identified, the sources also would be disposed of at NNSS if they meet the NNSS waste acceptance criteria.

Prior to transport to NNSS, a Waste Certifying Official, or designee from an NNSS-approved program, would visually examine and verify the sealed sources. The sources are often encapsulated in special-form capsules (to allow for the consolidation of more sources with higher activity in one package) and then placed in a shielded disposal package inside an appropriate certified transportation package (generally a Type B container). The Waste Certifying Official would observe the packaging activities, and then seal the shielded disposal package and transportation package with tamper indicating devices so that NNSS staff would know that the content has not been altered en route to the site. When the shipment arrives at NNSS, NNSS staff would remove the shielded disposal package from the transportation package and dispose of it.

In the case of the Indian-origin sources included in the shipment from Uruguay, the sources would be removed from the sealed special-form capsule so that an Indian representative could confirm that the sources are of Indian origin to support the decision on whether the sources would be repatriated to India for final disposition. This is a requirement of India; Canada does not have a similar requirement. To remove the sources from the special-form capsule, SwRI would open the capsule in its hot cell by cutting the end off the capsule using a remotely-operated band saw and the sources would be removed from the special-form capsule to allow them to be visually inspected. If the decision is made to repatriate these sources to India for final disposition, they would be repackaged in special-form capsules and placed in either two Type A shipping containers or one Type B shipping container. Otherwise, the sources would be placed in a new special-form capsule and returned to storage pending a decision on final disposition.

1.4.3 Affected Environment

1.4.3.1 Global Commons

As addressed in Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, global commons are areas outside the jurisdiction of any nation (e.g., the oceans or Antarctica). Transport of sealed sources from a country such as Uruguay to the United States and from the United States to another country (such as India for some of the sealed sources from Uruguay) would involve transport over the global commons. This SA does not evaluate the potential environmental impacts of actions taken in a foreign country (e.g., Uruguay or India) or from the overflight or airport operations of any foreign nations.

[8] *OSRP accepts sealed sources with the expectation that a disposition pathway is available, through repatriation or reuse, or by disposal. If a sealed source cannot be repatriated or reused and does not meet the Nevada National Security Site waste acceptance criteria in its as-received condition, it would remain in storage at Southwest Research Institute until suitable disposal arrangements are made.*

1.4.3.2 United States Locations

For the shipment of sealed sources from Uruguay, the affected environment includes the airports in Miami and San Antonio as well as the area surrounding SwRI. These areas are representative of other cities or locales that could be affected by the shipment of sealed sources from other countries to the United States. For example, Miami International Airport is located in a highly populated area and is representative of a large airport in a large city.

Miami International Airport—The Miami International Airport is located in Miami-Dade County, Florida, approximately 13 kilometers (8 miles) northwest of the City of Miami. The airport is situated on 1,308 hectares (3,230 acres) of land and has three runways. For the year ending January 2010, Miami International Airport hosted more than 16.5 million passengers and handled approximately 480 million pounds of freight (**BTS 2010**). The population within 80 kilometers (50 miles) of the airport is about 4.7 million. The analyzed population distribution for Miami International Airport is based on the 2000 Census (**Census 2001, 2002**) adjusted for population growth estimates from the Census Bureau through 2009.[9] Low-income and minority populations in the counties surrounding Miami International Airport account for 13 percent and 62 percent of the total population, respectively. In the host county of Miami-Dade, low-income and minority populations account for 16 percent and 82 percent of the total population, respectively (**Census 2009b**).

San Antonio—San Antonio is located in Bexar County in south-central Texas. The San Antonio International Airport is about 11 kilometers (7 miles) north of downtown San Antonio. The year 2009 population within 80 kilometers (50 miles) of the airport was about 2.2 million people. The population was estimated in a manner similar to that described for the Miami International Airport. Low-income and minority populations in the counties surrounding San Antonio account for 16 percent and 62 percent of the total population, respectively. In the host county of Bexar, low-income and minority populations account for 17 percent and 68 percent of the total population, respectively (**Census 2009c**).

Southwest Research Institute—SwRI is about 11 kilometers (7 miles) west of downtown San Antonio. The travel distance from the airport to SwRI is about 22 kilometers (14 miles). The campus of SwRI occupies more than 1,200 acres and provides nearly two million square feet of laboratories, test facilities, workshops, and offices. SwRI is certified to International Organization for Standardization (ISO) 14001, Environmental Management System. SwRI's Environmental, Safety, and Quality Systems organization manages issues related to handling and storage of chemicals and hazardous materials (including radioactive materials such as sealed sources) in a manner that prevents pollution to air, water, and soil, and controls radiation exposure, in accordance with applicable federal, state, and local regulations governing protection of the environment.

SwRI has three facilities used for the receipt and storage of sealed sources. The hot cell facility includes two sets of remote slave manipulators on either side of the source storage area. Each hot cell area provides the capability for removing sources from their shipping containers and placing them into storage containers. In the same building, but separate from the hot cells, is one of two interim storage areas. The second interim storage area is in a separate building. Sources being stored under contract are kept in shielded casks in the storage area between the hot cells or in one of the interim storage areas.

In addition to license compliance inspections by the Texas Department of State Health Services, the security features of the facilities used for sealed source management have been reviewed directly by

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[9] *The population surrounding Miami International Airport consists primarily of individuals living in Miami-Dade, Broward, and Palm Beach Counties. The 2000 Census reported the populations of these counties as 2,253,362, 1,623,018, and 1,131,184 respectively. In 2009, the Census Bureau estimated that the population had increased to 2,500,625, for Miami-Dade County, to 1,766,476 for Broward County, and 1,279,950 for Palm Beach County (**Census 2009a**). In total, the population of these three counties was estimated to have increase by approximately 11 percent between 2000 and 2009.*

NRC. GTRI also has independently evaluated and installed physical protection upgrades at three SwRI facilities used for sealed source management. An initial security assessment was conducted by GTRI in April 2009 and security upgrades were completed by December 2009. Security upgrades included high security locks, bars on windows, hardened steel doors, access controls, and video surveillance. Following installation of the upgrades, a review was conducted to verify they met the *GTRI Protection and Sustainability Criteria* (**DOE 2010**). The facilities at SwRI are monitored 24 hours a day by an on-site security guard force.

Nevada National Security Site—NNSS is a DOE/NNSA site that occupies approximately 3,500 square kilometers (1,360 square miles) of desert and mountain terrain in southern Nevada, approximately 92 kilometers (57 miles) northwest of Las Vegas. The site has three core missions: national security/defense, environmental management, and nondefense. Within the environmental management mission, NNSS receives LLW that meets the site's waste acceptance criteria for disposal at the Area 5 Radioactive Waste Management Complex. The Area 5 Radioactive Waste Management Complex, in the southeastern portion of NNSS, is more than 32 kilometers (20 miles) from the nearest community and more than 105 kilometers (65 miles) from Las Vegas. Sparsely vegetated basins or flats, separated by low mountains, dominate the eastern side and southern end of the NNSS, which includes Area 5. Temperatures and precipitation vary across the NNSS with lower elevations like Area 5, having higher temperatures (average high of about 100 degrees Fahrenheit in the summer and 70 degrees Fahrenheit in the winter) and less precipitation (average annual precipitation is about 13 centimeters [5 inches]). The Radioactive Waste Management Complex comprises about 740 acres, including about 160 acres of existing and proposed disposal cells for burial of LLW and mixed LLW.

2.0 Analysis and Discussion

Shipment and receipt of sealed sources under the Proposed Action would use existing infrastructure at airports and SwRI and during ground transportation. There would be no construction or modification of facilities to support transport, receipt, or storage of sealed sources. Under incident-free transport conditions, there would be no releases of radioactive material. There would be no releases of nonradiological pollutants other than those typical of plane and truck exhaust emissions. The Proposed Action would result in only incidental amounts of LLW such as wipes and contamination control materials.

Consistent with Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, this SA does not evaluate impacts in foreign countries from packaging and transport from the facilities housing the sealed sources to the point of departure, loading the sealed sources onto the plane at the point of departure, or air transport through the air space or airports of participating foreign countries. Similarly, it does not evaluate potential impacts from overland transport and management in foreign countries from those sources that are repatriated. It does, however, evaluate the potential impacts of these shipments on the global commons.

Representative of the types of shipments and activities that could be undertaken with respect to the transport and storage of sealed sources by the OSRP, this section analyzes the potential environmental impacts of: transporting 28 sealed sources by commercial cargo aircraft from Uruguay to Miami International Airport and from Miami to San Antonio; overland transport (commercial truck) from Miami International Airport to a licensed facility in San Antonio; transport from San Antonio to the Canadian border (commercial truck), Mumbai, India (commercial truck and cargo aircraft), or NNSS (commercial truck); opening and repackaging the special-form capsule containing Indian sources; and storage of the sealed sources at SwRI. The impacts presented in this section are compared to those presented in the *LANL SWEIS* (**DOE 2008**), the *Unirradiated Reactor Fuel Transport EA* (**DOE 2005**), and the *FRR SNF EIS* (**DOE 1996a**).

Packaging sealed sources recovered from domestic sources at the point of origination was included as part of the Proposed Action analyzed in previous DOE/NNSA NEPA documents (Section 1.3) and is part of ongoing operations. DOE/NNSA is not proposing any change in regard to this activity. Packaging can vary depending on the type of sealed source and its use. In some cases, the sealed source is in a shielded head that is removed intact from a larger piece of equipment prior to packaging. Sources are packaged in Type A or Type B packages, depending on the quantity of radionuclides, in accordance with Department of Transportation regulations. During packaging activities, administrative and engineered controls are used to maintain doses to workers packaging the sealed sources as low as reasonably achievable.

2.1 Air Transport

2.1.1 Impacts to the Global Commons

Incident-Free Transport

Transporting the sealed sources from Uruguay would result in only minor incremental nonradiological impacts. The only expected impacts would be the emission of exhaust from the combustion of aircraft fuel. Whether the sealed sources are transported on a regularly scheduled commercial cargo flight or a chartered cargo flight, the flight would be one of more than 30,000 daily air flights by commercial and air cargo airlines that occur over the United States (**NATCA 2010**). Because there would be no release of radioactivity under incident-free transport, there would be no radiological impacts on the global commons.

Transportation Accident

The analyses of the potential environmental impacts of an accident over the global commons assumed the loss of the packages of sealed sources in the ocean. The analyses further assumed that through either acute or long-term processes, the contents of the packages would be released into the ocean. Impacts to marine life from such an accident would be similar to those discussed in other analyses involving transport of radioactive material over the global commons (**DOE 1994a, 2005**). These analyses concluded that there could be some loss of marine life directly exposed to radioactive material. Yet because of the large volumes of water involved, mixing mechanisms, existing background radiation concentrations, and radiation-resistance of aquatic biota, the radiological impact of an accident would be localized (**DOE 1994a, 2005**). An accident involving an aircraft carrying the sealed sources from Uruguay resulting in a crash in the ocean was also assumed to result in a release of all of the radioactive materials. The release could be immediate, but the packaging and containerization as a special form radioactive material would make a gradual failure and release more likely. Whether immediate or gradual, this SA assumes that the release would result in the loss of marine organisms near the released material.

2.1.2 Incident-Free Air Transportation Impacts

Because of the distances that would be maintained between the packages and the nearest members of the general public (i.e., non-crew members) during air transport, there would be no radiological exposure to the general public from incident-free transport of sealed sources on a commercial cargo aircraft. Incident-free transport would result in radiological exposure only to the personnel on the aircraft. The radiological doses to the crew on the aircraft would be proportional to the package surface dose rate, the crew-view package characteristic dimensions (i.e., the surface of the package array that faces the crew), the crew-to-package distance, any radiation shielding (e.g., other cargo) between the package array and the crew, and the time between boarding the aircraft and exiting it after landing.

The *Unirradiated Reactor Fuel Transport EA* analyzed potential impacts from the air transport of unirradiated research reactor fuel from foreign nations to an East Coast airport; transport from Argentina to Miami International Airport was included in the analysis. A variety of commercial aircraft were considered. The aircraft used and the placement of the cargo within the aircraft would affect parameters such as the crew-to-package distance or the presence of any additional cargo between the packages and the crew that could provide shielding against external radiation. Hence, a conservative assumption that would apply regardless of the aircraft selected was made for calculating the dose in the *Unirradiated Reactor Fuel Transport EA*. Based on the fuel being unirradiated, it was assigned a transport index (TI) of 1. The dose and risk to the commercial flight crew was conservatively estimated by assuming a maximum hourly dose rate of 1.3×10^{-5} rem per hour per person that was applied to any commercial transport of the research reactor fuel. Aircrew dose and risk, calculated for a crew of 4 using a risk factor of 0.0006 latent cancer fatalities (LCFs) per person-rem (**DOE 2003**), were 4.8×10^{-4} person-rem and 3×10^{-7} LCFs, respectively, or a probability of about 1 in 3.3 million of an LCF among the crew from this exposure. Impacts for transportation from a point of origin in Europe and points of origin in Asia were also evaluated. The largest impacts (for a shipment from Asia) were 7.3×10^{-4} person-rem and 4×10^{-7} LCFs, or a probability of 1 in 2.5 million of an LCF among the crew from this exposure.

The dose to the aircrew from the shipment of the sealed sources from Uruguay could be higher than the doses estimated in the *Unirradiated Reactor Fuel Transport EA* because the shipping packages holding the sealed sources would have a higher surface dose rate due to the gamma-emitting radionuclides. The TI for the sealed sources after they were packaged was approximately 5 (**NPI 2010a**).[10] However, a more

[10] *The actual transportation indexes for the three packages after they were prepared in Uruguay were 0.1 for the Cs-137 source, 0.7 for the Indian Co-60 sources, and 5 for the other Co-60 sources (**NPI 2010a, 2010b**).*

conservative TI of 10 was assumed for analysis in this SA. Based on this assumption, the hourly dose to a crew of four was estimated to be 5.5×10^{-4} person-rem. The flight times from Uruguay with an intermediate stop (if necessary) or from Argentina to Miami would be similar, approximately 10 hours. For this SA, the dose to the aircrew was calculated including a layover of one hour in Santiago plus another hour total for pre-flight and post-flight activities in Montevideo and Miami, respectively. Therefore, it was estimated that the aircrew would be exposed to the sealed sources for approximately 12 hours. Using these assumptions, the dose to the crew from shipping the sealed sources from Uruguay would be 6.5×10^{-3} person-rem with an associated risk of approximately 4×10^{-6} LCFs, or a probability of 1 in approximately 250,000 of an LCF among the crew. Similarly, assuming a TI of 10 like that for the Uruguay shipment, the risks from transport from a more distant location would be about a factor of 10 higher than those from the transportation of unirradiated fuel over the same distance (for example, a sealed source shipment from Asia would result in a dose of about 7.6×10^{-3} person-rem and 5×10^{-6} LCFs, or a probability of 1 in approximately 200,000 of an LCF among the crew compared to a similar shipment of unirradiated fuel which would result in a dose of 7.3×10^{-4} person-rem and 4×10^{-7} LCFs, or a probability of 1 in approximately 2.5 million of an LCF among the crew).

Table 2–1 shows the estimated aircrew dose and risk for the air shipment of sealed sources from Uruguay compared to the dose and risk for the shipment of unirradiated research reactor fuel from Argentina. The estimates associated with the shipments from Uruguay are approximately ten times higher than the estimates for shipment of the unirradiated research reactor fuel. However, they remain small in absolute terms, relative to applicable standards, and in terms of potential risk. Also, these dose estimates are relatively small compared to the radiation doses the crew would normally receive from cosmic radiation on a flight of similar duration. Each member of the flight crew would receive approximately 0.6 millirem per hour of cosmic radiation while the plane is in flight. Over 10 hours of flying, a 4 person aircrew would receive a dose from cosmic radiation of approximately 0.024 person-rem with an associated risk of 1×10^{-5} LCFs or a probability of 1 in approximately 100,000 of an LCF among the crew. For a 14-hour flight from a distant location such as Asia, the crew dose from cosmic radiation would be approximately 0.034 person-rem with an associated risk of approximately 2×10^{-5} LCFs or a probability of 1 in approximately 50,000 of an LCF among the crew.

Table 2–1 Comparison of Aircrew Dose and Risk for Selected Commercial Cargo Routes

Scenario	*Airport of Entry*	*Aircrew Dose (person-rem)*	*Aircrew Risk (LCF)*
Unirradiated Reactor Fuel Transport from Buenos Aires, Argentina	Miami International Airport, Miami, Florida	4.8×10^{-4}	3×10^{-7}
Sealed Source Transport from Montevideo, Uruguay	Miami International Airport, Miami, Florida	6.5×10^{-3}	4×10^{-6}

LCF = latent cancer fatality

Once the packages of sealed sources clear customs, they would be transferred to a commercial aircraft or a commercial truck for overland transportation to SwRI in San Antonio. If they were shipped via commercial aircraft to San Antonio from Miami, the crew of that plane would be exposed to the same risks as those discussed above with the exception that the flight time from Miami to San Antonio is shorter, less than 3 hours. Assuming that the aircrew would be exposed for an hour for combined preflight and post-flight activities, the total exposure would be about 4 hours. The dose to a crew of four from shipping the sealed sources via air from Miami to San Antonio would be up to 2.2×10^{-3} person-rem with an associated risk of 1×10^{-6} LCFs or a probability of 1 in approximately 1 million of an LCF among the crew. Similar to the doses associated with the flight from South America to Miami, these doses are relatively small compared to the radiation doses the crew would normally receive on such a flight from cosmic radiation. Over 3 hours of flying, a 4 person aircrew would receive a dose of approximately

7.2×10^{-3} person-rem from cosmic radiation with an associated risk of 4×10^{-6} LCFs or a probability of 1 in approximately 250,000 of an LCF among the crew.

Should the Indian-origin sources be returned to India for final disposition, they would be flown there via commercial aircraft. There are no direct flights from San Antonio to India so it is assumed that the Indian sources would be shipped back to Miami from San Antonio where they would be transferred onto an overseas flight to India. On a flight from San Antonio to Miami, the risks to the crew would be less than the risks discussed above. The estimated doses shown above for the shipment from Miami to San Antonio were based on an assumed TI of 10 for the packages being sent from Uruguay. The TI for two Type A packages containing the Indian-origin sources would be much lower than 10 since only Co-60 sources would be shipped and the TI for the Type B shipping package containing these sources from Uruguay is 0.7; however, for purposes of analysis and to provide a conservative results that would encompass a broader range of shipments, the TI for this shipment is assumed to be 10 (**NPI 2010b**).

At the airport in Miami, the shipping container with the Indian sources would be transferred onto another plane for the flight to India. Because there are no direct flights from Miami to India, it is assumed that the flight would make one stop along the way for refueling and a crew change. For the purposes of this analysis, it is assumed that the flight would make a stopover in Frankfurt, Germany for 1 hour. As a result, the crew of four would be exposed to the package for a total of 10 hours for the leg from Miami to Frankfurt (9 hours in flight and 1 hour on the ground). The dose to a crew of four from shipping the Indian-origin sealed sources via air from Miami to Frankfurt would be up to 5.5×10^{-3} person-rem with an associated risk of 3×10^{-6} LCFs or a probability of 1 in approximately 330,000 of an LCF among the crew.

The final leg of the trip would be from Frankfurt to Mumbai. The crew of four for this leg is assumed to be exposed to the package for a total of 9 hours (8 hours in flight and 1 hour on the ground). The dose to a crew of four from shipping the Indian-origin sealed sources via air from Frankfurt to Mumbai would be up to 4.9×10^{-3} person-rem with an associated risk of 3×10^{-6} LCFs or a probability of 1 in approximately 330,000 of an LCF among the crew.

These doses are relatively small compared to the radiation doses from cosmic radiation the crew would normally receive on such flights. For example, over 9 hours of flying, a 4 person aircrew flying from Miami to Frankfurt would receive a dose from cosmic radiation of approximately 0.022 person-rem with an associated risk of 1×10^{-5} LCFs or a probability of 1 in approximately 100,000 of an LCF among the crew.

2.1.3 Impacts from Air Transportation Accidents

It is possible, although very unlikely, that an aircraft containing sealed sources would have an accident. Two types of accidents were considered with respect to shipment from Uruguay – one is a landing-stall-fire accident that is assumed to occur at Miami International Airport or San Antonio International Airport during landing or takeoff; the other is an in-flight accident that is independent of the airport used. These accidents are representative of the types of air transportation accidents that could occur during the transportation of sealed sources.

Landing-Stall-Fire Accident

The maximum consequence accident would be one where the aircraft stalls and crashes while attempting to land or take off, resulting in a fire from the aircraft fuel. The following assumptions were made regarding the accident:

- The radiological impacts are independent of the type of plane. Rather, the radiological impacts are a function of the plume heat energy, plume height, plume duration, the fraction of the shipped radiological materials released to the environment as respirable particles, the population distribution surrounding the airport, and meteorological conditions.
- The impact and fire would cause failure of all of the transport packages, exposing all of the radiological materials contained in the sealed sources to the fire. This is extremely unlikely because it would require failure of the Type B packaging as well as the special form containment of the sealed sources.

Radiological impacts were calculated as follows:[11]

- Population doses and risks were calculated for the population estimated to be within 80 kilometers (50 miles) of the accident site.
- Individual doses and risks were calculated for a maximally exposed individual (MEI), a hypothetical individual member of the public who would likely receive the maximum dose from an accident. Because this is a public airport, members of the public (including airport workers) could be near the crash location; a distance of 100 meters (330 feet) from the accident site was assumed.

Impacts to members of the flight crew are not explicitly evaluated in this SA. In a landing-stall-fire accident that causes enough damage that the transportation packages leak, crew members may suffer fatalities from the crash. If the flight crew members survived the crash, they are trained to respond in the event of an accident. They would evacuate the plane and move away from the crash site, getting away from the potential source of radiation.

The analysis of the airborne release from this accident was conducted using the MELCOR Accident Consequence Code System, Revision 2, Version 1.13.1 (MACCS2). Doses were calculated due to inhalation of airborne material and external exposure to the passing plume. These represent the major portion of the dose that an individual would receive as a result of an aircraft accident.[12]

MACCS2 input parameters were all set to maximize the calculated dose and produce a conservative radiological consequence to the public. Key input parameters that were set to result in higher calculated doses included plume heat energy, plume height, plume duration, and the fraction of available radioactive material that was released to the environment as respirable particles. No credit was taken for emergency response evacuations or temporary relocation of the public.

In sealed sources used in medical applications like those in the shipment from Uruguay, Cs-137 is in the form of a salt powder, cesium chloride, while Co-60 is in the form of metallic cobalt or a metal alloy (**ANL 2005, NRC 2008**). An aircraft fuel fire would be expected to melt, but not disperse respirable particles of cobalt-60 because of its metallic form and high boiling temperature of 5,301 °F (2,927 °C)

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[11] *The impacts of an accident on the aircrew are not evaluated quantitatively. No adequate method exists for calculating meaningful consequences at or near the location where the accident might occur. The aircrew could be killed in the crash; if they survive the crash, they would be fully trained in emergency procedures, including response to potential accidents.*

[12] *The longer-term effects of radioactive material deposited on the ground after a postulated accident, including the re-suspension and subsequent inhalation of radioactive material and the ingestion of contaminated crops, were not modeled. Re-suspension pathways are typically much smaller than those involving inhalation of airborne material and external exposure to the passing plume. Pathways involving ingestion of contaminated crops would be controlled. (Assuming such an accident occurred, a radiological response action would occur. Both short- and long-term potential impacts [e.g., from food consumption] would be assessed and interdicted if they exceeded established requirements.) Hence, the deposition velocity of the radioactive material was set to zero for purposes of the MACCS2 model, so that material that might otherwise be deposited on surfaces remains airborne and available for inhalation. Thus, the method used in this assessment is conservative compared with dose results that would be calculated if deposition and re-suspension were taken into account.*

(American Elements 2010). Conversely, the physical form of the Cs-137 would be expected to result in an airborne dispersion of respirable particles.

Based on the physical and chemical form of the Cs-137, an airborne respirable fraction of 6.0×10^{-5} **(DOE 1994b)** would be released to the atmosphere due to the fire. The loss of Type B package shielding due to this accident would expose both the Cs-137 and the Co-60. Cs-137 emits a 0.66 megaelectron-volt (MeV) gamma ray and Co-60 emits 1.17 and 1.33 MeV gamma rays. Thus, the landing-stall-fire accident results in two human health radiological exposure modes: airborne respirable particles and direct gamma radiation. Assuming that the entire payload of Cs-137 and Co-60 were exposed to the environment without any intervening shielding, the dose rate as a function of distance from a point source representing the total payload activity of both radioisotopes was developed. Nobody would be expected to be near enough to the accident location (less than 4 meters [13 feet]) to receive a fatal radiation dose. At the MEI distance of 100 meters (330 feet), the direct radiation dose rate would be about 0.18 rem per hour resulting in a 2-hour exposure of 0.36 rem (an LCF risk of 0.0002 or 1 chance in 5,000 of an LCF).

The high dose rate close to the sources would necessitate appropriate procedures and use of shielding, robots, and other techniques to minimize the radiological impacts to cleanup workers, but would not result in serious effects to members of the public.

An accident was analyzed in the *LANL SWEIS*, in which a sealed source was assumed to be destroyed in a seismic accident, exposing an individual to direct radiation from Co-60. In that accident, it was assumed that a shipping container containing 6,000 curies was breached; it was estimated that a person at a distance of 100 meters (330 feet), would receive a dose of 0.5 rem over a 2-hour period (representing an LCF risk of 0.0003 or approximately 1 chance in 3,300 of an LCF) **(DOE 2008)**.

Also, the *FRR SNF EIS* included an analysis of consequences versus distance as a result of direct radiation exposure from an intentional destructive act that breached a spent fuel cask, exposing a much larger amount of radioactive material than would be contained in any shipment of sealed sources under the Proposed Action. The *FRR SNF EIS* analysis estimated that a person at a distance of 100 meters (330 feet) would receive a dose of approximately 20 rem per hour **(DOE 1996a)**. If the person were exposed for 2 hours, the dose would be approximately 40 rem (representing an LCF risk of 0.048 [13] or approximately 1 chance in 20 of an LCF).

The MACCS2 code was used to calculate doses and risks to an MEI and the population within 80 kilometers (50 miles) due to a release of respirable Cs-137 associated with the landing-stall-fire accident at Miami International Airport or San Antonio International Airport. Based on the total respirable release fraction for cesium chloride powder, the source term is 0.0287 curies of Cs-137. Because the amount of aircraft fuel that would result in a fire engulfing the Cs-137 could be a range of values, a plume sensitivity study was performed using plume energies of 1×10^4, 1×10^5, 1×10^6, 1×10^7, and 1×10^8 watts; the plume energy that resulted in the largest impacts was used in the analysis. The commercial cargo aircraft frequency for a landing-stall-fire accident is 4.5×10^{-6} per landing **(DOE 2005)**.

Table 2–2 shows that the collective dose to the population within an 80-kilometer (50-mile) radius of Miami International Airport would be approximately 0.019 person-rem (1×10^{-5} LCFs). This is equivalent to about 1 chance in 100,000 of a single excess cancer fatality in the population if such an accident were to occur. The risk of a cancer fatality is much smaller (about 5×10^{-11} or 1 chance in 20 billion) when considering the 4.5×10^{-6} estimated frequency of accident occurrence. The collective dose to the population within an 80-kilometer (50-mile) radius of San Antonio International Airport would be approximately 0.014 person-rem (8×10^{-6} LCF). This is equivalent to about 1 chance in

[13] *For individual doses in excess of 20 rem, the risk factor of 0 0006 LCFs per rem is doubled* ***(NCRP 1993)***.

125,000 of a single excess cancer fatality in the population if such an accident were to occur. The risk of a cancer fatality is much smaller (about 4×10^{-11} or 1 chance in 25 billion) when considering the estimated frequency of accident occurrence. At either airport, the accident dose to the MEI, located 100 meters from the accident, would be 1.5×10^{-5} rem. The risk to the MEI of an LCF would be 9×10^{-9}, about 1 chance in 110 million that the MEI would develop cancer if the accident were to occur. Including the estimated frequency of such an accident occurring, the risk to the MEI would be negligible.

Table 2–2 Landing-Stall-Fire Accident Airborne Release Radiological Impacts from Transport of Sealed Sources from Uruguay

Receptor	*Impact*
Population Impacts within 50 Miles of Miami International Airport	
Total population dose (person-rem) [a]	0.019
Population LCF [b]	1×10^{-5}
Population risk [c]	5×10^{-11}
Population Impacts within 50 Miles of San Antonio International Airport	
Total population dose (person-rem) [d]	0.014
Population LCF [b]	8×10^{-6}
Population risk [c]	4×10^{-11}
MEI Impacts at either Miami or San Antonio International Airport	
Dose at 100 meters (330 feet) (rem)	1.5×10^{-5}
LCF assuming accident occurs [b]	9×10^{-9}
MEI risk [c]	4×10^{-14}

LCF = latent cancer fatality, MEI = maximally exposed individual.

[a] Data from 2000 Census (**Census 2001, 2002**) increased by 11 percent to reflect the estimated growth in Miami-Dade, Broward, and Palm Beach Counties through 2009 (**Census 2009a**).

[b] Based on a conversion from radiation dose of 0.0006 LCF per rem. These estimates of LCFs assume the accident occurs.

[c] Risk includes consideration of the estimated frequency of the accident occurring (4.5×10^{-6}).

[d] Data from 2000 Census (**Census 2001, 2002**) increased by 23 percent to reflect the estimated growth in Bexar, Hays, Comal, and Guadalupe Counties through 2009 (**Census 2009a**).

The total dose to the MEI and population would be the sum of doses from direct gamma radiation and the airborne radiation that would result from the release of respirable cesium. As shown in **Figure 2–1**, the direct gamma dose rate would decrease rapidly with distance; for example, at a distance of about 200 meters (660 feet), the dose rate would be less than 0.1 rem per hour. Because of the buffer area between runways (where the accident might occur) and residential areas, the distance, intervening structures, and the radiation attenuation of air would greatly reduce the dose from direct radiation to the offsite public. Therefore, the population dose would be dominated by the airborne plume of Cs-137, whereas the MEI dose would be dominated by direct gamma radiation because of the assumed proximity (100 meters [330 feet]) of the MEI to the sources and the lofting effect of a fire energy plume of respirable Cs-137. The maximum total doses and risks to the MEI and population from both direct gamma radiation and airborne respirable Cs-137 are presented in **Table 2–3**. These impacts can be compared to those in the *Unirradiated Research Reactor Fuel EA* (**DOE 2005**) for a landing-stall-fire accident at Miami International Airport that would result in a population dose of 0.0787 person-rem, with an associated risk of an LCF of 5×10^{-5} if the accident were to occur. When the estimated frequency of the accident was taken into account, the risk of an LCF was estimated to be 2×10^{-10}.

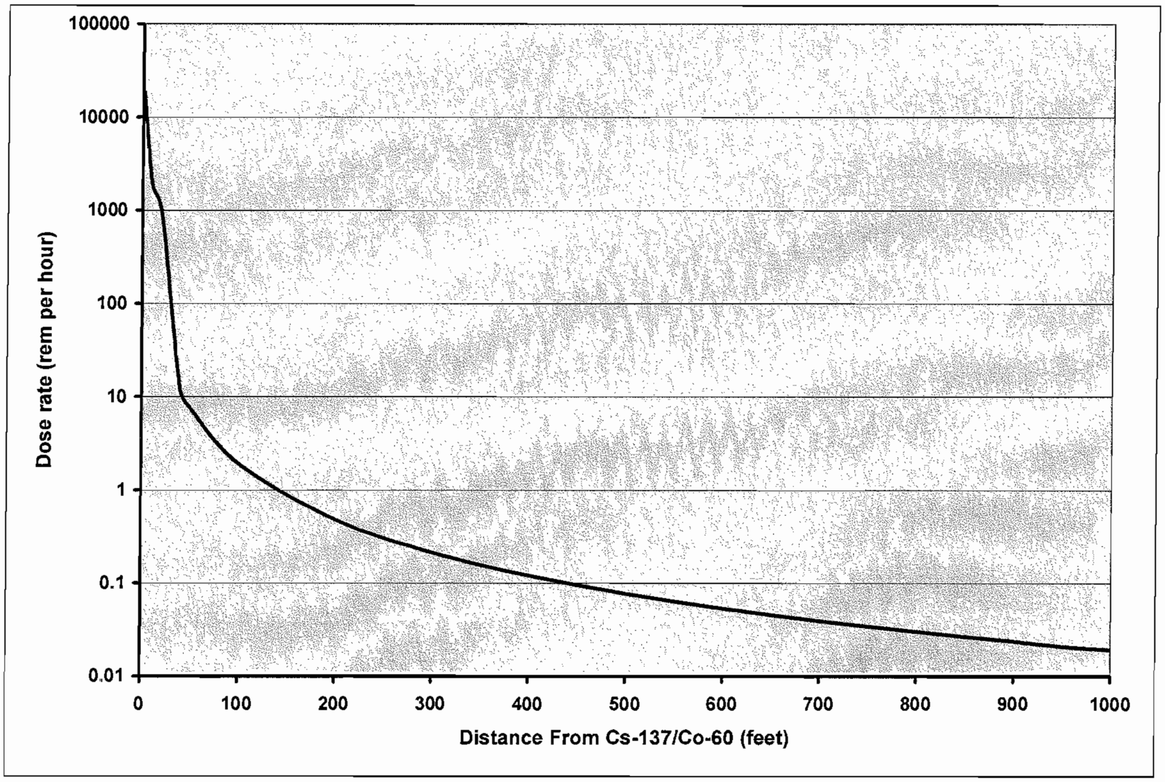

Figure 2–1 Landing-Stall-Fire Accident Direct Gamma Dose Rate

Table 2–3 Landing-Stall-Fire Accident Total Radiological Impacts from Transport of Sealed Sources from Uruguay

	MEI at 100 Meters (330 feet) [a]		*80-Kilometer (50-mile) Population* [a]	
Airport	***Dose (rem)***	***LCF Risk*** [b]	***Dose (person rem)***	***LCF Risk*** [b]
Miami	0.36	1×10^{-9}	0.019	5×10^{-11}
San Antonio			0.014	4×10^{-11}

LCF = latent cancer fatality, MEI = maximally exposed individual.

[a] Total radiological impacts include doses from direct gamma radiation and from airborne releases. For the MEI, the dose is dominated by direct gamma radiation; for the population, the dose is dominated by the airborne release.

[b] The LCF risk includes a dose-to-risk factor of 0.0006 LCFs per rem and the 4.5×10^{-6} estimated frequency of the accident occurring

In the event the Indian-origin sources are returned to India for final disposition, the doses from a possible landing-stall-fire accident at the airport in San Antonio or Miami would be less than the doses shown in Table 2–3 because a much smaller amount of radioactive material would be at risk. The Indian sources include approximately 17 curies of Co-60 and no Cs-137 as opposed to the accident analyzed above for the sources being shipped from Uruguay (including the Indian sources) which include approximately 2,600 curies of Co-60 and 480 curies of Cs-137.

In-flight Accident

A methodology for evaluating the potential impacts of an in-flight accident to a generic urban population while flying over U.S. territory has been developed (**DOE 1994a**). The estimated frequency of an in-flight accident occurring is a function of the amount of time flown over U.S. territory. For example, the estimated frequency of an in-flight accident, considering both the over-land distance to Miami and the distance from Miami to San Antonio, is about 2×10^{-9}, much lower than the estimated frequency of a landing-stall-fire accident (4.5×10^{-6}). A conservatively long distance of travel over the continental United States would be 3,000 miles. The estimated frequency of an in-flight accident over this distance would be less than 4.5×10^{-9}. The estimated frequency of an in-flight accident is well below the 1×10^{-7} level that DOE typically considers as a reasonably foreseeable accident (**DOE 2002**).

2.2 Airport Ground Operations Impacts

Upon arrival at Miami International Airport or any international airport in the United States that could receive sealed source shipments from overseas, the packages containing sealed sources would be unloaded from the aircraft by cargo carrier personnel and placed into a warehouse pending customs clearance. The packages would be placed in a secluded area of the warehouse set aside for hazardous (including radioactive) materials and could remain there for two to three days before they receive customs clearance. Once the packages clear customs, they would be loaded onto a domestic cargo aircraft or a commercial truck for transport to San Antonio. The individuals who unload and load packages would receive some radiological exposure. Additionally, other workers who enter the warehouse while the packages are in storage (cargo handlers, security personnel) could also receive a radiological exposure although the packages would be stored in a secluded, low-traffic area. For safety and security reasons, members of the general public (e.g., not warehouse workers) would not be in the cargo handling areas of the airport or the warehouse. Therefore, they would not be expected to be closer than a few dozen meters to the packages and only for brief periods, so under incident-free conditions the dose to members of the public would be essentially immeasurable.

The estimated incident-free handling dose rate to a representative worker unloading and loading such packages with a TI of 10 would be approximately 11 millirem per hour. In the case of the shipment from Uruguay, there would be only three packages, and it was conservatively assumed that it would take 1.5 hours total to remove the packages from the incoming aircraft, place them into the customs warehouse, remove them from the customs warehouse, and load them onto a domestic cargo aircraft or truck and that two handlers would be involved in the operation. The worker dose would be approximately 0.034 person-rem. Assuming that any other workers would be approximately 10 meters (33 feet) from any packages, the dose to a typical individual was estimated to be 0.6 millirem per hour. Assuming three other workers would be present, their collective dose would be approximately 2.7×10^{-3} person-rem. The dose to all five workers would be about 0.036 person-rem, with an associated risk of an LCF of about 2×10^{-5} (1 chance in 50,000).

If the decision is made to return the Indian-origin sources to India, similar doses would be received by the cargo handlers working with the one or two shipping containers that would be used for the Indian sources. Cargo handling would be needed to load the packages onto the plane in San Antonio, and to unload the packages from the plane in Miami and transfer them onto another plane bound for Mumbai. Once the plane was unloaded in Mumbai, cargo handlers would be exposed once again (the activities performed under the auspices of and in another country are not the subject of this analysis). Because there would be at most 2 packages involved with these shipments as opposed to the three packages from Uruguay, and the total surface dose rates would be lower, the doses for each set of cargo handlers at the different airports would be less than those presented above.

The estimated dose rate for a worker incidentally exposed during the unloading and loading operation of 0.6 millirem per hour can also be used to provide a conservative estimate of the potential dose to a worker while the packages are in storage. Assuming the packages would be in storage for 3 days and a worker is exposed to 0.6 millirem per hour for an entire work shift each of those days, the dose would be about 14 millirem; this corresponds to an increased risk of an LCF of 9×10^{-6} (1 chance in 110,000). This estimated dose is extremely conservative and would be mitigated by a number of factors. The location for hazardous (including radioactive) materials is in a secluded location in the warehouse so it is not near areas normally occupied by workers. Workers would not be in a single location throughout a shift that would result in a constant exposure rate. A warehouse worker would be moving material into or out of the warehouse and security personnel would move around the warehouse making rounds. In addition, the other cargo in the warehouse would serve as shielding at any time it was between workers and the storage location.

2.3 Ground Transportation

DOE has broad authority under the Atomic Energy Act of 1954, as amended, to regulate all aspects of activities involving radioactive materials that are undertaken by DOE or on its behalf, including the transportation of radioactive materials. The NRC and DOT have primary responsibility for Federal regulations governing commercial radioactive material transportation in the United States. DOE works with DOT and NRC in developing requirements and standards for radioactive material transportation. All DOE shipments meet or exceed the requirements and standards of the NRC and DOT, unless national security or another critical interest requires different action.

After 2001, the NRC, in coordination with IAEA, identified 16 radioactive materials (including Co-60, Sr-90, Cs-137, and Ra-226) that in certain quantities could pose a threat in the hands of terrorists. Above certain threshold levels, these 16 are now referred to as Radioactive Materials in Quantities of Concern (RAMQC). The quantity of Co-60 in the sealed sources in the representative shipment from Uruguay makes this a shipment of RAMQC. The carrier of RAMQC is required by NRC to implement additional security measures beyond those otherwise required for radioactive materials shipments. Requirements for security during transport of the sealed sources would include:

- verifying that the recipients of the shipment are authorized to receive the material;
- coordinating the expected departure time and arrival time of the shipment;
- confirming receipt of the shipment;
- using carriers that have continuous and active monitoring systems;
- assuring the trustworthiness and reliability of the drivers and other personnel with knowledge of the shipment;
- maintaining constant control or surveillance during shipment;
- providing a communications center that has the capability to continuously and actively monitor in-progress shipments;
- monitoring the shipment with a telemetric position monitoring system that communicates with the communications center or is equipped with an alternative tracking system that communicates position information to the communications center;
- ensuring redundant communications to allow the carrier to be able to contact the communications center at all times;
- pre-planning and coordinating with the state agencies along the shipment routes;
- providing at least 7 days advance notice of the shipment to the NRC and the affected states;
- initiating an investigation if the shipment does not arrive at the expected arrival time;
- if the shipment becomes lost, stolen or missing, immediately notifying the NRC Operations Center and local law enforcement agencies and the appropriate Agreement State regulatory authority[14] (NNSA would also be notified if a shipment was lost, stolen, or missing);

[14] *NRC provides assistance to States expressing interest in establishing programs to assume NRC regulatory authority under the Atomic Energy Act of 1954, as amended. Section 274 of the Act provides a statutory basis under which NRC relinquishes to the*

- developing policies and procedures for proper handling and protection against unauthorized disclosure of transportation security information; and
- developing normal and contingency procedures to cover notifications, communications protocols, loss of communications, and response to actual, attempted, or suspicious activities related to theft, loss, diversion, or sabotage of a shipment.

The following analysis summarizes the impacts associated with transporting the sealed sources by commercial truck from Miami International Airport to a licensed facility in San Antonio. If the sealed sources were transported by aircraft to San Antonio, the ground transportation impacts from the airport to SwRI would be much less than those presented below. This analysis was derived from a similar analysis in the *LANL SWEIS*, which was performed using the RADTRAN (updated herein to use Version 6 rather than Version 5 used for analysis in the *LANL SWEIS*) and RISKIND Version 2.0 computer codes. The truck accident and fatality rates were adjusted to correct an underreporting of accident data used in the analysis for the *LANL SWEIS*.[15] This adjustment increases the accident and fatality rates by a factor of 1.64, and 1.57, respectively (**UMTRI 2003**).

The *LANL SWEIS* analyzed shipments of sealed sources containing Cs-137 and Co-60 from Bangor, Maine to LANL as a representative route for shipments of sealed sources that may be recovered as part of the OSRP. In the *LANL SWEIS*, the shipments were assumed to contain 10,000 curies of Cs-137 or 6,000 curies of Co-60.[16] The distance from Bangor to LANL is 4,072 kilometers (2,530 miles), a longer distance than from Miami to San Antonio (2,265 kilometers [1,400 miles]). However, because of differences in population densities along the routes and the number of packages included in the shipments, the doses associated with the incident free transportation of sealed sources to LANL from Bangor as analyzed in the *LANL SWEIS* and those associated with the shipment of the Uruguayan sealed sources from Miami to San Antonio would be comparable. The crew dose for the Uruguayan sealed sources transport is smaller primarily due to the assumed placement of the packages 6 meters (20 feet) from the crew (approximately in the center of the trailer), compared to the 3-meter (10-foot) distance assumed in the *LANL SWEIS* analysis. Actual placement would depend on factors such as direction dictating where to place the package(s), ease of loading/unloading, and whether other items are being transported.

The impacts are presented in terms of the collective dose in person-rem resulting in excess LCFs. Similar to the assumption used in the *LANL SWEIS*, the analysis assumes an external dose rate of 10 millirem per hour at a distance of 1 meter (3.3 feet) from the trailer transporting the packages. The proposed overland transport of sealed sources analyzed in this SA involves three sealed source packages per transport from Miami to San Antonio and two packages from Miami to Canada should the decision be made to send some of the sources back to Canada. If the sealed sources meet the NNSS waste acceptance criteria, it is assumed that transportation to NNSS could be accomplished in one large package.

There are several makes and models of certified Type B transportation packages that include sealed sources (or activated metal) as allowable content on their Certificates of Compliance (CoC). Certified Type B packages list specific devices as content and cannot be used for the transport of sources and source-containing devices beyond those specifically referenced in their CoC. Some licensed contractors

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States portions of its regulatory authority to license and regulate byproduct materials (radioisotopes); source materials (uranium and thorium), and certain quantities of special nuclear materials.

[15] *The main source of transportation accident and fatality rates for the LANL SWEIS is Saricks and Tompkins (ANL/ESD/TM-150), which is based on Motor Carrier Management Information System (MCMIS) data for the years 1994-1996. The University of Michigan Transportation Research Institute (UMTRI) found the MCMIS data to under report accident data (see the UMTRI 2003-6, "Evaluation of the Motor Carrier Management Information System Crash File, Phase 1").*

[16] *The LANL SWEIS also evaluated the shipment of Sr-90 from Bangor, Maine to LANL. However, this shipment represented a much larger source (183,400 curies) than the potential shipments of Sr-90 envisioned under the Proposed Action analyzed in this SA (less than 10 curies)*

and device manufacturers use specification Type B packages for which the allowable content is not listed in a CoC. OSRP relies on the use of a variety of containers and a variety of subcontractors using applicable certified containers. External dose rates on all of the containers are typically comparable and are always below the regulatory limits. Analysis in this SA with respect to the representative shipment from Uruguay assumes use of two specific containers: CNS 10-160-B for shipments from SwRI to NNSS and the 9215/B(U) (NPI 20 WC-6 MKII) for shipments from SwRI to Alexandria Bay, New York. The CNS 10-160B is a large transportation cask and is capable of holding 10 55-gallon drums of radioactive material with a total weight of more than 6,350 kilograms (14,000 pounds).

Table 2–4 shows the collective crew (2 people) and public doses and risks for transporting the Uruguayan sealed sources from Miami to San Antonio using a commercial truck. The table also shows the increased risk from traffic accidents (without release of radioactive material) and radiological accidents (in which radioactive material is released). Considering the information presented in Table 2–4, transporting Uruguayan sealed sources to San Antonio using a commercial truck would be unlikely to cause doses exceeding 100 millirem in a year[17] to any individual member of the public or a transport crewmember and no fatalities would be expected as a result of an accident involving these shipments. For comparison, Table 2–4 shows the potential impacts from the transport of Cs-137 and Co-60 sources from Bangor, Maine to LANL. These impacts reflect a reanalysis of the sealed source transport in the *LANL SWEIS* using a more recent version of the RADTRAN computer code and adjusting for the underreporting of traffic accident and fatality rates (**UMTRI 2003**).

Table 2–4 Radiation Dose and Latent Cancer Fatality Risk for Overland Transport of Sealed Sources to Storage Facilities

			Crew		*Public*		*Accidents* [a]	
Sealed Source Isotope	***Route***	***One-Way Distance (kilometers)***	***Dose (person-rem)***	***Risk (LCF)***	***Dose (person-rem)***	***Risk (LCF)***	***Risk (LCF)***	***Risk (traffic fatalities)***
Cesium-137	Bangor to LANL [b]	4,072	0.35	2×10^{-4}	0.023	2×10^{-5}	4×10^{-12}	1.4×10^{-4}
Cobalt-60	Bangor to LANL [b]	4,072	0.35	2×10^{-4}	0.023	2×10^{-5}	3×10^{-12}	1.4×10^{-4}
Cesium-137 & Cobalt-60	Miami to San Antonio	2,265	0.058	3×10^{-5}	0.026	2×10^{-5}	$2 \text{ x } 10^{-12}$	8.2×10^{-5}

LANL = Los Alamos National Laboratory, LCF = latent cancer fatality.

[a] Reported values incorporate adjustments for previous underreporting (UMTRI 2003). Risk from traffic fatalities includes analyzing a return trip equal to the one-way distance.

[b] Transportation analysis from the *LANL SWEIS* (DOE 2008) has been updated using RADTRAN 6, the most recent version of the software.

Note: To convert kilometers to miles, multiply by 0.62137.

Table 2–5 shows the collective crew (2 people) and public doses and risks for truck transportation of the Uruguayan sealed sources from San Antonio to the Canadian border and from San Antonio to NNSS. Canada would be responsible for any environmental analysis for shipment of the sealed sources within Canada. The table also includes the increased risk from traffic accidents (without release of radioactive material) and radiological accidents (in which radioactive material is released) associated with such shipments. Considering the information presented in Table 2–5, transporting Uruguayan sealed sources to San Antonio would be unlikely to cause doses exceeding 100 millirem in a year to any individual member of the public or a transport crewmember and no fatalities would be expected as a result of an accident involving these shipments.

[17] *See 10 CFR 20.1301 for NRC's standards for Radiation Dose Limits for Individual Members of the Public.*

Table 2–5 Radiation Dose and Latent Cancer Fatality Risk for Overland Transport of Sealed Sources to Potential Disposition Sites

			Crew		*Public*		*Accidents* [a]	
Sealed Source Isotope	***Route***	***One-Way Distance (kilometers)***	***Dose (person-rem)***	***Risk (LCF)***	***Dose (person-rem)***	***Risk (LCF)***	***Risk (LCF)***	***Risk (traffic fatalities)***
Cesium-137 & Cobalt-60	San Antonio to Alexandria Bay, NY [b]	3,044	0.078	5×10^{-5}	0.035	2×10^{-5}	2×10^{-12}	1.1×10^{-4}
Cesium-137 & Cobalt-60	San Antonio to NNSS [c]	2,266	0.14	8×10^{-5}	0.037	2×10^{-5}	7×10^{-16}	7.0×10^{-5}

LCF = latent cancer fatality, NNSS = Nevada National Security Site.

[a] Reported values incorporate adjustments for previous underreporting (UMTRI 2003). Risk from traffic fatalities includes analyzing a return trip equal to the one-way distance.

[b] Transport from the storage facility in San Antonio to the port of departure from the United States for transporting sealed sources to AECL Canada in two 20WC-6 MkII (9215/B(U)) packages.

[c] Transport from the storage facility in San Antonio to NNSS in a single CNS 10-160B cask.

Note: To convert kilometers to miles, multiply by 0.62137.

Because the estimated dose is a function of package characteristics (the side-view length and crew-view diagonal length), and the CNS 10-160B cask (which could be used for shipments to NNSS) is both wider and taller than an array of two 20WC-6 MkII (9215/B(U)) packages (the package planned to be used for shipment to the United States, from the airport to the storage facility, and from the storage facility to Canada) (see **Figure 2–2**), the doses from the transport of sealed sources in the CNS 10-160B cask would be higher (for the same TI) than those for transport in the 20WC-6 MkII. Therefore, even though the distance to NNSS is less than the distance to Alexandria Bay, New York, the dose to the crew and the public would be larger for transport to NNSS if the CNS 10-160B package were used.

Similar doses would be expected to result from the incident-free shipment of sealed sources if the sealed sources were transported from other locations in the United States to SwRI. The resulting doses would largely be a function of the distance traveled and the distance traveled would likely be less than the distance assumed in the *LANL SWEIS* (Bangor, Maine to LANL). In all cases, the shipments would have to meet NRC and DOT regulations governing commercial radioactive material transportation in the United States. The shipping containers would have to be certified and the external doses from any container proposed to be loaded with sealed sources would have to be within the regulatory limit of 10 millirem per hour at 1 meter (3.3 feet) from the surface of the container although it is likely that the actual doses would be much lower than the limit.

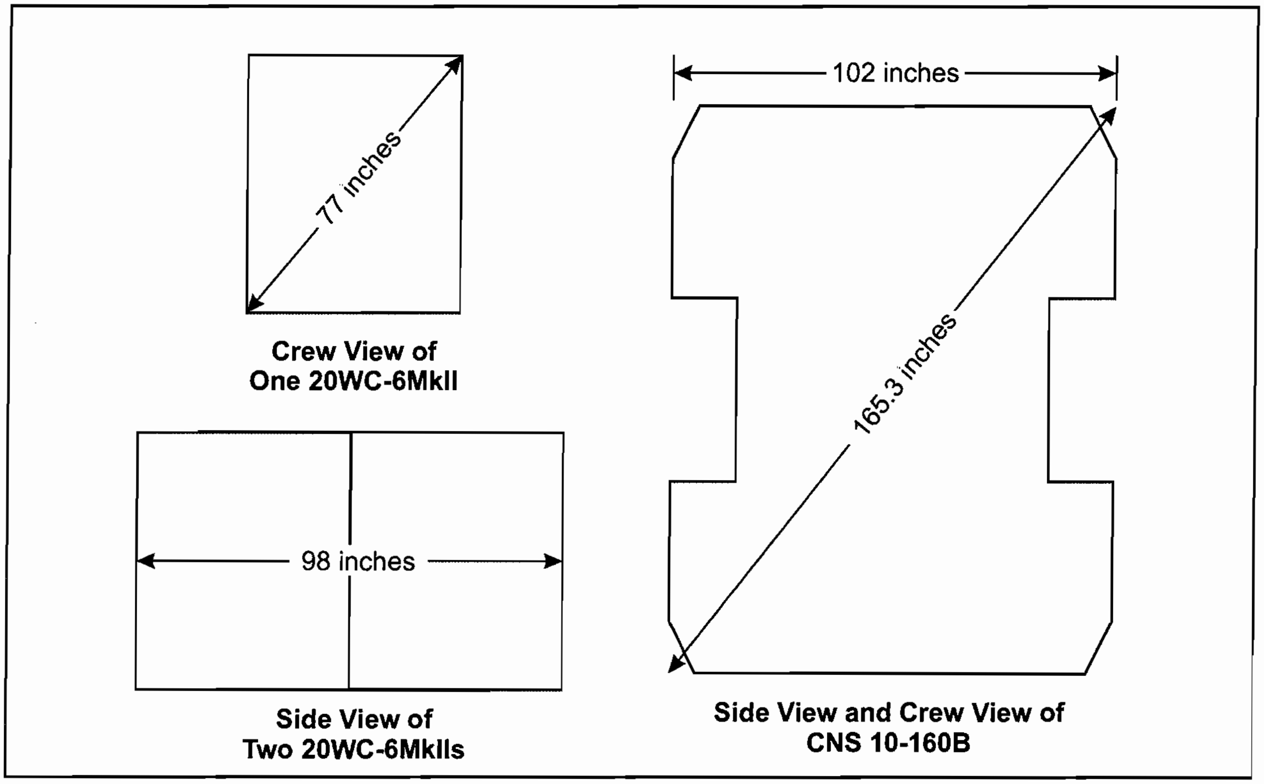

Figure 2–2 Comparison of the Characteristic Lengths of a CNS 10-160B Package and 20WC-6 MkII Packages

2.4 Storage Site

SwRI has been licensed by the Texas Department of State Health Services (acting under its State Agreement with NRC) to receive, store, and transfer to authorized recipients Co-60 and Cs-137 in sealed sources (**TDSHS 2009a**). SwRI also is able to receive any radionuclide (including Co-60, Cs-137, Ra-226, and Sr-90) in quantities incident to decommissioning or decontaminating sealed sources (**TDSHS 2009b**)[18]. Because SwRI handles RAMQC, personnel at SwRI with unescorted access to such materials are subject to Federal Bureau of Investigation identification and criminal history records checks and fingerprinting under NRC orders. The Texas Department of State Health Services inspected SwRI in 2008 and "determined that the [NRC] requirements for increased security of radioactive material quantities of concern appear to be in compliance" (**TDSHS 2008c**). The security features of the facilities used for sealed source management have been reviewed directly by NRC also (**NRC 2010**).

In addition, during the procurement process for storage and related services, OSRP ensures that the storage facilities to be used have current NRC or Agreement State licenses for storage of the material recovered by OSRP. OSRP also confirms that licensed potential storage contractors (or existing contractors, in the case of an option year addition on an existing contract) are in acceptable compliance status with their regulator and have no unaddressed notices of violation. OSRP would only ship sources to a facility for storage if the facility has adequate existing storage capacity and necessary capabilities at the time of the proposed shipment.

[18] *The expiration date on SwRI License No L 00775-000, Amendment 79, was December 31, 2010 SwRI made timely application for a license extension, so the license remains in effect while the Texas Department of State Health Services processes the application.*

The potential radiological impacts to workers and the public associated with management of sealed sources at SwRI are managed using technical and administrative controls included in SwRI's radioactive materials license. By definition, sealed sources do not spread radioactive material.[19] Consequently, SwRI is not required to have any environmental discharge permits (air emission or liquid discharges) for the facilities in which it manages the sealed sources, including the hot cell facility. Compliance with dose limits for members of the public and nonradiation workers is demonstrated through records of radiation surveys and knowledge of the occupancy time of particular areas. Compliance with dose limits for radiation workers is demonstrated using the results of personal dosimeters.

At SwRI, surveys are performed periodically to assure that the dose to an individual (nonradiation worker or visitor) 30 centimeters (1 foot) from the radiological materials storage building wall or the fence around the storage areas would not exceed 100 millirem annually under expected occupancy (**SwRI 2010a**). Areas around storage locations are designated into 3 categories, fully occupied (40 hours per week), partially occupied (2 hours per day), or occasionally occupied (0.5 hours per day). SwRI personnel maintain radiation survey data and control the allowable dose rate in each of these areas to maintain doses below 100 millirem per year (**TDSHS 2008a**). The SwRI property fence line is 260 to 340 meters (850 to 1,200 feet) or more from the buildings in which sealed sources are stored. Because SwRI controls dose rates to maintain doses to low levels near the storage locations, the dose to a person at the fence line would be well below the 100-millirem annual dose limit for exposure of a member of the public. SwRI would manage the dose contribution from the sources from Uruguay by the use of shielding and the location in which they are stored. The surveys as described above would continue to be used to maintain doses to nonradiation workers and the public below 100 millirem per year.

Radiation doses to the approximately 300 SwRI radiation workers are generally minimal. Less than 40 of the SwRI radiation workers have had an annual dose of more than 10 millirem in any given year. In 2008, the highest whole body exposure of any SwRI hot cell worker was 742 millirem (**SwRI 2010b**). The Texas State Department of State Health Services (TDSHS) performs compliance inspections with respect to SwRI's operations regarding its radiation safety program as it pertains to current authorizations, adequate recordkeeping, and conformance to approved operating and safety procedures. Inspections in 2004, 2006, and 2008, indicated that SwRI's "radiation safety program, as it pertains to current authorizations, adequate recordkeeping, and conformance to approved operating and safety procedures, appears to be in compliance" (**TDSHS 2005, 2006, 2008b**). In 2010, TDSHS issued a Notice of Violation because a physical sealed source inventory was not conducted and documented at the required interval; the agency later accepted SwRI's proposed corrective actions (**SwRI 2011, TDSHS 2010, 2011**).

While in storage at SwRI, the Indian-origin sources would be inspected in SwRI's hot cell to assure Indian representatives that the sources originated in India. SwRI's hot cell consists of 1.2-meter (4-feet) thick high-density concrete shielding and 1-meter (40-inch) lead glass viewing windows. To allow for this inspection, the end of the special-form capsule, into which the Indian-origin sealed sources were placed in Uruguay to expedite shipping, would be cut off in the hot cell using a remotely operated band saw and the sources would be removed from the capsule. SwRI estimates that the total worker dose would be less than 1 millirem (**SwRI 2010c**). This operation does not damage the sealed sources themselves and they remain intact after being removed from the special-form capsule. Therefore, there would be no release of radioactive materials and no dose to the public.

For the purposes of this analysis, two accidents scenarios were hypothesized that would be representative of accidents involving sealed sources at a storage location. In the first accident it is assumed that the sealed sources are breached in the process of cutting the end off of the special-form capsule. The result would be the release of a fraction of the Co-60 inventory to the interior of the hot cell. Because Co-60

[19] *Sealed source means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material (10 CFR 30.4)*

sources are metallic, little of the material would be expected to become airborne. If any radioactive material did become airborne (from any of the sealed sources), the high-efficiency particulate air (HEPA) filters installed on the hot cell exhaust would prevent any significant release of material to the environment. As a result, there would not be any expected dose to the public from this accident. Also, the shielding provided by the hot cell would be expected to limit doses to the involved workers. During a previous accident at SwRI, approximately 3,000 curies were released in the hot cell, and there was no appreciable public or worker dose from the accident (**SwRI 2010c**).

The second accident scenario in the hot cell was also assumed to take place during the cutting operation. It was assumed that a fire starts in the hot cell during the cutting operation and spreads to combustible materials present in the hot cell, such as paper used for contamination control on the bench top and/or wood pallets on which the shielded container was placed. The fire is assumed to be large enough to ignite the facility's HEPA filters, releasing radioactive material that has accumulated on the HEPA filters prior to the accident. A number of conservative assumptions are included in this accident scenario to ensure that the resulting estimated dose is conservative. These assumptions include:

- The maximum historical HEPA filter hot spot contamination of 2,000 disintegrations per minute per 100 square centimeters (**SwRI 2010c**) is spread uniformly over the entire surface area of the filters (two 2-foot by 2-foot filters);
- There would be enough combustible material available in the hot cell at the time of the fire to ignite the HEPA filters;
- The fire would result in a release of all of the contamination on the HEPA filters at the time of the fire; and
- All of the contamination from the HEPA filter would be released out of the facility's stack, none of the contamination would plate out or deposit on the downstream duct work or the inside of the stack.

The MACCS2 computer code, Version 1.13.1, was used to calculate doses and risks to an MEI and the population within 80 kilometers (50 miles) of SwRI due to this hot cell accident. The dose to the MEI, located 340 meters from the accident, would be 5.8×10^{-11} rem. The increased risk of an LCF for the MEI would be 3×10^{-14}, or essentially zero. The collective dose to the population would be approximately 1.7×10^{-7} person-rem (1×10^{-10} LCFs). This is equivalent to about 1 chance in 10 billion of an excess cancer fatality in the affected population if such an accident were to occur. The low likelihood of such an accident occurring means risks to the MEI and the affected public would be negligible.

2.5 Disposal Site

The Radioactive Waste Management Complex in Area 5 at NNSS receives and disposes of LLW as part of ongoing operations. Sealed sources already have been disposed at NNSS consistent with the site's waste acceptance criteria, and sealed sources received via OSRP as part of the Proposed Action could only be disposed at NNSS if they meet the NNSS waste acceptance criteria. Based on existing decisions and quantities of LLW disposed at NNSS to date, the Area 5 Radioactive Waste Management Complex could dispose of approximately 425,000 cubic meters (15,000,000 cubic feet) of additional LLW. This is far more than needed to support the Proposed Action. A shipment of sealed sources for disposal represents a very small portion of the number of shipments and quantity of LLW received and disposed of at NNSS annually; in the years 2006 through 2010, about 40,000 cubic meters (1.1 million cubic feet) per year of LLW and mixed LLW were received and disposed at the Area 5 Radioactive Waste Management Complex. The average number of annual shipments during this period was about 1,800. A representative quantity of sealed sources for disposal would be 1 to 2 cubic meters (35 to 70 cubic feet) per shipment.

Work practices for dealing with potentially high-activity beta/gamma sources would maintain worker doses as low as reasonably achievable. The worker doses from receipt and disposal of sealed sources would be a fraction of the annual dose from all LLW and MLLW disposal activities.

2.6 Intentional Destructive Acts

Substantive details of terrorist attack scenarios, security countermeasures, and potential impacts are not released to the public because disclosure of this information could be exploited by terrorists to plan attacks. NNSA has prepared a separate Official Use Only appendix that evaluates the potential impacts of intentional destructive acts related to the transport and management of high-activity sealed sources. One of the goals of the GTRI program is to remove from domestic locations and foreign countries radioactive material that represents potential targets for diversion or terrorist actions and place the material in more secure and protected locations, an action that would significantly reduce health and safety risks to members of the public.

2.7 Cumulative Impacts

The CEQ regulations (40 CFR Parts 1500-1508) define cumulative impacts as the effects on the environment that result from implementing the Proposed Action or any of its alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the other actions (40 CFR 1508.7).

Receipt of these sources from Uruguay would occur as part of ongoing OSRP activities that could involve the recovery and management of similar high-activity beta/gamma sources from about 20 locations (domestic or foreign) annually. Though the origination point for these sources would vary, management of these sources would involve the same types of activities and storage facility as the sources proposed for recovery from Uruguay. The majority of recovered high-activity beta/gamma sources would be from locations within the United States, and some could be recovered from foreign countries.

These shipments would be a small fraction of the shipments of radioactive materials sent across the United States on an annual basis. In 1983, a survey of radioactive materials transportation in the United States was conducted. This survey included NRC, Agreement State licensees, and DOE. Weiner et al. used the survey to estimate collective doses from general transportation. Weiner et al. evaluated eight categories of radioactive material shipments: (1) industrial, (2) radiography, (3) medical, (4) fuel cycle, (5) research and development, (6) unknown, (7) waste, and (8) other. It is estimated that over 1.6 million shipments of radioactive materials are made annually. Based on a median external exposure rate, an annual collective worker dose of 1,400 person-rem and an annual collective general population dose of 1,400 person-rem were estimated (**Weiner et al. 1991**). More recent data implies that the annual number of radioactive materials shipments has increased. The DOE Office of Packaging and Transportation reports an estimated 400 million hazardous materials shipments occur in the United States each year by rail, air, sea, and land. Of these shipments, about three million are radiological shipments (**DOE 2011**).

Packaging of the Uruguay sealed sources is not discussed in this SA because that activity occurred within Uruguay. For recovery of devices containing high-activity sealed sources from locations within the United States, contractors holding the requisite Radioactive Materials Licenses typically would travel to and disassemble the devices at the licensed facility. They then would remove the device's internal shield assembly/head and package it in a certified Type B package or transfer the source(s) from the shielded assembly/head to a certified transportation shield that is part of a Type B package. (The latter would be done, for example, when there is no longer a certified shipping package for the type of device being recovered.) All packaging operations would be conducted according to applicable worker health and safety requirements and standard practices to maintain exposure as low as reasonably achievable.

These packages would then be transported to SwRI where the heads or transportation shields would be removed from the Type B transport packages and placed in a hot cell. SwRI staff would remove the sources from the shields/heads and consolidate them with others in a shielded storage container. The sources would be stored at SwRI as described for the sources from Uruguay, pending transfer back to the originating country (e.g., Canada) or, if no domestic use for the sources is identified, disposal as LLW at NNSS if the sources meet NNSS waste acceptance criteria. There would be no releases of radioactive material associated with management of the sealed sources. The radiological practices in force at SwRI would be expected to maintain doses to onsite personnel not directly involved in hot cell operations below 100 millirem per year; because of distance to the site boundary, doses to the offsite public would remain well below this level. NNSA would not take any action that would pose the individual or cumulative potential to exceed the conditions of SwRI's license or capacity and capability of existing facilities at SwRI.

None of the sources that would be shipped under the OSRP is expected to exceed the radioactivity associated with the 10,000 curies of Cs-137 or 6,000 curies of Co-60 assumed in the transportation analysis in the *LANL SWEIS*, and all of the ground transport distances within the United States would be expected to be within the parameters assumed in the *LANL SWEIS*. As indicated in Section 2.3, the dose estimates for the shipment of sealed sources included in this SA are different than those presented in the *LANL SWEIS* as a consequence of an adjustment to reflect more recent data on traffic accident and fatality rates. However, the dose estimates, and associated LCF risk estimates, remain small. Air transport could be involved in the recovery of sealed sources from foreign countries. The potential impacts of air transport would be of the same types as discussed in this SA – exposure to the flight crew and accidents – and similar in degree. For example, as discussed in this SA, the flight crew's potential for exposure to radiation is in direct proportion to total flight time, which either would be comparable to that assumed in this SA or not sufficiently different to change the overall magnitude of the dose estimates.

3.0 Conclusion

An SA is a DOE document that is used to determine whether a Supplemental EIS or a new EIS should be prepared pursuant to 40 CFR 1502.9(c). This SA analyzes the potential environmental impacts associated with the shipment of sealed sources from domestic or foreign locations to the United States and storage of those sources at a state-licensed facility. As representative of the potential impacts, the shipment of 28 sealed sources containing Co-60 or Cs-137 from Uruguay to the United States, offloading the shipment to a transport vehicle, transporting the sources to a state-licensed facility for storage pending a decision on final disposition, and transportation to a final disposition destination were analyzed. This SA considers the potential impacts of these shipments in the context of NNSA's ongoing recovery efforts for similar high-activity beta/gamma sources.

Doses and risks to workers involved in the representative shipment of sealed sources from Uruguay are summarized in **Table 3–1** for incident free transportation; the values in Table 3-1 are collective doses for the number of personnel indicated. Using an assumed TI of 10 for a Type B shipping package, the largest dose and risk to an individual were estimated to be approximately 0.07 rem and 4×10^{-5} LCF (1 chance in 25,000) to a member of the crew transporting sealed sources from San Antonio to NNSS (the results are based on a CNS 10-160B with an external dose rate of 10 millirem per hour at 1 meter [3.3 feet]; the 28 sealed sources from Uruguay plus others could fit in the transportation container and meet this limit).

Table 3–1 Summary of Doses and Risks to Workers for Selected Cargo Routes and Transportation Operations

Scenario	*Transportation Route*	*Number of Personnel*	*Dose (person-rem)*	*Risk (LCF)*
Sealed source transport from Montevideo, Uruguay	Montevideo, Uruguay to Miami International Airport, Miami, Florida	4	6.5×10^{-3}	4×10^{-6}
Sealed source transport from Miami to San Antonio	Miami International Airport to San Antonio International Airport	4	2.2×10^{-3}	1×10^{-6}
Indian sealed source transport from Miami to Frankfurt, Germany	Miami International Airport to Frankfurt International Airport	4	5.5×10^{-3}	3×10^{-6}
Indian sealed source transport from Frankfurt to Mumbai, India	Frankfurt International Airport to Mumbai International Airport	4	4.9×10^{-3}	3×10^{-6}
Cargo handling at airport	Transfer of shipping containers from aircraft to warehouse to aircraft/truck associated with all of the sources from Uruguay	2	0.036	2×10^{-5}
Commercial truck transportation	Truck transportation from Miami to San Antonio	2	0.058	3×10^{-5}
Commercial truck transportation	Truck transportation from San Antonio to Nevada National Security Site	2	0.14	8×10^{-5}
Commercial truck transportation	Truck transportation from San Antonio to Alexandria Bay, New York	2	0.078	5×10^{-5}

LCF = latent cancer fatality.

Incident-free transport of sealed sources by aircraft would not result in a dose to the general public. Doses and risks to the public from incident-free ground transportation of the sources are summarized in **Table 3–2**. The largest dose and risk to the public from the representative shipment from Uruguay were estimated to be 0.037 person-rem and approximately 2×10^{-5} LCFs (1 chance in 50,000) to the public residing along the transportation route from San Antonio to NNSS should the decision be made to send all of the sources to NNSS for final disposition (the results are based on use of a CNS 10-160B with an external dose rate of 10 millirem per hour at 1 meter [3.3 feet]; the 28 sealed sources from Uruguay plus other sources also meeting the NNSS waste acceptance criteria could fit in the transportation container and meet this limit). The conservative analysis of the shipment from Bangor, Maine to LANL of sealed sources analyzed in the LANL SWEIS would result in a similar population risk, 2×10^{-5}.

Table 3–2 Summary of Doses and Risks to the Public for Incident-Free Transportation

Scenario	*Transportation Route*	*Dose (person-rem)*	*Risk (LCF)*
Commercial truck transportation	Truck transportation from Miami to San Antonio	0.026	2×10^{-5}
Commercial truck transportation	Truck transportation from San Antonio to Nevada National Security Site	0.037	2×10^{-5}
Commercial truck transportation	Truck transportation from San Antonio to Alexandria Bay, New York	0.035	2×10^{-5}

LCF = latent cancer fatality.

Radiological doses and risks to the public as a result of accidents involving these shipments were also analyzed (see **Table 3–3**). The radiological risks in Table 3–3 are based on the inventories associated with the Uruguay sealed sources as a representative shipment of sealed sources under the OSRP. By comparison, the analysis in the LANL SWEIS for shipments of up to 10,000 curies in sealed sources yielded radiological accident risks on the order of 1×10^{-6} to 9×10^{-6}. The largest radiological risk to the population would be from a landing-stall-fire accident at Miami International Airport. When nonradiological risks are included, the largest risk to the public would be a traffic accident involving a truck carrying the shipping containers from San Antonio to Alexandria Bay, New York should such a shipment occur. For this transportation leg, the risk of a fatal traffic accident is estimated to be 5.6×10^{-5} (1 chance in 18,000).

Table 3–3 Summary of Risks to the Public from Accidents

Scenario	*Receptor*	*Risk (LCF)*
Landing-stall-fire accident at Miami International Airport	Population	5×10^{-11}
Landing-stall-fire accident at San Antonio International Airport	Population	4×10^{-11}
Landing-stall-fire accident (either airport)	MEI	1×10^{-9}
Truck transport from Miami to San Antonio	Population	2×10^{-12}
Truck transport from San Antonio to Nevada National Security Site	Population	7×10^{-16}
Truck transport from San Antonio to Alexandria Bay, New York	Population	2×10^{-12}
Hot cell accidents in San Antonio	Population	Negligible
Hot cell accidents in San Antonio	MEI	Negligible

LCF = latent cancer fatality, MEI = maximally exposed individual.

The sealed sources proposed to be stored at SwRI in San Antonio are within the authorized limits for such materials in SwRI's state-issued operating license. Because there would be no release of radioactive materials, there would be no significant impacts expected on the environment in the vicinity of SwRI as a result of storing these sealed sources and others that may be stored there pending a final disposition decision. Members of the public would be placed at no radiological risk during normal operations because of the radiological controls and practices at SwRI. Because all members of the public would be protected from radiological risk, no disproportionately high and adverse radiological risks are expected among low-income and minority populations.

The potential environmental impacts calculated in this SA from shipment of sealed sources from Uruguay are consistent with those for other environmental analyses considering shipments of radiological materials to and within the United States and can be considered representative of similar shipments of sealed sources that may be made in the future under the OSRP. The incident-free ground transportation impacts would be comparable to those calculated for representative ground transportation of sealed sources in the *LANL SWEIS* (public LCF risk of 2×10^{-5}, crew LCF risk of 2×10^{-4}). The radiological risks to the population from an accident during ground transport would be smaller than those for sealed source shipments analyzed in the *LANL SWEIS* (4×10^{-12} LCFs for Cs-137; 3×10^{-12} LCFs for Co-60).

Although the dose impact from air transport of the sealed sources would be larger than that calculated in the *Unirradiated Reactor Fuel Transport EA* for a shipment from Argentina (crew LCF risk of 3×10^{-7}), the dose and risk would still be very small. The consequences and risks to the population from a landing-stall-fire accident would be comparable to those calculated in the *Unirradiated Reactor Fuel Transport EA* (population LCF risk of 2×10^{-10}). The MEI risk from an accident that exposed the sealed sources (LCF risk of 1×10^{-9} or 1 chance in 1 billion) would be far less than that calculated for the rupture of a spent fuel cask as evaluated in the *FRR SNF EIS* (LCF risk of 0.048 or 1 chance in 21).

4.0 Determination

In compliance with DOE NEPA regulations, 10 CFR 1021.314(c), NNSA has analyzed the circumstances relevant to the Proposed Action to transport sealed sources from about 20 locations (domestic or foreign) annually, to SwRI, a licensed commercial storage facility in San Antonio, Texas, where they would be placed in storage pending decisions regarding disposition. Transport and receipt, as well as the storage and/or disposition of these sources would occur as part of ongoing OSRP activities that involve the recovery and management of similar high-activity beta/gamma sources. The transport of sealed sources from Uruguay to the United States is typical of the Proposed Action. This analysis was prepared to determine whether the Proposed Action would result in substantial changes relevant to environmental concerns to the original proposal to collect disused sealed sources for storage or disposal as analyzed in the *LANL SWEIS* (**DOE 2008**) or other relevant NEPA documents. This analysis was also prepared to determine if there were significant new circumstances or information relevant to environmental concerns as discussed in 40 CFR 1502.9(c)(1).

Potential radiological impacts of ground transport of sealed sources within the United States were analyzed in the *LANL SWEIS*. Results of the current analysis are consistent with those in the *LANL SWEIS*. Transportation of sealed sources through the global commons to the United States was not analyzed the *LANL SWEIS*, but has been analyzed in other DOE NEPA documents, for example, the *Unirradiated Reactor Fuel Transport EA* (**DOE 2005**). The potential radiological impacts of air transport of the sealed sources would be higher than those analyzed in the *Unirradiated Reactor Fuel Transport EA*, but would be small and well below all applicable standards. Receipt and management of beta/gamma sealed sources at SwRI is within the scope and license requirements of work routinely performed there; potential radiological impacts to workers would be small and impacts to the public would be essentially zero. This SA demonstrates that implementation of the Proposed Action would be expected to result in either environmental impacts that are within the range of the environmental impacts previously analyzed or that present no substantive change to those impacts.

The Proposed Action would not constitute a substantial change in action relevant to environmental concerns. There are no significant new circumstances or information relevant to environmental concerns related to the Proposed Action or its impacts within the meaning of 40 CFR 1502.9(c)(1) and 10 CFR 1021.314. Therefore, neither a supplemental EIS to the *LANL SWEIS* nor a new EIS is needed; no additional NEPA documentation is required.

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