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SUPPLEMENT ANALYSIS
FOR THE
URANIUM LEASE AND TAKE-BACK PROGRAM FOR IRRADIATION FOR PRODUCTION OF MOLYBDENUM-99 FOR MEDICAL USE

National Nuclear Security Administration

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U.S. DEPARTMENT OF ENERGY

NATIONAL NUCLEAR SECURITY ADMINISTRATION

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LIST OF ABBREVIATIONS and ACRONYMS

AEA	Atomic Energy Act
AMIPA	American Medical Isotopes Production Act
BR-2	Belgian Reactor 2
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EIS	environmental impact statement
ETTP	East Tennessee Technology Park
EA	environmental assessment
EPA	U. S. Environmental Protection Agency
FY	fiscal year
GTCC	Greater-than-Class C low-level waste
HLW	high-level (radioactive) waste
HEU	highly enriched uranium
HFR	High Flux Reactor
INL	Idaho National Laboratory, Idaho Falls, Idaho
LCF	latent cancer fatality
LEU	low-enriched uranium
LLW	low-level (radioactive) waste
Mo-99	molybdenum-99
mrem	millirem
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Administration
NRC	U. S. Nuclear Regulatory Commission
NRU	National Research Universal (Reactor)
OPAL	Open Pool Australian Light-Water (Reactor)
ORR	Oak Ridge Reservation, Oak Ridge, Tennessee
OPAL	Open-Pool Australian Light Water (Reactor)
ORNL	Oak Ridge National Laboratory, Oak Ridge, Tennessee
RCRA	Resource Conservation and Recovery Act
rem	Roentgen equivalent man
SA	supplement analysis
SAFARI	South African Fundamental Atomic Research Installation (Reactor)
SNF	spent nuclear fuel
SRNL	Savannah River National Laboratory, Aiken, South Carolina
SRS	Savannah River Site, Aiken, South Carolina
Tc-99m	metastable isotope of technetium-99
TRIGA	Training, Research, Isotopes, General Atomics
ULTB Program	Uranium Lease and Take-Back Program
U.S.	United States of America
U.S.C.	United States Code
Y-12	Y-12 National Security Complex, Oak Ridge, Tennessee

1 INTRODUCTION AND PURPOSE AND NEED

1.1 INTRODUCTION

The National Nuclear Security Administration (NNSA), a semi-autonomous agency within the Department of Energy (DOE), prepared this Supplement Analysis (SA) to evaluate whether the potential environmental impacts associated with the implementation of the Uranium Lease and Take-Back Program for Irradiation for Production of Molybdenum-99 for Medical Use (ULTB Program) have been adequately considered in existing National Environmental Policy Act (NEPA) analyses. The purpose of an SA is to determine whether there are substantial changes in a proposed action that are relevant to environmental concerns or whether new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts are significant (10 Code of Federal Regulations (CFR)) 1021.314). This SA considers whether the proposed ULTB Program makes substantial changes in actions already considered in existing NEPA analyses or new circumstances or new information that would trigger the need for a supplemental environmental impact statement (EIS) pursuant to 40 CFR 1502.9(c). Specifically, this is an SA of the following documents:

- *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex. DOE/EIS-0387.* (DOE 2011a*).* This EIS evaluates the Y-12 National Security Complex (Y-12) resources and activities associated with the production of enriched uranium. Y-12 would be the provider of low-enriched uranium (LEU) to the molybdenum--99 (Mo-99) producers expressing interest in the ULTB Program.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement, DOE/EIS-0279.* (DOE 2000). This EIS evaluates Savannah River Site (SRS) resources and activities involved in management of spent nuclear fuel (SNF). Mo-99 producers might generate SNF for storage at SRS pending availability of a repository.

This SA was prepared in accordance with the requirements of the DOE NEPA Implementing Procedures (10 CFR Part 1021) and the DOE Recommendations for the Supplement Analysis Process (DOE 2005).

1.2 PURPOSE AND NEED

DOE's purpose and need for the ULTB Program is based on the American Medical Isotopes Production Act of 2012 (AMIPA), included within the National Defense Authorization Act for Fiscal Year (FY) 2013 (PL 112-239, Section 3173(e)). AMIPA addresses the anticipated domestic supply challenges for Mo-99[1] and directs DOE to implement a technology-neutral

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[1] The domestic supply challenges stated above refer to the current lack of domestic suppliers. AMIPA was enacted to implement a domestic supply program. The current conditions are more fully elaborated in Section 1.4, Background.

program to make LEU available, through lease contracts, for the domestic production of Mo-99 for medical uses. AMIPA further requires that DOE: 1) retain title to and be responsible for the final disposition of the SNF created by the irradiation, processing, or purification of the leased LEU; and 2) take title to and be responsible for the radioactive waste created by the irradiation, processing or purification of the leased LEU for which the Secretary determines the producer does not have access to a disposal path. The ULTB Program would support domestic production of Mo-99 for medical use without the use of highly enriched uranium (HEU).[2]

Council on Environmental Quality (CEQ) regulations under 40 CFR 1502.9(c) require Federal agencies to prepare a supplement to an EIS or a new EIS when an agency makes substantial changes to a proposed action that are relevant to environmental concerns, or when there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. DOE regulations under 10 CFR 1021.314(c) direct that, when it is unclear whether a supplement to an EIS is required, a Supplement Analysis (SA) should be prepared to assist in that determination.

In accordance with CEQ and DOE requirements, NNSA has prepared this SA to evaluate the potential environmental impacts that may result from DOE establishing and implementing the ULTB Program as compared to the environmental impacts analyzed in the aforementioned NEPA analyses of various DOE programs.

DOE's consideration of the environmental impacts of establishing the ULTB Program is distinguished from the NEPA analysis conducted by the U.S. Nuclear Regulatory Commission (NRC) for construction and operation of the Mo-99 production facilities. As discussed in Section 1.8.2 of this SA, NRC has jurisdiction over the licensing and regulation of the construction and operation of commercial nuclear activities, including the production of medical radioisotopes[3] (NRC 2004). NRC would prepare appropriate NEPA analyses of the facility construction and operating activities conducted pursuant to the NRC licensing actions. Section 3173(d) of AMIPA provides that DOE and NRC shall ensure, to the maximum extent practicable, that environmental reviews for the production of the medical radioisotopes shall complement and not duplicate each review. Accordingly, this SA does not evaluate in detail those potential impacts associated with Mo-99 producer's transportation, possession and use of LEU that are under the NRC authority. The SA does present as a connected action comparative transportation analyses based on the limited data available to the ULTB Program.

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[2] NNSA's Office of Conversion continues to work towards converting all domestic HEU research reactors to the use of LEU fuel. The majority of reactors that could convert with existing LEU fuels have converted. There are some remaining reactors that require new LEU fuels that are still under development.

[3] Section 3174(h)(4) of AMIPA defines "medical isotopes" to include molybdenum-99, iodine-131, xenon-133, and other radioactive materials used to produce a radiopharmaceutical for diagnostic or therapeutic procedures or for research and development.

1.3 PROPOSED ACTION

DOE proposes to establish and implement a ULTB Program pursuant to the statutory direction within the AMIPA. The proposed action is to establish the ULTB Program to make LEU available through lease contracts for irradiation for the production of the radioactive isotope Mo-99 for medical use and to take back certain SNF and radioactive waste for which DOE is responsible under AMIPA. Specifically, DOE would produce LEU at Y-12 and lease it to the Mo-99 producers. DOE would receive eligible material[4] from Mo-99 producers at Y-12, would receive ULTB Program SNF at SRS for storage pending disposition, and would take back radioactive waste for which the Secretary determines the producer does not have access to a disposal path.

The prospective Mo-99 producers listed in **Table 1-1** have expressed interest in participating in the ULTB Program. These companies are at different stages in the NRC licensing process. The NRC licensing process is further discussed in Section 1.8.2 of this SA.

This SA is based on a composite of projected quantities of LEU to be obtained from DOE and corresponding quantities of eligible material, SNF, and radioactive waste potentially to be returned to DOE. These projected composite quantities were derived from an analysis of the results of survey data received from the Mo-99 producers and are used in this SA as the basis for comparison with existing NEPA analyses of ongoing DOE programs. It should be noted that if all of the prospective Mo-99 producers manufacture their projected quantities of Mo-99, their combined production would far exceed the current world demand for Mo-99 of about 9,000 6-day curies per week (Charlton 2015). Therefore, this SA should be considered a bounding analysis, since the SA uses these projected values as the basis for comparison rather than lower values that would be more consistent with the current world demand.

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[4] For the purpose of this analysis, eligible material is defined as "LEU provided under a Lease Contract for which DOE determines it can economically recover value; provided that, Eligible Material does not include: (a) LEU that has been consumed by Customer or disposed of as commercial waste in accordance with this Lease Contract; (b) any Mo-99 produced from the LEU; and (c) Spent Nuclear Fuel or Radioactive Waste accepted by DOE pursuant to Take-Back Contract …."

Table 1-1: Mo-99 Producers Currently Considering Mo-99 Production Using LEU.

Company	Technology
Proposed New Reactors for Mo-99 Production	
Coqui Radiopharmaceuticals, Alachua, Fl. (http://www.coquipharma.com/wordpress1/)	Irradiation of LEU targets in new twin research reactors; will also need LEU to fuel the reactor
Eden Radioisotopes, Hobbs, NM	Irradiation of LEU targets in a new reactor based on a Sandia National Laboratory conceptual process; will also need LEU to fuel the reactor
Flibe Energy, Huntsville, Al. (http://flibe-energy.com/)	New reactor technology (similar to a molten salt reactor) that uses uranium fluoride salts; Mo-99 is extracted from the fuel
Process Applications Using Existing Reactors	
Northwest Medical Isotopes, Columbia, MO (http://nwmedicalisotopes.com/)	Developing LEU targets that will be irradiated in existing U.S. reactors (MURR and OSU)
General Atomics, San Diego, CA (www.GA.com)	LEU target assembly tubes to be irradiated in the reflector zone of MURR, an existing reactor at the University of Missouri
Proposed Mo-99 Production Using Accelerators (Non-Reactor Based)	
Niowave, Lansing, MI. (http://www.niowaveinc.com/)	Superconducting electron linear accelerator (LINAC) to convert photons into a nuclear fission reaction – no reactor
SHINE Medical Isotopes, Janesville, WI. (http://shinemed.com/)	Accelerator-generated fission in a uranyl nitrate solution (subcritical) in a vessel - no reactor

LEU = low enriched uranium; MURR = University of Missouri Research Reactor, OSU – Oregon State University Reactor

1.4 BACKGROUND

Production of Mo-99. More than 80 percent of nuclear medicine diagnostic imaging (over 30 million investigations per year) use radiopharmaceuticals containing the metastable isotope technetium-99m (Tc-99m) (IAEA 2010). Tc-99m is produced from the radioactive decay of Mo-99. Because Mo-99 has a relatively short half-life[5] of 66 hours, it cannot be stockpiled for use and must be produced on a weekly or more frequent basis to ensure continuous availability (NRC 2009). The production and delivery processes are tightly scheduled and highly time

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[5] A half-life is the amount of time it takes for one half of quantity of a radioactive isotope to decay. So after one half-life, half of the original quantity remains; after another half-life, half of that quantity (one quarter of the original quantity) remains.

dependent; an interruption at any point in the production, transport, or delivery can have substantial impacts on patient care (NRC 2009).

Global Mo-99 Supply Chain. Currently, the United States supply of Mo-99 is dependent on a global supply chain with the irradiation necessary to produce Mo-99 occurring in reactors in foreign countries. **Figure 1-1** illustrates the current global Mo-99 production process that supplies U.S. hospitals and other users.

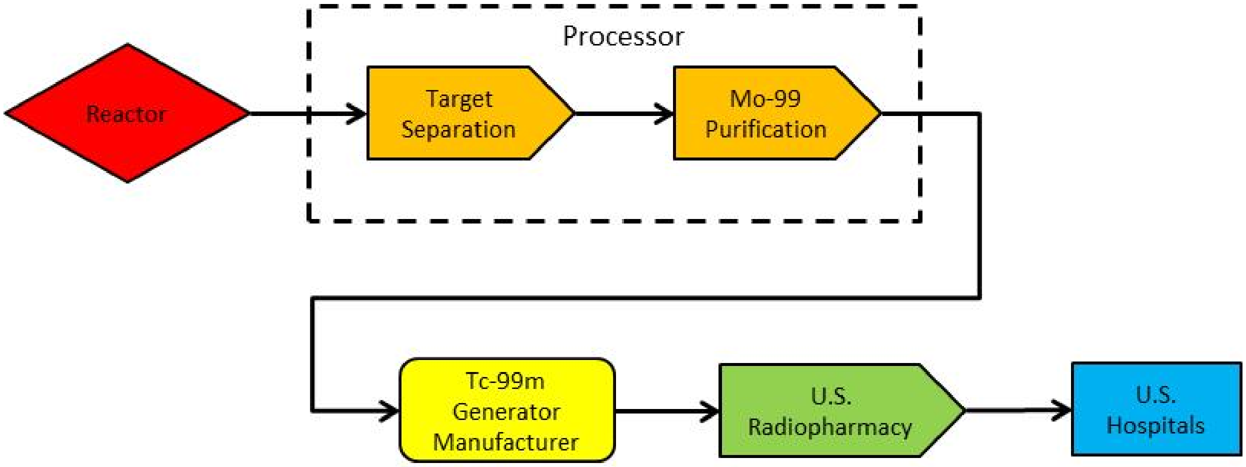

Figure 1-1: Schematic of the Current Global Molybdenum-99 Production Process

Source: NSAC 2014

At this time, Mo-99 is produced in nuclear research reactors (IAEA 2010). Currently, there are eight foreign research reactors that produce the entire global supply of Mo-99[6] (NSAC 2014; Seestrom 2014; White House 2012). Two of these reactors, the National Research Universal (NRU) Reactor in Chalk River, Ontario, and the High Flux Reactor (HFR) in Petten, the Netherlands,[7] produce 70 percent of the entire global supply and most of the United States supply (IAEA 2010; NSAC 2014). Processors separate and purify the Mo-99 and ship the product to a manufacturing facility where it is incorporated into a Tc-99m generator. Technetium-99m generators are radiation-shielded cartridges containing Mo-99 that has been adsorbed onto an alumina (Al_2O_3) column (NRC 2009). Manufacturers recover Tc-99m from the

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[6] The current research reactors are: HFR, the Netherlands; Maria, Poland; BR2, Belgium; LVR-15, Czech Republic; Osiris, France; SAFARI, South Africa; NRU, Canada; OPAL, Australia.

[7] Both the NRU and the HFR are research reactors. The NRU is owned and operated by Canadian Nuclear Laboratories, and has been a major component of Canadian nuclear research (See: https://cna.ca/technology/research-development/research-reactors/). The HFR is owned by the Institute for Energy of the Joint Research Center of the European Commission, and supports research and development in nuclear fission and fusion energy, and radioisotope production (see: http://www.emtr.eu/hfr.html).

generators by passing a saline solution through the alumina column (NRC 2009). The saline removes the Tc-99m but leaves the Mo-99 in place. This process can be conducted several times a day over a period of about a week before a fresh Tc-99m generator is needed (NRC 2009). The extracted Tc-99m is used to manufacture, compound and dispense Tc-99m-based products to nuclear pharmacies. The nuclear pharmacies distribute the products to the nuclear medical facilities and hospitals for administration to patients.

Over the past few years, the global Mo-99 supply chain has suffered repeated interruptions from unplanned reactor outages (Nuclear News 2015). Future production is also challenged as several of these older reactors are scheduled to be decommissioned. Six of these research reactors are between 45 and 55 years old (IAEA 2010; NSAC 2014). In 2000, Canadian Nuclear Laboratories announced that the NRU reactor in Chalk River, Ontario, Canada (originally commissioned in 1957), which produces approximately half of the United States supply, would be decommissioned (Blake 2014; NSAC 2014). Although the decommissioning date was recently extended from 2016 to 2018 (as an emergency measure in case of delays in establishing of new Mo-99 production facilities), the planned closure of this reactor is projected to dramatically impact the future global supply of Mo-99 (Blake 2014). The HFR (originally commissioned in 1960) has suffered chronic production challenges and was scheduled to be decommissioned in 2015; it has recently been funded for an upgrade that would prolong its life to 2025 (World Nuclear News, 2014). The Osiris reactor in France (commissioned in 1957) will also soon be decommissioned, further reducing the global supply of Mo-99 and potentially impacting product availability in the United States (OECD 2014).

Plan to Address Need for Mo-99 **-** To address these challenges to the domestic Mo-99 supply chain, the U.S. Congress passed AMIPA directing DOE to establish a program to make LEU available, through lease contracts, for irradiation for the production of Mo-99 for medical uses. DOE would establish the ULTB Program to achieve the purposes of AMIPA. The ULTB Program would provide for DOE to enter into contracts through which it would lease LEU to individual Mo-99 producers and take back spent nuclear fuel and certain radioactive wastes.[8]

Under the ULTB Program contracts, LEU would be made available to the Mo-99 producers in the form and volume stipulated in producer-specific lease contracts. Provision of LEU to a Mo-99 producer pursuant to a contract would be contingent upon the producer demonstrating possession of an NRC license (or Agreement State license where necessary) to receive and possess the LEU for purposes of manufacturing Mo-99. DOE would make LEU available at the Y-12 facility. The contracts also would provide for the Mo-99 producers to return to DOE leased LEU determined to be eligible material.

Under the ULTB Program take-back contracts, DOE would retain responsibility for the final disposition of SNF and would take title to and be responsible for the final disposition of

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[8] DOE anticipates entering into contracts for the lease of LEU material (ULTB Lease Contracts) and the return of SNF and radioactive waste (ULTB Take-Back contracts). As these contracts are expected to evolve over the course of the ULTB Program rollout, drafts of these contracts are not appended to this SA.

radioactive waste[9] created by the irradiation, processing, or purification of leased uranium for which the Secretary determines the producer does not have a disposal path. Under the take-back contracts, producers would be responsible for accurately characterizing, appropriately packing and transporting the SNF or radioactive waste for which the Secretary determines that the producer does not have access to a disposal path.

DOE evaluated the management of SNF, including material derived from domestic research reactors (DRRs) and foreign research reactors (FRRs), at two DOE sites, the Idaho National Laboratory (INL) near Idaho Falls, Idaho, and the Savannah River Site (SRS) near Aiken, South Carolina (DOE 1995a). For the purposes of this SA, SRS has been considered for the receipt and management of SNF.

Low-level radioactive waste (LLW) would be managed in accordance with the classification of the waste and availability of disposal facilities. At this time, DOE has concluded that producers have access to commercial disposal pathways for Class A, B, and C LLW. At present, there is no disposal capability for Greater-Than-Class C (GTCC) LLW. For purposes of analysis in this SA, it is assumed that DOE would be responsible for GTCC LLW generated under the ULTB Program.

Producers would assume responsibility for transport of the LEU from Y-12 to their respective production facilities. Producers would be responsible for leased-LEU from the time they accept custody at Y-12 until the eligible material, SNF, or radioactive waste is appropriately dispositioned through commercial disposal pathways or returned to DOE pursuant to the lease contracts and take-back contracts. Producers would also assume responsibility for transport of eligible materials, SNF, and radioactive wastes (that do not have a disposal path) from producer facilities to designated DOE facilities.

Domestic Production of Mo-99 **-** Several Mo-99 production technologies are being pursued. Some of the technologies would use LEU as a target in either a reactor or an accelerator. Table 1−1 identifies the companies that have expressed interest in participating in the ULTB Program and technologies currently being pursued. These companies are at different stages in the NRC licensing process. The NRC licensing process is further discussed in Section 1.8.2 of this SA. There are other technologies that do not use uranium and thus would not participate in the ULTB program.[10] Appendix A provides a summary of the various technologies currently being pursued to produce Mo-99.

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[9] Section 3173(f) of the AMIPA states that: “Notwithstanding section 2 of the Nuclear Waste Policy Act of 1982 (42 U.S.C. 10101), radioactive material resulting from the production of medical isotopes that has been permanently removed from a reactor or subcritical assembly and for which there is no further use shall be considered low-level radioactive waste if the material is acceptable under Federal requirements for disposal as low-level radioactive waste.”

[10] For example, Northstar Medical Radioisotopes LLC., in Madison, WI, is planning the construction and operation of a Mo-99 production facility that would employ an accelerator technology that does not use LEU (see http://www.northstarnm.com/company-overview). Accordingly, Northstar is not considered further in this SA.

1.5 SCOPE OF THIS SUPPLEMENT ANALYSIS

DOE and NRC have complementary responsibilities in implementing the ULTB Program. This SA focuses on DOE's responsibilities under the program.

The ULTB Program would:

- Establish supply agreements negotiated between the individual Mo-99 producers and DOE. DOE would make defense-related LEU available to the Mo-99 producers at the Y-12 facility in Oak Ridge, Tennessee. This SA evaluates DOE producing and providing LEU to the Mo-99 producers.
- Identify that each Mo-99 producer would be responsible for arranging transport of the LEU to its NRC-licensed facility for the purpose of producing medical radioisotopes. Transportation of radioactive material is considered a connected action, and is briefly described in the respective sections of this SA. Transportation of LEU by the Mo-99 producer is expected to be further evaluated during the NRC licensing process as part of the commercial movement of radioactive material and consistent with the NRC and U.S. Department of Transportation (DOT) regulation of such transport. Prior to releasing LEU to producers, DOE would review the associated NRC licensing documentation to confirm that transportation had been appropriately evaluated. The NRC has evaluated the commercial transport of radioactive material in the *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* NUREG-0170 (NRC 1977). This EIS is the foundation for NRC NEPA analyses of domestic commercial transport of radioactive material. This SA provides a brief overview of the commercial movement of radioactive material as a connected action.
- Recognize NRC licensing and regulation of Mo-99 producers' utilization of the LEU to generate Mo-99. The construction and operation of the Mo-99 facility is evaluated by NRC as part of the NRC licensing process, and is thus outside the scope of this SA.
- Recognize that the commercial production, ownership, and distribution of Mo-99 for medical use is an NRC-licensed and regulated activity and thus considered outside the scope of this SA. These activities are evaluated during the NRC licensing process.
- Provide for each Mo-99 producer to retain possession of the leased LEU (DOE would retain title) until such time as the Mo-99 producer determines that the leased LEU is of no further value to the production of medical radioisotopes.
- Provide an appropriate disposition path for all LEU determined to be eligible material and for all SNF and radioactive wastes for which DOE is responsible under the AMIPA. At the time the Mo-99 producer deems the leased LEU is of no further value in the production process, the Mo-99 producer would provide written notice to the DOE that the LEU is no longer needed. LEU that DOE determines does not have economic value

would be declared SNF or radioactive waste to be disposed according to its waste classification.[11] The following DOE ULTB Program activities are considered in this SA:

- LEU determined by DOE to be eligible material of economic value that would be returned to Y-12 in accordance with the lease contract.
- SNF would be returned by Mo-99 producers to a DOE designated facility in accordance with take-back contracts. Mo-99 producers would transport SNF to a DOE designated facility for storage. The transport of SNF by the Mo-99 producer to the DOE designated facility is considered a connected action, and is briefly described in the respective sections of this SA. Transportation of eligible material, SNF, and radioactive waste by the Mo-99 producer is expected to be further evaluated during the NRC licensing process as part of the commercial movement of radioactive material and consistent with the NRC and DOT regulation of such transport. ULTB Program SNF received for storage at a DOE designated facility would be transported by DOE to a repository consistent with transportation arrangements for the entire site's SNF inventory.
    - ULTB Program SNF would be stored at the DOE designated facility until a repository is open for disposition of SNF.
- DOE would take title to and be responsible for final disposition of radioactive waste created by the irradiation, processing, or purification of leased uranium for which the Secretary determines the producer does not have access to a disposal path.
    - Currently, only GTCC LLW has no disposition pathway. DOE would be responsible for GTCC LLW upon acceptance of title and responsibility under a ULTB Take-Back contract with a Mo-99 producer, in which case the waste would be managed as GTCC-like waste, and stored pending the availability of a disposal path. The potential quantities of GTCC LLW and GTCC-like waste considered in this SA are consistent with the analysis provided in the *Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (Draft GTCC EIS, GTCC DEIS) (DOE/EIS-0375-D) (DOE 2011b).

Table 1-2 provides a summary of the projected composite quantities of ULTB Program LEU and corresponding projections of potential eligible material, SNF, and radioactive waste that has no disposition pathway compared to DOE capabilities. As noted in section 1.3, these projected quantities were derived from survey data received from the Mo-99 producers. Additionally, the

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[11] If it is Class A, B, or C LLW the producer would be responsible for disposal as commercial disposition paths are available. Based on current analysis, there are commercial disposal options for disposal of Class A, B, and C LLW. Accordingly, disposal of Class A, B and C LLW is outside of the scope of this SA. If in the future this were to change, DOE would address the issue with the producers and prepare additional NEPA analysis as necessary. At the current time, DOE has no evidence to suggest that commercial disposal options would become unavailable.

quantities presented in Table 1-2 are long-term average yearly values (with the exception of radioactive waste without a disposition path that is presented as a projected lifetime total). If the prospective Mo-99 producers manufacture their projected quantities of Mo-99, their combined production would far exceed the current world demand for Mo-99 of about 9,000 6-day curies per week (Charlton 2015).

Table 1-2: Summary of ULTB Program Mo-99 Producer Projections and DOE Capabilities

	LEU requirement (kg U per year)	Potential eligible material return (kg U per year)[a]	SNF Return (per year)	Radioactive waste without disposition path[b] (lifetime[c] total)
Mo-99 Producer Projections[c]	~700 – 800	~690	~60 (kg U) or ~4.5 L-Bundle equivalents	~ 280 cubic meters
DOE Capabilities	Well within Y-12 capacity[d]	Well within Y-12 capacity[d]	Mass is not anticipated to be an issue at SRS[e] Based on current FRR/DRR projections, space is available[e]	~ 390 cubic meters[f]

DRR = Domestic Research Reactor; FRR = Foreign Research Reactor; kg = kilogram; LEU = low enriched uranium; SNF = spent nuclear fuel; U = uranium

a) See footnote 4 in text for the definition of "eligible material"
b) Currently, only GTCC LLW has no disposition pathway.
c) Lifetime is based on a 20-year NRC operating license.
d) Values reflect a long-term average based on projections provided by prospective Mo-99 producers. These values likely overestimate the actual quantity that would be needed because each producer projects meeting all or a large part of the Mo-99 demand.
e) Total Y-12 depleted uranium, LEU and enriched uranium Y-12 capacity or capability is sensitive and not available for public release. Y-12 activities in support of the ULTB Program are deemed to be an insignificant amount in the context of the overall capacity. Source DOE 2015b.
f) Source DOE 2015a.
g) Source DOE 2011b.

1.6 PUBLIC INVOLVEMENT

On July 10, 2015, DOE provided notices of DOE's initiation of a NEPA review of the ULTB Program to the states of Georgia, Idaho, South Carolina and Tennessee, and the Shoshone-Bannock tribes in Fort Hall, Idaho. There is no requirement to notify stakeholders of the determination to prepare an SA or issue the document for public comment. Accordingly, DOE did not provide public notice or distribution of the SA. The SA will be posted on the DOE and DOE/NNSA web sites following approval.

1.7 RELEVANT NEPA DOCUMENTATION

The purpose of an SA is to determine whether there are substantial changes in a proposed action that are relevant to environmental concerns or whether new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts are significant (10 CFR 1021.314). This SA considers whether the proposed ULTB Program makes substantial changes in actions already considered in existing NEPA analyses or new circumstances or new information that would trigger the need for a supplemental EIS pursuant to 40 CFR Section 1502.9(c). This SA presents a supplement analysis of the following two documents:

- *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex. DOE/EIS-0387.* (DOE 2011a)
- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement, DOE/EIS-0279.* (DOE 2000)

1.8 LAWS AND REGULATIONS

1.8.1 The American Medical Isotopes Production Act (AMIPA) and other DOE Authority

The Atomic Energy Act of 1954, as amended (AEA) (42 U.S.C. §§ 2011 et. seq.), provides the basic statutory framework for DOE's use and management of radioactive materials. DOE has issued a series of orders to establish a system of standards and requirements to ensure safe operation of DOE facilities.

The National Environmental Policy Act of 1969 (NEPA) applies to Federal agencies and actions. This law established a national policy of environmental protection and directs all Federal agencies to utilize a systematic, interdisciplinary approach incorporating environmental values into decision making. NEPA requires that environmental information be made available to both decision makers and the public before decisions are made and actions taken. This SA has been prepared pursuant to NEPA and DOE's NEPA implementing regulations (10 CFR Part 1021) to support DOE's creation and implementation of the ULTB Program.

The American Medical Isotopes Production Act of 2012 (AMIPA) (Title XXXI, Subtitle F, P.L. 112-239, codified in relevant part at 42 U.S.C. 2065), included within the National Defense Authorization Act for FY 2013, directs the Secretary of Energy to establish a program to make LEU available through lease contracts for the production of the radioactive isotope Mo-99 for medical use.

DOE would establish the ULTB Program to carry out this statutory mandate. The ULTB Program would be executed under the authority of the Department of Energy Organization Act of 1977, the AEA, and AMIPA.

Roles and responsibilities are defined within AMIPA. Pursuant to Section 3173(c)(2) of AMIPA, the producers of the Mo-99 shall take title to and be responsible for the Mo-99 created by the irradiation, processing, or purification of the leased uranium. AMIPA further provides, in Section 3173(c)(3)(B) that the Mo-99 producer would be responsible for accurately characterizing, appropriately packaging, and transporting the SNF and radioactive waste prior to acceptance by DOE.

Pursuant to Section 3173(c)(3)(A) of AMIPA, the Secretary would retain responsibility for the final disposition of SNF created by the irradiation, processing, or purification of the uranium supplied under a lease agreement for the production of Mo-99 and would take title to and be responsible for the final disposition of radioactive waste[12] created by the irradiation, processing, or purification of the uranium supplied under a lease agreement for which the Secretary determines the producer does not have access to a disposal path.

AMIPA also provides, in Section 3173(d) for the coordination of environmental reviews between DOE and NRC. This provision is discussed in the context of NRC authority in the following section.

1.8.2 U.S. Nuclear Regulatory Commission Regulatory Authority

The AEA authorizes the NRC to license and regulate the construction and operation of, among other things, production and utilization facilities from the standpoint of promoting the common defense and security and protecting public health and safety and the environment. The NRC has jurisdiction over the licensing and regulation of the construction and operation of commercial nuclear activities, including the production of medical radioisotopes (NRC 2004).

NRC's site licensing authority is exercised in accordance with three regulatory programs:

- Domestic Licensing of Production and Utilization Facilities is conducted under 10 CFR Part 50. These regulations provide for licenses, certifications, and regulatory approvals for construction and operation of a facility using nuclear materials.
- Domestic Licensing of Special Nuclear Material is conducted under 10 CFR Part 70.
- Rules of General Applicability to Domestic Licensing of Byproduct Material are administered under 10 CFR Part 30.

The NRC anticipates that most Mo-99 production facilities will be licensed under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." NRC has indicated that the production of Mo-99 by target irradiation is performed by *utilization facilities,* and the fission product separation is conducted in *production facilities* (NRC 2015a). The NRC could also license certain facilities under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material" or 10 CFR Part 30, "Domestic Licensing of Byproduct Material," depending upon specific aspects of the proposed production process.

The NRC's licensing process includes an environmental review. The environmental review, governed by the requirements in 10 CFR Part 51, utilizes an environmental report prepared by

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[12] Section 3173(f) of AMIPA provides that radioactive material resulting from the production of medical isotopes that has been permanently removed from a reactor or subcritical assembly and for which there is no further use shall be considered low-level radioactive waste if the material is acceptable under Federal requirements for disposal as low-level radioactive waste.

the applicant to evaluate the environmental impacts of, and alternatives to, the proposed action. The NRC NEPA analysis presents the results of this evaluation and assesses the environmental impacts of the proposed action(s). The NRC considers the findings in the NEPA analysis in its decision to grant or deny the issuance of a construction permit.

NRC has received license applications from SHINE Medical Technologies (SHINE) and Northwest Medical Isotopes (NWMI) (NRC 2015b; NWMI 2015**.** Additionally, NRC has received a license amendment request from Oregon State University (OSU) and has issued a materials license to Niowave. NRC anticipates a license amendment request from University of Missouri Research Reactor Center (MURR) in support of General Atomics (GA). NRC has published a Final EIS for the proposed SHINE medical radioisotope production facility in Janesville, Wisconsin (NRC 2015b). DOE is a cooperating agency involved in the preparation of these NRC NEPA analyses.

As noted above, Section 3173(d) of AMIPA provides for the coordination of environmental reviews between DOE and NRC. The DOE and NRC NEPA analyses are considered complementary of each other. This DOE NEPA analysis pertains to the creation and implementation of the ULTB Program with respect to LEU supply, and SNF and radioactive waste acceptance. It also includes analysis of the connected transportation actions. NRC's NEPA analysis pertains to actions undertaken by the Mo-99 producer relative to construction and operation of the Mo-99 production facility and related radioactive material transport to and from the facility. DOE anticipates being a cooperating agency involved in the preparation of NRC NEPA analyses for participants in the ULTB Program.

2 PROPOSED ACTION

The Proposed Action encompasses the supply of LEU to the Mo-99 producers and DOE's acceptance of SNF and radioactive waste at the end of the Mo-99 production cycle. The AMIPA directs the Secretary of Energy to make LEU available for the domestic production of Mo-99 for medical uses. DOE would establish and implement the ULTB Program to carry out this statutory mandate. **Figure 2-1** illustrates the proposed ULTB Program. The sections that follow present an overview of the activities within each major aspect of the proposed action.

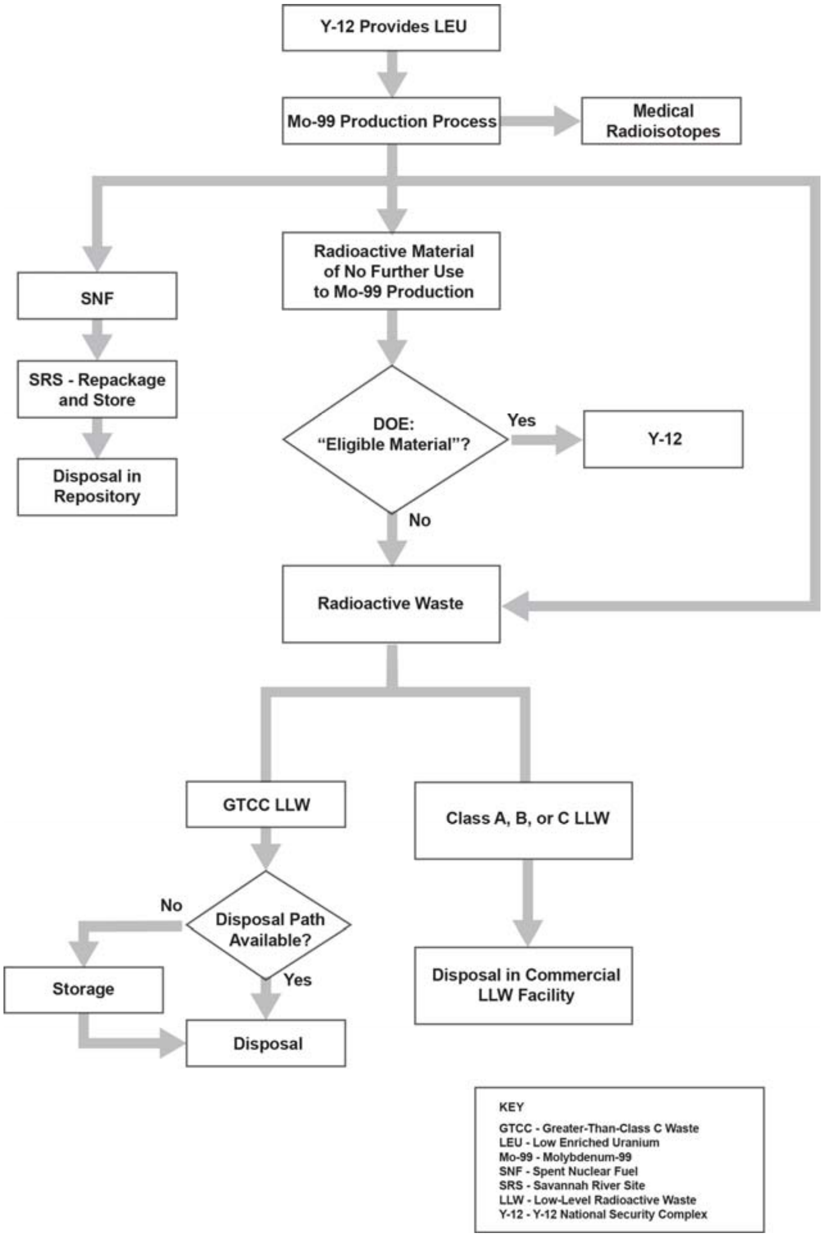

Figure 2-1: Uranium Lease and Take-Back Program Process Schematic

2.1 LOW-ENRICHED URANIUM

2.1.1 Provision of LEU

DOE would negotiate and enter into contracts with Mo-99 producers to provide LEU for use in the production of medical radioisotopes. DOE would make LEU available to the Mo-99 producer in the specifications for purity, form, and other physical or chemical properties desired. LEU is defined as uranium having an assay greater than 0.711 percent uranium-235 (U-235) but less than 20 percent U-235. The LEU would be made available at Y-12 in Oak Ridge, Tennessee.

The provision of LEU would be supported by the Y-12 Metallurgical Operations, Special Processing and Development, and the Enriched Uranium Storage Operations (DOE 2015b). Metallurgical Operations provides the capacity to cast enriched uranium metal for reactors. These operations, part of the Enriched Uranium Complex, provide existing facilities, infrastructure and resources (including staff) to safely prepare and package the LEU for offsite transportation, and account for the LEU that is presented to the Mo-99 producers (DOE 2011a). Staging for shipping of the LEU would be conducted through the Enriched Uranium Storage Operations, which has the current capacity to warehouse for shipping LEU. Y-12 infrastructure and processes supporting the preparation of LEU in the quantities and assay levels contemplated by the ULTB Program have been considered within existing NEPA documents (i.e., the *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex* (DOE 2011a)).

2.1.2 Shipment of Leased LEU from Y-12 to the Mo-99 Producer Facility

Mo-99 producers acquiring LEU would take possession of the LEU at the Y-12 facility and would be responsible to transport the material to their respective NRC-licensed facilities. This activity is regulated by DOT and NRC. The transportation of LEU material by the Mo-99 producer is considered in this SA as a connected action.

The Mo-99 producer would be responsible for providing appropriate certified shipping packages and related equipment to ensure the safe transport of the material. DOE assumes that all such transportation would be conducted using appropriate transportation packages[13] (see *NRC Regulations on Packaging and Transportation of Radioactive Material* at 10 CFR Part 71). The Mo-99 producer would ensure that the transport of the LEU meets all environmental, safety, and security requirements consistent with U.S. laws and applicable DOT regulations (see *DOT Radioactive Material Transportation Review* [DOT 1998] and corresponding regulations at 49 CFR Part 171, et seq.) and would provide documentation of compliance for DOE review prior to receiving LEU.

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[13] The NRC establishes the criteria for transportation packages based upon the specific isotopic activity and material concentration. The regulations provide that LEU may be transported in Type A packages; SNF in Type B packages; and GTCC LLW in Type B packages, depending on the isotope activity of the GTCC LLW.

2.2 MO-99 PRODUCTION

The NRC licenses the construction and operation of commercial medical radioisotope production facilities and production and distribution of medical radioisotopes. Mo-99 producer activities that utilize LEU would be conducted pursuant to NRC regulatory oversight and consistent with the Mo-99 producer's NRC issued license. NRC regulatory oversight of Mo-99 production is summarized in Section 1.8.2 of this SA. Mo-99 producer activities associated with construction and operation of the production facility are evaluated by NRC within the context of the NRC license, therefore, these activities are not considered in detail in this SA.

Over time, and in the course of Mo-99 production, the LEU would eventually become of no further use to the Mo-99 producer. The Mo-99 producer would generate one or more of the following depending on the Mo-99 production process:

- The Mo-99 producer might generate eligible material, defined as leased LEU which DOE determines it can economically recover. Eligible material would be packaged and transported by the Mo-99 producer to Y-12. DOE receipt and handling of this eligible material at Y-12 is further discussed in Section 2.3.

  It is technically feasible to process ULTB Program-derived LEU that has been contaminated with fission products so as to separate the residual LEU from those fission products. H-Canyon at SRS was reviewed as a possible processing facility as it has processed stockpiled HEU (DOE 2000). ULTB Program LEU would present a comparatively small volume of material, making the recovery processes inefficient (DOE 2015a). Moreover, if the ULTB Program LEU were received as an oxide, liquid, or non-dissolvable solid (i.e. stainless, Hastalloy, or zirconium oxide, etc.) the recovery process would have to modified and would not be considered economically feasible (DOE 2015a). Accordingly, processing of LEU through H-Canyon is not addressed further in this SA.

- SNF might be generated. DOE is responsible for disposition of SNF. The Mo-99 producer would be responsible for packaging and transporting SNF to the designated DOE facility.

  It is technically feasible to process ULTB Program LEU SNF so as to separate the LEU from the fission products. H-Canyon at SRS was reviewed as a possible processing facility. However, H-Canyon processing of LEU SNF has been deemed not economically feasible, given the large amount of HEU SNF stored at SRS. Accordingly, processing of ULTB Program SNF through H-Canyon is not considered further in this SA.

  DOE would receive, dry, package, and store the SNF at the DOE site for eventual transportation to and disposal in a repository when it becomes available. ULTB Program-derived SNF would be dispositioned as described in Section 2.4.

- Radioactive waste might be generated. The Mo-99 producer would be responsible for packaging and transporting LLW to the appropriate disposition facility. Radioactive waste for which the Secretary determines the producer does not have access to a disposal path is discussed further in Section 2.5.

2.3 LEU ELIGIBLE MATERIAL RECEIPT AND MANAGEMENT

DOE would retain title to the LEU leased and possessed by the Mo-99 producer throughout the Mo-99 production process. Eligible material would be returned to DOE pursuant DOE instructions provided in the LEU lease contract. It is expected that the transport of the eligible material by the Mo-99 producer to DOE would be evaluated by the NRC during the NRC licensing process as a commercial movement of radioactive material. The transport of the eligible material by the Mo-99 producer to DOE is summarized in Chapter 3 as a connected action.

Y-12 would accept receipt of the eligible material and place it into storage for future use in DOE programs.

Y-12 provides the processes and infrastructure to receive uranium from scrap materials and convert it to a form suitable for storage or future disposition (DOE 2011a). The receipt and storage of returned LEU would be conducted through the Y-12 Enriched Uranium Storage Operations. The Enriched Uranium Storage Operations has the resources required to receive and warehouse LEU from other sites for future use in DOE programs.

2.4 SPENT NUCLEAR FUEL RECEIPT AND MANAGEMENT

AMIPA provides that DOE retains responsibility for the final disposition of SNF created by the irradiation, processing, or purification of the LEU leased under the ULTB Program. The *Programmatic Final Environmental Impact Statement on Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs* (SNF Programmatic EIS) (DOE 1995a) identified INL and SRS as destinations for receipt of DOE SNF, including SNF derived from DRRs and FRRs. For the purposes of this SA, SRS has been considered for the receipt and management of this SNF.

ULTB Program SNF shipments would be received by truck at the SRS L-Area Storage Basin. SNF can be received in skid-mounted casks as well as ISO containers. SNF shipments (such as FRR and DRR SNF) are currently received into the L-Area Storage Basin and packaged prior to storage in L-Basin.

Casks are unloaded either within an underwater disassembly basin or using a Shielded Transfer System (SRNS 2009). Most of the FRR and DRR SNF are packaged underwater in the L-Area Disassembly Basin into storage bundles (L-bundles). DOE would use the same processes and infrastructure to package SNF received under the ULTB Program.

Expanded Basin Storage (EBS) racks are the primary L-Basin SNF storage system. L-Basin currently has the capacity to store 3,650 L-bundles in the EBS racks, with 4 to 5 FRR/DRR fuel assemblies per bundle (typical). As of January 2015, 3,016 bundles were in storage (Rose 2015). Based on current SNF transportation guidance, it is assumed that the transportation of SNF from

SRS to a repository would be conducted using Type B containers, and the transport would be by rail.[14]

The ULTB Program-derived SNF projected by the Mo-99 producers has similar characteristics as existing SNF that has been considered within existing SRS NEPA documents (i.e., *SRS SNF Management Final EIS* [*SRS SNF EIS*] [DOE/EIS-0279, DOE 2000]; *Supplement Analysis SRS SNF Management*, [DOE/EIS-0279-SA-01/DOE/EIS-0218-SA-06] [DOE 2013a]) and therefore would not require modification of SRS infrastructure or processes to be received and stored at the site. SRS has the capacity to receive and store the volume of ULTB Program SNF meeting these characteristics (DOE 2015a). The volume of compatible ULTB Program SNF projected would not require modification to SRS infrastructure or processes (DOE 2015a). DOE would revisit the appropriate NEPA analyses for the potential future disposal of SNF when the material is presented for disposal.

2.5 RADIOACTIVE WASTE RECEIPT AND MANAGEMENT

DOE would take title to and be responsible for final disposition of radioactive waste created by the irradiation, processing, or purification of leased uranium for which the Secretary determines the producer does not have access to a disposal path. At present, there is no disposal capability for GTCC LLW. DOE would be responsible for GTCC LLW upon acceptance of title and responsibility under a ULTB Take-Back contract with the Mo-99 producer, in which case the waste would be managed as GTCC-like waste. This SA considers the disposition of GTCC LLW and GTCC-like waste based on the analysis provided in the Draft GTCC EIS (DOE/EIS-0375-D) (DOE 2011b). It is anticipated that Mo-99 producers would be responsible for final disposition of Class A, B, and C LLW as there are currently commercial disposal pathways for these wastes. Therefore the disposition of Class A, B, and C LLW is not considered in detail in this SA.

Mo-99 producers have estimated that the production of Mo-99 from LEU leased under the ULTB Program would generate LLW (NWMI 2015, Table 19-14; and Shine 2013, Table 19.2.5-1). These producers estimate that Class A, B, C,[15] and GTCC[16] LLW would be generated.

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[14] In April, 2004, DOE issued a Record of Decision announcing the selection of the mostly rail scenario as the primary means of transporting SNF and high-level radioactive waste to the Federal repository site (DOE 2004). This decision was further evaluated in the Nevada Rail Corridor EIS (DOE 2008).

[15] Classes of low level radioactive waste (i.e., Class A, B, and C) are determined through the waste classification method established by NRC at 10 CFR 61.55, *Waste Classification*. States are responsible for providing for the disposal of Class A, B, or C LLW. DOE is responsible for providing for the disposal of any other LLW with concentrations of radionuclides that exceed the limit established by the NRC for Class C Waste at 10 CFR 61.55 (Low Level Radioactive Waste Policy Act of 1985, as Amended, Section 3(b)(1)(D), 42 U.S.C. 2021c(b)(1)(D)).

[16] GTCC LLW refers to waste that has a radionuclide concentration that exceeds the limits for Class C waste in 10 C.F.R. 61.55. GTCC waste is generated by activities of NRC and Agreement State licensees. The NRC waste classifications do not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. DOE owns or generates radioactive waste that has characteristics similar to those of GTCC waste. For the purposes of the Draft GTCC EIS, DOE included this DOE-owned waste in its impact analysis as GTCC-like waste because a

There are currently four commercial LLW disposal sites that offer disposal paths for Class A, B, and C LLW:

- Energy*Solutions*, Barnwell, South Carolina is licensed by the State of South Carolina to accept Class A, B, and C LLW from states in the Atlantic Compact (South Carolina, Connecticut, and New Jersey).
- Energy*Solutions*, Clive, Utah is licensed by the State of Utah to accept Class A LLW from the entire United States.
- US Ecology Inc., Richland, Washington is licensed by the State of Washington to accept Class A, B, and C LLW from the states in the Northwest Compact (Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington, and Wyoming) and the Rocky Mountain Compact (Colorado, Nevada, and New Mexico).
- Waste Control Specialists LLC, Andrews, Texas is licensed by the State of Texas and can accept Class A, B, and C LLW from Texas, Vermont, and the Federal Government. Out-of-compact waste generators may also access WCS for Class A, B, and C LLW disposal.

Mo-99 producer disposal of LLW would be considered in the NRC licensing and associated NRC NEPA analysis (NRC 2015b). As noted above, commercial disposal is available for Class A, B, and C LLW. Accordingly, this SA does not evaluate the consequences of disposition of Class A, B, or C wastes generated by a Mo-99 producer. Should this situation change in the future and commercial disposition becomes unavailable, DOE would consider the facts of such a situation and the need to prepare a NEPA analysis. At the current time, DOE has no evidence that commercial disposition would not be available, accordingly no other NEPA analysis is required.

Currently there are no disposal sites that offer a disposal path for GTCC LLW or GTCC-like waste.[17] (Marcinowski 2015). DOE is evaluating the environmental impacts of potential GTCC disposal sites, including the following: the Waste Isolation Pilot Plant (WIPP) in New Mexico for deep geologic disposal; and Hanford Reservation, INL, Los Alamos National Laboratory, Nevada National Security Site, SRS, a WIPP-Vicinity Site, and generic commercial sites in the four NRC regions for borehole, trench and vault disposal, as applicable (DOE 2011b).

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common disposition approach is reasonably foreseeable. This distinction is carried through this SA as a basis for comparison with potential ULTB-Program GTCC waste.

[17] Regulatory authority (including rulemaking) over GTCC LLW disposal at a commercial facility resides with the NRC. Through its Agreement State Program, the NRC may delegate authority to states to regulate certain radioactive materials activities within their respective borders. In July 2014, Waste Control Specialists (WCS) submitted a Petition for Rulemaking to the Texas Commission on Environmental Quality (TCEQ) requesting the State to revise certain provisions of the Texas Administrative Code to remove prohibitions on disposal of GTCC LLRW, GTCC-like waste and TRU waste at its TCEQ licensed facilities. On January 30, 2015, TCEQ sent a letter to NRC requesting guidance on the State of Texas's authority to license disposal of GTCC LLRW, GTCC-like waste and TRU waste. This matter is under review by NRC.

In general, storage for GTCC LLW could be accommodated: 1) by the Mo-99 producer in accordance with the producer's existing license conditions, 2) by the Mo-99 producer in accordance with an amendment to the producer's license, 3) by the Mo-99 producer entering into a third-party arrangement with a radioactive waste management service provider, or 4) by DOE, upon acceptance of title and responsibility under a ULTB take-back contract with a Mo-99 producer, in which case the waste would be managed as GTCC-like waste. This SA considers DOE storage of GTCC-like waste in Section 3.4.3.

3 ULTB PROGRAM SUPPLEMENT ANALYSES

3.1 INTRODUCTION

In this chapter, the facilities or areas within each site that may be affected by the ULTB Program Proposed Action are described, and the potential impacts of ULTB Program processes are compared with existing NEPA analyses at the respective sites to determine whether additional NEPA analyses are required.

As discussed in Section 1.1, DOE is using this SA to determine whether there are substantial changes in a proposed action that are relevant to environmental concerns or whether new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts are significant (10 CFR 1021.314). This chapter of the SA considers whether the proposed ULTB Program makes substantial changes in actions already considered in existing NEPA analyses or new circumstances or new information that would trigger the need for a supplemental EIS pursuant to 40 CFR 1502.9(c).

The DOE sites and the GTCC LLW and GTCC-like waste storage and disposal alternatives are considered in this SA as follows: 1) Y-12, in Oak Ridge, TN is considered in Section 3.2; 2) SRS, in Aiken, SC is considered in Section 3.3, and 3) the GTCC LLW and GTCC-like waste storage and disposal alternatives are summarized in Section 3.4. The level of detail presented in each section varies depending on the potential for impacts to the environmental resources at the respective site, facilities and areas. The descriptions presented provide the context for understanding the environmental consequences and serve as baselines from which any potential environmental impacts can be evaluated and compared against existing NEPA analyses.

Existing DOE site infrastructure and ongoing processes at Y-12, SRS, and the potential GTCC LLW and GTCC-like waste disposal sites are not anticipated to change to accommodate the proposed ULTB Program activities based on Mo-99 producer projections of LEU supply needs and eligible material to be returned, or SNF and radioactive waste generation. The potential impacts of ongoing and proposed activities at these DOE sites have been previously evaluated in one or more DOE NEPA analyses. Within these NEPA analyses, site baseline descriptions and potential impacts to site environments have been considered across a wide range of environmental aspects, including potential impacts to the site physical environment (i.e., soil, water, and air quality), biological resources (i.e., animal and plant communities), and the man-made environment (i.e., transportation and traffic, socioeconomics, cultural resources, and environmental justice). These existing NEPA analyses provide the foundation for the analyses in this SA, and are specifically referenced where appropriate. Rather than repeat the extensive analyses presented in previously published NEPA analyses of site infrastructure and processes that are not expected to change if the ULTB Program is implemented, the reader is directed to those previous documents for additional details on those environmental aspects for the various sites.

This SA focuses on those environmental aspects that might potentially be affected by the production of LEU and movement and handling of ULTB Program eligible material, SNF, and radioactive wastes. Based on the results of a survey of the Mo-99 producers, DOE determined that the only environmental aspects potentially impacted by the proposed ULTB program are transportation, human health, and waste management on a site-specific basis.

3.2 Y-12 NATIONAL SECURITY COMPLEX

3.2.1 Y-12 Background Description and Involvement in the ULTB Program

Y-12, on the Oak Ridge Reservation (ORR) in Oak Ridge, TN, would produce LEU for the ULTB Program. Y-12 would also receive eligible material derived from the ULTB Program.

ORR was established in 1943 as one of the three original Manhattan Project sites, and includes Y-12, the Oak Ridge National Laboratory (ORNL), and the East Tennessee Technology Park (ETTP). ORR consists of approximately 35,000 acres and is located mostly within the corporate limits of the city of Oak Ridge; however, the city limits end west of ETTP (DOE 2011a).

The main area of Y-12 is largely developed and encompasses approximately 800 acres, nearly 600 of which are considered a high security boundary area that is enclosed by perimeter security fences. The main site, which has restricted access, is roughly 2.5 miles in length and 0.5 miles wide (DOE 2011a). The Y-12 Site Map is presented in **Figure 3-1**.

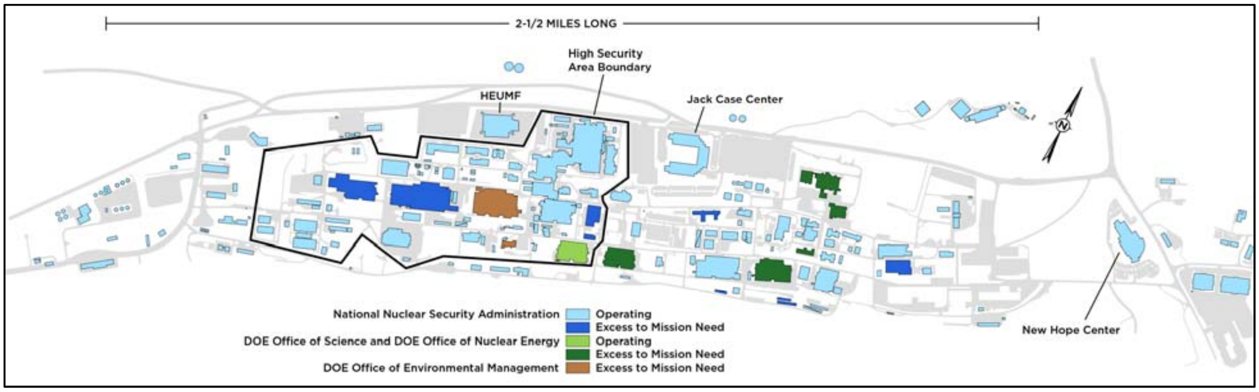

Figure 3-1 Y-12 National Security Complex Site Map

Source: DOE 2011a

DOE would negotiate and enter into contracts with Mo-99 producers to provide LEU for use in the production of medical radioisotopes. DOE would make LEU available to the Mo-99 producer in the specifications for purity, form, and other physical or chemical properties desired. LEU is defined as uranium having an assay greater than 0.711 percent U-235 but less than 20 percent U-235. Y-12 is currently supplying LEU to both domestic and foreign entities through a variety of sales agreements; that activity is analyzed in the *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex* (*Y-12 Site-Wide EIS*) (DOE 2011a).

The principal facilities at Y-12 that would support the ULTB Program are the Y-12 Enriched Uranium Facilities Complex, Special Processing and Development, and the Enriched Uranium Storage Operations. The Enriched Uranium Facilities Complex includes the Enriched Uranium Metallurgical Operations which provide the capacity to cast enriched uranium metal for reactors (DOE 2011a). The Enriched Uranium Metallurgical Operations provide existing facilities, infrastructure, and resources (including staff) to safely prepare and package the LEU for offsite transportation, and account for the LEU that is presented to the Mo-99 producers (DOE 2011a). Enriched Uranium Facilities Complex also includes the Special Processing Operations and Development which provide the capacity to produce and package LEU. Staging for shipping of the LEU would be conducted through the Enriched Uranium Storage Operations, which has the current capacity to warehouse for shipping LEU.

A LEU Contract would provide that a Mo-99 producer in possession of eligible material would package and transport that material to Y-12. Y-12 would accept the eligible material and reincorporate it into the Y-12 Enriched Uranium Facilities Complex. The receipt and storage of returned LEU would be conducted through the EU Storage Operations. The EU Storage Operations has the resources required to receive and warehouse LEU from other sites for future use in DOE programs.

Y-12 provides the processes and infrastructure to produce LEU and to receive enriched uranium scrap materials to a form suitable for storage or future disposition (DOE 2011a).[18] Y-12 has the current capacity to produce sufficient LEU to accommodate Mo-99 producer projected demand. Y-12 currently receives EU, including slightly irradiated LEU, from other DOE sites for incorporation within the enriched uranium production process, and has the capacity to receive projected amounts of eligible material returned by Mo-99 producers (DOE 2015b). No changes in Y-12 infrastructure or resources are required to supply the required LEU and to support the return of LEU in support of the ULTB Program (DOE 2015b).

The Y-12 local and regional affected environment, infrastructure, and processes that would support the preparation of the LEU and receipt of eligible material have been considered within the *Y-12 Site-Wide EIS* (DOE 2011a). Chapter 4 of the *Y-12 Site-Wide EIS* provides detailed descriptions of the local and regional environment around the Y-12 site that might be impacted by past, present, and future Y-12 operations.

Most of the descriptive information on the Y-12 Affected Environment in the areas of transportation, human health, and waste management are extracted directly from the *Y-12 Site-Wide EIS.* The information is reproduced in the following sections for the convenience of the reader in comparing the potential impacts of the implementation of the ULTB Program on Y-12 site with existing NEPA analyses of Y-12 infrastructure and processes.

The impacts of LEU production at Y-12 for Mo-99 producers would not add substantially to the impacts of ongoing uranium processing. As illustrated in **Table 3-1**, projected ULTB Program

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[18] Information pertaining to Y-12's capability and capacity to produce and receive enriched uranium is sensitive and therefore, not presented in this SA.

LEU activities are well within the capacity of Y-12 (DOE 2015b). Y-12 has performed this activity for decades, has included LEU supply for medical isotope production in the Y-12 *Site-Wide EIS* analysis, and the impacts are well known and discussed in detail in the *Y-12 Site-Wide EIS*. The impacts of the No Action Alternative of the *Y-12 Site-Wide EIS* were considered the most relevant for comparison to the ULTB Program. The overall impacts of Y-12 operation are summarized in Table 3.5-1 of the *Y-12 Site-Wide EIS* (page 3-46). The table summarizes the projected impacts for all impact areas. Prior to the AMIPA requirement for a ULTB Program, the large capacity for enriched uranium processing, including LEU supply for medical isotope production, had already been analyzed in the *Y-12 Site-Wide EIS*. The impacts for LEU production at Y-12 in support of the ULTB Program are small relative to ongoing Y-12 activities. There are no incremental impacts of the ULTB Program expected and any changes would be negligible. The potential impact of the ULTB Program on transportation, health and safety, and waste management are summarized here. Unless otherwise noted, the projected impacts were based on the specific sections from the *Y-12 Site-Wide EIS* with consideration for the relative magnitude of the proposed Mo-99 support.

Table 3-1: Bounding Annual Y-12 Support Requirements to the ULTB Program

Y-12 LEU Activities	Annual UTLB LEU[a] (kg U)	Total Y-12 DU, LEU and EU Capacity[b] (kg U)
Preparation of LEU for Mo-99 producers	~700 - 800	Well within Y-12 capacity
Receipt of potential eligible material returned from Mo-99 producers[c]	~690	Well within Y-12 capacity

DU = depleted uranium; EU = enriched uranium; kg = kilogram; LEU = low-enriched uranium; U = uranium.

a) Values based on projections provided by potential Mo-99 producers

b) Total Y-12 DU, LEU and EU Y-12 capacity or capability is sensitive and not available for public release. Y-12 activities in support of the ULTB Program are deemed to be an insignificant amount in the context of the overall capacity.

c) See Footnote 4 in text for the definition of "eligible material."

Source: DOE 2015b

It is important to note that the site activities associated with LEU production and LEU storage are so similar that it becomes quite difficult to differentiate potential risks to workers and the public between these two activities. Accordingly, the potential risks to workers and public health are combined in the analysis presented here.

3.2.2 Existing Analyses of Y-12

3.2.2.1 Provision of LEU by Y-12

The provision of LEU would be supported by the Y-12 Metallurgical Operations, Special Processing and Development Operations, and the Enriched Uranium Storage Operations. The Metallurgical Operations provides the capacity to cast enriched uranium metal for reactors. These operations, part of the Enriched Uranium Complex, provide existing facilities, infrastructure and resources (including staff) to safely prepare and package the LEU for offsite transportation, and account for the LEU that is presented to the Mo-99 producers (DOE 2011a). Special Processing and Development Operations support special uranium preparations. Staging for shipping of the LEU would be conducted through the Enriched Uranium Storage Operation s, which has the current capacity to warehouse LEU for shipping. Y-12 infrastructure and processes supporting the preparation of the LEU in support of ULTB Program have been considered within an existing NEPA document (i.e., the *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex* (DOE 2011a)). Mo-99 producer requests for LEU that do not fall within existing analyses and/or that require modifications to Y-12 infrastructure or processes may require further NEPA analyses. At the current time, DOE has no evidence to suggest that Mo-99 producers would request LEU for which Y-12 does not have existing capability. Accordingly, no further NEPA analyses are required.

Table 3-1 summarizes the projected LEU activities at Y-12 that would support the ULTB Program. As illustrated in Table 3-1, the overall requirements of Y-12 to support the UTLB Program could fit into the overall Y-12 ongoing activities without significant additions of personnel or need for modified or new facilities.

3.2.2.2 Managing Eligible Material Returned to Y-12

Y-12 provides the processes and infrastructure to receive enriched uranium from scrap materials to a form suitable for storage or future disposition (DOE 2011a). The receipt and storage of returned LEU would be conducted through the Enriched Uranium Storage Operations. The Enriched Uranium Storage Operations has the resources required to receive and warehouse LEU from other sites for future use in DOE programs. No changes in Y-12 infrastructure or resources are required to support the return and handling of LEU in support of the ULTB Program (DOE 2015b).

The eligible material returned to Y-12 would be placed into storage pending future reuse in DOE programs. Reuse of the LEU is not addressed in this SA. Clean material is routinely recycled back into the production processes as a part of normal operations. Y-12 activities in support of the ULTB Program are well within Y-12 capacity (DOE 2015b). The Y-12 Site-Wide EIS evaluates the total impacts from all Y-12 operations including uranium metal production, receipt of uranium material, storage awaiting future reuse in DOE programs and radiological impacts of the transportation of radioactive wastes and radioactive materials. The full range of impacts of uranium operations at Y-12 are summarized in the Y-12 Site-Wide EIS (see, e.g. Table 3.5-1 Comparison of Impacts..., page 3-46).

3.2.3 Site Facility Potentially Affected Environment

3.2.3.1 Transportation

Y-12 related transportation is briefly summarized here because Y-12 is the point of origin for LEU materials destined for distribution to and receipt from the Mo-99 producers. The transportation of LEU from Y-12 to the Mo-99 Producer would be evaluated as a part of the NRC licensing process as a commercial transport of radioactive material conducted pursuant to NRC and DOT regulations (See, e.g. DOT 1998 and NRC 1977). This aspect of material transportation is summarized here to indicate relative magnitude of the ULTB Program related transportation activities to the overall Y-12 transportation activities.

<u>Non-Radiological Transportation Impacts at Y-12:</u> The following discussion is intended to provide a summary overview of the current transportation and traffic conditions at Y-12 and any potential changes that might occur with implementation of support for the ULTB Program at Y-12.

Figure 3-2 illustrates the transportation network around Y-12. Y-12 is located within 50 miles of three interstate highways: I-40, I-75, and I-81. Interstate 40, an east-west highway, extends from North Carolina to California. Interstate 75 is a north-south highway extending from Michigan to Florida. Interstate 81 is a north-south interstate extending from New York to Tennessee. Interstate 81 connects with I-40 east of Knoxville, and I-40 and I-75 connect west of Knoxville near the city of Oak Ridge. In addition, TSRs 61, 162, and US25W at Clinton serve Y-12 transportation needs offsite (DOE 2011a). Primary roads on ORR serving Y-12 include TSRs 95, 58, 62, and 170 (Bethel Valley Road). Traffic on Bear Creek Road, north of Y-12, flows in an east-west direction and connects Scarboro Road on the east end of the plant with TSRs 95 and 58. Bear Creek Road has restricted access around Y-12 and is not a public thoroughfare. Bethel Valley Road is also closed to public access (DOE 2011a). The daily traffic numbers for various public roads at ORR are given in **Table 3–2**.

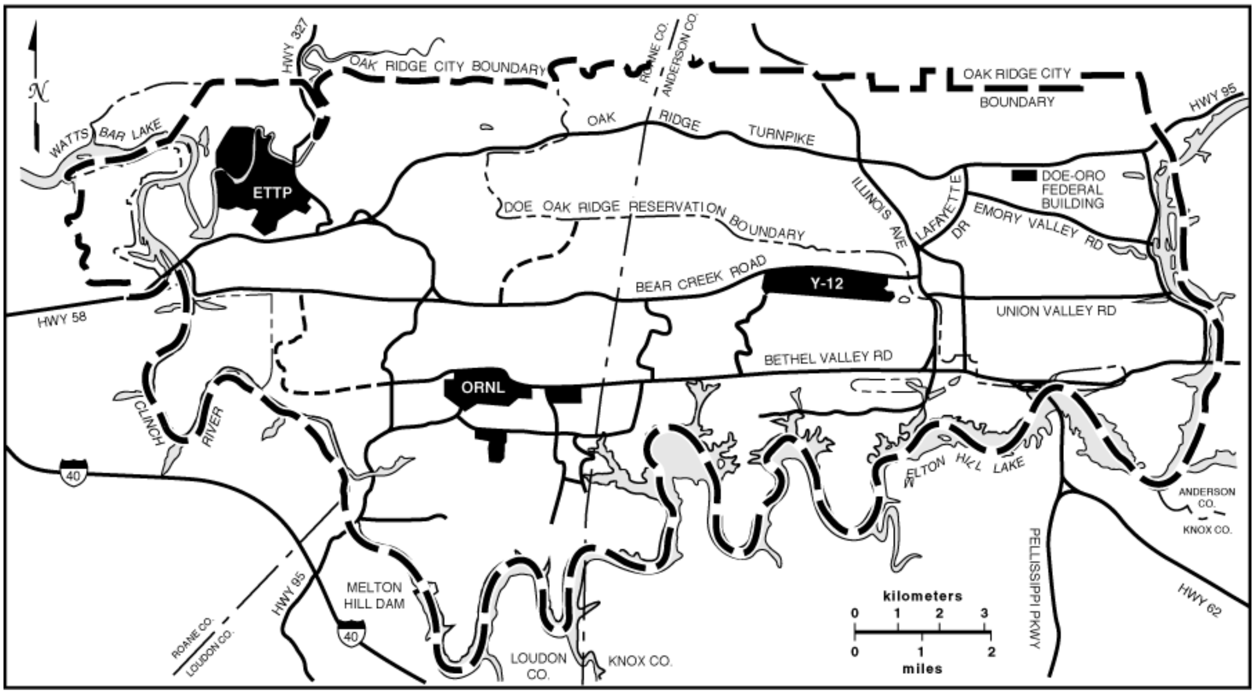
ORNL-DWG 93M-9616R3

Figure 3-2: Road Network around the Y-12 National Security Complex

Source: DOE 2011a

Table 3-2: Existing Average Daily Traffic Counts on ORR Serving Y-12.

Road	To	From	Average Daily Traffic (Vehicles/day)
TSR 58	TSR 95	I-40	13, 970
TSR 95	TSR 62	TSR 58	25,150
TSR 62	TSR 170	N/A	31,620
TSR 170 (Bethel Valley Road)	TSR 62	N/A	9,350

N/A = not available; TSR = Tennessee State Road

Source: DOE 2011a

The Y-12 Site contains 65 miles of roads ranging from well-maintained paved roads to remote, seldom-used roads that provide occasional access. Primary roads serving Y-12 include Tennessee State Routes (TSRs) 58, 62, 95, and 170 (Bethel Valley Road) and Bear Creek Road. Except for Bethel Valley and Bear Creek roads, all are public roads. In addition, Y-12 is located within 50 miles of three interstate highways, I-40, I-75, and I-81.

Various chemicals and other materials being used for Y-12 operations are transported by truck using TSRs 58, 62, 95, and 170; and interstate routes I-40, I-75 and I-81.

As indicated in Table 3-2, Y-12 has a mature transportation infrastructure and road network around Y-12 with average total daily traffic counts in the 10 to 30 thousand vehicles/day range. The minor incremental addition of traffic to support the movement of ULTB from and into Y-12 is well within the bounding estimates for transportation considered in the Y-12 Site-Wide EIS. Section 5.4 of the Y-12 Site-Wide EIS evaluates the fatality risk to workers with approximately 0.8 fatalities expected based on the traffic flow under the Y-12 Site-Wide EIS No Action alternative. The number of shipments into and out of Y-12 to support the ULTB Program are comparatively small and are well within the analyses conducted for the Y-12 Site-Wide EIS.

Radiological Transportation Impacts: The Y-12 SWEIS evaluated in Section 5.4.2 the transportation impacts associated with two material types (radioactive wastes and radioactive materials) to and from ORR and multiple offsite locations. The analysis considered a large number of shipments to and from the Oak Ridge, TN facilities. The analysis used standard assumptions used in other DOE EISs. Radiological impacts were evaluated for both normal, incident-free transportation and for radiological accident impacts associated with transportation of radioactive wastes and materials. The Y-12 SWEIS analysis indicated that the annual radiological transportation impacts under all alternatives evaluated in the SWEIS were about 0.024 latent cancer fatalities associated with all of the Y-12 transportation of radiological materials, with the handling activities contributing most of that dose (DOE 2011a, Table 5.4.2-1). Similar analysis for the radiological impacts from the transportation of LLW from Y-12 to Nevada facilities ranged from 0.67 to 1.8 latent cancer fatalities associated with shipment of 30,000 to 94,000 LLW drums (DOE 2011a, Table 5.4.2-2 & 3). Again, the handling activities and hence worker doses contribute most of that radiological impacts and not impacts to the public.

Overall Transportation Impacts: At this stage of the ULTB Program, the number of shipments of ULTB Program related materials, including LEU and waste, to and from Y-12 are unknown and speculative. Table 3-1 presents bounding estimates of the annual Y-12 support requirements for LEU. The number of shipments of radiological materials to and from Y-12 is sensitive and not available for public release. Y-12 activities in support of the ULTB Program are deemed to be an insignificant amount in the context of the overall capacity. The *Y-12 Site-Wide EIS* (DOE 2011a) did estimate that the annual number of LLW shipments could range from 383 to 1178, depending on different hypothetical annual waste generation levels. The overall number of additional shipments to or from the Y-12 in support of the ULTB Program is expected to be insignificant.

3.2.3.2 Health and Safety

Human health risks associated with current Y-12 processes are considered in the *Y-12 Site-Wide EIS* (DOE 2011a). The following discussion considers the human health impacts from current releases of radioactive and nonradioactive materials at Y-12 as described in the Y-12 Site-Wide EIS and provides a comparison with potential impacts projected for implementation of the ULTB Program.

Current activities associated with routine operations at Y-12 have the potential to affect worker and public health. Air emissions at Y-12 can lead to exposure to radioactive and non-radioactive materials. Liquid effluents discharged into nearby waterbodies may affect downstream populations using the water for drinking or recreation. Additionally, workers are exposed to occupational hazards similar to those experienced at most industrial work sites. Monitoring of materials released from ORR and environmental monitoring and surveillance on and around the ORR are discussed in Sections 4.6 and 4.7 of the *Y-12 Site-Wide EIS* (DOE 2011a).

Radiological. This section presents estimates of potential radiation doses to the public from releases of radiological materials at Y-12. The dose estimates are performed using monitored and estimated release data, environmental monitoring and surveillance data, estimated exposure conditions that tend to maximize the calculated doses, and environmental transport and dosimetry codes that also tend to overestimate the calculated doses. Thus, the presented dose estimates do not necessarily reflect doses received by typical people in the vicinity of ORR; they are likely to be overestimates.

Calculated radiation doses to maximally exposed individuals (MEI) from airborne releases from ORR are listed in **Table 3-3**. The hypothetical MEI for ORR was located about 3.6 miles south of the main Y-12 Complex release point, about 2.6 miles east northeast of the 7911 stack at ORNL, and about 6.8 miles east of the *Toxic Substances Control Act* (TSCA) Incinerator (stack K-1435) at the ETTP. This individual could have received an effective dose (ED) of about 0.3 mrem, which is well below the NESHAP standard of 10 mrem and is 0.1 percent of the 360 mrem that the average individual receives from natural sources of radiation (EPA 2009). The calculated collective ED to the entire population within 50 miles of ORR (about 1,040,041 persons) was about 19.5 person-rem, which is approximately 0.005 percent of the 374,415 person-rem that this population received from natural sources of radiation (based on an individual dose of 360 mrem per year) (DOE 2008). For liquid effluents, the MEI dose to a member of the public would be approximately 0.006 mrem per year (DOE 2011a).

Table 3-3: Calculated Radiation Doses to Maximally Exposed Offsite Individuals from Airborne Release during 2007

Plant	Effective Dose (mrem)	
	At plant max	At ORR max
Oak Ridge National Laboratory	0.26[a]	0.26
East Tennessee Technology Park	0.02[b]	0.009
Y-12	0.15[c]	0.009
Entire ORR	d	0.3[e]

mrem = millirem

a The maximally exposed individual was located 5,060 meters east of X-3039 and 4,259 meters east-northeast of X-7911.

b The maximally exposed individual was located 685 meters west of TSCA Incinerator stack.

c The maximally exposed individual is located 2,307 meters northeast of Y-12 release point.

d Not Applicable.

e The maximally exposed individual for the entire ORR is ORNL maximally exposed individual.

Source: DOE 2011c

The maximally exposed individual for Y-12 was located at about 1.43 miles northeast of the main Y-12 site release point. This individual could have received an ED of about 0.15 mrem from Y-12 emissions. Inhalation and ingestion of uranium radioisotopes (i.e., U-232, U-233, U-234, U-235, U-236, and U-238) accounted for essentially all (about 99 percent) of the dose. The contribution of Y-12 emissions to the 50-year committed collective ED to the population residing within 50 miles of ORR was calculated to be about 1.5 person-rem, which is approximately 8 percent of the collective ED for ORR (DOE 2011c).

One of the major goals of DOE is to keep worker exposures to radiation and radioactive material as low as reasonably achievable (ALARA). The purpose of an ALARA program is to minimize doses from both external and internal exposures. Y-12 worker doses have typically been well below DOE worker exposure limits. The Radiation Exposure and Monitoring System 2009 Annual Report indicates that Y-12 personnel received a total internal dose of 49 person-rem. The Y-12 internal dose is spread across approximately 2,450 workers. About 10 percent of those workers account for about half the total exposure, mainly hands-on production and maintenance workers. None of the internal exposures exceeded the site's 1.0 rem administrative limit. The exposures ranged from 0 to 0.823 rem (DOE 2011c).

As indicated in Table 3-1, the amount of uranium metal potentially to be required to support the ULTB Program is small in comparison to ongoing uranium metal production activities. The projected LEU production for the ULTB Program is expected to be less than 1% of the total

Y-12 uranium production activities. As noted above, because the site activities associated with LEU production and LEU storage are so similar and a small fraction of activity already analyzed, it is difficult to differentiate potential risks to workers and the public between the ongoing Y-12 activities and proposed ULTB Program activities. Accordingly, the potential risks to workers and public health are combined in the analysis presented here.

It is expected that the contribution of the ULTB Program activities to the health and safety of the public and workers, from both routine activities and accidents, is approximately proportional to the amount of uranium metal handled. From a radiological exposure perspective, the dominant radionuclide is U-234. Therefore, highly enriched uranium has correspondingly more U-234 than LEU, natural uranium, or depleted uranium and higher potential for radiological impact. Since most of the uranium handled at Y-12 has historically been highly enriched uranium, the impacts from the HEU have dominated radiological impacts at Y-12.

Radiological impacts to the public and workers from ongoing Y-12 activities have been considered in the context of HEU processing described in the Y-12 Site-Wide EIS. The activities anticipated in support of the ULTB Program are compatible with ongoing processes at Y-12, and do not require any changes to site infrastructure or processes. Health and safety impacts associated with the ULTB Program are within the bounds of those impacts assessed in these other NEPA analyses.

Routine – Workers and the Public: Detailed information on the health and safety impacts of normal operations on the workers and the public is reported in Sections D.4 and D.5 of Appendix D of the *Y-12 Site-Wide EIS*.

Y-12 workers could be exposed to radiation from working in facilities with nuclear materials. **Table 3-4** presents the annual average individual and collective worker doses from Y-12 operations from 2009 through 2013. These doses fall within the regulatory limits of the DOE regulation, "Occupational Radiation Protection" (10 CFR Part 835.202) of 5 rem (5,000 mrem) total effective dose to a general employee. Using the risk estimator of 600 LCFs per 1 million person-rem, the calculated average annual LCF risk of 0.04 in the workforce indicates a low probability of a single cancer fatality in the worker population.

Table 3-4: Radiation Doses to Y-12 Site Workers from Operations During 2009–2013

	From Onsite Releases and Direct Radiation by Year[a]					
Occupational Personnel	**2009**	**2010**	**2011**	**2012**	**2013**	**Average**
Average radiation worker (millirem)[b]	45	43	38	42	37	41
Total worker dose (person-rem)	62	70	59	59	50	60
Number of workers receiving a measurable dose	1,379	1,635	1,537	1,413	1,337	1,460

[a] total effective dose equivalent

[b] No standard is specified for an "average radiation worker;" however, the maximum dose to an individual worker is 5,000 millirem per year (10 CFR Part 835). DOE's goal is to maintain radiological exposure as low as reasonably achievable (ALARA) and has therefore established an Administrative Control Level of 1,000 millirem per year (Y-12 Sitewide, Appendix D, Page D-8). Reported radiation doses are based on worker and environmental monitoring.

Source: DOE 2012a; 2014.

The overall impacts to workers and the public are reported in the *Y-12 Site-Wide EIS* No-Action Health and Safety Impacts (Table 3.5-1 Comparison of Impacts.., page 3-55) as:

> *All radiation doses from normal operations would be below regulatory standards with no statistically significant impact on the health and safety of workers or public. Dose from air emissions: MEI: 0.15 mrem/yr (9.0×10-8 LCFs). Population: 1.5 person-rem/yr (0.0009 LCFs). Dose from liquid effluents: MEI: 0.006 mrem per year (4.0×10-9LCFs) Population: 6.3 person-rem/yr (0.004 LCFs). Dose to Workers: 49.0 person-rem/yr (0.03 LCFs* (DOE 2011a).

Based on the ratio of uranium material produced annually, the projected impacts from LEU production for Mo-99 within the ULTB Program are bounded by the *Y-12 Site-Wide EIS*, and would not be expected to substantially increase health and safety risks.

Accidents: Evaluation of potential accidents, including radiological accidents, associated with uranium operations at Y-12 are discussed in detail in Section 5.14 and Section D.9 of Appendix D of the *Y-12 Site-Wide EIS* (DOE 2011a). The proposed LEU production activities supporting the ULTB Program are identical to ongoing LEU metal processing activities at Y-12 and similar to past and ongoing HEU and depleted uranium metal processing activities. The *Y-12 Site-Wide EIS* did not attempt to distinguish the subtle differences in accident impacts or risks among the potential alternatives considered in the *Y-12 Site-Wide EIS*. Instead, the *Y-12 Site-Wide EIS* presents the credible (though extremely unlikely) accidents that presented the highest radiological consequences to workers or the public. The radiological accidents presented in the *Y-12 Site-Wide EIS* would also apply to the ULTB Program support activities. As noted in Table 3-1, the quantities involved with ULTB Program support, however, are a small fraction and hence the probabilities of accidents associated with the ULTB Program material even lower than those estimated in the *Y-12 Site-Wide EIS* (DOE 2015b).

Section D.9.4 of the Y-12 Site-Wide EIS indicates major fires are the bounding accident and the only accidents analyzed in detail (DOE 2011a). Other accidents, such as small spills, are easily contained and would release much smaller quantities of uranium to the environment and hence do not present the highest radiological consequences. Radiological source terms for the *Y-12 Site-Wide EIS* accidents are up to a few tens-of-kilograms of enriched uranium. While some release locations are also given in the *Y-12 Site-Wide EIS*, the detailed accident information, including material at risk and location is not given in the *Y-12 Site-Wide EIS* due to security concerns and are instead extracted from various Y-12 safety documents.

The overall impacts to workers and the public from radiological accidents are reported in the *Y-12 Site-Wide EIS* as: (Table 3.5-1 Comparison of Impacts.., page 3-57):

> *The bounding accident with the most severe consequences would be an aircraft crash into the EU facilities. Approximately 0.4 LCFs in the offsite population could result. MEI dose: 0.3 rem; MEI LCF risk: $2x10^{-4}$ chance of developing a LCF, or about 1 in 5,000. When probabilities are taken into account, the accident with the highest risk is the design basis fire for HEU storage. For this accident, the maximum LCF risk to the MEI would be $4.4x10^{-7}$, or about 1 in 2.3 million. For the population, the LCF risk would be $4x10^{-4}$,*

or about 1 in 2,500 (Source: Table 3.5-1 Comparison of Impacts.., page 3-57) (DOE 2011a).

The radiological accident frequency and consequences for Y-12 uranium operations from the Y-12 Site-Wide EIS are summarized in **Table 3-5** below. The annual cancer risks are summarized in **Table 3-6**. In both tables, these scenarios, accident frequencies, consequences, and risks should substantially bound any of the anticipated operations at Y-12 in support of the ULTB Program. Actual ULTB Program materials at risk in any accident would be much smaller, on the order of less than 1% of that evaluated for these accidents in the Y-12 Site-Wide EIS (DOE 2015b). Based on the ratio of uranium material produced annually, the projected impacts from LEU production for Mo-99 within the ULTB Program are bounded by the *Y-12 Site-Wide EIS*, and would not be expected to substantially increase health and safety risks.

Table 3-5: Y-12 Radiological Accident Frequency and Consequences

Accident	Frequency (per year)	Maximally Exposed Individual[a]		Offsite Population[b]		Noninvolved Worker[c]	
		Dose (rem)	Latent Cancer Fatalities[d]	Dose (Person-rem)	Latent Cancer Fatalities[d]	Dose (rem)	Latent Cancer Fatalities[d]
Major fire	$10^{-4} – 10^{-6}$	0.59	0.00036	520	0.31	16.3	0.0098
Explosion	$10^{-4} – 10^{-6}$	0.058	0.000035	51.2	0.031	1.18	0.00071
Fire in EU Warehouse	$10^{-4} – 10^{-6}$	0.69	0.00041	608	0.36	17.4	0.010
Design-basis fires for HEU Storage[e]	$10^{-2} – 10^{-4}$	0.073	0.000044	66.1	0.04	1.08	0.00065
Aircraft crash	$10^{-4} – 10^{-6}$	0.3	0.0002	665	0.4	0.39	0.00023

EU = enriched uranium; HEU – highly enriched uranium

a) At site boundary, approximately 1.3 miles from release.

b) Based on a projected future population (year 2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.

c) At approximately 3,300 feet from release.

d) The conversion factor used for dose to latent cancer fatalities is 0.0006; any discrepancies are due to rounding.

e) The accident analysis includes accidents for all major facilities/operations at Y-12. Impacts are addressed for UPF, HEUMF, EU processing facilities, and other facilities (see Y-12 Site-Wide EIS Appendix D (Section D.9.3).

Note 1: These scenarios, accident frequencies, consequences, and risks substantially bound any of the anticipated operations at Y-12 in support of the ULTB Program. Actual ULTB Program materials at risk in any accident would be much, much smaller than those evaluated for these accidents in the Y-12 Site-Wide EIS (DOE 2015b).

Source: DOE 2011a, Table 5.14.1-1. *Radiological Accident Frequency and Consequences: All Alternatives*.

Table 3-6: Y-12 Annual Cancer Risks

Accident	Maximally Exposed Individual[a]	Offsite Population[b]	Noninvolved Worker[c]
Major fire	3.6×10^{-8}	3.1×10^{-5}	9.8×10^{-7}
Explosion	3.5×10^{-9}	3.1×10^{-6}	7.1×10^{-8}
Fire in EU Warehouse	4.1×10^{-8}	3.6×10^{-5}	1.0×10^{-6}
Design-basis fires for HEU Storage[d]	4.4×10^{-7}	4.0×10^{-4}	6.5×10^{-6}
Aircraft crash	2.0×10^{-8}	4.0×10^{-5}	2.3×10^{-8}

EU = enriched uranium; HEU – highly enriched uranium.

a – At site boundary, approximately 1.3 miles from release.

b – Based on a projected future population (year 2030) of approximately 1,548,207 persons residing within 50 miles of Y-12 location.

c – At approximately 3,300 feet from release.

d – The accident analysis includes accidents for all major facilities/operations at Y-12, including UPF, HEUMF, EU processing facilities, and other facilities (see Y-12 Site-Wide EIS Appendix D, Section D.9.3).

Note 1: These scenarios, accident frequencies, consequences, and risks substantially bound any of the anticipated operations at Y-12 in support of the ULTB Program. Actual ULTB Program materials at risk in any accident would be a small fraction, on the order of less than 1 % of that evaluated for these accidents in the Y-12 Site-Wide EIS.

Source: Y-12 Site-Wide EIS Table 5.14.1-2, *Annual Cancer Risks: All Alternatives.*

3.2.3.3 Waste Management

There are many waste management facilities at Y-12. The disposal facilities and landfills are operated by the Environmental Management Program; the majority of the waste management, treatment and storage facilities are operated by NNSA (DOE 2011a). The Y-12 waste management facilities are located in buildings, or on sites, dedicated to their individual functions, or are collocated with other waste management facilities or operations (DOE 2011a). Many of the facilities are used for more than one waste stream (DOE 2011a).

The TDEC Division of Solid Waste Management (DSWM) regulates the management of waste streams under the *Tennessee Solid Waste Management Act* (TSWMA). Onsite waste disposal facilities in operation at Y-12 include industrial, construction/demolition landfills, and a CERCLA waste landfill.

The major waste types generated at Y-12 from routine operations include LLW, MLLW, hazardous waste, and nonhazardous waste. **Table 3-7** presents the types of wastes generated by Y-12 and the way these wastes are managed. **Table 3-8** presents a summary of waste generation totals for routine operations at Y-12 for FY 2007 and FY 2014. Other waste includes sanitary and industrial wastewater, PCBs, asbestos, construction debris, general refuse, and medical wastes.

Table 3-7: Waste Management Programmatic Environmental Impact Statement Records of Decision Affecting Y-12.

Waste Type	Preferred Action
Low-level radioactive[a]	DOE decided to treat ORR liquid low-level radioactive waste on-site[a]. Separate from the Waste Management PEIS, DOE prefers offsite management of ORR solid low-level radioactive waste after temporary onsite storage.
Mixed low-level radioactive[b]	DOE decided to regionalize treatment of mixed low-level radioactive waste at ORR. This includes the onsite treatment of ORR waste and could include treatment of some mixed low-level radioactive waste generated at other sites.
Hazardous[c]	DOE decided to use commercial and onsite ORR facilities for treatment of ORR non-wastewater hazardous waste. DOE will also continue to use onsite facilities for wastewater hazardous waste.

ORR = Oak Ridge Reservation

a – From the ROD for low-level waste (65 FR 10061).

b – From the ROD for mixed low-level waste (65 FR 10061).

c – From the ROD for hazardous waste (63 FR 41810).

Table 3-8: Waste Generation Totals by Waste Type for Routine Operations at Y-12.

Waste Type	Waste Volume (FY-2007)[a]	Current Waste Volume (FY 2014)[b]
Low-level waste (liquid) (gallons)	713	1,104
Low-level waste (solid) (cubic yards)	9,405	6,208
Mixed low level waste (liquid) (gallons)	1,096	5,907
Mixed low level waste (solid)(cubic yards)	126	237
RCRA[c] waste (metric tons)	11.62 s	4.2
TSCA waste (metric tons)	0.73	NA
Mixed TSCA (metric tons)	15.89	NA
Sanitary waste (metric tons)	10,373.88	NA

NA = Not available

a DOE 2011a

b DOE 2015b

c RCRA = Resource Conservation and Recovery Act

High-Level Radioactive Waste (HLW) and Transuranic (TRU) Waste. Y-12 does not generate or manage high-level radiological waste or TRU waste.

Low-Level Waste. Solid LLW, consisting primarily of radioactively contaminated scrap metal, construction debris, wood, paper, asbestos, filters containing solids, and process equipment is generated at Y-12. In FY 2014, Y-12 generated approximately 6,208 cubic yards of solid LLW. Liquid LLW is treated in several facilities, including the West End Treatment Facility (WETF).

Y-12 is the largest generator of routine LLW at Oak Ridge. In FY 2014, Y-12 generated 1,104 gallons of liquid LLW (DOE 2011a).

Mixed Low-Level Waste. Mixed waste subject to treatment requirements to meet Land Disposal Restrictions (LDRs) under RCRA are generated and stored at Y-12. DOE is under a State Commissioner's Order (October 1, 1995) to treat and dispose of these wastes in accordance with milestones established in the *Site Treatment Plan for Mixed Waste on the Oak Ridge Reservation* and to comply with the *Federal Facilities Compliance Act* (FFCA) that went into effect on January 1992 (DOE 2011a). TSCA-regulated waste (containing PCBs) that is also radioactive waste is managed under a separate FFCA agreement, first effective August, 1997 (ORR 1997). In FY 2014, Y-12 generated 237 cubic yards of solid mixed low-level waste and 5,907 gallons of liquid MLLW (DOE 2011a).

Hazardous Waste. RCRA-hazardous waste is generated through a wide variety of production and maintenance operations. The majority of RCRA-hazardous waste is in solid form. In FY 2014, Y-12 generated 4.2 metric tons of RCRA waste. The hazardous waste is shipped offsite for treatment and disposal at either DOE or commercially-permitted facilities (DOE 2011a).

Other Waste Types. Treated sanitary wastewater is discharged to the sanitary system in accordance with the Industrial and Commercial User Wastewater Discharge Permit No. 1-91. PCBs are transported to permitted facilities for treatment and disposal. Medical wastes are autoclaved to render them noninfectious and are then sent to a Y-12 sanitary industrial landfill, as are asbestos wastes and general refuse. Construction, demolition, and nonhazardous industrial materials are disposed of in a construction/demolition landfill at Y-12 (DOE 2011a).

Capacities. Excess treatment and disposal capacity for hazardous waste exist both onsite and offsite at Y-12. Storage capacities at Y-12 are currently adequate for hazardous, MLLW, and LLW (DOE 2011a).

As noted in Table 3-8, a wide variety of LLW, mixed LLW, and hazardous waste are generated at Y-12. The *Y-12 Site-Wide EIS* (Section 3.5.13, Impacts Summary) concluded that under all alternatives, Y-12 would continue to generate and manage wastes, including LLW, mixed LLW, hazardous waste, and sanitary/industrial (nonhazardous) waste (DOE 2011a).

Table 3-9 illustrates the comparison of waste currently generated with that projected to support the ULTB Program. Based on the ratio of uranium material produced annually, the projected waste volume generation from LEU production for Mo-99 is expected to be less than 1% of the total Y-12 waste generation projected for the No Action alternative in the Y-12 Site-Wide EIS (See Table 3.5-1 *Comparison of Impacts...*, page 3-56)(DOE 2011a). This small amount of waste would not require additional infrastructure and fits within the bounds of the existing NEPA analysis described above.

Table 3-9: Comparison of Waste Quantity Currently Generated at Y-12 to Potential Waste Volume Associated with ULTB Program

Waste Type	Current Waste Volume	Comparison of UTLB Waste to Current Program Waste[a]
LLW Liquid (gallons)	1,104[a]	<0.01
LLW Solid (cubic yards)	6,208[a]	<0.01
Mixed LLW Liquid (gallons)	5,907[a]	<0.01
Mixed LLW Solid (cubic yards)	237[a]	<0.01
Hazardous (metric tons)	12[b]	<0.01
Nonhazardous (metric tons)	10,374[b]	<0.01

a) As previously noted, details on enriched uranium handling at Y-12 is highly sensitive. Accordingly, a precise comparison is not available. The ULTB Program contribution to current waste handling at Y-12 is deemed insignificant, presented here as less than 1 percent of current operations.

Source:

a DOE 2015b.

b DOE 2011a

3.2.3.4 Cumulative Impacts

Information on cumulative impacts to onsite and offsite projects associated with the Y-12 facility has been previously described in detail in Chapter 6 of the *Y-12 Site-Wide EIS* (DOE 2011a). The activities and incremental changes associated with the implementation of the ULTB Program at Y-12 would be very small. Accordingly, previous analyses of cumulative impacts are unchanged by the implementation of the ULTB Program.

3.2.4 Conclusion

DOE activities associated with the fulfillment of projected Mo-99 producer requests for LEU have been addressed in existing NEPA analyses.

No changes in Y-12 infrastructure or resources are required to support the return and storage of eligible material in support of the ULTB Program. The receipt of eligible material at Y-12 from the Mo-99 producer is consistent with the primary missions performed at Y-12 and adequately considered in existing NEPA documents (DOE 2011a).

Radiological impacts to the public and workers from ongoing Y-12 activities have been considered in the context of HEU processing described in the *Y-12 Site-Wide EIS* (DOE 2011a). The activities and quantities of materials anticipated in support of the ULTB Program are compatible with ongoing processes at Y-12, and do not require any changes to site infrastructure or processes. Health and safety impacts associated with the ULTB Program are within the bounds of those impacts assessed in these other NEPA analyses. The small amount of waste associated with ULTB Program support would not require additional infrastructure and fits within the bounds of the existing NEPA analysis.

3.3 SAVANNAH RIVER SITE

3.3.1 SRS Background Description and Involvement in the ULTB Program

DOE proposes to use the Savannah River Site (SRS) near Aiken, South Carolina for the receipt and management of SNF derived from the ULTB Program. This section focuses on the receipt and storage of ULTB Program SNF at L-Area within SRS.

Located in southwestern South Carolina, SRS occupies an area of 198,344 acres (80,268 hectares) in a generally rural area about 25 miles (40 kilometers) southeast of Augusta, Georgia, and 12 miles (19 kilometers) south of Aiken, South Carolina, the nearest population centers. It is bordered by the Savannah River to the southwest and includes portions of three South Carolina counties: Aiken, Allendale, and Barnwell. **Figure 3-4** is a map of SRS. SRS is a controlled area. Public access is limited to through traffic on State Highway 125 (SRS Road A), U.S. Highway 278 (SRS Road 1), and the CSX railway line (DOE 2015a).

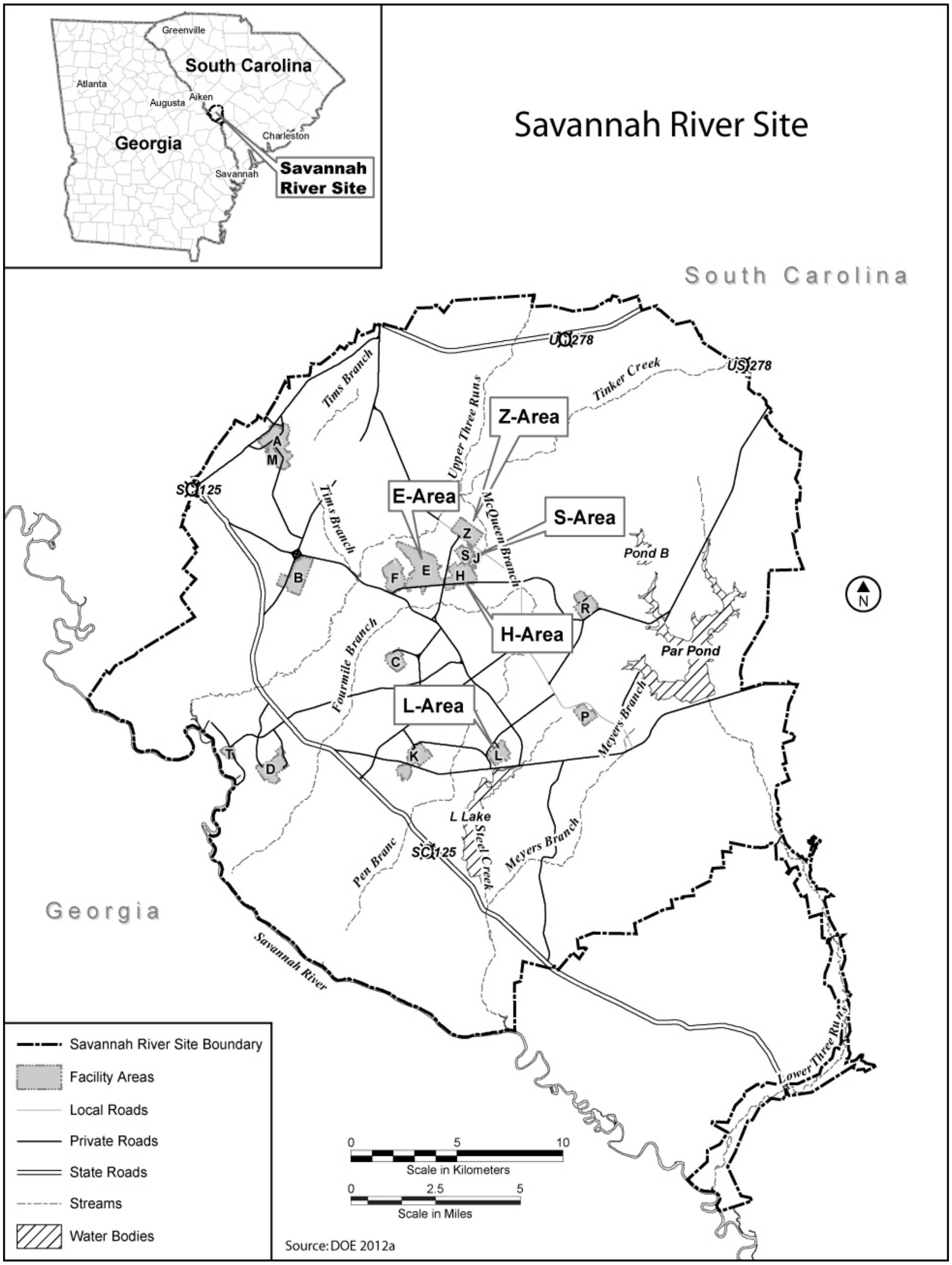

Figure 3-3: Savannah River Site Map

Source: DOE 2015c

L-Area is located in the south-central part of SRS, approximately 5.7 miles (9.2 kilometers) from the site boundary. L-Area was initially constructed as a nuclear reactor for nuclear materials production in the 1950s. The reactor was shut down in 1968, and then restarted for a short period in the 1980s. In the 1990s, the function of the facility was changed to storing nuclear material. The L-Reactor Facility is now called the Material Storage Facility. The current mission for the L-Area Materials Storage Facility is to provide for the safe receipt, storage, handling, and shipping of SNF and special nuclear materials. Spent fuel assemblies are received from research reactors in the United States, other DOE facilities, and from foreign research reactors. The Material Storage Facility also receives, stores, handles, and ships moderator and fissile/fissionable material from various DOE facilities (SRNS 2014a). ULTB Program SNF would be received and stored in the L-Area.

Currently, radioactive material stored in L-Basin consists of:

- Foreign and domestic research reactor Material Test Reactor (MTR) Fuel Assemblies (Al-based, Al-clad and non-Al-clad)
- High Flux Isotope Reactor (HFIR) cores
- Miscellaneous targets and other material stored in isolation cans (Espinosa 2015)

Approximately 15,000 SNF assemblies are currently stored in L-Basin (Rose 2015).

ULTB Program SNF would be received, packaged and stored at this DOE facility only until such time as a repository is open for disposition of SNF. DOE would dry, package, and arrange for transport of its ULTB Program SNF to the repository. Packaging would be compatible with repository and shipping requirements.

3.3.2 Existing Analyses of SRS

The potential impacts associated with the current SRS infrastructure and processes that would support the receipt and storage of SNF pending transportation to a repository have been considered within existing NEPA documents, principally the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (*FRR SNF EIS*) (DOE/EIS-0218F) (DOE 1996), and *The Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (SRS SNF EIS)* (DOE/EIS–0279) (DOE 2000). Most recently, the 2015 *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (*SPD SEIS*) (DOE/EIS-0283-S2) (DOE 2015c) provides a 55-page *Affected Environment* chapter that presents a description of the local and regional environment around the SRS that might be impacted by past, present, and future SRS operations.

This SA focuses on those environmental aspects that have the potential to be impacted by the ULTB Program, i.e., transportation, human health, and waste management. Most of the descriptive information on the SRS Affected Environment in the areas of transportation, human health, and waste management are extracted from the 2015 *SPD SEIS* and discussed in the following sections to support the comparison of existing NEPA analyses with the potential impacts of the SRS support to the ULTB Program.

3.3.2.1 Receipt and Management of Spent Nuclear Fuel

ULTB Program SNF would be transported by the Mo-99 producers to SRS for storage pending the availability of a repository. **Table 3-10** summarizes the potential SRS support requirements to the ULTB Program.

Table 3-10: Annual SRS Support Requirements to the ULTB Program

SRS ULTB Program SNF Activities	Annual ULTB Program SNF Requirements[a]	20-Year ULTB Program SNF Requirements[a]	SRS SNF Receipt and Storage Capacity[b]
SNF mass (kg HM)	~60	~1200	Mass is not anticipated to be an issue at SRS
SNF assemblies expressed as L-Bundle equivalents[c]	~4.5	~90	~ 3,650. Based on current FRR/DRR projections, space is available. Physical space exists for rack installation projects if needed.
SNF shipments	~5 to 10	~200	<5 per year through 2019 and up to 10 per year after 2019

DRR = domestic research reactor; FRR = foreign research reactor; HM = heavy metal; kg = kilogram; SNF = spent nuclear fuel

a) Values based on projections provided by potential Mo-99 producers
b) DOE 2015a.
c) An L-bundle equivalent is approximately 4 to 5 MTR assemblies.

The specific characteristics of the ULTB Program SNF, or whether it would be produced at all, are unknown and will not be known until detailed designs for the Mo-99 production facilities are further developed. However, based on Mo-99 producer projections of anticipated LEU fuel (i.e., Al-clad fuels), any ULTB Program SNF that would be sent to SRS is expected to fall within the radiological characteristics of the "reference fuel" developed by SRS for used in their safety analyses and in the radiological impacts analysis in the *SRS SNF EIS (DOE 2000).* Based on the projections from a survey of Mo-99 producers, it is likely that the impacts of ULTB Program SNF activities at SRS would be similar to ongoing SNF operations at SRS evaluated in the *SRS SNF EIS* (DOE 2000) and the *SRS FRR EIS* (DOE 1996). If the characteristics of the ULTB Program SNF should deviate from the Mo-99 producer survey projections, additional NEPA analyses would be performed as appropriate.

ULTB Program SNF shipments would be received by truck at the SRS L-Area Storage Basin. SNF can be received in skid-mounted casks as well as ISO containers. SNF shipments (such as FRR and DRR SNF) are currently received into the L-Area Storage Basin and packaged prior to storage in L-Basin. Acceptance criteria for receipt of SNF at SRS have been detailed and considered in several environmental impact statements, including the *SRS SNF EIS* and *SRS FRR EIS.*

L-Area currently handles three types of domestic Type B SNF transport casks[19] within the lifting limits of the 85 ton transfer bay crane. A Mo-99 producer would be advised to select a transport cask that would be compatible with SRS infrastructure. If a Mo-99 producer needed to use a different Type B transport package, the proposed different transport package would need to be

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[19] Current casks that can be received at SRS include the BRR cask (USA/0452/B(U)F-96), the NAC LWT cask (USA/9225/B(U)F-96), and the GE2000 HFIR cask (USA/9228/B(U)F-96) (Dunsmuir and Magoulas 2015).

evaluated for compatibility with SRS infrastructure. L-Area preparations to receive a new cask can take 18 to 24 months depending on the complexity of the packaging, designing/procuring new rigging and tools, and operator training. Mo-99 producers seeking to submit material using a new cask type would be expected to store the material at their production facility until SRS infrastructure could be modified to accommodate the new cask type (DOE 2015a).

ULTB Program SNF would be stored at L-Basin. Expanded Basin Storage (EBS) racks are the primary L-Basin SNF storage system. L-Basin currently has the capacity to store 3,650 fuel bundles, in the EBS racks, with 4 to 5 FRR/DRR fuel assemblies per bundle. As of January 2015, 3,016 bundles were in storage (Rose 2015). In September 2014, SRS initiated processing of 1,000 MTR fuel bundles to free up additional storage space in L-Basin for expected future SNF receipts. From fiscal year (FY) 2015 to FY 2033, SRS assumes that 1,176 fuel bundles will be added to L-Basin storage (not counting any ULTB Program SNF) (Espinosa 2015). Transportation of SNF from SRS to a repository would be conducted by rail (DOE 2008).

The impacts of activities at SRS, including receipt, storage, and preparation for shipment to a repository, for various types of SNF comparable to ULTB Program SNF have been evaluated extensively in a series of NEPA documents, including the *FRR SNF EIS*, the *SRS SNF EIS* and multiple supplement analyses **(**e.g. *FRR SNF EIS* Supplement Analyses DOE-EIS-0218-SA-1 and DOE/EIS-0218-SA-06, *SRS SNF EIS* Supplement Analysis DOE/EIS-0279-SA-01**)**. The *FRR SNF EIS* identified 17,803 FRR assemblies (18.2 MTHM) that could be shipped to SRS. The *SRS SNF EIS* specifically addressed a path forward for 68.2 MTHM of SNF, including 20 MTHM of “Material Test Reactor-Like” SNF from domestic and foreign research reactors. In addition, the *SRS SNF EIS* addressed options for about 48.2 MTHM of other types of SNF, including uranium and thorium fuels, non-aluminum-clad fuels, and other SNF materials.

As of January 2015, SRS had received approximately 9,500 FRR SNF assemblies (Espinosa 2015). It is anticipated that an additional ~2,000 assemblies will be received by 2019 (Rose 2015), for a total of approximately 11,500 assemblies. Thus, the additional ULTB Program SNF assemblies that could be received (equivalent to about 450 MTR assemblies over 20 years) would result in a total of ~11,950 assemblies, which is less than the 17,800 assemblies analyzed in the *FRR SNF EIS*.

ULTB Program SNF would have characteristics compatible with existing SRS SNF infrastructure. Accordingly, SRS processes and infrastructure would not require modification to store this material. As shown in Table 3-10, SRS has the capacity to receive and store the volume of SNF meeting these characteristics and anticipated to be generated under the ULTB Program. ULTB Program SNF with characteristics that are incompatible with existing SRS SNF management infrastructure and processes may require modifications to SRS infrastructure or processes, as well as further NEPA analyses. At the current time, DOE has no evidence to suggest that the Mo-99 producers would generate SNF requiring such modifications. If a need for such modifications is identified, DOE would conduct the appropriate NEPA analysis.

3.3.3 SRS Facility Potentially Affected Environment

3.3.3.1 Transportation and Traffic

SRS-related transportation is briefly discussed in this section because of the potential for Mo-99 producers to transport SNF to SRS for storage and DOE to transport SNF to a repository for disposal. Transport of SNF by the Mo-99 producer to SRS is considered a connected action for the purpose of this analysis. This aspect of material transportation is summarized here to indicate relative magnitude of the ULTB Program related transportation activities to the overall *SRS SNF EIS* transportation activities.

Non-Radiological Transportation Impacts at SRS: This section provides a summary of the current transportation and traffic conditions at SRS.

As shown in **Figure 3-4**, material could be transported into and out of SRS by either truck or rail, and transport between the SRS facilities evaluated in this SA can be accomplished by both surface roads and railroads. The Savannah River Site is serviced by a system of Interstate, U.S. and state highways, and railroads. SRS is managed as a controlled area with limited public access.

The regional transportation networks provide service to SRS employees residing in South Carolina and Georgia. Vehicular access to SRS is provided from South Carolina State Highways (SCSH) 19, 64, 125, 781, and U.S. Highway 278. Commuter traffic between SRS and Georgia crosses the Savannah River primarily on I–20 and I–520 and primary arteries Routes 28 and 1 and Business Route 25 to the north of SRS. In addition to the vehicular roadways, railroads are used for transporting large volumes or oversized loads of materials or supplies (DOE 2015c).

Rail service in the region is provided by the Norfolk Southern Corporation and CSX Transportation. Rail access to SRS is provided by the Robbins Station on the CSX Transportation line. Within SRS, there are approximately 32 miles (51 kilometers) of railroad track (DOE 2015c). The railroad tracks are well maintained, and the rails and cross lines are in good condition. The Savanah River rail classification yard is east of P area. This facility sorts and redirects railroad cars. The railroads support delivery of foreign and domestic research reactor SNF shipments, delivery of construction materials for new projects, and movement of nuclear materials and equipment on site.

Within SRS, there are approximately 130 miles (209 kilometers) of primary and 1,100 miles (1,770 kilometers) of secondary roads (DOE 2015c). The primary SRS roadways are in good condition, and are typically wide, firm shoulder border roads that are either straight or have wide gradual turns. Intersections are well marked for both traffic and safety identification.

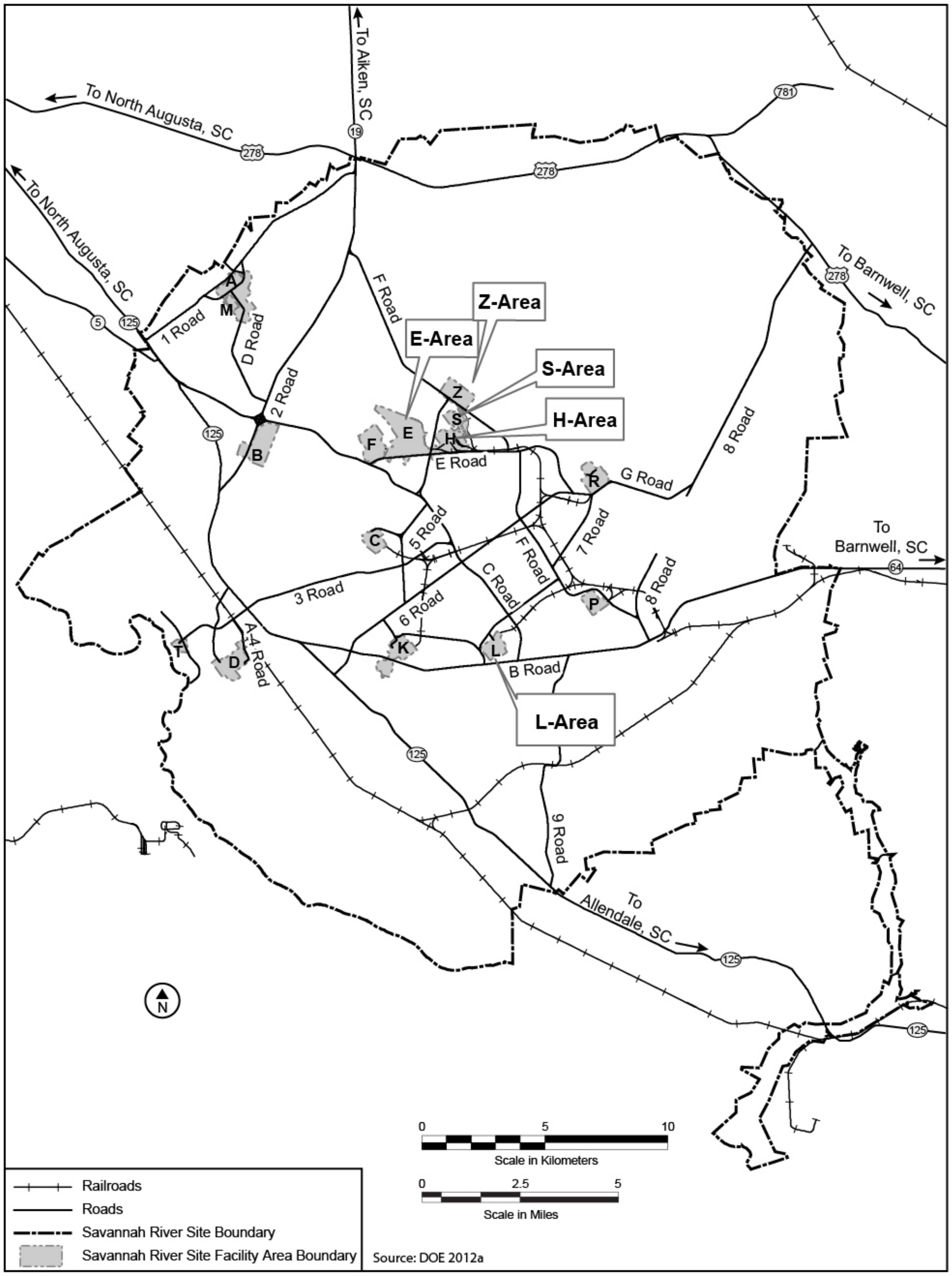

Figure 3-4: Savannah River Site Transportation Infrastructure

Source: DOE 2015c

<u>Radiological Transportation Impacts</u>: Radiological impacts of transporting radioactive materials and wastes to and from SRS have been evaluated in a number of NEPA documents, including the *SRS SNF EIS (DOE 2000)*. These evaluations use standard DOE models and assumptions and evaluate the incident-free (without accidents) non-radiological and radiological impacts to the transportation workers and the public. The analyses also evaluate the radiological impacts of severe accidents that result in the release of radioactive materials from the shipping packages.

In the *SRS SNF EIS* (DOE 2000), radiological impacts from both onsite and offsite shipments were evaluated. As indicated in Table 4.1-21 of the *SRS SNF EIS*, most of the radiological impacts from shipments of the most radioactive materials such as the shipments to the proposed Yucca Mountain Geologic Repository would be occupational or during stops. The incident-free radiological impacts of 1,400 offsite truck shipments of spent nuclear fuel were estimated to result in a total of 0.366 latent cancer fatalities among the general public. Dose rates from individual shipments of ULTB Program SNF to and from SRS should be no greater than those projected for the shipments of spent nuclear fuel. Thus the transportation shipping analyses in the *SRS SNF EIS* can be used to bound the transportation impacts of shipments of ULTB Program materials to and from SRS.

Overall Transportation Impacts: As indicated in Table 3-10, the number of shipments into SRS in support of the ULTB Program is relatively small in comparison to ongoing transportation activities. SRS has a mature transportation infrastructure and road network around the site. The potential impacts of the proposed ULTB Program on the transportation system at SRS would be minor with respect to the impacts evaluated in the existing SRS NEPA documents.

The ULTB Program SNF received at SRS would be stored in anticipation of disposition at a repository. The transportation of SNF from SRS to a repository would be conducted using Type B containers, and the transport would be by rail within the packaging and handling conditions considered in the *Nevada Rail Corridor EIS* (DOE 2008). The *Yucca Mountain EIS* (DOE 2002) evaluated the potential environmental impacts of loading and transporting SNF and HLW from SRS to a repository. The EIS estimated that a maximum of 5,254 SNF and HLW rail cask shipments would be made from SRS to a repository. The total number of disposal canisters transported would be 7,599. Based on the ULTB Program SNF projected to be received at SRS in Table 3-10, the proposed ULTB Program would add only about 13 disposal canisters (assuming 5 assemblies per L-Bundle and 36 assemblies per canister), or < 0.2 percent to these totals.

ULTB Program SNF would be received, packaged and stored at this DOE facility only until such time as a repository is open for disposition of SNF. DOE would dry, package, and arrange for transport of its ULTB Program SNF to the repository. Packaging would be compatible with repository and shipping requirements.

No changes to SRS infrastructure or processes are necessary to dry, store and package the ULTB Program SNF in anticipation of future transportation to a repository, and the number of associated shipments represent a small fraction of the total. Therefore, the potential incremental impacts of the proposed ULTB Program on the transportation system at SRS and the transportation of SNF from SRS to a repository would be minimal.

3.3.3.2 Health and Safety

This section provides a summary of the public and worker health conditions at SRS. Public and occupational health and safety issues at SRS are potentially adverse effects on human health that result from acute and chronic exposure to ionizing radiation and hazardous chemicals.

3.3.3.2.1 Public Health

The annual doses to the public from recent releases of radioactive materials (2009 through 2013) and the average annual doses over this 5-year period are presented in **Table 3-11**. These doses fall within limits established per DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011d) and are much lower than background radiation.

Using a risk estimator of 600 latent cancer fatalities (LCFs) per 1 million rem or person-rem (or 0.0006 LCFs per rem or person-rem) (DOE 2003), the annual average LCF risk to the maximally exposed member of the public due to radiological releases from SRS operations from 2009 through 2013 is estimated to be 7×10^{-8}. That is, the estimated probability of this person developing a fatal cancer at some point in the future from radiation exposure associated with 1 year of SRS operations is 1 in 14 million. (Note: It takes a number of years from the time of radiation exposure until a cancer manifests, if at all.)

Using the same risk estimator, annual emissions from normal operations during 2009-2013 are not expected to result in any excess latent fatal cancers (LFC) (calculated value of 0.001) in the population living within 50 miles (80 kilometers) of SRS. The incremental change associated with the implementation of the ULTB Program is quite minor, and is well within the bounding analysis considered in these analyses.

Table 3-11: Annual Radiation Doses to the Public from SRS Operations for 2009–2013

Members of the Public	Year	Atmospheric Releases[a]	Liquid Releases[b]	Total [c, d]
Maximally exposed individual (millirem)[e]	2009	0.04	0.08	0.12
	2010	0.05	0.06	0.11
	2011[f]	0.06	0.08	0.14
	2012[f]	0.04	0.10	0.14
	2013[f]	0.04	0.05	0.09
	2009–2013 Average	0.05	0.07	0.12
Population within 50 miles (person-rem)[g]	2009	2.0	2.2	4.2
	2010	1.9	1.9	3.8
	2011[f]	1.2	1.8	3.0
	2012[f]	0.76	1.9	2.7
	2013[f]	2.2	1.2	3.4
	2009–2013 Average	1.6	1.8	3.4
Average individual within 50 miles (millirem)[h]	2009	0.0028	0.0025	0.0053
	2010	0.0024	0.0020	0.0044
	2011	0.0015	0.0019	0.0034
	2012	0.0010	0.0020	0.0030
	2013	0.0028	0.0013	0.0041
	2009–2013 Average	0.0021	0.0019	0.0041

[a] Maximally exposed individual doses from atmospheric releases are those reported for compliance with Clean Air Act regulations. DOE Order 458.1 (DOE 2011d) and Clean Air Act regulations in 40 CFR Part 61, Subpart H, establish a compliance limit of 10 millirem per year to a maximally exposed individual.

[b] Includes all water pathways, not just the drinking water pathway. Though not directly applicable to radionuclide concentrations in surface water or groundwater, an effective dose equivalent limit of 4 millirem per year for the drinking water pathway only is frequently used as a measure of performance. It is based on the National Primary Drinking Water Regulations maximum contaminant level for beta and photon activity that would result in a dose equivalent of 4 millirem per year (40 CFR 141.166).

[c] Total effective dose

[d] DOE Order 458.1 establishes an all-pathways dose limit of 100 millirem per year to individual members of the public.

[e] The Savannah River Site Environmental Report for 2013 (SRNS 2014b), uses a “representative person” as the receptor for analysis of impacts on an individual. The representative person receives a dose that is “representative of the more highly exposed individuals in the population.” This table does not distinguish between the MEI and representative person.

[f] In the *Savannah River Site Environmental Report for 2011 (*SRNS 2012b, DOE includes the potential dose from use of Savannah River water for irrigation as part of the liquid pathway dose (not included in the doses in this table). Including the contribution from the irrigation pathway increases the average annual MEI dose by 0.09 millirem to 0.21 millirem, the offsite population dose by 2 person-rem to 5.4 person-rem.

[g] About 713,500 for 2009, based on 2000 census data, and about 781,060 for 2010–2013, based on 2010 census data. For liquid releases occurring from 2009 through 2013, an additional 161,300 water users in Port Wentworth, Georgia, and Beaufort, South Carolina (about 98 river miles downstream), are included in the assessment.

[h] Obtained by dividing the population dose by the number of people living within 50 miles of SRS for atmospheric releases; for liquid releases, the number of people includes water users who live more than 50 miles downstream of SRS.

Note: Sums and quotients presented in the table may differ from those calculated from table entries due to rounding. To convert miles to kilometers, multiply by 1.6

Source: DOE 2010; 2011c; 2012; 2013b, 2014.

3.3.3.2.2 Worker Health

SRS workers could be exposed to radiation from working in facilities with nuclear materials. **Table 3-12** presents the annual average individual and collective worker doses from SRS operations from 2009 through 2013. These doses fall within the regulatory limits of the DOE regulation, “Occupational Radiation Protection” (10 CFR Part 835). Using the risk estimator of 600 LCFs per 1 million person-rem, the calculated average annual LCF risk of 0.08 in the workforce indicates a low probability of a single cancer fatality in the worker population. The incremental change associated with the implementation of the ULTB Program is quite minor, and is well within the bounding analysis considered in these analyses.

Table 3-12: Radiation Doses to Savannah River Site Workers from Operations During 2009–2013

Occupational Personnel	**From Onsite Releases and Direct Radiation by Year**[a]					
	2009	**2010**	**2011**	**2012**	**2013**	**Average**
Average radiation worker (millirem)[b]	50	70	60	71	60	62
Total worker dose (person-rem)	109	180	150	145	89	135
Number of workers receiving a measurable dose	2,185	2,587	2,512	2,044	1471	2,160

[a] total effective dose equivalent

[b] No standard is specified for an “average radiation worker;” however, the maximum dose to an individual worker is 5,000 millirem per year (10 CFR Part 835). DOE’s goal is to maintain radiological exposure as low as reasonably achievable (ALARA) and has therefore established an Administrative Control Level of 2,000 millirem per year. The SRS ALARA goal is to limit annual exposures to 500 millirem (DOE 2009; SRS 2014). Reported radiation doses are based on worker and environmental monitoring.

Source: DOE 2012a; 2014.

3.3.3.3 Waste Management

SRS Areas involved in waste management (e.g. E-, S-, and Z-Areas) provide existing infrastructure for managing the treatment, storage, and disposition of waste generated at the SRS site. Processing ULTB Program SNF through H-Canyon was considered but dismissed because it is not economically viable, therefore, no HLW would be generated and there would be no use of the waste management facilities in S- and Z-Areas.[20] Any LLW generated as a result of receiving and storing UTLB SNF would be managed in existing facilities in E-Area; no new infrastructure or processes are required to manage LLW.

A wide variety of LLW, mixed LLW, hazardous, and non-hazardous wastes are generated and managed at SRS. **Table 3-16** summarizes the waste generation rates for the SRS facilities potentially involved in the ULTB Program. The receipt and storage of a small quantity of ULTB Program SNF would generate comparatively small quantities of LLW such as worker personal protective equipment (gloves, booties, etc.) that would be consumed during the receipt and

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[20] See Section 2.2 for a brief summary of DOE’s consideration of potential processing of LEU in H-Canyon.

removal of the SNF containers from the shipping casks. These potentially contaminated materials would be treated as LLW and disposed of in accordance with SRS waste management practices. Based on the ratio of ULTB Program SNF received and stored to the current and projected SRS SNF inventory, the total annual volume associated with ULTB Program SNF could be a few cubic feet per year, which would be negligible within the overall SRS waste volumes and is well below the volume of wastes considered in the SNF EIS (DOE 2000).

Table 3-13: Waste Generation Rates at the Savannah River Site

Waste Type	Savannah River Site – Total		L-Area Complex		Z-Area Saltstone		E-Area and Hazardous/Mixed Waste Storage	
	5-Year Average	FY 2014	5-Year Average	FY 2014	5-Year Average	FY 2014	5-Year Average	FY 2014
LLW[a]	13,000	4,000	250	60	180	120	5	5

FY = fiscal year; LLW = low-level radioactive waste; N/A = not available;

[a] Waste generation expressed as cubic meters

Note: To convert cubic meters to cubic feet, multiply by 35.314.

Source: *DOE 2015c*

The detailed radiological character of the ULTB Program SNF is unknown and would not be known until detailed designs for the Mo-99 production facilities are completed and license applications to the NRC are submitted. Based on the Mo-99 producer projections available to date, the ULTB Program material that would be sent to SRS is expected, however, to fall within the radiological characteristics of the “reference fuel” developed by SRS for used in their safety analyses and in the radiological impacts analysis in the *SRS SNF EIS (DOE 2000).* If ULTB Program SNF were found to not meet these “reference fuel” characteristics, additional NEPA analyses may be required. For purposes of this SA, it is anticipated that the impacts of ULTB Program SNF activities at SRS would be minor and well within those impacts considered for ongoing SNF operations at SRS evaluated in the *SRS SNF EIS* (DOE 2000) and the *SPD EIS* (DOE 2015c).

3.3.3.4 Cumulative Impacts

Information on cumulative impacts to on-site and offsite projects associated with SRS have been previously described in numerous analyses, including the recent Final Surplus Plutonium Disposition Supplemental EIS DOE/EIS-0283-S2 (DOE 2015c), and the Savannah River Site Spent Nuclear Fuel Management EIS, DOE/EIS-0279 (DOE 2000). The cumulative analyses presented in these two documents consider the potential radiological and chemical exposures associated with ongoing activities at SRS. The activities associated with the implementation of the ULTB Program at SRS are not anticipated to deviate from those activities described in these two analyses.

3.3.4 Conclusion

ULTB Program SNF with physical characteristics comparable to SNF considered within existing NEPA documents (e.g. *SRS SNF EIS* (DOE/EIS-0279); *Supplement Analysis SRS SNF Management*, (DOE/EIS-0279-SA-01/DOE/EIS-0218-SA-06)) would not require modification of SRS infrastructure or processes to be received and stored at the site. SRS has the capacity to receive and store the volume of SNF meeting these characteristics and projected to be generated under the ULTB Program. SRS also has the infrastructure and capacity to dry and package the material for transport to the repository.

Based on the ratio of ULTB Program SNF received and stored to the current and projected SRS SNF inventory, the projected waste volume generation from these activities supporting the storage of material derived from the ULTB Program pending subsequent disposal is expected to be less than ~1% of the current total SRS waste generation.

These projections involve only minor changes with respect to the NEPA impact analyses considered above. No new NEPA analyses are required.

3.4 GTCC LOW LEVEL WASTE

3.4.1 GTCC LLW Program Background Description and Potential Involvement in the Storage and Disposal of ULTB Program Radioactive Waste

Pursuant to the ULTB Program Take-Back Contracts, DOE would take title to and be responsible for final disposition of radioactive waste created by the irradiation, processing or purification of leased uranium for which the Secretary determines the producer does not have access to a disposal path. At present, there is no disposal capability for GTCC LLW. DOE would be responsible for GTCC LLW upon acceptance of title and responsibility under a ULTB Take-Back contract with a Mo-99 producer, in which case the waste would be managed as GTCC-like waste. This SA considers the disposition of GTCC LLW and GTCC-like wastes based on the analysis provided in the GTCC DEIS (DOE/EIS-0375-D). It is anticipated that Mo-99 producers would be responsible for final disposition of Class A, B and C LLW as there are currently commercial disposal pathways for these wastes. It is also expected the amounts of Class A, B and C LLW generated by the Mo-99 producers would be relatively small compared to the annual total domestic generation and hence well within the planned capacity of the commercial disposal options. Accordingly, the disposition of Class A, B and C LLW is not evaluated in detail in this SA.

While there is currently no disposal capability for GTCC LLW or GTCC-like waste (Marcinowski 2015), DOE evaluated alternative disposal sites through the GTCC DEIS (DOE/EIS-0375-D) (DOE 2011b). DOE is preparing the Final EIS. DOE's evaluation of the range of action alternatives addresses various methods and sites. DOE evaluated the following five alternatives in the EIS: no action; disposal at the WIPP geologic repository; disposal in a new borehole disposal facility; disposal in a new trench disposal facility; and disposal in a new vault disposal facility (DOE 2011b).

For deep geologic disposal, WIPP in New Mexico was evaluated because of its characteristics as a geologic repository. Three land disposal methods (borehole, trench, and vault) were evaluated at six federally owned sites: Hanford Site, Washington; INL, Idaho; LANL, New Mexico; NNSS, Nevada; SRS, South Carolina; and lands in the WIPP Vicinity (two different locations, within and outside the land withdrawal boundaries of WIPP). In addition to the federally owned sites, the land disposal methods were evaluated for generic commercial sites in the four regions that make up the United States. These regions correspond to the four NRC regions. **Table 3-14** presents the land disposal methods considered in the GTCC DEIS.

Table 3-14: Land Disposal Methods Evaluated at the Six Federal Sites and Generic Regional Commercial Sites.

Site	Borehole	Trench	Vault
Hanford Site	X	X	X
INL	X	X	X
LANL	X	X	X
NNSS	X	X	X
SRS	Not Evaluated	X	X
WIPP Vicinity	X	X	X
NRC Region I	Not Evaluated	Not Evaluated	X
NRC Region II	Not Evaluated	X	X
NRC Region III	Not Evaluated	Not Evaluated	X
NRC Region IV	X	X	X

Source: DOE 2011b

The presentation of the GTCC waste site "Affected Environment" in this SA is limited to this summary overview. Specific impact areas associated with each of the proposed GTCC LLW and GTCC-like waste disposal sites are evaluated in detail in the GTCC DEIS. After DOE has selected a disposal method and site for the GTCC waste, the specific design for the facility will be prepared. DOE would conduct additional reviews under NEPA, as appropriate, to address the impacts from constructing and operating the selected disposal method at the selected site (DOE 2011b). GTCC LLW and GTCC-like waste storage options are discussed in Section 3.4.3 of this SA.

3.4.2 Comparative Analyses of GTCC Program Activities

The GTCC DEIS considers the potential impact of the disposal of the combined GTCC LLW and GTCC-like waste inventory, with a packaged volume of approximately 12,000 m^3 (420,000 ft^3). The Draft GTCC EIS considers two GTCC waste groups: Group 1 wastes consist of wastes from currently operating facilities; Group 2 wastes consist of projected wastes from proposed actions or planned facilities not yet in operation (DOE 2011b). Some of the Group 1 wastes have already been generated and are in storage awaiting disposal (DOE 2011b). Group 2 consists of wastes that might be generated from proposed future activities, including Mo-99 production projects.

The GTCC DEIS considered the movement of GTCC LLW and GTCC-like waste by truck and rail to each potential disposal site considered within the GTCC DEIS (DOE 2011b). The impacts for both routine and accident conditions were compared against regulatory limits for DOT (Radiation Level Limitations at 49 CFR 173.441) and NRC (External Radiation Standards for All Packages at 10 CFR 71.47). Should the WIPP repository or one of the land disposal methods be selected as the option for disposal of these LLW, DOE would conduct further evaluation and analysis to optimize the waste shipment configuration so as to minimize to the extent possible the number of shipments and potential transportation impacts (DOE 2011b).

The GTCC DEIS considered GTCC LLW generated by Mo-99 production. The total volume of GTCC LLW produced over this time frame attributed to Mo-99 production projects is estimated in Appendix B of the DEIS to be about 390 m^3 (14,000 ft^3) (DOE 2011b). Projections obtained from the Mo-99 producers suggest that GTCC LLW generation is likely to be less than 300 m^3 (10,600 ft^3) over the lifetime[21] of the ULTB Program. The projected quantity of ULTB GTCC LLW is less than the quantity of ULTB GTCC LLW disposal analyzed in the GTCC DEIS. Implementation of the Proposed Action is not expected to impact the implementation of the GTCC Waste Program.

3.4.3 Storage of ULTB Program GTCC Waste

In general, storage of GTCC LLW could be accommodated: 1) by the Mo-99 producer in accordance with the producer's license conditions, 2) by the Mo-99 producer in accordance with an amendment to the producer's license, 3) by the Mo-99 producer entering into a third-party arrangement with a radioactive waste management service provider, or 4) by DOE, upon acceptance of title and responsibility under a ULTB Take-Back contract with a Mo-99 producer, in which case the waste would be managed as GTCC-like waste. This section considers DOE storage of GTCC-like waste under a ULTB Take-Back contract.

DOE considered storage of GTCC-like waste from the ULTB Program at DOE sites and at commercial facilities.[22] GTCC-like waste is currently stored at four DOE sites: Idaho National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and West Valley. DOE has evaluated the storage of GTCC-like waste at these locations to assess the feasibility of receiving and storing ULTB Program derived GTCC-like waste. Upon reviewing these four sites, DOE found as follows:

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[21] As noted in Table 1-2, note c, lifetime is based on a 20-year NRC operating license.

[22] GTCC-like waste refers to radioactive waste that is owned or generated by DOE and has characteristics sufficiently similar to those of GTCC LLW such that a common disposal approach may be appropriate (DOE 2011a).

Idaho National Laboratory site storage authority and capacity is limited to GTCC-like waste generated as a result of INL site activities. While the Idaho Settlement Agreement allows for off-site wastes to be received, it is only for the purposes of sampling and treatment and cannot remain in Idaho longer than one year (Sturm 2015). Accordingly, storage of ULTB Program GTCC-like waste at INL was deemed not feasible.

Los Alamos National Laboratory (LANL) stores GTCC-like waste (DOE 2011b). However, LANL has no additional capacity to store its GTCC-like waste. LANL would need to initiate a multi-year process of preparing and obtaining a modification to a relevant permit. Accordingly, storage of ULTB Program GTCC-like waste at LANL was deemed not feasible.

Oak Ridge National Laboratory - The Oak Ridge Environmental Management Program (OREM) owns and operates facilities at the Oak Ridge National Laboratory (ORNL) that store legacy GTCC-like waste. Part of OREM’s mission is to de-inventory the ORNL facilities by processing the legacy transuranic waste of defense origin for future disposal. Once the ORNL facilities are emptied of waste, the facilities will be transferred to ORNL for future programmatic missions or undergo decontaminating and demolishing (D&D) to allow transfer of the land for future use. OREM’s primary mission is cleanup and closure of facilities and property for future mission needs or reindustrialization. Therefore, storage of ULTB Program GTCC-like waste at Oak Ridge was deemed not feasible.

West Valley has limited capacity for storage of GTCC-like waste generated as a result of West Valley Demonstration Project cleanup activities being conducted at the Western New York Nuclear Service Center owned by the New York State Energy Research and Development Authority (NYSERDA). There is no statutory basis or authority under the WVDP Act that allows the DOE to store waste, other than that generated by the WVDP at the site. Accordingly, storage of GTCC-like waste at West Valley was deemed not feasible.

DOE analyzed commercial radioactive waste management service providers to determine if they could store GTCC-like waste. It was determined that GTCC-like waste could be stored at a licensed commercial facility. In this scenario, DOE could enter into a third-party arrangement with a commercial radioactive waste management service provider to store GTCC-like waste (such as, Waste Control Specialists (WCS) in Andrews, Texas). The potential environmental impacts of activities associated with storage of GTCC LLW or GTCC-like waste through a radioactive waste management service provider would be considered within the NRC NEPA analysis of the third-party storage facility.

3.4.4 Conclusion

The GTCC DEIS considers the potential impact of the disposal of the combined GTCC LLW and GTCC-like waste inventory, with a packaged volume of approximately 12,000 m^3 (420,000 ft^3) (DOE 2011b). The GTCC-DEIS considers two GTCC waste groups: Group 1 wastes consist of wastes from currently operating facilities; Group 2 wastes consist of projected wastes from proposed actions or planned facilities not yet in operation (DOE 2011b). Some of the Group 1 wastes have already been generated and are in storage awaiting disposal (DOE 2011b). Group 2 consists of wastes that might be generated from proposed future activities, including Mo-99 production projects. The GTCC DEIS estimates the total volume of GTCC LLW produced over this time frame for Mo-99 projects would be about 390 m^3 (14,000 ft^3). Projections obtained from the Mo-99 producers suggests that GTCC LLW production under the ULTB Program is likely to be less than 300 m^3 (10,600 ft^3) over the lifetime of the program. The projected quantity of ULTB GTCC LLW is less than the quantity of ULTB GTCC LLW disposal analyzed in the GTCC DEIS.

If, in the future, DOE were to accept GTCC LLW under the ULTB Program Take-Back contract and storage of the waste would occur at a DOE site, DOE would undertake additional NEPA analysis as deemed appropriate. Storage of GTCC-like LLW at a commercial radioactive waste management service provider is feasible. The potential environmental impacts of activities associated with storage of GTCC LLW or GTCC-like waste through a commercial radioactive waste management service provider would be considered within the NRC NEPA analysis of the third-party storage facility.

As the potential ULTB Program GTCC LLW for disposal from Mo-99 producers, whether or not part of the ULTB Program, was considered in the Draft GTCC EIS, no additional new analysis is required regarding disposal of GTCC LLW or GTCC-like waste. GTCC LLW and GTCC-like waste disposal will be addressed in the Final GTCC EIS.

4 CONCLUSION AND DETERMINATION

4.1 SUMMARY

This SA considered whether the proposed ULTB Program makes substantial changes in actions already considered in existing NEPA analyses or new circumstances or new information that would trigger the need for a supplemental environmental impact statement (EIS) pursuant to 40 Code of Federal Regulations (CFR), Section 1502.9(c). Specifically, this is a SA to the following documents:

- *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex. DOE/EIS-0387.* (DOE 2011a*).* This EIS provides a description of the Y-12 resources and activities associated with the production of low-enriched uranium (LEU). Y-12 would be the provider of LEU to the Mo-99 producers expressing interest in the ULTB Program.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement, DOE/EIS-0279.* (DOE 2000). This EIS evaluates Savannah River Site (SRS) resources and activities involved in disposition of SNF. Mo-99 producers might generate spent nuclear fuel (SNF) for storage at SRS pending availability of a repository.

This SA was prepared in accordance with the requirements of the DOE NEPA Implementing Procedures (10 CFR Part 1021) and the DOE Recommendations for the Supplement Analysis Process (DOE 2005).

Table 4-1 presents a summary comparison of the ULTB Program requirements and the DOE capabilities to support the ULTB Program. This section presents summaries of the SA findings for Y-12 (Section 4.2), SRS (Section 4.3) and the GTCC Program (Section 4.4). The SA Determination is presented in Section 4.5.

Table 4-1: Summary of ULTB Program Mo-99 Producer Projections and DOE Designated Facilities Capabilities

	LEU requirement (kg U per year)	Potential eligible material return (kg U per year)[a]	SNF Return (per year)	Radioactive waste without disposition path[b] (lifetime total)[c]
Mo-99 Producer Projections[c]	~700 – 800	~690	~60 (kg U) or ~4.5 L-Bundle equivalents	~ 280 cubic meters
DOE Designated Facilities Capabilities	Well within Y-12 capacity[d]	Well within Y-12 capacity[d]	Mass is not anticipated to be an issue at SRS.[e] Based on current FRR/DRR projections, space is available.[e]	~ 390 cubic meters[f]

DRR = Domestic Research Reactor; FRR = Foreign Research Reactor; kg = kilogram; LEU = low enriched uranium; SNF = spent nuclear fuel; U = uranium

a) See Footnote 4 in text for the definition of "eligible material"
b) Currently, only GTCC LLW has no disposition pathway.
c) Lifetime is based on a 20-year NRC operating license
d) Values reflect a long-term average based on projections provided by all prospective Mo-99 producers. These values likely overestimate the actual quantity that would be needed because each producer projects meeting all or a large part of the Mo-99 demand.
e) Total Y-12 DU, LEU and EU Y-12 capacity or capability is sensitive and not available for public release. Y-12 activities in support of the ULTB Program are deemed to be an insignificant amount in the context of the overall capacity. Source DOE 2015b.
f) Source DOE 2015a.
g) Source DOE 2011b.

4.2 Y-12

DOE activities associated with the fulfillment of Mo-99 producer requests for LEU, where the requested LEU meets DOE's current specifications, have been thoroughly addressed in existing NEPA analyses.

Radiological impacts to the public and workers and waste generation from ongoing Y-12 activities have been considered in the context of HEU and LEU processing described in the Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex, DOE/EIS-0387 (DOE 2011a). The activities anticipated in support of the ULTB Program are compatible with ongoing processes at Y-12, and do not require any changes to site infrastructure or processes. Health and safety impacts and impacts to waste management and transportation associated with the ULTB Program are minor with respect to potential impacts assessed in these other NEPA analyses.

No changes in Y-12 infrastructure or resources are required to support the return and handling of eligible material in support of the ULTB Program. The receipt of eligible material at Y-12 from the Mo-99 producer is identical to activities performed at Y-12 and adequately considered in existing NEPA documents (DOE 2011a).

4.3 SRS

ULTB Program SNF with physical characteristics comparable to SNF considered within existing NEPA documents, notably the Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement, DOE/EIS-0279 and associated *Supplement Analysis SRS SNF Management*, (DOE/EIS-0279-SA-01/DOE/EIS-0218-SA-06), would not require modification of SRS infrastructure or processes to be received and stored at the site. SRS has the capacity to receive, dry, package and store the volume of SNF meeting these characteristics and anticipated to be generated under the ULTB Program.

Based on the ratio of ULTB Program SNF received and stored to the current and projected SRS SNF inventory, the projected waste volume generation from these activities supporting the processing of material derived from the ULTB Program is expected to be less than ~1% of the current total SRS waste generation.

These projections are minor with respect to potential impacts assessed in the NEPA impact analyses considered above. No new NEPA analyses are required.

4.4 GTCC

The GTCC DEIS considers the potential impact of the disposal of the combined GTCC LLW and GTCC-like waste inventory, with a packaged volume of approximately 12,000 m^3 (420,000 ft^3) (DOE 2011b). The GTCC DEIS estimates the total volume of GTCC LLW produced over this time frame for Mo-99 projects would be about 390 m^3 (14,000 ft^3). Projections obtained from the Mo-99 producers suggests that GTCC LLW production under the ULTB Program over the lifetime of the program is likely to be less than the total volume evaluated within the analysis of GTCC LLW disposal presented in the GTCC DEIS.

If, in the future, DOE were to accept GTCC LLW under the ULTB Program Take-Back contract and storage of the waste were to occur at a DOE site, DOE would undertake additional NEPA analysis as deemed appropriate. Storage of GTCC-like waste by a commercial radioactive waste management service provider is feasible. The potential environmental impacts of activities associated with storage of GTCC LLW or GTCC-like waste through a commercial radioactive waste management service provider would be considered within the NRC NEPA analysis of the third-party storage facility.

4.5 CONNECTED AND CUMULATIVE ACTIONS – TRANSPORTATION

The implementation of the ULTB Program would result in the transportation of radioactive materials to and from the DOE sites and the Mo-99 producer sites as discussed in the previous sections. This transportation of radioactive material is considered a connected action. As indicated in the previous sections, the types of materials that would be shipped in support of the ULTB Program are similar to ongoing shipments by the DOE throughout the country and present no new or unique hazards. The number of shipments of unirradiated LEU fuel, irradiated LEU fuel, and radioactive wastes due to the implementation of the ULTB Program is a small fraction of the ongoing shipments to and from the DOE facilities. While the exact numbers of shipments are unknowable at this early stage of the ULTB Program, it is obvious due to the limited nature of the program that they would be minor relative to ongoing and projected transportation activities at Y-12, SRS, and DOE and commercial waste facilities.

Detailed transportation impacts would be evaluated as a part of the NRC licensing process as the details of the transportation activities are developed during the NRC license application process. At this time, those transportation details are not known and speculative and hence the time is not right for their detailed evaluation. The information presented in this SA is included to indicate relative magnitude of the ULTB Program related transportation activities to the overall Y-12 and SRS transportation activities.

Site-related cumulative impacts are presented in each of the respective site or program discussions in Chapter 3. No cumulative impacts were identified. Potential cumulative impacts of transportation as a connected action are presented here, with a concentration on radiological impacts from offsite transportation throughout the nation that would result in potential radiation exposure to the transportation crew and general population, in addition to those impacts evaluated in this SA. Cumulative radiological impacts from transportation are measured using the collective dose to the general population and workers because dose can be directly related to LCFs using a cancer risk coefficient.

The cumulative impacts from transport of radioactive material consist of impacts from historical shipments of radioactive waste and used (irradiated) nuclear fuel; reasonably foreseeable actions that include transportation of radioactive material identified in Federal, non-Federal, and private environmental impact analyses; and general radioactive material transportation that is not related to a particular action. The timeframe of impacts was assumed to begin in 1943 and continue to some foreseeable future date. Projections for commercial radioactive material transport extend to 2073 based on available information.

As noted in the program discussions in Chapter 3, impacts from transportation in this SA are minor compared with overall cumulative transportation impacts. The impacts in terms of LCFs to the transportation workers and general population due to ULTB Program activities was shown in Sections 3.2.3.1 and 3.3.3.1 to be a small fraction of the transportation activities associated with Y-12 and SRS operations. In addition, the ongoing and projected future Y-12 and SRS transportation impacts are small compared to the national transportation of radiological material impacts. For example, the recent SPD Supplemental EIS (DOE 2015c) estimated the total number of LCFs (among the workers and the general population) to result from radioactive material transportation over the period between 1943 and 2073. A total of 252 LCFs among transportation workers and 262 LCFs among the general population, or an average of about 4 LCFs per year, as estimated (DOE 2015c, Table 4-49). The potential transportation-related LCFs projected represent an extremely small fraction of the overall annual number of cancer deaths; indistinguishable from the national fluctuation in the total annual death rate from cancer. Note that the majority of the cumulative risks to workers and the general population would be due to the general transportation of radioactive material unrelated to activities evaluated in this SA. No cumulative impacts from the connected action of transportation are anticipated from the implementation of the ULTB Program.

4.6 DETERMINATION

The analyses considered in this SA support DOE's determination that the implementation of the ULTB Program represent neither substantial changes to the actions evaluated in previous NEPA analyses (DOE 2000; 2011a), nor represent significant new circumstances or information relevant to environmental concerns. This SA confirms that the potential environmental impacts associated with the provision of LEU to the Mo-99 producers, the transport of LEU to and LLW and SNF from the Mo-99 producers would be very low and not significantly different from the impacts reported in either of these previous NEPA analyses. Additionally, the evaluation in this SA indicates that the quantity and types of SNF and GTCC LLW expected under the ULTB Program are consistent with those addressed by DOE programs for disposition of those radioactive materials. Consequently, they also do not represent significant new circumstances or information relevant to environmental concerns. Therefore, pursuant to 10 CFR 1021.314(c), I have determined that 1) no supplemental or new EISs are required to establish and implement the ULTB Program, and 2) no further NEPA documentation is required to establish and implement the ULTB Program.

Issued at Washington, D.C. on February 11, 2016.

Anne Harrington

Deputy Administrator for Defense Nuclear Nonproliferation (NA-20)

5 REFERENCES

Blake, E. Michael. 2014. The campaign to resume domestic production of molybdenum-99. Nuclear News. Vol 57, Number 12, November 2014.

Charlton, K. 2015. *OECD-NEA Update. Mo-99/Tc-99m Market Demand and Production Capacity Projection 2015-2020,* presented at the Mo-99 Topical Meeting, Boston Massachusetts, September 1, 2015

DOE (U.S. Department of Energy). 1995a. *Programmatic Final Environmental Impact Statement on Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs.* DOE-EIS-0203F. Washington, DC: Assistant Secretary for Environmental Management. April.

DOE (U.S. Department of Energy). 1995b. *Record of Decision for Programmatic Final Environmental Impact Statement on Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs.* DOE-EIS-0203F. Washington, DC: Assistant Secretary for Environmental Management. May 3, 1995. http://babel.hathitrust.org/cgi/pt?id=coo.31924073440434;view=1up;seq=5, last accessed November 3, 2015.

DOE (U.S. Department of Energy). 1996. *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* DOE-EIS-0218F. Washington, DC: Assistant Secretary for Environmental Management. http://www.energy.gov/nepa/downloads/eis-0218-final-environmental-impact-statement

DOE (U.S. Department of Energy). 2000. *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement*, DOE/EIS-0279. Washington, DC. March. http://www.energy.gov/nepa/eis-0279-spent-nuclear-fuel-management-aiken-south-carolina

DOE (U.S. Department of Energy). 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250* *http://www.energy.gov/nepa/downloads/eis-0250-final-environmental-impact-statement*

DOE (U.S. Department of Energy). 2005. *Recommendations for the Supplement Analysis Process*. Office of NEPA Policy and Compliance, Washington, D.C. July 2005.

DOE (U.S. Department of Energy). 2008. *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada – Nevada Rail Transportation Corridor* DOE/EIS-0250F-S2 *and Final Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada* DOE/EIS-0369 Office of Civilian Radioactive Waste Management, Las Vegas, NV June 2008. http://www.energy.gov/nepa/downloads/eis-0250-s2-and-eis-0369-final-supplemental-environmental-impact-statement

DOE (U.S. Department of Energy). 2009. *Radiological Control, DOE-STD-1098-2008.* Washington, DC.

DOE (U.S. Department of Energy). 2010. *DOE 2009 Occupational Radiation Exposure.* Washington DC: Office of Health, Safety and Security. September.

DOE (U.S. Department of Energy), National Nuclear Security Agency (NNSA). 2011a. *Final Site-Wide Environmental Impact Statement for the Y-12 National Security Complex*. DOE/EIS-0387. DOE-NNSA Y-12 Site Office, February. http://www.energy.gov/nepa/downloads/eis-0387-final-site-wide-environmental-impact-statement

DOE (U.S. Department of Energy). 2011b. *Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste*, DOE/EIS-0375-D. Office of Environmental Management, Washington, DC. February. http://www.energy.gov/nepa/downloads/eis-0375-draft-environmental-impact-statement

DOE (U.S. Department of Energy). 2011c. *DOE 2010 Occupational Radiation Exposure.* Washington DC: Office of Health, Safety and Security. November.

DOE (U.S. Department of Energy). 2011d. *Radiation Protection of the Public and the Environment* DOE Order 458.1

DOE (U.S. Department of Energy), 2012a, *DOE 2011 Occupational Radiation Exposure*, Office of Health, Safety and Security, December

DOE (U.S. Department of Energy) 2012b. Contract DE-EM0002405 between the U.S. Department of Energy and Waste Control Specialists LLC, dated March 13, 2012, as amended

DOE (U.S. Department of Energy). 2013a. *Supplement Analysis: Savannah River Site Spent Nuclear Fuel Management,* DOE/EIS-0279-SA-01/DOE/EIS-0218-SA-06. Office of Environmental Management, Aiken, S.C. March http://www.energy.gov/nepa/downloads/eis-0279-sa-01-supplement-analysis

DOE (U.S. Department of Energy). 2013b. *DOE 2012 Occupational Radiation Exposure Report*. Washington DC: Office of Health, Safety and Security.
http://www.energy.gov/ehss/listings/annual-doe-occupational-radiation-exposure-reports
Accessed August 18, 2015.

DOE (U.S. Department of Energy). 2014. *DOE 2013 Occupational Radiation Exposure.* Washington DC: Office of Environment, Health, Safety and Security. November.

DOE (U.S. Department of Energy). 2015a. *DOE Site Data Call Questionnaire,* Savannah River Site, South Carolina. September 28, 2015.

DOE (U.S. Department of Energy). 2015b. *DOE Site Data Call Questionnaire, Y-12, Oak Ridge, TN.* September 28, 2015.

DOE (U.S. Department of Energy). 2015c. *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement*. DOE/EIS-0283-S2. National Nuclear Security Administration, Washington, DC. June. http://www.energy.gov/nepa/downloads/eis-0283-s2-final-supplemental-environmental-impact-statement

DOT (U.S. Department of Transportation). 1998. Radioactive Material Regulations Review RAMREG-001-98.

Dunsmuir, M. and Magoulas, V 2015., *Uranium Lease and Take Back Materials Acceptance Criteria and Dry Storage Cost Model*, SRNL-STI-2015-00287, Revision 2, Savannah River National Laboratory, July 2015

EPA (U.S. Environmental Protection Agency) 2009. *National Primary and Secondary Ambient Air Quality Standards*, 40 CFR 50, July.

Espinosa, Edgard. 2015. *Department of Energy Spent Nuclear Fuel – Update, Briefing for the Institute for Nuclear Materials Management*, January 13, 2015

Grimm, Terry L., et al. 2014. *Mo-99 Production Using a Superconducting Electron Linac*, presented at the June 2104 M-99 Topical Meeting, Washington D.C.

Hinshelwood, et al 2011. *High-Power, Pulsed Bremsstrahlung Source for Inducing Photofission,* presented at the 2011 IEEE Pulsed Power Conference

IAEA (International Atomic Energy Agency). 2010. *Production and Supply of Molybdenum-99, Nuclear Technology Review 2010 Supplement.* https://www.iaea.org/About/Policy/GC/G48.C54/GC54InfDocuments/English/gc54inf-3-att7_en.pdf . Accessed 5/28/15.

Marcinowski, F. 2015. *Status of Disposal Capabilities for Greater-than-Class C (GTCC) Low-Level Radioactive Waste*, briefing presented at the 8/13/2015 NRC Meeting - Briefing on Greater-Than-Class C Low-Level Radioactive Waste, http://www.nrc.gov/reading-rm/doc-collections/commission/slides/2015/20150813/marcinowski-20150813.pdf

NNSA (National Nuclear Security Administration). 2014. GTRI: Reducing Nuclear Threats. Fact Sheet May 29, 2014. http://nnsa.energy.gov/mediaroom/factsheets/reducingthreats, Accessed July 24, 2015.

NRC (National Research Council). 2009. *Medical Isotope Production Without Highly Enriched Uranium*. Committee on Medical Isotope Production without Highly Enriched Uranium. National Academies Press, Washington, D.C.

NRC (Nuclear Regulatory Commission). 1977. *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*. NUREG-0170. Washington, D.C. December 1977. Available at: http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf

NRC (Nuclear Regulatory Commission). 2004. Nuclear Power Plant Licensing Process. NUREG/BR-0298, Rev. 2. July 2004

NRC (Nuclear Regulatory Commission), 2015a. Licensing Update on Medical Radioisotope Production Facilities, Office of Nuclear Reactor Regulation Presentation to Office of Science and Technology Policy Meeting on Mo-99, April 7, 2015.

NRC (U.S. Nuclear Regulatory Commission). 2015b. *Environmental Impact Statement for the Construction Permit for the SHINE Medical Radioisotope Production Facility (Final Report)*, Office of Nuclear Reactor Regulation. NUREG-2183. October, 2015. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2183/ Accessed December 1, 2015.

NSAC (Nuclear Science Advisory Committee). 2014. Report to the Nuclear Science Advisory Committee: Review of the NNSA GTRI Mo-99 Program. Report of the NSAC 99Mo Sub-Committee.

Nuclear News. 2015. Molybdenum-99: Startup of new supply source planned for 2017. April 2015

NWMI (Northwest Medical Isotopes). 2015. Chapter 19.0 – Environmental Review: Construction Permit Application for Radioisotope Production Facility, NWMI-2013-021, Rev. 0, January, 2015.

OECD (Office for Economic Cooperation and Development). 2014. The Supply of Medical Radioisotopes: Medical Isotope Supply in the Future: Production Capacity and Demand Forecast for the 99Mo/99mTc Market, 2015 – 2020. High-Level Group on the Security of Supply of Medical Radioisotopes NEA/SEN/HLGMR(2014)2.

Rose, David. 2015. *Spent Nuclear Fuel Receipt, Storage and Disposition at Savannah River Site (SRS)*, presented at the January 2015 INMM Spent Fuel Management Seminar

Seestrom, Susan. 2014. Mo-99 Presentation to NSAC, April 25, 2014. Los Alamos National Laboratory.

SHINE (Shine Medical Technologies, Inc.). 2013. Chapter 19 – Environmental Report in Support of an Application to Construct and Operate a Radioisotope Facility in Janesville, Wisconsin – Rev. 0

SRNS (Savannah River Nuclear Solutions). 2009. Facts About the Savannah River Site: L Area Complex. May 2009.

SRNS (Savannah River Nuclear Solutions). 2014a. Savannah River Site Comprehensive Plan/Ten Year Plan, Limited Update FY 2014-2024. SRNS RP-2014-00006, Aiken, SC.

SRNS (Savannah River Nuclear Solutions). 2014b. *Savannah River Site Environmental Report for 2013. SRNS-STI-2014-00006*. Aiken, SC.

SRS (Savannah River Site). 2014. *ALARA (As Low as Reasonably Achievable).* January 21. http://www.srs.gov/general/programs/alara/. Last Accessed January 30, 2015.

White House, 2012 Fact Sheet: Encouraging Reliable Supplies of Molybdenum-99 Produced without Highly Enriched Uranium. https://www.whitehouse.gov/the-press-office/2012/06/07/fact-sheet-encouraging-reliable-supplies-molybdenum-99-produced-without-Retrieved March 19, 2015.

World Nuclear News. 2014. Nuclear Power in the Netherlands. http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Netherlands/ Retrieved 080515

APPENDICES

Appendix A: Alternative Molybdenum-99 Production Processes

There are three primary methods for producing Mo-99: neutron-induced fission of uranium-235 (U-235), gamma-induced fission of uranium-238 (U-238), and neutron capture of molybdenum-98 (Mo-98). These methods are illustrated in **Figure A-1**, **Figure A-2**, and **Figure A-3**, respectively.

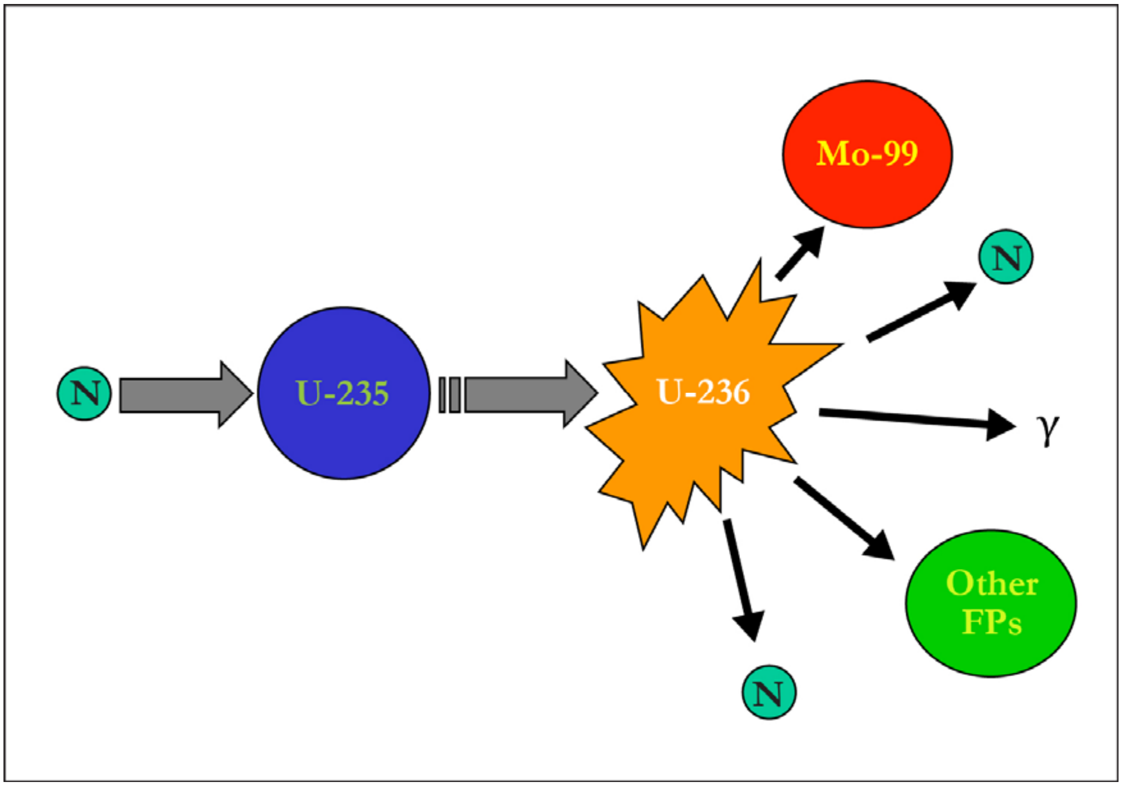

Figure A-1: Schematic representation of the uranium-235 fission process for the production of Mo-99

Notes: ^{235}U = Uranium 235, ^{236}U = Uranium 236. ^{99}Mo = molybdenum-99, N = neutron, FP = fission products, γ = gamma radiation

Source: NRC 2009

In the neutron-induced fission process, Mo-99 is recovered from the fission of U-235 (NRC 2009). Two types of fission targets are in use today: highly enriched uranium (HEU) (defined as typically containing more than 90% mass of U-235), and LEU (defined as containing less than 20% mass of U-235) (NRC 2009). Presently, most of the Mo-99 is produced from HEU targets.

In addition to providing for a reliable domestic supply of medical radioisotopes, a key goal of the Act is to move the medical radioisotope industry away from the use of HEU and encourage the development of procedures using LEU. This goal is consistent with the Global Threat Reduction Initiative Program.[23]

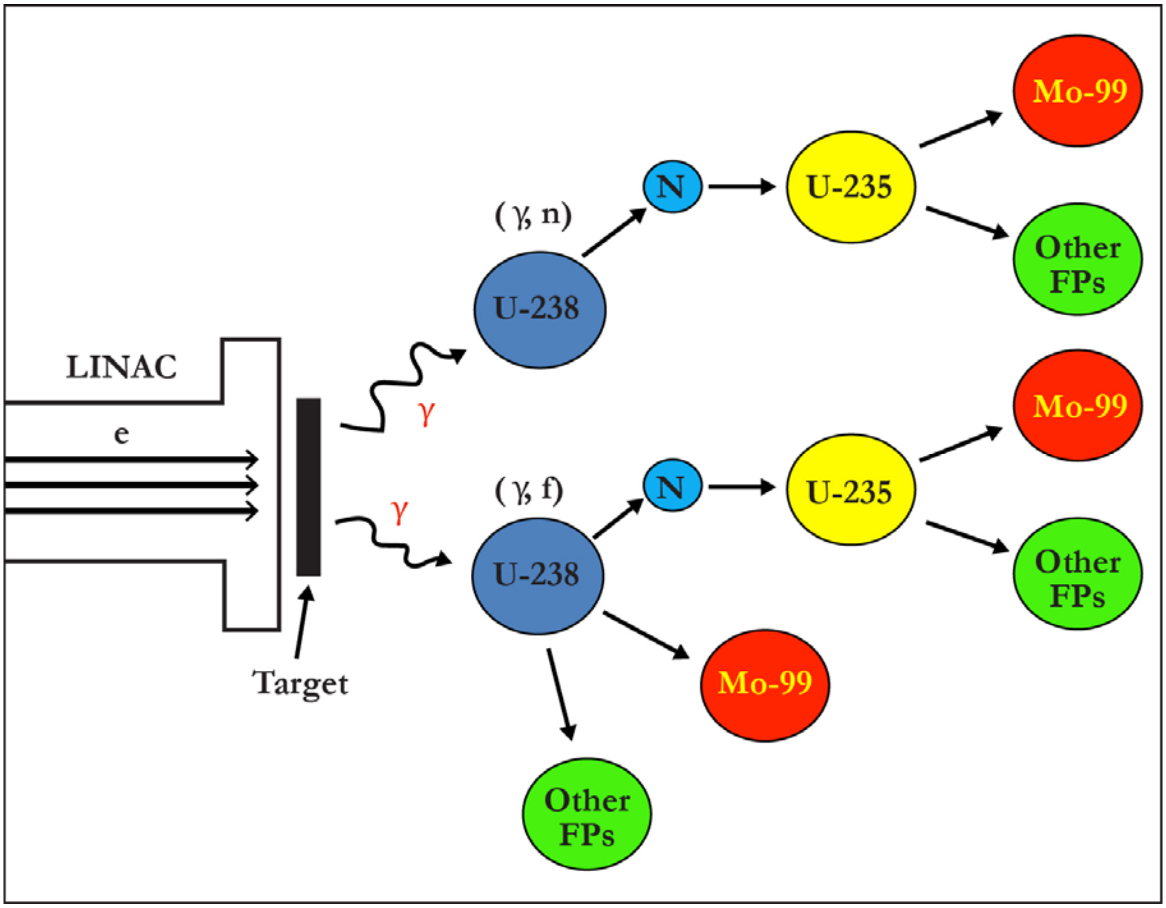

Figure A-2: Schematic representation of the production of Mo-99 Using Gamma-Induced Fission

Notes: ^{238}U = Uranium 238, ^{235}U = Uranium 235. ^{99}Mo = molybdenum-99, N, n= neutron, FP = fission products, γ = gamma radiation,

Source: Adapted from Grimm, et al 2014

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[23] The Global Threat Reduction Initiative (GTRI) was established in 2004 in the NNSA Office of Defense Nuclear Nonproliferation to, as quickly as possible, identify, secure, remove and/or facilitate the disposition of high risk vulnerable nuclear and radiological materials around the world that pose a threat to the United States and the international community. Under the GTRI Convert Initiative, NNSA seeks to convert research reactors and isotope production facilities from the use of highly enriched uranium (HEU) to low enriched uranium (LEU) or verify their shutdown. (NNSA 2014) See: http://nnsa.energy.gov/mediaroom/factsheets/reducingthreats, Accessed July 24, 2015.

In the gamma-induced fission process, Mo-99 is recovered from the gamma-induced fission of uranium-238 (U-238) in the LEU target. This process is called photo-fission, and it requires incident gamma rays of high energy (>5.5 MeV) (Hinshelwood, et al 2011). In addition, neutrons are produced by the U-238 fissions and by (ɤ, n) reactions in U-238 (which may occur instead of photo-fission); these neutrons are used to fission the U-235 present in the target to increase the yield of Mo-99 (Grimm, et al 2014).

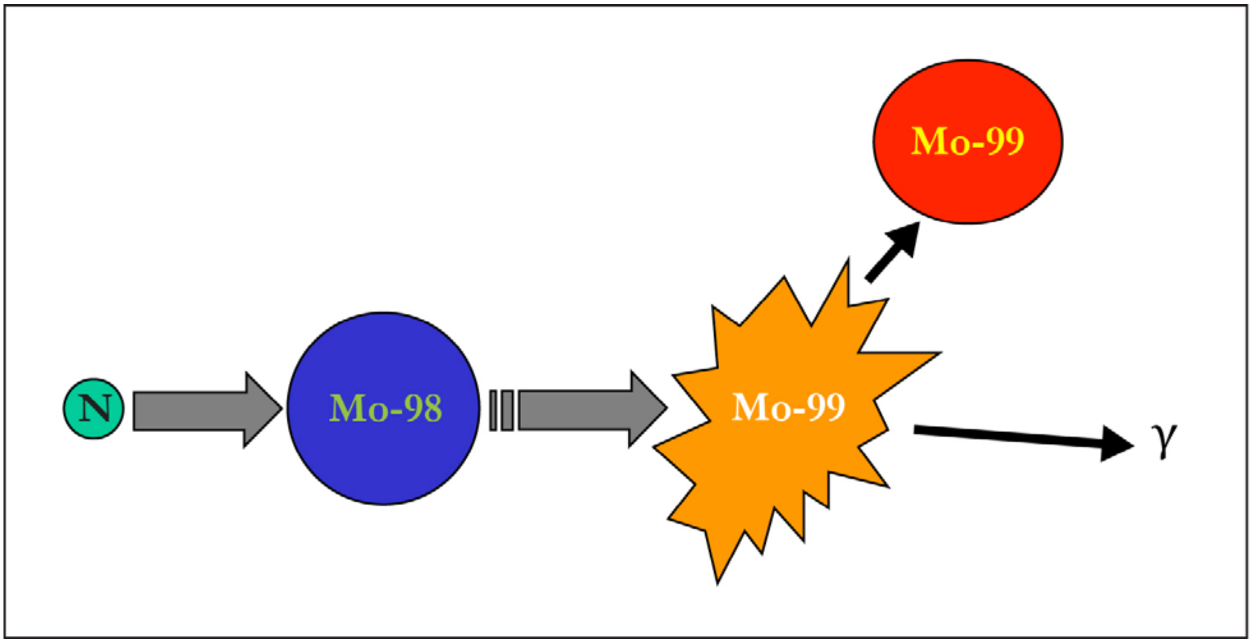

Figure A-3: Schematic representation of the production of Mo-99 from neutron capture.

Notes: ^{98}Mo = molybdenum 98, ^{99}Mo = molybdenum-99, N = neutron, γ = gamma radiation

Source: NRC 2009

In the activation process, Mo-99 is produced from naturally occurring Mo-98 by neutron capture (NRC 2009). Both natural and enriched molybdenum can be used for this purpose. The efficiency of the activation route is less than in the fission route. The specific activity of the molybdenum in the activation route is very low (more than 500 times lower than in the fission route), and a dedicated technetium purification step is sometimes needed before the latter is usable for medical diagnostics (NRC 2009). Note that since this process does not utilize LEU, it is outside the scope of the ULTB Program and this SA.

Several different methodologies can be used to produce the neutrons or gamma rays needed for the Mo-99 production processes. The methodology currently in use for Mo-99 production involves using neutrons generated from the fission process in a nuclear reactor; “targets” containing U-235 are placed in the reactor, and the reactor-generated neutrons produce additional fissions (and neutrons) in the targets. An alternative method proposed to generate neutrons utilizes a linear accelerator (LINAC) to accelerate deuterium ions into a gas containing tritium to induce d-t fusion; the resulting fusion-produced neutrons are then used for Mo-99 production in LEU targets (SHINE 2013b). A method proposed to produce gamma-rays uses a high-energy super conducting LINAC to accelerate electrons into a liquid metal target to produce gamma rays via the Bremsstrahlung process (Grimm, et al 2014).