DEFENSE NUCLEAR FACILITIES SAFETY BOARD

625 Indiana Avenue, NW, Suite 700, Washington, D.C. 20004-2901
(202) 694-7000

March 21, 2002

The Honorable Spencer Abraham
Secretary of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Abraham:

The Defense Nuclear Facilities Safety Board (Board) issued Recommendations 94-1, *Improved Schedule for Remediation in the Defense Nuclear Facilities Complex*, and 2000-1, *Prioritization for Stabilizing Nuclear Materials*, to address the nuclear safety issues related to the remnants of weapons production. Recommendation 94-1, agreed to by the Secretary of Energy, required that the most hazardous nuclear materials be stabilized within two to three years and that the remaining materials be stabilized by the year 2002, which was considered a reasonable period of time. Both Recommendations also recognized the unique chemical separations capability of the F- and H-Canyon facilities at the Savannah River Site as an important and integral part of the Department of Energy's (DOE) stabilization mission.

As this stabilization has proceeded during the years 1995–2002, a number of events affecting the effort have evolved.

First, a considerable amount of the high risk materials identified at the initiation of the stabilization program, has been stabilized and placed in safe storage. However, the initially programmed effort fell behind schedule and in 2001, the schedule was lengthened. Much remains to be done.

Second, the inventory of materials requiring treatment and stabilization continued to grow as the weapons program downsized and the clean out of facilities accelerated, i.e., progress in stabilization has been partially offset by new additions.

Third, a change in the nuclear weapons posture has occurred. This adds uncertainty regarding the future stream of materials that will require stabilization and safe storage pending final disposition.

Fourth, in 2002, DOE established a new direction for its clean-up program that focused on reducing risks, not just managing them.

DOE has advised the Board of its intent to immediately shut down chemical processing at F-Canyon. The Board questions the wisdom of this course of action since operation of both canyons:

(1) appears to offer the best means for achieving DOE's risk reduction objectives by treatment and stabilization of known inventories of remnant materials;

(2) maintains a known capability for dealing with materials not yet identified but almost certain to be added to the existing inventory as the clean-up effort continues; and

(3) offers the prospect of completing stabilization work earlier.

The Board has steadfastly advised DOE to avoid the pressure to shut down existing processing facilities so long as there remains a stream of materials that requires those facilities for stabilization and preparation for safe storage. At the same time, the Board recognizes these existing facilities are old and facing end of life. By prematurely shutting down one-canyon, it is likely that DOE will significantly extend both the time to complete its stabilization work and the time the remaining canyon must operate. Instead, DOE needs to proceed expeditiously to treat materials now in the stabilization queue and plan for future capability to deal with the inventory that is yet to come.

The Board has completed an analysis of the stabilization work required for the known inventory of hazardous nuclear materials and evaluated the risk reduction benefit that a two-canyon approach would offer. The results are presented in the enclosed technical report, DNFSB/TECH-32. Before proceeding with the deactivation of F-Canyon, the Board urges DOE to compare the risk reduction benefit, that a two-canyon program offers, to the cost of such an approach, using ideas of the Board's technical report.

The remaining stabilization campaign, be it either one-canyon or two-canyon, will result in these facilities having been operated for a long period of time. While safe operation in the near term is reasonably assured, the longer term (greater than10 years) will bring the uncertainty of further facility aging. This near term period of canyon operation should be used as an opportunity to work off the current inventory of hazardous materials from past production and to plan for dealing with inventories of scrap and wastes yet to come.

The Board would like to hear from DOE on this subject. In preparation for this, and pursuant to 42 U.S.C. § 2286b(d), the Board requests that it be provided a report within 60 days that reflects DOE's consideration of this matter and the Board's report, as well as DOE's view as to how it plans to proceed and the rationale for doing so.

Sincerely,

John T. Conway
Chairman

c: The Honorable Jessie Hill Roberson
Mr. Mark B. Whitaker, Jr.

Enclosure

DNFSB/TECH-32

SAVANNAH RIVER SITE CANYON UTILIZATION

Defense Nuclear Facilities Safety Board

Technical Report

March 2002

SAVANNAH RIVER SITE CANYON UTILIZATION

This report was prepared for the Defense Nuclear Facilities Safety Board by:

A. J. Eggenberger
Daniel G. Ogg

Outside Expert: Herbert J. C. Kouts

EXECUTIVE SUMMARY

The Department of Energy (DOE) and its contractor at the Savannah River Site (SRS) operate two chemical separations facilities at the site that play a vital role in reducing the risks posed by the remnants of DOE's weapons production activities. These two facilities, the F- and H-Canyons, have been the centerpieces of DOE's program to stabilize hazardous materials at SRS in accordance with the combined Implementation Plan for the Board's Recommendations 94-1, *Improved Schedule for Remediation in the Defense Nuclear Facilities Complex*, and 2000-1, *Prioritization for Stabilizing Nuclear Materials*. In addition, the canyons have served to stabilize many radioactive materials from DOE sites other than SRS.

Although the SRS canyons are well suited to the stabilization mission, DOE has attempted to identify other disposition paths for many excess nuclear materials. DOE's overall plan is to pursue these other disposition paths, concurrently stabilize some materials at H-Canyon, and shut down F-Canyon. However, many of the disposition paths are highly uncertain, and some have already failed. Without the capacity of both canyons, the timely stabilization of materials remaining from weapons production cannot be ensured.

In this report, a case is made for the continued operation of F-Canyon as part of a carefully balanced utilization of both the F- and H-Canyon facilities. Such use of both canyons would allow DOE to accomplish the necessary risk reduction in a timely and efficient manner, without relying on unproven, unfunded, or potentially impractical material disposition paths. The presence and availability of a fully operational and fully staffed facility with a high capacity for materials stabilization should not be so easily dismissed.

TABLE OF CONTENTS

1. INTRODUCTION

Two chemical separations facilities at the Savannah River Site (SRS)—F-Canyon and H-Canyon—have been and continue to be vital elements of the Department of Energy's (DOE) capability to stabilize the remnants of nuclear weapons production. The facilities are operated as an important component of DOE's program to protect the health and safety of the public and the workers. The canyon facilities were designed for and are well suited to the dissolution and chemical separation of special nuclear material from fission products and other materials. Many types of excess, surplus, unwanted, and waste materials can be processed in the canyons and then stabilized in the FB-Line or HB-Line facilities. In these facilities, uranium, plutonium, other actinides, and fission products are converted to forms that are suitable for shipment, long-term storage, or disposal.

The importance of the canyons and the B-Lines to stabilization of the remnants of weapons production has been clearly recognized by Congress, DOE, and the Defense Nuclear Facilities Safety Board (Board). In 1994, the Board issued Recommendation 94-1, *Improved Schedule for Remediation in the Defense Nuclear Facilities Complex*, identifying the need for the stabilization of materials that would otherwise pose a risk to workers in the DOE weapons complex and to the public. To date, DOE's implementation of this Recommendation has relied heavily on the operation of the F- and H-Canyon facilities.

In its Recommendation 2000-1, *Prioritization for Stabilizing Nuclear Materials*, the Board reiterated its concerns regarding the hazards presented by materials that had yet to be stabilized. The materials in need of timely attention included solutions containing highly enriched uranium (HEU), americium, curium, neptunium, and plutonium in the F- and H-Canyons at SRS.

In writing the two Recommendations mentioned above, the Board anticipated that the shipment, long-term storage, and disposal of unneeded nuclear materials would be fraught with schedule delays caused by budget shortfalls and other problems. To minimize the safety effects of long-term delays in ultimate disposition, the Recommendations require and are based on stabilization of nuclear materials.

The need for timely processing and stabilization of the hazardous materials in the defense nuclear complex, especially before processing capabilities are lost or abandoned, has been noted consistently by the Board. One of the more sobering lessons learned was from the premature shutdown of the Plutonium-Uranium Extraction (PUREX) facility at the Hanford Site. When PUREX was shut down in 1990 (and DOE chose not to restart it in 1992), more than 2100 metric tons (MT) of spent nuclear fuel from the N-Reactor was left stranded in the K-East and K-West Basins at the Hanford Site. The subsequent struggle by DOE and its contractor to retrieve and stabilize this spent fuel has been exceptionally challenging and greatly prolonged—a situation that represents continuing risk as long as degrading spent fuel exists in these unlined, water-filled basins that are located within a few hundred yards of the Columbia River. In a complex engineering undertaking, the fuel is now being placed in containers and moved to a more secure location on the Hanford Site. This compensatory project has been under way for more than 8 years, will continue for at least 2 more years, and has a total project

cost in excess of $1.5 billion. By comparison, PUREX, if still operating, could have processed the same fuel in approximately 23 months at an estimated cost of $400 million (based on the cost of operating F- or H-Canyon today).

A parallel example is the fate of the spent research reactor fuel stored at SRS. Chemical processing of these aluminum-based fuel elements in H-Canyon would allow retrieval and safe storage of the enriched uranium and byproduct radioactive materials using a known and proven technology. To avoid chemical processing of this material, DOE had planned to develop, construct, and operate a facility using a new and untested method called "melt-and-dilute." The spent fuel would have been melted at a high temperature and mixed with depleted or natural uranium to destroy its ability to sustain a chain reaction. It appears now that the melt-and-dilute concept may be abandoned to reduce costs. Funding for the program has been cut from the fiscal year (FY) 2002 budget. The problem of spent aluminum-based fuel is discussed at more length later in this report.

The above are examples of what might be called a DOE fixation on shutting down the capability to conduct chemical processing of spent nuclear fuel. This fixation has endured despite the fact that chemical processing is a well-developed, tested, and reliable technology that is already available to solve the problems of hazardous nuclear materials, whereas alternatives either do not yet exist or are still speculative. Chemical processing is not inexpensive, but it has so far been the path of least cost.

Clearly, needless delays in stabilization and safe storage of these hazardous nuclear materials are to be avoided. The prudent course is to take advantage of the opportunities for remediation while they exist. Lessons learned from the examples cited above should lead DOE to consider carefully the mode of utilization of the F- and H-Canyon facilities before terminating their operation. Recognizing the significance of F-Canyon operation, Congress included the following requirements in the National Defense Authorization Act for Fiscal Year 2001 (Public Law 106-395):

(a) CONTINUATION.

> The Secretary of Energy shall continue operations and maintain a high state of readiness at the F-canyon and H-canyon facilities at the Savannah River Site, Aiken, South Carolina, and shall provide technical staff necessary to operate and so maintain such facilities.

(b) LIMITATION ON USE OF FUNDS FOR DECOMMISSIONING OF F-CANYON FACILITY.

No amounts authorized to be appropriated or otherwise made available for the Department of Energy by this or any other Act may be obligated or expended for purposes of commencing the decommissioning of the F-canyon facility at the Savannah River Site until the Secretary and the Defense Nuclear Facilities Safety Board jointly submit to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives the following:

(1) A certification that all materials present in the F-canyon facility as of the date of certification are safely stabilized.

(2) A certification whether or not the requirements applicable to the F-canyon facility to meet the future needs of the United States for fissile materials disposition can be met through full use of the H-canyon facility at the Savannah River Site.

(3) If the certification required by paragraph (2) is that such requirements cannot be met through such use of the H-canyon facility—

(A) an identification by the Secretary of each such requirement that cannot be met through such use of the H-canyon facility, and

(B) for each requirement identified in subparagraph (A), the reasons why that requirement cannot be met through such use of the H-canyon facility and a description of the alternative capability for fissile materials disposition that is needed to meet that requirement.

While DOE's current plans envision only shutting down the canyons according to schedules discussed below, and not decommissioning them, it is recognized that restart would be so massive and costly an undertaking that shutdown would for all intents and purposes amount to decommissioning.

2. BACKGROUND

F-Canyon began operations in 1954 and H-Canyon in 1955. The facilities use nitric acid dissolution and a chemical solvent extraction process to separate special nuclear material (e.g., plutonium and uranium) from irradiated reactor targets, spent nuclear fuel, and other materials returned from the nuclear weapons complex. Recovered plutonium nitrate solutions are transferred to the FB-Line facility or the HB-Line facility for conversion to either plutonium metal or plutonium oxide, respectively. Other elements, such as neptunium, can be separated in H-Canyon and converted to an oxide in HB-Line. Uranium recovered from the H-Canyon processing stream is stored to feed the new HEU blenddown project. In their current configurations, F-Canyon can process several metric tons of material per day, and H-Canyon can process several metric tons per year.

The Secretary of Energy ordered the phase-out of F- and H-Canyon operations in 1992, but emergent needs for the stabilization of nuclear materials led to a decision to keep both canyons in operation. Several assessments, including DOE's complex-wide plutonium and uranium vulnerability assessments and the Board's Recommendation 94-1, clearly pointed out that the processing capabilities of both canyons would be needed for several more years. In July 1997, the Assistant Secretary for Environmental Management reaffirmed this conclusion with the issuance of a "Canyon Strategy" memorandum that authorized the restart of H-Canyon (which was in a standby mode) and the operation of both canyons through at least 2000. This continuing use of the canyons and the processing lines has been essential to efficient and timely stabilization of many of the remaining hazardous materials. In Recommendation 2000-1, the Board again emphasized the need for continued canyon processing to stabilize materials that still posed a risk to workers and the public.

As of this writing, both canyons are authorized by DOE to operate, and both are in operation stabilizing nuclear materials: F-Canyon dissolving sand, slag, and crucible materials generated at the FB-Line facility, and H-Canyon dissolving spent nuclear fuel (Mark16/22) and special uranium oxides stored at SRS. Consistent with the 1997 Canyon Strategy memorandum, however, DOE plans to shut down F-Canyon chemical separation (PUREX) operations by the end of March 2002. This shutdown would include the portions of FB-Line that are used to convert plutonium solutions to metal.

3. PLANNING FOR CANYON UTILIZATION

At the urging of Congress and the Board, DOE and its contractor at SRS, the Westinghouse Savannah River Company (WSRC), have undertaken several studies to identify materials requiring stabilization to ensure that no materials are left without a disposition path when F-Canyon operations are stopped. DOE has commissioned or referred to several assessments and plans:

- Processing Needs Assessment (WSRC, 1998)
- Materials Requiring Savannah River Site Canyon Processing (WSRC, 1999)
- Plan for Implementation of Recommendations 94-1 and 2000-1 (WSRC, 2000)
- Integrated Nuclear Materials Management Plan (DOE, 2000a)
- Nuclear Material Identification Study (DOE, 2001a)
- Long Term Canyon Use Strategy Study (WSRC, 2001)
- Unallocated Off-Specification HEU Study (DOE, 2001b)

These extensive reviews to identify materials in the weapons complex that remain to be stabilized have led to what is termed the DOE Base Case plan.

Section 3.1 below examines three canyon utilization plans developed by SRS personnel. The current Base Case plan being pursued by DOE is presented in Section 3.1.1, and the two contingency plans developed by the site contractor are presented in Sections 3.1.2 and 3.1.3. Section 3.2 reviews the significant uncertainties that exist in these plans. An alternative concept prepared by the Board that would lead to a more balanced utilization of the SRS canyons is presented in Section 3.3. Under this concept, more assured and expedited stabilization and disposition of hazardous nuclear materials could be accomplished through continued use of both canyons.

3.1 SITE PLANS FOR CANYON UTILIZATION

DOE and its contractor have agreed to a Base Case plan for the operation of F- and H-Canyons that is reflected in the site-wide planning and budgeting process. In addition, a number of uncertainties associated with the disposition of many materials in the weapons complex have led to the development of two contingency plans that would provide the capability to stabilize the additional materials (WSRC, 2001). The three site plans are as follows:

- Base Case
- Base Case with Additional Highly Probable HEU Materials (HEU)
- Base Case with HEU and Additional High-Potential Materials

As used in the site plans, the term “highly probable” refers to those materials for which canyon processing is highly probable because the materials have current disposition paths that are not likely to

succeed. "High-potential" materials are those that have a high potential for canyon processing because current disposition paths for these materials are still not definitive. Each of the three site plans assumes the shutdown of F-Canyon PUREX operations in FY 2002. The three plans are discussed in more detail below.

3.1.1 Base Case

The Base Case plan presently being pursued is depicted in Figure 1. In Figure 1 and in all subsequent figures, the Base Case activities are shown in green.

In the Base Case, DOE plans to complete the campaign to dissolve sand, slag, and crucible materials at F-Canyon, and then initiate deinventory and shutdown of the facility in the interest of reducing costs. This plan includes the shutdown of PUREX processing in F-Canyon and parts of FB-Line, with other portions of the facility remaining in operation for several years. Systems continuing to be operated include the main ventilation system, portions of the process vessel vent system, and electrical systems.

DOE has plans for another stabilization campaign in F-Canyon to neutralize and transfer approximately 3000 gallons of americium and curium solutions to the high-level waste tank farms. This activity is in the planning stages and is scheduled to occur in early FY 2003. The project includes the use of some F-Canyon tanks and transfer systems, but the PUREX process is not needed to complete this work.

Operators at the FB-Line facility are scheduled to finish converting plutonium solutions to metal and canning the plutonium metal in the Bagless Transfer System. Other continuing missions include characterization and repackaging of plutonium residues, surveillance of plutonium in the storage vault, and installation and operation of a system to package plutonium materials to meet DOE-STD-3013-2000, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*. The latter two activities are forecast to last beyond FY 2015.

In the Base Case, DOE intends to continue operating H-Canyon until FY 2008. Materials to be stabilized in H-Canyon include irradiated plutonium production fuel, unirradiated fuel, special uranium oxides, and other miscellaneous targets and spent nuclear fuels.

Operators in HB-Line are scheduled to conduct stabilization activities until 2007. These activities include dissolution of plutonium residues and plutonium-238 sources in HB-Line Phase I, and conversion of plutonium and neptunium solutions to oxide in HB-Line Phase II.

To implement the shutdown of F-Canyon, DOE established a $5 million contractor incentive for completing F-Canyon PUREX operations by June 2002. DOE offered an additional $3.5 million incentive if PUREX operations were completed by March 2002.

3.1.2 Base Case with Highly Probable HEU Materials (HEU)

The Base Case with Highly Probable HEU Materials (HEU) is depicted in Figure 2. In Figure 2 and in all subsequent figures, the added activities corresponding to Highly Probable HEU materials are shown in purple.

As mentioned in the previous section, all site plans call for the shutdown of PUREX operations in F-Canyon in FY 2002. This version of the plan makes no adjustments to utilization of either F-Canyon or FB-Line.

DOE managers have stated that they intend to include several other materials in the H-Canyon processing queue. This version of the plan includes these materials, which are also likely to be included in the next update of the Base Case plan. The additional materials include several groups of enriched uranium parts from many sites, comprising more than 800 kilograms (kg) of material. Also included are Rocky Flats Environmental Technology Site (RFETS) composite parts—85 items containing plutonium and uranium. The full scope of enriched uranium materials to be dispositioned is discussed in the Unallocated Off-Specification HEU Study (DOE, 2001b). This version of the plan provides an estimate that processing of these additional materials will extend H-Canyon operations by about 1 year until FY 2009.

Under this plan, operations in HB-Line would be extended about 4 years beyond the closure date in the Base Case, to FY 2008. Activities added include stabilization of various enriched uranium residues and approximately 240 kg of uranium oxide from Idaho National Engineering and Environmental Laboratory (INEEL). Also, HB-Line operators would produce plutonium oxide from solutions generated in the expanded H-Canyon campaign discussed above.

3.1.3 Base Case with HEU and Additional High-Potential Materials

The Base Case with HEU and Additional High-Potential Materials is depicted in Figure 3. In Figure 3 and the subsequent figure, the added activities corresponding to high-potential materials are shown in yellow.

Under this version of the plan, PUREX operations in F-Canyon would still end in FY 2002, but new missions in the F-Canyon facility are proposed to stabilize two types of material that have significant uncertainty in preferred disposition paths: Mark 18A targets and uranium-233 (^{233}U) materials. Work at the FB-Line facility under this version of the plan is the same as that in the Base Case.

The Mark 18A targets consist of 65 californium production targets that were irradiated at SRS and are now stored in the L-Reactor spent fuel storage basin. DOE's Office of Defense Nuclear Nonproliferation and Office of Security and Emergency Operations have concluded that plutonium-244 (^{244}Pu), an isotope found in the Mark 18A targets, has important future applications. Therefore, the targets are to be processed and the ^{244}Pu recovered. Current plans are uncertain, but options include processing at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, or Oak Ridge National Laboratory—all of which would require shipment of the targets from SRS. These shipments involve their own set of uncertainties, including those associated with identifying or designing a shipping package, having the shipping package certified, and obtaining approvals for the shipments.

The F-Canyon alternative for processing the Mark 18A targets involves use of the Multi-Purpose Processing Facility (MPPF), located in F-Canyon. F-Canyon personnel would have to expend significant time, money, and effort to modify MPPF for this mission, but given the uncertainty involved in other options, DOE is considering this option (shown in Figure 3). If DOE were to decide that the ^{244}Pu is not needed, the Mark 18A targets could be dissolved in F-Canyon and the resulting material discarded as waste.

Materials containing ^{233}U are stored at several sites in the weapons complex. DOE plans to issue a Request for Proposals to solicit plans for recovering isotopes from these materials for beneficial medical uses. The portion of ^{233}U that may be processed at SRS is part of 1 metric ton of material, mostly from the Consolidated Edison Uranium Solidification Program. This material is contained in more than 1000 cans at Oak Ridge National Laboratory. The most feasible option at SRS for the disposition of this material is processing in the F-Canyon MPPF. The contractor would have to make additional modifications to MPPF beyond those proposed for Mark 18A targets to process the ^{233}U materials. These two activities have the potential to extend operations in the non-PUREX portion of F-Canyon for about 8 years, to FY 2010. Many other ^{233}U materials at Los Alamos National Laboratory and INEEL also have undefined disposition paths, but DOE does not believe they will require canyon processing.

Additional materials to be stabilized in H-Canyon under this plan include low-assay plutonium oxides managed by the Office of Fissile Material Disposition, europium control elements, and various plutonium-bearing standards and samples. DOE's plans for each of these groups of materials are sufficiently uncertain as to warrant continued consideration of processing at the SRS canyons. These stabilization activities would extend H-Canyon operations by 4 more years, to FY 2013.

Similarly, some material groups with uncertain disposition paths could be stabilized in the HB-Line facility. These groups include plutonium fluoride compounds at both the Hanford Site and RFETS, and low-assay plutonium oxides currently stored at many sites, including Hanford, RFETS, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory. Further details on these materials are provided later in this report. HB-Line operations would be extended until at least FY 2013 to accomplish these additional stabilization missions.

3.1.4 Other Materials Not Included in Plans

There are many other nuclear materials stored in the defense nuclear complex. Some of these materials originated in the weapons programs, while others are non-weapons materials that are now stored or expected to be received at defense nuclear facilities. DOE believes there are viable disposition plans for these materials and that they are not likely to require processing in the SRS canyons. These other materials are discussed in more detail below.

Other Materials from the Weapons Program. In addition to those materials designated highly probable and high-potential in the existing plans, there are thousands of weapons-related items throughout the complex for which DOE believes disposition plans are adequate, although these plans remain tenuous for financial, technical, or practical reasons. The body of materials that falls within this category is large and continues to grow as program managers throughout the DOE weapons complex compare their material holdings against their programmatic needs. These other materials are not shown in the canyon utilization plans but are listed in Table 1. As examples, the following are some of the more significant of these items with their contemplated disposition paths (masses are approximate):

- 9.6 MT of Type III off-specification HEU material at the Oak Ridge, Y-12 National Security Complex (Y-12): shipment to the Tennessee Valley Authority (TVA) for use in commercial fuel,

- Greater than 1 MT of HEU oxide contaminated with technetium at Portsmouth, Ohio: shipment to TVA for use in commercial fuel,

- 2100 MT of N-Reactor spent nuclear fuel at the Hanford K-Basins: eventual disposal in a deep geologic repository,

- 9 MT of Type II off-specification HEU alloy ingots at SRS and at Y-12: shipment to TVA for use in commercial fuel,

- 6 MT of plutonium metal and oxide at many sites (part of surplus Pu managed by the Office of Fissile Material Disposition): was to go to the Plutonium Immobilization Plant, which has now been abandoned as a concept,

- 4.8 MT of unirradiated reactor fuel at several sites (part of surplus Pu managed by the Office of Fissile Material Disposition): was to be irradiated or sent to the Plutonium Immobilization Plant,

- 2.5 MT of spent nuclear fuel at several sites (part of surplus Pu managed by the Office of Fissile Material Disposition): disposal in a deep geologic repository, and

- 3.6 MT of plutonium residues (part of surplus Pu managed by the Office of Fissile Material Disposition): disposal in the Waste Isolation Pilot Plant (WIPP).

Non-Weapons Materials. Most of the items in this category that will ultimately require treatment for stabilization or disposal are spent fuel elements from research and test reactors. Most of these items are stored in basins at SRS. Although the number of research reactors whose spent fuel is shipped to SRS has declined greatly in the past few years, a steady stream of spent fuel from remaining facilities continues to arrive for storage. DOE had intended to prepare this spent fuel for disposal through use of the melt-and-dilute process. That speculative technology remains untested and unfunded, however.

3.2 SIGNIFICANT UNCERTAINTIES IN THE DEPARTMENT OF ENERGY'S PLANS

There are significant uncertainties in the disposition programs that led to the current DOE and contractor plans for canyon utilization. Several of the programs are unfunded, and many are still being designed. Some face significant political obstacles. If some of the programs fail for financial, technical, or other reasons, the canyon utilization plans will have been misdirected. Recent examples of major DOE projects that have failed for these reasons include the Actinide Packaging and Storage Facility, the americium/curium vitrification project, and the 235-F plutonium stabilization and packaging project. The principal uncertainties in DOE's plans are discussed below.

3.2.1 Aluminum-Based Spent Nuclear Fuel

The *Record of Decision for the Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement* (DOE, 2000b) lists a new melt-and-dilute technology as the preferred alternative for the treatment of aluminum-based fuel. This technology was to be demonstrated in a pilot plant called the L-Area Experimental Facility (LEF) and implemented in a production plant called the Treatment and Storage Facility. The Record of Decision also states that "DOE will ensure continued availability of the SRS Conventional Processing facilities until DOE has demonstrated implementation of the Melt and Dilute technology." During FY 1999–2001, DOE funded, designed, and constructed LEF, complete with all hazard analyses, safety documents, and procedures. Early in FY 2002, the contractor finished construction and began assessments to confirm readiness to operate.

In January 2002, when LEF was nearly ready to operate, DOE announced that the project would be suspended indefinitely because of a lack of funding. DOE made this decision as part of its annual budget cycle. The FY 2002 budget for DOE approved by Congress included a $100 million reduction in the funding for environmental management at SRS. In setting priorities for funding, both DOE and its contractor agreed that LEF was of lower priority and should be suspended.

The Board has long believed that processing of spent nuclear fuel in H-Canyon—the mission for which that facility was designed and built—is still the best alternative. Such a course would meet the objective of stabilizing the fissionable material and fission products in a timely and straightforward manner. In its technical report, *Savannah River Site Spent Nuclear Fuel* (DNFSB, 1999), the Board questioned the wisdom of developing the melt-and-dilute technology. The report also stated the Board's conclusion that conventional canyon processing would be the preferred alternative.

Although DOE is considering several options for disposition of the spent fuel, no clear alternative has been identified. As much as 28 MT of additional spent fuel is scheduled to be shipped to SRS during the next several years. This fuel includes 5 MT to be shipped from INEEL, 18 MT from foreign research reactors, and another 5 MT from domestic research reactors. The spent fuel will be added to the fuel already stored in the spent fuel basin at the L-Reactor facility. Prolonged wet storage of the spent fuel is not desirable, however, because corrosion mechanisms could eventually degrade the fuel, causing the release of fission products.

3.2.2 Disposition of Identified Surplus Plutonium

As a central part of DOE's plans for disposal of surplus plutonium, much of that material is to be incorporated in nuclear fuel to be burned in commercial nuclear power plants. This reactor fuel is to be made available by processing plutonium from surplus weapon pits and other material through the Mixed Oxide Fuel Fabrication Facility (MOX FFF), which is now scheduled to begin operation in FY 2007.

Plutonium feed for the MOX FFF is to be provided through operation of another new facility, the Pit Disassembly and Conversion Facility (PDCF). However, schedule delays and funding shortfalls have led DOE to postpone the availability of PDCF by several years. Other plutonium not destined for use in reactor fuel was to be disposed of at the WIPP or rendered unuseable in a Plutonium Immobilization Plant (PIP). Plans for PIP have now been suspended. Since PDCF was designed as the primary source of plutonium oxide feed for MOX FFF but is now delayed, DOE must find a suitable means of providing feed to MOX FFF until PDCF becomes operational. This gap in feed may be as long as 2–3 years.

In 2001, DOE explored several other options for providing feed to support MOX FFF startup. DOE tasked the MOX FFF contractor to examine the possibility of modifying the head-end, or aqueous polishing, stage of MOX FFF to accept a wider range of plutonium feed materials. DOE also explored the possibility of using the F-Canyon and FB-Line facilities to provide feed to MOX FFF. In January 2002, DOE decided that modifications to MOX FFF were preferable and that F-Canyon and FB-Line would not be used for the MOX FFF mission
(DOE, 2002).

Current DOE plans call for the disposition of identified surplus plutonium through burning as mixed-oxide reactor fuel or disposal as waste. Approximately 26 MT of this material is in the form of weapon pits and clean metal and is suitable for disassembly and processing in PDCF as feed to MOX FFF. An additional 2 to 8 MT may be processed in the aqueous polishing portion of MOX FFF, depending on the expansion of the original design; much of this material contains impurities such as chlorides, other salts, and uranium that introduce significant uncertainty into the success of aqueous polishing. Another 4 MT of surplus plutonium is of poor quality and could be disposed of at WIPP, although this option may become impractical. DOE plans to send approximately 7 MT of plutonium contained in spent fuel to a deep geologic repository, if and when such a repository opens. Of the 5 MT of plutonium in fresh fuel, 4 MT may be retained for programmatic use, but the planned disposition path for 1 MT was lost when PIP was suspended. Additionally, 3 MT of non-weapons-grade plutonium in impure metal and oxides was stranded when PIP was suspended. DOE has not identified a clear disposition path for these materials, although the F-Canyon complex is well suited for and could quickly stabilize these materials or dispose of them as waste.

To summarize, the DOE's disposition plans for identified surplus plutonium are as follows (masses are approximate):

Surplus Plutonium	Disposition Likely (MT Pu)	Disposition Uncertain (MT Pu)	Disposition Path
Weapons-grade (WG) pits and clean metal	26		PDCF—MOX FFF
WG impure metal, oxide	2		Aqueous polishing—MOX FFF
WG impure metal, oxide	4	2	Expanded aqueous polishing—MOX FFF
Spent fuel		7	Opening of repository
Fresh fuel	4	1	PIP—suspended (some fuel retained)
Non-WG impure metal, oxide		3	PIP—suspended
WG residues		4	WIPP
Total	36	17	

While there is reasonably good assurance of sound disposition paths for 36 MT of these materials, the disposition paths for approximately 17 MT of metal, oxides, and fuel have considerable uncertainty. Of this latter group, about 6 MT of material has no disposition path.

3.2.3 Other Materials from the Weapons Program

DOE's Office of Environmental Management has been the lead office for examining the utilization of F- and H-Canyons at SRS. Environmental Management personnel involved in this examination have consulted other DOE offices to help identify materials that may potentially require

canyon processing. However, thorough reviews of all unneeded or unwanted materials at Defense Programs sites have not been completed. Numerous gaps remain. Many materials have not been inventoried or characterized for a number of years and may be declared surplus or excess to national security needs.

DOE has not allowed for the possibility that these materials may have to be processed at SRS. Reviews conducted by the Board's staff at Lawrence Livermore National Laboratory identified numerous items that may be declared surplus and may be candidates for canyon processing. Additionally, Los Alamos National Laboratory has yet to produce a sound plan for the disposition of many materials stored at that site, and it is possible that a number of these items may require canyon processing.

The previous section addressed the details of identified surplus plutonium in some detail. However, there are substantial quantities of plutonium and HEU that may be declared surplus as a result of new arms reduction initiatives. DOE's current plans do not account for the disposition of this potentially large body of materials.

3.2.4 H-Canyon Workload

DOE's Base Case with HEU and Additional High-Potential Materials plan, proposes a workload that extends planned operations at H-Canyon through FY 2013. Section 3.1.3 of this report explains the details of this workload. Given the uncertainties in the disposition paths of the materials discussed above, however, the extension of H-Canyon operations for many additional years could be required.

As an example of additional possible workload, the processing of all aluminum-based spent nuclear fuel at H-Canyon would add at least 10 years to the canyon's operating life. Additionally, the processing of surplus plutonium materials originally slated for PIP would require another 10 years of H-Canyon operations. These activities would add a workload to H-Canyon that could extend its operations beyond FY 2030—more than 20 years later than the currently planned date of FY 2008 for the canyon's shutdown. Given the age of the facility, it is unlikely that H-Canyon operations can be reliably maintained until FY 2030.

3.3 ADVANTAGES OF A BALANCED UTILIZATION OF F- AND H-CANYONS

Examination of the numerous uncertainties and likely gaps in DOE's plans, as discussed above, leads to the conclusion that most of the problems are the direct product of an urge to end aqueous chemical treatment of spent nuclear fuel in the defense programs. That has been motivated and driven in part by nonproliferation pressures. This motive has led DOE to search for speculative solutions to cleanup problems, in lieu of established solutions. This situation leads to the primary question

addressed in this report: whether it might not be possible to identify a strategy free of such constraints that would make better use of the canyons, whose capability has been so well demonstrated in the past. Such use of the canyons would allow DOE to achieve its stabilization needs more expeditiously.

An additional motivation for DOE has been cost savings. For planning purposes, DOE often estimates the cost savings of shutting down F-Canyon PUREX by using the full cost of operating the canyon (approximately $200 million per year). However, because many systems would be required to remain in operation, more recent contractor estimates of the savings that may be realized by shutting down PUREX are about $20 million per year for the first 5 years following shutdown.

To examine usage of the canyons, the Board has developed the Balanced Canyon Utilization plan, which is depicted in Figure 4. In Figure 4, the activities that have been added, which represent the concept developed by the Board, are shown in red.

The Balanced Canyon Utilization plan illustrates how many of the significant uncertainties involved in stabilizing hazardous materials can be mitigated or eliminated through a balanced utilization of both F- and H-Canyons at SRS. The plan proposes a more equal, or balanced, distribution of materials between the two canyons: in general, those materials rich in plutonium would be processed at F-Canyon, and those rich in uranium would go to H-Canyon.

This concept accommodates the materials DOE included in the Base Case plan, as well as materials categorized as highly probable and high-potential. Moreover, it accounts for materials that DOE has not yet considered, such as aluminum-based spent nuclear fuel and materials that may not be needed by the Office of Defense Programs.

3.3.1 Aluminum-Based Spent Nuclear Fuel

Capital funding for major new projects to deal with hazardous nuclear materials face stiff competition for budgetary support. LEF is a prime example. Although the facility was proceeding on schedule toward testing of the melt-and-dilute technology, it was suspended because DOE needed to find ways to cut costs. This episode highlights the fact that many of DOE's new, major acquisition projects that represent alternatives to chemical processing in the canyons are vulnerable to the annual budget process.

Through the proper distribution of processing loads between F- and H-Canyons, aluminum-based spent fuel could be processed at H-Canyon. This course of action would prevent leaving spent fuel in wet storage for extended periods of time, reaching the full capacity of L-Basin, and expending additional funds for other storage and processing facilities. H-Canyon offers the most readily available, efficient, and cost-effective option for processing this spent fuel. The processing of all aluminum-based spent fuel in H-Canyon would last from approximately FY 2009 to FY 2019 and would be possible if the mission of processing other plutonium-bearing materials were moved to F-Canyon.

3.3.2 Disposition of Identified Surplus Plutonium

Several groups of surplus plutonium materials that are managed by the Office of Fissile Materials Disposition have uncertain disposition paths. Under the Balanced Canyon Utilization plan, weapons-grade metal and oxide would be processed in HB-Line to provide MOX FFF feed or dissolved in F-Canyon to be disposed of as waste through the high-level waste system and the Defense Waste Processing Facility. The oxides and residues that were to go to PIP or to WIPP would also be processed in F-Canyon; however, most of the spent fuel in this group of materials is unsuitable for F-Canyon processing. The processing of these surplus plutonium materials would add approximately 3 years to F-Canyon PUREX operations.

3.3.3 Other Materials from the Weapons Program

The full scope of materials that may be surplus to Defense Programs remains unclear. Beyond those materials currently in inventory at Defense Programs sites, substantial quantities of additional plutonium and HEU materials will likely be declared surplus as more nuclear weapons are dismantled under new arms reduction initiatives. It is likely that the F- and H-Canyon facilities are well suited to stabilize or dispose of many of these items. Although the scope of the stabilization of these materials is highly uncertain, their processing is shown in Figure 4. Only a rough estimate of the processing campaign for these materials can be given at this time.

3.3.4 H-Canyon Workload

DOE and its contractor have listed the H-Canyon facility as a possible back-up processing capability for many materials that have yet to be stabilized. Because the current disposition paths for many of these materials are uncertain and could fail, H-Canyon could be called upon to stabilize these materials, possibly extending its operations beyond FY 2030. However, it is likely that H-Canyon would reach the end of its useful life before all of these materials are stabilized. Some materials would then remain unstabilized posing a continuing hazard to the public and workers.

The Balanced Canyon Utilization plan suggests several changes to the utilization of both F- and H-Canyon designed to preclude the extension of H-Canyon's operations well beyond its useful operating life. These changes include the processing of RFETS composite parts, low-assay plutonium oxides, and plutonium-bearing standards and samples at F-Canyon. Each of these changes is discussed below and reflected in Figure 4.

DOE's current plans include the use of H-Canyon to process 85 composite parts from RFETS containing plutonium and uranium (see Section 3.1.2). However, this activity would occupy much-needed dissolver time in H-Canyon. Additionally, the processing of plutonium solutions from the composite parts could preclude plans to decontaminate neptunium solutions in H-Canyon. As stated in

the Implementation Plan for Recommendation 2000-1, DOE planned to process the neptunium solutions to remove protactinium-233 contamination and thereby reduce subsequent dose rates to workers in HB-Line, where the neptunium would be converted to an oxide. F-Canyon is better suited to handle the plutonium content of the RFETS parts and has a much higher throughput, so the processing could be completed in a more timely manner. The movement of the RFETS parts to F-Canyon would free up dissolver time at H-Canyon and accommodate neptunium processing.

The Balanced Canyon Utilization plan moves the processing of RFETS composites to F-Canyon during FY 2003. It also includes the purification of neptunium solutions in H-Canyon in FY 2005–2006, consistent with the Implementation Plan for Recommendation 2000-1.

H-Canyon processing is DOE's backup plan for stabilizing low-assay plutonium oxides that are part of the inventory of materials managed by the Office of Fissile Material Disposition. Under the balanced plan, these oxides would be moved from H- to F-Canyon, which is much better suited for processing plutonium-bearing materials. For the same reason, a small group of plutonium-bearing standards and samples would be moved from H- to F-Canyon. Plutonium solutions generated in F-Canyon would be transferred to FB-Line and converted to metal.

3.3.5 Summary of Balanced Canyon Utilization

Although DOE and its contractor have already begun a course of action to shut down F-Canyon, the canyon's capabilities will not be significantly reduced until the Summer of 2002. This is the time at which DOE and its contractor plan to turn off important safety-related equipment and suspend surveillance and maintenance activities necessary to ensure the proper operation of that equipment. DOE also plans to reassign operators to other facilities on site, thus allowing their F-Canyon operator qualifications to lapse. Once this portion of the shutdown is complete, recovery of the F-Canyon PUREX capability would be expensive, and essentially impossible to achieve.

The Board suggests that DOE earnestly consider the possibility of continuing F-Canyon operations for at least 6 to 7 more years in order to process and stabilize those materials for which F-Canyon is best suited. By carefully planning a balanced division of the workload between F- and H-Canyons, DOE can process and stabilize those materials discussed above that currently have highly uncertain disposition paths. By using this Balanced Canyon Utilization plan, DOE can achieve several important safety goals:

- Accomplish significant risk reduction now, by:
  - Processing materials that have no other disposition path; and
  - Processing materials that have uncertain disposition paths in a more timely and efficient manner.

- Maintain optimum canyon processing capability to accommodate future requirements for material stabilization.

- Maintain processing flexibility and reliability through the use of two canyons.

- Use resources that exist today, rather than relying on new, major acquisition projects that depend on untested and speculative technology and that may be descoped, underfunded, or not funded.

As an alternative, DOE might well consider developing a new flexible chemical separations facility. If such a course were taken, it would be prudent for DOE to maintain its current separations capability until the new facility was sufficiently complete to ensure its operation. Furthermore it is probable that DOE, with its unclear program, will produce more material in the future that will require aqueous processing before disposal. The new facility could be much smaller, less expensive to operate, safer and more reliable if it were designed specifically to address DOE's remaining cleanup problems.

4. CONCLUSION

There are several compelling reasons to maintain the chemical processing capability of the F-Canyon facility at SRS. A great deal of uncertainty remains in the disposition paths for many hazardous nuclear materials that pose a risk to workers and the public. F-Canyon offers the ability to achieve risk reduction by stabilizing these materials more expeditiously and surely than could be accomplished through operation of the H-Canyon alone. DOE's long-term remediation program would best be served by maintaining F-Canyon in an operational state. F-Canyon is a resource that exists today, one that is fully operational and fully staffed with qualified operators.

Recent developments highlight the need to maintain the PUREX capability at F-Canyon and to further evaluate the best, most efficient use of the capabilities of both F- and H-Canyons. These developments include (1) the suspension of work on the processing capability for aluminum-based spent nuclear fuel, (2) frequently changing and uncertain plans for the disposition of surplus plutonium, and (3) the possibility of a need for processing and stabilization of substantial additional materials as the weapons stockpile is downsized.

DOE's disposition plans that require substantial new capital funds are vulnerable to budget cuts and unforseen technical difficulties. Stabilization activities at the Hanford Plutonium Finishing Plant and Spent Nuclear Fuel Project fall in this category, as do many activities at RFETS and at Los Alamos National Laboratory. It would be prudent for DOE to retain sufficient canyon processing capacity to accommodate these materials if their preferred disposition paths should fail.

DOE may explore other, new alternatives to PUREX processing for stabilizing the remnants of weapons production, but, like the spent fuel project at Hanford, these alternatives can be extremely expensive and difficult to implement. Recent unsuccessful attempts to process and store nuclear materials serve as good examples of this phenomenon: the Actinide Packaging and Storage Facility, the americium/curium vitrification project, the 235-F plutonium stabilization and packaging project, the PIP, and LEF. Each of these projects was cancelled or suspended indefinitely after the expenditure of many millions of dollars and before any material had been stabilized. The availability of a fully funded, staffed, and operational facility such as F-Canyon that can produce immediate risk reduction by stabilizing hazardous nuclear materials should not be so easily dismissed.

DOE should examine more carefully the scope of materials remaining to be stabilized and determine the balance of operations between F- and H-Canyons that will best support this stabilization mission. The Balanced Canyon Utilization plan presented in this report is offered as a plan for the continued operation and optimum utilization of the canyon facilities at SRS in a program squarely directed at expeditious remediation and stabilization of material remaining at nuclear weapons sites.

FIGURES AND TABLES

Facility	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY 13
F-Canyon		#										
Dissolver 1	SSC											
Dissolver 2	SSC											
FB-Line												
Mech. Line	Pu metal											
3013	Design/Const	Package Pu metal and oxide				Support Vault Surveillance					(beyond 2015)	
H-Canyon												
Dissolver 1	Irradiated Mk 16/22s		Unirradiated Mk-22 Tubes									
Dissolver 2	SF Oxide	M	5.2-1	Misc. Fuel								
HB-Line												
Phase I	Dissolve Residues				R	Pu srcs.						
Phase II	Pu residue solutions to oxide				Np to Oxide							

NOTES:
SSC—Sand, slag,and crucible from plutonium metal production.
#—Americum/Curium campaign will use 1st cycle tanks for approximately 3 months.
3013—production line to package plutonium to be compliant with DOE-STD-3013-2000.
SF Oxide—Sterling Forest Oxide.
M—Mark 53 targets (neptunium production targets).
5.2-1—"Table 5.2-1" fuel added by the spent nuclear fuel Environmental Impact Statement (EIS).
R—Retool in HB-Line and start up HB-Line Phase I, South line.

Green indicates activities in the Base Case plan.

FIGURE 1. BASE CASE

Facility	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY 13
F-Canyon		#										
Dissolver 1	SSC											
Dissolver 2	SSC											
FB-Line												
Mech. Line	Pu metal											
3013	Design/Const	Package Pu metal and oxide				Support Vault Surveillance					(beyond 2015)	
H-Canyon												
Dissolver 1	Irradiated Mk 16/22s			Unirradiated Mk-22 Tubes			EU metal parts					
Dissolver 2	SF Oxide	M	5.2-1	RF composites		EU metal parts		Misc. Fuel				
2nd Pu		S/U preps		2nd Pu cycle								
HB-Line												
Phase I	Dissolve Residues			R	Pu srcs.	R	INEEL U	EU res.				
Phase II	Pu residue solutions to oxide				Np to oxide	Pu-oxide						

NOTES:
SSC—Sand, slag, and crucible from plutonium metal production.
#—Americum/Curium campaign will use 1st cycle tanks for approximately 3 months.
3013—production line to package plutonium to be compliant with DOE-STD-3013-2000.
SF Oxide —Sterling Forest Oxide.
M—Mark 53 targets (neptunium production targets).
5.2-1—"Table 5.2-1" fuel added by the spent nuclear fuel Environmental Impact Statement (EIS).
R—Retool in HB-Line and start up HB-Line Phase I, South line.

Green indicates activities in the Base Case plan; purple indicates activities in the Base Case with Highly Probable HEU Materials (HEU) plan.

FIGURE 2. BASE CASE WITH HIGHLY PROBABLE HEU MATERIALS (HEU)

Facility	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY 13
F-Canyon	#											
Dissolver 1	SSC											
Dissolver 2	SSC											
MPPF			Design, construct		Mk-18A			^{233}U				
FB-Line												
Mech. Line	Pu metal											
3013	Design/Const		Package Pu metal and oxide			Support Vault Surveillance					(beyond 2015)	
H-Canyon												
Dissolver 1	Irradiated Mk 16/22s			Unirradiated Mk-22 Tubes			EU metal parts		Low Pu Oxide			(2014)
Dissolver 2	SF Oxide	M	5.2-1 SNF	RF composites		EU metal parts		Misc. Fuel	E	S	Low Pu Oxide	(2014)
2nd Pu cycle		S/U preps		2nd Pu cycle								
HB-Line												
Phase I	Dissolve Residues			R	Pu srcs.	R	INEEL U	EU res.	RF, RL Fluorides		Low Pu Oxide	
Phase II	Pu residue, solutions to oxide				Np to oxide		Pu-oxide	Standby		Pu to oxide		(2014)

NOTES:
SSC—Sand, slag, and crucible from plutonium metal production.
#—Americum/Curium campaign will use 1st cycle tanks for approx. 3 months.
3013—production line to package plutonium to be compliant with DOE-STD-3013-2000.
SF Oxide—Sterling Forest Oxide.
M—Mark 53 targets (neptunium production targets).
5.2-1—"Table 5.2-1" fuel added by the spent nuclear fuel Environmental Impact Statement (EIS).
E—Europium control elements.
S—Standards and samples.
R—Retool in HB-Line and start up HB-Line Phase I, South line.

Green indicates activities in the Base Case plan; purple indicates activities in the Base Case with Highly Probable HEU Materials (HEU) plan; yellow indicates activities in the Base Case with HEU and Additional High-Potential Materials plan.

FIGURE 3. BASE CASE WITH HEU AND ADDITIONAL HIGH-POTENTIAL MATERIALS

Facility	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
F-Canyon	#											
Dissolver 1	SSC C	RF	Surplus Pu, Low Pu Oxide	S	DP Material. . .(est.)							
Dissolver 2	SSC	RF	Surplus Pu, Low Pu Oxide		DP Material. . .(est.)							
MPPF			Design, construct		Mk-18A			^{233}U				
FB-Line												
Mech. Line	Pu metal	Pu metal										
3013	Design/Const		Package Pu metal and oxide			Package Pu metal and oxide			Support Vault Surveillance (beyond 2015)			
H-Canyon												
Dissolver 1	Irradiated Mk 16/22s			Unirradiated Mk-22 Tubes				EU metal parts	Foreign/Domestic Research Rx Fuel (2019)			
Dissolver 2	SF Oxide	M	5.2-1	Misc. Fuel		EU metal parts		E	Foreign/Domestic Research Rx Fuel (2019)			
2nd Np cycle			S/U preps	2nd Np Cycle								
HB-Line												
Phase I	Dissolve Residues			R	Pu srcs.	R	INEEL U	EU res.	RF, RL Fluorides			
Phase II	Pu residue solutions to oxide				Np to oxide							

NOTES:
SSC—Sand, slag, and crucible from plutonium metal production.
#—Americum/Curium campaign will use 1st cycle tanks for approximately 3 months.
RF—RFETS composite parts.
S—Standards and Samples.
Cv—Convert FB-Line to oxide production to support feed to MFFF.
3013—production line to package plutonium to be compliant with DOE-STD-3013-2000.
M—Mark 53 targets (neptunium production targets).
5.2-1 "Table 5.2-1" fuel added by the spent nuclear fuel Environmental Impact Statement (EIS).
E—Europium control elements.
R—Retool in HB-Line and start up HB-Line Phase I, South line.

Green indicates activities in the Base Case plan; purple color indicates activities in the Base Case with Highly Probable HEU Materials (HEU) plan; yellow indicates activities in the Base Case with HEU and Additional High-Potential Materials plan; red indicates activities in the Balanced Canyon Utilization plan.

FIGURE 4. BALANCED CANYON UTILIZATION PLAN

Table 1. Nuclear Materials Requiring Processing

Facility	Material	Source	Mass - Heavy Metal (kg)	Canyon Dissolver Years	Notes
	Materials to be Processed (as shown in the Balanced Canyon Utilization plan)				
F-Canyon	SSC—sand, slag, and crucible	Pu metal production in FB-Line			SSC will be dissolved after each major campaign of metal production in FB-Line
	Am/Cm—Americium/ Curium solutions	SRS F-Canyon		n/a	Requires ~3 mo. of canyon time for solution treatment and transfers
	RF—RFETS composite parts	Historical RFETS pit production		1.0	85 parts— require dissolver insert fabrication
	MD Pu metal, oxides, other forms (surplus Pu)	Various	6000		Weapons- and non-weapons grade Pu—originally planned to go to PIP
	Low Pu oxide (20–30% Pu)	RFETS and 5 other sites	420	2.0	~820 items that are too rich in Pu for WIPP
	S—Standards and Samples	Many sites	~30	0.3	Hundreds of items (Pu-239, Np-237) at dozens of sites
	Defense Programs Material	LLNL unneeded Pu	Classified		1734 Pu items—metals, oxides, residues
		LLNL unneeded HEU	Classified		624 HEU items—metals and oxides
		LLNL unneeded other materials	Classified		~80 items (Am, Np, ^{233}U, Pu-238)—metals and oxides
		LANL, other sites	??		??
	Mark 18A—reactor targets	SRS californium production targets	1	n/a	65 Mark 18A targets stored in RBOF/L-Basin may be processed in the F-Canyon MPPF
	^{233}U	ORNL, LANL, LLNL	~815 (^{233}U)	n/a	~1250 items at ORNL, LANL, and LLNL; would be processed in MPPF
FB-Line	Pu metal	Solution feed from F-Canyon		n/a	Pu metal production in FB-Line mechanical line

Table 1. Nuclear Materials Requiring Processing (Continued)

Facility	Material	Source	Mass - Heavy Metal (kg)	Canyon Dissolver Years	Notes
	Packaging of Pu in 3013 containers	Various		n/a	Ongoing mission to package Pu metal and oxide
	Support for vault surveillance	SRS	n/a	n/a	Surveillance to open, inspect, and repackage Pu
H-Canyon	Irradiated Mark 16/22s	SRS spent nuclear fuel	3270	3.0	In progress—~55% of 1883 assemblies dissolved
	Unirradiated Mark 22s	SRS unused fuel	7220	3.5	Non-94-1 materials
	EU metal parts	RFETS + 6 other sites	800+ (total is classified)	~3.0	Consists mostly of 250 EU parts contaminated with Pu
	Sterling Forest oxide	SRS	70	1.5	Spent fuel material
	Mark 53	SRS		0.25	9 Np production targets
	Table 5.2-1 SNF	SRS (from many sites)	2130	1.0	Identified in SRS SNF EIS ROD
	Miscellaneous SNF	SRS		1.0	810 items identified in SNF EIS (mostly Co-60 slugs)
	E - Europium	ORNL High Flux Isotope Reactor (HFIR)		0.2	11 control cylinders and control plates + 2 every 4 years during HFIR ops
	Research Reactor Fuel	SRS (from many sites)	28000	14.0	Foreign and domestic research Reactor SNF—Now significant with the suspension of LEF
HB-Line	Residues	SRS		n/a	Ongoing 94-1 mission, ~75% complete
	Pu-238 sources	SRS		n/a	48 items
	INEEL U oxide (denitrator product)	INEEL	240	n/a	276 cans of UO_3 stored in Bldg. 651 vault
	EU residues	Various			Unallocated off-spec. HEU residues and oxides
	RF, RL fluorides	RFETS, Hanford	4	n/a	26 items of high-assay Pu fluorides—may go to WIPP
	Pu to oxide	SRS		n/a	Stabilization of 34,000 liters of 94-1 Pu solutions in H-Canyon

Table 1. Nuclear Materials Requiring Processing (Continued)

Facility	Material	Source	Mass - Heavy Metal (kg)	Canyon Dissolver Years	Notes
	Np to oxide	SRS		n/a	Stabilization of 6000 liters of 94-1 Np solutions in H-Canyon
	Pu to oxide	various		n/a	Oxide production from other Pu material processed in H-Canyon
	Other Material (not in Canyon Utilization Plans)				
	LAMPRE Fuel	LANL Molten Pu Rx Experiment		1.0	3 containers of lightly irradiated fuel
	Plutonium residues (10–20% Pu)	RFETS, LANL, Hanford	400	12.0	>1000 items of oxide, alloys, compounds, and residues
	Scrap, samples, and standards	Many sites	~10	0.2	Hundreds of transuranics items at dozens of sites
	RL SSC	Hanford	~20	1.0	High-assay SSC (Pu)—plan is to ship to WIPP
	Cs/Sr Capsules	Hanford	0		1936 capsules of CsCl and SrF containing >130 M Ci; DOE investigating disposition by vitrification
	SSC (RL, LANL)	Hanford, LANL	60	19.0	>1500 items of low-assay SSC
	Irradiated sodium-bonded, EBRII and Fermi blanket fuel	INEEL	260	10.0	Fuel and blanket material stored at ANL-W and CPP-749; Processing time assumes the material is declad; baseline—electro-metallurgical processing
	Type III off-spec. HEU metal	OR, Y-12	9600		Type III off-spec. HEU metal—originally from SRS
	High-purity Pu oxides and metals	Pantex and 5 other sites	25000 (Pu)		Pits, clean metal, and Pu oxide—expected to go to PDCF
	Hanford off-spec. HEU	Hanford	40		Compounds, metal, oxides, fuel, samples

Table 1. Nuclear Materials Requiring Processing (Concluded)

Facility	Material	Source	Mass - Heavy Metal (kg)	Canyon Dissolver Years	Notes
	RFETS DU and DU/Pu	RFETS	Classified		220 parts, classified shapes, and masses; no baseline disposition
	INEEL (ICPP) reactor fuel	INEEL			>100 items of zirconium-based spent fuel in drums
	Portsmouth oxide	Portsmouth, Ohio	>1000	n/a	528 containers—returned from USEC due to Tc-99 contam; could be processed in HB-Line
	NFS off-spec. HEU	Nuclear Fuel Services; OR, Y-12	~300		Expected to go into the TVA program
	U-core N-reactor fuel	Hanford K-Basins	2100000	10 (in F)	Path—dry, package, ship from Hanford to repository
	RFETS SSC		130	3.0	2100 containers—blend down—POC—WIPP
	SRS and OR off-spec. HEU (ingots)	SRS, OR, Y-12	~9000	12.0	~7900 ingots (Type II) HEU alloy
	MD ZPPR, FFTF, fresh fuel	Various	4800		Originally planned to be irradiated or sent to PIP
	MD spent fuel (surplus Pu)	Various	2500		Planned to be sent to the HLW repository
	MD other forms, residues (surplus Pu)	Various	3600		TRU waste—to be sent to WIPP

NOTES:
Mass rounded to the nearest 10 kg
n/a—not applicable
Sources: Department of Energy, 2001b; Westinghouse Savannah River Company, 1995, 2001.

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GLOSSARY OF ACRONYMS AND TERMS

Board	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
EIS	Environmental Impact Statement
FY	fiscal year
HEU	highly enriched uranium
INEEL	Idaho National Engineering and Environmental Laboratory
kg	Kilogram
LEF	L-Area Experimental Facility
MOX FFF	Mixed Oxide Fuel Fabrication Facility
MPPF	Multi-Purpose Processing Facility
MT	metric ton
PDCF	Pit Disassembly and Conversion Facility
PIP	Plutonium Immobilization Plant
Pu	plutonium
PUREX	Plutonium Uranium Extraction
RFETS	Rocky Flats Environmental Technology Site
SRS	Savannah River Site
SSC	sand, slag, and crucible
TVA	Tennessee Valley Authority
WG	weapons grade
WIPP	Waste Isolation Pilot Plant
WSRC	Westinghouse Savannah River Company
Y-12	Oak Ridge, Y-12 National Security Complex
^{233}U	uranium-233
^{244}Pu	plutonium-244