DOE/EIS-0269

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR ALTERNATIVE STRATEGIES FOR THE LONG-TERM MANAGEMENT AND USE OF DEPLETED URANIUM HEXAFLUORIDE

Summary

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ABSTRACT: This PEIS assesses the potential impacts of alternative management strategies for depleted uranium hexafluoride (UF_6) currently stored at three DOE sites: Paducah site near Paducah, Kentucky; Portsmouth site near Portsmouth, Ohio; and K-25 site on the Oak Ridge Reservation, Oak Ridge, Tennessee. The alternatives analyzed in the PEIS include no action, long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal. DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

* Vertical lines in the right margin of this document indicate changes that have been added after the public comment period.

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SUMMARY[1]

S.1 INTRODUCTION

This programmatic environmental impact statement (PEIS) assesses the potential impacts of alternative strategies for managing the depleted uranium hexafluoride (UF_6) currently stored in cylinders at three U.S. Department of Energy (DOE) sites: the Paducah site near Paducah, Kentucky; the Portsmouth site near Portsmouth, Ohio; and the K-25[2] site on the Oak Ridge Reservation in Oak Ridge, Tennessee. A management strategy is a series of activities needed to achieve the safe long-term storage, use, or disposal of the depleted UF_6 inventory.

The proposed selection and implementation of a long-term management strategy constitute a major federal action with potentially significant environmental consequences. As such, it falls under the *National Environmental Policy Act* (NEPA). This PEIS has been prepared in compliance with the NEPA and all applicable NEPA implementing regulations set forth in the *Code of Federal Regulations* (40 CFR Parts 1500-1508 and 10 CFR Part 1021). Additional NEPA analyses, as appropriate, will be prepared once a long-term management strategy has been selected. The follow-on NEPA analyses will evaluate issues such as where to locate facilities (siting), which specific technologies or processes to use, and what site-specific impacts might result from construction and operations.

National Environmental Policy Act (NEPA) Regulations

NEPA regulations require, among other things, federal agencies to include discussion of a proposed action and all reasonable alternatives in an environmental impact statement (EIS). Sufficient information must be included in the EIS for reviewers to evaluate the relative merits of each alternative. A programmatic EIS (PEIS) is an evaluation of a broad agency action setting the course of future activities.

The agency must briefly discuss any alternatives that were eliminated from further analysis. The agency should identify its preferred alternatives, if one or more exist, in the draft EIS and must identify its preferred alternative in the final EIS unless another law prohibits naming a preference. After completing the final EIS and in order to implement an alternative, the federal agency must issue a Record of Decision that announces the decision made and identifies the alternatives considered.

1 Vertical lines in the right margin of this summary indicate changes that have been added after the public comment period.

2 The site of the K-25 plant is now called the East Tennessee Technology Park but is referred to by its original name, the K-25 site, throughout this PEIS.

S.1.1 Background

Depleted UF_6 results from the process of making uranium suitable for use as fuel for nuclear reactors or military applications. The use of uranium in these applications requires increasing the proportion of the uranium-235 isotope found in natural uranium, which is approximately 0.7%, through an isotopic separation process called uranium enrichment. An enrichment process called gaseous diffusion is currently used in the United States.

The gaseous diffusion process requires uranium in the form of UF_6. UF_6 is a chemical compound consisting of one atom of uranium combined with six atoms of fluorine. It can be a solid, liquid, or gas, depending on its temperature and pressure. (See Appendix A of the PEIS for additional information on the properties of UF_6.) It is used for the gaseous diffusion process primarily because it can conveniently be used in the gas form for processing, in the liquid form for filling or emptying containers or equipment, and in the solid form for storage. At atmospheric pressure, UF_6 is a solid at temperatures below 134°F (57°C) and a gas at temperatures above 134°F. Solid UF_6 is a white, dense, crystalline material that resembles rock salt.

Inventory of Depleted UF_6 Cylinders Considered in the PEIS

	No. of Cylinders (metric tons)		
Site	DOE-Generated	USEC-Generated[a]	Total
Paducah	28,351 (342,000)	12,000 (144,000)	40,351 (486,000)
Portsmouth	13,388 (161,000)	3,000 (36,000)	16,388 (197,000)
K-25	4,683 (56,000)	None	4,683 (56,000)
Total			61,422 (739,000)

[a] In May and June 1998, DOE assumed management responsibility for approximately 11,400 cylinders generated by United States Enrichment Corporation. For purposes of the PEIS, management of up to 15,000 USEC-generated cylinders was considered.

In the gaseous diffusion process, a stream of heated UF_6 gas is separated into two parts: one enriched in uranium-235 and the other depleted in uranium-235. The enriched UF_6 is used for manufacturing commercial reactor fuel, which typically contains 2 to 5% uranium-235, or for military applications (e.g., naval reactor fuel), which requires further enrichment of up to 95% or more uranium-235. The depleted UF_6, which typically contains 0.2 to 0.4% uranium-235, is stored as a solid in large metal cylinders at the gaseous diffusion facility.

Large-scale uranium enrichment in the United States began as part of atomic bomb development by the Manhattan Project during World War II. Uranium enrichment activities were subsequently continued under the U.S. Atomic Energy Commission and its successor agencies, including DOE. The K-25 plant was the first of three gaseous diffusion plants constructed to produce enriched uranium. The K-25 plant ceased operations in 1985, but uranium enrichment continues at both the Paducah and Portsmouth sites. These two plants are now operated by the United States Enrichment Corporation (USEC), created by law in 1993 to privatize the uranium enrichment program.

Since the 1950s, depleted UF_6 has been stored at all three storage sites in large steel cylinders. Several different cylinder types are in use, although the vast majority of cylinders have a 14-ton (12-metric-ton) capacity. A typical cylinder is shown in Figure S.1. The cylinders are typically 12 ft (3.7 m) long by 4 ft (1.2 m) in diameter, with most having a wall thickness of 5/16 in. (0.79 cm) of steel. Similar, but slightly smaller, cylinders with a capacity of 10 tons (9 metric tons) are also in use. During storage, a cylinder contains solid UF_6 in the bottom and UF_6 gas at less than atmospheric pressure in the top. The depleted UF_6 cylinders managed by DOE at the three sites are typically stacked two cylinders high in large areas called yards (Figure S.2).

The characteristics of UF_6 pose potential health risks, and the material is handled accordingly. Uranium is radioactive, and UF_6 in storage emits low levels of gamma and neutron radiation. The radiation levels measured on the outside surface of filled depleted UF_6 storage cylinders are typically about 2 to 3 millirem per hour (mrem/h), decreasing to about 1 mrem/h at a distance of 1 ft (0.3 m). In addition, if UF_6 is released to the atmosphere, it reacts with water vapor in the air, forming hydrogen fluoride (HF) and a uranium-fluoride compound called uranyl fluoride (UO_2F_2). These products are chemically toxic. Uranium is a heavy metal that, in addition to being radioactive, can have toxic chemical effects (primarily on the kidneys) if it enters the bloodstream by means of ingestion or inhalation. HF is an extremely corrosive gas that can damage the lungs and cause death if inhaled at high enough concentrations.

Cylinders are stored with minimum risks to workers, members of the general public, and the environment at the Paducah, Portsmouth, and K-25 sites. DOE maintains an active cylinder management program to improve storage conditions in the cylinder yards, to monitor cylinder integrity by conducting routine inspections for breaches, and to perform cylinder maintenance and repairs as needed.

Because storage began in the early 1950s, many of the cylinders now show evidence of external corrosion. Before 1998, seven cylinders (one at Paducah, two at Portsmouth, and four at K-25) had been identified that had developed holes (breaches), generally around spots previously damaged by handling activities. In 1998, one additional cylinder breach occurred during the course of cylinder maintenance operations. Because the depleted UF_6 is a solid at ambient temperatures and pressures, it is not readily released from a cylinder following a leak or breach. When a cylinder is breached, moist air reacts with the exposed UF_6 solid and iron, resulting in the formation of a dense plug of solid uranium and iron compounds and a small amount of HF gas. This plug limits the amount of material released from a breached cylinder. When a cylinder breach is identified, the cylinder is repaired or its contents are transferred to a new cylinder.

DOE has responsibility for continued management of the depleted UF_6 cylinders stored at the Paducah, Portsmouth, and K-25 sites. The management plan in place during much of the preparation of this PEIS was to continue safe storage of the cylinders and, if feasible alternative uses

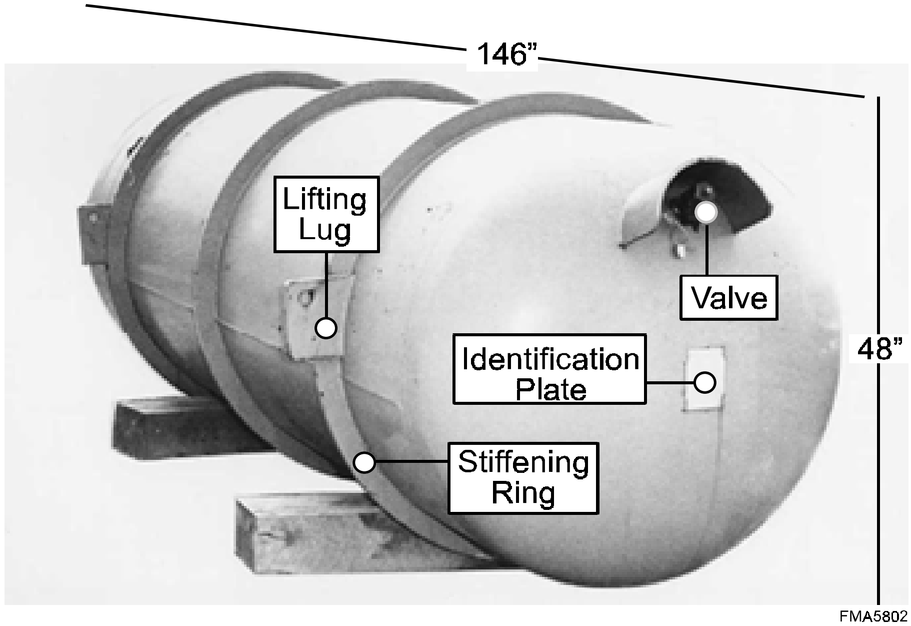

FIGURE S.1 Typical Depleted UF_6 Storage Cylinder (Cylinders are constructed of steel, with the majority of cylinders having a 14-ton capacity.)

FIGURE S.2 Depleted UF_6 Cylinders in Storage Yards

for the depleted uranium had not been found by about the year 2010, take steps to convert the UF_6 to triuranium octaoxide (U_3O_8) beginning in the year 2020. The U_3O_8, which is more chemically stable than UF_6, would be stored until there was a determination that all or a portion of the depleted uranium was no longer needed. At that point, the U_3O_8 would be disposed of as low-level radioactive waste (LLW). The basis for the plan was to reserve depleted UF_6 for future defense needs and other potentially productive and economically viable purposes, including possible reenrichment in an atomic vapor laser isotope separation plant, conversion to depleted uranium metal for fabricating penetrators (anti-tank weapons) for military use, and use as fuel in advanced liquid metal nuclear reactors.

Since the former plan was put in place, several developments have occurred that suggest this plan should be revised. For example, the Energy Policy Act of 1992 assigned responsibility for uranium enrichment and development of atomic vapor laser isotope separation to the USEC, the demand for penetrators has diminished, and the advanced liquid metal nuclear reactor program has been canceled. In addition, stakeholders near the current cylinder storage sites have expressed concerns regarding potential environmental, safety, health, and regulatory issues associated with the continued storage of the depleted UF_6 inventory. The Ohio Environmental Protection Agency issued a Notice of Violation to DOE (which has since been resolved), and the Defense Nuclear Facilities Safety Board (DNFSB) provided a recommendation to the Secretary of Energy regarding improvements in the management of depleted UF_6.

DOE also entered into a Consent Order with the Department of Environment and Conservation of the State of Tennessee with respect to the management of the depleted UF_6 stored at the K-25 site. DOE has agreed that if it chooses any action alternative as the outcome of this PEIS, it shall, subject to appropriate NEPA review, either remove all known depleted UF_6 cylinders from K-25 or complete the conversion of their contents by December 31, 2009.

In July 1998, the President signed Public Law 105-204 which provides, in part, the following (see Appendix N for the complete text of Public Law 105-204):

> *(a) PLAN. – The Secretary of Energy shall prepare, and the President shall include in the budget request for fiscal year 2000, a Plan and proposed legislation to ensure that all amounts accrued on the books of the United States Enrichment Corporation for the disposition of depleted uranium hexafluoride will be used to commence construction of, not later than January 31, 2004, and to operate, an onsite facility at each of the gaseous diffusion plants at Paducah, Kentucky, and Portsmouth, Ohio, to treat and recycle depleted uranium hexafluoride consistent with the National Environmental Policy Act.*

DOE provided its initial plan for the conversion of depleted UF_6, responsive to Public Law 105-204, to Congress on March 12, 1999. In addition, it issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999. (This is referred to on page 13 of the March 8 issue of the *Commerce Business Daily* published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

At this time, DOE has not recommended to the President that any additional legislation be proposed. Any proposal to proceed with the location, construction, and operation of a facility or facilities will involve additional review under NEPA.

S.1.2 Purpose and Need

The purpose of the PEIS is to reexamine DOE's management strategy for depleted UF_6 and alternatives to that strategy; DOE needs to take action in response to current economic, environmental, and legal developments. This PEIS examines the environmental consequences of alternative strategies of long-term storage, use, and disposal of the depleted UF_6 inventory. A long-term management strategy will be selected in the Record of Decision, which is scheduled to be issued no sooner than 30 days after the issuance of this PEIS.

S.1.3 Proposed Action

The proposed action assessed in this PEIS is DOE's selection of a long-term management strategy for depleted UF_6 that will be implemented following the Record of Decision. A strategy is a set of activities or steps for managing depleted UF_6, from its current storage at the three DOE storage sites to its ultimate use, long-term storage, or disposal. The alternative strategies considered in the PEIS evaluate options for continued storage of cylinders; conversion of the UF_6 to other chemical forms; use of the uranium as a metal or an oxide; long-term storage, disposal, and/or transportation. The time period for which activities were assessed for all strategies was approximately 40 years: generally 10 years for siting, design, and construction of any required new facilities; about 26 years for operations; and, when appropriate, about 4 years for monitoring.[3] In addition, for the continued storage component of all alternatives and for the disposal alternative, long-term impacts (primarily from potential groundwater contamination) were estimated. The actual implementation schedule would depend on the ultimate strategy selected in the Record of Decision and on other considerations, and activities could continue beyond the 40-year period. DOE would conduct additional NEPA reviews for such activities as appropriate.

The PEIS provides a broad environmental analysis of the various programmatic management strategies available to DOE. DOE has identified a preferred management strategy in the draft PEIS and modified the strategy in this final PEIS on the basis of public comments.

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[3] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

S.1.4 DOE's Depleted Uranium Hexafluoride Management Program

The DOE Depleted Uranium Hexafluoride Management Program was established to accomplish the long-term management of depleted UF_6. The program has two phases: (1) the selection of a strategy for long-term management of depleted UF_6; and (2) implementation of the strategy selected. The first phase is under way and is the subject of this PEIS. After this final PEIS is issued, DOE will select the strategy for long-term management of depleted UF_6 and describe the strategy selected in a Record of Decision that will be published in the *Federal Register* (FR). In the second phase of the program, DOE will identify specific sites and technologies necessary to carry out the strategy. These sites and technologies will be evaluated in subsequent NEPA reviews.

The program has and is conducting a variety of technical analyses in parallel with the PEIS. Technology assessment evaluations are based on suggestions for uses of depleted UF_6 and management technologies provided by respondents to a DOE Request for Recommendations issued on November 10, 1994 (59 FR 56324). This request resulted in a report entitled *Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride*, which was released on June 30, 1995. An engineering analysis, which is documented in the engineering report prepared in parallel with this PEIS — *Depleted Uranium Hexafluoride Management Program; Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* — provides an in-depth technical analysis of feasible options identified in the technology assessment report and includes all the options addressed in the PEIS. The life-cycle costs of alternative management strategies are also being assessed, and the results are documented in the *Cost Analysis Report for Alternative Strategies for the Long-Term Management of Depleted Uranium Hexafluoride*.

The estimation of potential environmental impacts in the PEIS was based primarily on information provided in the engineering analysis report, which is incorporated by reference. The engineering analysis report contains preliminary facility design data for cylinder preparation, conversion, long-term storage (except for long-term storage of cylinders in yards), manufacture and use, and disposal options. For these options, the engineering analysis report includes descriptions of facility layouts, resource requirements, and construction requirements; estimates of effluents, wastes, and emissions during operations; and descriptions and estimated frequencies for a range of potential accident scenarios. These facility design data, as well as environmental setting information, were used as input to the calculational models or "tools" for estimating potential environmental impacts that could result under each alternative. The summary of the engineering analysis report is included in its entirety in Appendix O.

In addition to the management strategies considered in this PEIS, the use of some depleted UF_6 is being considered pursuant to other DOE programs, such as the disposition of surplus plutonium. Uses being considered by other DOE programs, which are subject to future decisions and other NEPA reviews, would generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy.

S.1.5 Scope of the Depleted UF_6 PEIS

On January 25, 1996, DOE published a Notice of Intent in the *Federal Register* (61 FR 2239), stating its plans to prepare the Depleted UF_6 PEIS and requesting comments on the scope of the PEIS. Three public scoping meetings were held between February 13 and February 20, 1996, at locations near each of the three depleted UF_6 storage sites. One important objective of scoping was to obtain public comments on DOE's proposed alternative management strategies. No new alternative management strategies were identified as a result of public comments.

This PEIS evaluates the environmental impacts of a range of alternative management strategies (these strategies are in addition to the potential use of some of the depleted UF_6 under other programs). Each alternative strategy consists of a series of activities needed to achieve the safe and effective long-term management of depleted UF_6. These activities could be accomplished in a number of different ways (called options). Options include technology or design variations for cylinder preparation, conversion of depleted UF_6 to another chemical form, use, storage, disposal, and transportation. The PEIS includes an assessment of the potential environmental impacts from a range of options for each activity. Representative options were evaluated in the PEIS; specific technologies and facilities will be evaluated in future NEPA reviews after an overall management strategy is selected in a Record of Decision. The PEIS evaluates the potential impacts to human health and safety, air, land, water, biota, cultural resources, waste management capabilities, socioeconomics, and environmental justice.

This final PEIS considers the depleted UF_6 inventory stored at the Paducah site, Portsmouth site, and K-25 site for which DOE has management responsibility. This inventory includes depleted UF_6 generated by DOE before the formation of USEC in July 1993 as well as depleted UF_6 generated by USEC that has been or will be transferred to DOE. Specifically, the PEIS considers the management of 46,422 cylinders (560,000 metric tons) generated by DOE and up to 15,000 cylinders (180,000 metric tons) generated by USEC.

S.1.6 Public Review of the Draft PEIS and Major Changes from the Draft to the Final PEIS

The draft PEIS was mailed to stakeholders in mid-December 1997, and a notice of availability was published by the U.S. Environmental Protection Agency (EPA) in the *Federal Register* on December 24, 1997. In addition, the entire PEIS was also made available on the World Wide Web at the same time. Stakeholders were encouraged to provide comments on the draft PEIS during a 120-day review period, from December 24, 1997, until April 23, 1998. Comments could be submitted via a toll-free number, fax, letter, e-mail, or the World Wide Web site. Comments could also be submitted at four public hearings held during a period from February 19, 1998, to March 10, 1998. Public hearings were held near each of the three current storage sites (Paducah, Kentucky; Oak Ridge, Tennessee; and Portsmouth, Ohio), and another was held in Washington, D.C.

A total of about 600 comments were received during the comment period. Comments received on the draft PEIS were considered in preparing the final PEIS. (As noted earlier, changes to the draft PEIS are denoted by a vertical line in the right margin of this final PEIS.) All comments received, along with DOE's responses to those comments, are presented in Volume 3 of this PEIS. A summary of the major issues raised by the reviewers of the draft PEIS, DOE's resolution of these issues, and resulting changes to the PEIS follows here.

- *The preferred alternative.* Many of the reviewers questioned DOE's preference for beginning to convert the depleted UF_6 inventory to uranium oxide or uranium metal only as uses for these materials became available. Several reviewers expressed a desire for DOE to start conversion as soon as possible. Conversion to U_3O_8 was the option most often cited as preferred, although several reviewers thought conversion to metal would be more advantageous. In addition, many reviewers expressed doubt about the prospects for any widespread uses for depleted uranium now or in the future.

  After careful consideration of comments, DOE revised the preferred alternative for the final PEIS. The preferred alternative, as stated in Sections S.5.1 and 2.5 of this final PEIS, calls for prompt conversion of the depleted UF_6 inventory to U_3O_8 and long-term storage of that portion of the U_3O_8 that cannot be put to immediate use. Under this revised preferred alternative, conversion to depleted uranium metal would take place only if uses for the metal products become available. The impacts of the preferred alternative are discussed in Sections S.5.2, 2.5.2, 5.7, and 6.3.7 of the PEIS.

- *Seismic hazards at the Paducah site.* Several reviewers commented that the draft PEIS did not adequately address the seismic hazards at the Paducah site. They requested that DOE review new information and reevaluate the risks associated with potential earthquakes at Paducah.

  In response, DOE reviewed those references that were available at the time this final PEIS was prepared. DOE determined that the analyses performed as part of the safety analysis reports recently completed at the three current storage sites (including Paducah) and for this PEIS were adequate. DOE will review any new data that become available and take appropriate action to maintain the safety basis of its cylinder management program.

- *Potential life-cycle impacts.* Several reviewers stated that depleted uranium and products made from using depleted uranium in various chemical forms would eventually need to be disposed of. They requested that the PEIS include a discussion of impacts for the disposal of these materials following long-term storage and use.

In response to their requests, a new section was added to this Summary (Section S.6) and to Chapter 5 of the PEIS (Section 5.9) to discuss issues related to the potential impacts of the long-term (beyond 2039) management of materials containing depleted uranium under all alternatives.

- *Cylinder inventory.* Several reviewers questioned the accuracy of the reported number of DOE-owned cylinders of depleted UF_6 (46,422) considered in the draft PEIS. Other reviewers requested that USEC-generated cylinders also be included within the scope of the PEIS.

  Although the number 46,422 used in the draft PEIS was accurate at the time the document was published, subsequent privatization of USEC and transfer of some cylinders from USEC to DOE changed the inventory of depleted UF_6 that falls within the scope of the PEIS (see Section 1.5.2). Chapter 6 has been added to the PEIS, and Chapter 2 and the Summary have been revised so the PEIS includes the impacts associated with the management of additional USEC-generated cylinders.

- *Current cylinder management.* Several reviewers raised questions and concerns about the current management of the cylinders at the three DOE locations.

  In response to these concerns, it has been emphasized that DOE's current cylinder management program provides for safe storage of the depleted UF_6 cylinders. DOE is committed to the safe storage of the cylinders at each site during the decision-making period and also through the implementation of the decision made in the Record of Decision. DOE has an active cylinder management program that involves upgrading cylinder storage yards, constructing new yards, repainting cylinders to arrest corrosion, and regular inspection and surveillance of the cylinders and storage yard conditions.

The changes made in response to public comments, including the inclusion of up to 15,000 USEC cylinders, did not affect the types or overall significance of the environmental impacts presented in the draft PEIS. Although the estimated impacts did increase by up to 30% in some assessment areas, this increase was generally not significant because the impacts were typically small to begin with. Many impacts did not change at all with the inclusion of the USEC cylinders because these impacts were related to factors that were unaffected by the inventory increase. For example, the consequences of potential accidents did not increase because accidents generally involve only a limited amount of material that would be available, regardless of the overall inventory. In addition, other impacts did not change because they were related to the annual material processing rates, which were assumed to remain the same when the USEC cylinders were included. Consequently, it was not necessary to recirculate the draft PEIS for additional public review. The nature and magnitude of changes in environmental impacts resulting from the addition of USEC cylinders are discussed in Sections 2.4, 2.5, and Chapter 6 of the PEIS.

S.2 DESCRIPTION OF ALTERNATIVES

The alternative management strategies (also termed "alternatives") evaluated in this PEIS were developed by considering the two possible permanent dispositions for depleted uranium, use or disposal, and long-term storage of depleted uranium. Each of the alternatives involves some combination of seven activities: continued cylinder storage at the current sites, cylinder preparation for shipment, conversion to another chemical form, long-term storage, manufacture and use, disposal, and transportation. The activities required for each alternative are illustrated in Figure S.3 and summarized in Table S.1.

Alternative Management Strategies Considered in the PEIS*

No Action — Continued storage of depleted UF_6 cylinders indefinitely in yards at the Paducah, Portsmouth, and K-25 sites.

Long-Term Storage as UF_6 — Storage as UF_6 cylinders in yards, buildings, or a mine at a consolidated site.

Long-Term Storage as Uranium Oxide — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by storage in buildings, belowground vaults, or a mine at a consolidated site.

Use as Uranium Oxide — Conversion of UF_6 to an oxide, followed by the manufacture of oxide-shielded spent nuclear fuel or high-level waste storage containers (casks).

Use as Uranium Metal — Conversion of UF_6 to uranium metal, followed by the manufacture of metal-shielded spent nuclear fuel or high-level waste storage containers (casks).

Disposal — Conversion of UF_6 to an oxide, either UO_2 or U_3O_8, followed by disposal as low-level waste in shallow earthen structures, belowground vaults, or a mine.

*DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.

The alternatives for long-term management of depleted UF_6 evaluated for the period 1999 through 2039 are (1) no action, which involves continued storage of cylinders indefinitely at the three current storage sites; (2) long-term storage as UF_6 at a consolidated site; (3) long-term storage as an oxide at a consolidated site; (4) use as uranium oxide; (5) use as uranium metal; and (6) disposal as oxide. The first two alternatives involve the continued management of uranium in the form of UF_6. The other alternatives involve the conversion of UF_6 to another chemical form, either uranium oxide or uranium metal. During conversion, large amounts of HF would be produced that could potentially be sold for use or neutralized to calcium fluoride (CaF_2), which could be sold or disposed of.

DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental,

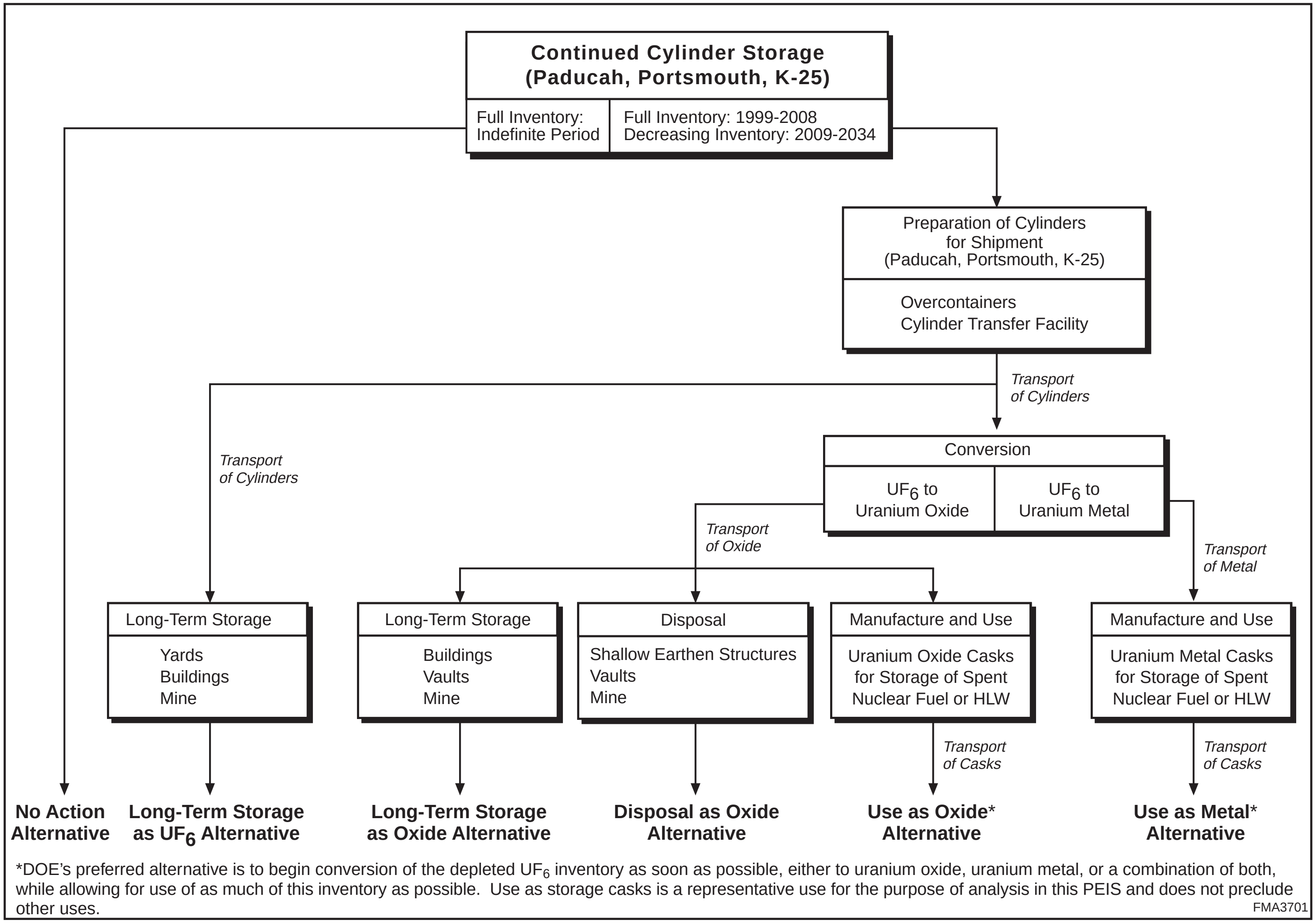

FIGURE S.3 Major Components of the Alternative Management Strategies

TABLE S.1 Comparison of Activities under the PEIS Alternatives (Note that DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Continued Cylinder Storage at Paducah, Portsmouth, and K-25			
The entire cylinder inventory would continue to be stored indefinitely at the Paducah, Portsmouth, and K-25 sites (impacts were evaluated from 1999 through 2039). Cylinders would be subject to a comprehensive monitoring and maintenance program, which would include routine inspections, cylinder painting, and cylinder yard upgrades.	The entire cylinder inventory would continue to be stored at the three current storage sites from 1999 through 2008. The inventory at each site was assumed to decrease to zero cylinders over the period 2009 through 2034 as cylinders were shipped to an off-site location.[a] During storage at current locations, cylinders would be subject to similar management activities as under no action.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Cylinder Preparation for Transportation			
Not applicable. The cylinders would remain at the three current storage sites.	The cylinders would be prepared at each current storage site for off-site shipment. Cylinders not suitable for shipment would either be provided with over-containers or the contents would be transferred to new cylinders.	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative	Same as long-term storage as UF_6 alternative
		Conversion			
Not applicable.	Not applicable.	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to the oxide UO_2 at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium metal at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]	UF_6 would be converted to uranium oxide (U_3O_8 or UO_2) at a location to be determined in the future. Conversion would occur over the period 2009 through 2034.[a]

TABLE S.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Consolidated Long-Term Storage			
Not applicable. Cylinders would remain at the three current storage sites.	UF_6 cylinders would be stored for the long term in yards, buildings, or a mine at a site to be determined in the future. Cylinders would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Oxide (either U_3O_8 or UO_2) would be stored for the long term in drums in buildings, belowground vaults, or a mine at a site to be determined in the future. Material would be placed into storage over the period 2009 through 2034 and remain through 2039.[a]	Not applicable.	Not applicable.	Not applicable.
		Manufacture and Use			
Not applicable.	Not applicable.	Not applicable.	Depleted uranium oxide (UO_2) would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Depleted uranium metal would be manufactured into casks for storage of spent nuclear fuel or HLW at a site to be determined. Manufacture would occur from 2009 through 2034.[a]	Not applicable.
		Disposal of Uranium			
Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Uranium oxide (either U_3O_8 or UO_2) would be disposed of as LLW at a site to be determined in the future. Disposal was considered for grouted (immobilized) and ungrouted oxide (in drums) in shallow earthen structures, belowground vaults, and a mine.

TABLE S.1 (Cont.)

No Action Alternative	Long-Term Storage as UF_6	Long-Term Storage as Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Oxide
		Transportation[b]			
Small amounts of LLW and LLMW would be shipped from the current storage sites to treatment/disposal site(s).	UF_6 cylinders would be shipped from the current storage sites to a long-term storage site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.	UF_6 cylinders would be shipped from the current storage sites to a conversion site.
	LLW/LLMW would be shipped from storage sites to a disposal/treatment site.	Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a long-term storage site.	Uranium oxide (UO_2) would be shipped from a conversion site to a manufacturing site.	Uranium metal would be shipped from a con-version site to a manufacturing site.	Uranium oxide (U_3O_8 or UO_2) would be shipped from a conversion site to a disposal site.
		HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.	HF (if produced) would be shipped from a conversion site to a user site.
		CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.	CaF_2 (if produced) would be shipped from a conversion site to a user or disposal site.
		NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.	NH_3 would be shipped from a supplier to a conversion site.
		LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.	LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site.	LLW/LLMW would be shipped from conversion/ storage/manufacturing sites to a disposal/treatment site.	LLW/LLMW would be shipped from conversion/ storage sites to a disposal/ treatment site.
			Casks would be shipped from a manufacturing site to a user site.	Casks would be shipped from a manufacturing site to a user site.	
				Magnesium fluoride (MgF_2) would be shipped from a conversion site to a disposal site.	

[a] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

[b] Because the locations of conversion, manufacture, long-term storage, and disposal sites will be decided in future studies, it was assumed that these sites were at separate locations, requiring transportation between them. This approach was intended to provide a conservative estimate of potential transportation impacts. Colocation of facilities would reduce transportation impacts.

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride; UO_2 = uranium dioxide; U_3O_8 = triuranium octaoxide.

economic, technical, and other factors. This identification does not represent a decision by DOE; rather, it reflects the DOE's preference on the basis of existing information. A discussion of the preferred alternative is presented in Section S.5. The Record of Decision, when issued, will present DOE's decision for the long-term management of depleted UF_6.

S.3 AFFECTED ENVIRONMENT

The affected environment is defined as the location or locations that may be impacted by the proposed action. For this PEIS, the affected environment consists of the three current depleted UF_6 storage locations: the Paducah site, the Portsmouth site, and the K-25 site.

S.3.1 Paducah Site

The Paducah site is located in rural McCracken County, Kentucky, approximately 10 miles (16 km) west of the city of Paducah and 3.6 miles (6 km) south of the Ohio River. The site includes 3,423 acres (1,386 ha) surrounded by an additional 2,781 acres (1,125 ha) owned by DOE but managed by the State of Kentucky as part of the West Kentucky Wildlife Management Area. The city of Paducah is the largest urban area in the six counties surrounding the site. The area is primarily rural, with industrial uses accounting for less than 5% of land use.

The Paducah Gaseous Diffusion Plant (PGDP) within the Paducah site occupies a 750-acre (303-ha) complex that is surrounded by a security fence. The PGDP, now operated by the USEC and previously operated by DOE, has been in operation since 1955. The Paducah site has 13 yards that are used for storage of DOE-generated depleted UF_6 cylinders; an additional 4 yards are used for storage of USEC-generated cylinders that are now managed by DOE.

The air quality region that includes the Paducah site is in attainment for all six criteria pollutants; that is, the ambient air concentrations of the criteria pollutants — carbon monoxide, sulfur dioxide, particulate matter, ozone, nitrogen oxides, and lead — are within the corresponding standards. The Paducah site is also in compliance with 40 CFR 61 (National Emission Standards for Hazardous Air Pollutants, or NESHAPS), which places a maximum dose limit of 10 mrem/yr for the maximally exposed individual (MEI) of the general public from emissions of radioactive materials.

Several zones of faulting occur in the vicinity of the Paducah site. The largest earthquake in the region, with a magnitude of 7.3, occurred in 1812. The epicenter was 60 miles southwest of the site.

Big Bayou Creek and Little Bayou Creek, tributaries of the Ohio River, receive drainage from the Paducah site. All effluent discharges are regulated under the Kentucky Pollutant Discharge Elimination System. Groundwater at the Paducah site is monitored for pollutants, and trichloroethylene has been detected at levels above the drinking water standard at several off-site locations. The radioactive isotope technetium-99 has also been detected in groundwater at the site. A municipal water supply has been provided to all residents whose wells are within the area of groundwater contamination from the site.

About 5 acres (2 ha) of jurisdictional wetland have been identified in drainage ditches scattered throughout the PGDP, and a large number of wetlands occur in the natural areas surrounding the developed center of the site where the yards are located. No federal-listed threatened or endangered species are known to occur on the Paducah site; however, several state-listed threatened and special concern terrestrial and aquatic species have been found outside the security fence of the PGDP.

The Paducah site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and low-level mixed waste (LLMW). Wastewater is discharged through permitted outfalls; nonhazardous solid waste is disposed of at an on-site landfill; and nonradioactive hazardous waste is stored on-site and sent to permitted commercial disposal facilities. The LLW is sent to a commercial facility for volume reduction; LLMW is currently stored on-site or, if appropriate, sent to the K-25 site for incineration.

Both workers and members of the general public receive small radiation doses from Paducah site operations. The estimated maximum radiation dose to a member of the general public near the site is about 2 mrem/yr, which is 2% of the DOE maximum dose limit. The 2-mrem/yr dose also represents less than a 1% increase over the 360-mrem/yr average dose from background radiation in the United States. Cylinder yard workers receive average radiation doses of about 16 to 56 mrem/yr, which is considerably below DOE's maximum dose limit of 5,000 mrem/yr for workers. Under normal operating conditions, cylinder yard workers at the Paducah site are not exposed to chemicals in amounts that exceed guideline values.

S.3.2 Portsmouth Site

The Portsmouth site is located in Pike County, Ohio, approximately 22 miles (35 km) north of the Ohio River and 3 miles (5 km) southeast of the town of Piketon. The two largest cities in the vicinity are Chillicothe, located 26 miles (42 km) north of the site, and Portsmouth, 22 miles (35 km) south. Wayne National Forest borders the plant site on the east and southeast, and Brush Creek State Forest is located to the southwest, slightly over 1 mile (1.6 km) from the site boundaries.

The Portsmouth site includes the Portsmouth Uranium Enrichment Complex, a gaseous diffusion plant operated by the USEC and previously operated by DOE. The Portsmouth site occupies 3,708 acres (1,500 ha) of land, with an 800-acre (320-ha) fenced area containing the core facilities. The 2,908 acres (1,180 ha) outside the fenced area consist of restricted buffer zones, waste management areas, plant management and administrative facilities, and vacant lands. The Portsmouth site contains two storage yards for DOE-generated depleted UF_6 cylinders; one additional yard is used for storage of USEC-generated cylinders that are now managed by DOE.

The air quality region that includes the Portsmouth site is in attainment for all six criteria pollutants. The Portsmouth site is also in compliance with NESHAPS for radionuclide emissions (40 CFR 61). The Portsmouth site is drained by Big Beaver Creek and Little Beaver Creek. All site effluents are discharged either through permitted outfalls to Little Beaver Creek or downstream to the Scioto River. Groundwater is monitored at and around the Portsmouth site; several chlorinated hydrocarbons, uranium, and other metals have been detected in on-site monitoring wells.

Approximately 34 acres (13.8 ha) of wetlands occur on the Portsmouth site, excluding retention ponds. Two wetland areas near the site have been listed by the Ohio State Division of Natural Areas and Preserves as significant wetland communities. No federal-listed threatened or endangered plant or animal species are known to occur on the Portsmouth site, although the endangered Indiana bat may be present in the summer. One state-listed endangered species occurs on the site, and one threatened species occurs near the site.

The Portsmouth site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and LLMW. Wastewater is treated and discharged through permitted outfalls; and nonhazardous solid waste is disposed of at an on-site landfill. Nonradioactive hazardous waste is stored on-site until treatment or disposal; solid nonradioactive hazardous waste is sent to permitted commercial disposal facilities, whereas liquid nonradioactive hazardous waste streams are sent to the approved incinerator at the K-25 site in Tennessee. The LLW is sent to off-site treatment/disposal facilities. Some LLW has been sent to the DOE Hanford site (Washington) for disposal. The LLMW is currently stored on-site or, if appropriate, sent to K-25 for incineration.

Both workers and members of the general public receive small radiation doses from Portsmouth site operations. The estimated maximum radiation dose to a member of the general public is about 0.07 mrem/yr, approximately 0.07% of the DOE maximum dose limit. Cylinder yard workers receive average radiation doses of about 55 to 196 mrem/yr, which is considerably below the 5,000 mrem/yr DOE maximum dose limit. Under normal operating conditions, cylinder yard workers at Portsmouth are not exposed to chemicals in amounts that exceed guideline values.

S.3.3 K-25 Site on the Oak Ridge Reservation

The K-25 site is part of the Oak Ridge Reservation, which consists of three major facilities (the K-25 site, Oak Ridge National Laboratory, and the Y-12 plant) and surrounding property in Anderson and Roane Counties, Tennessee, approximately 25 miles (40 km) west of the city of Knoxville. The K-25 site, in the northwest part of the Oak Ridge Reservation, consists of 1,700 acres (688 ha) and contains the former Oak Ridge Gaseous Diffusion Plant, which has been inactive since 1985. Currently, the primary mission of the K-25 site is environmental restoration and waste management activities. The K-25 site contains three storage yards for depleted UF_6 cylinders.

The air quality region that includes the K-25 site is in attainment for all six criteria pollutants. The K-25 site is also in compliance with NESHAPS for radionuclide emissions (40 CFR Part 61). The

K-25 site is drained by Poplar Creek and the Clinch River, and permitted outfalls are located on both streams. Contaminants detected in groundwater from on-site wells include trichloroethylene and radioactivity.

Numerous wetlands are found in the vicinity of the K-25 site along the creeks and rivers. No federally listed threatened or endangered species are known to occur on the K-25 site; however, several state-listed threatened or endangered plant and animal species are known to be in the vicinity of the K-25 site.

The K-25 site generates wastewater, nonhazardous waste, nonradioactive hazardous waste, LLW, and LLMW. Wastewater is treated and discharged through permitted outfalls. Nonhazardous solid waste is disposed of at a landfill at the Y-12 Plant on the Oak Ridge Reservation. Solid nonradioactive hazardous waste is stored on-site in permitted facilities until it is sent to off-site permitted disposal facilities, and liquid nonradioactive hazardous waste is treated in a permitted on-site incinerator. The LLW is either treated and sent to disposal facilities on the Oak Ridge Reservation or stored for off-site disposal. The LLMW is sent to the K-25 site incinerator.

The estimated maximum radiation dose to a member of the general public from site operations is approximately 5 mrem/yr, about 5% of the DOE maximum dose limit. The average annual dose to cylinder yard workers ranges from 32 to 92 mrem/yr, much less than the 5,000 mrem/yr DOE maximum dose limit. Under normal operating conditions, cylinder yard workers are not exposed to chemicals in amounts that exceed guideline values.

S.3.4 Representative Environmental Settings for Future Depleted UF_6 Management Activities

Because this PEIS is an analysis of programmatic strategies, rather than specific siting alternatives, certain impacts have been assessed using representative or generic environmental settings. In particular, impacts associated with potential conversion, long-term storage, manufacturing, and disposal activities were assessed assuming representative or generic site environmental conditions. The purpose of this approach was to provide as substantive an assessment as possible and to allow for a comprehensive comparison of alternative management strategies. Therefore, the following settings were developed to provide a reasonable range of environmental conditions for impact assessment:

- For conversion and long-term storage, the range of environmental conditions present at the current storage sites was used as the representative range for purposes of analysis. Because of the large quantity of material to be shipped and the consequent costs, conversion and long-term storage facilities might be located at relatively short distances from the current storage sites. The current storage sites have a well documented and comparable set of environmental data on both the natural environment and on operations of facilities handling depleted UF_6. Use of these data allows for a comprehensive assessment of impacts associated with potential conversion and long-term storage facilities. However, use of the current storage site settings does not imply that a conversion facility or a long-term storage facility would be located there.

- For long-term storage in a mine, a “dry” environmental setting (climatic conditions typical of the western United States) was assumed.

- For disposal, both a “wet” setting (climatic conditions typical of the eastern United States) and a dry setting were assessed. The settings were assumed to be in a rural environment (low population density).

- For manufacturing, both a rural setting (low population density) and an urban setting (high population density) were evaluated for both wet and dry conditions.

- For transportation, representative truck and rail route characteristics were defined on the basis of national statistics; however, transportation accidents were evaluated for both rural and urban locations.

S.4 SUMMARY AND COMPARISON OF IMPACTS FOR ALTERNATIVE MANAGEMENT STRATEGIES

For each of the alternative management strategies considered in the PEIS, the potential environmental consequences were estimated for a period of about 40 years, from 1999 through 2039. In addition, long-term impacts (primarily from potential groundwater contamination) were estimated for the continued storage component of all alternatives and for the disposal alternative. Consequences were evaluated in the areas of human health and safety (normal operations and accidents), air quality, water and soil, socioeconomics, ecology, waste management, resource requirements, land use, cultural resources, and environmental justice. The assessment considered impacts that could result from construction of necessary facilities, normal operations of facilities, accidents, and transportation of materials.

The potential environmental consequences of the alternative management strategies would depend on the type and number of activities necessary to accomplish each strategy. The no action alternative (continued cylinder storage) would involve the fewest activities. It would require only limited construction of new or improved storage yards and routine monitoring and maintenance of cylinders to ensure continued safe storage. All other alternatives would involve activities in addition to continued cylinder storage. For example, the long-term storage as UF_6 alternative would require the construction and operation of a long-term cylinder storage facility. Each of the other four alternatives would require construction and operation of a conversion facility to convert UF_6 to another chemical form. The converted material would then be stored, disposed of, or manufactured and used.

The original scope of the PEIS considered the management and processing of only DOE-generated cylinders (i.e., 46,422 cylinders). It was assumed that facilities for cylinder preparation, conversion, long-term storage, manufacture, and disposal would process this inventory over a 20-year period. The final PEIS considers the additional management of up to 15,000 USEC-generated cylinders. In general, it was assumed that the processing of the USEC-generated inventory would be accomplished by extending the operational period of required facilities from 20 to 26 years.

A comparison of the estimated environmental impacts associated with management of the total cylinder inventory (DOE-generated plus USEC-generated cylinders) for each alternative is provided in Table S.2. To supplement the information in Table S.2, each area of impact evaluated in the PEIS is discussed separately in Sections S.4.1 through S.4.12. Major similarities and differences among the alternatives are highlighted. The preferred alternative, which combines aspects of several of the alternatives evaluated in the PEIS, is discussed separately in Section S.5.

S.4.1 Human Health and Safety — Normal Facility Operations

For all alternatives, exposures of workers and members of the public to radiation and chemicals were estimated to be within applicable public health standards and regulations during normal facility operations. Levels of radiation and/or chemical exposures for the general public and noninvolved workers for all alternatives during normal facility operations were estimated to be very low, with zero latent cancer fatalities (LCFs) expected among these groups over the duration of the program. Involved workers (persons directly involved in the handling of radioactive or hazardous materials) could be exposed to low-level radiation emitted by uranium during the normal course of their work activities, and this exposure could result in a slight increase in the risk for radiation-induced cancer fatality among the involved worker population. The annual number of workers so exposed could range from about 70 (under the no action alternative) to about 700 (under the use as metal alternative.) For management of DOE- and USEC-generated cylinders, the increased exposure to radiation resulted in total estimates of from 1 LCF among workers (under the no action alternative) up to 3 LCFs among workers (under the long-term storage as oxide and disposal alternatives) over the assessment period.

Possible radiological exposures from using groundwater potentially contaminated from releases from breached cylinders or facility releases were also evaluated. For all alternatives except the disposal as oxide alternative, these exposures were estimated to be within applicable public health standards and regulations. During the operational phase of the disposal as oxide alternative, exposures were also estimated to remain within standards and regulations.

TABLE S.2 Summary Comparison of Potential Environmental Consequences of Alternative Management Strategies[a]

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
	Human Health and Safety — Normal Facility Operations[b]					
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within regulatory limit of 5 rem/yr or lower	Same as NAA[c]	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among involved workers (1999–2039)	1 additional LCF	1 to 2 additional LCFs	1 to 3 additional LCFs	1 to 2 additional LCFs	1 to 2 additional LCFs	1 to 3 additional LCFs
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total health effects among noninvolved workers (1999-2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA for a disposal facility located in a dry environmental setting. In a wet environmental setting, the maximum dose from the use of groundwater was estimated to be about 100 mrem/yr within 1,000 years of facility failure.
Total health effects among members of the public (1999-2039)	0 additional LCFs from routine site emissions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI[d]	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Human Health and Safety — Normal Facility Operations[b] (Cont.)						
General public MEI	No (Hazard Index <1)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Operational Phase: Same as NAA. Postclosure Phase: Same as NAA in a dry environmental setting. In a wet environmental setting, a hazard index of about 10 was estimated within 1,000 years of facility failure.
Human Health and Safety — Facility Accidents[b]						
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999–2039)	0 fatalities; 180 injuries	1–2 fatalities; 310–1,200 injuries	1–3 fatalities; 900–2,100 injuries	2–3 fatalities; 1,600–2,600 injuries	2–3 fatalities; 1,700–2,700 injuries	1–3 fatalities; 900–2,400 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[e]						
Accident[f]	Corroded cylinder spill, dry conditions	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 10 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	4 potential accidents	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	70	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Likely Cylinder Accidents (Cont.)						
Radiation exposure – public						
Dose to MEI	3 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	1 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	0.4 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	77 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	3 in 100,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	2.2 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Low Frequency-High Consequence Cylinder Accidents[h]						
Accidents[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Release	Uranium, HF	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Estimated frequency	~ 1 in 100,000 years	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	1	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Irreversible adverse effects	300	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Fatalities	3	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Human Health and Safety — Facility Accidents[b] (Cont.)						

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	7 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to population	1 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Risk of LCF	8 in 1 million	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total dose to workers	16 person-rem	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Total LCFs	0	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Noninvolved workers	0 fatalities	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h]						
Chemical accident[f]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as NAA	HF or NH_3 tank rupture	Same as LTSO[c]	Same as LTSO	Same as LTSO
Release	Uranium, HF	Same as NAA	HF, NH_3	Same as LTSO	Same as LTSO	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Same as LTSO	Same as LTSO	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	< 1 in 1 million years	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 50,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as NAA	41,000	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	1	Same as NAA	1,700	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	0	Same as NAA	30	Same as LTSO	Same as LTSO	Same as LTSO
Chemical exposure – noninvolved workers[g]						
Adverse effects	1,000	Same as NAA	1,100	Same as LTSO	Same as LTSO	Same as LTSO
Irreversible adverse effects	300	Same as NAA	440	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	3	Same as NAA	4	Same as LTSO	Same as LTSO	Same as LTSO

Human Health and Safety — Facility Accidents[b] (Cont.)

Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[h] (Cont.)

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
Accident risk (consequence times probability)						
General public	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Noninvolved workers[g]	0 fatalities	Same as NAA	0 fatalities	Same as LTSO	Same as LTSO	Same as LTSO
Radiological accident[f]	Vehicle-induced fire, 3 full cylinders	Same as NAA	Earthquake damage to storage building at conversion site	Earthquake damage to storage building at conversion site	Vehicle-induced fire, 3 full cylinders	Same as LTSO
Release	Uranium	Same as NAA	Uranium (U_3O_8)	Uranium (UO_2)	Uranium	Same as LTSO
Accident location	Current storage site	Same as NAA	Conversion site	Conversion site	Conversion site	Same as LTSO
Estimated frequency	~ 1 in 100,000 years	Same as NAA	1 in 100,000 years	1 in 100,000 years	1 in 100,000 years	Same as LTSO
Accident probability (1999–2039)	~ 1 chance in 2,500	Same as NAA	1 chance in 5,000	1 chance in 5,000	1 chance in 5,000	Same as LTSO
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	15 mrem	Same as NAA	270 mrem	68 mrem	15 mrem	Same as LTSO
Risk of LCF	7 in 1 million	Same as NAA	1 in 10,000	3 in 100,000	7 in 1 million	Same as LTSO
Total dose to population	28 person-rem	Same as NAA	20 person-rem	5.1 person-rem	56 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Radiation exposure – noninvolved workers[g]						
Dose to MEI	20 mrem	Same as NAA	9,000 mrem	2,300 mrem	20 mrem	Same as LTSO
Risk of LCF	8 in 1 million	Same as NAA	1 in 250	9 in 10,000	8 in 1 million	Same as LTSO
Total dose to workers	16 person-rem	Same as NAA	840 person-rem	210 person-rem	8 person-rem	Same as LTSO
Total LCFs	0	Same as NAA	0	0	0	Same as LTSO
Accident risk (consequence times probability)						
General public	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO
Noninvolved workers[g]	0 LCFs	Same as NAA	0 LCFs	0 LCFs	0 LCFs	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b]			
Major Materials Assumed to Be Transported between Sites	LLW/LLMW	UF_6 cylinders LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0	0	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Negligible	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	Negligible	2 fatalities	4 fatalities	4 fatalities	4 fatalities	4 fatalities
Maximum use of rail	Negligible	1 fatality	2 fatalities	3 fatalities	2 fatalities	2 fatalities
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Not applicable	Urban rail accident involving 4 cylinders	Same as $LTSUF_6$[c]	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Release	Not applicable	Uranium, HF	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident probability (1999–2039)	Not applicable	1 chance in 10,000	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Human Health and Safety — Transportation[b] (Cont.)			
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	4	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Fatalities	Not applicable	0	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Radiation exposure – All workers and members of general public						
Total LCFs	Not applicable	60	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Accident risk (consequence times probability) – Workers and general public	Not applicable	0 fatalities	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Not applicable	Not applicable	Urban rail accident involving anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Release	Not applicable	Not applicable	Anhydrous HF	Same as LTSO	Same as LTSO	Same as LTSO
Accident probability (1999–2039)	Not applicable	Not applicable	1 chance in 30,000	Same as LTSO	Same as LTSO	Same as LTSO
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	Not applicable	Not applicable	30,000	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	300	Same as LTSO	Same as LTSO	Same as LTSO
Accident risk (consequence times probability)						
Irreversible adverse effects	Not applicable	Not applicable	1	Same as LTSO	Same as LTSO	Same as LTSO
Fatalities	Not applicable	Not applicable	0	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concen- trations well within standards at other sites; criteria pollutants well within standards at all sites	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]						
Pollutant emissions during construction and operations	Not applicable	Pollutant emissions well within standards (all less than 20% of standards)	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as LTSO	Same as LTSO	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Water and Soil[j]			
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other parameters[k]	No change	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Surface water, groundwater, and soil quality	Not applicable	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Uranium concentration in groundwater would remain within guideline for more than 1,000 years after failure in a dry environmental setting; could exceed guideline before 1,000 years after failure in a wet setting
Other parameters[k]	No change	Site-dependent; none to moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Site-dependent; negligible to moderate impacts
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Change in topography from 210,000 to 2.1 million yd^3 of excavated material	Change in topography from 100,000 to 2.6 million yd^3 of excavated material	Not applicable	Not applicable	Change in topography from 400,000 to 3.6 million yd^3 of excavated material

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics [l]			
Current Storage Sites						
Continued storage	**Jobs:** 38 peak year, construction; 140 per year over 40 years, operations **Income:** $1.8 million peak year, construction; $6.0 million per year over 40 years, operations	**Jobs:** 38 peak year, construction; 150 per year over 26 years, operations **Income:** $1.8 million peak year, construction; $7 million per year over 26 years, operations	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Cylinder preparation	Not applicable	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 26 years, operations **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 26 years, operations	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities						
Conversion (Site undetermined)	Not applicable	Not applicable	**Jobs:** 340–730 peak year, construction; 330–490 per year over 26 years, operations **Income:** $16–33 million peak year, construction; $20–28 million per year over 26 years, operations	Same as LTSO	**Jobs:** 480–540 peak year, construction; 340–500 per year over 26 years, operations **Income:** $17–21 million peak year, construction; $20–28 million per year over 26 years, operations	Same as LTSO

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Socioeconomics[l] (Cont.)			
Other Facilities (Cont.)						
Long-term storage (Site undetermined)	Not applicable	**Jobs:** 100–500 peak year, construction; 60-70 per year over 30 years, operations **Income:** $5–29 million peak year, construction; $4 million per year over 30 years, operations	**Jobs:** 120–410 peak year, construction; 70–80 per year over 30 years, operations **Income:** $5–20 million peak year, construction; $4–5 million per year over 30 years, operations	Not applicable	Not applicable	Not applicable
Manufacturing (Site undetermined)	Not applicable	Not applicable	Not applicable	**Jobs:** 160 peak year, construction; 470 per year over 26 years, operations **Income:** $7 million peak year, construction; $33 million per year over 26 years, operations	**Jobs:** 190 peak year, construction; 470 per year over 26 years, operations **Income:** $9 million peak year, construction; $33 million per year over 26 years, operations	Not applicable
Disposal (Site undetermined)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	**Jobs:** 65–770 peak year, construction; 60–180 per year over 26 years, operations **Income:** $3.5–42 million peak year, construction; $6–18 million per year over 26 years, operations

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Ecology			
Current Storage Sites						
Habitat loss	Up to 7 acres; negligible impacts	Up to 28 acres; negligible to potential moderate impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Wetlands and threatened or endangered species	None to negligible impacts	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]						
Habitat loss[m]	Not applicable	**Long-term storage:** 110–170 acres; potential large impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** 80-–260 acres; potential moderate to large impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–35 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** 90 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** 30–40 acres; potential moderate impacts to vegetation and wildlife **Disposal:** 40–590 acres; potential moderate to large impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility accidents	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Below harmful levels for more than 1,000 years in a dry environmental setting; potential chemical effects on aquatic biota before 1,000 years after failure in a wet setting; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Not applicable	Site-dependent; avoid or mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 30%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	**Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste **Long-term storage:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required); potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste **Manufacturing:** Negligible impacts with respect to current regional or nationwide waste generation	**Conversion:** Same as LTSO **Disposal:** Negligible to low impacts with respect to both current and projected nationwide waste generation

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Resource Requirements[n]			
All Sites	No effects on local, regional, or national availability of materials are expected	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation dependent on site location	Same as $LTSUF_6$	Same as NAA	Same as NAA	Same as $LTSUF_6$
			Land Use[m]			
Current Storage Sites	Up to 7 acres; less than 1% of available land; negligible impacts	Up to 28 acres; less than 1% of available land; negligible impacts	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$
Other Facilities[i]	Not applicable	**Long-term storage:** 110–170 acres; potential moderate impacts	**Conversion:** 30–40 acres; negligible impacts **Long-term storage:** 80–260 acres; potential moderate to large impacts	**Conversion:** 30–40 acres; negligible impacts **Manufacturing:** 90 acres; potential moderate impacts	**Conversion:** 30–35 acres; negligible impacts **Manufacturing:** 90 acres; potential moderate impacts	**Conversion:** 30–40 acres; negligible impacts **Disposal:** 40–590 acres; potential moderate to large impacts
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as NAA	Same as NAA	Same as NAA	Same as NAA	Same as NAA
Other Facilities[i]	Not applicable	Impacts dependent on location; avoid and mitigate	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

TABLE S.2 (Cont.)

Environmental Consequence	No Action Alternative (Continued Storage as UF_6)	Long-Term Storage as UF_6	Long-Term Storage as Uranium Oxide	Use as Uranium Oxide	Use as Uranium Metal	Disposal as Uranium Oxide
			Environmental Justice			
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$	Same as $LTSUF_6$

[a] Includes both DOE- and USEC-generated cylinders.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] LTSO = long-term storage as oxide alternative; $LTSUF_6$ = long-term storage as UF_6 alternative; NAA = no action alternative.

[d] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[e] Accidents with probabilities of occurrence greater than 0.01 per year.

[f] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[g] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

[h] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[i] Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

[j] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g (EPA 1995a).

Footnotes continue on next page

TABLE S.2 (Cont.)

Footnotes (Cont.)

[k] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[l] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages except for continued storage, which is reported for the peak year of operation.

[m] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[n] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

Although design criteria are such that disposal facilities would not be expected to fail (i.e., release material to the environment) until several hundred years after closure, for purposes of analysis, it was assumed that these facilities would fail 100 years after closure. For the disposal as oxide alternative, if the disposal facility was located in a "wet" environment (typical of the eastern United States), the estimated dose from the use of groundwater at 1,000 years after the assumed failure of the facility would be about 100 mrem/yr, which would exceed the regulatory dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A for the disposal of LLW. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices would range up to 10, indicating the potential for chemically induced adverse effects from the possible use of contaminated groundwater. The groundwater analysis indicated that if disposal was in a dry environmental setting (typical of the western United States), no measurable groundwater contamination would occur at 1,000 years after failure of the disposal facility, because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.

S.4.2 Human Health and Safety — Facility Accidents

S.4.2.1 Physical Hazards

Under all alternatives, workers (including both involved and noninvolved) could be injured or killed from on-the-job accidents unrelated to radiation or chemical exposure. On the basis of accident statistics for similar industries, under the no action alternative, it was estimated that zero fatalities and about 180 injuries might occur over the period 1999 through 2039. Under all other alternatives, it was estimated that from one to three fatalities and from 310 to 2,700 injuries might occur over the same period. Accidental injuries and deaths are not unusual in industries that use heavy equipment to manipulate heavy objects and bulk materials. The differences among the alternatives reflect differences in the total number of work hours that would be required.

S.4.2.2 Facility Accidents Involving Releases of Radiation or Chemicals

Under all alternatives, accidents are possible that could release radiation or chemicals to the environment, potentially causing adverse health effects among workers and members of the public. Of all the accidents considered, those involving depleted UF_6 cylinders and those involving chemicals at a conversion facility were estimated to have the largest potential adverse effects.

Under all alternatives, accidents involving UF_6 cylinders could occur at the current storage sites because continued storage of cylinders is a component of all of the alternatives. In addition, cylinder accidents could occur at a consolidated long-term storage facility and at a conversion facility. Cylinder accidents could release UF_6 to the environment. If a release occurred, the UF_6 would combine with moisture in the air, forming gaseous HF and UO_2F_2, a soluble solid in the form of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public to radiation and chemical effects. The amount released would depend on the severity of the accident and the number of cylinders involved. The potential consequences of cylinder accidents are presented in Table S.2 for (1) accidents that might happen at least once in 100 years (considered "likely" accidents; assumed frequency of once in 10 years for probability calculations) and (2) accidents that might happen much less frequently, from once in 10,000 to less than once in 1 million years (assumed frequency of once in 100,000 years for probability calculations).

For releases involving UF_6 and other uranium compounds, both chemical and radiological adverse effects could occur if the material was ingested or inhaled. The chemical effect of most concern associated with internal uranium exposure is kidney damage, and the radiological effect of concern is an increase in the probability of developing cancer. For uranium, chemical effects (kidney damage) occur at lower exposure levels than radiological effects. Exposure to HF from accidental releases could result in a range of health effects, from eye and respiratory irritation to death, depending on the exposure level.

Chemical and radiological exposures for involved workers (those within 100 m of the release) under accident conditions would depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical forces causing or caused by the accident, meteorological conditions, and characteristics of the room or building if the accident occurred indoors. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so that quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this PEIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident did occur.

For accidents involving cylinders that might happen at least once in 100 years ("likely" accidents), the off-site concentrations of HF and uranium were estimated to be considerably below levels that would cause adverse chemical effects among members of the general public from exposure to these chemicals. However, up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that three noninvolved workers might experience potential irreversible adverse effects that are permanent in nature (such as lung damage or kidney damage), with no fatalities among these workers expected. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or members of the general public for these types of accidents.

Cylinder accidents that are less likely to occur could be more severe, having greater consequences that could potentially affect off-site members of the general public. These types of accidents are considered extremely unlikely, expected to occur with a frequency of between once in 10,000 and once in 1 million per year of operations. Over the period 1999 through 2039, the probability of this type of accident would be about 1 chance in 2,500. Among all the accidents analyzed, the accident resulting in the largest number of people with adverse effects (including mild and temporary, as well as permanent effects) was a vehicle-induced fire involving three cylinders. If this type of accident occurred, it was estimated that up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse chemical effects from HF and uranium exposure (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). More adverse effects are estimated among the general public than among noninvolved workers because of buoyancy effects of the fire on contaminant plume spread (that is, concentrations that occur are higher at points distant from the release than at closer locations).

The modeled accident resulting in the largest number of persons with irreversible adverse health effects was a corroded cylinder spill under wet conditions. If this accident occurred, it was estimated that 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage). No fatalities would be expected among the public; there would be a potential for three fatalities among noninvolved workers from chemical effects. Radiation exposures were estimated to result in no additional cancer fatalities among noninvolved workers or the general public.

The number of persons actually experiencing adverse or irreversible adverse effects from cylinder accidents would likely be considerably fewer than those estimated for this analysis and would depend on the actual circumstances of the accident and the individual chemical sensitivities of the affected persons. For example, although exposures to releases from cylinder accidents could be life-threatening (especially with respect to immediate effects from HF inhalation), the guideline exposure level of 20 parts per million (ppm) of HF used to estimate the potential for irreversible adverse effects from HF exposure is likely to result in overestimates. This is because no deaths have been known to occur as a result of acute exposures (i.e., 1 hour or less) of animals or humans at concentrations of less than 50 ppm, and generally, if death does not occur quickly after HF exposure, recovery is complete.

Similarly, the guideline intake level of 30 mg used to estimate the potential for irreversible adverse effects from the intake of uranium in this PEIS is that suggested in guidance given by the U.S. Nuclear Regulatory Commission (NRC). This level is somewhat conservative; that is, it is intended to overestimate rather than underestimate the potential number of irreversible adverse effects in the exposed population following uranium exposure. In over 40 years of cylinder handling activities, no accidents involving releases from cylinders containing *solid* UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers. In previous accidental exposure incidents involving *liquid* UF_6 in gaseous diffusion plants, some worker fatalities occurred immediately following the accident as a result of inhalation of HF generated from the UF_6. However, no fatalities occurred as a result of the toxicity of the uranium exposure. A few workers were exposed to estimated amounts of uranium approximately three times the guideline level (30 mg) used for assessing irreversible adverse effects, but none of these workers actually experienced such effects.

For all of the management strategies considered in the PEIS, low-probability accidents involving chemicals at a conversion facility were estimated to have the largest potential consequences to noninvolved workers and members of the public. Conversion would be required for long-term storage as oxide, use as oxide, use as metal, and disposal. At a conversion site, accidents involving releases of chemicals, such as ammonia and HF, are possible. Ammonia is used for some conversion options, and HF can be produced as a by-product of converting UF_6 to either uranium oxide or uranium metal. The primary impacts from conversion accidents are related to potential chemical exposures to the released material.

The conversion accidents estimated to have the largest potential consequences were accidents involving the rupture of tanks containing either anhydrous HF or ammonia. Such accidents could be caused by a large earthquake and are expected to occur with a frequency of less than once in 1 million per year of operations. The probability of these types of accidents occurring during the operation of a conversion facility would be about 1 chance in 50,000. If such accidents occurred, it was estimated that up to 41,000 members of the general public around the conversion facility and 1,100 noninvolved workers might experience adverse effects from chemical exposures (mostly mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function). Of these, up to 1,700 members of the general public and 440 noninvolved workers might experience irreversible adverse effects (such as lung damage or kidney damage), with the potential for about 30 fatalities among the public and 4 fatalities among noninvolved workers. In addition, irreversible or fatal effects among involved workers very near the accident scene are possible.

These high consequence accidents are expected to be extremely rare. The risk (defined as consequence multiplied by probability) for these accidents would be zero fatalities and zero irreversible adverse health effects expected for noninvolved workers and the members of the public combined, and one adverse health effect expected for the general public. Ammonia and anhydrous HF are commonly used chemicals for industrial applications in the United States. Industrial accident prevention and mitigative measures are well established for HF and ammonia storage tanks. These include storage tank siting principles, design recommendations, spill detection, and containment measures. These measures would be implemented, as appropriate, if conversion were required by the selected alternative.

S.4.3 Human Health and Safety — Transportation

A conservative estimate of transportation impacts was provided by assuming that continued cylinder storage, conversion, consolidated long-term storage, manufacture and use, and disposal facilities would be located at separate sites, requiring transportation of materials between these sites. The actual transportation requirements would depend on the management strategy selected in the Record of Decision and the ultimate locations of any required facilities.

Under the no action alternative, only small amounts of LLW and LLMW generated during cylinder maintenance activities would require transportation, with only negligible impacts expected. The major materials assumed to require transportation for the other alternatives are summarized in Table S.2. Most materials could be shipped by either truck or rail. For purposes of comparison among the alternatives, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. (Transportation impacts are evaluated for a range of shipment distances in Appendix J of the PEIS). Most shipments were assumed to occur over a 26-year period, from 2009 through 2034. Impacts from transportation activities could be reduced if several facilities were located at the same site.

During normal transportation operations, radioactive material and chemicals would be contained within their transport packages. Potential health impacts to crew members (i.e., workers) and members of the general public along the route could occur if there were exposure to low-level external radiation in the vicinity of shipments of uranium materials. In addition, exposure to vehicle engine exhaust emissions could potentially cause adverse health effects from inhalation. Under all alternatives other than the no action and long-term storage as UF_6 alternatives, it was conservatively estimated that no more than one fatality would occur from these causes. Under all alternatives, members of the general public living along truck and rail transportation routes would receive extremely small doses of radiation from shipments, less than 0.1 mrem over 40 years. This would be true even if a single person were to be exposed to every shipment of radioactive material during the program.

Under all alternatives, traffic accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public either from the actual accident or from accidental releases of radioactive materials or chemicals.

Under each alternative, the total number of traffic fatalities (unrelated to the type of cargo) was estimated on the basis of national traffic statistics for shipments by both truck and rail modes. If it was assumed that shipments were predominantly by truck, it was estimated that from two to four traffic accident fatalities could occur over the duration of the program. If shipments were predominantly by rail, it was estimated that one to three traffic accident fatalities could possibly occur. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

Severe transportation accidents could also result in a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how quickly the released material dispersed and diluted to lower concentrations as it moved downwind.

All alternatives other than the no action alternative could involve the transportation of UF_6 cylinders between sites. For cylinder shipments, among all the accidents analyzed, a severe rail accident involving four cylinders was estimated to have the highest potential consequences. The consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 for shipping all cylinders by rail (the actual probability would depend on the route selected). In the unlikely event that such an accident were to occur, it was estimated that approximately four persons might experience irreversible adverse effects (such as lung damage or kidney damage) from chemical exposure to HF and uranyl fluoride generated from released UF_6, with zero fatalities expected. Over the long term, radiation effects would also be possible from exposure to the uranium released. It was estimated that approximately 60 cancer fatalities could occur in the urban population from such an accident in addition to the approximately 700,000 that would occur from all other causes (approximately 3 million persons were assumed to be exposed to low levels of uranium from the accident as the uranium dispersed in the air). The radiological risk (consequence multiplied by probability) for this accident would be zero expected LCFs.

For all other materials assumed to be transported in this PEIS, the highest potential accident consequences would be caused by a rail accident involving anhydrous HF that might be produced during conversion. Conversion would be required for the long-term storage as oxide, use as oxide, use as metal, and disposal alternatives. Although anhydrous HF is a highly corrosive and hazardous gas, it has many industrial applications and is commonly safely transported by industry as a liquid in trucks and rail tank cars. Anhydrous HF could be produced during conversion and could potentially be transported to a user. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site could potentially experience irreversible adverse effects from chemical exposure to HF. However, the probability of such an accident occurring if all the anhydrous HF produced was transported 620 miles (1,000 km) was estimated to be only about 1 chance in 30,000. Anhydrous HF is routinely shipped commercially in the United States for industrial applications. To provide perspective, since 1971, the period covered by U.S. Department of Transportation records, there have been no fatal or serious injuries to the public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars have been reported that had no associated evacuations or injuries. The only major release (estimated at 6,400 lb of anhydrous HF) occurred in 1985 and resulted in approximately 100 minor injuries. Another minor HF release during transportation occurred in 1990. The improved safety record of transporting anhydrous HF in the past 10 years can be attributed to several practices. Such practices include installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center.

Nonetheless, if the unlikely rail accident described above (i.e., release of HF from a railcar in a densely populated urban area under stable weather conditions) were to occur, it was estimated that up to 30,000 persons might experience irreversible adverse effects (such as lung damage), with the potential for about 300 fatalities. If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, including one expected fatality. The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF accident would be much less under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and lower downwind concentrations. Under unstable conditions, an area of about 1 mi^2 (2 km^2) could be affected by an accident. If such an accident occurred in an urban area, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, with the potential for about 30 fatalities. If the accident occurred in a rural area under unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with zero fatalities expected. When considering the probability of an HF accident occurring, one person would be expected to experience irreversible adverse effects, and no fatalities would be expected over the shipment period.

S.4.4 Air Quality

For management of both DOE- and USEC-generated cylinders, air quality from construction and facility operations for all alternatives would be within existing regulatory standards and guidelines. All construction activities planned to support continued cylinder storage (e.g., constructing new storage yards) would be required within the first 10 years of continued storage, when all cylinders would still be in storage under each alternative. Therefore, air quality impacts from construction activities at the current storage sites would be the same across the alternatives. Estimated concentrations of particulate matter (dust) that could be generated during construction activities are close to the regulatory standard levels; these temporary emissions could be controlled by good construction practices.

If it is assumed that cylinder maintenance and painting activities would not reduce cylinder corrosion rates, it is possible that cylinder breaches could result in HF air concentrations greater than the regulatory standard level at the K-25 storage site around the year 2020; HF concentrations at the Paducah and Portsmouth sites were estimated to remain within applicable standards or guidelines. However, if continued cylinder maintenance and painting were effective in controlling corrosion, as expected, air concentrations of HF would be kept within regulatory standards at all storage sites.

S.4.5 Water and Soil

For operations under all alternatives, uranium concentrations in surface water, groundwater, and soil at the three current storage sites would remain below guidelines throughout the project duration (when the EPA proposed maximum contaminant level [MCL] of 20 µg/L for drinking water is used as a guideline for water and the EPA health-based residential soil guideline of 230 µg/g is used as a guideline for soil). Under the no action alternative, if cylinder maintenance and painting would not reduce cylinder corrosion rates, it is possible that the uranium groundwater concentration could be greater than the 20 µg/L guideline at all three sites at some time in the future (earliest about the year 2100 at the Paducah site). However, if continued cylinder maintenance and painting are effective in controlling corrosion, as expected, groundwater uranium concentrations would remain less than 20 µg/L. For all other alternatives, groundwater concentrations would remain less than 20 µg/L, even without continued cylinder maintenance and painting, because the cylinders would begin to be removed around the year 2009.

Under the disposal alternative, if a disposal facility in a dry environmental setting were to fail, groundwater impacts would be unlikely for at least 1,000 years. (No measurable groundwater contamination would have occurred because of the small amount of rainfall and large distance to the groundwater table typical of a dry environment.) For a disposal facility in a wet environmental setting, the uranium concentration in groundwater beneath the facility might be greater than 20 µg/L within 1,000 years after failure of the facility. It should be noted, however, that the disposal calculations are subject to a great deal of uncertainty, and results would depend greatly on the specific disposal facility design and site-specific factors, such as soil characteristics, water infiltration rates, depth to groundwater, and the chemical characteristics of uranium and the soil beneath the disposal facility. Such factors would be considered during site selection, facility design, performance assessment, and licensing activities if disposal were part of the management strategy selected. If disposal was implemented in the future, all disposal activities would take place in accordance with applicable rules and regulations for disposal of LLW.

Under all alternatives, construction activities have the potential to result in surface water, groundwater, or soil contamination through spills of construction chemicals. By following good engineering practices, concentrations in soil and wastewater (and therefore surface water and groundwater) could be kept well within applicable standards or guidelines.

Under the long-term storage as UF_6, long-term storage as oxide, and disposal as oxide alternatives, from 100,000 yd^3 to 3.6 million yd^3 (76,000 to 2.8 million m^3) of soil and rock could require excavation and surface disposal, depending on whether yards, buildings, shallow earthen structures, vaults, or a mine was selected. The excavated material could result in changes to topography at the facilities; these changes could be mitigated, if necessary, through trucking the excavated material off-site and/or by contouring and reseeding the site. Mine storage and disposal would generally result in the largest excavation volumes. If mine storage or disposal were selected as a UF_6 management strategy, excavation volumes could also be reduced through use of a previously existing mine.

S.4.6 Socioeconomics

Socioeconomic impacts are evaluated in terms of jobs and income generated, which are considered positive impacts. The no action alternative would result in the smallest positive socioeconomic impacts of the alternatives considered, creating about 140 direct jobs and generating about $6 million in direct income per operational year. The long-term storage as UF_6 alternative would have the second smallest socioeconomic impacts because conversion would not be required; this alternative would create about 610 to 1,200 direct jobs and generate about $35 to $65 million in direct income per year. The other alternatives (long-term storage as oxide, use as oxide, use as metal, and disposal as oxide) would have similar socioeconomic impacts, creating about 970 to 1,600, 1,250 to 1,600, 1,260 to 1,600, and 900 to 2,100 direct jobs per year, respectively, and generating about $55 to $85 million, $79 to $93 million, $79 to $93 million, and $55 to $120 million in direct income per year, respectively. Under the storage and disposal alternatives, the upper ends of the ranges of jobs created and income generated correspond to options requiring mine excavation. The process of manufacturing under the use as oxide and use as metal alternatives is labor-intensive and makes the socioeconomic impacts under these two alternatives similar to those under the long-term storage and disposal alternatives.

Continued cylinder storage under all alternatives would result in negligible impacts on regional growth and housing near the three current storage sites. Such impacts would be site dependent, but would be minor for conversion and long-term storage on the basis of the analysis for representative sites.

S.4.7 Ecology

Habitat loss at the current storage sites for all alternatives would range from 0 to 7 acres (2.8 ha) for the no action alternative to 0 to 28 acres (11 ha) or less for all other alternatives, depending on whether cylinder transfer facilities at the three sites were selected as the cylinder preparation option. These habitat losses would constitute less than 1% of available land at the current sites and would have negligible impacts on biota.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 110 to 170 acres (44 to 68 ha) for long-term storage as depleted UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 40 to 590 acres (16 to 240 ha) for disposal. The large ranges in estimated land requirements result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. The consequences of habitat loss would be site dependent in terms of adverse impacts to threatened and endangered species and wetlands, and they would be evaluated in subsequent site-specific NEPA reviews. As a general guideline, potential moderate adverse impacts to vegetation and wildlife from habitat loss were assumed if the required land area was greater than 10 acres, and potentially large adverse impacts were assumed if the required land area was greater than 100 acres.

If a disposal facility in a wet environmental setting were to fail, the uranium concentration in groundwater beneath the facility might exceed the guideline value of 20 µg/L within 1,000 years after failure. If the groundwater discharged to nearby surface waters, aquatic biota might be exposed to elevated concentrations of uranium, possibly resulting in adverse chemical effects; however, no adverse radiological effects would occur at the concentrations estimated.

S.4.8 Waste Management

During continued storage at the current sites under all alternatives, LLMW would be generated from cylinder scraping and painting activities. The amount of LLMW generated from these activities could result in moderate impacts to waste management at the Paducah site (annual volumes could be about 30% of the current site annual LLMW generation volume of 100 m^3/yr); however, the amount is less than 1% of the current estimated annual LLMW treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr) and would have a negligible to low impact on DOE's waste management system as a whole.

The alternatives requiring conversion to oxide are long-term storage as oxide, use as oxide, and disposal as oxide. Depending on the conversion option selected, anhydrous HF or CaF_2 could be produced. Industrial experience indicates that anhydrous HF, if produced, would contain only trace amounts of depleted uranium (less than 1 part per million [ppm]). Because of the considerable market for HF (it is commonly used for many industrial applications, including the production of UF_6 from natural uranium ore), it was assumed that if anhydrous HF was produced, it would be sold for use. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use.

If an option involving CaF_2 production was selected, it is currently unknown whether CaF_2 generated in the conversion to oxide processes could be sold, whether the low uranium content would allow disposal as nonhazardous solid waste, or whether disposal as LLW would be required. The low level of uranium contamination expected (i.e., less than 1 ppm) suggests that sale or disposal as nonhazardous solid waste would be most likely. If sold for use, the use would be subject to review and approval by DOE or NRC, depending on the specific use. Waste management for disposal as nonhazardous waste could be handled through appropriate planning and design of the facilities. If the CaF_2 was considered to be LLW, the largest CaF_2 generation volumes (about 550,000 m^3 over the 26-year period for the conversion to oxide with neutralization of HF option) would represent about 13% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e., 4.25 million m^3) and could result in moderate impacts on waste management (if the LLW was considered to be DOE waste).

Under alternatives requiring conversion to either oxide or metal, the empty cylinders would be treated to remove the heels material and crushed. It is assumed that the treated, crushed cylinders would become part of the DOE scrap metal inventory. If a decision to dispose of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 4% addition to the projected DOE complexwide LLW disposal volume. This would constitute a low impact on DOE's waste management system as a whole.

Under the use as metal alternative, magnesium fluoride (MgF_2) would also be produced during conversion. It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonhazardous solid waste. (It is estimated that the MgF_2 would contain uranium at a concentration of about 90 ppm.) If the MgF_2 was considered to be DOE LLW, the volume generated would represent about 8% of the projected DOE complexwide LLW disposal volume, a low to moderate impact on DOE's waste management system as a whole. Under the metal conversion option, if the HF was neutralized and the CaF_2 generated was considered to be DOE LLW, the CaF_2 would represent approximately an additional 4% of the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact on DOE's waste management system.

The LLW volumes requiring disposal under the disposal as oxide alternative represent an addition of about 3 to 10% to the projected DOE complexwide LLW disposal volume, constituting a low to moderate impact for DOE's waste management system. The waste management impacts for all alternatives requiring conversion of UF_6 would be similar, having the potential for a moderate impact on DOE's LLW management system.

S.4.9 Resource Requirements

Resource requirements include construction materials, fuel, electricity, process chemicals, and containers. In general, all of the alternatives would have a negligible effect on the local or national availability of these resources (when both DOE- and USEC-generated cylinders are considered). However, under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during mine construction (up to 1,400 MW-yr). The availability of this electricity would depend on site location, and use of a previously existing mine would substantially decrease the electrical requirements. Also, the disposal alternative would result in permanent disposition of the depleted uranium, a material that DOE considers to be a valuable national resource. Disposal would constitute an irreversible and irretrievable commitment of this resource to a nonproductive purpose.

S.4.10 Land Use

For current sites, continued storage and cylinder preparation could require up to 28 acres (11 ha) of land for new or reconstructed cylinder yards and transfer facilities, if built. This acreage constitutes less than 1% of available land at the three sites. Furthermore, it is likely that previously developed land could be used for these needs.

New facilities would disturb from 30 to 40 acres (12 to 16 ha) for conversion, 110 to 170 acres (44 to 68 ha) for long-term storage as depleted UF_6, 80 to 260 acres (32 to 100 ha) for long-term storage as oxide, 90 acres (36 ha) for manufacturing, and 40 to 590 acres (16 to 240 ha) for disposal. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres around the conversion facilities. The large ranges in the estimated land required result from the various options that could be selected; options involving disposal in a mine could require the largest amounts of land. Potential land-use impacts would depend on where the facilities were sited. As a general guideline, potentially moderate land use impacts were assumed if the required land area was greater than 50 acres, and potentially large land use impacts were assumed if the required land area was greater than 200 acres.

S.4.11 Cultural Resources

Impacts to cultural resources at the current storage sites would be unlikely. Potential for impacts at new sites would depend entirely on their locations. Such impacts would be minimized through surveys conducted prior to construction activities and through consultation with state historic preservation officers.

S.4.12 Environmental Justice

No disproportionately high or adverse human health or environmental impacts would be expected to minority or low-income populations during normal facility operations for any of the alternatives (when both DOE and USEC-generated cylinders are considered). Although the consequences of facility accidents could be high if severe accidents occurred, the risk of irreversible adverse effects (including fatalities) among members of the general public from these accidents (taking into account the consequences and probability of the accidents) would be less than one. Furthermore, transportation accidents with high and adverse impacts are unlikely, their locations have not been projected, and the types of persons who would be involved cannot be reliably predicted; therefore, there is no reason to expect that minority and low-income populations would be affected disproportionately by high and adverse impacts.

S.4.13 Cumulative Impacts

The continued cylinder storage and cylinder preparation components of the depleted UF_6 management alternatives would result in environmental impacts that, even when combined with other activities that could occur at the three current storage sites, would be expected to be relatively minor. The estimated cumulative doses to members of the general public at all three sites would be below levels expected to result in a single cancer fatality over the life of the project, and the annual dose to the off-site maximally exposed individual would be considerably below the EPA maximum standard of 10 mrem/yr from the air pathway. The cumulative collective dose to workers at the three sites would result in one to three additional cancer fatalities over the duration of the program. Cumulative demands for water, wastewater treatment, and power would be well within existing capacities at all three sites. Relatively small amounts of additional land would be needed for depleted UF_6 management at the three current storage sites. If continued cylinder maintenance and painting were effective in reducing corrosion rates, as expected, groundwater concentrations would remain below the 20-µg/L guideline level at all three sites. If continued maintenance and painting of the cylinders were not able to reduce corrosion rates, the uranium concentration in groundwater could exceed 20 µg/L at some time in the future at all three sites. In addition, if continued cylinder maintenance and painting were to be ineffective, the concentration of HF in air could exceed the regulatory standard at the K-25 site around the year 2020; HF air concentrations at the Paducah and Portsmouth sites would be expected to remain within applicable standards and guidelines.

The cumulative impacts of conversion, long-term storage, and disposal activities could not be determined because specific sites and technologies have not been designated for these options. Further analyses of cumulative impacts would be performed as required by NEPA and DOE regulations for any technology or siting proposals that would involve these facilities.

S.5 DOE'S PREFERRED ALTERNATIVE

S.5.1 Description

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The preferred alternative would allow beneficial use of the material with regard to environmental, economic, technical, and other factors.

DOE's preferred alternative consists of the following elements: continuing the safe, effective management of the cylinders; beginning the prompt conversion of the depleted UF_6 into depleted uranium oxide and HF or CaF_2; storing depleted uranium oxide; converting depleted UF_6 into depleted uranium metal and HF or CaF_2 as uses for depleted uranium metal products become available; and/or fabricating depleted uranium oxide and metal products for use. Conversion to oxide or metal would generate fluorine or fluorine compounds such as HF, which would also have beneficial uses. This preferred alternative provides the flexibility to respond to changing market conditions and to the continued development of new uses for the conversion products. During the time that the depleted UF_6 inventory is being converted for long-term storage and product applications, some depleted UF_6 would also be available for other uses that might develop.

Potential uses for fluorine products exist now in the aluminum, chemical, steel, and glass industries. Large-scale uses for the depleted uranium products are under development. These uses include radiation-shielding applications, in which uranium oxide is used as a substitute for the aggregate in concrete. Concrete made with depleted uranium would be a more effective shielding material than conventional concrete and would provide the same level of radiation shielding with less thickness than conventional concrete. Among other uses, this concrete could be fabricated into casks for storage of spent nuclear fuel or HLW.

In addition to the above potential large-scale uses of the depleted UF_6, small-scale use of some depleted UF_6 is being considered in industrial applications and by other DOE program decisions and NEPA analyses, such as that for the disposition of surplus plutonium. At this time, uses being considered by other DOE programs generally involve only a small fraction of the depleted UF_6 inventory currently in storage and would not affect the selection of a long-term management strategy in the Record of Decision to be issued following the publication of this PEIS.

DOE issued a Request for Expressions of Interest for a Depleted Uranium Hexafluoride Integrated Solution Conversion Contract and Near-Term Demonstrations on March 4, 1999. (This is referred to on page 13 of the March 8 issue of the *Commerce Business Daily* published by the U.S. Department of Commerce.) Responses to this request will provide DOE with information to develop a detailed procurement strategy for an integrated approach to the management of DOE's depleted UF_6 inventory. A final plan, incorporating information from the private sector and other stakeholders, is expected to be issued later in 1999.

The locations for conversion and fabrication facilities, the start-up date for conversion, the rate of conversion, and the chemical form of depleted uranium and fluorine products would be subject to follow-on (tiered) NEPA analyses and availability of any necessary federal funding. Conversion of the depleted UF_6 to uranium oxide under the preferred alternative would begin as early as practicable. DOE expects that in the future, uses will be available for some portion of the converted material. The value of depleted uranium and HF or CaF_2 for use is based on their unique qualities, the size of the inventory, and the history of uses already implemented (e.g., industrial applications for fluorine compounds). DOE plans to continue its support for the development of government applications for depleted uranium products and, for as long as is necessary, to continue the safe management of its depleted uranium inventory.

Current practices for managing the depleted UF_6 cylinder inventory include visual inspections, ultrasonic testing of cylinder wall thickness, radiological surveys, and surveillance and maintenance of the cylinders and cylinder yards. Under the preferred alternative, these practices would continue or be modified, as necessary, to meet any changing requirements for protection of worker and public health and safety and of the environment. Safe management of the cylinder inventory would continue through conversion of 100% of the inventory for use or storage. Aggressive cylinder management will ensure that continued storage of the depleted UF_6 cylinders prior to conversion will be consistent with DOE's policy of safe, effective material management.

S.5.2 Impacts of the Preferred Alternative

DOE's preferred alternative is to begin conversion of the UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. Conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. Most of the inventory would likely require interim storage as depleted uranium oxide pending use. The impacts of the 100% use as oxide alternative, 100% use as metal alternative, and 100% long-term storage as oxide alternative are described in detail in Sections 5.3, 5.4, and 5.5 of the PEIS for the DOE-generated cylinders. The impacts of adding the USEC cylinders under these alternatives are described in Sections 6.3.3, 6.3.4, and 6.3.5 of the PEIS. The impacts of these three alternatives may be considered representative for the preferred alternative. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide was also analyzed. The potential impacts of this combination strategy are discussed in detail in Section 5.7 and Section 6.3.7 of the PEIS. A tabular summary of the potential impacts of this combination strategy that is representative of the preferred alternative is shown in Table S.3.

For the four alternative management strategies considered representative of the preferred alternative (100% use as oxide; 100% use as metal; 100% long-term storage as oxide; and combination 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide), potential environmental impacts for many technical areas are very similar (Tables S.2 and S.3). With respect to human health and safety impacts of normal facility operations, the strategies have similar impacts; that is, radiological and chemical exposures for the general public and workers would remain well within regulatory limits and public health standards under all four strategies. Also, the maximum-consequence accidents would be similar under all four strategies. Impacts to air quality, water and soil quality, and waste management would also be similar for the four management strategies representative of the preferred alternative.

Potential differences in impacts arise under the 25% use as oxide, 25% use as metal, 50% long-term storage as oxide combination strategy because of increased requirements for workforce, acreage, and construction and operational materials associated with the potential need for two conversion facilities, two manufacturing facilities, two cylinder treatment facilities, and a long-term storage facility. The resources required for these facilities are nonlinear with throughput; that is, the resources required to build and operate a 25%-capacity or a 50%-capacity facility are more than one-quarter or one-half the resources required to build and operate one 100%-capacity facility. This situation results in some increased impacts for the combination strategy. For example, the estimated number of worker fatalities and injuries for construction and operation under the combination strategy (4 to 5 fatalities; 2,900 to 4,100 injuries) is about 1.5 times that estimated for the 100% use as oxide and 100% use as metal strategies, separately. Similarly, required jobs and income produced under the combination strategy are greater than they are under the 100% use strategies. If the combination strategy resulted in construction of separate conversion, manufacturing, cylinder

TABLE S.3 Summary of Potential Environmental Consequences of a Combination Management Strategy Representative of the Preferred Alternative[a]

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Normal Facility Operations[b]	
Radiation Exposure	
Involved Workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	2 to 3 additional LCFs
Noninvolved Workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General Public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[c]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[b]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	4–5 fatalities; 2,900–4,100 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[d]	
Accident[e]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	4 potential accidents

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[f]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[g]	
Accident[e]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – Noninvolved workers[f]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)	
Radiation exposure – Noninvolved workers[f]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[g]	
Chemical accident[e]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[f]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident[e]	Earthquake damage to storage building at conversion site
Release	Uranium (U_3O_8)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Facility Accidents[b] (Cont.)	
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	270 mrem
Risk of LCF	1 in 10,000
Total dose to population	20 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[f]	
Dose to MEI	9,000 mrem
Risk of LCF	1 in 250
Total dose to workers	840 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[b]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations	
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)	
Maximum use of trucks	5 fatalities
Maximum use of rail	2 fatalities

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Human Health and Safety — Transportation[b] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequency-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[h]	

Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Water and Soil [i]	
Current Storage Sites	
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[j]	No change
Other Facilities[h]	
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[j]	Site-dependent; none to moderate impacts
Excavation of soil for long-term storage	Change in topography from 51,000 yd^3 to 1.3 million yd^3 of excavated material
Socioeconomics [k]	
Current Storage Sites	
Continued storage	**Jobs:** 38 peak year, construction; 150 per year over 26 years of operation **Income:** $1.8 million peak year, construction; $7 million per year over 26 years of operation
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 26 years of operation **Income:** $0–26 million peak year, preoperations; $19–25 million per year over 26 years of operation
Other Facilities[h]	
Conversion	**Jobs:** 670–960 peak year, construction; 510–720 per year over 26 years of operation **Income:** $28–41 million peak year, construction; $30–41 million per year over 26 years of operation

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Socioeconomics*[k] *(Cont.)	
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 26 years of operation **Income:** $13 million peak year, construction; $30 million per year over 26 years of operation
Long-term storage	**Jobs:** 60-210 peak year, construction; 39–46 per year over 30 years of operation **Income:** $3–10 million peak year, construction; $3–4 million per year over 30 years of operation
Ecology	
Current Storage Sites	
Habitat loss[l]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[h]	
Habitat loss[l]	**Conversion:** Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 79 acres at a single site; total of 160 acres; potential moderate impacts to vegetation and wildlife **Long-term storage:** About 61 acres; potential moderate impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
	Waste Management
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (increase of about 30%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation
Other Facilities[h]	
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
Long-term storage	Negligible impacts with respect to current regional or nationwide waste generation
	Resource Requirements[m]
All Sites	No effects on local, regional, or national availability of materials are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[h]	
Conversion	Up to 30 acres at a single site; total of up to 50 acres; potential moderate impacts
Manufacturing	Up to 79 acres at a single site; total of 160 acres; potential moderate impacts
Long-term storage	About 61 acres; potential moderate impacts
	Cultural Resources
Current Storage Sites	Impacts unlikely

Other Facilities[h]	Impacts depend on location; avoid and mitigate

TABLE S.3 (Cont.)

Environmental Consequence	Combination Strategy: 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage as Oxide
Environmental Justice	
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely

[a] Includes both DOE- and USEC-generated cylinders.

[b] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

[c] Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[d] Accidents with probabilities of occurrence greater than 0.01 per year.

[e] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[f] In addition to noninvolved worker impacts, involved worker injuries and fatalities are possible from chemical, radiological, and/or physical forces of accidents. Chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[g] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[h] Other facilities are facilities for conversion, manufacturing, and storage.

[i] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water "at the tap" of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

[j] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[k] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages except for continued storage, which is reported for the peak year of operations.

[l] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing about 960 acres around the facility.

[m] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 µm or less; UF_6 = uranium hexafluoride.

treatment, and long-term storage facilities, total land use requirements could almost double, also resulting in an increased potential for adverse ecological impacts.

For the purposes of analysis of the combination strategy, it was assumed that independent conversion, manufacturing, and storage facilities would be constructed. However, in practice, such facilities may be located together, which would reduce the resource needs of the combination strategy.

S.6 SUMMARY OF ISSUES RELATED TO LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the PEIS. The potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready to be decided upon at this time. Issues related to the potential life-cycle impacts associated with depleted uranium management are summarized here.

The management of depleted uranium beyond the year 2039 would depend on the management strategy in place at that time. If depleted uranium was in long-term storage in 2039, the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and then used or disposed of. Continued storage may require refurbishment or replacement of facilities and containers as their design lifetimes are exceeded.

Depleted uranium might also require management after use, depending on the type of product and nature of the use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or treated and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time. Disposal after use may also require further treatment or processing, such as conversion to a suitable chemical form. Some uses might also result indirectly in the permanent disposal of the material. For example, it is possible that casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or high-level radioactive waste in a geologic repository.