Summary

S.1 PURPOSE AND NEED FOR AGENCY ACTION

Under the authority of the Atomic Energy Act of 1954, as amended, the U.S. Department of Energy (DOE) is responsible for ensuring the availability of isotopes for medical, industrial and research applications, meeting the nuclear material needs of other Federal agencies, and undertaking research and development activities related to development of nuclear power for civilian use.

To meet these responsibilities, DOE maintains nuclear infrastructure capabilities that support various missions in areas such as nuclear materials production and testing, research, and development activities related to civilian applications of nuclear power. These infrastructure capabilities include research and test facilities such as research reactors and accelerators used for steady-state neutron irradiation of materials to produce radionuclides, as well as shielded "hot cell" and glovebox facilities used to prepare materials for testing and/or to handle postirradiation materials. An additional component of this infrastructure is the highly trained workforce that specializes in performing complex tasks that have been learned and mastered over the life of these facilities.

Over the years, DOE's nuclear facility infrastructure has diminished because of the shutdown of facilities, recent examples being the High Flux Beam Reactor at Brookhaven National Laboratory (BNL), New York, and the Cyclotron Facility at Oak Ridge National Laboratory (ORNL), Tennessee. This, in turn, has hampered DOE's ability to satisfy increasing demands in various mission areas. To continue to maintain sufficient irradiation facilities to meet its obligations under the Atomic Energy Act, DOE has assessed the need for expansion of its existing nuclear infrastructure in light of its commitments to ongoing programs, its commitments to other agencies for nuclear materials support, and its role in supporting civilian nuclear energy research and development programs to maintain the viability of civilian nuclear power as one of the major energy sources available to the United States.

The Nuclear Energy Research Advisory Committee (NERAC) was established in 1998 by DOE in accordance with the Federal Advisory Committee Act to provide independent, expert advice on complex science and technical issues that arise in the planning, management, and implementation of DOE's civilian nuclear energy research programs. The chairman of NERAC has informed the Secretary of Energy that:

- "There is an urgent sense that the nation must rapidly restore an adequate investment in basic and applied research in nuclear energy if it is to sustain a viable United States capability in the 21st Century."

- "[T]he most important role for DOE [Office of Nuclear Energy, Science and Technology] in the nuclear energy area at the present time is to ensure that the education system and its facility infrastructure are in good shape."

- "Of particular need over the longer term are dependable sources of research isotopes and reactor facilities providing high volume flux irradiation for nuclear fuels and materials testing" (Duderstadt 2000).

Under the guidance of NERAC, DOE has completed an internal assessment of its existing nuclear facility infrastructure capabilities. This *Nuclear Science and Technology Infrastructure Roadmap* evaluates the existing DOE infrastructure, and identifies gaps in that infrastructure for meeting projected demands (DOE 2000a). The basic finding of this assessment also concluded that the capabilities of currently operating

DOE facilities will not meet projected U.S. needs for nuclear materials production and testing, research, and development.

Consistent with these findings, DOE recognizes that adequate nuclear research reactor, accelerator, and associated support facilities must be available to implement and maintain a successful nuclear energy program. As demand continues to increase for steady-state neutron sources needed for isotope production and civilian nuclear energy research and development, DOE's nuclear infrastructure capabilities to support this demand have not improved. To continue meeting its responsibilities under the Atomic Energy Act and to satisfy projected increases in the future demand for isotope products and irradiation services, DOE proposes to enhance its existing nuclear facility infrastructure to provide for: (1) production of isotopes for medical, research, and industrial uses, (2) production of plutonium-238 for use in advanced radioisotope power systems for future National Aeronautics and Space Administration (NASA) space exploration missions, and (3) support of the Nation's civilian nuclear energy research and development needs.

To evaluate the potential environmental impacts associated with this proposed enhancement, DOE has prepared the *Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility* (*Nuclear Infrastructure Programmatic Environmental Impact Statement* [NI PEIS]). The NI PEIS evaluates impacts from new facility construction, modification, startup, and 35 years of operation, followed by decommissioning when applicable. For analysis purposes, a 35-year operating period was established based on the projected availability of existing DOE irradiation facilities to potentially support these missions. This timeframe also accommodates current projections that indicate the demand for radioisotopes and civilian nuclear energy research and development will extend for at least the next 20 years (Wagner et al. 1998; NERAC 2000a; DOE 2000a).

Medical and Industrial Isotope Production

Over the past few decades, isotopes have become vital tools for use in medicine, industry, and scientific research. Isotopes, including both radioisotopes and stable isotopes, play a particularly important role in medical diagnosis, treatment, and research. Currently, more than 12 million nuclear medicine procedures are performed each year in the United States, and approximately one-third of all patients admitted to U.S. hospitals undergo at least one medical procedure that employs the use of medical isotopes (NERAC 2000a). Many medical isotopes are produced in the United States by DOE in nuclear reactors and particle accelerators. In limited cases, some medical isotopes can also be produced by extracting them from existing radioactive materials, such as thorium-229 obtained from DOE's existing stockpile of uranium-233. Radioisotopes are used for both diagnosis and therapy. Diagnostic radioisotopes are used for imaging internal organs. Unlike conventional radiology, imaging with radioisotopes reveals organ function and structure, which provides additional data for a more accurate diagnosis, and assists in the early detection of abnormalities. In ongoing clinical testing, therapeutic isotopes have proven effective in treating cancer and other illnesses by cell-directed localized radiation therapy (i.e., deploying antibodies or carriers of radioactive isotopes to seek and destroy invasive cancer cells). This directed therapy can minimize adverse side effects (e.g., healthy tissue damage, nausea, hair loss), making it an effective, attractive alternative to traditional chemotherapy or radiation treatments.

For nearly 50 years, DOE has actively promoted the use of radioisotopes to improve the health and well-being of U.S. citizens. DOE's use of its unique technologies and capabilities to develop isotopes for civilian purposes has enabled the widespread application of medical and industrial isotopes seen today. DOE must provide an adequate supply of isotopes to keep pace with the growing and changing needs of the research community if it is to continue to serve this key role.

An Expert Panel convened by DOE in 1998 reviewed several industry projections for growth in demand for medical isotopes. The Expert Panel concluded that the growth rate in medical isotope use will be significant over the next 20 years (Wagner et al. 1998). Specifically, the Expert Panel estimated that the expected growth rate of medical isotope use during the next 20 years will range from 7 to 14 percent per year for therapeutic applications, and from 7 to 16 percent per year for diagnostic applications. The panel noted that these growth rates are attainable only if basic research in nuclear medicine is supported and modern, reliable isotope production facilities are available. In the period since the initial estimates were made, the actual growth of medical isotope use has tracked at levels consistent with the Expert Panel findings. DOE and NERAC have agreed with the following findings and recommendations provided by the Expert Panel.

- Several isotopes have proven their clinical efficacy, but supply and cost concerns could dramatically affect the use of these isotopes in the practice of nuclear medicine.

- Although commercial and research applications for certain isotopes have been developed or are being developed, their limited availability and high prices are inhibiting their use in clinical applications.

- Research isotopes that have shown promise as diagnostic and therapeutic materials are not being explored because of their lack of availability or high price.

- At present, there is no domestic production facility to guarantee the continued supply of many of these isotopes.

- To meet current and future needs of the biomedical sciences community, the Expert Panel recommended:

  > ". . . the United States develop a capability to produce large quantities of radionuclides [radioisotopes] to maintain existing technologies and to stimulate future growth in the biomedical sciences. The successful implementation of such a program would help insure our position as an international leader in the biomedical sciences well into the twenty-first century. The panel recommends that the U.S. Government build this capability around a reactor, an accelerator, or a combination of both technologies as long as isotopes for clinical and research applications can be supplied reliably, with diversity in adequate quantity and quality" (Wagner et al. 1998).

In its recent report from the Subcommittee for Isotope Research and Production Planning, NERAC further identified that:

> "It is now widely conceded that limited availability of specific radionuclides is a constraint on the progress of research. The problem is especially apparent in a number of medical research programs that have been terminated, deferred, or seriously delayed by a lack of isotope availability . . . The lack of radionuclides significantly inhibits progress in evaluating a host of promising diagnostic and therapeutic drugs in patients with debilitating and fatal diseases, examining fundamental basic science questions, studying human behavior and normal growth and development, and exploring the aging process and the products of transgene expression . . . the DOE long-term goal to have a reliable isotope supply system in place that would enable scientists to bring their creative ideas into practical use safely, quickly and efficiently is appropriate, be it basic science research, clinical medicine, or industrial endeavors. The discovery and dissemination of new knowledge should continue to be a core mission, and basic science and the application of basic science to clinical research discoveries

> to improve the diagnosis and treatment outcomes should be a crucial component of that mission. [DOE], in providing a federal system for the reliable supply of stable and radioactive isotopes for research, will be an important aspect of fulfilling the federal responsibility to support biomedical research" (NERAC 2000a).

Current domestic and global producers of radioisotopes include governments that operate reactors and accelerators at national laboratories or institutes, and private sector companies that own and operate accelerators. There are also many partnership arrangements where companies lease irradiation space in government reactors or operate processing facilities in coordination with the government. A few universities also produce radioisotopes, but their ability to provide reliable and diverse supplies is generally limited by the small-scale capabilities or operating schedules of their facilities.

DOE's production and sale of radioisotopes fall into two categories: "commercial" and "research". Commercial radioisotopes are those that are produced in large, bulk quantities and sold to pharmaceutical companies or distributors, or to equipment or sealed source manufacturers. DOE only produces commercial isotopes when there is no U.S. private sector capability or when foreign sources do not have the capacity to meet U.S. needs reliably.

In contrast, research radioisotopes are typically produced and sold in small quantities in response to specialty orders from researchers preparing experiments in the field of medicine, with small quantities of these radioisotopes also purchased by industrial researchers. Because small-quantity production of research isotopes is not financially attractive to private-sector producers, it is generally not undertaken. DOE attempts to provide all research radioisotopes that are requested, subject to production capability, inventory, and financial constraints. As successful application of a specific research isotope is established, the production and sales of that radioisotope may shift from research to commercial status. In recent years, over 95 percent of DOE's sales of radioisotopes by dollar volume were commercial, and 5 percent were for research.

DOE produces radioisotopes using the High Flux Isotope Reactor (HFIR) at ORNL, the Advanced Test Reactor (ATR) at Idaho National Engineering and Environmental Laboratory (INEEL), and the Annular Core Research Reactor at Sandia National Laboratories. DOE also produces radioisotopes using accelerators, namely the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL) and the Brookhaven LINAC (Linear Accelerator) Isotope Producer (BLIP) at BNL. At each of these DOE sites, the radioisotope production mission shares the reactor or accelerator with other basic energy sciences or defense missions that are generally much larger and exercise considerable influence on facility schedules and priorities. As such, radioisotope production is often relegated to fulfilling a secondary mission that is dependant on the operating constraints of these larger, primary missions. Currently, approximately 50 percent of DOE's isotope production capability is being utilized. Assuming a midpoint growth curve for future isotope demand and ensuring a diversity and redundancy of isotope supply, DOE estimates that its isotope production facilities would be fully used within a 5- to 10-year timeframe if no enhancements to the existing nuclear facility infrastructure are implemented. This projection is made in the context of a worldwide market for radioisotopes. Although DOE's market share is a small fraction of the overall total, it is very significant for some radioisotopes and particularly important for a large number of radioisotopes that are used in relatively small quantities for research. These isotopes, which are used almost exclusively by researchers at universities and hospitals, are not purchased in quantities that would attract private industry to take over their production. However, DOE may need to significantly increase the production levels of these radioisotopes as world demand changes and promising research developments in their medical use are brought to commercialization.

Recent analyses indicate that the greatest challenge to meeting projected isotope market requirements over the next 20 years will be in the area of therapeutic medical isotopes, several of which are currently unavailable or are available only in limited quantities (Battelle 1999). For the purpose of analysis in the NI PEIS, a representative set of isotopes was selected on the basis of the recommendations of the Expert Panel, medical market forecasts (Frost & Sullivan 1997), reviews of medical literature, and more than 100 types of ongoing clinical trials that use radioisotopes for the treatment of cancer and other diseases. Currently, these medical applications primarily involve the diagnosis and treatment of three major classes of disease—cancer, vascular disease, and arthritis. Although these isotopes are a representative sample of possible isotopes that could be produced, DOE expects that the actual isotopes produced as a result of the proposed action would vary from year to year in response to the focus of clinical research and the specific market needs occurring at that time.

The United States currently purchases approximately 90 percent of its medical isotopes from foreign producers, most notably Canada. However, Canada only supplies a limited number of economically attractive commercial isotopes (primarily molybdenum-99), and it does not supply research isotopes or the diverse array of medical and industrial isotopes considered in the NI PEIS. As such, reliance on Canadian sources of isotopes to satisfy projected U.S. isotope needs would not meet DOE's mission requirements.

Industrial isotope applications fall into three broad categories: nucleonic instrumentation, irradiation and radiation processing, and technologies that use radioactive tracers. Examples of nucleonic instrumentation include gauges for measuring physical parameters, e.g., detection systems for pollutants, explosives, drugs, ores, petroleum, and natural gases; nondestructive testing by gamma radiography; and smoke detectors. Irradiation and radiation processing technologies include radiation sterilization of food and medical products and the curing of plastics. Radioactive tracer applications include studies of chemical synthesis reactions; mass transfer monitoring in industrial plants; analysis of the transport and uptake of nutrients, fertilizers, herbicides, and waste materials in plants, soils, and groundwater; and laboratory-based studies of the properties of materials.

In proposing to expand its radioisotope production capability, DOE intends to continue to complement the commercial availability of these radioisotopes. Consistent with current isotope production activities, DOE will continue to make its facilities available to the private sector to support production and sales of isotopes.

Plutonium-238 Production for Space Missions

As part of its charter under the Atomic Energy Act, DOE and its predecessor agencies have been developing and supplying radioisotope power systems to NASA for space exploration for more than 30 years. These radioisotope power systems include radioisotope thermoelectric generators used to power electrical components and radioisotope heater units used to keep spacecraft instruments warm. Previous NASA space missions that have used radioisotope power systems include the Apollo lunar scientific packages and the Pioneer, Viking, Voyager, Galileo, and Ulysses deep space probes. More recent missions include the Mars Pathfinder mission launched in 1996 and the Cassini mission launched in 1997. These radioisotope power systems have repeatedly demonstrated their performance, safety, and reliability in various NASA space missions. Without these power systems, these types of space exploration missions could not have been performed by NASA.

The radioisotope used in these power systems is plutonium-238. Through a Memorandum of Understanding with NASA, DOE provides these radioisotope power systems, and the plutonium-238 that fuels them, for space missions that require or would be enhanced by their use (DOE and NASA 1991). In addition, under the National Space Policy issued by the Office of Science and Technology Policy in September 1996, and consistent with DOE's charter under the Atomic Energy Act, DOE is responsible for maintaining the capability to provide the plutonium-238 needed to support these missions. The Intersector Guidelines section of the National Space Policy states that, "The Department of Energy will maintain the necessary capability to support space missions which may require the use of space nuclear power systems" (The White House 1996). Although research to identify other potential fuel sources to support these space exploration missions has been conducted, no viable alternative to using plutonium-238 has been established.

Historically, the reactors and chemical processing facilities at DOE's Savannah River Site (SRS) were used to produce plutonium-238; however, downsizing of the DOE nuclear weapons complex resulted in the shutdown of the last remaining SRS operating reactor, K-Reactor, in early 1996. Also, in 1992 then-Secretary of Energy Watkins issued a decision to phase out operations at the two chemical processing facilities (F-Canyon and H-Canyon) at SRS. In accordance with that decision, the separation facilities are planned to be shut down following completion of their current missions to stabilize and prepare for the disposition of Cold War legacy nuclear materials and certain spent nuclear fuel, and a determination that a new nonchemical processing technology is capable of preparing aluminum-based research reactor spent nuclear fuel for ultimate disposition.

In order to obtain a source of plutonium-238 to support NASA space missions, DOE signed a 5-year contract in 1992 to purchase plutonium-238 from Russia, authorizing the United States to purchase up to 40 kilograms (88.2 pounds) of plutonium-238, with the total available for purchase in any one year limited to 10 kilograms (22 pounds).[1] Under this contract, DOE purchased approximately 9 kilograms (19.8 pounds) of plutonium-238[2]. This material constitutes the only available U.S. inventory that has been reserved for space missions, an amount that is expected to be depleted by approximately 2005. DOE's practice of purchasing on an as-needed basis has avoided the costs from processing the plutonium-238 to remove the decay products that would result from storing it for an extended period of time. In 1997, DOE extended the contract for another 5 years; therefore, it is set to expire in 2002. Any purchases beyond 2002 would likely require the negotiation of a new contract and may require additional NEPA review. The long-term viability of pursuing additional contract extensions or entering into a new contract is unclear.

The political and economic climate in Russia creates uncertainties that could affect its reliability as a source of plutonium-238 to satisfy future NASA space mission requirements. Reestablishing a domestic plutonium-238 production capability would ensure that the United States has a long-term, reliable supply of this material. In doing so, the United States would have greater control over the available supply, plans for satisfying future demand, and the nuclear safety and nonproliferation implications of the material. As such, DOE's preference is to reestablish a domestic plutonium-238 production capability rather than to rely on Russia as the sole long-term supplier. A plutonium-238 production rate of 2 to 5 kilograms (4.4 to 11 pounds) per year is expected to be sufficient to meet NASA's estimated long-term requirements.

DOE is planning to provide radioisotope heater units for several NASA Mars Exploration missions over the next 10 years. Each heater unit would require approximately 2 grams (0.07 ounce) of plutonium-238. The number of heater units varies depending on the spacecraft. Each of the two Mars missions in 2003 is projected to require up to 11 heater units. In May 2000, NASA provided preliminary guidance to DOE to also plan for the potential use of radioisotope power systems for the Pluto/Kuiper Express mission scheduled for launch in 2004, the Europa Orbiter mission scheduled for launch in 2006, and the Solar Probe mission scheduled for launch in 2007 (NASA 2000a). The amount of plutonium-238 needed for these missions was approximately 7.4 kilograms (16.3 pounds) for the Pluto/Kuiper Express mission, which would use an existing spare radioisotope thermoelectric generator, and approximately 3 kilograms (6.6 pounds) each for the Europa Orbiter and Solar Probe missions, which would use the Stirling radioisotope power system (SRPS). With NASA's current emphasis on smaller and less expensive spacecraft, the SRPS is being developed as a new, more efficient and lighter weight power system requiring one-third less plutonium-238 as its fuel source. However,

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[1] The NI PEIS presents the weight of plutonium-238 in terms of kilograms of isotope. In contrast, NASA documentation expresses this weight in terms of plutonium oxide. The equivalent plutonium oxide weight can be approximated by multiplying the isotope kilogram weight by 1.134.

[2] The environmental impacts of purchasing plutonium-238 from Russia are evaluated and documented in the *Environmental Assessment of the Import of Russian Plutonium-238* (DOE 1993), prepared by DOE's Office of Nuclear Energy.

the technology is developmental, and NASA has requested that the plutonium-238 needed for a large radioisotope thermoelectric generator be maintained as backup.

A plutonium-238 production goal of 2 to 5 kilograms (4.4 to 11 pounds) per year could produce sufficient quantities of plutonium-238 to theoretically yield a SRPS every 8 months if production were maintained at the high end of the range. However, DOE chose the 5-kilogram (11-pound) per year production rate as an upper bound due to uncertainties in the SRPS technology development requirements for backup units, and variability in the amount of plutonium-238 that may be needed for each of the units to meet NASA's power requirements.

In updated mission planning guidance provided in September 2000, NASA indicated that for programmatic and technical reasons, implementation of the Pluto/Kuiper Express mission as currently conceived was being deferred, and that the SRPS generators were candidate power systems for the Europa Orbiter and Solar Probe missions (NASA 2000b, 2000c). NASA also requested that the spare radioisotope thermoelectric generator and assembling and fueling a spare thermoelectric converter be maintained as backups for the Europa Orbiter mission in the event the SRPS technology was not ready in time. If NASA chooses to use the SRPS to support the Europa Orbiter and Solar Probe missions, there would be no change in NASA's requirements regarding the plutonium-238 needed for these two missions (i.e., approximately 3 kilograms [6.6 pounds] each, as described above), although the remaining quantity of plutonium-238 would not be sufficient to support additional deep space or long-lived exploration missions. Should NASA decide to use the backup radioisotope thermoelectric generators rather than the SRPS to support the Europa Orbiter mission, approximately 8 kilograms (17.6 pounds) of plutonium-238 would be needed, which would effectively expend all of DOE's available plutonium-238 inventory prior to supporting the Solar Probe mission. While this latest NASA guidance modifies the specific radioisotope power systems and missions for which DOE needs to plan, it does not fundamentally change NASA's overall potential plutonium-238 requirements, or the expectation that the available U.S. inventory of this material would effectively be depleted by approximately 2005.[3]

Although future space mission schedules over a long-term planning horizon of 10 to 35 years cannot be specified at this time, DOE anticipates that NASA space exploration missions conducted during this period will continue to require plutonium-238-fueled power systems. For example, NASA announced in a recent press conference (October 26, 2000) that mission launches in 2014 and 2016 for the long-term exploration of Mars would involve long-life rover vehicles. Radioisotope power systems would be required to provide the long-life capability.

Therefore, DOE proposes to reestablish a domestic capability for producing and processing this material. Because the SRS facilities previously used for plutonium-238 production are no longer available, DOE needs to evaluate other DOE irradiation and chemical processing facilities, as well as potential commercial light water reactors (CLWR), for this mission. Unless an assured domestic supply of plutonium-238 is established, DOE's ability to provide radioisotope power systems to support future NASA space exploration missions may be lost.

Civilian Nuclear Energy Research and Development

Nuclear energy is an important contributor in reducing greenhouse gas emissions in the United States, Asia, and Europe. Globally, nuclear energy produces 17 percent of the world's electricity. In the United States, nuclear energy generated 20 percent of all electricity consumed in 1999. In view of energy and environmental contributions, there is a renewed interest in nuclear power to meet an equivalent portion of the Nation's future expanding energy requirements.

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[3] Applicable NASA mission planning correspondence is presented in Appendix R, Volume 2 of the NI PEIS.

In January 1997, President Clinton tasked his Committee of Advisors on Science and Technology (PCAST) to evaluate the current national energy research and development portfolio and to provide a strategy that ensures the United States has a program to address the Nation's energy and environmental needs for the next century. In its November 1997 report responding to this request, the PCAST Energy Research and Development Panel determined that restoring a viable nuclear energy option to help meet our future energy needs is important and that a properly focused research and development effort to address the potential long-term barriers to expanded use of nuclear power (e.g., nuclear waste, proliferation, safety, and economics) was appropriate. The PCAST panel further recommended that DOE reinvigorate its nuclear energy research and development activities to address these potential barriers.

Clean, safe, reliable nuclear power has a role today and in the future for our national energy security. Recognizing this need, two significant new nuclear energy research and development programs have been initiated: the Nuclear Energy Research Initiative (NERI) and Nuclear Energy Plant Optimization (NEPO). The NERI program, initiated in fiscal year 1999, sponsors new and innovative scientific and engineering research and development to address the potential long-term barriers identified by the PCAST Panel affecting the future use of nuclear energy. The NEPO program, a cost-shared program with industry, initiated in fiscal year 2000, sponsors applied research and development to ensure that current nuclear plants can continue to deliver adequate and affordable energy supplies up to and beyond their initial 40-year license period by resolving open issues related to plant aging, and by applying new technologies to improve plant reliability, availability, and productivity.

The NERAC Subcommittee on Long-Term Planning for Nuclear Energy Research has set forth a recommended 20-year research and development plan to guide DOE's nuclear energy programs in areas of materials research, nuclear fuel, and reactor technology development (NERAC 2000b). This plan stresses the need for DOE facilities to sustain the nuclear energy research mission in the years ahead. Such civilian nuclear energy research and development initiatives requiring an enhanced DOE nuclear facility infrastructure fall into three basic categories: materials research, nuclear fuel research, and advanced reactor development.

Materials Research. The high radiation fields, high temperatures, and corrosive environments in nuclear reactors (terrestrial or space) and other complex nuclear systems (e.g., accelerator transmutation of waste [ATW] systems) can accelerate the degradation of pressure vessels and structural material, component materials, material interfaces and joints between materials (e.g., welds). Radiation effects in materials can cause a loss of mechanical integrity (fracture toughness and ductility) by embrittlement, dimensional changes (creep and swelling), and fatigue and cracking (irradiation-assisted stress corrosion cracking). Acquiring a fundamental understanding of radiation effects in current and future reactor materials (engineered steel alloys, ceramics, composites, and refractory metals), as well as the experimental validation of analytical models and computational methods, would require material irradiation testing over a range of neutron energies (thermal and fast flux) and doses. Material testing under simulated reactor conditions would be required to ensure the compatibility of advanced materials with the various moderators/coolants of future reactor concepts. In addition, the thermophysical properties and behaviors of liquid metal coolants being considered for advanced reactor (terrestrial or space) and ATW systems require further irradiation testing. One key area of materials research that is important to plant safety and the license renewal of existing nuclear power plants is the accelerated aging of materials to simulate radiation effects over a plant lifetime. Researchers from the United States and many foreign countries use DOE's high flux research reactors for materials testing and experimentation. These facilities have the capability to maintain a high density of neutrons in a given test volume for materials testing; shorten the time needed for such testing; tailor the neutron flux to simulate the different reactor types and conditions; and instrument the core for close monitoring of the test conditions.

Nuclear Fuel Research. Increasing demands are being placed on nuclear fuel and cladding material performance as the fuel burnup limits are extended in existing light water reactors to maximize plant performance and economic benefits. New fuel types and forms are being investigated that offer potential benefits such as enhanced proliferation resistance (uranium-thorium fuel), higher burnup, and improved waste forms for the new reactor concepts being researched and developed by DOE. In addition, plutonium-uranium mixed oxide fuels are being developed for the disposition of surplus weapons material, and high temperature, long-life fuels may be required for space reactors. Each of the various fuel and cladding types, forms, and material compositions would require research and irradiation testing under prototypical reactor conditions to fully understand fuel performance, cladding performance, cladding/fuel interaction, and cladding/coolant material compatibility. Fuel research includes a variety of thermal and fast spectrum power reactor fuel forms (ceramic, metal, hybrids such as cermet) and various fuel types (oxides, nitrides, carbides, and metallics). Irradiation experiments to characterize fuel performance would require the capability to test fuel pellets, pins, and fuel assemblies under steady-state and transient conditions in the higher temperature environments expected in future reactor designs. Reactor physics and criticality safety data for benchmarking computational codes and analytical methods used in fuel design and performance analysis would also be required.

Advanced Reactor Development. Certification and licensing of advanced reactor and complex nuclear systems will require the demonstration and validation of reactor and safety system thermal and fluid dynamic properties under steady-state and transient conditions. Typically, nonnuclear test loops are used to perform this research. However, because of the unique nature of some proposed advanced reactor concepts, test loop operation under prototypical temperature and neutron flux conditions would be necessary to adequately test and demonstrate coolant/moderator physics and thermal properties, heat transfer, fluid flow, and fuel-moderator performance.

S.2 SCOPE OF THE NI PEIS

Public Scoping Process

On October 5, 1998, DOE published in the Federal Register (63 FR 53398) a Notice of Intent to prepare an environmental impact statement (EIS) on the proposed production of plutonium-238 for use in advanced radioisotope power systems for future space missions. With that announcement, DOE began preparing the *Environmental Impact Statement for the Proposed Production of Plutonium-238 for Use in Advanced Radioisotope Power Systems for Future Space Missions* (*Plutonium-238 Production EIS*). The scope of the *Plutonium-238 Production EIS* was established through a public scoping process conducted from November 4, 1998 through January 4, 1999. As part of the scoping process for that draft, DOE announced that the Fast Flux Test Facility (FFTF) would not be considered a reasonable alternative for the plutonium-238 production mission unless restart of the facility was proposed for other reasons.

Since then, the Secretary of Energy announced on August 18, 1999, that DOE would prepare the NI PEIS. Because plutonium-238 production would be among the missions considered in the NI PEIS, the scope of the *Plutonium-238 Production EIS* in its entirety was incorporated within the scope of the NI PEIS, and preparation of the *Plutonium-238 Production EIS* as a separate National Environmental Policy Act (NEPA) review was terminated.

On September 15, 1999, DOE published in the Federal Register a Notice of Intent to prepare the NI PEIS (64 FR 50064). In this Notice of Intent, DOE invited the public to comment on the proposed actions during the 45-day NI PEIS scoping period that ended October 31, 1999. During this period, DOE held public scoping meetings at seven locations: Oak Ridge, Tennessee; Idaho Falls, Idaho; Richland and Seattle, Washington; Hood River and Portland, Oregon; and Washington, D.C. The written and oral comments received at these meetings and the additional comments received via U.S. mail, electronic mail, and toll-free faxes and telephone calls during the public scoping period were reviewed and considered by DOE in preparing the NI PEIS. Similarly, DOE reviewed and considered all comments and input originally received from the public during the *Plutonium-238 Production EIS* scoping period in the preparation of the NI PEIS.

For the *Plutonium-238 Production EIS*, approximately 750 scoping comments were received by DOE. At the scoping meetings on the *Plutonium-238 Production EIS*, the following general issues and concerns were raised:

- Additional irradiation service alternatives, such as CLWRs and accelerators
- Additional storage, target fabrication, and target processing alternatives, such as Argonne National Laboratory's Hot Fuels Examination Facility and the SRS H-Canyon and HB-Line
- Generation of additional waste
- Costs of implementing the various alternatives

In general, the people who attended the meetings in Idaho and Tennessee were supportive of DOE's proposed plans to produce plutonium-238 domestically for future space missions. However, in Richland, Washington, the meeting was attended by several stakeholder and environmental groups who voiced considerable opposition to DOE's consideration of FFTF for plutonium-238 production.

At the meeting in Richland, Washington, the main concern was that DOE should not consider restarting FFTF, that DOE has worked hard over the years to change the Hanford Site's (Hanford) mission from "production" to "cleanup," and that DOE should continue to honor its commitment to cleanup. There were concerns about the generation of additional waste at the site and the operational safety of FFTF. There was strong opposition to restart of FFTF for any mission.

For the NI PEIS, approximately 7,000 scoping comments were received by DOE. At the scoping meetings on the NI PEIS, the most prevalent concerns were:

- Status of and commitment to cleanup at Hanford and the impact of FFTF restart on the existing waste cleanup at Hanford
- Lack of justification for the identified missions
- Costs of implementing the various alternatives
- Need for an additional alternative calling for the permanent deactivation of FFTF coupled with the No Action alternative elements, that is, no plutonium-238 production and no additional research and development or medical isotope production beyond existing operating levels

The number of people who commented at the scoping meetings conducted in Oak Ridge, Tennessee; Idaho Falls, Idaho; and Washington, D.C., was smaller in comparison to the meetings held in the Pacific Northwest. At the scoping meeting in Oak Ridge, Tennessee, a commentor was concerned with the relationship of the NI PEIS to other DOE programs and the relative merits of accelerator and reactor performance. The commentor stated that the NI PEIS should include an explanation of mixed oxide fuel disposition. In addition, the commentor supported medical isotope production in Oak Ridge because it is near a transportation hub and some medical isotopes are short-lived; therefore, transportation is key.

At the scoping meeting in Idaho Falls, Idaho, most commentors supported siting the new missions at INEEL. The commentors also stated that the socioeconomic impacts of the alternatives need to be considered in the NI PEIS. A commentor stated that decisions in regard to medical isotope production should be based on the needs of the Nation as a whole and not on perceived commercial needs. The commentor also stated that incremental DOE and commercial investments in ATR would be sufficient to enhance reactor radioisotope production needs and meet the requirements of the nuclear medicine industry.

At the scoping meetings held in the states of Washington and Oregon, many of the comments concerned using FFTF to accomplish the proposed action. Many who attended the meetings in Seattle, Washington; Portland, Oregon; and Hood River, Oregon, were strongly opposed to restart of FFTF. Many commentors stated that the Hanford cleanup mission would be jeopardized, especially when DOE has not met the Hanford cleanup milestones. Many of the comments received at the Richland, Washington, meeting supported restarting FFTF, stated that restart would not hamper Hanford's cleanup mission, and further stated that operation of FFTF could help save the lives of many people by producing isotopes to be used in new ways to treat cancer, heart disease, and other illnesses. Commentors were also concerned about the potential generation of radioactive and hazardous wastes as a result of the proposed action, as well as DOE's commitment to ongoing cleanup programs, particularly at Hanford.

At the scoping meeting in Washington, D.C., the commentors supported the need for medical isotope production. Several commentors were against the restart of FFTF and others stated that DOE needs to consider partnerships with private industry to generate necessary funds for restart. Some commentors thought a cost study should be prepared and include avoided future health care costs and cost savings to the national Medicare and Medicaid programs that could be realized by using nuclear isotopes in medical applications. Proliferation concerns were also raised as some commentors stated that: (1) the United States would be sending the wrong message by restarting FFTF; (2) a change in the U.S. nonproliferation policy will be required to import German mixed oxide fuel; and (3) the use of highly enriched uranium is contrary to existing U.S. nonproliferation policy. Other concerns included waste generation, Hanford cleanup, and safety at FFTF.

Comments received during the scoping periods were systematically reviewed by DOE. As a means of summarizing the issues raised during scoping, those comments with similar or related topics were grouped into categories to identify specific issues of public concern. After these issues were identified, they were further evaluated to determine whether they fell within or outside the proposed scope of the NI PEIS. In several instances, the original scope was expanded to accommodate additional issues resulting from the public scoping process.

Comments received that contributed to expansion of the scope concerned the following general areas:

- Deactivate FFTF: Alternative 5, Permanently Deactivate FFTF with no new missions at existing facilities, has been added to the scope of the NI PEIS.

- Cleanup at Hanford: Although not within the scope of the NI PEIS, information is included about the cleanup mission at Hanford and land-use planning efforts.

- Environmental contamination at Hanford: Information is included about the groundwater quality at the Hanford Site.

- Nonproliferation issues: The import of German SNR–300 fuel is addressed, and a separate *Nuclear Infrastructure Nonproliferation Impact Assessment for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including* *the Role of the Fast Flux Test Facility* (*NI Nonproliferation Impact Assessment*) report was prepared and distributed to the public in September 2000.

- Transition of FFTF stewardship after it is deactivated: The appropriate transition information is included.

- Restart of FFTF and budget constraints: DOE has made a commitment that implementation of the Record of Decision will not divert or reprogram budgeted funds designated for Hanford cleanup.

- Tri-Party Agreement at Hanford: Information about the Tri-Party Agreement and its relationship to the NI PEIS is included.

The public comments and materials submitted during the public scoping periods for both the *Plutonium-238 Production EIS* and the NI PEIS were logged and placed in the Administrative Record for the NI PEIS. Appendix N of the NI PEIS summarizes the comments received during both public scoping periods.

Issues Raised During the Public Comment Period on the Draft NI PEIS

DOE published the Draft NI PEIS in July 2000. In accordance with Council on Environmental Quality (CEQ) and DOE NEPA regulations, DOE announced the availability of the Draft NI PEIS in the Federal Register (65 FR 46443) and invited interested parties to provide comments on the Draft NI PEIS analysis and results. The Draft NI PEIS or Summary was distributed to approximately 6,000 individuals.

NEPA regulations mandate a minimum 45-day comment period after the U.S. Environmental Protection Agency's (EPA) Notice of Availability of a draft EIS to provide an opportunity for the public to comment on the EIS analysis and results. The original 45-day comment period on the Draft NI PEIS began on July 28, 2000. To provide interested parties with additional time to comment, the deadline for transmittal of comments was changed from September 11, 2000 (as stated in the transmittal letter of the Draft PEIS and the Summary) to September 18, 2000. During the 52-day comment period, DOE held seven hearings to discuss the proposed action and to receive oral and written comments on the Draft NI PEIS. These hearings were held at Oak Ridge, Tennessee; Idaho Falls, Idaho; Hood River, Oregon; Portland, Oregon; Seattle, Washington; Richland, Washington; and Arlington, Virginia. In addition, the public was encouraged to submit comments via U.S. mail, e-mail, a toll-free phone line, and a toll-free fax line. During the public comment period, DOE received approximately 3,400 submittals containing over 6,200 comments. DOE has responded to all comments received during the public comment period. These comments are presented in Volume 3 of the Final NI PEIS. DOE considered comments received after the close of the public comment period to the extent practicable.

The public comments received on the Draft NI PEIS addressed a wide range of issues. The following discusses the major issues raised, and DOE's responses to these issues. Changes made in response to comments received on the Draft NI PEIS are described in the next section.

Major issues raised addressed purpose and need for the proposed action; impact of FFTF on Hanford cleanup; waste management and spent nuclear fuel; cost of the various alternatives; nuclear nonproliferation policy; public involvement; and environmental impacts. Aside from comments on the proposed action and its environmental impacts, many commentors expressed support for or opposition to FFTF restart, the major point of public controversy associated with the NI PEIS.

Purpose and Need for the Proposed Action. Many commentors expressed the opinion that DOE failed to demonstrate a compelling argument for the projected need for medical isotopes, and that such medical isotopes could be produced or purchased elsewhere, particularly in Canada. In contrast, a large number of commentors expressed support for expanded isotope production by sharing personal stories of how medical isotopes had either saved a relative or friend, or could have saved them had isotopes been available. As presented in Section 1.2.1 of Volume 1 of the NI PEIS, DOE sought independent analysis of trends in the use of medical isotopes, and established two advisory bodies, the Expert Panel and the NERAC. DOE has adopted these growth projections as a planning tool for evaluating the potential capability of the existing nuclear facility infrastructure to meet programmatic requirements. In the period since the initial estimates were made, the actual growth of medical isotope use has tracked at levels consistent with the Expert Panel findings. While Canada currently provides a large amount of the medical radioisotopes used in the United States, it only supplies a limited number of economically attractive commercial isotopes (primarily molybdenum-99), and it does not supply research isotopes or the diverse array of medical and industrial isotopes considered in the NI PEIS.

A number of commentors also questioned the suitability of using FFTF for producing research isotopes in light of findings presented in the NERAC Subcommittee for Isotope Research and Production Planning Report (NERAC 2000a). While it would not be cost effective to restart FFTF for the singular purpose of producing small quantities of various research isotopes, sustained operation of FFTF for the production of larger quantities of both research and commercial isotopes would be viable if FFTF were operated in concert with producing plutonium-238 and conducting nuclear energy research and development for civilian applications. In recognition of these constraints on its operational feasibility, the NI PEIS only evaluates the use of FFTF for isotope production when coupled with these other missions.

Commentors also questioned the need for the United States to reestablish domestic production of plutonium-238. In particular, commentors pointed to the availability of plutonium-238 that could be purchased from Russia, and recent guidance from NASA stating that DOE no longer needed to support certain radioisotope power systems. As discussed in Section 1.2.2 of Volume 1, DOE could purchase plutonium-238 from Russia. However, for supply reliability reasons and concern of nuclear nonproliferation, DOE's preference is to establish a domestic plutonium-238 production capability. Current NASA guidance to DOE is also discussed in Section 1.2.2. The May 22, 2000, correspondence from NASA identifies that it no longer has a planned requirement for Small Radioisotope Thermoelectric Generator (SRTG) power systems (NASA 2000a). This does not mean that NASA no longer requires DOE to provide the necessary plutonium-238 to support deep space missions. Rather, SRTG development efforts were stopped in order to permit reprogramming of funds to support development of a new radioisotope power system based on an SRPS technology. This new radioisotope power system, referred to in the subject correspondence, requires one-third less plutonium as its fuel source. Because the SRPS technology is developmental, NASA has requested in a September 22, 2000, letter to DOE that the plutonium-238 needed for a large radioisotope thermoelectric generator be maintained as a backup (NASA 2000b).

Impact of FFTF Restart on Hanford Cleanup. A number of commentors expressed concern that DOE's primary mission at Hanford needs to be cleanup, including compliance with the Tri-Party Agreement. Although beyond the scope of the NI PEIS, ongoing Hanford cleanup activities are high priority to DOE. Hanford environmental restoration activities are conducted in accordance with the Tri-Party (i.e., DOE's Richland Operations Office, EPA, and the State of Washington Department of Ecology) Agreement. This agreement specifies milestones and schedules for restoration of all parts of Hanford. FFTF milestones in the Tri-Party Agreement were placed in abeyance (suspension) by agreement of the three parties until a decision is made on the future of FFTF. Public meetings were held on this formal milestone change. DOE is fully committed to honoring this agreement.

A number of commentors also expressed concern that funding for Hanford cleanup would be diverted for FFTF restart and hamper the progress of cleanup activities. The U.S. Congress funds Hanford cleanup through the Office of the Assistant Secretary for Environmental Management. Congress also funds FFTF through the Office of Nuclear Energy, Science and Technology (NE). The nuclear infrastructure missions described in Section 1.2 of Volume 1 would also be funded through NE, which has no funding connection to Hanford cleanup activities. As stated in Section N.3.2 of Volume 2, implementation of the nuclear infrastructure alternatives would not divert or reprogram budgeted funds designated for Hanford cleanup, regardless of the alternative(s) selected.

Waste Management and Spent Nuclear Fuel. A number of commentors expressed concern over the generation and disposition of waste resulting from the proposed action. In particular, commentors pointed to past DOE waste management practices and questioned whether wastes resulting from proposed NI PEIS activities would be properly managed. The NI PEIS addresses wastes produced for each alternative, as well as cumulative impacts related to waste production. Waste minimization programs at each of the alternative sites are also addressed. These programs would be implemented for the alternative selected in the Record of Decision. The waste generated from any of the alternatives considered in the NI PEIS would be managed (i.e., treated, stored, and disposed of) in a safe and environmentally protective manner and in compliance with all applicable Federal and state laws and regulations and applicable DOE orders.

A number of commentors expressed specific concern over the generation and disposition of waste resulting from FFTF restart and operation, and how this would impact Hanford's existing waste management infrastructure. Management of wastes that would be generated under implementation of Alternative 1 (Restart FFTF) is discussed in Section 4.3 of Volume 1 (e.g., see Section 4.3.1.1.13). Section 4.3.1.1.13 of the NI PEIS was revised to clarify that the Hanford waste management infrastructure is analyzed in the PEIS for the management of waste resulting from FFTF restart and operation. This analysis is consistent with policy and DOE Order 435.1, *Radioactive Waste Management,* that DOE radioactive waste shall be treated, stored, and in the case of low-level waste, disposed of at the site where the waste is generated, if practical, or at another DOE facility. However, if DOE determines that use of the Hanford waste management infrastructure or other DOE sites is not practical or cost effective, DOE may issue an exemption under DOE Order 435.1 for the use of non-DOE facilities (i.e., commercial facilities) to store, treat, and dispose of such waste generated from the restart and operation of FFTF. In addition, Sections 4.3.3.1.13 and 4.4.3.1.13 also address the potential impacts associated with the waste generated from the target fabrication and processing in the Fuels and Materials Examination Facility (FMEF) and how this waste would be managed at the site.

A number of commentors also raised concern that processing of irradiated targets for production of plutonium-238 would generate high-level radioactive waste. DOE Manual 435.1, *Radioactive Waste Management,* defines high-level radioactive waste as "the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation." DOE has prepared an implementation guide to M 435.1 to assist in implementing the requirements contained in that manual. For this particular "requirement," the definition of high-level radioactive waste, the guide is intended to facilitate the classification of indefinite waste as to whether or not it is high-level radioactive waste. It is recognized that the definition of high-level radioactive waste is not precise and is essentially a source-based definition that also alludes to concentrations of a given waste stream. Page II-8 of the guide notes that "For the purpose of managing high-level waste under DOE M 435.1 [sic], spent nuclear fuel includes spent driver elements and/or irradiated target elements that contain transuranium elements." This statement was included in the guide because the concentrations of long-lived isotopes are likely to be somewhat high during reprocessing and it also meets the source-based definition. As a result of reviewing this guide and to address the comments raised, DOE is considering whether the waste from processing of irradiated neptunium-237 targets should be classified as high-level radioactive waste and not transuranic waste. As a result, the Waste Management sections (i.e., Sections 4.3.1.1.13, 4.3.2.1.13, 4.3.3.1.13, and 4.4.3.1.13) of the

NI PEIS have been revised to reflect this different classification from what was assumed in the Draft NI PEIS. As discussed in these revised sections, irrespective of how the waste is classified (i.e., transuranic or high-level radioactive waste), the composition and characteristics are the same and the waste management (i.e., treatment and onsite storage) for the NI PEIS would be the same. In addition, even if the waste is managed as high-level radioactive waste it would have no impact on the existing high-level radioactive waste management infrastructure (e.g., high-level waste storage tanks) because the high-activity waste from processing of the targets would be initially stored and vitrified within the processing facility (i.e., FMEF, the Radiochemical Engineering Development Center (REDC) or the Fluorinel Dissolution Process Facility [FDPF]).

Commentors also expressed concern over the potential impacts of spent nuclear fuel generation from FFTF restart and operation, particularly regarding human health risk. The NI PEIS estimates that about 16 metric tons of heavy metal spent nuclear fuel would be generated over 35 years of operation of FFTF. Hanford is currently managing about 2,000 metric tons of heavy metal spent nuclear fuel. The radiation risk to a maximally exposed individual from normal operational activities during management of the current stored spent nuclear fuel over 35 years is 1.4×10^{-8} latent cancer fatality. The risk to the maximally exposed individual that would be associated with the new nuclear infrastructure operations to restart FFTF and operate FMEF or the Radiochemical Processing Laboratory is 9.5×10^{-8} latent cancer fatality. Furthermore, only a small fraction of this risk would be attributable to management of the additional spent nuclear fuel at FFTF. The annual dose to the maximally exposed individual from all current and reasonably foreseeable activities at Hanford is less than 0.2 millirem. The dose is well within the DOE dose limits given in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. As discussed in that order, the dose limit from airborne emissions is 10 millirem per year, as required by EPA regulations under the Clean Air Act; the dose limit from drinking water is 4 millirem per year, consistent with the EPA drinking water criteria under the Safe Drinking Water Act; and the dose limit from all pathways combined is 100 millirem per year. The risk to the population from all activities at Hanford would be 0.21 latent cancer fatality over 35 years. DOE has committed to remove the spent nuclear fuel at Hanford for ultimate disposition in a geologic repository.

Cost of the Various Alternatives. Commentors expressed opinions about the costs related to the stated missions. Commentors stated that a cost-benefit analysis was necessary to show the value of production of medical isotopes balanced against facility costs, in particular, the restart of FFTF, and noted that perhaps facilities would be able to pay for themselves. There were concerns that FFTF restart would take funds away from the cleanup of Hanford. Commentors noted that the decommissioning costs were not included for the restart FFTF option in the *Cost Report for Alternatives Presented in the Draft Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility (NI Cost Report)*. Several commentors remarked that the expense of plutonium-238 production cannot be justified when DOE needs to clean up existing problems at its sites.

Although the costs of proposed actions are not required by NEPA and CEQ regulations to be included in a PEIS, DOE prepared a separate *NI Cost Report*. This report would provide additional pertinent information to the Secretary of Energy so that he may make an informed decision with respect to the alternatives presented in the Final NI PEIS. Pursuant to CEQ regulations (40 CFR Section 1505.1(e)), such documents comparing alternatives should be made available to the public prior to any decision being made. DOE mailed this document to more than 730 interested parties on August 24, 2000. This report was made available immediately upon release on the NE web site (http://www.nuclear.gov) and in the public reading rooms. DOE has also provided the summary of the *NI Cost Report* in Appendix P, of the Final NI PEIS.

Nuclear Nonproliferation Policy. Commentors expressed opinions about the nuclear nonproliferation implications of the proposed action. Commentors were concerned about keeping plutonium-238 out of the hands of third parties, and it was suggested that the purchase of plutonium-238 from Russia would stop proliferation of the material and the United States would know the disposition of the quantity purchased. Several commentors raised concerns about specific facilities described in the NI PEIS, including FDPF and FFTF. The use of highly enriched uranium fuel in FFTF was questioned related to possible violation of U.S. nuclear nonproliferation policy. Conversely, the shutdown of FFTF that occurred previously was characterized as being done to discourage proliferation of nuclear weapons worldwide, but had instead weakened the U.S. position as a world leader in nuclear technology. There were comments about the timeliness of release of the *NI Nonproliferation Impact Assessment*, that no nonproliferation information was included in the Draft NI PEIS, and that nuclear nonproliferation policy should be considered by DOE in selection of its preferred alternative.

The plutonium being considered for production in the NI PEIS is plutonium-238, which is not the same isotope of plutonium that is used in nuclear weapons. The production of plutonium-238 does not present a nonproliferation concern. DOE developed the separate *NI Nonproliferation Impact Assessment*, published in September 2000, that analyzed the nonproliferation impacts of the actions considered in the NI PEIS and found that there are no U.S. nonproliferation policies, laws, regulations, or international agreements that preclude the use of any of the facilities in the manner described in the Draft NI PEIS. Although this policy analysis is not required under NEPA, it is an essential element in the decision-making process for the DOE nuclear infrastructure. A summary of the *NI Nonproliferation Impact Assessment* is included in Appendix Q of the Final NI PEIS. It is also available on the DOE NE web site (http://www.nuclear.gov).

Public Involvement. Commentors expressed opinions about the length of the comment period on the Draft NI PEIS, and said they wanted additional time to obtain and review relevant documents, including the *NI Cost Report* and *NI Nonproliferation Impact Assessment*. The deadline for transmittal of comments was changed from September 11, 2000 (as stated in the transmittal letter of the Draft PEIS and the Summary) to September 18, 2000. While the official comment period ended on September 18, 2000, DOE addressed late comments to the extent practicable and considered all comments received through October 31, 2000, in preparing the Final NI PEIS. Comments that were received through September 25, 2000, along with corresponding responses, have been included in Chapter 2 of the comment response volume (Volume 3). Direct responses are not included to comments that were received after September 25, 2000. However, all of these comments were considered and are characterized by other comments received during the comment period (for which a response has been provided).

Many commentors expressed the opinion that public input is intended for “show only,” and that DOE has already made its decisions. Commentors also stated that they had given the same comments over and over again and that DOE representatives were not listening. DOE policy encourages effective public participation in its decision-making process. In compliance with NEPA and CEQ regulations, DOE provided opportunity to the public to comment on the scope of the NI PEIS and the environmental impact analysis of DOE's proposed alternatives. DOE gave equal consideration to all comments. In preparing the Final NI PEIS, DOE carefully considered all comments received from the public.

Some commentors expressed opinions about the conduct of the hearings, both positive and negative. The public hearing format was designed to be fair. The public hearing format used was based on stakeholder input and was presented in the Notice of Availability (65 FR 46443 et seq.) for the Draft NI PEIS. This format was intended to encourage public participation, regardless of the motivation for attending the hearing. It provided an opportunity for the participants to meet, exchange information, and share concerns with DOE personnel available throughout the course of each hearing to answer questions. The meetings were facilitated by an independent moderator to ensure that all persons wishing to speak had an opportunity to do so. Persons wishing to comment were selected at random from the audiences rather than according to the order in which they registered. This was accomplished by a random number drawing. In addition to the comment recorder stationed at the main hearing, a second recorder was available in an adjacent room to receive comments without the need to await selection at the main proceeding. The hearing format promoted open and equal representation by all individuals and groups.

Environmental Impacts. A number of commentors questioned the results of the environmental impact analysis and cumulative impacts, specifically at Hanford. Many of these comments focused on concerns that the proposed action would result in negative impacts to the health of individuals residing in the Hanford region. The NI PEIS analyzes the impacts of the various alternatives, and the environmental impacts associated with all proposed nuclear infrastructure activities are addressed in detail in Chapter 4 of Volume 1. Specifically, the environmental impacts associated with operation of the Hanford facilities during normal operations and from postulated accidents are presented in Section 4.3. These assessments were made using well-established and accepted analytical methods, as described in Appendixes G through L in Volume 2. The analytical methodology is conservative by nature; the actual impacts to the environment would be expected to be less than calculated. All impacts have been shown to be small. No fatalities among workers or the general public would be expected over the 35-year operational period. The impacts to the biosphere (air, water, and land) were also evaluated and determined to be small.

Some commentors raised specific concern over potential contamination of the Columbia River resulting from the restart of FFTF. However, FFTF is approximately 4.5 miles from the Columbia River. There are no discharges to the river from FFTF and no radioactive or hazardous discharges to groundwater. As indicated in analyses presented in Chapter 4 of Volume 1 (e.g., Sections 4.3.1.1.4, 4.3.3.1.4, 4.4.3.1.4, 4.5.3.2.4, and 4.6.3.2.4), there would be no discernible impacts to groundwater or surface water quality at Hanford from operation of Hanford facilities that would support the nuclear infrastructure missions described in Section S.1.

A number of commentors also expressed concern that DOE would expose individuals in the Pacific Northwest to risks associated with the importing weapons-grade plutonium. None of the proposed alternatives involve the shipment of any weapons-grade plutonium to any port in the United States. Alternative 1 does postulate that DOE might decide at some point to import mixed oxide fuel from Europe to fuel FFTF. At this time, however, DOE has not proposed to import this fuel through any specific port. If DOE ultimately decides to import fuel from Europe, it would perform a separate NEPA analysis to select a port. This review would address all relevant potential impacts of overseas and inland water transportation, shipboard fires, package handling, land transportation, as well as safeguards and security associated with the import of SNR–300 mixed oxide fuel through a variety of specific candidate ports on the west and east coasts. It would take into account all public comments, including local resolutions, concerning the desirability of bringing mixed oxide fuel into the proposed alternative ports.

In the event that DOE decides to enhance its nuclear infrastructure, it would not expose any population to high, unacceptable risks under any alternative. Any transportation activities that would be conducted by DOE would comply with U.S. Nuclear Regulatory Commission (NRC) and U.S. Department of Transportation regulations. Associated transatlantic shipments would comply with International Atomic Energy Agency requirements. In Section J.6.2 of Volume 2, DOE reviewed the potential maximum impacts from the marine transportation of mixed oxide fuel from Europe to a representative military port (Charleston, South Carolina), and overland transportation to Hanford. Also in that section, the results of a bounding analysis show that the maximum potential radiological risks to the surrounding public from mixed oxide fuel shipments would be extremely small (e.g., less than 1 chance in a trillion for a latent cancer fatality per shipment from severe accidents at docks and in channels and less than 1 chance in 50 billion for a latent cancer fatality per shipment from overland highway accidents).

Changes from the Draft NI PEIS

In response to comments on the Draft NI PEIS and as a result of information that was unavailable at the time of its issuance, the Final NI PEIS contains revisions and new information. These revisions and new information are indicated by sidebars. A brief discussion of the most important changes included in the Final NI PEIS is provided in the following paragraphs.

Chapter 1. ***Purpose and Need for Agency Action:*** As a result of public comments, additional discussion was incorporated to address DOE's production of medical, research, and industrial isotopes relative to global isotope production and availability. In addition, the discussion of the need for plutonium-238 production for space missions was expanded and updated to reflect the most recent planning guidance provided by NASA to DOE.

Issues Raised During the Public Comment Period on the Draft NI PEIS: Section 1.5, Issues Raised During the Public Comment Period on the Draft NI PEIS, was added to the Final NI PEIS.

Related NEPA Reviews: The Final NI PEIS was revised to add descriptions of the *Final Environmental Impact Statement, Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington* (DOE/EIS-0245F), and the *Environmental Assessment, Management of Hanford Site Non-Defense Production Reactor Spent Nuclear Fuel* (DOE/EA-1185). The impacts of these NEPA actions were factored into the assessment of potential cumulative impacts resulting from the NI PEIS proposed action. The Final NI PEIS was also revised to reflect recent Records of Decision that have been issued for the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (DOE/EIS-0218F), the *Final Environmental Impact Statement for Treating Transuranic (TRU)/Alpha Low-Level Waste at the Oak Ridge National Laboratory Oak Ridge, Tennessee* (DOE/EIS-0305), and the *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE/EIS-0306).

Changes from the Draft NI PEIS: Section 1.8, Changes from the Draft NI PEIS, was added to the Final NI PEIS.

Chapter 2. ***Transportation Requirements:*** Additional U.S. ports were named as candidates for receiving mixed oxide fuel from Europe.

Alternatives Considered and Dismissed: Information was provided to explain why the IPF at LANL, the BLIP and the Alternating Gradient Synchrotron (AGS) accelerator complex at BNL, and CLWRs were not considered reasonable alternatives for the production of medical isotopes. Information was also provided to explain why increasing the power levels at ATR and/or HFIR or installing rapid radioisotope retrieval systems would be insufficient to meet the long-term growth projection needs and therefore dismissed as reasonable alternatives.

Preferred Alternative: The discussion of DOE's preferred alternative for accomplishing the proposed action, that is, Alternative 2, Use Only Existing Operational Facilities, Option 7, is included in the Final NI PEIS.

Summary of Environmental Impacts: Section 2.7 of the NI PEIS was revised in response to comments that it was difficult to compare environmental impacts among alternatives. Although estimates of the environmental impacts that would result from implementation of the alternatives are the same as those in the Draft NI PEIS, the tables and accompanying text were reformatted for ease in comparing environmental impacts among alternatives and among options within alternatives. Section 2.7 was also revised to focus on incremental impacts that would result from implementation of the alternatives. Baseline environmental impacts were removed from the comparisons among alternatives and options. This information is now presented in Chapter 3.

Chapter 3. ***Affected Environment:*** Additional information was provided on the environmental baseline at each site, including graphics to more clearly illustrate existing surface water and groundwater conditions.

Estimates of existing impacts for current HFIR/REDC operations were added to Sections 3.2.3.2 (Air Quality), 3.2.9.1.2 (Radiation Exposure and Risk), and 3.2.11.1 (Waste Inventories and Activities). Similarly, estimates for current ATR operations were added to Sections 3.3.3.2 (Air Quality), 3.3.9.1.2 (Radiation Exposure and Risk), and 3.3.11.1 (Waste Inventories and Activities). Information was also provided on the impacts of the range fires affecting Hanford and INEEL during the summer of 2000. In addition, site data were updated to reflect recent measurements and analyses. Estimates of existing impacts of maintaining FFTF in standby were added to Section 3.4.3.1 (Air Quality).

In response to public comments on the Draft NI PEIS, additional information on health studies conducted in the Hanford area was also incorporated.

Chapter 4. ***Air Quality:*** Stack parameters used for the air quality modeling were added. In response to public comment, estimates of the ambient air quality concentrations from FFTF sources were added to the deactivation section.

Water Resources: New water use and sanitary wastewater generation increments for REDC and FDPF were added to reflect the revised additional workforce required at these facilities and to be consistent with FMEF. Water use and waste water generation rates for the New Accelerator(s) and New Research Reactor alternatives were also revised. These changes were also incorporated into the waste management analyses.

Ecological and Cultural and Palentological Resources: These sections were updated to reflect consultations concerning threatened and endangered species and cultural resources conducted with appropriate Federal and state agencies. Consultations were also conducted with interested Native American tribes. No major issues were raised as a result of these consultations.

Socioeconomics**:** Section 4.5.1.1.8 was revised to reflect changes in the number of workers associated with FFTF operations and deactivation. The associated impacts on community services were also incorporated. In addition, the number of workers at the Oak Ridge Reservation was revised to reflect the entire site workforce rather than just the number of workers at ORNL.

Normal Operations: Based on more recent site data on occupational radiation exposure for workers at REDC, all worker health impacts for target processing at REDC, FMEF, and FDPF and for neptunium target storage at REDC, Chemical Processing Plant 651 (CPP–651), and FMEF were updated. Also, low-energy accelerator source terms were modified to properly reflect normal operational emissions resulting in modifications to the population health impacts for all options of Alternative 3.

Facility Accidents: The high-energy accelerator analysis was redone to incorporate a more accurate revised source term, and the risks for currently operating reactors were added to the tables. An additional analysis addressing industrial accidents was also performed and incorporated into Chapter 4.

Transportation: The neptunium inventory was revised to use the recently declassified actual inventory. The number of actual shipments from SRS to the processing facilities and the transportation risk estimates were modified accordingly.

Waste Management: The analysis for the Draft NI PEIS assumed that the waste generated from the processing of irradiated neptunium-237 targets is transuranic waste. However, as a result of comments received during the public comment period, DOE is considering whether the waste from processing of irradiated neptunium-237 targets should be classified as high-level radioactive waste and not transuranic waste. The Waste Management sections (i.e., Sections 4.3.1.1.13, 4.3.2.1.13, 4.3.3.1.13, and 4.4.3.1.13) were revised to reflect this different classification from what was assumed in the Draft NI PEIS.

Spent Nuclear Fuel Management: The sections were revised to quantify the generation of spent fuel from 35 years of operation and to state that dry spent nuclear fuel storage at the FFTF site is similar to NRC-approved methods currently being used for interim storage of commercial spent nuclear fuel. In addition, based on public comments, a K Basins spent fuel storage reference document was added.

Cumulative Impacts: Cumulative impact tables in Section 4.8 were revised to present the contributions from each of the various site actions anticipated during the course of the operational period evaluated in the NI PEIS. Air quality tables were also revised to incorporate the revised baseline from Chapter 3. In addition, waste management tables were revised to include the site's treatment, storage, and disposal capacities for easier comparison of the waste generations, by waste type, to the waste management capacities at the sites.

Chapter 5. In response to public comments, a list of organizations that DOE contacted during the consultation process was added.

Volume 2. Summaries of the *NI Cost Report* and *NI Nonproliferation Impact Assessment* were added as Appendixes P and Q, respectively. NASA mission guidance correspondence was added as Appendix R.

Volume 3. Volume 3 of the NI PEIS was added to present the comments received during the public review period for the Draft NI PEIS and DOE's responses to these comments.

S.3 ALTERNATIVES EVALUATED IN THE NI PEIS

The NI PEIS analyzes the potential environmental impacts of using various irradiation and processing facilities to meet the following projected DOE irradiation service mission needs for 35 years: (1) production of medical and industrial isotopes, (2) production of up to 5 kilograms (11 pounds) per year of plutonium-238 for use in advanced radioisotope power systems for future NASA space missions, and (3) support for U.S. civilian nuclear energy research and development activities. The proposed irradiation facilities include facilities that are currently operating, those that could be brought on line, or those that could be constructed and operated to meet DOE's nuclear infrastructure mission requirements. A No Action Alternative and five programmatic alternatives are listed below.

No Action Alternative
Alternative 1—Restart FFTF
Alternative 2—Use Only Existing Operational Facilities
Alternative 3—Construct New Accelerator(s)
Alternative 4—Construct New Research Reactor
Alternative 5—Permanently Deactivate FFTF (with No New Missions)

It is possible during the Record of Decision process that a combination of the alternatives could be selected, for example, a low-energy power accelerator in combination with the existing reactors to optimize research isotope production, or in combination with FFTF to optimize research and therapeutic isotope production.

The alternatives, their associated facility options, and their relative capabilities are described in detail in Chapter 2 of the NI PEIS. As presented in **Table S–1**, the NI PEIS evaluates 26 specific technology/siting options associated with the alternatives identified above. DOE's Preferred Alternative for accomplishing expanded civilian nuclear energy research and development and isotope production missions in the United States is Alternative 2, Use Only Existing Operational Facilities, Option 7. Under this alternative and option, DOE would reestablish domestic production of plutonium-238, as needed, using irradiation capabilities at both ATR at INEEL and HFIR at ORNL. REDC at ORNL would be used to store neptunium-237 and to fabricate and process the targets irradiated at ATR and HFIR. The production of medical and industrial isotopes and support of civilian nuclear energy research and development would continue and increase to the extent possible under current reactor operating levels. FFTF at Hanford would be permanently deactivated. The preferred alternative is discussed in more detail at the end of this section.

No Action Alternative. Under the No Action Alternative (maintain status quo), FFTF would be maintained in standby status for all or a portion of the 35-year evaluation period for operations covered in the NI PEIS. For purposes of analysis in the NI PEIS, the maximum of 35 years was assumed. Ongoing operations at existing facilities, as described in Chapter 3 of the NI PEIS, would continue under this alternative. DOE would not establish a domestic plutonium-238 production capability, but could, instead, continue to purchase Russian plutonium-238 to meet the needs of future U.S. space missions. For the purposes of analysis in the NI PEIS, DOE assumed that it would continue to purchase plutonium-238 to meet the space mission needs for the 35-year evaluation period, and has included in the NI PEIS the transportation impacts of purchasing up to 175 kilograms (385.8 pounds) from Russia. However, DOE recognizes that any purchase beyond what is currently available to the United States through the existing contract will require additional NEPA review. DOE would continue its medical and industrial isotope production and civilian nuclear energy research and development activities at the current operating levels of existing facilities. A consequence of a No Action decision would be the need to determine the future of the neptunium-237 stored at SRS. Therefore, the impacts of possible future transportation and storage of neptunium-237 are evaluated as part of the No Action Alternative.

Four options are analyzed under the No Action Alternative. If DOE decides not to establish a domestic plutonium-238 production capability in the future, the neptunium-237 would have no programmatic value and Option 1 would be selected. Under this option, DOE would follow its current stabilization strategy for the neptunium-237, currently in solution form at SRS. If, however, DOE decides to maintain the neptunium-237 inventory for future plutonium-238 production, the neptunium-237 oxide would be transported from SRS to one of three candidate DOE sites for up to 35 years of storage for possible future use: Option 2, REDC at ORNL; Option 3, Building CPP–651 at INEEL; or Option 4, FMEF at Hanford.

Alternative 1—Restart FFTF. Under Alternative 1, FFTF at Hanford would be restarted and operated at a nominal 100 megawatts for the 35-year evaluation period. FFTF would be used to irradiate targets for medical and industrial isotope production, plutonium-238 production, and research and development irradiation requirements. Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue.

Targets for medical and industrial isotope production would be fabricated in one or more facilities at Hanford. Target material would typically be acquired from ORNL, where enrichment processes are conducted to produce high purity target material suitable for production of medical isotopes, and stored at Hanford. The targets would be irradiated at FFTF and then returned to the fabrication facility for postirradiation processing. From there, the isotope products would be sent directly to commercial pharmaceutical distributors.

Table S–1 NI PEIS Alternatives and Options

			Plutonium-238 Production Mission		Medical and Industrial Isotope Production and Civilian Nuclear Energy Research and Development Mission	
	Option Number	**Irradiation Facility**	**Storage Facility**	**Target Fabrication and Processing Facility**	**Storage Facility**	**Target Fabrication and Processing Facility**
No Action Alternative	1	–	–	–	–	–
	2	–	REDC	–	–	–
	3	–	CPP–651	–	–	–
	4	–	FMEF	–	–	–
Alternative 1: Restart FFTF	1	FFTF[a]	REDC	REDC	RPL/306–E	RPL/306–E
	2	FFTF[a]	FDPF/CPP–651	FDPF	RPL/306–E	RPL/306–E
	3	FFTF[a]	FMEF	FMEF	FMEF	FMEF
	4	FFTF[b]	REDC	REDC	RPL/306–E	RPL/306–E
	5	FFTF[b]	FDPF/CPP–651	FDPF	RPL/306–E	RPL/306–E
	6	FFTF[b]	FMEF	FMEF	FMEF	FMEF
Alternative 2: Use Only Existing Operational Facilities	1	ATR	REDC	REDC	–	–
	2	ATR	FDPF/CPP–651	FDPF	–	–
	3	ATR	FMEF	FMEF	–	–
	4	CLWR	REDC	REDC	–	–
	5	CLWR	FDPF/CPP–651	FDPF	–	–
	6	CLWR	FMEF	FMEF	–	–
	7	HFIR and ATR	REDC	REDC	–	–
	8	HFIR and ATR	FDPF/CPP–651	FDPF	–	–
	9	HFIR and ATR	FMEF	FMEF	–	–
Alternative 3: Construct New Accelerator(s)	1	New	REDC	REDC	New[c]	New[c]
	2	New	FDPF/CPP–651	FDPF	New[c]	New[c]
	3	New	FMEF	FMEF	New[c]	New[c]
Alternative 4: Construct New Research Reactor	1	New	REDC	REDC	New[c]	New[c]
	2	New	FDPF/CPP–651	FDPF	New[c]	New[c]
	3	New	FMEF	FMEF	New[c]	New[c]
Alternative 5: Permanently Deactivate FFTF (with No New Missions)	–	–	–	–	–	–

a. Hanford FFTF would operate with mixed oxide fuel for 21 years and highly enriched uranium fuel for 14 years.
b. Hanford FFTF would operate with mixed oxide fuel for 6 years and highly enriched fuel for 29 years.
c. The new facility would not be required if a DOE site with available support capability and infrastructure is selected.
Key: ATR, Advanced Test Reactor at INEEL; CLWR, commercial light water reactor; CPP–651, INEEL Building CPP–651 Storage Vault; FDPF, Fluorinel Dissolution Process Facility at INEEL; FFTF, Fast Flux Test Facility at Hanford; FMEF, Fuels and Materials Examination Facility at Hanford; HFIR, High Flux Isotope Reactor at ORNL; REDC, Radiochemical Engineering Development Center at ORNL; RPL/306–E, Radiochemical Processing Laboratory and Building 306–E at Hanford.

Targets for plutonium-238 production would be fabricated in one of three candidate facilities at ORNL, Hanford, or INEEL. The material needed for target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities, where it would be stored until fabrication. The nonirradiated targets would be transported to and irradiated at FFTF and transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would be transported to LANL for fabrication into heat sources for radioisotope power systems and heating units.

Under Alternative 1, raw materials, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for raw target material acquisition, material storage, target fabrication, target irradiation, and postirradiation processing and the final destination for the medical and industrial isotopes and the plutonium-238 product or various research and development test sites.

The six options under this alternative are associated with the type of nuclear fuel to be used for FFTF operations and the specific facilities to be used for target fabrication and processing. The first three options (Options 1 through 3) would involve operating FFTF with a mixed oxide fuel core for the first 21 years and a highly enriched uranium fuel core for the remaining 14 years. The last three options (Options 4 through 6) would involve operating FFTF with a mixed oxide fuel core for the first 6 years and a highly enriched uranium fuel core for the remaining 29 years. FFTF can provide similar irradiation services with either a mixed oxide core or a highly enriched uranium core. Potential impacts from the deactivation of FFTF at the end of its operating life are not explicitly covered under this alternative, but are addressed under Alternative 5.

The U.S. nonproliferation policy (U.S. House of Representatives 1992 and the White House 1993) strongly discourages the use of highly enriched uranium fuel in civilian research and test reactors. The Reduced Enrichment for Research and Test Reactors Program implements this policy by developing technical means to reduce and eventually eliminate the use of highly enriched uranium in research and test reactors throughout the world and in the United States, without decreasing their safety or significantly affecting their performance and operating costs.

To be in compliance with these policy directives, the most appropriate fuel supply for FFTF in the out years (beyond current Hanford mixed oxide and possible SNR–300 mixed oxide supplies) must be determined by a technical study with the preferred fuel source being low-enriched uranium. Highly enriched uranium fuel should only be considered if low-enriched uranium is not technically feasible, or if there are significant impacts on safety, performance, or cost associated with using fuels other than highly enriched uranium.

In the event that a decision is made to restart the reactor, and to support these policy directives, DOE's Office of Nonproliferation and National Security would undertake a study to consider the technical feasibility of low-enriched uranium fuel (under the Reduced Enrichment for Research on Test Reactors Program) for FFTF. If low-enriched uranium fuel is found infeasible, DOE would subsequently procure highly enriched uranium fuel in a manner consistent with U.S. nonproliferation policy. This study would be conducted, decisions implemented, and fuel made available during the time period between a Record of Decision indicating an FFTF restart and prior to the end of available Hanford mixed oxide and possible SNR–300 mixed oxide fuel supplies.

For the purposes of presenting a bounding analysis in the NI PEIS, DOE has analyzed the impacts of using highly enriched uranium fuel in FFTF after the available mixed oxide fuel supplies have been expended. These impacts would bound those of using a low-enriched uranium fuel form.

Alternative 2—Use Only Existing Operational Facilities. Under Alternative 2, DOE would use existing operating DOE reactors or U.S. commercial nuclear power plants to produce plutonium-238 for future space missions. The production of medical and industrial isotopes and support of civilian nuclear energy research and development in DOE reactors and accelerators would continue at the No Action Alternative level.

The currently operating DOE reactors, HFIR and ATR, cannot fully meet the projected long-term need for medical isotope production and civilian nuclear energy research and development, with or without the plutonium-238 production mission. Depending on the combination of facilities used in Alternative 2, HFIR and ATR could continue their current support of the medical and industrial isotope and research and development missions, including some near-term growth, while accommodating the production of plutonium-238. Under other scenarios, some of the near-term growth in medical and industrial isotope production and civilian nuclear energy research and development possible in these reactors could be limited by the addition of the plutonium-238 production. In any case, non-DOE use of these facilities would be affected by the addition of the plutonium-238 mission. If a commercial reactor were used for plutonium-238 production, the DOE facilities would be unaffected and would continue operating as discussed under the No Action Alternative.

Another component of Alternative 2 is permanent deactivation of FFTF. Permanent deactivation of FFTF (Alternative 5) would occur in conjunction with any of the options under Alternative 2, 3, or 4. Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue under Alternative 2.

Targets for plutonium-238 production would be fabricated in one of three facilities at ORNL, INEEL, or Hanford. The material needed for target fabrication (neptunium-237) would be processed and transported from SRS to the fabrication facilities where it would be stored until fabrication. The targets would be irradiated at existing reactor facilities (HFIR, ATR, CLWR, as described in Section S.4) and would be transported back to the fabricating facilities for postirradiation processing.

Under Alternative 2, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, and postirradiation processing. In addition, the plutonium-238 product would be transported to LANL.

Nine options are proposed under this alternative. Options 1 through 3 involve the irradiation of targets in ATR at INEEL. Options 4 through 6 involve the irradiation of targets in a generic CLWR. Options 7 through 9 involve the irradiation of targets in both INEEL's ATR and ORNL's HFIR.

Alternative 3—Construct New Accelerator(s). Under Alternative 3, one or two new accelerators would be used for target irradiation for the evaluation period of 35 years. The new accelerator(s), which would be constructed at an existing DOE site(s), would be used to irradiate all of the targets (i.e., for production of plutonium-238, isotopes for medical and industrial uses, and materials testing for research and development). Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue.

The targets for plutonium-238 production would be fabricated in one of the three alternative facilities at ORNL, INEEL, or Hanford. The material needed for the target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities, where it would be stored until fabrication. The targets would be irradiated at a new high-energy accelerator facility and transported back to the target fabricating facilities for postirradiation processing.

Targets for medical and industrial isotope production would be fabricated in a new support facility located at the same site as the low-energy accelerator. Target materials would be stored on site until fabrication. The targets would be irradiated in the low-energy accelerator and returned to the new support facility for postirradiation processing. Site selection for Alternative 3 is not evaluated as part of the NI PEIS. Because Alternative 3 is evaluated at a generic DOE site, no credit was taken for any support infrastructure existing at the site, and it was postulated that a new support facility would be required to support operation of the low-energy accelerator and its missions and the high-energy accelerator civilian nuclear energy research and development missions if both accelerators were located on the same site. While this approach bounds the environmental impact assessment for the implementation of Alternative 3, it overstates the impacts because the NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 3 or the low-energy accelerator alone is selected by the Record of Decision for subsequent consideration, follow-on NEPA reviews would evaluate potential locations for either both accelerators or one of the accelerators. It is unlikely that DOE would consider locating the new low-energy or high-energy accelerator on a DOE site that does not have existing infrastructure capable of supporting all or most of the mission requirements.

Under Alternative 3, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, postirradiation processing, and the final destination of the plutonium-238. Alternative 3 also would include decontamination and decommissioning of the accelerator(s) and the processing facility when the missions are over, as well as deactivation of FFTF at Hanford.

Alternative 4—Construct New Research Reactor. Under Alternative 4, a new research reactor would be used for target irradiation for the evaluation period of 35 years. The new research reactor, to be constructed at an existing DOE site, would be used to irradiate all targets (i.e., for the production of plutonium-238, isotopes for medical and industrial uses, and materials testing for civilian nuclear energy research and development). Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue.

The targets for plutonium-238 production would be fabricated in one of the three facilities at ORNL, INEEL, or Hanford. The material needed for the target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities where it would be stored until fabrication. The targets would be irradiated at the new research reactor facility and transported back to the target fabrication facilities for postirradiation processing.

Targets for medical and industrial isotope production would be fabricated in a new support facility located at the same site as the new research reactor. Target materials would be stored on site until fabrication. The targets would be irradiated in the new research reactor and returned to the new support facility for postirradiation processing.

Alternative 4 site selection is not evaluated as part of the NI PEIS. Because Alternative 4 is evaluated at a generic DOE site, no credit was taken for any existing support infrastructure at the site and it was postulated that a new support facility would be required to support operation of the new research reactor and its missions. While this approach bounds the environmental impact assessment for the implementation of Alternative 4, it overstates the impacts because the NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 4 is selected by the Record of Decision for subsequent consideration, follow-up NEPA reviews would evaluate potential locations for the new research reactor. It is unlikely that DOE would consider locating the new research reactor on a DOE site that does not have existing infrastructure capable of supporting all or most of the proposed medical and industrial isotope production and civilian nuclear energy research and development mission requirements.

Under Alternative 4, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, postirradiation processing, and the final destination of the plutonium-238. Alternative 4 also would include the decontamination and decommissioning of both the research reactor and the support facility when the missions are over, as well as deactivation of FFTF at Hanford.

Alternative 5—Permanently Deactivate FFTF (with No New Missions). Under Alternative 5, DOE would permanently deactivate FFTF, with no new missions. Medical and industrial isotope production and civilian nuclear energy research and development missions, at the existing facilities described in Chapter 3, would continue. DOE's nuclear facilities infrastructure would not be enhanced.

Selection of Alternatives

In the NI PEIS Record of Decision, DOE can select any alternative or combination of alternatives or elements of alternatives. For example, DOE could select Alternative 2 in combination with the new low-energy accelerator element of Alternative 3. This combination of alternative elements would provide for the requirements of the plutonium-238 production, enhanced civilian nuclear energy research and development capability, and enhanced medical and industrial isotope production capability.

Alternatives Considered and Dismissed

In developing a range of reasonable alternatives, DOE examined the capabilities and available capacities of the existing and planned nuclear research facilities (accelerators, reactors, and processing [hot] cells) that potentially could be used to support one or all of the proposed isotope production and research missions (DOE 2000a). The following facilities were initially considered, but were subsequently dismissed as reasonable alternatives for meeting DOE's nuclear infrastructure mission requirements.

Irradiation Facilities Dismissed. DOE evaluated the irradiation capabilities of existing government, university, and commercial irradiation facilities to determine whether they could significantly support the proposed expanded nuclear infrastructure missions. **Table S–2** presents irradiation facilities that were initially considered but dismissed from further evaluation because they lacked technical capability or available capacity. Reasons for lacking technical capability include that the facility has been permanently shut down, it does not possess the capability to produce steady-state neutrons, or that it could not maintain sufficient power levels to adequately support steady-state neutron production. Facilities were similarly dismissed if existing capacity was fully dedicated to existing missions, or if use of existing capacity to support the NI PEIS proposed action would impact existing missions. Although a number of facilities shown in Table S–2 have some available capacity, their combined available capacity is a very small percentage of the capacity needed to support the missions evaluated in the NI PEIS.

Two of these facilities, IPF at the Los Alamos Neutron Science Center (LANSCE) and BLIP at BNL, were identified in the NI PEIS Notice of Intent as existing facilities that could potentially support the proposed nuclear infrastructure missions. IPF produces radioisotopes using LANSCE's half-mile accelerator that delivers medium-energy protons. IPF's three major products include germanium-68, strontium-82, and sodium-22. As a result of changing DOE missions, the production of radioisotopes at target area "A" of the LANSCE has been rendered inoperable. DOE is currently in the process of upgrading the LANSCE facility with a new 100-million-electron-volt IPF. The facility is scheduled for completion in 2001. After completion of the LANSCE upgrade, the existing capability at these two facilities will be twice the current need for accelerator-generated medical isotopes. Thus, no new accelerator capacity is needed in the short term. Should isotope demand grow consistent with the Expert Panel Report, there will be a need for expanded isotope production capacity for those isotopes generated by IPF and BLIP. IPF and BLIP were dismissed as a reasonable alternative for the production of medical isotopes because they cannot meet the projected future demand for accelerator-produced isotopes.

Table S–2 Irradiation Facilities Considered and Dismissed from Further Evaluation

Reasons for Dismissal	Facility
Facilities lacking sufficient neutron production capacity to support the NI PEIS proposed action without impacting existing missions	Neutron Radiographic Reactor Argonne National Laboratory–West
	Brookhaven Medical Research Reactor Brookhaven National Laboratory
	National Bureau of Standards Reactor National Institute of Standards and Technology
	General Atomics Training, Research, and Isotope Production Reactors
	University Small Research Reactors
	University Large Research Reactors (i.e., Massachusetts Institute of Technology and University of Missouri)
	ATLAS Heavy Ion Facility Argonne National Laboratory
	Holifield Radioactive Ion Beam Facility Oak Ridge National Laboratory
	Oak Ridge Electron Linear Accelerator Oak Ridge National Laboratory
	Heavy Ion Linear Accelerator Lawrence Berkeley National Laboratory
	Alternating Gradient Synchrotron Heavy Ion Facility Brookhaven National Laboratory
	Continuous Electron Beam Accelerator Facility Thomas Jefferson National Accelerator Facility
	Electron Linear Accelerator Lawrence Livermore National Laboratory
	University Linear Accelerators
Facilities with capacity fully dedicated to existing missions	Annular Core Research Reactor Sandia National Laboratory
	Brookhaven LINAC Isotope Producer Brookhaven National Laboratory
Facilities not capable of steady-state neutron production	Sandia Pulse Reactor II and III Sandia National Laboratory
	Transient Reactor Test Facility Argonne National Laboratory–West
	Zero Power Physics Reactor Idaho National Engineering and Environmental Laboratory
	Power Burst Facility Idaho National Engineering and Environmental Laboratory
	Intense Pulsed Neutron Source Argonne National Laboratory
	Flash X-Ray Facility Lawrence Livermore National Laboratory
Facilities with insufficient power to sustain adequate steady-state neutron production	Brookhaven Medical Research Reactor Brookhaven National Laboratory
	Los Alamos Critical Assembly Facility Los Alamos National Laboratory
	General Atomics Training, Research and Isotope Production Reactors
	University Small Research Reactors
	Booster Applications Facility Brookhaven National Laboratory

Table S–2 Irradiation Facilities Considered and Dismissed from Further Evaluation (Continued)

Reasons for Dismissal	Facility
Facilities with insufficient power to sustain adequate steady-state neutron production (continued)	Cyclotron Facility Brookhaven National Laboratory
	Low-Energy Demonstration Accelerator[a] Los Alamos National Laboratory
Facilities that jointly can meet existing accelerator-produced medical isotope demands but cannot meet projected future demands.	Los Alamos Neutron Science Center Linear Accelerator Isotope Production Facility Los Alamos National Laboratory
	Brookhaven LINAC Isotope Producer Brookhaven National Laboratory
Facilities that are under construction with capacity fully dedicated to other planned missions	Dual Axis Radiographic Hydrodynamic Test Facility Los Alamos National Laboratory
	Spallation Neutron Source Oak Ridge National Laboratory
Facilities that have been permanently shut down	High Flux Beam Reactor Brookhaven National Laboratory
	Tower Shielding Facility Oak Ridge National Laboratory
	Cyclotron Facility Oak Ridge National Laboratory

a. Not listed in source document.
Key: LINAC, linear accelerator; ATLAS, Argonne Tandem - LINAC Accelerator System.
Source: DOE 2000a.

The AGS accelerator complex at BNL was evaluated for meeting the mission requirements of medical and industrial isotope production, plutonium-238 production, and civilian nuclear energy research and development. AGS presently accelerates up to 7×10^{13} protons to 24 gigavolts (1,000 million electron volts) with a cycle time of approximately 2.5 seconds. This corresponds to a beam power of approximately 100 kilowatts. The complex was dismissed as a reasonable alternative because the potential neutron flux generated by the facility in the required configuration (i.e., with a spallation target) would not be adequate to meet the mission goals and, in addition, operating the complex in the required configuration would not be compatible with the present primary mission of the facility (Kovar 2000).

Two existing operating DOE facilities, ATR and HFIR, were evaluated as components of Alternative 2, Use Only Existing Operational Facilities. These two facilities currently provide isotope production capability, and were examined for their ability to meet the isotope production and civilian nuclear energy research and development requirements of the proposed expanded missions. In addition, DOE considered whether production from ATR and HFIR could be enhanced by increasing power levels at the reactors or through other modifications to the facilities, which included the installation of rapid radioisotope retrieval systems for the production of isotopes with a short half-life. In general, the installation of rapid radioisotope retrieval systems in reactors does not increase the ability of reactors to produce larger quantities of isotopes, it enable the reactors to produce a broader spectrum of isotopes. While some growth is possible in isotope production at ATR and HFIR, such growth would be insufficient to meet the long-term growth projections. Further growth could only be enabled by increasing reactor power levels. At ATR, increases in power levels are possible to the extent that priority DOE Office of Naval Reactor missions are not impacted. Raising ATR power would only delay the point in time at which capacity is reached. The power level at HFIR is already at 100 percent of its current Authorization Basis (85 megawatts), and modification of this Authorization Basis would be required to increase to full-design power (100 megawatts). Increasing the power levels at ATR and/or HFIR will enhance the isotope production capability of these reactors. However, the enhancement in production capability would not be adequate to meet the future demand for isotope production; it would only delay the point in time at which the United States' reactor isotope production capacity is reached. Therefore, increasing the power levels at ATR and/or HFIR was dismissed as a reasonable alternative for meeting the requirements of the DOE missions.

Modification of CLWRs to enable online insertion and retrieval of targets for the medical and industrial isotope production missions was evaluated and dismissed as a reasonable alternative. This decision was made because the required facility modifications would be significant and would include penetrations into the reactor vessel and, potentially, the containment vessel. Additional facility modifications would be required to enable loading of the targets into a shielded cask for transport to a processing facility. Performing these facility modifications would require an extended refueling outage (with a resulting loss of power generation revenue to the CLWR owner) and could potentially extend subsequent maintenance or refueling outages to inspect, test and maintain the insertion and retrieval system, reactor vessel penetrations, and potential containment vessel penetrations. CLWRs were considered for the production of medical isotopes with moderate and long half-lives by irradiating targets in the CLWR vessel but outside the reactor core region (i.e., outside of the fuel assembly region). Only one isotope, strontium-89, was considered a potential candidate for production in the CLWR outside of the reactor core region. Strontium-89 has a half-life of 50.5 days. Irradiated targets containing strontium-89 could only be harvested from a CLWR every 18 to 24 months during a scheduled reactor refueling outage. Approximately 10 CLWRs, with refueling outages scheduled every 2 to 3 months, would be required to support a program to ensure a continuous and reliable supply of strontium-89. Due to the CLWR's ability to irradiate targets for only a very limited array of medical isotopes (only one isotope in current demand was identified), it was not considered a reasonable alternative for expanding the U.S. infrastructure to provide an overall enhancement of the medical isotope production mission. CLWRs were also considered for the DOE civilian nuclear energy research and development missions. CLWRs will continue to support the commercial industry research and development activities by providing a test bed for industry sponsored lead test assemblies and other related research. CLWRs cannot meet most of the requirements for supporting the DOE civilian nuclear energy research and development missions and were therefore dismissed as a reasonable alternative for supporting these missions.

Canadian Deuterium Uranium (CANDU) reactors, operating in Canada, were considered for supplying irradiation services for the plutonium-238 production mission. (Note: Canada is currently the major supplier of medical radioisotopes used in the United States.) Since use of the CANDU reactors does not meet the programmatic issue being addressed in the NI PEIS, that is the enhancement of the United States infrastructure to support the proposed missions, the CANDU reactors were considered and dismissed as a reasonable alternative. However, the environmental impacts associated with transporting the nonirradiated and irradiated neptunium-237 targets between the CANDU reactors and the target fabrication and processing facilities in the United States are bounded by the evaluations presented in the NI PEIS for the commercial light water reactor options of Alternative 2, Use Only Existing Operational Facilities.

Some facilities listed in Table S–2 that do not have the capacity to support the proposed action without impacting existing missions do have some existing medical or industrial isotope production or civilian nuclear energy research and development missions. These facilities will continue to support their existing missions at current levels.

Processing Facilities Dismissed. Numerous existing U.S. processing hot cell facilities possess the capabilities and capacity to support the proposed missions. Given this general availability, only existing processing facilities that are colocated at DOE's candidate irradiation facility sites (i.e., ORNL, INEEL, and Hanford) were evaluated in the NI PEIS. Although multiple processing facilities exist at each of these sites, only the most suitable facilities in terms of capability, capacity, and availability were given further consideration. The processing facilities that were dismissed from consideration are listed in **Table S–3**.

Table S–3 Processing Facilities Considered and Dismissed from Further Evaluation

Location	Facility
Argonne National Laboratory	Irradiated Materials Facility
	Alpha-Gamma Hot Cell Facility
	Building 205
Argonne National Laboratory–West	Hot Fuel Examination Facility
	Analytical Laboratory
	Fuel Conditioning Facility
Brookhaven National Laboratory	Target Processing Laboratory
	Metallurgical Evaluation Laboratory
	High Intensity Radiation Development Laboratory
Hanford Site	222-S Facility
	Postirradiation Testing Laboratory
	Shielded Material Facility
Idaho National Engineering and Environmental Laboratory	Test Area North Hot Shop and Hot Cell Facilities
	Remote Analytical Laboratory
	Fuel Processing Facility
Los Alamos National Laboratory	Chemistry and Metallurgical Research Building
	Technical Area TA–48
Oak Ridge National Laboratory	Radioactive Materials Analytical Laboratory
	Building 4501
	Irradiated Materials Examination and Testing Facility
	Radioisotope Development Laboratory
	Irradiated Fuels Examination Laboratory
Sandia National Laboratories	Hot Cell Facility
Savannah River Site	Defense Waste Processing Facility
	High-level cells
	Intermediate-level cells
	Californium shipping/receiving facility
	Californium processing facility

Source: DOE 2000a.

Based on comments on the scope of the *Plutonium-238 Production EIS*, the H-Canyon and HB-Line facilities at SRS that previously performed the processing for the plutonium-238 production mission were reconsidered as potential processing facilities for the proposed plutonium-238 production mission even though the facilities are not colocated with a proposed irradiation facility. After reviewing the plutonium-238 production target fabrication and processing requirements, the capabilities and capacities of the facilities, and the modifications and resources required to support the plutonium-238 production mission, use of the H-Canyon and HB-Line facilities was dismissed as a reasonable alternative because:

1. DOE plans to shut down these facilities following completion of their current missions to stabilize and prepare for disposition of Cold War legacy nuclear materials and certain spent nuclear fuel, and a determination that a new nonchemical processing technology is capable of preparing aluminum-clad research reactor spent nuclear fuel for ultimate disposition.

2. The cost to extend the operating lives of these facilities to support plutonium-238 production for the proposed 35-year evaluation period would be approximately one order of magnitude higher than the costs associated with the processing facilities evaluated in the NI PEIS.

A commentor also proposed using the H-Canyon and HB-Line for a short campaign to produce all of the required plutonium-238. Based on prior production rates, it would take approximately 7 years to produce 175 kilograms (385 pounds) of plutonium-238, the total plutonium-238 production goal. The target fabrication and irradiation requirements to support this processing campaign to produce 25 kilograms (55 pounds) per year of plutonium-238 would be significant but feasible. The irradiation requirements could be supported by operating five CLWRs or operating FFTF at the 400-megawatt power level. However, a concern about the short campaign option is that the plutonium-238 would be stored a long time before use and because of natural decay may not meet the specification requirements when finally needed. This alternative was dismissed because of the uncertainty that, over time, the plutonium-238 produced may not meet the required specification for NASA missions.

Preferred Alternative

CEQ regulations require an agency to identify its preferred alternative(s) in the final programmatic environmental impact statement (40 CFR 1502.14(e)). The preferred alternative is the alternative that the agency believes would fulfill its statutory mission, giving consideration to environmental, economic, technical, and other factors. Consequently, to identify a preferred alternative, DOE has developed information on potential environmental impacts, costs, policy issues, technical risks, and schedule risks for the alternatives under consideration. The NI PEIS provides information on the environmental impacts. Cost, nonproliferation policy, and various technical reports have also been prepared and are available in the appropriate DOE Reading Rooms for public review.

Based on the analysis discussed above, DOE's Preferred Alternative is to apply its existing infrastructure to the extent possible to pursue the missions outlined in the NI PEIS, that is, Alternative 2, Option 7. Under this approach, DOE proposes to consider opportunities to enhance its existing facilities to maximize the agency's ability to address future mission needs.

The Preferred Alternative also addresses the future of FFTF. While DOE recognizes that this facility has unique capabilities, the Department did not receive the commitments from the private sector or other governments that would clearly justify the restart of the facility. Lacking such commitment, DOE would permanently deactivate FFTF under the Preferred Alternative.

Finally, under the Preferred Alternative, DOE proposes to reestablish domestic production of plutonium-238, as needed, to support U.S. space exploration. ATR in Idaho and HFIR in Tennessee would be used, as appropriate, to irradiate targets for this purpose without interfering with either reactor's primary mission. The Preferred Alternative includes processing the irradiated plutonium-238 targets at REDC at ORNL.

In view of the lack of commitments that would justify the restart of FFTF or the construction of new facilities as proposed under Alternatives 3 and 4, DOE anticipates that its current infrastructure will serve the needs of the research and isotope communities for the next several years. In particular, DOE will consider opportunities to enhance its effort to provide medical and research isotopes. If significantly larger amounts of isotopes are required in the future, DOE would rely on the private sector to fulfill these needs.

As a potential option for the longer-term future, DOE proposes to work over the next 2 years to establish a conceptual design for an Advanced Accelerator Applications (AAA) facility. Such a facility, which would be used to evaluate spent fuel transmutation, conduct various nuclear research missions, and ensure a viable backup technology for the production of tritium for national security purposes, was proposed and initial work funded in the fiscal year 2001 Energy and Water Appropriation. If DOE proposes specific enhancements of existing facilities or development of the AAA facility, further NEPA review would be conducted.