Appendix P
Nuclear Infrastructure Cost Report Summary

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

August 2000

SUMMARY

S.1 INTRODUCTION AND BACKGROUND

The following is a summary of a report evaluating the costs associated with the U.S. Department of Energy (DOE) proposal to enhance its existing nuclear facility infrastructure to accommodate new and expanding missions in the areas of nuclear research and development and isotope production. DOE currently does not have sufficient steady-state irradiation sources to meet the Nation's projected needs for: (1) isotopes for medical and industrial uses, (2) fuel to power future U.S. National Aeronautics and Space Administration (NASA) spacecraft, and (3) nuclear research and development.

The alternatives for the proposed expanded isotope production missions that were evaluated in this Cost Report are 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* (Nuclear Infrastructure Programmatic Environmental Impact Statement [NI PEIS]) (DOE 2000).

Costs of potential decisions are not typically evaluated in an environmental impact statement (EIS), but DOE recognizes that the financial implications of its future programs are important considerations for decision making and has resolved to inform the public about those costs. The findings of this Cost Report and public input received on the NI PEIS are among the factors that DOE will consider when preparing the Record of Decision.

The programmatic alternatives considered in this Cost Report focus on the use of irradiation facilities that are currently operating, could be brought online, or could be constructed and operated to meet DOE's irradiation needs. Thus, the report considers the following alternatives (presented in more detail in Chapter 2 of the NI PEIS):

- **No Action Alternative**, maintaining the status quo; that is, DOE's existing facilities would continue to meet their current mission requirements within their operating levels, and DOE would not enhance existing U.S. nuclear facility infrastructure or expand its current missions to accommodate new missions.

- **Alternative 1**, which includes resuming operation of the Fast Flux Test Facility (FFTF) at the Hanford Site (Hanford) in Richland, Washington

- **Alternative 2**, using only existing operational facilities (the Advanced Test Reactor [ATR] at Idaho National Engineering and Environmental Laboratory [INEEL], the High Flux Isotope Reactor [HFIR] at Oak Ridge National Laboratory [ORNL], or a generic commercial light water reactor [CLWR]) to accommodate the plutonium-238 production mission

- **Alternative 3**, constructing and operating one or two new accelerator(s) at an existing DOE site

- **Alternative 4**, constructing and operating a new research reactor at an existing DOE site

- **Alternative 5**, permanently deactivate Hanford's FFTF without enhancing U.S. nuclear facility infrastructure to accommodate new or expanded missions. Although Alternatives 2, 3, and 4 include the deactivation of FFTF, Alternative 5 is included as a stand-alone alternative in response to numerous public comments received during the scoping period for the NI PEIS.

The No Action Alternative and Alternatives 1 through 4 each have several options, evaluated in this Cost Report. These options involve primarily DOE facilities that could be used for fabrication, storage, and postirradiation processing of the targets necessary for the program missions. Among the facilities proposed are: (1) the Radiochemical Engineering Development Center (REDC) at ORNL, (2) the Fluorinel Dissolution Process Facility (FDPF) and/or the Chemical Processing Plant (CPP) Building 651 (CPP–651) (storage only) at INEEL, (3) the Fuels and Materials Examination Facility (FMEF) at Hanford, (4) Building 325, the Radiochemical Processing Laboratory (RPL), and Building 306–E at Hanford, and (5) a new facility to be constructed and operated at an existing DOE site to support the one or two new accelerator or new research reactor alternatives. **Table S-1** presents an overview of the alternatives and options evaluated in the NI PEIS.

S.2 DECISIONS TO BE MADE

In reaching programmatic decisions regarding potential expansion of its existing nuclear facility infrastructure, DOE will factor the analytical environmental results of the NI PEIS together with the findings presented in this Cost Report and the NI Nonproliferation Impacts Assessment[1], the *Nuclear Science and Technology Infrastructure Roadmap*, recommendations of the Nuclear Energy Research Advisory Committee (NERAC) and its various subcommittees, public input, and other DOE policy and programmatic considerations.

With the benefit of this broad base of information, DOE intends to make the following decisions:

- Whether to expand its current nuclear facility infrastructure to meet projected requirements for future medical and industrial isotope production, plutonium-238 production, and nuclear research and development.

- If a decision is made to expand DOE's existing nuclear facility infrastructure, whether to (1) construct new facilities (one or two accelerators or a research reactor), or (2) restart FFTF at Hanford as part of a nuclear infrastructure expansion program and, if not, whether to remove FFTF from standby mode and permanently deactivate it in preparation for its eventual decontamination and decommissioning.

- If a decision is made not to expand DOE's existing nuclear facility infrastructure, decide whether to (1) select from existing operating facilities those needed to support the proposed plutonium-238 mission, or (2) continue purchasing plutonium-238 from Russia to support future NASA space missions, and (3) whether DOE inventories of neptunium-237 should be relocated and stored for future plutonium-238 production needs. Existing operating facilities performing medical, research, and/or industrial isotope production and/or nuclear research and development missions would continue to support existing missions at current levels.

The programmatic decisions to be made in association with the NI PEIS are the responsibility of the DOE Office of Nuclear Energy, Science and Technology. In addition to the range of reasonable programmatic alternatives evaluated in the NI PEIS, DOE could choose to combine components of several alternatives in selecting the most appropriate strategy. For example, DOE could select a low-energy accelerator to produce medical, research, and industrial isotopes, and an existing operating reactor to produce plutonium-238 and conduct nuclear research and development. If alternatives were selected involving the siting, construction, and operation of one or two new accelerators or a new research reactor, appropriate site- and project-specific National Environmental Policy Act (NEPA) documentation, tiered from the NI PEIS, would be prepared.

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[1]The DOE Office of Arms Control and Nonproliferation is analyzing the nonproliferation policy impacts of FFTF's restart, and of the other alternatives and their various options, and will be reporting its findings in the *Nonproliferation Impacts 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* (Nuclear Infrastructure Nonproliferation Impacts Assessment).

Table S–1 Alternatives and Options Evaluated in the NI PEIS

	Option Number	Irradiation Facility	*Plutonium-238 Production Mission*		*Medical and Industrial Isotopes Production and Nuclear Research and Development Mission*	
			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)	–	–	–	–	–	–

Key: RPL/306-E = Radiochemical processing Laboratory and Hanford 300 Area Building 306-E.

a. Hanford FFTF would start up and operate with onsite and German mixed oxide (MOX) fuel and then highly enriched uranium (HEU) fuel.

b. Hanford FFTF would start up and operate with only the onsite MOX fuel and then HEU fuel.

c. The new facility would not be required if a DOE site with available support capability and infrastructure is selected.

The programmatic decisions to be reached in association with the NI PEIS are schematically presented in **Figure S–1.** In accordance with the first-tier "yes or no" decision to be made (as seen in Figure S–1), alternatives analyzed in the NI PEIS were arranged into two groups—nonexpanded infrastructure alternatives, including the No Action Alternative and Alternatives 2 and 5; and expanded infrastructure alternatives, including Alternatives 1, 3, and 4. Cost estimates for the nonexpanded and expanded infrastructure alternatives were also arranged into these groups and are presented in Section S.3, Results and Conclusions.

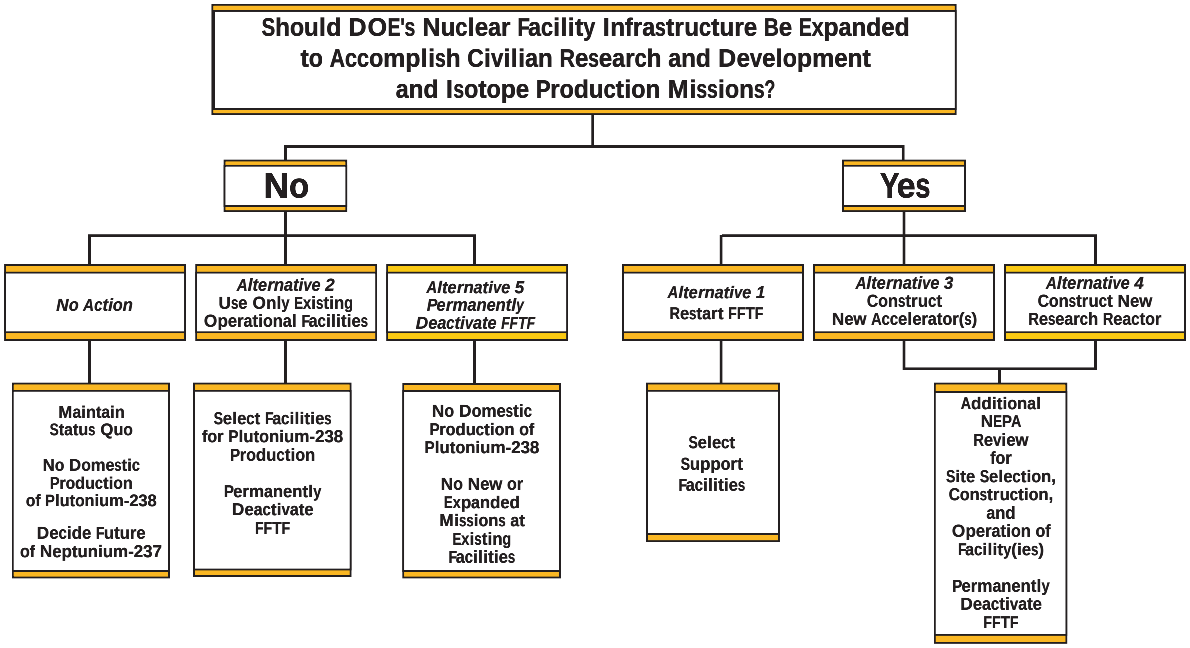

Figure S–1 Pending Decisions

S.3 RESULTS AND CONCLUSIONS

Summaries of cost estimates for the nonexpanded and expanded infrastructure alternatives identified in Figure S–1 are presented in **Tables S–2** and **S–3**. All figures shown represent millions of FY 2000 dollars. No credit was taken for projected revenues from medical and industrial isotope sales, or from fees paid by domestic or international users of facilities.

Nonexpanded Infrastructure Alternatives

A summary of the estimated costs of the nonexpanded infrastructure alternatives (the No Action Alternative and Alternatives 2 and 5 of the NI PEIS) is presented in Table S–2. Capital costs (costs of modifying existing facilities), costs for permanently deactivating FFTF (where appropriate), annual operating costs, and transportation costs are presented for irradiation facilities and neptunium-237 storage and plutonium-238 processing facilities. In addition, costs for the purchase and transport of Russian plutonium-238 are presented. DOE would continue its medical and industrial isotope production and nuclear research and development activities of the current operating levels of existing facilities.

Table S–2 Summary of Estimated Costs of Nonexpanded Infrastructure Alternatives (Millions of FY 2000 Dollars)

					Alternatives									
					Alternative 2: Use Only Existing Operational Facilities									*Alternative 5: Deactivate FFTF*
Cost Elements	*No Action*				*ATR*			*CLWR*			*ATR and HFIR*			
Irradiation Facilities														
FFTF in standby mode (annual) (A)	40.8													
FFTF deactivation (B)					281.2			281.2			281.2			281.2
Startup; target development, testing, and evaluation (C)					2			20			3.5			
Operations (annual) (D)					8.1			5.1			8.1			
Russian Plutonium-238														
Purchase 5 kilograms (11 pounds) of Russian Plutonium-238 (annual)	8.7 [a]													
Transport Russian Plutonium-238 to LANL (annual) (E)	0.14													
Total Annual Costs	**8.84**													
Processing Facility Alternative Options	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Neptunium-237 Storage and Plutonium-238 Processing Facilities		**REDC**	**CPP-651**	**FMEF**	**REDC**	**FDPF**	**FMEF**	**REDC**	**FDPF**	**FMEF**	**REDC**	**FDPF**	**FMEF**	
Modification and startup costs (F)		16.9	2.12	19.3	51.2	37.2	72.8	55.1	41.2	72.8	51.2	37.2	72.8	
Operations (annual) (G)		1.5	1.5	2.6	7.8	6.7	15.3	10.8	9.7	18.3	7.8	6.7	15.3	
Medical and Industrial Isotope/Nuclear Research and Development Processing Facilities [b]														
Modification or construction and startup costs														
Operations (annual)														
Combined Estimated Costs														
Total Costs (B+C+F)	**0**	16.9	2.12	19.3	334.4	320.4	356	356.3	342.4	374	335.9	321.9	357.5	281.2
Annual Costs (A+D+E+G)	49.6	51.1	51.1	52.2	15.9	14.8	23.4	15.9	14.8	23.4	15.9	14.8	23.4	0
Plutonium-238 Production Transportation														
Neptunium-237 from SRS (total)		1.4	7.1	8.5	1.4	7.1	8.5	1.4	7.1	8.5	1.4	7.1	8.5	
Total annual plutonium-238 production shipping and handling costs					0.39	0.24	0.32	0.41	0.40	0.46	0.34	0.29	0.35	
Medical and Industrial Isotope Transportation (annual) [b]														

Key: LANL = Los Alamos National Laboratory; SRS = Savannah River Site.

a. Based on FY 2000 contract year eight, $1.74 million per kilogram × 5 kilograms. Succeeding year purchase price escalated at a contractual 3.5 percent per year for the remaining two years of the contract.

b. DOE would continue its medical and industrial isotope production and nuclear research and development activities at the current operating levels of existing facilities.

Note: Shaded areas indicate that no costs would be incurred under that alternative and/or option.

Table S–3 Summary of Estimated Costs of Expanded Infrastructure Alternatives (Millions of FY 2000 Dollars)

Cost Elements	*Alternatives*								
	Alternative 1: Restart FFTF			*Alternative 3: Construct New Accelerator(s)*			*Alternative 4: Construct New Research Reactor*		
Irradiation Facilities									
Modification or construction and startup, including target development, testing, and evaluation	314			1,096.0			312		
FFTF deactivation				281.2			281.2		
Total costs (A)	**314**			**1,377.2**			**593.2**		
Operations (annual) [a] (B)	58.9			45.1			25		
Processing Facility Alternative Options	**1 and 4 [b]**	**2 and 5 [b]**	**3 and 6 [b]**	**1**	**2**	**3**	**1**	**2**	**3**
Plutonium-238 Production Facilities	**REDC**	**FDPF**	**FMEF**	**REDC**	**FDPF**	**FMEF**	**REDC**	**FDPF**	**FMEF**
Modification and startup costs (C)	55.1	41.2	72.8	51.2	37.2	72.8	51.2	37.2	72.8
Operations (annual) (D)	10.8	9.7	18.3	7.8	6.7	15.3	7.8	6.7	15.3
Medical and Industrial Isotope/Nuclear Research and Development Processing Facilities	**RPL/306-E**		**FMEF**	**New Processing Support Facility**			**New Processing Support Facility**		
Modification or construction and startup costs (E)	29.4		36.8	71.1			71.1		
Operations (annual) (F)	12.1		12.9	23.3			23.3		
Combined Estimated Costs									
Total Costs (A+C+E)	398.5	384.6	423.6	1,499.5	1,485.5	1,521.1	715.5	701.5	737.1
Annual Operating Costs [c] (B+D+F)	81.8	80.7	90.1	76.2	75.1	83.7	56.1	55	63.6
Plutonium-238 Production Transportation									
Neptunium-237 from SRS (total)	1.4	7.1	8.5	1.4	7.1	8.5	1.4	7.1	8.5
Total annual plutonium-238 production shipping and handling costs	0.41	0.28	0.28	1.54	1.50	1.54	2.39	2.37	2.42
Medical and Industrial Isotope Transportation (annual)	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73

Key: SRS = Savannah River Site; RPL/306-E = Radiochemical Processing Laboratory and Hanford 300 Area Building 306-E.

a. Annual operating costs are an average of FFTF operating costs using onsite mixed oxide fuel (MOX) = $56.2 million, German MOX fuel = $56.7, highly enriched uranium (HEU) fuel = $63.9 million.

b. Options 1, 2, and 3 assume FFTF would use onsite MOX, German MOX, and then HEU fuel during operations. Options 4, 5, and 6 assume FFTF would use onsite MOX and then HEU fuel during operations.

c. Alternative 1 annual operating costs include an average of the FFTF operating costs.

Note: Shaded area indicates that no costs would be incurred under that alternative cost element.

- Under the No Action Alternative, FFTF would be maintained in its current standby mode at a cost of $40.8 million per year. The No Action Alternative would also include the annual purchase of 5 kilograms (11 pounds) of Russian plutonium-238 at an assumed annual cost of $8.84 million per year. Additional costs would depend on which option is chosen under the No Action Alternative. Option 1 would only incur the cost of maintaining FFTF in standby and the purchase of plutonium-238 from Russia. Options 2, 3, or 4 would involve the transport of neptunium-237 from SRS to REDC, CPP-651, or FMEF for long-term storage (costing $17 to 19 million for storage modifications and startup at REDC and FMEF and $2 million at CPP-651, which has existing storage capacity). Annual operating costs at all three storage sites would be approximately $1.5 to 2.6 million per year. The total costs of transporting neptunium-237 from SRS to storage facilities is a function of distance and would vary from $1.4 million for transport to REDC to $7.1 to 8.5 million to CPP-651 or FMEF, respectively.

- Alternative 2 would combine the use of existing irradiation facilities (ATR, ATR in combination with HFIR, or a CLWR) with the choice of three processing facilities (REDC, FDPF, or FMEF) to provide nine different options for producing plutonium-238. FFTF would be deactivated at a cost of $281 million constituting the major cost element of all options under Alternative 2. In addition, the following costs would be incurred:

  – Processing facility modification costs would be about $37 million for FDPF; $51 million for REDC; and $73 million for FMEF (for the addition of most process flowsheet items of equipment, within existing plant and services) for Options 1, 2, 3, 7, 8, and 9. An additional cost of $4 million for additional facility modifications was estimated for REDC and FDPF to fabricate stainless steel targets for the CLWR under Options 4, and 5.

  – Processing facility operating costs would be about $7 to 8 million per year for REDC and FDPF and $15 million per year for FMEF for Options 1, 2, 3, 7, 8, and 9. An additional cost of $3 million was estimated for REDC, FDPF, and FMEF for the fabrication of stainless steel targets for the CLWR under Options 4, 5, and 6.

  – Irradiation charges would be $8 million per year for ATR and ATR in combination with HFIR, and $5 million per year for the CLWR.

  – Total transportation costs for the shipment of neptunium-237 from SRS to processing facilities would be the same as previously described for the No Action Alternative. Differences in annual plutonium-238 production shipping and handling costs between the options are due to distance, the location of the irradiation facility, and the number of shipments. All shipments to and from irradiation facilities under this alternative would be by commercial truck.

- Alternative 5 would involve the deactivation of FFTF, at a cost of $281 million.

The sum of all facility modification costs for the nonexpanded infrastructure alternatives would be $0 to 19 million for the No Action Alternative; $320 to 374 million for Alternative 2; and $281 million for Alternative 5. The sum of all annual facility operating costs (less transportation) for this program would be $50 to 52 million for the No Action Alternative; $15 to 23 million for Alternative 2; and $0 for Alternative 5.

Expanded Infrastructure Alternatives

A summary of the estimated costs of the expanded infrastructure alternatives (Alternatives 1, 3, and 4 of the NI PEIS) is presented in Table S–3. Capital costs (costs of either modifying existing facilities or constructing new facilities), costs for permanently deactivating FFTF (where appropriate), annual operating costs, and transportation costs are presented for irradiation and processing facilities.

With respect to irradiation facilities, which constitute the major cost element of these alternatives, it can be seen that:

- Capital costs would be in the order of $300 million for Alternative 1 (FFTF restart) and Alternative 4 (construction of a new research reactor), and more than $1 billion for Alternative 3 (construction of new accelerators). An additional burden of $281 million would be placed on Alternatives 3 and 4 for FFTF deactivation costs because these alternatives involve the construction of new facilities. Alternative 1, FFTF restart, would not incur this cost.

- The estimated annual costs of operating the irradiation facilities would be: $25 million per year for the new research reactor in Alternative 4; $45 million per year for the accelerators in Alternative 3; and $59 to 64 million per year for FFTF in Alternative 1.

It can also be seen that the other types of facilities used in the expanded infrastructure alternatives (isotope processing facilities and support facilities that fabricate targets for irradiation and chemically process irradiated targets to recover, package, and ship isotopes) are specific to the production of either (1) plutonium-238, or (2) medical and industrial isotopes.

- Costs of modifying REDC, FDPF, or FMEF to support plutonium-238 production, together with startup costs, would range from $37 to 73 million. The lower end of this range of front-end costs represents investments in REDC and FDPF, which have been built. FMEF has not been fully equipped nor operated, and would therefore require the higher modification costs to bring this facility online. Similarly, the annual operating costs for these facilities, would range from about $7 to 18 million per year, due to the availability of shared resources that can reduce operating costs, compared to a nonoperating facility like FMEF. An additional cost of $4 million for additional facility modifications at REDC and FDPF and $3 million operating costs at REDC, FDPF, and FMEF was estimated for the fabrication of stainless steel targets for the FFTF under Alternative 1.

- The mission to produce medical and industrial isotopes and expand nuclear research and development capabilities would be supported by either the modification of existing operational facilities at Hanford under Alternative 1 (RPL/Building 306–E or FMEF) or the construction of a new facility supporting either new accelerators (Alternative 3) or a new research reactor (Alternative 4). The investment for modifications or construction and startup would amount to about $29 to 37 million for the Hanford facilities and $71 million for a newly constructed processing support facility. Annual operating costs would be lower for the two existing facilities compared to a new processing support facility ($12 to 13 million per year for RPL/Building 306–E or FMEF and $23 million per year for a new processing support facility).

Transportation costs for the expanded infrastructure alternatives would be higher for the plutonium-238 production mission than the medical and industrial isotope mission, due to distances traveled, (e.g., REDC at ORNL to FFTF at Hanford versus shipping to the nearest air freight terminal) the number of shipments, and the cost of secure shipments. Differences in annual plutonium-238 production shipping and handling costs between the three alternatives are due to the cost of secure transport versus commercial truck and the number of shipments. Under Alternative 1, commercial trucks would be used to transport neptunium targets between processing facilities and FFTF. Alternative 3 would have the fewest number of shipments but requires the use of secure transport. Alternative 4 would have the same number of shipments and nearly the same shipping and handling costs as Alternative 1, but would require the use of secure transport to ship fabricated neptunium-237 targets from processing facilities to the new research reactor. The difference in the total costs of shipping neptunium-237 from the Savannah River Site (SRS) to plutonium-238 processing facilities is a function of distance from SRS. These costs would range from a low of $1.4 million per year for REDC to about $7 to 8 million per year for FDPF and FMEF. By comparison, transportation costs in medical and industrial isotope production (involving intrasite transfers of relatively small targets and offsite transfers to the nearest air freight terminal) would amount to $0.73 million per year for each alternative.

The sum of all facility modification costs in the expanded infrastructure alternatives would be $385 to 424 million for Alternative 1; $1,485 to 1,521 million for Alternative 3; and $702 to 737 million for Alternative 4. The sum of all annual facility operating costs (less transportation) would be $82 to 90 million per year for Alternative 1; $75 to 84 million per year for Alternative 3; and $55 to 64 million per year for Alternative 4.

S.4 RISK ANALYSIS OF COST ESTIMATES

Although several types of contingencies can be defined, in general, a contingency refers to the cost that must be added to a base estimate to account for "unknown" costs. Two broad types of contingencies have been identified by Los Alamos National Laboratory (LANL) in the conceptual design report for a high-energy tritium production linear accelerator (LANL 1997). The most common type of contingency is an allowance for indeterminates, such as uncertainties in time, materials, or equipment items which may have inadvertently been omitted from the estimate. It should also be noted that the quality of the design basis for the development of the cost estimate is often a determinant of the magnitude of this type of contingency (Peters and Timmerhaus 1991). The Contingencies and Uncertainties columns in **Table S–4** reflect these types of uncertainties. A second type of contingency, often termed "risk contingency," is particularly applicable to projects involving new technologies (e.g., projects which require the preparation of cost estimates while nuclear research and development is still in progress). This contingency covers the cost effects of unforeseen design changes, altered performance requirements, or major schedule delays due to developmental problems. The Technical Risk and Schedule Risk columns in Table S–4 are indicative of risk contingency considerations.

The contingencies listed in Table S-4 that apply to the costs of the alternatives can be considered under these definitions:

No Action Alternative—Alternative cost involves little or no contingencies, technical or schedule risk, as no action is being taken other than the purchase and transport of Russian plutonium-238 to LANL and transport of neptunium-237 from SRS to long-term storage facilities at either REDC, CPP-651, or FMEF. There is a high uncertainty regarding the future purchase price for Russian plutonium-238 that could significantly affect the current estimated cost of this alternative. The current estimate for the cost for purchasing Russian plutonium-238 assumed that the contract price would be extended using the negotiated annual escalation rate of 3.5 percent for the duration of the project planning period described in the NI PEIS. The contract for the purchase of Russian plutonium-238 is in year eight, with two years remaining (DOE 1997). Beyond the last two years of the contract, the future price of Russian plutonium-238 is unknown.

Alternative 1: Restart FFTF—This alternative uses existing facilities and proven technologies, which implies relatively low contingencies (in the order of 10 to 20 percent), which is customary for this type of operation. The potential exists for schedule delays in the neptunium-237 and medical and industrial isotope stainless steel target development for FFTF. The schedule risk is considered low, because it was assumed that neptunium-237 and medical and industrial isotope target development and testing would be accomplished during FFTF startup. However, some schedule risk would remain if stainless steel targets should fail during testing or not meet performance requirements during target evaluation prior to isotope production.

Table S–4 Risk Analysis of Cost Estimates

Alternatives	*Contingencies*	*Uncertainties*	*Technical Risk*	*Schedule Risk*	*Discussion*
No Action	Low range	High	None	Low	Uncertainty: cost of Russian plutonium-238
Alternative 1: Restart FFTF	Low range	Low	None	Low	Schedule risk: neptunium-237 and medical and industrial isotope target development
Alternative 2: Use Only Existing Operational Facilities					
ATR and HFIR	Low range	Low	None	Low	Existing technology
CLWR	Moderate range	Moderate	Low	High	Schedule risk: neptunium-237 target development. Uncertainties: proprietary irradiation services costs and unknown target development cost
Alternative 3: Construct New Accelerator(s)					
High-energy linear accelerator	High range	High	High	Very high	Contingency: factor associated with preconceptual design and target/blanket development. Uncertainty: technology in development for this application. Schedule risks: target/blanket shipping cask development and certification
Low-energy cyclotron accelerator	Low range	Low	None	Low	Proven technology
Alternative 4: Construct New Research Reactor	High range	Moderate	Low	Moderate	Contingency: factor associated with preconceptual design, capability risk. Schedule risk: neptunium-237 target development
Alternative 5: Deactivate FFTF	Low range	None	None	Low	None

Alternative 2: Use Only Existing Operational Facilities—This alternative should have a low contingency of 20 percent or less because of existing technology. This alternative presents no technological requirements for modifications to existing operational facilities for the production of isotopes or the use of new technologies.

CLWR use is considered a low technological risk because it is a proven technology and an ongoing operation. However, the schedule risk is considered high because of uncertainties associated with the development of neptunium-237 targets for a CLWR (i.e., neptunium-237 target development, testing, and evaluation would have to fit in with the CLWR refueling cycle). If the neptunium-237 target fails during testing or does not meet performance requirements during target evaluation, additional target testing could not occur until the next refueling cycle (generally, another 18 months). CLWR irradiation services costs are also uncertain due to the proprietary nature of the industry.

Alternative 3: Construct New Accelerator(s)—This alternative involves the use of high-energy linear accelerator technology for the production of neutrons via spallation for isotope production. This technology places Alternative 3 in an area of high technological and schedule risks, and of high contingency factors in several areas of component development for the application of high-energy linear acceleration for plutonium-238 production.

Conversely, low-energy cyclotron accelerator use for the production of medical and industrial isotopes is a low-cost, proven technology, is currently used commercially, and has little or no schedule risk.

Alternative 4: Construct New Research Reactor—This alternative involves the use of proven research reactor technology, which implies low risk; however, the very nature of the preconceptual design requires that a high level of contingency be applied to the construction cost estimate and operating costs. The schedule risk for neptunium-237 target development is considered moderate, because even though the new research reactor design is based on proven research reactor and fuel technologies, it is preconceptual. Like FFTF, it was assumed that neptunium-237 and medical and industrial isotope target development, testing, and evaluation would be accomplished during construction and startup of the new research reactor. Unlike the CLWR, targets can be pulled from the new research reactor core at any time during testing for evaluation.

Alternative 5: Deactivate FFTF—This alternative involves only the deactivation of the FFTF reactor, which is currently in standby mode; except for uncertainties associated with the disposal of the sodium coolant, the deactivation of FFTF poses little or no technological risk and has a low-cost contingency.