Department of Energy
Washington, D.C. 20545

Docket No. 50-537
HQ:E:82:012

MAR 19 1982

Mr. Paul S. Check, Director
CRBR Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Check:

CRBRP FUEL CYCLE

On March 12, 1982, we submitted a revised and supplemented Environmental Report Section 5.7.1, CRBRP Fuel Cycle, to you. It was noted in the March 12, 1982, transmittal letter that we intended to supplement the safeguards portion of Section 5.7.1 at a later date. The enclosure to this letter contains this supplemental information.

Included, as requested, is an estimate of the costs of safeguarding the CRBRP fuel cycle. Safeguards costs for the reprocessing plant are unavailable as yet. We intend to submit these no later than March 24, 1982. Safeguards costs are included for the fuel fabrication facilities and the CRBRP. This includes a breakout of the number of CRBRP plant personnel making up the guard force.

We would appreciate having any comments or questions that you might have on Section 5.7.1 by March 26, 1982. In parallel, we initiated an independent review of Section 5.7.1 by Oak Ridge National Laboratory and we intend to have this review completed by March 26, 1982. Any changes resulting from these reviews will be incorporated prior to formal issuance of Section 5.7.1 as an amendment to the Environmental Report.

A change in this version of Section 5.7.1 from that provided on March 12, 1982, is our description of an alternate technique for disposing of krypton recovered at the reprocessing plant. The enclosure describes a krypton management technique wherein the radioactive gas would be incorporated into a metal matrix for disposal as a solid.

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One other change from the previous version is the inclusion of the 308 building at the Hanford reservation in the fuel cycle. Core fuel for the CRBRP is planned to be fabricated into pins at the SAF line and then mechanically fabricated into assemblies at the 308 building. The enclosure has been modified to reflect this.

If you have any questions or comments on this submittal, please contact me.

Sincerely,

John R. Longenecker, Manager
Licensing & Environmental
Coordination
Office of Nuclear Energy

Enclosure

cc: Service List
Standard Distribution
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5.7 OTHER EFFECTS OF PLANT OPERATION

Operation of the CRBRP should institute no changes in land use not already abrogated during the construction phase. Comparison of the construction phase to the operational phase should, in fact, result in relief of some of the man-induced stresses due to significant reductions in the motion and noise of heavy equipment and vehicular traffic at the plant site. Stabilization of routing should result in greater tolerance of the installation by the terrestrial population. The effects of plant operation are discussed in Sections 5.1 through 5.6. Because of the plant design and the distance of the Site from other industrial or power plants in the area (ORGDP is three miles north-northwest) the CRBRP should not have either thermal or radioactive waste interaction with effluents released by other plants in the area. No wastes from the plant are anticipated to be disposed of by means other than those discussed in Sections 5.3 through 5.5.

5.7.1 CRBRP FUEL CYCLE

The CRBRP fuel cycle includes mixed oxide (MOX) fuel fabrication, blanket element fabrication, reprocessing, management of the wastes generated by facilities in the fuel cycle and transportation of wastes and products among the various facilities. Some of the facilities required to support the CRBRP fuel cycle are not yet available. Notable examples are a fuel reprocessing plant capable of handling CRBRP fuel, and a federal repository for disposal. The environmental impacts estimated herein use existing information regarding the most likely design of these facilities for those that are not yet available. This assessment also assumes that appropriate facilities will be available in time to support the CRBRP fuel cycle such that interim measures like away from reactor fuel storage and product storage are not required.

A simplified schematic diagram of the CRBRP fuel cycle employing plutonium recycle is shown in Figure 5.7-2. The mass flow parameters are characteristic of those for the CRBRP under pseudo-average equilibrium-cycle conditions (where the cycle-to-cycle variations in the batch CRBRP fuel management have been averaged out). At equilibrium, approximately 0.9 MT of plutonium and 11 MT of depleted uranium are fabricated into mixed-oxide fuel and blanket assemblies per year. One half of one percent heavy metal has been assumed to be lost in the fabrication process. In the reactor core, irradiation at 975 MW(th) for 274 equivalent full power days destroys approximately .28 MT of plutonium and 0.39 MT of uranium per year through fission and nuclear transmutation reactions. 0.27 MT of fission product isotopes are produced per year. Because of the breeding characteristics of the CRBRP, plutonium is both produced and destroyed in the core and the discharge fuel and blankets contain approximately 0.97 MT of plutonium. This spent fuel is chemically reprocessed, where once again 1/2% of heavy metal isotopes are assumed to be lost or unrecoverable. Fission products, irradiated structural material and other wastes are shipped to a waste disposal facility. The recovered plutonium (0.96 MT/year), and perhaps the uranium as well, is recycled as fresh fuel input to the fuel fabrication facilities. The net gain of approximately 0.07 MT of plutonium per year can be stored for later use. The contribution of the plant fuel cycle to the environment is in Table 5.7-1, "CRBRP Summary of Environmental Considerations for Fuel Cycle." Below is a description of the facilities and methods used to estimate the Table 5.7-1 impacts.

Adequate supplies of plutonium are projected to be available from DOE-produced material to startup and operate CRBRP during the five-year demonstration period. No impacts are included in the estimate in Table 5.7-1 for production of this material. These impacts are addressed in environmental impact documents covering DOE production activities. The DOE-produced plutonium must be converted to an oxide form at a yet to be determined facility prior to fuel fabrication. Oxide conversion is planned as a step at the reprocessing plant. The impacts of conversion are bounded by the impacts of operating the reprocessing plant given in Table 5.7-1.

5.7.1.1 CRBRP FUEL FABRICATION

Fabrication of the mixed oxide core fuel is planned to be performed at the Secure Automated Fabrication (SAF) line, to be installed in the Fuels and Materials Examination Facility (FMEF) at DOE's Hanford reservation. CRBRP fuel fabrication will require about 65 percent of the SAF line operational schedule (15 of every 24 months). The data presented in Table 5.7-1 for mixed oxide fuel fabrication are based on the impacts in DOE/EA-0116 "Environmental Assessment for the Fuels and Materials Examination Facility," July 1980, and supplement.(6),(7)

The Secure Automated Fabrication (SAF) Program has as its objective to develop and demonstrate an advanced manufacturing line (SAF) for plutonium oxide breeder reactor fuel pins. This line will be the source of fuel for the FFTF and the CRBRP. The SAF line will utilize technology that focuses on improved safety features for plant operating personnel, the public, and the environment. Equipment and process improvements incorporated by the SAF line will yield significant gains in nuclear materials safeguards, product quality and productivity. The SAF line provides the key link between development and full-scale demonstration of technology that will enable commercialization of LMFBR fuel fabrication in the future.

Fabrication of fuel on the SAF line in the fully automated and remotely operated mode results in the following important advances over current manual fuel fabricaton technology:

- Reduced radiation exposure to plant personnel
- Reduced access to Special Nuclear Materials (SNM)
- Improved containment of SNM
- Near real-time accountability of SNM
- Improved product cost and quality
- Increased protection of the public and the environment from radiation or contamination

The basic fabrication process includes receiving and assaying nuclear ceramic powders, blending of the powders, pelletizing and sintering the powders into fuel pellets, and loading these pellets into finished fuel pins. The SAF line will include necessary support systems for nondestructive assay, SNM accountability, rapid chemical analysis, waste and scrap handling, maintenance, and material handling. All processing equipment and support systems will be combined to form an interdependent, fully integrated, automated and remotely operated fuel fabrication system.

Upon initial installation of the SAF line, all equipment items will be manually adjusted, calibrated and thoroughly tested using materials simulating flow/handling characteristics of MOX. While these tests are progressing, manual adjustments and corrections will be permitted. At the completion of the tests, the SAF line will be subjected to a MOX demonstration and preproduction qualifications test program to demonstrate capability to proces MOX fuels and to qualify the products for compliance with specifications. During the preproduction qualification test, all operational control, parameter adjustments, and equipment adjustment and calibration will be performed through the remote process control system. If manual operation/adjustments or equipment repair are required, the fuel material will be emptied from the equipment being worked on as required to minimize radiation exposure. On completion of the preproduction qualification tests, the entire process line will be emptied of fuel material and a material balance will be performed to demonstrate the capability of the safeguards and accountability system. After completion of this activity, final adjustment and correction of the process equipment will be made to prepare the SAF line for full-scale production operations.

Prior to introduction of feed materials to the fabrication line, an analysis and characterization of the feed will be performed. As the feed material progresses, automatic measurements of the quantity of SNM will be conducted and recorded in the process control and safeguards computers to maintain a continuous record for process monitoring and for safeguards and accountability purposes.

The SAF line is designed to minimize the spread of contamination and the threat of diversion. Process enclosures are designed for each subsystem. Glove ports and windows will be incorporated to allow for "hands-on" maintenance. All containment structures will have built-in shielding, and the process equipment will incorporate supplemental shielding as necessary to meet radiation exposure criteria.

SAF equipment is within contamination control enclosures physically located behind isolation walls that function as a secondary confinement barrier. Plant operating personnel are normally located in an operating corridor that is on the opposite side of the isolation wall or in the operations computer center where all process operations are monitored and coordinated. Under normal operating conditions, plant personnel located in the operating corridor can control and monitor the performance of process equipment. There will be no penetrations in the isolation walls that would provide direct access to the process equipment by the operators. Under abnormal conditions, the operator can utilize local controls that can be activated to control operation of the process equipment while visually monitoring its performance. If tooling changes must be made or when routine maintenance must be performed that requires the presence of an operator at the working face of the containment, the fuel material will be removed from the equipment as necessary to maintain personnel exposure limits and to minimize SNM access.

The mechanical assembly of the welded fuel pins produced by the SAF line into fuel assemblies will be performed in Building 308 on the Hanford Reservation. This is an existing, multi-purpose, plutonium facility that is safeguarded as described in 5.7.1.5. The first four cores of the FFTF were assembled into driver fuel assemblies here. The CRBRP assembly operation will produce no gaseous, solid or liquid radioactive or toxic effluents and will have no significant environmental impact.

Uranium dioxide feed material for the SAF line will be obtained by having existing UF6 at DOE's diffusion plants converted at a to be determined commercial facility. For the purpose of estimating environmental impacts in Table 5.7-1, conversion is assumed to take place at the blanket fuel fabrication facility. The total uranium conversion capacity required to support the CRBRP fuel cycle, including blanket fabrication, on an annual average basis is 11MT.

Blanket fuel fabrication for the CRBRP will be carried out at a yet to be selected commercial facility. An average of 70 blanket fuel assemblies will be required per year. There will be about 100 kg of uranium per assembly. Thus, a conservative throughput of about 7.5 MT/yr of uranium is assumed. For the purpose of estimating the environmental impacts in Table 5.7-1, the impacts of the model UO_2 fuel fabrication facility in WASH 1248, were apportioned to a 7.5 metric ton/year throughput.

5.7.1.2 CRBRP FUEL REPROCESSING

President Reagan's nuclear policy statement of October 8, 1981, endorsed nuclear fuel reprocessing by private industry. The Department of Energy has requested private industry to consider the possibility of making a future commitment to build and operate a reprocessing plant to meet near-term industry requirements. Should the industry not make such a commitment in a time frame compatible with CRBRP needs, other alternatives are available, such as the modification and use of existing reprocessing facilities at Savannah River, Hanford or Barnwell, construction of new facilities, or possible multi-national ventures.

For the purpose of estimating atmospheric radiological releases, gaseous radioactive effluents were calculated by applying the confinement factors of the model reprocessing plant in WASH 1535 to the average annual CRBRP fuel source term (see Table 5.7-8). For comparison, we have also estimated the environmental impacts which would result were the CRBRP spent fuel reprocessed in the Developmental Reprocessing Plant (DRP). The DRP, described below, is planned by DOE to demonstrate the advanced technology now under development for reprocessing of LMFBR fuels.

Table 5.7-8 shows that the radiological releases from reprocessing CRBRP fuel in the DRP are similar to those for the model reprocessing plant. The bounding reprocessing impacts, those from the DRP, are included in Table 5.7-1. Other effluents from the reprocessing plant, provided in Table 5.7-1, were estimated by apportioning the effluents of the model plant in WASH 1535 to the 12 metric ton/year throughput required for CRBRP. These are expected to bound the actual CRBRP reprocessing impacts regardless of what reprocessing alternative is eventually used.

There has been some preliminary conceptual design of the DRP, sufficient for completion of an environmental analysis which indicates that such a facility can be operated within existing and proposed environmental guidelines. Similarly, a safeguards analysis has indicated that such a facility can be operated within existing and proposed safeguards guidelines and serve as a model for international safeguards demonstration.

Reprocessing capacity for the DRP has been set at about 1/2 metric ton of heavy metal (MTHM) per day. This capacity has been selected as a compromise between the minimum that will permit scale-up to a production-scale operation with reasonable assurance of success, and the maximum that will permit a meaningful demonstration of reliable reprocessing systems with the limited quantities of LMFBR type fuels that will be available during the demonstration period. In order to provide economical operation during the early periods of operation and in order to have a full reprocessing load to provide an adequate demonstration of operability (300 day-per-year operation is contemplated), reprocessing of LMFBR fuels will be supplemented by reprocessing of LWR fuels in the DRP.

Study and plans to date for the DRP have focused on a new stand-alone facility at a new site. However, some preliminary thought has been given to constructing a "breeder head-end" (fuel receipt and storage, shearing, dissolution, feed clarification, first cycle solvent extraction, and waste processing) at an existing reprocessing plant. Final decision on a "stand-alone," "breeder head-end," or alternative DRP will consider cost, environmental impact, impact on existing reprocessing plant programs, and importance of a reliable demonstration.

The DRP design is based on the following philosophy:

- The DRP is a U.S. Government owned developmental fuel reprocessing demonstration facility

- Public and worker health and safety are of fundamental concern

- Safety and safeguards-related features are designed and will be constructed and operated in accordance with industrial standards applicable to nonreactor nuclear facilities. Nationally recognized codes such as the ASME, ANSI, and similar codes will be followed. The NRC Regulatory Guides, which provide guidelines in meeting those requirements, will be observed.

- The DRP will be operated and maintained within the constraints of 10 CFR 20 for radioactive effluents and personnel exposure, and the 40 CFR 190 environmental standards for exposure of the general public to radioactive material. The DRP is also designed to guidelines equivalent to the 10 CFR 100 accidental release limits for power reactors. Nonradioactive effluents will meet applicable state and local air and water quality standards.

- The DRP is a developmental facility. Operating flexibility, including the ability to change equipment, is needed to meet U.S. Government program objectives.

DRP Support Facilities. The DRP provides all of the facilities and services necessary for routine operation and maintenance of fuel storage and processing activities. The services include water supply, sanitary waste disposal, electrical supply, steam and compressed gas supply, access roads, rail spurs, etc. Support facilities include on-site maintenance shops, mockup areas, laboratory and routine analytical services, cooling services, warehouses, and offices.

<u>DRP Fuel Receiving and Storage</u> The DRP is capable of receiving and storing currently conceived types of spent oxide fuel assemblies from plutonium breeder reactors as well as from light-water reactors. Space is also provided for future storage and reprocessing of carbide breeder fuel, consistent with U.S. Government decisions regarding use of carbide fuels. The specific reactors and fuels that the DRP currently has capability for reprocessing are listed in Table 5.7-7.

The DRP is capable of receiving fuel assemblies that have cooled a minimum of 150 days. For purposes of calculating transportation impact however, the spent fuel and blanket was assumed to be shipped after 100 days, which is conservative.

<u>DRP Fuel Shipping Casks</u> The DRP is capable of (1) unloading casks that have been shipped by either truck or rail, (2) removing road dirt and external surface contamination from casks upon receipt, and (3) decontaminating casks prior to shipment from the DRP. The DRP is capable of removing fuel from all of the casks which will be used to ship fuel from the reactors listed in Table 5.7-7.

Capability is also provided to identify fuel assemblies for verification and inventory control, and to assay fuel assemblies for fissile material content.

<u>DRP Fuel Storage</u> A water-filled pool is provided with capacity to store enough fuel for 100 days of operations at 0.5 MT/day capacity with CRBRP-type fuel assemblies. The storage facility has provisions for detecting, handling, and canning (if necessary) suspect or known failed-fuel assemblies.

DRP Cask Maintenance. The capability to perform limited maintenance operations on shipping casks is provided. This capability is limited to removing contaminated water coolant from casks and canisters and placing them in storage tanks; decontaminating the internal surfaces of casks; and limited repair of cask internals and externals.

DRP Fuel Reprocessing The reprocessing facility initially provides equipment to reprocess fuel assemblies containing uranium, plutonium, and radioactive fission products, clad in either stainless steel or zirconium alloy. The process functions, as shown in Figure 5.7-3 are:

- Fuel receiving, cleaning, and storage
- Mechanical processing and shearing
- Dissolution, feed clarification, and feed adjustment
- Solvent extraction for purification of uranium and plutonium
- Uranium oxide production
- Mixed uranium-plutonium oxide production
- Reagent makeup and distribution
- Rework of off-specification process liquids
- Process heating and cooling

<u>DRP Type of Process</u>. Separation of the fission products from the fissile and fertile material is based upon liquid-liquid solvent extraction. The standard Purex process, modified as required for specific nuclear fuels, is the basic process.

The Purex process utilizes a tributylphosphate (TBP) extractant in a normal paraffinic hydrocarbon (NPH) solvent. Normally, core and axial blanket fuel is processed together. However, provisions are made to segregate the axial blanket, which is then processed separately from the core in special cases. Radial blankets can also be processed separately from the core.

The uranium and plutonium products are converted to oxides in a form to be used directly in fuel fabrication.

Storage capacity for all oxide products is provided for 100 days of operation at the maximum production rate for the two oxide products stated above. Capacity to store liquid products temporarily for 30 days of operation is also provided. The design for storage and shipment of uranium and plutonium is in accordance with the requirements of 10 CFR 70, 10 CFR 73, and applicable Department of Energy Orders.

<u>DRP Process Liquid Recycle and Disposition</u>. Contaminated water and acid used in the processes are recovered, purified, and recycled to the extent practical. Water additions to the process are thus minimized, and excess water is decontaminated prior to release from the stack as a vapor. Radioactivity limits in the vaporized water are consistent with the design objectives for fission product emission. There are no radioactive liquid releases.

DRP Waste and Effluents The DRP will be capable of being operated and maintained within the environmental constraints imposed by Federal, state, and local regulations. This specifically includes consideration of the provisions of 10 CFR 20, 40 CFR 190, and applicable portions of Appendix I of 10 CFR 50 for routine operations, and 10 CFR 100 for accident conditions. Consistent with these regulations, effluent control systems were designed to provide overall plant confinement factors when processing typical breeder reactor fuel as shown in Table 5.7-8. The annual effluent releases from the DRP as a result of processing CRBRP fuel after 150 days of decay are also shown in Table 5.7-8.

DRP Waste Management Systems. The high-level liquid waste system is designed to accommodate the wastes resulting from the reprocessing of 150 metric tons per year of heavy metal. The waste storage capacity is designed for two years' processing capacity, concentrated to 200 gallons per ton of heavy metal.

High-level liquid wastes are concentrated, solidified, and packaged for subsequent transfer to a Federal repository in accordance with the requirements of 10 CFR 50. The current interpretation of these guidelines is that the centerline temperature of the canistered waste after solidification (assuming solidified glass process) shall not exceed 800^{o}C, the waste canisters shall not exceed 12 inches in diameter by 10 feet high, and the decay heat output of the individual canisters shall not exceed 5 kW at the time of shipment to a repository. It is anticipated that this heat output level may be reduced to 3 kW per canister, and additional constraints might be placed on these wastes following complete and thorough analysis of their effect on a repository. Storage space is provided in the waste pool to anticipate such change.

Radioactive metal scrap originating from the fuel assemblies, process operations, and nonrepairable in-cell equipment is consolidated and packaged for shipment to a Federal repository.

The overall size, weight, capacity, etc., of waste shipping casks to be handled by the DRP are not yet established.

Nonprocess, potentially contaminated wastes, such as change room showers, sink effluents, and fire-protection water discharges, are routed to a collection system for monitoring and processing to assure compliance with the effluent release requirements. All liquid wastes discharged to the environment will meet EPA Clean Water Act requirements.

All solid wastes that are potentially contaminated are inspected, processed or packaged, as required, and shipped to a suitable burial site.

Combustible wastes, including waste process organics, are treated by a suitable combustion process to reduce them to a noncombustible material for disposal. The remaining wastes will be packaged as required and sent to a suitable disposal site.

5.7.1.3 RADIOACTIVE WASTES FROM THE CRBRP FUEL CYCLE

Radioactive wastes are a by-product of the CRBRP fuel cycle. Table 5.7-10 summarizes the types, quantities, key constituents, and disposition of the wastes from the CRBRP fuel cycle. Table 5.7-5 compares the quantities of wastes expected to be produced in the CRBRP fuel cycle with those of the once-through and uranium-only recycle fuel cycles for LWR's. The following discusses the waste generated at each step in the fuel cycle and the environmental impacts from disposing of these wastes.

Adequate supplies of depleted uranium in the form of UF_6 are currently available at DOE enrichment plants to supply blanket material for the CRBRP indefinitely. The depleted UF_6 is left over from production of enriched uranium for LWR's. No incremental waste generation nor environmental impacts are attributed to the CRBRP for production of this material.

Operation of the CRBRP does not require the use of enriched uranium for fuel material. This is an important difference between the LWR fuel cycle and the CRBRP fuel cycle. As such, the CRBRP fuel cycle generates no radioactive wastes nor environmental impacts from uranium enrichment.

Conversion of depleted UF_6 to UO_2 for CRBRP blankets is planned to be performed at the blanket fuel fabrication facility. As noted in section 5.7.1.1, both UO_2 for blanket fabrication and for fabrication of core fuel would be converted. During UF_6 conversion, CaF_2 will be formed. This is the most significant waste generated at the blanket fuel fabrication plant.

The CaF_2 will be contaminated with about 0.01 uCi/gm of uranium. The 11 MT/year of CaF_2 generated by the CRBRP fuel cycle is based on the production rate of one metric ton for each metric ton of uranium processed as given in section 3.2.5, NUREG 0116[12] The CaF_2 is expected to be disposed of at the blanket fabrication facility in bulk form. Based on the solubility of CaF_2, any uranium leached out would be present in the leachate at concentrations of about 10^{-3} of MPC, which is so low as to be insignificant as a potential radiation hazard (see WASH 1248, p. E-16).

Operation of the SAF line is expected to produce about 200 m^3 of transuranic contaminated wastes per year[6]. As CRBRP requires about 65 percent of the SAF line capacity, about 130 m^3 of transuranic wastes will be generated from fabrication of the annual CRBRP core fuel. These wastes will be contaminated with uranium, plutonium, and daughter products to levels in excess of 10 nanocuries per gram. The CRBRP wastes will be partially compacted and packaged into about 145, 55 gallon drums annually.

The transuranic wastes generated from operation of the SAF line will be transported to an existing DOE transuranic waste storage site on the Hanford Reservation. Environmental impacts from operation of the Hanford Reservation are addressed in ERDA-1538, "Waste Management Operations, Hanford Reservation," December 1975. CRBRP transuranic waste will be a small addition to over 155,000 m^3 of transuranic waste already in storage at the Hanford facility and will result in an insignificant incremental environmental impact compared with the totality of Hanford waste management.

As the LWR fuel cycle does not involve plutonium recycle, as yet, a key difference between the LWR and CRBRP fuel cycle is the generation of transuranic contaminated wastes from fuel fabrication. This difference is evident from Table 5.7-5. For the purpose of estimating the environmental impacts from this unique CRBRP fuel cycle waste stream, it was assumed that these wastes would be ultimately disposed of in a Federal respository. The environmental impacts from disposing of about 85,000 m^3 of transuranic waste in the proposed Waste Isolation Pilot Plant(11) were apportioned to the 130 m^3 annual generation rate for CRBRP, and included in Table 5.7-1.

Wastes generated at the CRBR plant are addressed in section 3.5. Low-level wastes from the plant will be transported to a shallow land burial site for disposal. An estimate of the environmental impacts from disposal of these wastes is based on section 4.7.3.4 of Reference (12). Disposal of this waste will require the commitment of about 0.006 acres of land annually. As indicated in the reference, the routine atmospheric effluents from disposal of low-level wastes are insignificant.

Appropriate fuel reprocessing capability is expected to be available in time to support the CRBRP fuel cycle. No need is anticipated to supplement the approximately 4 years of spent fuel storage capacity at CRBRP with away from reactor storage. As such, no wastes are identified from operation of such a facility to support the CRBRP fuel cycle.

The types and quantities of waste in Table 5.7-5 from reprocessing were estimated based on the conceptual DRP design. The DRP is expected to generate about 25 m^3 of miscellaneous low-level wastes annually in support of the CRBRP fuel cycle. These wastes will be generated from fuel storage, handling and cleaning operations prior to reprocessing. The key contaminants are short lived fission and activation products with a total activity level typically of 10Ci/m^3. The low-level wastes will contain less than 10 nanocuries per gram of transuranic contaminants.

For the purpose of estimating environmental impacts, it is assumed that the low-level wastes will be fixed in concrete, packed in about 120, 55 gallon drums annually, and shipped to a shallow land burial facility for disposal. Based on the analysis in section 4.7.3 of NUREG-0116, the reprocessing plant low-level wastes will require the commitment of approximately 0.0025 acres of land annually and result in insignificant routine atmospheric effluents.

Metal scrap waste is generated at the DRP consisting of hulls and hardware from fuel element disassembly and nonrepairable in-cell equipment. The bulk of this waste, that from fuel element disassembly, will be contaminated with about 0.05 percent of residual fuel material and with activation products formed during irradiation. The metal scrap is expected to have a total activity of about 4×10^5 Ci/m^3. For the purpose of estimating environmental impacts, the metal scrap is assumed to be partially compacted, packaged into about 8, 10 inch diameter by 10 feet high stainless steel cylinders annually and shipped to a Federal repository for disposal.

Operation of the DRP also produces some transuranic contaminated wastes. Essentially all wastes produced from operation of the plant, except for fuel storage and handling, are assumed to be contaminated with greater than 10 nanocuries per gram of transuranics as well as fission and activation products. These wastes range from 1000 Ci/m^3 to 10^6 Ci/m^3 in total activity. For the purpose of estimating environmental impacts, these wastes are assumed to be fixed in concrete, packaged in 10, 55 gallon drums annually, and shipped to a federal repository for disposal.

Approximately 1 m^3 of; solidified high-level waste is expected to be generated from reprocessing CRBRP fuel on an annual average basis. The high-level waste will be fixed in a matrix with a very low leach rate (such as borosilicate glass) and packaged in 12-inch diameter by 10 feet long stainless steel cylinders for disposal at a Federal repository. About six cylinders of high-level waste will be produced annually from CRBRP fuel reprocessing.

The key constituents of CRBRP high-level waste are in Table 5.7-6. These were calculated to contain 10% of the tritium, 0.5% of the uranium and plutonium, and all of the non-volatile fission products and other transuranic elements. The fuel was conservatively assumed to be reprocessed 150 days after reactor discharge and the waste is stored as a liquid until solidification 1 year after discharge from the reactor.

NUREG 0116 estimates the environmental impacts from disposal of the transuranic and high-level wastes from reprocessing LWR spent fuel in a uranium only recycle mode. The plutonium produced in the LWR is assumed to be disposed of with the high-level wastes in a geologic repository. The constituents of this high-level waste are shown for comparison to those generated from reprocessing CRBRP fuel in Table 5.7-8. These constituents were calculated to contain all of the non-volatile fission products and transuranic elements, 0.5 percent of the uranium and all of the plutonium for spent fuel 1 year after reactor discharge given in NUREG - 0116, Appendix A.

It is evident from Table 5.7-5 that most CRBRP high-level waste constituents are enveloped by the constituents of LWR high-level wastes from U-only recycle. There are three exceptions. Ru-103 and Cm-242 have relatively short half lives and can be expected to decay to negligible levels before any significant release would be anticipated from the waste package. The third is

Am-241, the incremental environmental impact of which would be overshadowed by the significantly higher concentrations of neptunium, plutonium and uranium in the LWR wastes. The environmental impacts of disposal of CRBRP high-level wastes are therefore expected to be similar to those from the LWR high-level wastes given in NUREG-0116.

Similarly, the environmental impacts from geologic disposal of transuranic contaminated and metal scrap waste from LWR fuel reprocessing envelope the impacts from disposal of similar CRBRP wastes. The impacts included in Table 5.7-1 for geologic disposal of fuel reprocessing plant wastes are those calculated in section 4.4 of NUREG 0116.

The DRP does not vent all of the Kr-85 and I-129 in the CRBRP spent fuel to the atmosphere. Instead, Kr-85 is captured and implanted in a metal (nickel-lanthanum alloy) matrix by a sputtering process.(13) The metal matrix containing the krypton is loaded into 9 inch diameter by 65 inch high steel cylinders. Approximately one cylinder will be generated for every 28 years of CRBRP operation. These cylinders are expected to be disposed of in shallow dry wells at a federal geologic repository.

I-129 will be fixed in concrete as barium iodate and packaged in about 0.05, 55 gallon drums annually. This waste stream will be sent to a Federal repository for disposal.

For the purpose of estimating the environmental impacts of waste management in Table 5.7-1, the captured Kr-85 is assumed to be retained within the metal matrix for a period of 100 years. After this time, the remaining krypton (about 55 curies) is assumed to be released to the atmosphere.

Disposal of the very long half-life (1.72×10^7 years) but low specific activity I-129 should not result in a significant incremental environmental impact over those estimated from disposal of other wastes in the Federal repository.

The nonradiological environmental effects of the shipment of materials from the CRBRP fuel cycle are similar to those characteristic of the trucking industry in general. The CRBRP fuel cycle and waste transportation has been estimated to add 450,000 miles of transportation, including the return shipments of empty casks, shipping containers, and protective overpacks. Based upon NUREG 0116, the emissions from transportation are presented in Table 5.7-1.

5.7.1.4 DOSES FROM CRBRP FUEL CYCLE

Doses from Facility Operations CRBRP fuel fabrication (core fuel) requires about 65% of the SAF line operational schedule (15 of every 24 months). Thus, the environmental impact of CRBRP fuel fabrication is a portion of the SAF line impact, which is a portion of the FMEF impact. The FMEF annual 50-year dose commitments to maximum individuals and the general population within 50 miles of the FMEF are as follows:

Organ	Maximum Individual Dose (millirem)	Population Dose (Man-rem)
Whole Body	1.5×10^{-3}	4.6×10^{-3}
Thyroid	2.2×10^{-4}	9.0×10^{-4}
Lung	2.9×10^{-3}	1.1×10^{-2}
Bone	9.5×10^{-3}	4.0×10^{-2}
Liver	5.3×10^{-3}	2.1×10^{-2}

Natural background and medical exposures would give an annual average exposure to individuals of about 150 millirem. The annual whole body population doses due to natural radioactivity would be about 25,000 man-rem for the year 2000 population within 50 miles of the FMEF.

Accidental release of radioactivity and resulting consequences are given in Reference 7. Routine atmospheric releases of plutonium from the SAF line are given in the following table.

Isotope	Annual Release (Ci/yr)	Isotopic Composition (%)
Pu-236	2.0×10^{-9}	8×10^{-6}
Pu-238	3.4×10^{-6}	0.5
Pu-239	2.2×10^{-6}	72.
Pu-240	2.2×10^{-6}	20.
Pu-241	3.0×10^{-4}	6.
Pu-242	3.0×10^{-9}	1.5

These releases are based on the above isotopic composition, a throughput of 4.0 MT/yr of plutonium, release factors (from the SAF line) of 10^{-3}, and cleanup factors of 1.25×10^{-8}* (for 3 HEPA filters in series, where each HEPA filter would have a separate tested efficiency of 99.95%). There are no liquid radioactivity releases associated with SAF line operation.

Routine atmospheric releases of uranium (throughput of 6.0 MT/yr of uranium) and other radionuclides from the SAF line were calculated on essentially the same basis and are given below.

Isotope	Annual Release (Ci/yr)	Isotopic Composition (%)
U-232	-	-
U-234	5.8×10^{-11}	5×10^{-3}
U-235	2.5×10^{-12}	0.72
U-236	-	-
U-238	5.4×10^{-11}	99.27
Th-231	$<2.5 \times 10^{-12}$	-
Th-234	$<5.4 \times 10^{-11}$	-
Pa-234	$<5.4 \times 10^{-11}$	-

Blanket fuel fabrication for the CRBRP will be carried out at a yet-to-be selected commercial facility. For purposes of this assessment, it is assumed that the commercial facility selected will have three stages of HEPA filters (with an efficiency of 99.9% per stage), yielding an overall confinement factor of 10^9. Atmospheric releases for blanket fuel fabrication calculated on this basis are given in the following table.

*This is a conservative assumption. Actual cleanup factors would range from 10^{-9} to 1.25×10^{-10}.

Isotope	Annual Release (Ci/yr)
U-234	-
U-235	3.2×10^{-11}
U-236	-
U-238	2.5×10^{-9}
Th-231	$<3.2 \times 10^{-11}$
Th-234	$<2.5 \times 10^{-9}$
Pa-234	$<2.5 \times 10^{-9}$

The releases are based on a 7.5 MT/yr throughput and isotopic composition of 0.2% U-235 and 99.8% U-238. This 7.5 MT/yr throughput is less than 1% of the annual throughput of the model fuel fabrication plant described in WASH-1248 (900 Mt/yr), which could handle the fuel fabrication requirements of 26 light water reactors annually. Thus, CRBRP blanket fuel fabrication environmental impacts, on an annual basis, would be about 1/4 of the comparable impacts given in WASH-1248 for light water reactor fuel fabrication.

Annual 50-year dose commitments to maximum individuals and the general population within 50 miles of the model LMFBR fuel reprocessing plant in WASH-1535 for atmospheric releases given in Table 5.7-8 would be as follows:

Organ	Maximum Individual Dose (millirem)	Population Dose (Man-rem)
Whole Body	0.06	1.01
Thyroid	0.87	9.0
Lung	0.10	1.02
Bone	0.15	2.33
Liver	0.08	1.38

Natural background exposures would give an annual average exposure to individuals in the vicinity of the model plant site of about 102 millirem.[9] The annual whole body population dose due to natural radioactivity for the population within a 50 mile radius of the model plant is estimated to be 1.02×10^5 man-rem.[9]

It should be noted that there would be no liquid releases of radioactivity from the model plant. The C-14 released would produce a world-wide population dose commitment, over all time, of 37 man-rem, based on a constant world population of 6×10^9 people.[10]

The doses associated with reprocessing spent CRBRP fuel in the DRP were calculated assuming the model fuel reprocessing plant site described in WASH-1535. Conservative confinement factors were chosen to estimate radioactivity releases. Table 5.7-8 gives information on confinement factors and atmospheric releases of radioactivity associated with reprocessing CRBRP fuel in the DRP.

Annual 50-year dose commitments to maximum individuals and the general population within 50 miles of the DRP at the model LMFBR fuel reprocessing plant site for these atmospheric releases would be as follows:

Organ	Maximum Individual Dose (millirem)	Population Dose (Man-rem)
Whole Body	0.06	1.01
Thyroid	3.9	81.2
Lung	0.10	1.02
Bone	0.15	2.33
Liver	0.08	1.38

Natural background exposures would give an annual average exposure to individuals in the vicinity of the model plant site of about 102 millirem.[3] The annual whole body population dose due to natural radioactivity for the population within a 50 mile radius of the DRP is estimated to be 102,000 man-rem.[9]

It should be noted that there would be no liquid releases of radioactivity from the DRP. The C-14 released would produce a world-wide population dose commitment, over all time, of 3.7×10^3 man-rem, based on a constant world population of 6×10^9 people.[10]

Note that the DRP doses differ only slightly from those resulting from the model reprocessing plant, primarily due to use of different confinement factors for C-14 and I-129.

Impacts from high level waste product solidification are included within the total impact from operation of the reprocessing facility.

Doses from Transportation Impacts from transportation of new fuel (on average 84/yr of fuel and 70/yr of blanket) to CRBRP, from operation of CRBRP and from transportation of spent fuel from CRBRP are identified in Section 5.3.

The doses from transportation of wastes from reprocessing are given below:

	Volume/yr	Trips/yr	Dose (Person-rem)
Low Level	882 ft^3	11	0.220
Metal Scrap & Transuranic	530 ft^3	40	0.660
High Level	35 ft^3	3	0.117

The transuranic wastes from core fuel fabrication are to be stored at the DOE's Hanford Reservation. Transportation from the fuel fabrication plant to the waste management site occurs over a route completely within the Hanford Reservation, with no public exposure. Thus there will be no impact from this transportation phase.

The calculational approach identified in NUREG-0170 was used to determine the population doses due to all different phases of the fuel cycle. The assumptions made for these calculations are as follows:

Shipment of New Fuel from Fabricator by Truck (SST)

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	30	50	55
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
One way traffic per hr.	3,000	800	500

Additional Assumptions:

- o Fuel/food stops in population areas of 200/mile^2, 4 hr/day.
- o 14 shipments/year, 2500 miles
- o Shielding of new fuel gives same external dose as for spent fuel shipping cask. Dose Rate Factor - K = 10^3
- o Four lane traffic exists only in high population zones. This contributes 2% of high-population traffic.
- o Shipment duration 2.5 days.

Shipment of New Blanket from Fabricator by Truck

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	30	50	55
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
One way traffic per hr.	3,000	800	500

Additional Assumptions:

- o All stops in low population areas for rest.
- o Fuel/food stops in med-population areas, 1 hr/day
- o 14 hr/day lay over
- o 12 shipments/year, 2500 miles
- o Dose Rate Factor K=10
- o Four lane traffic exists only in high population zones. This contributes 2% of high-population zones.
- o Shipment duration 5 days

Shipment of Plant Radwaste from Plant by Truck

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	30	50	55
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
One way traffic per hr.	3,000	800	500

Additional Assumptions:

- o All stops in low population areas for rest.
- o Fuel/food stops in med-population areas, 1 hr/day
- o 14 hr/day layover
- o 8 shipments/year, 2500 miles
- o Dose Rate Factor $K=10^3$
- o Four lane traffic exists only in high population zones. This contributes 2% of high-population traffic.
- o Shipment duration 5 days.

Shipment of Spent Fuel from CRBRP by Rail

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	15	25	25
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
Stop Duration (hrs)	0	0	36

Additional Assumptions:

- o 14 shipments/year, 2500 miles
- o Dose Rate Factor $K=10^3$
- o Per NUREG-0170, on-link persons dose considered negligible.

Shipment of Spent Blanket from CRBR by Rail

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	15	25	25
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
Stop Duration (hrs)	0	0	36

Additional Assumptions:

- 12 shipments/year, 2500 miles
- Dose Rate Factor - no credit taken for reduction in source strength compared to spent fuel. ($K=10^3$)
- Per NUREG-0170, on-link persons dose considered negligible.

Shipment of Irradiated Control and Removable Radial Shield Assemblies from CRBRP by Rail

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	15	25	25
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
Stop Duration (hrs)	0	0	36

Additional Assumptions:

- o 2 shipments/year, 2500 miles
- o Dose Rate Factor K=10
- o Per NUREGO-0170, on-link persons dose considered negligible.

Shipment of PuO_2 from Reprocessing Plant by Truck (SST)

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	30	50	55
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
One way traffic per hr.	3000	800	500

Additional Assumptions:

- o Fuel/food stops in population areas of 200/mile^2, 4 hr/
- o 14 shipments/yr, 3000 miles
- o Dose Rate Factor $K=10^3$
- o Four lane traffic exists only in high population zones. This contributes 2% of high-population traffic.
- o Shipment duration 3 days

Shipment of HLW from Reprocessing Plant by Rail

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	15	25	25
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
Stop Duration (hrs)	0	0	36

Additional Assumptions:

- o 3 shipments/year, 2500 miles
- o Assume 36 hour layover in train yards, 65 person/mile^2

Shipment of TUW and Metal Scrap from Reprocessing Plant by Truck

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	30	50	55
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
One way traffic per hr.	3000	800	500

Additional Assumptions

- 6 shipment/year, 2500 miles
- Dose Rate Factor $K=10^3$
- 530 ft^3 of material/year @ 3×10^4 Ci/ft^3
- All stops in low population areas for rest.
- Fuel/food stops in med-population areas, 1 hr/day
- 14 hrs/day layover
- Four lane traffic exists only in high population zones. This contributes 2% of high-population traffic.
- Shipment duration 5 days

Shipment of LLW from Reprocessing Plant by Truck

Shipment Parameters	High Population Areas	Med. Population Areas	Low Population Areas
Average Speed (MPH)	30	50	55
Population Density (person/mile^2)	10,000	2,000	15
Fraction of distance traveled	0.05	0.05	0.90
One way traffic per hr.	3000	800	500

Additional Assumptions:

- o All stops in low population areas for rest
- o Fuel/food stops in med-population areas, 1 hr/day
- o 14 hr/day layover
- o 2 shipments/year, 2500 miles
- o Dose Rate Factor $K=10^3$
- o Four lane traffic exists only in high population zones. This contributes 2% of high-population traffic.
- o Shipment duration 5 days
- o 882 ft^3 of material/year @ 0.3 Ci/ft^3
- o 60 drums per truck

Doses to maximum individuals were calculated for the two different modes of transportation, truck and rail shipment. For truck shipments, the maximum allowable dose in the cab of an exclusive-use tank is 2 mrem/hr. The dose rate at 3 feet from the surface of a cask containing spent fuel is 10 mrem/hr. Assuming a crew member spends 9 hrs. per day in the truck cab and 1/2 hr. per day inspecting the shipment, the dose is calculated per trip as:

(trip/yr)(day/trip)[(9 hrs/day)(2 mrem/hr)+(0.5 hr/day)(10 mrem/hr

For rail shipment, it is assumed that the maximum individual would be a person in the yard where the train stops for rest. Assuming this person was three feet from the cask for the full duration of the stop, the maximum individual dose would be calculated as:

(10 mrem/hr)(stop duration)

The results of the calculations are presented in Table 5.7-9.

5.7.1.5 SAFEGUARDS AND SECURITY

Special Nuclear Material (SNM) includes plutonium, U-233 or uranium enriched in the 235 isotope. The presence of SNM in the CRBRP fuel cycle requires that safeguards be applied to prevent unlawful diversion of material. The principal fuel cycle operations that will support the CRBRP are transportation of fresh fuel, fuel fabrication, spent fuel transportation, chemical reprocessing of the spent fuel, and disposal/storage of radioactive wastes derived from spent fuel. The following discussion reviews each aspect of the supporting fuel cycle operations from a safeguards standpoint to show that the overall risks and costs attributable to CRBRP fuel cycle activities are not likely to be significant.

The safeguards and security requirements for DOE facilities are specified in DOE orders, number 5630 for Material Control and Accounting and 5632 for Physical Protection. These are comparble to the NRC requirements published in the Federal Register 10CFR70 and 73.

The most recent design basis threats are given in 10CFR73.1, for sabotage or theft: a determined, violent, external assault, attack by stealth or deceptive actions, by a small group of well trained, dedicated individuals with inside knowledge of the syte[m] and possibly the assistance of one insider, and equipped with automatic weapons, explosives and other tools, or a conspiracy between individuals in any position who have access to and detailed knowledge of the materials and facilities. The DOE threat is similar in character including insiders and external assault.

A. Conversion to Plutonium Oxide (PuO_2)

Plutonium for the fuel during the 5-year demonstration period of the CRBRP will be obtained from DOE stocks. This material will be converted from its storage form to plutonium-oxide (PuO_2) in an as yet undetermined DOE facility. A candidate facility for PuO_2 conversion is the Purex Reprocessing Plant at the 200 West Site of the DOE Hanford Reservation. The safeguards provisions at the Purex Plant, described below, are representative of those for the PuO_2 conversion facility ultimately selected.

Safeguards for these facilities, as at all DOE facilities that possess significant quantities of plutonium or high enriched uranium, employ physical protection, material controls, and accounting procedures to detect and to respond to attempts to seize or to steal nuclear material or to commit sabotage. Cetain individuals are assigned to provide assurance that the physical protection, material control and accounting procedures are carried out effectively. DOE Headquarters and field office personnel inspect the facilities for compliance with the procedures manuals, and assess the effectiveness of the safeguards/security measures as they are carried out.

Several processes may be used to convert plutonium-nitrate, which is the usual product of a reprocessing facility, or plutonium metal or other chemical forms to PuO_2. As far as safeguards are concerned the important features are that the plutonium is accurately measured at the input. It is then fed into several successive chemical processing stages, alon with reagent to form a precipitate which is baked in a controlled atmosphere to form dry PuO_2 powder. The plutoni in the waste streams and the PuO_2 product are measured. Th processing equipment will be operated remotely. Unit-process, real-time accounting for such a facility has been demonstrated at Los Alamos.(14)

The physical security system at the 200 West Site consists of an isolation zone, a controlled area, associated offices and laboratories, the Purex reprocessing building, and the material access areas within the buildings. The isolation zone is an open area surrounding the protected zone except where the hardened guard post, personnel and vehicle gates are located. At the perimeter of the protected area is a chain-link fence, capped with barbed wire and equipped with sensors. The protected area has additional personnel detectors, is illuminated, patrolled and under CCTV surveillance. Only authorized personnel and vehicles are admitted. Access to each building with nuclear materials is also controlled and limited to those authorized to enter particular buildings. Personnel and packages are subject to searches, e.g., portal monitors to detect weapons, explosives or plutonium on personnel. Employees have DOE clearances, others must be escorted by guards or employees with Q clearances.

The PuO_2 conversion process MBA will be a material access area, probably within the Purex reprocessing building. Access to the latter will be limited to personnel authorized for that facility, and access to the PuO_2 conversion material access area will be limited to those who have a need to be in that area. Again, all personnel will have DOE clearances and there will be portal monitors and NDA or opened search of packages, etc.

The area has a second, hardened security post. The guards are equipped with two way radios. The two guard posts are linked to each other, to other DOE security posts in the

Richland-Hanford complex and to the local and state police by phone and by radio.

The material control or internal controls include the containment and surveillance features described above, plus the following: a material control and accounting staff is required and assigned specific responsibilities for keeping track of where all materials are and for witnessing and recording all transfers, internal to a facility as well as receipts from and transfers to others. In this case, they would witness removals from the storage vaults, transfer to the PuO_2 conversion material access area, input to the process, withdrawal and packaging of the PuO_2 product and transfer of the latter to the FMEF. They would process and analyze the data from the input, output, waste, and unit process measurements or instruments, and observe and analyze the data obtained in periodic cleanouts and material balances. The throughput of this conversion facility could be as much as 1,000 kg per year, or a few kg per day of operation. The near-real-time accounting system should be able to detect considerably less than 1 kg. diverted by insiders in a day or a week.

There have been improvements in the accuracy and reliability of the measurements of plutonium metal and compounds in the last 8 years, as well as in the instruments and the analytical techniques for near-real-time-accounting. It should be possible for DOE contractors to measure the plutonium fed into a conversion facility and the PuO^2 product to 0.1% at the 95% confidence level. The plutonium held-up in or on the processing equipment, after a year might be comparable. Since the waste streams of a conversion facility contain much less than 1% of the material processed, a 10% assay is adequate. The overall limit of error for a year should be 2 kg or less for 1,000 kg processed.

B. Transportation of MOX and Fresh MOX Fuel

Under contract with Project Management Corporation for the CRBRP, DOE maintains ownership of the fuel for the initial core and first four reloads, and is responsible for delivery of the fuel to the plant. Since October 1976, DOE has required that all shipments of more than two kilograms of plutonium or uranium-233, or five kilograms of uranium-235 in high-enriched uranium, should be made in Safe Secure Transport vehicles with armed escorts and monitored by the DOE radio-communication system. The vehicles are similar to those being used for secure transport of nuclear weapons, and provide a level of assurance in excess of that associated with commercial shipment (10CFR 73.25 - .37). The CRBRP fresh fuel shipments will use the DOE system, which includes the following security measures:

1. The fresh fuel will be carried in a special penetration-resistant vehicle. The vehicle includes active and passive barriers to protect the cargo, crew compartment armor, and means to immobilize the vehicle.

2. The cargo vehicle itself contains two reliable and trustworthy armed couriers (both drivers) and will be accompanied by a minimum of one escort vehicle carrying three additional armed couriers (all drivers).

3. Couriers are carefully selected for reliability, trustworthiness and physical fitness, and are specially trained, equipped, and armed.

4. Shipments are under the direct control of a central dispatcher. A system for redundant, all-weather communication between shipments anywhere in the

continental United States and the dispatcher is in operation. It provides for digital and voice 2-way communications, and for emergency signaling under duress. Communication is by means of an array of widely-spaced transmitter-receiver stations connected by land lines to the central dispatcher, with automatic switching and acknowledgement. Both escort and cargo vehicles can communicate with the dispatcher, and routine reports are submitted at frequent intervals.

5. Specific standing arrangements are in effect with state police and certain other local law-enforcement agencies to provide timely response in emergencies. Studies have been made to determine expected response times at various locations; operations have been geared to realistic response-time estimates. Liaison is maintained with other Federal agencies to facilitate further support in extreme emergencies.

C. Fabrication of MOX Fuel

The fabrication of CRBRP Mixed Oxide (MOX) fuel is planned for the Secure Automated Fabrication (SAF) line which will be installed in the Fuels and Materials Examination Facility. Welded fuel pins from the SAF line will then be assembled into fuel assemblies in Building 308 at DOE's Hanford Reservation.

The physical protection system employs multiple barriers: (1) a controlled area, surrounded by a fence, (2) the building, FMEF or 308, and (3) the secure automated fabrication (SAF) process equipment which is a material access area within the FMEF building. Personnel and vehicle traffic are controlled from a hardened guard post, at the fence, and access to the FMEF and Building 308 and to the material access areas within either facility is also controlled. Persons and packages entering or leaving are subject to search for contraband and nuclear materials. A second hardened guard post is located within the facility building. Intrusion alarms are installed on the fence and in the controlled area, which is illuminated and under closed circuit television (CCTV) surveillance. There are redundant communication links within the facility, from this facility to other DOE facilities in the area, and to the local police.

All employees are selected for reliability and must obtain DOE clearances. Security guards and other responsible individuals must receive training and take qualification tests, periodically.

The SAF process line will be fully automated from the blending of powders through the sintering and examination of pellets, and equipped with sensors so that material balances can be drawn about individual processes and for the whole material balance area every day. Whenever operators have access to the materials, they will be accompanied by materia control and health physics personnel.

The SAF line will incorporate provisions for safeguards and accountability of SNM throughout the fabrication process. The following features will be included:

- One Material Balance Area (MBA) will be established on the 70-ft level of FMEF containing the SAF Line.

- The SAF Line MBA shall generate data that details the quantity of SNM received into the MBA, shipped from the MBA or remaining with the MBA. All SNM entering and leaving the MBA shall be measured by both the shipper and receiver, unless the SNM is in a container sealed with a Tamper Indicating Device (TID).

- SNM will be carefully characterized before it enters the SAF Line MBA. SNM will travel through the processing operations using item identification and weight as the primary accountability measurements.

- In instances where weight and item identification do not sufficiently identify the SNM (i.e., scrap and waste), nondestructive examination of the material will be required.

- Unit Process Accountability areas (UPAAs) will be established around each processing step within the SAF Line MBA. Generally, these will coincide with boundaries established for the purpose of criticality control.

- o All SNM entering and leaving UPAAs will be measured. When SNM leaving a UPAA enters another UPAA through a common point, only a single measurement is required.
- o Data on all SNM movement within the SAF Line MBA will be available such that a material balance can be drawn around each UPAA within 24 hours.

D. Spent Fuel Transportation

Irradiated (spent) fuel removed from CRBRP represents a small incremental risk over other fuel cycle operations. The spent fuel is hot, both radiologically and thermally, and therefore requires special equipment for even the simplest handling operations. The material is highly unattractive as a target for diversion, since chemical and mechanical operations requiring expensive complex facilities and equipment are required to reduce it to a usable form. Spent fuel assemblies would be transported and protected in large casks weighing many tons. Irradiated fuel assemblies would be contained in a removable cannister inserted in the cask. The fuel casks will be designed to be transported on a 100-ton capacity railroad flatcar. The cask/car combination will be designed in accordance with DOT and NRC regulations, which include provision for crash protection and passive cooling capability. Specific elements which will serve to protect the spent CRBRP fuel while in transit in the cask include multiple heavy steel shells, a thick, dense gamma (radiation) shield, a liquid jacket and sacrificial impact absorbers. These protection elements, while designed to enable the irradiated fuel to withstand crash, also provide substantial protection against sabotage.

Nevertheless, the possibility of sabotage with release of radioactivity does exist. A preliminary 1977 version of the study "Transportation of Radionuclides in Urban Environs," projected over a thousand latent cancers associated with a worst case estimate. Experimental effort to evaluate the extent of the radioactive release by sabotage (source term) has significantly reduced the estimate of expected latent cancers. However, DOE instituted interim "DOE Requirements for the Physical Protection of Highway Shipment of Irradiated Reactor Fuel." These upgraded requirements for the protection of irradiated reactor fuel include:

1) The shipment having an escort, either two individuals in the vehicle cab or one in the vehicle cab and two additional escorts in a separate vehicle.

2) Appropriate communication devices for maintaining continual contact with a central communication center and improved emergency communication and vehicle location capability.

3) Improved coordination with local law enforcement agencies and routing avoiding urban areas consistent with U.S. Department of Transportation's (Docket HM-164) regulations.

These requirements have been officially accepted by the Department of Transportation as essentially equivalent to 10CFR73.37 under Section 173.22(b) (Docket HM-164).

E. Chemical Reprocessing

The safeguards provisions of the reprocessing facility are expected to be similar to those for the model facility in WASH 1535 or those of the Demonstration Reprocessing Plant (DRP) described below.

The safeguards system for the DRP will provide both physical protection and nuclear material control and accounting capabilities to satisfy Federal [Nuclear Regulatory Commission (NRC) and DOE] regulatory requirements. In addition to these traditional safeguards capabilities, the system will provide for the protection and control of classified matter and information, and the DRP plant and property (i.e., Government property). The system includes mechanisms and provisions for deterrence, detection, delay, communications, assessment, accounting, control, and response as required to meet the above regulations plus anticipated future requirements. The DRP physical protection system includes security zones, facility architectural and design features, personnel and vehicle access control, intrusion detection and assessment, automated alarm reporting, surveillance, communications, and computer security.

Physical security zones include an isolation zone, a protected zone, a hardened area, no access areas, material access areas, vital areas and limited access areas. The isolation zone is an open area surrounding the Protected Zone except where support facilities for personnel/vehicle/rail egress and ingress control are provided. It will ensure that only authorized entry is made to the Protected Zone and will detect unauthorized entry attempts. This zone will be bounded by two chain link fences and will be clear of all objects that could conceal or shield an individual. The Isolation Zone will be equipped with intrusion detection equipment and closed-circuit television (CCTV) to allow rapid reviewing and assessment of this zone. This zone also has a vehicle barrier designed to prevent forced entry with automoblies or light trucks, exterior to the outer of the two zone fences.

The protected zone is the area totally enclosed by the Isolation Zone that contains the Process Building (the hardened Process Building shell included), the open area between the Process Building and the Isolation Zone boundary fence and any other support structures within the area surrounded by the Isolation Zone. The area outside the Process Building will also be lighted during darkness or periods of poor visibility.

The Protected Zone is further subdivided by the hardened area. The hardened area is the portion of the Process Building enclosed within a tornado missile barrier. This includes the hardened shell of the main Process Building and the hardened control centers. Normal and routine entry is restricted with a hardened guard station, at the hardened shell perimeter.

The facility architectural and design features assure that significant quantities of SNM are physically separated from all personnel during normal operations, and access control to the security areas is provided. The monolithic structure of the Process Building and the relatively straight building lines at ground level provide the detection and assessment capability of the safeguards system and limit the ease of forceful entry. The natural phenomena barrier that encloses most of the Process Building is a major barrier of the safeguards system. The limited number of entrances to this hardened area controls access to the Process Building.

The entry-control system will allow surveillance, monitoring and control of personnel, vehicles and materials to and from the Controlled Zone, the Protected Zone, the Process Building, and the hardened areas. Vehicle inspection portals exist at entries to the Protected Zone to allow search of vehicles prior to entry and upon exit. Personnel access portals exist at entry and exit ways of security areas.

A defense in depth concept for physical security depends on the use of electronic devices to detect intruders at each level of defense. Alarms given by the system are both audible and visual and all are received at the safeguards control center and the secondary alarm station. The intrusion detection system consists of exterior and interior intrusion detectors and CCTV cameras, secure signal transmission, alarm assessment and display equipment and alarm and CCTV recording eqiupment. This system will be used to detect unauthorized entry into the Controlled Zone, Isolation Zone, and Protected Zone. Interior alarms will annunciate in the continuously-manned safeguards control center and at the secondary alarm station.

To ensure immediate reporting and assessment of possible attempts at intrusion, the intrusion detection sensors and key-card access control system will report through a computer-initiated automatic-alarm switching system. This system integrates at the computer, intrusion detection devices, key-card alarms, response action instructions and outline maps with closed-circuit television (CCTV) surveillance and alarm assessment system display.

Security surveillance of activities and processes involving special nuclear materials and/or impacting on security of these processes is a fully integrated safeguards subsystem. Primary forms of surveillance used in the DRP will include:

- o Guard force (fixed, vehicular and foot patrols)
- o Management and supervisory observation
- o Closed-circuit television (CCTV) surveillance monitored and managed at the safeguards control center (SCC) and the secondary alarm station (SAS).

Full-time surveillance is employed for security barrier fencelines, the Isolation Zone cleared areas and entry/exit-ways through primary barriers.

The communications network for the DRP physical protection system will allow rapid and continuous communication among on-site security force personnel and between on-site and off-site response forces. Off-site communications needs are met using telephones for routine communications and a radio link for emergency communications. Similarly, a radio communication system consisting of base stations, mobile radios and hand-carried portable transceivers will meet on-site communication needs under most conditions.

Since the efficiency and effectiveness of the entry control and intrusion detection systems depend on automatic data processing, computer security will have a high priority in the overall safeguards system. As such, computer facilities (to include hardware and software) require that level of security for vital areas. Access to the computer facilities (the SCC or SAS) requires a key-card reader and digital code operated locking system. Safeguards computer transmission lines will be under constant line supervision and all panel boxes, connectors, etc., will be affixed with tamper devices or switches.

In addition to physical security, the DRP Safeguards System includes material control and accounting capabilities. Both passive and active material control features are included. Passive material control is accomplished by placing barriers or impediments between SNM and an inside adversary. All significant quantities of SNM are processed and stored in remotely operated cells which limit direct personnel access during routine operation. Active material control is accomplished by monitoring cell penetrations from sensitive process equipment to occupied areas for the presence of nuclear materials.

The DRP material accounting system will be based on a series of Material Balance Areas (MBA). An MBA is an identifiable physical area around which accurate SNM balances can be performed. The material balance areas will consist of a small pool to store spent fuel assemblies, the chemical separation equipment area, storage vessels for the uranium and plutonium nitrate products of the extraction-purification stages, the chemical processing equipment used to convert plutonium nitrate to plutonium oxide (or to MOX), a product storage vault, and the analytical laboratory.

All of the process equipment will be contained within massive shielding, operated under remote control, and with provision for remote repair and maintenance. Material control is achieved primarily by this containment. Where spent fuel, products or samples are handled, guards and/or materials control personnel will provide continuous surveillance. In addition, personnel and packages entering or leaving the operations areas will be subject to search for contraband and nuclear materials.

Material accounting will be on a near-real-time basis. Spent fuel assemblies will be accounted for as discrete, numbered items. After disassembly and dissolution of the pellets, an accurate measurement will be made of the volume of solution, the concentration of uranium and plutonium in the solution, and the isotopic compositions of both. For process control and accounting, the quantities of uranium and plutonium in the process vessels and intermediate buffer vessels will be continuously monitored. Intermediate nitrate products, oxide products and all waste streams will be measured.

It is anticipated that the CRBRP will discharge 1,000 kg or less per year of plutonium along with about 11,000 kg of depleted uranium. The limit of error of the measurement system should be in the range of ±0.25% of throughput, or 2.5 kg of plutonium per year, which is less than the quantity of 8 kg/year presently employed by the IAEA as a design goal. It should be noted that the physical protection and material control functions are designed to prevent any diversion by sub-national adversaries as well as to thwart any attempts to sabotage the equipment.

F. Radioactive Wastes

Because of the low concentration of plutonium and uranium in radioactive wastes, it is not considered attractive for diversion purposes. However, there are certain inherent safeguards features within radioactive waste handling and management procedures.

High level radioactive waste (HLW) will be stored within the physical security bounds of the reprocessing plant prior to shipment. Due to the relatively high radioactivity and thermal generation associated with HLW, transport to a repository will be accomplished in a similar fashion to spent fuel. At the repository, the physical security of the site as well as the remote location of the wastes deep underground should effectively deter diversion. Similarly, transuranic and low level wastes will be packaged in DOT approved shipping containers and transported from points of origin to disposal facilities, where they will be handled within existing physical security systems.

G. Safeguards Costs

The incremental cost of safeguarding the facilities in the fuel cycle, apportioned to reflect the part of the facility operations dedicated to the CRBRP fuel cycle, are shown in Table 5.7-11. Costs are included for safeguarding facilities for fuel fabrication, fuel reprocessing, the CRBRP plant, and transportation of special nuclear materials (SNM) among the facilities. Both initial investment and annual operating costs are given in constant FY 1982 dollars. It is evident from the totals in Table 5.7-11 that the costs of safeguarding SNM in the CRBRP fuel cycle are a small portion of the total facility costs.

Costs are given separately for physical security of the facilities, the materials control and accounting (MC&A) provisions, and the guard forces. Physical security costs include such things as perimeter and entry controls, video surveillance and internal security systems. MC&A costs are those incremental costs of upgrading normal process control and monitoring instrumentation for safeguards application, non-secure software and communications systems, and the maintenance thereof. The guard force costs include salaries, benefits, overhead and equipment. The assumptions and basis for these costs are described below for each facility.

Fuel Fabrication

The CRBRP fuel pins are planned to be fabricated at the Secure Automated Fabrication (SAF) line, located within the Fuels and Materials Examination Facility (FMEF) at DOE's Hanford Reservation. The resulting fuel pins will be transported a short distance on the Hanford site to the 308 Building where they are formed into final fuel assemblies. The safeguards provisions at these facilities are described above.

The SAF line is an addition to the FMEF. Only the incremental costs for securing the SAF line are attributable to the CRBRP fuel cycle. The SAF line will share the FMEF perimeter security system, guard force center, display consoles, guard forces, etc.

The initial costs of installing the SAF physical security system include:

$0.5M - entry control portals, hand geometry controls, key card controlled doors, map displays, TV monitors, alarm processors, TV switchers, video recording equipment, electrically locked doors, sensors and closed circuit TV cameras.

$0.4M - installation of the above equipment
0.2M - software development
$1.1M

The annual cost of operating the SAF physical security system is estimated to be $70,000 including equipment replacements and minimal incremental manpower over that required for FMEF. No significant increase in FMEF annual period force expense is estimted as a result of adding SAF.

The initial investment for the SAF MC&A system is estimated as:

$0.5M - computer
$1.5M - software development
$0.5M - upgraded measurement capability for safeguards purpose
$2.5M

The $1.5 million annual cost of operating the SAF MC&A system assumes the following staff on a 4 shift, 365 day a year schedule:

4 safeguard officers
4 safeguard assistants
12 computer specialists
4 instrument technicians
8 safeguards line inspectors
32 or 8 per shift

As the CRBRP fuel cycle utilizes about 65 percent of SAF's operational schedule, only that portion of the above costs are included in Table 5.7-11.

The 308 Building is located within the 300 area at DOE's Hanford reservation. Based on discussions with the Hanford Engineering and Developmet Laboratory staff that operate the 308 Building, the physical security system costs for the 300 area are: a) initial investment - $7.5 million, b) annual operating expense - $0.3 million, and c) annual guard force expense - $3.2 million. The 300 area is manned by a staff of 70 guards.

Support of the CRBRP fuel cycle requires about 20% of the 300 area activities, and only that portion of the security costs are included in Table 5.7-11. The 20% figure is based on the 308 Building being about 1/3 of the major facilities in the 300 area requiring physical security (in addition to the 324 and 325 Buildings) and that CRBRP fuel cycle support requires about 65% of the fuel assembly capacity of Building 308.

The 308 Building MC&A system accounts for discrete, numbered items only. No liquid or powder process steps are involved and no volume, density or concentration measurements are required. As such, no costs are estimated for upgraded measurement capability. The initial investment for the 308 Building MC&A system is estimated as follows:

$0.5M - computer hardware
1.5M - software development
$2.0M

The $0.7 million annual cost of operating the 308 Building MC&A system assumes one safeguards inspector per shift and one safeguards supervisor, or 5 total personnel for 4 shift operation.

Support of the CRBRP fuel cycle requires about 65 percent of the 308 Building fuel assembly capacity, and only that portion of the MC&A costs are included in Table 5.7-11.

The total fuel fabrication safeguards system costs in Table 5.7-11 are a summation of the appropriate portions of the costs for the SAF and 308 Building.

Plant

The CRBRP safeguards provisions are described in PSAR Section 13.7. The following is a breakdown of the physical security system costs.

	Initial Investment	Maintenance and Operating
Electronic Security System (includes CCTV, alarms, computers, access control electronics)	$ 1.80 M	$ 90 K
Gate House (less access control electronics) and Central Alarm Station	0.42 M	8 K
Fencing and Related Items Such As Sewer Pipe Grating and Derailers	0.19 M	4 K
Electrical (wiring, conduit, uninterruptible power supply, batteries)	1.33 M	66 K
Communications	0.12 M	6 K
	$ 3.86 M	$174 K

Accountability of fissile and fertile material is inherent in the design of the CRBRP refueling system for reasons other than security. After inspection at receipt, the assemblies are not visually identified again until shipment of the irradiated assemblies. The assemblies are mechanically identified prior to insertion into the core and subsequent to removal from the core as part of the reactor safety program. All movements of fuel within the plant are monitored and/or recorded on the refueling system computer for inventory purposes and to insure reactor safety during core configuration changes. No incremental cost is assumed for safeguards accountability at the plant.

The CRBRP security force consists of:

1 - Unit Chief
1 - Operations Captain
1 - Administration Captain
1 - Training Officer
5 - Shift Supervisors
5 - Alarm System Monitors
55 - Public Safety Officers
3 - Clerk-Typists
72 Personnel

The initial investment of hiring, training and equipping this force is estimated to cost $47,000. The bulk of the security force will be onsite when the fuel arrives, approximately 9 months prior to fuel loading. The cost of guards during the year prior to criticality is estimated at $1.1 million. From the year of criticality onward, the guard force is estimated to cost about $2.1 million annually.

Transportation

The number of shipments per year for the different materials in the CRBRP fuel cycle are given on Table 5.7-9. Special safeguards measures are provided for the shipment of fresh fuel, PuO_2, spent fuel and spent blanket assemblies. The other materials transported within the CRBRP fuel cycle do not contain sufficient quantities of SNM to warrant special safeguards measures.

Transportation of new fuel and PuO_2 is planned using DOE's Safe Secure Transport (SST) system. As this system will have sufficient capacity and communications capability to accommodate CRBRP transportation requirements, no initial investment costs are anticipated. Operating costs for SST shipments are estimated to cost $18,000 per 2500 mile shipment, round trip.

Transportation of spent fuel and spent blanket assemblies require two escorts and appropriate communications devices. The incremental cost per escort for these provisions is estimated to be $50,000 per year.

The safeguards cost of transportation within the CRBRP fuel cycle is summarized below:

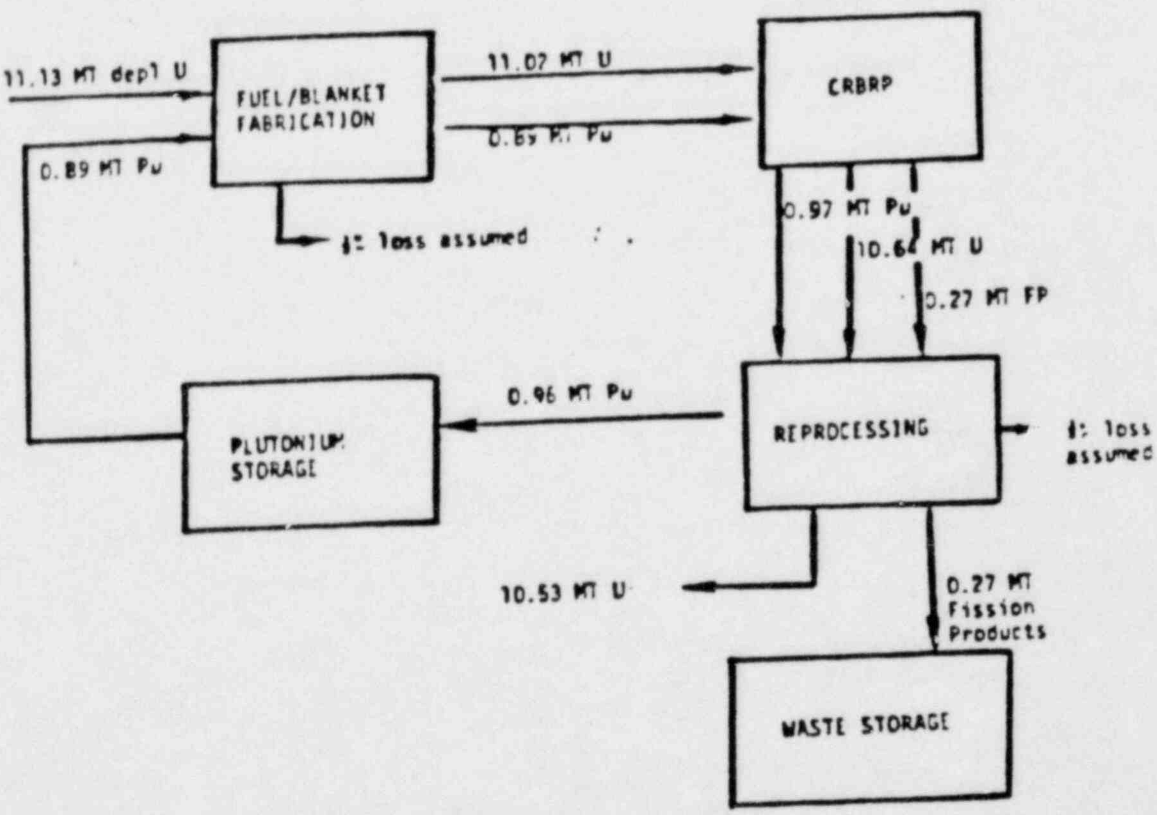
Material	Shipments/Yr.	Cost/Shipment	Annual Cost
PuO_2	14	18,000	252,000
Fresh Fuel	14	18,000	252,000
Spent Fuel	14	N/A	100,000
Spent Blankets	12	N/A	100,000
			$704,000

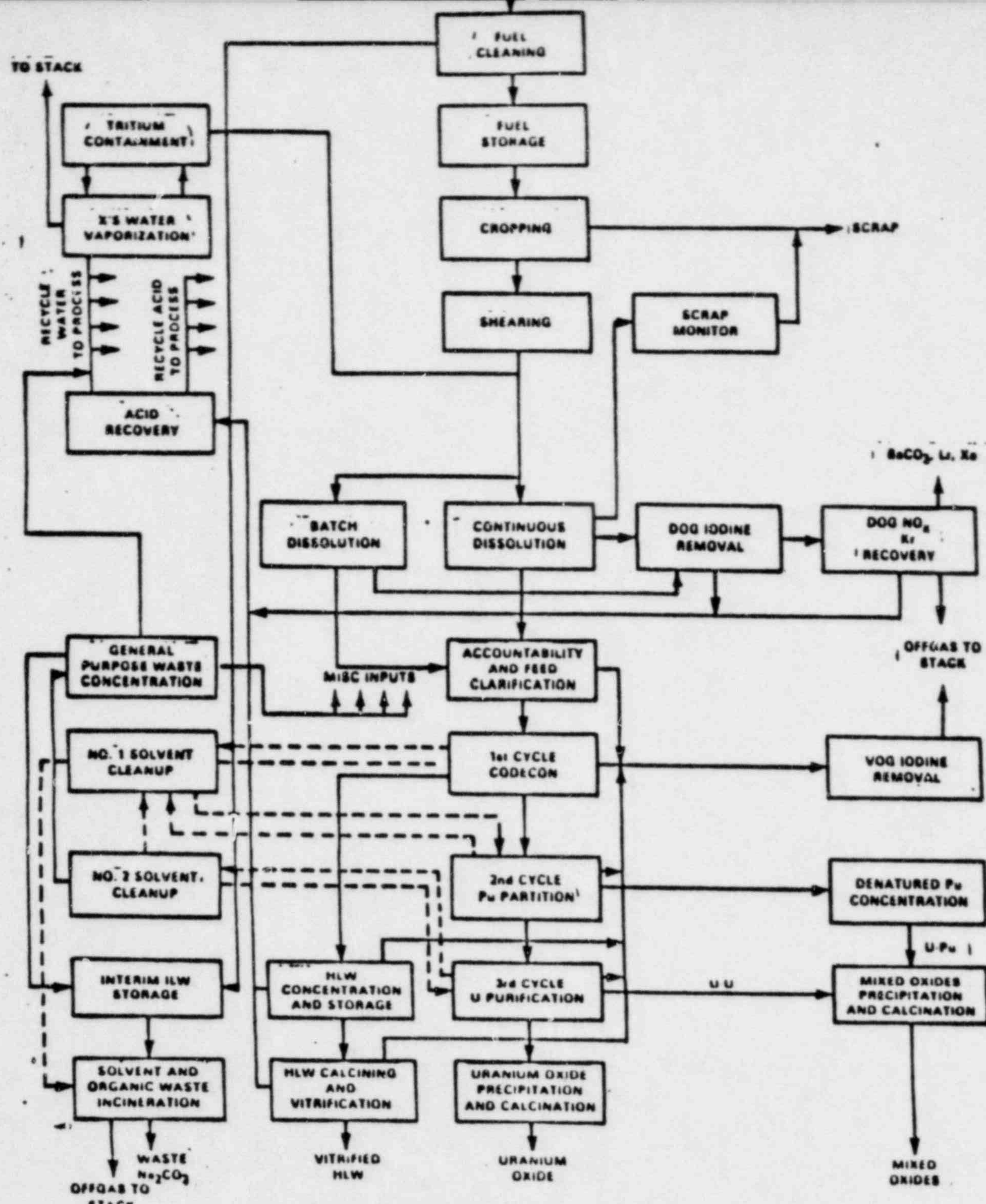
FIGURE 5.7-2

CRBRP EQUILIBRIUM FUEL CYCLE

PLUTONIUM AND URANIUM MASS FLOW

(MT/year, average)





FUEL REPROCESSING SCHEMATIC

Figure 5-7.3

TABLE 5.7-1

CRBRP - SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR FUEL CYCLE

Natural Resource Use	Fuel Fabrication Mixed Oxide (Core Fuel)	Fuel Fabrication Uranium Dioxide*** (Blanket)	Reprocessing****	Waste Management	Transportation	Total
Land (acres)						
Temporarily Committed	--	0.05	10.0	1.3	--	11.35
Undisturbed Area	--	0.04	9.0	--	--	9.04
Disturbed Area	--	0.01	1.0	--	--	1.01
Permanently Committed	--	--	--	2.3	--	2.3
Water (gallons/day)						
Discharged to air	--	--	4.2×10^6	2.7×10^2	--	4.2×10^6
Discharged to water bodies	--	1.3×10^4	--	--	--	1.3×10^4
Discharged to ground	7.5×10^2	--	--	2.2×10^3	--	2.95×10^3
Total Water	7.5×10^2	1.3×10^4	4.2×10^6	2.47×10^3	--	4.2×10^6
Fossil Fuel						
Electrical Energy (MW-hr/yr)	9.0×10^3**	4.2×10^2	--	5.3×10^2	--	9.9×10^3
Equivalent Coal (MT/yr)	3.6×10^3**	1.6×10^2	1.3×10^3	2.0×10^2	--	5.26×10^3
Effluents						
Chemicals						
Gases* (MT/yr)						
SO_x	133	5.8	0.4	6×10^{-2}	1.2	140
NO_x	35.2	1.5	3.9	9.1×10^{-2}	15.4	56.1
Hydrocarbons	0.36	1.5×10^{-2}	--	5.1×10^{-3}	1.6	1.98
CO	0.86	3.8×10^{-2}	0.13	2.7×10^{-2}	9.4	10.5
Particulates	35.2	--	--	6.5×10^{-2}	0.6	35.9
F^-	--	1.2×10^{-3}	--	--	--	1.2×10^{-3}

TABLE 5.7-1 (Continued)

Effluents	Fuel Fabrication: Mixed Oxide (Core Fuel)	Fuel Fabrication: Uranium Dioxide*** (Blanket)	Reprocessing****	Waste Management	Transportation	Total
Liquids (MT/yr)						
H_2SO_4	1.0×10^{-1}	--	--	--	--	1.0×10^{-1}
HNO_3	1.0×10^{-1}	5.6	--	--	--	5.7
NH_3	--	2.1	--	--	--	2.1
F^-	--	1.0	--	--	--	1.0
PO_4^{3-}	1.0×10^{-2}	--	--	--	--	1.0×10^{-2}
PO_4^{3-} (after degrading)	1.0×10^{-3}	--	--	--	--	1.0×10^{-3}
Radiological (Curies/yr)						
Airborne						
Pu-236	2.0×10^{-9}	--	1.36×10^{-9}	--	--	3.36×10^{-9}
Pu-238	3.4×10^{-6}	--	8.45×10^{-5}	--	--	8.8×10^{-5}
Pu-239	2.2×10^{-6}	--	2.14×10^{-5}	--	--	2.34×10^{-5}
Pu-240	2.2×10^{-6}	--	2.20×10^{-5}	--	--	2.42×10^{-5}
Pu-241	3.0×10^{-4}	--	2.55×10^{-3}	--	--	2.85×10^{-3}
Pu-242	3.0×10^{-9}	--	4.70×10^{-8}	--	--	5.0×10^{-8}
U-232	--	--	6.22×10^{-11}	--	--	6.22×10^{-11}
U-234	5.8×10^{-11}	--	1.62×10^{-9}	--	--	1.68×10^{-9}
U-235	2.5×10^{-12}	3.2×10^{-11}	7.84×10^{-11}	--	--	1.13×10^{-10}

TABLE 5.7-1 (Continued)

Effluents	Fuel Fabrication: Mixed Oxide (Core Fuel)	Fuel Fabrication: Uranium Dioxide*** (Blanket)	Reprocessing****	Waste Management	Transportation	Total
Radiological (Curies/yr)						
Airborne						
U-236	--	--	1.58×10^{-10}	--	--	1.58×10^{-10}
U-238	5.4×10^{-11}	2.5×10^{-9}	7.36×10^{-9}	--	--	9.9×10^{-9}
Th-228	--	--	1.20×10^{-12}	--	--	1.20×10^{-12}
Th-231	2.5×10^{-12}	3.2×10^{-11}	7.84×10^{-12}	--	--	4.23×10^{-11}
Th-234	5.4×10^{-11}	2.5×10^{-9}	2.36×10^{-10}	--	--	2.79×10^{-9}
Am-241	--	--	2.06×10^{-5}	--	--	2.06×10^{-5}
Np-237	--	--	2.08×10^{-10}	--	--	2.08×10^{-10}
Pa-234	5.4×10^{-11}	2.5×10^{-9}	7.36×10^{-10}	--	--	3.29×10^{-9}
H-3	--	--	5.51×10^{3}	6.8×10^{-6}	--	5.51×10^{3}
Kr-85	--	--	4.75×10^{3}	5.5×10^{1}	--	4.80×10^{3}
C-14	--	--	1.44×10^{1}	--	--	1.44×10^{1}
I-129	--	--	3.26×10^{-4}	--	--	3.26×10^{-4}
I-131	--	--	3.61×10^{-2}	--	--	3.61×10^{-2}
Ru-103	--	--	1.84×10^{-3}	--	--	1.84×10^{-3}
Ru-106	--	--	7.09×10^{-3}	--	--	7.09×10^{-3}
Cs-134	--	--	5.60×10^{-5}	--	--	5.60×10^{-5}
Cs-137	--	--	1.60×10^{-4}	--	--	1.60×10^{-4}
Rn-220	--	--	--	3.0×10^{-4}	--	3.0×10^{-4}
Rn-222	--	--	--	8.2×10^{-3}	--	8.2×10^{-3}
Particulate Fission Products	--	--	6.16×10^{-4}	1.1×10^{-3}	--	1.72×10^{-3}

TABLE 5.7-1 (Continued)

Effluents	Fuel Fabrication Mixed Oxide (Core Fuel)	 Uranium Dioxide*** (Blanket)	Reprocessing****	Waste Management	Transportation	Total
Radiological (Curies/yr)						
Liquids						
U-Total	--	$5.0x10^{-3}$	--	--	--	$5.0x10^{-3}$
Th-234	--	$2.0x10^{-3}$	--	--	--	$2.0x10^{-3}$
Pa-234	--	$2.0x10^{-3}$	--	--	--	$2.0x1(^{-3}$
Solids (Ci/yr)						
Otner than high level						
Alpha	$1.0x10^5$	--	$7.0x10^5$	--	--	$8.0x10^5$
Beta-Gamma	34.	--	40	--	--	74
High Level	--	--	$3.8x10^6$	--	--	$3.8x10^6$
Thermal Generation (Btu/yr)	Not Available	$2.2x10^9$	$1.6x10^{10}$	$5.9x10^{10}$	$8.50x10^7$	$7.72x10^{10}$

*Based upon combustion of equivalent coal for power generation
**Total for FMEF operation
***Non-radiological estimates from WASH-1248, Table E-1 (divided by 4)
****Non-radiological estimates from WASH-1535, Vol. II, Section 4.4 (1500 MT/yr divided by 100, or 3 days of plant operation).

Table 5.7-5

Fuel Cycle Operation	Waste Type	Waste Volume per Year (m^3) CRBRP	1000 MWe LWR* No Recycle	1000 MWe LWR* U Recycle
UF_6 Conversion (dry)	CaF_2 Chem Waste	--	92	95
(wet)	CaF_2 Sludge, Chem Wastes	--	41	35
Enrichment	Low-Level Misc.	--	28	30
Fuel Fabrication	CaF_2, Misc.	11 (MT)	29	29
	TRU	130	--	--
Reactor	Low-Level	67	620	620
	Spent Fuel	--	35	--
Spent Fuel Storage	Low-Level	--	<3	<1
Fuel Reprocessing	Low-Level Misc.	25	--	7
	High-Level	1	--	8
	Misc. TRU	15	--	44
	Plutonium	--	--	6
	Kr-85 Cylinders	0.01	--	--
	I-129 Cylinders	0.01	--	--

* NUREG 0116, Table 3.3

TABLE 5.7-6

Comparison of Annual High-Level Waste Constituents (Ci)

Nuclide	Half-life	CRBRP	1000 Mwe LWR[1]
H-3	12.26Y	5.33×10^{2}	2.3×10^{3}
Sr-90	28Y	3.65×10^{5}	2.7×10^{6}
Ru-10[3]	40D	1.25×10^{5}	7.18×10^{4}
Ru-106	1.0Y	5.28×10^{6}	9.6×10^{6}
I-129	1.72×10^{7}Y	3.26×10^{-1}	1.31
I-131	8.05D	3.29×10^{-7}	6.97×10^{-7}
Cs-134	2.19Y	2.32×10^{5}	6.2×10^{6}
Cs-137	30Y	7.88×10^{5}	3.7×10^{6}
Ce-144	285D	3.95×10^{6}	1.6×10^{7}
Th-228	1.91Y	4.83×10^{-3}	1.18×10^{-1}
U-234	2.48×10^{5}Y	4.06×10^{-3}	2.66×10^{1}
U-235	7.13×10^{8}Y	1.96×10^{-4}	5.99×10^{-1}
U-236	2.39×10^{7}Y	3.96×10^{-4}	1.10×10^{1}
U-238	4.51×10^{9}Y	1.84×10^{-2}	1.01×10^{1}
Np-237	2.2×10^{6}Y	1.04	1.19×10^{1}
Pu-236	285Y	1.53×10^{-2}	9.63
Pu-238	89Y	8.41×10^{2}	1.0×10^{5}
Pu-239	2.44×10^{4}Y	2.14×10^{2}	1.1×10^{4}
Pu-240	6.58×10^{3}Y	2.20×10^{2}	1.7×10^{4}
Pu-241	13Y	2.47×10^{4}	3.5×10^{6}
Pu-242	3.79×10^{5}Y	4.70×10^{-1}	4.83×10^{1}
Am-241	458Y	1.04×10^{5}	8.8×10^{3}
Cm-242	163D	1.09×10^{6}	2.5×10^{5}
Cm-244	17.6Y	3.5×10^{3}	8.2×10^{4}

(1) "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0116, Appendix A; 10% of H-3, 100% of others, multiplied by 35 MTHM/annual LWR charge; 1 year after discharge.

Table 5.7-7

DRP PROCESS CAPABILITY
Throughput per 24 hour day

Reactor	Spent fuel, %	Element/ton	Fuel available, tons/yr	Fuel receiving, elements	Head-end, kg	Solvent extraction, kg	Mixed-oxide conversion, kg	U conversion kg
FFTF	U 72 Pu 28	31.7	3 (30 total by 1991)	24	500	U 360 Pu 140	250	
CRBRP core	U 69 Pu 31	32.6	2.5	24	500	U 440 Pu 60	240	250
CRBRP blanket	U 98 Pu 2	12.0	9.1	24	500	U 490 Pu 10	40	460
BWR	U 99 Pu 1	5.3	Unlimited	24	500	U 495 Pu 5	20	480
PWR	U 99 Pu 1	2.2	Unlimited	10	500	U 495 Pu 5	20	480
LDP core	U 78 Pu 22	7.8	18	10	500	U 437 Pu 63	252	248
LDP blanket	U 97 Pu 3	5.5	12	10	500	U 485 Pu 15	60	440

TABLE 5.7-8

Atmospheric Releases from Reprocessing CRBRP Spent Fuel

		Model Reprocessing Plant		DRP	
Radionuclide	Input (Ci/yr)*	Confinement Factor	Release (Ci/yr)	Confinement Factor	Release (Ci/yr)
H-3	$5.51x10^3$	1	$5.51x10^3$	1	$5.51x10^3$
C-14	$1.44x10^1$**	10^2	$1.44x10^{-1}$	1	$1.44x10^1$
Kr-85	$4.75x10^4$	10^2	$4.75x10^2$	10	$4.75x10^3$
Sr-90	$3.70x10^5$	$5x10^9$	$7.4x10^{-5}$	$5x10^9$	$7.4x10^{-5}$
I-129	$3.26x10^{-1}$	10^4	$3.26x10^{-5}$	10^3	$3.26x10^{-4}$
I-131	$3.61x10^1$	10^4	$3.61x10^{-3}$	10^3	$3.61x10^{-2}$
Ru-103	$1.84x10^6$	10^9	$1.84x10^{-3}$	10^9	$1.84x10^{-3}$
Ru-106	$7.09x10^6$	10^9	$7.09x10^{-3}$	10^9	$7.09x10^{-3}$
U-232	$3.11x10^{-2}$	$5x10^8$	$6.22x10^{-11}$	$5x10^8$	$6.22x10^{-11}$
U-234	$8.12x10^{-1}$	$5x10^8$	$1.62x10^{-9}$	$5x10^8$	$1.62x10^{-9}$
U-235	$3.92x10^{-2}$	$5x10^8$	$7.84x10^{-11}$	$5x10^8$	$7.84x10^{-11}$
U-236	$7.91x10^{-2}$	$5x10^8$	$1.58x10^{-10}$	$5x10^8$	$1.58x10^{-10}$
U-238	3.68	$5x10^8$	$7.36x10^{-9}$	$5x10^8$	$7.36x10^{-9}$
Pu-236	3.07	$2x10^9$	$1.36x10^{-9}$	$2x10^9$	$1.36x10^{-9}$
Pu-238	$1.69x10^5$	$2x10^9$	$8.45x10^{-5}$	$2x10^9$	$8.45x10^{-5}$
Pu-239	$4.27x10^4$	$2x10^9$	$2.14x10^{-5}$	$2x10^9$	$2.14x10^{-5}$
Pu-240	$4.40x10^4$	$2x10^9$	$2.20x10^{-5}$	$2x10^9$	$2.20x10^{-5}$
Pu-241	$5.10x10^6$	$2x10^9$	$2.55x10^{-3}$	$2x10^9$	$2.55x10^{-3}$
Pu-242	$9.40x10^1$	$2x10^9$	$4.70x10^{-8}$	$2x10^9$	$4.70x10^{-8}$
Cs-134	$2.80x10^5$	$5x10^9$	$5.60x10^{-5}$	$5x10^9$	$5.60x10^{-5}$
Cs-137	$7.99x10^5$	$5x10^9$	$1.60x10^{-4}$	$5x10^9$	$1.60x10^{-4}$
Th-228	$5.98x10^{-3}$	$5x10^9$	$1.20x10^{-12}$	$5x10^9$	$1.20x10^{-12}$
Th-231	$3.92x10^{-2}$	$5x10^9$	$7.84x10^{-12}$	$5x10^9$	$7.84x10^{-12}$
Th-234	3.68	$5x10^9$	$7.36x10^{-10}$	$5x10^9$	$7.36x10^{-10}$
Am-241	$1.03x10^5$	$5x10^9$	$2.06x10^{-5}$	$5x10^9$	$2.06x10^{-5}$
Np-237	1.04	$5x10^9$	$2.08x10^{-10}$	$5x10^9$	$2.08x10^{-10}$
Pa-234	3.68	$5x10^9$	$7.36x10^{-10}$	$5x10^9$	$7.36x10^{-10}$
Cm-242	$2.71x10^6$	$5x10^9$	$5.42x10^{-4}$	$5x10^9$	$5.42x10^{-4}$
Cm-244	$3.58x10^3$	$5x10^9$	$7.16x10^{-7}$	$5x10^9$	$7.16x10^{-7}$

* 150 days after discharge; fission products calculated with RIBD code; actinides calculated with ORIGEN code.

** 200 ppm N in fuel.

Table 5.7-9

Transportation Radiological Impact

Fuel Cycle Element	Shipment/ yr	Distance (Miles)	Pop. Dose (Person-Rem)	Max. Person Do (Person-Rem)
New Fuel	14	2500	0.449	1.40
New Blanket	12	2500	0.0065	0.013
Plant Radwaste	8	2500	0.430	0.878
Spent Fuel	14	2500	0.489	0.160
Spent Blanket	12	2500	0.432	0.160
Irradiated Control, RRS	2	2500	<0.001	0.002
PuO_2	14	3000	0.536	1.64
Reproc. Radwaste				
HLW	3	2500	0.0817	0.360
TRU & Metal Scrap	6	2500	0.324	0.660
LLW	2	2500	0.109	0.220

Table 5.7-10

Radioactive Wastes from the CRBRP Fuel Cycle

Facility	Waste/Form Containers	Annual Generation Volume(m^3)/# of Containers	Key Constituents	Disposition
Fuel Reprocessing Plant				
Low-Level	concrete/drums	25/120	Fission & Activation Products, 10. Ci/m^3	Shallow land burial
Misc. TRU	concrete/drums	10/50	Fission Products & >10 nCi/g TRU, 10^3-10^6 Ci/m^3	Repository
Metal Scrap	metal/cylinders	5/8	Fuel Material, Fission & activation products, $4x10^5$ Ci/m^3	Repository
High-Level	glass/cylinders	1/6	Fission Products, TRU, 1.5 x 10^7 Ci/m^3	Repository
Kr-85	metal matrix/cylinders	0.01/0.035	Kr in metal matrix $3.4x10^6$ Ci/m^3	Repository
I-129	concrete/drums	0.01/0.05	Barium Iodate $1.4x10^2$ Ci/m^3	Repository
Core Fuel Fabrication Plant				
TRU	solid/drums	130/145	U, Pu >10 nCi/g	Store at Hanford
Blanket Fuel Fabrication Plant				
LLW	CaF_2/bulk	11 MT	Uranium 0.01 uCi/g	Onsite disposal
CRBR Plant				
LLW	solid-concrete/drums	67/319	Fission, activation products <10^2 Ci/m^3	Shallow land burial

Table 5.7-11

CRBRP Fuel Cycle Security Costs by Plant Type

($ in millions)

	CRBRP Plant		Fuel Fabrication Plan	
Item	Capital	Annual Operating	Capital	Annual Operati
Physical Security System	3.86	0.17	2.2	0.1 1.2
Material Control and Accounting	-	-	2.9	1.4 0.3
Security Force	0.05	2.1	---	0.6 ---
	3.91	2.27	5.1	2.1 1.5