BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNITED STATES DEPARTMENT OF ENERGY	)	
PROJECT MANAGEMENT CORPORATION	)	Docket No. 50-537
TENNESSEE VALLEY AUTHORITY	)	
	)	
(Clinch River Breeder Reactor Plant)	)	

TESTIMONY OF DR. THOMAS B. COCHRAN

Part III

AS SUPPLEMENTED BY NEW INFORMATION IN CRBR FINAL ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT

(Primarily Intervenors' Contention 6(b)(1) and (3))

DATED: November 12, 1982

Q.1: Please identify yourself and state your qualifications to present this testimony.

A.1: My name is Thomas Brackenridge Cochran. I reside at 4836 North 30th Street, Arlington, Virginia 22207. I am presently a Senior Staff Scientist at Natural Resources Defense Council, Inc. My background and qualifications have been submitted in previous testimony in this proceeding (Tr. 2870-71, Cochran). Additional information on my background and qualifications is provided in Exhibit 1 to this testimony (Part III).

Q.2: What subject matter does this testimony address?

A.2: This testimony addresses primarily Intervenors' Contention 6(b)(1) and (3), which questions the adequacy of the Staff's analysis of the environmental impacts of the CRBR fuel cycle. Some of my testimony here also relates to Contentions 1-4, 6(b)(4), and 7(a), namely pages 7-20 herein. As amended by the October 26, 1982, Order of the Licensing Board, Contention 6 is summarized as follows:

> 6. The ER and FES do not include an adequate analysis of the environmental impact of the fuel cycle associated with the CRBR for the following reasons:
>
> * * * *
>
> b) The analysis of fuel cycle impacts in the ER and FES are inadequate since:
>
> 1) The impact of reprocessing of spent fuel and plutonium separation required for the CRBR is inadequately assessed;

* * * *

3) The impact of disposal of wastes from the CRBR spent fuel is inadequately assessed[.]

My testimony addressing Intervenors' Contention 6(b)(4):

> The impact of an act of sabotage, terrorism or theft directed against the plutonium in the CRBR fuel cycle, including the plant, is inadequately assessed, [as] is the impact of various measures intended to be used to prevent sabotage, theft or diversion.

is addressed in Part V of my testimony, provided separately.

Q.3: What is Staff's estimate of the radiological health effects associated with the CRBR fuel cycle?

A.3: Staff estimated that the dose to the whole body from annual operation of the CRBR supporting fuel cycle would be about 170 person-rem, of which 140 person-rem annually is due to reprocessing CRBR fuel. ("Final Supplement to Final Environmental Statement, CRBR," NUREG-0139, Supplement No. 1 (henceforth "FSFES,") pp. D-32, D-34.)

Q.4: Do you agree with this estimate?

A.4: No, I do not agree with the Staff assessment of the risks associated with reprocessing, fuel fabrication, or waste management.

Q.5: Why do you believe the Staff's estimate of the dose commitments from reprocessing CRBR fuel, 140 person-rem/year, is incorrect?

A.5: There are several errors and/or unrealistic assumptions in Staff's estimate of 140 person-rem from reprocessing annual CRBR fuel requirements, due to:

a) Staff's failure to accurately describe the CRBR fuel cycle and realistically estimate (or conservatively bound) risks associated with reasonably foreseeable fuel cycle alternatives (FSFES, pp. D-1 to D-4, and Staff Response to Interrogatory I.2, 27th Set, Oct. 1, 1982, p. 3);

b) Staff's failure to consider the environmental dose commitment (EDC) to persons beyond the U.S. boundaries (FSFES, pp. 5-19, D-30; Deposition of Staff Witness Branagan, Oct. 13, 1982, p. 14);

c) Staff's failure to consider the environmental dose commitment (EDC) beyond 100 years (FSFES, p. D-31; Deposition of Staff Witness Branagan, Oct. 13, 1982, pp. 26-31, 46-47; Staff Response to Interrogatory I.14.h, 27th Set, Oct. 1, 1982, p. 27b);

d) Staff's failure to report the dose to organs other than whole body (FSFES, Section D.2.4, pp. D-30 to D-36);

e) Staff's failure to use current dosimetric and metabolic models (cf., FSFES, p. 12-24; Staff Response to Interrogatories I.14.c and I.16.m, 27th Set, Oct. 1, 1982, pp. 27a and 29a);

f) Staff's superficial methodology for estimating the gaseous effluents of plutonium and other transuranics from fuel fabrication and fuel reprocessing plants (FSFES, pp. D-10,-11,-15,-16,-17);

g) Staff's failure to consider environmental releases due to accidents at fuel cycle facilities (Deposition of Staff Witness Lowenberg, Oct. 12, 1982, p. 28);

h) Staff's superficial methodology for estimating potential environmental releases from the proposed high-level radioactive waste (HLW) repository (FSFES, Table D.4, fn. B, p. D-9; Deposition of Staff Witnesses Branagan and Boyle, Oct. 13, 1982, pp. 37-44).

Q.6: Where is Staff's description of the CRBR fuel cycle set forth?

A.6: Section 5.7.2.7 (pp. 5-16 to 5-10) and Section D.1 (pp. D-1 to D-7) of the FSFES.

Q.7: Why doesn't this description fully and accurately reflect the reasonably foreseeable CRBR fuel cycle alternatives?

A.7: As indicated in Figures A5.1 (FSFES, p. 5-17) and D.1 (FSFES, p. D-3), most of the specific facilities that are listed for the proposed CRBR fuel cycle do not now exist; they are hypothetical future facilities. For example, the source of plutonium to fuel the CRBR has not been

established; whether and, if so, where CRBR spent fuel will be reprocessed has not been established; and the sites for interim high-level waste storage and for the final high-level waste repository have not yet been established. Staff and Applicants have failed to analyze all reasonably foreseeable fuel cycle alternatives, including, for example:

a) providing the initial plutonium fuel by reprocessing commercial reactor spent fuel at (i) Barnwell or (ii) the Savannah River Plant (SRP), or obtaining the initial plutonium from (iii) foreign sources (e.g., the UK) (FSFES pp. D-15 to D-16);

b) as an alternative to the postulated "Developmental Reprocessing Plant" (DRP), using one of the existing chemical reprocessing facilities at SRP, the PUREX facility at Hanford, or a small facility built into the FMEF, for recycling CRBR fuel (see FSFES pp. D-15 to D-16);

c) using plutonium bred in CRBR in nuclear weapons;

d) the potential unavailability of adequate plutonium to fuel the CRBR (ruled by the Board as beyond the scope of the LWA-1 proceeding).

All of these are possible alternatives and, considering the great expense to build new facilities, it appears quite likely that existing facilities may be used

instead. Yet none of these alternatives were considered. (FSFES, pp. 12-57,-58)

Staff makes the bald assertion that the environmental impacts of alternative fuel reprocessing plants to the DRP will be bounded by the impacts projected for the hypothetical DRP simply because DOE says it will be so in its Environmental Report. Staff has done no independent analysis of DOE's claim because "[t]here is no basis for analyzing it." (Deposition of Staff Witness Lowenberg, Oct. 12, 1982, at 13-14.) Staff gives the same basis -- that DOE says so -- for its confidence that DOE will comply with current guides and standards in the design for DRP or its alternatives. (Id. at 20.)

Q.8: Why is it important to know the source of the plutonium to fuel the CRBR?

A.8: First, I believe there is insufficient plutonium to provide the initial inventory and first four reloads of the core, and consequently the CRBR will not be able to meet its programmatic objectives during its five-year demonstration period (ruled by the Board as beyond the scope of the LWA-1 proceeding).

Second, the origin of the plutonium and the manner in which it is recycled determines the isotopic concentrations of the plutonium isotopes that are released

to the environment from the CRBR and its fuel cycle under normal and accidental conditions. The somatic (and, to a lesser extent, genetic) risks associated with plutonium releases are a function of the concentrations of the various Pu isotopes.

Third, the environmental (and safeguards) effects associated with supplying CRBR fuel, including the first core and initial reloads, and recycling CRBR fuel can vary significantly depending upon the actual facilities that will be used.

Staff's FSFES is inadequate in its failure to address any of these considerations.

Q.9: What is the basis for your view that there will not be adequate supplies of low-burnup (or high-burnup) plutonium and how does this relate to the Staff analysis of environmental releases from CRBR and the fuel cycle?

A.9: Applicants and Staff initially assumed that "The initial [CRBR fuel cycle] feed materials would consist of [low burnup, fuel-grade] plutonium (obtained from DOE stockpiles) ..." (FSFES, p. D-4, ER Amendment XVI p. 5.7-2), and initially assumed that the CRBR would be operated on an open fuel cycle with the initial plutonium making only one pass through the reactor (Deposition of Staff witness Lowenberg, Oct. 12, 1982, pp. 8-10). In the

FSFES, the Staff has included a "somewhat more realistic" overall fuel cycle which assumes a 5-year open fuel cycle involving fuel-grade DOE stockpile plutonium, followed by a closed fuel cycle involving repeated recycle. FSFES pp. D-35,-36. As shown below, neither of these scenarios adequately considers the reasonably foreseeable CRBR fuel cycle options or bounds the expected radiological releases from the CRBR fuel cycle.

Regarding the availability of fuel-grade DOE stockpile plutonium for the assumed 5-year open fuel cycle, DOE Deputy Assistant Secretary for Nuclear Materials F. Charles Gilbert stated on March 25, 1981, that quantities of available materials in the fuel-grade inventory are reserved for Defense Programs. Gilbert wrote that "the 4 MT of processed plutonium in the fuel-grade inventory is reserved for authorized activities in both defense and non-defense programs," and "a significant portion of the plutonium in N-Reactor spent fuel is reserved for Defense Programs" for use in blending. (Letter of F. C. Gilbert to Thomas B. Cochran, March 24, 1981.)

With the conversion of the N-reactor from fuel-grade plutonium (12% Pu-240) to weapon-grade plutonium (6% Pu-240) scheduled to have been completed in October 1982, DOE no longer is producing fuel-grade plutonium (DOE, "Hanford

Accomplishments, Jan. 1981-Present," Aug. 24, 1982). DOE is currently blending plutonium from its fuel-grade plutonium stockpile with super-grade plutonium (3% Pu-240) produced at SRP to meet nuclear weapons requirements. Under current DOE plans, there will be little if any fuel-grade plutonium available for allocation to CRBR for its first core and first few reloads by the time these cores are to be fabricated, due to the higher priority placed on meeting the plutonium requirements of the Defense Programs' activities.

On September 9, 1982, Deputy Secretary of Energy W. Kenneth Davis and Under Secretary of State Richard T. Kennedy testified on the Reagan Plutonium Policy before the Subcommittee on Energy, Nuclear Proliferation and Governmental Processes of the Senate Government Affairs Committee. The following exchanges took place:

> Senator Glenn: Gentlemen, why do we need the breeder and reprocessing now? Why do we need new plutonium production?
>
> Mr. Davis: Our prospective need for plutonium, which is some years off, has to be arranged sometime in the near future. We need a substantial amount to continue in operation our principal research facility, the Fast Flux Test Facility at Hanford, and for some of the other experimental facilities, and we will need a substantial amount of plutonium for the Clinch River Breeder fuel as it continues to operate.
>
> What we are contemplating is the possibility of entering into contracts for plutonium, but the plutonium itself would not be delivered for many years.

Senator Glenn: Correct me if I'm wrong, but I don't see how the plutonium is going to be used, because my understanding is that Barnwell will produce between 12 to 15 tons of this material per year, and that we only have a need for one or two tons per year for the U.S. breeder program. I understand that currently we have adequate plutonium to fuel all the upcoming breeder R&D that we have scheduled right now.

What are we going to do with the output of Barnwell?

Mr. Kennedy: We do not have the plutonium needed for Clinch River, we do not have the plutonium needed for the follow-on fuel for FFTF.

Senator Glenn: What is the relationship between Barnwell and Clinch River? Is the Department's view that the Clinch River reactor shouldn't be built unless the Barnwell facility is also built?

Mr. Davis: The Barnwell facility has already been built by private industry.

Senator Glenn: Does one depend on the other?

Mr. Davis: Only in the sense that we will need to acquire the reactor-grade plutonium needed for Clinch River somewhere.

Senator Glenn: Do we not now have enough plutonium stockpiled now to run Clinch River if it is built?

Mr. Davis: No, sir. Not earmarked for Clinch River.

Senator Glenn: How much is required to fuel Clinch River?

Mr. Davis: Over a period of some years, I will have to get the exact numbers.

Senator Glenn: Is the figure that Barnwell will produce 12 to 15 tons a year; is that correct?

Mr. Davis: Barnwell at full operation probably would produce something in the order of 10 tons a year, not 15.

Senator Glenn: How much will Clinch River use?

Mr. Davis: Over the period we are looking at, to the year 2000, about 15 tons.

Senator Glenn: Fifteen tons between now and--

Mr. Davis: FFTF about 8 tons. We foresee a requirement in total of perhaps 20 to 25 tons.

Senator Glenn: My time is up but I would just say, Gordon Chipman, head of the Clinch Project, and Kermit Laughan, head of DOE's reprocessing office, told my staff explicitly Barnwell is not needed for Clinch River and that adequate plutonium is available.

Were they wrong?

Mr. Davis: We do not know exactly where we will get the plutonium for Clinch River and some of the follow-on activities. We could get it from our military resources, but that doesn't seem to be a very good prospect if we are to meet our current Weapons Stockpile Memorandum requirements.

(Senate Governmental Affairs Transcripts for Sept. 9, 1982, after editing by DOE, pp. 44-50, emphasis added.)

In Mr. Davis's testimony above, he notes that DOE will need reactor-grade plutonium for CRBR. Reactor-grade plutonium is obtained from high-burnup spent fuel. By DOE definition, reactor-grade Pu contains an isotopic concentration of Pu-240 of 19% or greater.

From the above testimony, it is apparent that DOE now wishes to obtain the initial feed material for CRBR from

Barnwell and that the feed is contemplated to be reactor-grade plutonium. This alternative is not discussed in the FSFES, nor is it clear that even reactor-grade plutonium will be available during the first 5 years of CRBR operation. I believe it is unlikely that Barnwell will be operated due to the lack of private interest in completing and operating this facility without a huge government subsidy, which is unlikely to be forthcoming. Furthermore, the alternative of obtaining plutonium from foreign sources, namely the UK, appears highly unlikely due to he controversy this proposal has generated in the UK.

With regard to the Barnwell alternative, there have been numerous reports in trade journals on the lack of interest in private ownership of the Barnwell plant. One of the present owners, Allied General, is not interested in completing the plant and plans to "shut it down" whenever government funding runs out (Nucleonics Week, June 10, 1982, p. 10). A company official responding to a DOE plan for encouraging private ownership stated, "People don't go into the position of investing stockholders' money if it doesn't make sense" (ibid.). There are no reliable reports of other potential owners in private industry, and Bechtel and other potential investors are not interested in ownership themselves (ibid.).

Papers with tentative plans to encourage private ownership of Barnwell have been put forth by DOE and the Office of Science and Technology Policy (OSTP) (Nucleonics Week, June 3, 1981, p. 1; Inside Energy, Oct. 18, 1982, p. 1), but, according to press reports, there does not seem to be the remotest agreement within the government on how this is to be achieved. DOE's request for $250 million in FY 1984 to subsidize Barnwell through the guaranteed purchase of plutonium from an operating plant is considered grossly insufficient by OSTP for convincing the private sector to get involved (Inside Energy, Oct. 18, 1982, p. 1). OSTP is reported to have suggested a subsidy of five times more, or $1.25 billion, for the guaranteed plutonium purchase, but it has yet to make a formal recommendation (ibid.). There is no indication that Congress would be willing to appropriate this level of funding.

On the possibility of export of UK civil plutonium to the U.S. for the breeder program, British Under-Secretary of State for Energy John Moore emphatically announced to Commons on July 27, 1982, that there were "no further developments" and "no negotiations" following his original announcement of "approval in principle" on October 19, 1981 (Hansard, 19 Oct. 1981, c.79; 27 July 1982, c.438). Moore had stated on Dec. 21, 1981, that a US-UK agreement

would probably take the form of a commercial contract between the Central Electricity Generating Board (CEGB) and DOE (Hansard, 21 Dec. 1981, c.732-739). Subsequently, strong opposition to the possible export of UK plutonium to the US emerged from individual employees of CEGB and from the Electrical Power Engineers' Association (The Times, April 29, 1982, p. 3). Finally, reports appeared after the end of April 1982 that the US had abandoned plans to buy or lease plutonium from the UK civil stockpile (Financial Times, London, May 6, 1982, p. 9). Based upon the above reports, it appears that neither fuel-grade, (low burnup) plutonium from DOE stockpiles nor (high burnup) reactor-grade plutonium from commercial or foreign sources will be available to power the CRBR during its initial 5-year demonstration period. Even if high burnup reactor-grade plutonium were available during this period, the FSFES does not analyze the radiological releases associated with such fuel.

In sum, there is no basis for assuming that there is sufficient low-burnup plutonium from the DOE fuel-grade stockpile or from civilian power reactor fuel to meet CRBR needs. Furthermore, even if Barnwell were restarted or plutonium were obtained from foreign sources there is no basis for assuming that the plutonium would have concentrations of the controlling isotopes (Pu-238 and Pu-

241) as low as the concentrations assumed by Staff and Applicants.

Q.10: What are Staff's assumptions regarding the plutonium isotopic concentrations of CRBR fuel in the assumed closed fuel cycle?

A.10: The Staff based its radiological estimates, for CRBRP and its environs, of the impacts of routine operations and effluents on the following rough plutonium composition:

1%	Pu-238
72%	Pu-239
18%	Pu-240
6%	Pu-241
2%	Pu-242

(FSFES p. 12-22). Staff claimed that these estimates would be bounding radiologically with respect both to the proposed initial core loading and any core content expected during the lifetime of the plant. (ibid.).

Q.11: Do you believe these estimates to be bounding, and if not, what is the basis for your answer?

A.11: No. First Staff apparently justified the above estimates by relying upon DOE's estimates of the "average equilibrium recycle" plutonium composition. (Letter from

Allen Croff, Oak Ridge National Laboratory, to Homer Lowenberg, NRC Staff, dated October 11, 1982). Yet Staff has not defined what is meant by "average equilibrium recycle" or independently validated the correctnesss of DOE's estimates.

Second, this "equilibrium recycle" mode assumed by Staff appears to involve repeated recycle of CRBRP fuel in the CRBR, with no use of or commingling of plutonium obtained from LWR fuel or even FFTF fuel.

Applicants have stated that:

> If one assumes recycle with CRBRP operating by itself, requiring one full core load in the reactor and an additional reload core in reprocessing and fabrication, then the commitment from resources is on the order of 3.5 MT of plutonium plus 58.0 MT of uranium. (Emphasis Supplied).

(ER Amendment XVI at 5.8-3) This statement makes it clear that Applicants also contemplate recycling CRBR fuel, but Applicants' analysis even here is inadequate in that it is restricted to recycling only CRBR fuel in the CRBR itself. Staff apparently relied on this assumption as well in its analysis of a closed CRBR fuel cycle.

Q.12: Do you agree with the assumption that a closed fuel cycle would involve only CRBRP fuel; if not, what is the basis for your answer?

A12: No, This assumption is nonconservative and does not bound all likely or realistic alternatives. In particular, Staff fails to analyze the use in the CRBRP of

(i) plutonium obtained directly from high burnup LWR spent fuel (e.g. from Barnwell);

(ii) plutonium obtained from LWR or FFTF high-burnup spent fuel after this plutonium has been recycled several times in LWRs or FFTF, prior to use in CRBR; or

(iii) plutonium obtained from CRBR recycled fuel commingled with either (i) or (ii) above.

Each of these alternatives is a reasonably foreseeable one.

Applicants admit that their proposed reprocessing facility, the DRP, will reprocess fuel from the FFTF and commercial LWRs. (ER Amendment XVI, p. 5.7-78). They estimate that 3 tons/year of FFTF fuel would be available for DRP reprocessing (a total of 30 tons by 1991) as well as "unlimited amounts of BWR and PWR fuel" (ibid.). Surely one reasonably foreseeable alternative for fueling the CRBR would be to commingle or interchange some of the FFTF or LWR fuel with that from the CRBR, including after those fuels have gone through several recyles. Staff has no basis for assuming that such commingling would not occur at some point in the CRBR's operating life, and any assumption which claims to be bounding (or even realistic) would have to include such a scenario.

Plutonium recycle in LWRs (GESMO) was a major component of U.S. energy policy until April 1977 and the Barnwell reprocessing facility was designed in large part to facilitate such plutonium recycle. Now that reprocessing is once again a centerpiece of the Administration's energy policy and promotion of plutonium recycle in LWRs is occuring, at the very least, LWR fuel recycle is a reasonably forseeable alternative if one assumes plutonium will be available for CRBR at all. The proposed capacity of Barnwell, over 10 MT Pu/yr., is much too large to serve only the needs of the breeder programs, and the use of commercial Barnwell-recovered plutonium in the weapons program will most likely be prohibited in the forthcoming NRC Authorization Bill (S. 1207). If the Barnwell facility is ever built, plutonium recycle in LWRs seems to be not just a reasonably foreseeable alternative, but the only foreseeable use of most of the reprocessed plutonium.

Q.13: In your judgement, is the use of LWR or FFTF-recycled fuel in the CRBR, either alone or in combination with CRBR-recycled fuel, important to the radiological hazards estimated by Staff in the FSFES? Explain you answer.

A. 13: Yes, as stated by the Environmental Protection Agency in its comments on the FSFES:

> The specification of the source release from [for liquid and atmospheric effluents] may be the largest single source of uncertainty in the radiological assessment calculations, especially for short-term releases. An estimate of the core fuel composition and magnitude of various postulated releases from CRBRP is needed to establish a radiological envelope for operation of the plant over the 30-year period.

(FSFES, p. N-188).

Q.14: How is the hazard of plutonium affected by the origin of the plutonium fuel and the manner in which it is recycled?

A.14: In calculating the Site Suitability Source Term doses at the exclusion area and low population zone (LPZ) boundaries, the Staff assumed that the plutonium had the following isotopic concentrations (weight %):

1% Pu-238

74% Pu-239

20% Pu-240

5% Pu-241

0% Pu-242

(Staff Response to Interrogatory 23, 26th Set, July 27, 1982, p. 23; Tr-3128, Morgan.) While the basis for the choice of concentrations is not well documented, these values were apparently derived by working backwards from a calculation of total curie release made some five years ago, for the CRBR homogeneous core fueled with plutonium recovered from processing spent LWR fuel (Tr. 2346-47, Bell).

Dr. Morgan demonstrated that the Pu-238 and Pu-241 isotopes are controlling in terms of the bone surface dose. His calculations of the relative Hazard Index of the plutonium isotopes are reproduced in Table 1 below.

Table 1

Isotope (Pu-i)	Weight % Normalized Weight %	Weight % Normalized to Pu-239	Curies/ gram	(A) Ci Pu-i/ Ci Pu-239	(B) Bone Surf. Dose Norm. to Dose Due to Pu-239	(A)x(B) Hazard Index
Pu-238	1	0.0135	16.	3.5	0.81	2.8
Pu-239	74	1.	0.062	1.	1.	1.
Pu-240	20	0.27	0.22	0.96	1.	0.96
Pu-241	5	0.068	120.	130.	0.019	2.35

(Tr. 3129-30, Morgan.)

In the Staff's NEPA evaluation of accidents (FSFES, Table J.4 at p. J-13), the Staff assumed the inventories of plutonium isotopes in the reactor core were:

Pu-238 - 0.38 million curies

Pu-239 - 0.11

Pu-240 - 0.10

Pu-241 - 13.0

Pu-242 ---

(FSFES, Table J-4, p. J-14.)

These values are consistent with the isotopic concentrations used by the Staff in the Site Suitability Source Term analysis and reproduced above (i.e., 1% Pu-238, 74% Pu-239; 20% Pu-240, 5% Pu-241).

In the Staff NEPA evaluation of routine releases associated with CRBR fuel reprocessing, the Staff assumed the larger of two estimates of the source term for each isotope of importance:

Table 2

	Source Term (Ci/yr)		
	NRC-ORIGEN2 Basis	DOE-Amend XIV	NRC-Selected
Pu-236	3.3 E-09	1.5 E-09	3.3 E-09
Pu-238	8.1 E-06 (0.1%)	8.5 E-05 (1.1%)	8.5 E-05
Pu-239	2.7 E-05 (83%)	2.1 E-05 (73%)	2.7 E-05
Pu-240	1.7 E-05 (15%)	2.2 E-05 (21%)	2.2 E-05
Pu-241	8.5 E-04 (1.4%)	2.6 E-03 (5%)	2.6 E-03
Pu-242	5.2 E-09	4.7 E-08	4.7 E-08

(The values in parentheses represent my estimate of the corresponding approximate weight % of each isotope. See FSFES, Table D.8, p. D-16)

In deriving the above source terms, Staff assumed that the CRBR core was always fueled with plutonium containing 12% Pu-240 (NRC-ORIGEN2 Basis), whereas the DOE had assumed the CRBR was always fueled with 20% Pu-240 (DOE-Amend. XIV) (FSFES, p. D-13).

The values under the column labeled "NRC-ORIGEN2 Basis" were claimed by NRC Staff to represent plutonium that had an initial isotopic concentration assumed by DOE in the ER which was altered as a result of one pass through CRBR (Deposition of Staff Witness Lowenberg, Oct. 12, 1982, p. 18). For all practical purposes, the NRC-Selected values represent the DOE values (DOE-Amend. XIV), only the Pu-239 value is increased by 29%. And, as noted

above, the Staff FSFES estimate of routine releases assumed a plutonium isotopic concentration of roughly 1% Pu-238, 72% Pu-239, 18% Pu-240, and 6% Pu-241 (FSFES, p. 12-22), expected to be bounding during the lifetime of the plant.

The relative hazard of two plutonium fuel isotopic conentrations can be compared using a Hazard Index that is proportional to the bone surface dose, which is controlling for plutonium. The Hazard Index is taken as:

$$(HI) = K_1 M \sum_i w_i A_i D_i$$

where K_1 = proportionality constant
M = mass of plutonium in the reactor core
w_i = weight % of ith isotope of Pu
A_i = specific activity of Pu_i (Ci/g)
D_i = dose conversion factor (for bone surface (assumed to be controlling)) for Pu_i (rem/Ci)

Neither Applicants nor Staff have analyzed the CRBR core loading that would be required if reactor-grade plutonium from reprocessing commercial reactor fuel were used. (Staff Response to Interrogatory I.3, 27th Set, Oct. 1, 1982, p. 4). Nevertheless, the relative mass of plutonium in the reactor can be roughly approximated by:

$$M = K_2 \sum_i w_i \bar{\sigma}_{f_i}$$

where $\bar{\sigma}_{f_i}$ = average fission cross-section of ith isotope of Pu
K_2 = proportionality constant

Thus the relative hazard of two plutonium-fuel isotopic concentrations is:

$$\frac{(HI)_1}{(HI)_2} = \frac{\sum_i w_{i_1} \bar{\sigma}_{f_i}}{\sum_i w_{i_2} \bar{\sigma}_{f_i}} \cdot \frac{\sum_i w_{i_2} A_i D_i}{\sum_i w_{i_1} A_i D_i}$$

As an example calculation, I will compare the relative hazard of Pu recovered from spent LWR fuel (Column 1 of Table 3) to the Pu assumed by the Staff in Staff's Site Suitability Source Term and DSFES Appendix J analyses. The value of $\overline{\sigma_{f_i}}$ is approximated using group 3 constants from ANL 16-Group reactor constants published in ANL-5800.

$$\frac{(HI)_2}{(HI)_1} = \frac{74 \times 1.96 + 20 \times 1.59 + 5 \times 1.89}{57.9 \times 1.96 + 24.7 \times 1.59 + 11 \times 1.89 + 4.4 \times 1.45} \times$$

$$\frac{1.9 \times 16 \times 8.4 + 57.9 \times 0.062 \times 10.4 + 24.7 \times 0.22 \times 10.4 + 11.0 \times 120 \times 0.194}{1.0 \times 16 \times 8.4 + 74 \times 0.062 \times 10.4 + 20 \times 0.22 \times 10.4 + 5.0 \times 120 \times 0.194}$$

$$= \frac{186}{180} \times \frac{605}{344} = 2$$

Similarly, the Hazard Index for other assumed Pu isotopic concentrations relative to the Hazard Index of the Pu assumed in the Staff Site Suitability Source Term are:

	Relative Hazard Index
Staff Site Suitability Source Term & DSFES App. J	1
Pu recovered from spent U fuel (Table 3, col. 1)	2
Pu after one 4yr recycle (Table 3, col. 2)	3
Pu after two 4-yr recycles (Table 3, col. 3)	4.3*
Pu recycle model BWR (Table 3, col. 4)	3.7

* Morgan calculated 5.6. The difference is due to the fact that Morgan, as a first approximation, used only the ratio of the weight % of the Pu-239 and Pu-241 to approximate the relative difference in the mass of plutonium in the reactor in the two cases (see Affidavit of Karl Z. Morgan, Oct. 1, 1982).

Table 3

Calculated Plutonium Composition - Percent

	1 Pu Recovered Fr. Spent U Fuel	2 Pu After One 4-Yr. Recycle	3 Pu After Two 4-Yr. Recycles	4 Pu Recycle Model BWR
Pu-238	1.9	3.46	4.87	3.4
Pu-239	57.9	38.2	29.4	41.7
Pu-240	24.7	29.4	33.5	29.3
Pu-241	11.0	17.2	17.4	15.2
Pu-242	4.4	11.7	14.9	10.4
Pu_f*	68.9	55.4	46.8	57.0

* Pu_f = Pu-239 + Pu-241

As seen by comparing the relative isotopic concentrations in Tables 1 and 2 on a per gram basis, the hazard of the plutonium assumed by Staff to be released from the CRBR fuel reprocessing plant is comparable to the hazard of the plutonium assumed by Staff in its Site Suitability analysis.

In sum, by Staff's failure to consider plutonium from recycled LWR or FFTF spent fuel [redacted] in the CRBR, Staff has underestimated the hazard of plutonium releases by a factor from 2 up to about 4.3. A factor of 4.3 larger than that assumed by Staff in the Site Suitability Source Term analysis would be appropriate for bound[redacted] reasonably foreseeable alternatives.

Q.15: What is the effect of ignoring the environmental dose commitment (EDC) to persons beyond U.S. boundaries?

A.15: Staff has provided a breakdown of Staff's estimate of annual curie release and the 140 person-rem/year dose commitment to the U.S. population due to principal isotopes as follows:

Isotope	Annual Release (Curies/yr)	100-year Whole-Body Dose Commitment to U.S. Pop. (person-rem)
H-3	5900	74.5
C-14	14	66.2
Kr-85	5100	0.36
Radioiodine		0.19
I-129	(0.00037)	(0.02)
TRUs		0.105
Other		0.314
		141.7

(FSFES, p. D-7; Staff Response to Interrogatory I.16.a, 27th Set, p. 29a).

By Staff estimates, the 100-year whole body dose commitment to the U.S. population for:

H-3 is 98% of the worldwide value;

C-14 is 42% of the worldwide value;

Kr-85 is 22% of the worldwide value;

and consequently the worldwide value is 236 person-rem, with the C-14 contribution 158 person-rem.

Q.16: What is the effect of ignoring the environmental dose commitment beyond 100 years?

A.16: The EPA estimates the worldwide dose commitment from C-14 as:

28 person-rem/Ci released to the atmosphere, for the first 100 years;

120 person-rem/Ci released to the atmosphere, for the first 1000 years;

537 person-rem/Ci released to the atmosphere, integrated over the life of C-14.

(USEPA, "Health Impact Assessment of Carbon-14 Emissions from Normal Operations of Uranium Fuel Cycle Facilities," EPA-520/5-80-004, March 1981, p. 22.)

EPA's 100-year dose commitment factor is 2.5 times that assumed by the Staff, i.e., 28 person-rem/Ci released, compared to the Staff value of 66.2/14 = 4.7 person-rem/Ci. Use of these EPA data suggests that integrating over 1000 years would increase the worldwide C-14 dose by an additional factor of about 120/28 = 4.3, and that integrating over the lifetime of the C-14 isotope would increase the worldwide C-14 dose by a factor of $537/28 \simeq 19$.

Consequently, the worldwide C-14 dose integrated over the lifetime of the isotope would be about

$158 \times 19 \simeq 3000$ person-rem

based on Staff's 100-year dose commitment value, or

$537 \times 14 \simeq 7500$ person-rem

using the EPA dose commitment factor.

Staff similarly has failed to estimate the impact of I-129 beyond 100 years.

Without considering the additional dose contribution due to I-129 or other errors in Staff's estimates, the total whole body environmental dose commitment is approximately 22 to 54 times that presented by Staff in the FSTES (3080/140 $\simeq$ 22 and 7596/140 $\simeq$ 54).

Q.17: What is the effect of Staff failure to report the environmental dose commitment to organs other than whole body?

A.17: In Staff's response to NRDC 27th Set of Interrogatories (p. 29a and Enclosure B), Staff reported that its estimate of the 100 year environmental bone dose commitment to the worldwide population, 875 person-rem, was a factor of 875/236 = 3.7 times the whole body worldwide dose commitment. Furthermore, by Staff estimates 790 person-rem (90% of the 875 person-rem total) was due to C-14, 76 person-rem (9%) due to H-3, and 4 person-rem due to plutonium.

Staff claims its bone dose estimate is conservative because it is based on an old dosimetric model that uses an n-factor of 5, no longer recommended by ICRP. Although Staff fails to explain why it did not use current ICRP dosimetric models (and report bone marrow and bone surface

dose rather than bone dose), Staff estimates the bone dose to the U.S. population would be reduced to "about 400 person-rem (Staff Response to Interrogatory I.16.m, 27th Set, October 1, 1982, p. 29b). Staff gave no further explanation of how it arrived at this value.

Q.18: What plutonium gaseous effluent containment factor does Staff assume for the CRBR fuel fabrication and fuel reprocessing facilities?

A.18: For CRBR fuel fabrication, Staff and Applicants have assumed that all exhaust gases from the proposed SAF line would pass through a series of HEPA filters having an overall cleanup factor of 1.25×10^{-8}. (FSFES, p. D-9; Staff Response to Interrogatory I.10, 27th Set, Oct. 1, 1982, p. 14.) Staff further assumed that the exhaust gases prior to filtering would contain approximately 10^{-3} times the plutonium throughput of the facility for an overall plutonium containment factor of approximately 1.25×10^{-11}.1/

For the CRBR fuel reprocessing, Staff assumed 5.4×10^{4} Ci Pu-239 in CRBR spent fuel processed annually

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1/ This value is confirmed from Table D-6 (FSFES, p. D-10), where the Staff's estimate of CRBR Pu-239 released is given as 5.9×10^{7} Ci/yr = 9.4×10^{-6} g/yr. The assumed throughput of CRBR Pu-239 = (0.889 MT Pu) (0.86) = 7.6×10^{5} g (FSFES, p. D-10). The overall containment factor is therefore $9.4 \times 10^{-6}/7.6 \times 10^{5} = 1.24 \times 10^{-11}$. (See also ER Amendment XVI p. 5.7-22)

(FSFES, p. D-14) and 2.7 x 10^{-5} Ci Pu-239 released annually (FSFES, p. D-16) for an overall plutonium containment factor of 5 x 10^{-10}. This estimate is the same as Applicants' (ER Amendment XVI, p. 5.7-79).

While Staff claims these estimates are based in part on "the commitment on the part of DOE to use current guides and standards in the design of the proposed DRP (Staff Response to Interrogatory I.11, 27th Set, Oct. 1, 1982, p. 15), Staff has made no attempt to see if DOE meets current guides and standards at currently operating DOE facilities, or whether DOE can be relied upon to meet future commitments in this regard.

An assessment of the cleanup factors achieved at currently operating facilities, and those that have operated in the recent past, would be essential to assess whether the cleanup factors, 1.25 x. 10^{-11} for fuel fabrication and 5 x 10^{-10} for reprocessing, assumed by Staff are realistic. Staff Witness James Ayres agrees that such assessments would be useful (Depositicn of James Ayres, Oct. 13, 1982, pp. 53-54). Yet Staff has made no effort to assess the cleanup factors at any such facility, including:

a) Kerr-McGee, which was used to fabricate FFTF fuel;

b) NFS-Erwin, which formerly fabricated plutonium fuels;

c) NUMEC, which formerly fabricated plutonium fuels;

d) Rocky Flats, which currently chemically processes plutonium and fabricates plutonium components for nuclear weapons;

e) F and H canyons at Savannah River Plant, currently operating chemical processing plants;

f) NFS-West Valley, which formerly operated as a spent nuclear fuel reprocessing plant;

g) the Hanford PUREX plant, which formerly chemically processed N-reactor spent fuel;

h) any foreign nuclear spent fuel reprocessing plants.

(Responses to Interrogatories I.10 and I.11, 27th Set, Oct. 1, 1982, pp. 13-15; Deposition of Staff Witness Lowenberg, Oct. 12, 1982, at 41-42.)

Q.19: How do Staff's hypothetical containment factors compare to actual operating experience?

A.19: I have not reviewed in any detail the appropriate data for each of the above facilities (A.18, above). I have looked at the Savannah River Plant (SRP) F and H chemical processing facilities, and the Hanford PUREX plant.

The SRP chemical processing plants released approximately 3 Ci of Pu-239 between 1955 and 1978, and about $3.8 \pm 1.4 \times 10^{-4}$ Ci/year between 1975 and 1978. (C. Ashley and C.C. Zeigler, "Releases of Radioactivity at the Savannah River Plant 1954 through 1958," DPSPU 75-25-1, Feb. 1980, pp. 157-158.)

The quantity of weapon-grade plutonium discharged from the Savannah River production reactors and processed at the F and H chemical separation areas during operations through the end of 1978 is estimated to be 26 $\pm$ 10 metric tons, with about 1.2 $\pm$ 0.2 MT processed annually in the 1975 to 1978 period.[2/] These values correspond to about $1.7 \pm 0.6 \times 10^6$ Ci Pu-239 processed between 1955 and 1978 and $9 \pm 1 \times 10^4$ Ci Pu-239/yr between 1975 and 1978.

Thus, the plutonium containment factor at SRP averaged approximately 1.8×10^{-6} between 1955 and 1978, and about 4×10^{-9} between 1975 and 1978.

In 1972, in its last year of operation, the Hanford PUREX plant reportedly processed 1013 MT of N-reactor spent fuel and released as gaseous effluent 3×10^{-3} Ci of alpha activity (Rockwell International, "Environmental Report of Purex Plant and Uranium Oxide Plant - Hanford Reservation," RHO-CD-742, April 1979, pp. III-3, -5). With fuel requirements of 330 MT/yr, the N-reactor has a capacity of 600-630 kg/yr of fuel-grade plutonium (12% Pu-240). Assuming that the Pu-239 contribution to the total alpha activity is on the order of 10%, the containment

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2/ These values are my own estimates based on published data on the inventories of strontium and cesium isotopes in radioactive waste at SRP and production reactor operation data for 1978, about 1.1 MT of plutonium per year for 3 operating reactors at reduced output.

factor for gaseous plutonium releases at PUREX in 1972 was on the order of:

$$(3\times10^{-3})(0.1)/((1013)(600/330)(10^{3})(1Ci/16g)(0.84)) = 3 \times 10^{-9}$$

or about the same as that for reprocessing at SRP between 1975 and 1978.

In sum, the NRC is projecting that the CRBR fuel reprocessing facility will have a plutonium gaseous effluent containment factor about 10 times better than what is being achieved at PUREX or SRP in recent years, using current technology, and about 4000 times better than that achieved over the lifetime of SRP, which may include accidental as well as routine releases.

Some, perhaps all, of the other facilities mentioned in A.14 above may have achieved containment factors relative to the NRC Staff assumptions for fabrication and reprocessing operations that are even poorer than calculated for the SRP processing plants above. Rocky Flats, for example, has experienced plutonium releases more than an order of magnitude larger than those reported for SRP, yet the plutonium throughput at Rocky Flats is not an order of magnitude larger than the Pu production at SRP. Furthermore, the plutonium releases as a result of accidents at Rocky Flats are believed to have exceeded the routine releases, yet Staff has given no consideration to

accidents at CRBR fuel cycle facilities. In sum, the Staff assumptions cannot be accepted as realistic.

The potential error in Staff's assumption regarding the plutonium containment factor for CRBR fuel fabrication and reprocessing facilities must be considered in combination with the errors introduced by failure to consider recycled mixed-oxide (MOX) fuel and the uncertainties in the quality factors (particularly the dose distribution factor) appropriate for plutonium lung and bone surface dose calculations as discussed in NRDC testimony at the Hearing on Contentions related to CRBR Site Suitability. (Cf., Tr. 3081-85, Cochran; Tr. 3109, Cobb; Tr. 31391-42, Morgan.) When all these are considered together, it appears that Staff is underestimating the potential health effects due to CRBR fuel cycle plutonium release by several orders of magnitude. The Staff analysis is inadequate in its failure to discuss these uncertainties.

Q.20: Are there other errors or examples of nonconservatisms in the Staff's analysis of the environmental effects associated with the CRBR fuel cycle?

A.20: Yes -- the treatment of the potential health effects associated with waste management and disposal is non-conservative, and the somatic and genetic risk estimators (FSFES, pp. 5-13, 5-20) are nonconservative.

Q.21: What conclusions did Staff make with regard to the potential environmental radiological effects associated with CRBR high-level radioactive waste (HLW) disposal?

A.22: Staff concluded that (a) the effluents from the HLW stored in the geological repository would be zero (or negligible), and the only non-zero radiological effluents are releases of radon and its decay products associated with construction of the repository e.g., mining the repository cavity (FSFES,p D-23); and (b) these releases (associated with mining the cavity) are negligible by comparison with similar effects from other fuel cycle steps (FSFES pp.D-9, D-23; Deposition of Staff Witnesses Branagan and Boyle, Oct. 13, 1982, pp. 37-44).

Q.22: Do you agree with Staff's conclusions, and if not, what is the basis for your disagreement?

A.22: I do not agree that the Staff's conclusions reasonably reflect the uncertainties associated with HLW disposal. The basis for this disagreement is, in part, as follows:
a) First, the Draft EPA Proposed Environmental Standards and Federal Radiation Protection Guidance for Management and Disposal of High-Level and Transuranic Radioactive

Wastes (EPA, Working Draft 21, 6/14/82) establishes limits on radioactivity released to the "accessible environment" which are designed to limit long-term risks to 1000 health effects over 10,000 years for a 100,000 MTHM Repository, where:

> "accessible environment" includes (i) the atmosphere, (ii) land surfaces, (iii) surface waters, (iv) oceans, and (v) parts of the lithosphere containing significant amounts of groundwater; the accessible environment also includes (vi) parts of the lithosphere containing insignificant amounts of groundwater that are more than ten kilometers in any direction from the original location of the radioactive wastes in a disposal system.

(EPA, Working Draft 21, p. 38, emphasis added).

Staff assumes that CRBR high-level waste (over a 30-year operating period) will represent on the order of, or less than, 1/100 of the total repository volume (FSFES, p.D-20; Staff's response to Interrogatory I.12.1, 27th Set October 1, 1982, p.17). Thus, under proposed EPA standards, the CRBR contribution to the total health effects in the accessible environment during the first 10,000 years after closure is meant to be limited to 1000/100=10 health effects, or approximately 0.3 for each year of CRBR operation. This level of risk is an order of magnitude greater than other fuel cycle risks as estimated by the Staff, i.e. 0.023 potential cancers/year (FSFES, p. 5-21).

The above EPA limits (1000 health effects in 10,000 years per repository) do not apply to potential radiological releases to the biosphere within 10 km of the repository (i.e. 314 km^2, or 123 mi^2) or releases after 10,000 years. Staff has assumed that some 2 million people will reside within 80 km of the site DOE 1980b, Vol 2, p F.2). Applying this same population density within the 10 km radius implies there might initially be some 30,000 persons in this region, which is not part of the "accessible environment" as defined by EPA. The proposed EPA limits permit unlimited exposure to this population, for all times, and consequently the proposed EPA standards would not limit human health effects associated with CRBR waste operations to 10 persons (or 0.3/year).

b) Second, in light of the present status of the Federal efforts associated with HLW disposal, while it is theoretically possible to store HLW safely, I do not believe that there is currently any basis for high confidence that the radioactive waste <u>will</u> be safely sequestered. The basis for this view is set forth generally in NRDC testimony in the NRC's Waste Confidence Rulemaking (PR-50,51 (44 Fed. Reg. 61372)).

As but one further example of the many difficulties that remain unresolved, the first of three alternative HLW repository sites which DOE plans to characterize in

preparation for licensing review by NRC, is a basalt site at the Hanford Reservation. Following a November 1981 trip report to the Basalt Waste Isolation Project, NRC consultants concluded that the DOE's forthcoming site characterization report, when completed, may be inadequate, in part because

> There are currently several widely different views on the general pattern of groundwater flow in the Pasco Basin....
>
> It appears the five year hydrology test program will not result in sufficient data to answer basic questions about groundwater movement....
>
> The conceptual repository design is inadequate because it ignores the consequences of the indicated high stress field,...
>
> "The in situ test program that was discussed with NRC (i.e., Phase I of the Exploration Shaft), is insufficient to characterize the site at depth, determine site suitability, and determine design parameters for the repository."3/

c) Third, in light of the uncertainties associated with HLW disposal, the Staff's analysis is inadequate in its failure to discuss the full range of potential health effects associated with these uncertainties. M.J. Brown and E. Crouch (Health Physics 43, September 1982, pp. 345-

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3/ Brooks, D.J., et al, "Visit to the Basalt Waste Isolation Project (BWIP) - Hanford, Washington, USNRC, Nov. 1981, pp. 1-2.

354) have attempted to bound the potential health effects by examining two "extreme scenerios." Under one highly unlikely scenario involving a volcanic eruption at the repository site, Brown and Crouch estimated that the number of cancer doses from Sr-90 alone exceeded the population of the U.S. The second scenario, which I find far more credible, involved the contamination of a municipal drinking water supply. For a containment time of 400 years and a leach time of 6300 years, the cancer risk (from all causes) was increased 25% (id.).

DOE analyzed the 70-year "whole-body" dose commitment from solution mining a 47,000 MTHM salt dome repository for human salt consumption (i.e., for table salt) 1000 years after closure and estimated such an event could result in 1.6×10^{-7} person-rem. (DOE, "FEIS, Management of Commercially Generated Radioactive Wastes," DOE/EIS-0046F, Vol. 1, pp. 5.89-5.92.) Prorating 1/100 of this dose to CRBR, the resulting 160,000 person-rem is 1000 times the whole body dose commitment assumed by the Staff for the entire CRBR fuel cycle.

I do not mean to imply that the probability of such events is large; rather these examples are only to suggest that Staff's assumption that the health effects will be zero does not adequately reflect the uncertainties and in this regard also could be considered "extreme," but in the opposite direction.

d) Fourth, EPA and the U.S. Geological Survey ("USGS") have both expressed substantial reservations about the NRC's finding of no significant risk of radioactive releases from a permanent waste-storage facility. EPA, for example, suggested that the "Table S-3" chart (from which some of the DSFES Table D.4 entries were derived), should be accompanied by a narrative statement emphasizing the uncertainties underlying the numerical entries, particularly for long-term waste storage:

> A purely numerical table is, in fact, an implication of far greater certainty than is warranted by the facts. Clearly, for the time spans involved in presenting the impacts of certain radioactive effluents, there are environmental impacts difficult to quantify that require accompanying narrative.

EPA Response to NRDC's Proposed Questions of November 18, 1977, #2(d) at 1 (undated) (Table S-3 Rulemaking). These criticisms apply equally to the FSFES Appendix D discussion of HLW disposal, particularly Table D-4 (at p. D.9). A report by a panel of earth scientists, submitted to EPA, concluded that there are "extreme numerical uncertainties" attached to most of the factors bearing on the possibility of disruption of a waste repository. Report of Ad Hoc Panel of Earth Scientists, The State of Geological Knowledge Regarding Potential Transport of High-Level Radioactive Waste from Deep Continental Repositories, EPA/520/4-78-044, at 32 (June 1978).

Perhaps more significantly, the USGS -- the federal agency with the greatest technical expertise in geological matters -- concluded that "Table S-3 by itself clearly does not convey an appreciation of the risks involved in geologic disposal of high-level radioactive wastes or the uncertainties involved in determining such risks." USGS Reponse to NRDC's (Table S-3 Rulemaking) follow-up questions of December 16, 1977, #1 at 1 (undated). Moreover, a later USGS report warned that "given the current state of our knowledge, the uncertainties associated with hot wastes that interact chemically and mechanically with the rock and fluid system appear high," and these uncertainties are compounded by "the lack of a method for determining the future rates of many [geological] events and processes." Geologic Disposal of High-Level Radioactive Wastes -- Earth Science Perspectives, USGS Circular 779 at 6, 11 (1978).

Indeed, two government reports -- one issued by NRC -- have cautioned that predictions about the performance or feasibility of a waste-storage facility are subject to considerable uncertainty. The "Report to the President by the Inter-Agency Review Group on Waste Management" ("IRG Report"), for example, pointed out that risk assessments "based on idealized repository characteristics ...are subject to significant uncertainties," and concluded that

the "zero release of radionuclides cannot be assured." IRG Report, TID-29442, March, 1979, p. 45. Moreover, the Commission's own staff conceded:

> There are still uncertainties in areas such as the effect of waste presence on repository stability; the probabilities and consequences of intrusive acts by humans; the validity of data used in modeling studies; the design and regulatory actions needed to minimize possibilities of repository failure; projection of future societal habits and demography; and finally, the relative importance of various potential initiating events.

NUREG-0116, at 4-94.

For additional discussion of uncertainties regarding waste, and management, I incorporate by reference the comments of the California Energy Commission on the DSFES (reprinted in FSFES, pp. N-212 to N-230). Finally, recent events serve to highlight the persistence of uncertainty regarding the technical feasibility and safety of a long-term waste repository, as well as the institutional question whether an appropriate site can be selected and maintained. In the currently ongoing Waste Confidence proceeding, for example, the NRC has developed substantial evidence -- summarized in the Report of the NRC Working Group[4/] -- that uncertainty over these issues continues.

4/ U.S. Nuclear Regulatory Commission, Report on the Working Group on the Proposed Rule-making on the Storage and Disposal of Nuclear Wastes (January 29, 1981)

There are significant questions about the ability of the Department of Energy ("DOE") to find a suitable repository site and to design and build an adequate facility. As DOE has candidly admitted:

> Additional engineering development work remains to be done before safe waste disposal can actually be achieved...Until the [waste research and development] program is completed, there necessarily remains a degree of uncertainty regarding whether DOE will find the answer to questions still open and whether those answers, when found, will turn out as hoped for.

NRC Report, Introductory Statement at 7. Having identified twenty-six "major issues" still in contention, the Working Group has concluded that "there appear[s] to be a number of contingencies, both technological and institutional, on which the success and timeliness of waste disposal may hinge." NRC Report, Introductory Statement at 12.

In addition, other agencies continue to note significant uncertainties about the risk assessment models used by DOE. USGS, for example, has stated that any generic assessment that radioactive waste can be contained in a federal waste repository at acceptable levels of risk deserves only "limited credibility." NRC Report, Part 1.B at 17. USGS has also commented that any current determination of when a repository will be available is necessarily "imprecise and premature." Id. at 18. DOE,

too, recognizes that "important gaps exist in knowledge regarding rock properties and responses under extreme conditions of temperature, stress, and radiation over long periods of time."

Q.23: Why do you believe Staff's somatic and genetic risk estimators (FSFES, p. 5-15) are nonconservative?

A.23: Staff uses a geometric mean of the two limits on the range of the somatic (and genetic) risk estimates given in BEIR I as Staff's point estimates for the somatic (and genetic) risk estimators (FSFES, p. 5-15). Staff takes the upper limit of the BEIR I somatic risk estimator, based on the relative risk model as a "reasonable upper limit of the range of uncertainty" (FSFES, p. 5-15). The upper limit on the BEIR I somatic risks (based on the relative risk model) does not represent the full range of expert opinion on somatic risks, as discussed in Part IV of my testimony.

Concluding Question

Q.24: In light of the deficiencies of analysis you have outlined, what is your overall judgment as to Staff's analysis of the environmental effects associated with the CRBR fuel cycle?

A.24: Staff's analysis is inadequate, primarily in its failure to adequately address uncertainties associated with

Staff's estimates and in its treatment of potential transuranic releases from fuel fabrication and processing operations. The Staff analysis is also inadequate in its failure to consider all reasonably foreseeable fuel cycle alternatives. The environmental effects of the CRBR fuel cycle could be much higher than indicated by the NRC.

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

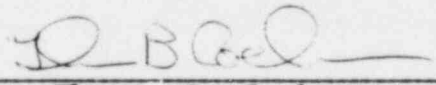
In the Matter of	)
UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGMENT CORPORATION TENNESSEE VALLEY AUTHORITY	)
(Clinch River Breeder Reactor Plant)	)

AFFIDAVIT OF DR. THOMAS B. COCHRAN

City of Washington)
) ss:
District of Columbia)

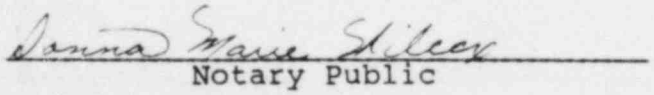
DR. THOMAS B. COCHRAN hereby deposes and says:

The foregoing testimony prepared by me and dated November 12, 1982, is true and correct to the best of my knowledge and belief.



Dr. Thomas B. Cochran

Signed and sworn to before me
this 12th day of November 1982.



Notary Public

My Commission Expires July 31, 1987

DR. THOMAS B. COCHRAN
ADDITIONAL BIOGRAPHICAL MATERIAL
RELATED TO TESTIMONY PRESENTED IN THE CRBR
PROCEEDING (DOCKET NUMBER 50-537)

From 1971 to 1979 I was employed by Resources for the Future as a Senior Research Associate. My work in that capacity was to analyze the environmental effluents associated with the fuel cycle of commercial nuclear power plants. While there I wrote a book, The Liquid Metal Fast Breeder Reactor: An Environmental and Economic Critique, which was published by Johns Hopkins Press for Resources for the Future in 1974. About one-third of this book was devoted to environmental, safety and safeguards aspects of the LMFBR.

In 1973, I joined the Natural Resources Defense Council, Inc. where I am presently employed as a Senior Staff Scientist. In 1974 I coauthored several hundred pages of technical comments on the Draft LMFBR Programmatic EIS (WASH-1535), including comments on the environmental effects of the LMFBR. In April 1975 I coauthored and submitted comments on the Proposed Final EIS on the LMFBR Program (WASH-1535), including comments on the effluents and safeguards associated with the LMFBR fuel cycle.

In December 1975 I coauthored testimony and testified at the EPA Public Hearings on Plutonium and Transuranium Elements.

On February 27, 1976 I coauthored testimony and testified with Dr. Author Tamplin before the House Interior Subcommittee on Energy and the Environment on safeguards as applied to the domestic nuclear industry.

In February 1976 I coauthored NRDC's Petition for Adoption of Emergency Safeguards Measures, or, Alternatively, for Revocation of Licenses. (Docket Nos. 70-8, et al).

The recently enacted Physical Security Upgrade Rule (10 CFR 73) was a direct consequency of the Commission's Order of January 21, 1977 disposing of the NRDC emergency safeguards petition. I subsequently filed comments on behalf of NRDC on the then-proposed physical security upgrade rule and more recently on the Commission's consideration to upgrade material control and accounting requirements for some facilities (46 Fed Reg. 45144, Sept. 10, 1981)

In 1976 - 1977 I was a member of the Office of Technology's 16-person Nuclear Proliferation and Safeguards Advisory Panel and assisted the OTA Staff in preparation of its report Nuclear Proliferation and Safeguards, published in 1977.

In February, 1977 I testified before the California Energy Resources Conservation and Development Commission on nuclear fuel reprocessing, waste disposal and the adequacy of safeguards at nuclear fuel facilities.

In April 1977 I testified before the Subcommittee on Energy and the Environment of the House Committee on Interior and Insular Affairs on H.R. 5234, a bill introduced by Congressman Bingham designed to prohibit the licensing of commercial nuclear fuel reprocessing and plutonium-fueled reactors.

In June 1977, I testified before the House Committee on Science and Technology, Subcommittee on Fossil and Nuclear Energy Research Development and Demonstration, on the nuclear weapons proliferation issue as it relates to the breeder program.

In July 1977 I testified before the House Committee on Interior and Insular Affairs, Subcommittee on Energy and the Environment, on the allegtions of James Conran, a member of NRC's Safeguards Staff, concerning the adequacy of safeguards at NRC-licensed facilities.

Also in 1977 I testified at the United Kingdom's Windscale Inquiry on the nuclear weapons proliferation and safeguards aspects associated with nuclear spent fuel reprocessing and plutonium recycle.

In 1977 I was a member of ERDA's LMFBR Review Steering Committee and coauthored the minority report, "Proliferation Resistant Nuclear Power Technologies: Preferred Alternatives to the Plutonium Breeder."

During the 1977-80 period I was a member of DOE's Nonproliferation Advisory Panel. This panel, which held numerous meetings over several years, assisted DOE and the State Department in their review of U.S. strategy and U.S. position papers in the International Nuclear Fuel Cycle Evaluation. We also assisted DOE in the review of the U.S. Government's nine-volume counterpart report, "Nuclear Proliferation and Civilian Nuclear Power: Report of the Nonproliferation Alternative Systems Assessment Program", published in June 1980.

In 1978 I served briefly as a consultant to the Interagency Review Group on Nuclear Waste Management.

In July 1978 I testified before the Subcommittee on Environment and Atmosphere of the House Science and Technology Committee on environmental aspects of nuclear waste management and disposal.

In September 1978 I coauthored testimony and appeared before the House Committee on International Relations concerning retransfer requests for reprocessing of U.S. nuclear fuel abroad.

In 1978-79 I was the principal investigator and coauthor of a study prepared for DOE (Contract ER-78-C-01-6596) on radioactive waste management. This study was submitted to DOE as a three-part report, "Radioactive Waste Management," on April 13, 1979.

In March 1979 I testified before the Subcommittee on Energy, Nuclear Proliferation and Federal Services of the Senate Committee on Governmental Affairs on the Report of the Interagency Review Group on Nuclear Waste Management.

In March - April 1979 I participated as an expert witness, at the request of the Minister-President Lower Saxony, at the "Gorleben International Review" Hearings in Hannover, FRG. I was coauthor of testimony on the waste disposal aspects of the FRG's proposed Gorleben Fuel Cycle Center for reprocessing and disposing of spent nuclear fuel.

In May 1979 I testified before the Subcommittee on Energy Research and Production of the House Committee on Science and Technology on radioactive waste management.

In July 1979 I coauthored testimony and testified before the Subcommittee on Energy and the Environment of the House Committee on Interior and Insular Affairs conerning the U.S. nuclear weapons non-proliferation strategy.

In July 1979 I testified before the Senate Governmental Affairs Committee, in a hearing held in Chicago, on issues related to nuclear waste storage and disposal.

In the 1979-81 period I was a member of the American Nuclear Society's 40.12 Committee, constituted to develop proposed standards related to high level radioactive waste disposal.

In October 1981 I testified before a House Government Operations Subcommittee on the nuclear proliferation risks associated with the then-proposed acquisition of Santa Fe International Corporation by the Kuwait Petroleum Corporation.

I am currently participating in the NFS-Erwin proceeding

(Docket No. 70-143, SNM License No. 124). I have prepared and submitted testimony in this proceeding addressing the adequacy of physical security and material control and accounting for the NFS-Erwin facility. This particular hearing is being heard by the full Commission. I have reviewed numerous classified documents related to physical security and material control and accounting at NFS-Erwin, including NFS Physical Security Plans, NFS-Nuclear Material Control Plans and numerous NRC inspection and enforcement reports.

Pursuant to 10 CFR Parts 10, 25, and 95 I have been granted by NRC a Security Facility Approval for safeguarding CONFIDENTIAL National Security Information and Restricted Data received or developed in conjunction with NRDC activities associated with the NRC.

I am principal editor and coauthor of the Nuclear Weapons Databook, Volumes I and II, the first volume of which is currently under review prior to submitting it to Ballinger Press within the next month or two.

While this is not an exhaustive list of my activiites related to the LMFBR fuel cycle and nuclear proliferation and safeguards, it serves to highlight my activities in these areas.

CERTIFICATE OF SERVICE

I hereby certify that copies of TESTIMONY OF DR. THOMAS B. COCHRAN PART III AS SUPPLEMENTED BY NEW INFORMATION IN CRBR FINAL ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT, TESTIMONY OF DR. THOMAS B. COCHRAN PART IV AS SUPPLEMENTED BY NEW INFORMATION IN CRBR FINAL ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT, SUPPLEMENT TO TESTIMONY OF THOMAS B. COCHRAN PART V, and LETTER TO GEORGE L. EDGAR were served this 12th day of November 1982 by hand upon:

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