U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-260 568

ADDENDUM TO THE FINAL ENVIRONMENTAL STATEMENT RELATED TO OPERATION OF NORTH ANNA POWER STATION UNITS 1 AND 2, VIRGINIA ELECTRIC AND POWER COMPANY

DOCKET NOS. 50-338 AND 50-339

NUCLEAR REGULATORY COMMISSION. WASHINGTON, D.C.

NOVEMBER 1976

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Addendum to the final environmental statement

NUREG-0134

related to operation of

NORTH ANNA POWER STATION UNITS 1 AND 2

VIRGINIA ELECTRIC AND POWER COMPANY

NOVEMBER 1976

Docket Nos. 50-338 and 50-339

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16. Abstracts An Addendum to the Final Environmental Statement for the operation of Virginia Electric and Power Company's North Anna Power Station, Unit Nos. 1 and 2 (Docket Nos. 50-338 and 50-339), located in Louisa County, Virginia, has been prepared by the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission (NRC). This addendum provides (1) a summary of environmental impact and adverse effects of the proposed facility, and (2) a consideration of principal alternatives. This addendum updates the FES (April 1973) in two ways: (1) by identifying the differences between environmental effects of operation (including those which would enhance as well as degrade the environment) currently projected and the impacts that were described in the FES; and (2) by identifying studies being performed by the applicant that will yield additional information relevant to the environmental impacts of operating the North Anna Power Station. The NRC staff has concluded, based on a weighing of environmental, economic, technical, and other benefits against environmental costs and available alternatives, that operating licenses could be granted.

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NUREG-0134

ADDENDUM TO THE FINAL ENVIRONMENTAL STATEMENT FOR THE OPERATION OF THE NORTH ANNA POWER STATION, UNITS NOS. 1 AND 2

VIRGINIA ELECTRIC AND POWER COMPANY

Docket Nos. 50-338 and 50-339

November 1976

UNITED STATES NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

SUMMARY AND CONCLUSIONS

This Environmental Statement Addendum has been prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (the staff).

1. The action is administrative.

2. The proposed action is the issuance of Operating Licenses to the Virginia Electric and Power Company for the startup and operation of the North Anna Power Station, Units No. 1 and 2, located on Lake Anna in Louisa County, 40 miles east of Charlottesville, Virginia (Docket Nos. 50-338 and 50-339).

   The facility will employ two pressurized-water reactors with a maximum design power level of 2900 megawatts thermal (MWt) per unit. Steam turbine-generators will use this heat to provide up to 980 megawatts (MWe) of electrical generation per unit. The exhaust steam will be condensed by once-through flow of water obtained from and discharged to Lake Anna.

3. On March 24, 1969, the Virginia Electric and Power Company (VEPCO) filed an application with the United States Atomic Energy Commission (AEC) for permits to construct North Anna Power Station, Units No. 1 and 2. Following reviews by the AEC regulatory staff and the Advisory Committee on Reactor Safeguards and following a public hearing before an Atomic Safety and Licensing Board in Louisa, Virginia, November 23-25, 1970, Construction Permits No. CPPR-77 and No. CPPR-78 were issued on February 19, 1971. As of October 1976, the construction of Unit 1 was 94% complete and Unit 2 was 73% complete, with proposed fuel-loading date of December 1976 for Unit No. 1 and January 1978 for Unit No. 2. The applicant has petitioned for licenses to operate both units and submitted in March 1972 the required environmental report (ER) to substantiate this petition. The staff reviewed the activities associated with the proposed operation of this plant and the potential impact. The conclusions obtained in the staff's environmental review were issued as a Final Environmental Statement (FES) in April 1973. By letter dated January 2, 1976 the staff requested that the applicant update the Environmental Report for the North Anna Power Station, Units Nos. 1 and 2, to ensure that the FES properly considers any design changes or other changes in conditions such as revisions in load forecasts. The information in this addendum represents the review of information provided by the applicant in an Environmental Report Supplement. Where necessary, revision of the assessment of the environmental impact associated with operation of the North Anna Power Station has been made.

4. On the basis of the analysis and evaluation set forth in this addendum and the FES, and after weighing the environmental, economic, technical and other benefits against environmental costs, and after considering available alternatives, it is concluded that the action called for under NEPA and Appendix D of 10 CFR Part 50 is the issuance of operating licenses for Unit No. 1 and Unit No. 2 of the North Anna Power Station subject to the following conditions for the protection of the environment:

   (A) License Conditions

   Before engaging in additional construction or operational activities which may result in a significant adverse environmental impact that was not evaluated by the Commission, the licensee will prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated, or that is significantly greater than that evaluated in the FES or any addendum thereto, the licensee shall provide a written evaluation of such activities and obtain prior approval from the Director, Office of Nuclear Reactor Regulation.

   (B) Significant Technical Specification Requirements

   (1) The applicant will carry out the environmental (thermal, chemical, radiological, ecological) monitoring program outlined in this addendum and in the FES. This study will include, but not be limited to, the following:

A comprehensive temperature monitoring program for the Waste Heat Treatment Facility, Lake Anna and the North Anna River in the vicinity of North Anna Dam. This program shall also incorporate measurements of meteorological conditions and the reservoir water balance. This program shall be implemented in a manner satisfactory to the Director, Office of Nuclear Reactor Regulation and soon enough that predictions of natural lake temperatures can be verified over at least a one-year period prior to initial operation of Unit No. 1. Subsequent to the commencement of operation of Unit No. 1, the results of this program shall be included in semi-annual reports. These reports shall compare actual temperature distributions versus those predicted by the applicant's model for each six-month period until Units No. 1 and 2 have completed one year of operation.

(2) If the analysis of Unit No. 1 operating experience should indicate that the incremental effects of operating Unit No. 2 will result in violation of State Water Quality Standards, the applicant shall propose a program which will minimize the impacts of Station operation on Lake Anna and the North Anna River and prevent violation of State standards.

(3) The applicant shall endeavor to minimize the impacts of the transmission lines to be constructed from the Station, and include the following procedures:

(a) Retain and augment as necessary the vegetation at road and river crossings, home sites and major water bodies to screen the transmission lines.

(b) Change the alignment of transmission lines on both sides of major road crossings where vegetation will be inadequate to avoid long views down the right-of-way.

(c) Place the tower structures along the lower slopes in hilly terrain, rather than on commonly visible high points, unless a long span is necessary which cannot otherwise be reasonably accomplished.

(d) Control the application of herbicides to rights-of-way so as to prevent drift, and apply no herbicides on rights-of-way over pasture, cropland and irrigation ditches or near water bodies, homes and recreation areas.

(4) If, during the operating life of the Station, evidence of irreversible damage is detected, the applicant will provide to the staff an analysis of the problem and a proposed course of action to alleviate the problem.

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ADDENDUM TO THE FINAL ENVIRONMENTAL STATEMENT RELATED TO OPERATION OF NORTH ANNA POWER STATION UNITS 1 AND 2, VIRGINIA ELECTRIC AND POWER COMPANY

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NOVEMBER 1976

The following narrative explanation of the values given in Table S-3 is drawn from the record and cross referenced to source documents for the benefit of readers seeking more information. The Table S-3 values which pertain to the front end of the fuel cycle (up to the loading of the fuel into the reactor) are taken from WASH-1248; values pertaining to the back end of the fuel cycle are taken from NUREG-0116, with changes which are noted in the hearing record.[4] Since the narrative is designed to help the reader in interpreting the environmental effects given on Table S-3, the forementioned documents, together with others that were cited in the documents or discussed during the hearings, are generally the only references cited in the narrative. The exceptions to this statement are found in Section III, where the staff has provided, for purposes of discussion only, information on how long term dose commitments might be calculated, and what incremental releases from waste disposal sites might be. Since these topics were not covered in detail in WASH-1248, NUREG-0116, NUREG-0216 or the hearing record, information not in the record had to be used to develop the material.

Section I of the narrative describes the extant LWR uranium fuel cycle, the broad alternatives and the individual operations of the fuel cycles; Section II contains a description of the environmental effects of the LWR fuel cycles and of the individual fuel cycle operations; Section III contains a discussion of dose commitments and health effects resulting from releases of radioactive materials from the fuel cycle. Section III also includes a discussion of how dose commitment evaluations over extended periods of time might be performed and what their significance might be. In addition, there is a discussion of what, if any, incremental releases from waste disposal sites might occur over very long periods of time (i.e., an evaluation of repository impacts for the repository considered in NUREG-0116.) Section IV contains a discussion of socioeconomic impacts.

B. Alternative Fuel Cycles

The several alternative fuel cycles which can be used for present generation LWR reactors can be primarily characterized by how the spent fuel is handled, since all presently available alternatives start with uranium fuel. The alternatives are:

Once-Through Fuel Cycle:

- o The spent fuel can be disposed of without recovery of residual fissionable isotopes; this is the present operating mode for U.S. nuclear reactors.

Uranium-Only Recycle:

- o Uranium can be recovered from spent fuel by reprocessing and can be recycled in nuclear fuel. Plutonium can be stored for later use or combined with residual radioactive materials as wastes. Uranium-only recycle, including plutonium storage, was considered to be the most likely mode of operation at the time of preparation of WASH-1248 (1972-1974), and was the fuel cycle addressed in that document.[5] In NUREG-0116, plutonium was considered to be a waste to be disposed of at a Federal repository.[6]

Uranium and Plutonium Recycle:

- o Both uranium and plutonium can be recovered from spent fuel by reprocessing and recycling to the reactor, the plutonium being recycled with

LIST OF FIGURES

FOREWORD

This Environmental Statement Addendum was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (the staff), in accordance with the Commission's regulation, Appendix D of 10 CFR Part 50, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action;

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented;

(iii) alternatives to the proposed action;

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and,

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

An environmental report accompanies each application for a construction permit or a full-power operating license. A public announcement of the availability of the report is made. Any comments by interested persons on the report are considered by the staff. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA and Appendix D of 10 CFR Part 50.

This environmental review deals with the impact of operation of North Anna Power Station, Units Nos. 1 and 2. Assessments that are found in this addendum supplement those described in the FES that was issued in April 1973 in support of continued construction and eventual operation of

North Anna Power Station, Units No. 1 and 2. The information to be found in the various sections of this addendum updates the FES in two ways: (1) by identifying differences between environmental effects of operation (including those which would enhance as well as degrade the environment) currently projected and the impacts that were described in the FES; (2) by identifying studies being performed by the applicant that will yield additional information relevant to the environmental impacts of operating the North Anna Power Station.

The staff recognized the difficulty a reader would encounter in trying to establish the conformance of this review with the requirements of the National Environmental Policy Act. Consequently, introductory resumes in appropriate sections of this addendum summarize both the extent of "updating," if any, and the degree to which the staff considers the subject to be adequately reviewed.

Single copies of this addendum may be obtained by writing the:

Director, Division of Site Safety
and Environmental Analysis
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. Paul Leech and Mr. Fred Hebdon are the NRC Environmental Project Managers for this project. Mr. Leech may be contacted at the above address or at (301)443-6980. Mr. Hebdon may be contacted at (301) 443-6950.

A.1. INTRODUCTION

A.1.1 HISTORY

On March 24, 1969, the Virginia Electric and Power Company (VEPCO) (applicant) filed an application with the Atomic Energy Commission (now Nuclear Regulatory Commission) for permits to construct the North Anna Power Station, Units Nos. 1 and 2. Construction Permits Nos. CPPR-77 and CPPR-78 were issued accordingly on February 19, 1971, following reviews by the AEC Regulatory staff and the Advisory Committee on Reactor Safeguards, as well as public hearings before an Atomic Safety and Licensing Board in Louisa, Virginia, on November 23-25, 1970.

In June 1970, VEPCO submitted an environmental letter concerning construction and operation of the North Anna Power Station. This letter was superseded by the applicant's Environmental Report Supplement (ER) dated March 15, 1972. This supplement was submitted to permit the staff's environmental review of the impact of continued construction and eventual operation of the North Anna Power Station. The conclusions resulting from the staff's environmental review were issued as a Final Environmental Statement (FES) in April 1973. In January 1976, the staff requested that the applicant update its ER to include any design changes or new information. The applicant submitted the requested supplement on March 5, 1976.

As required by Section B of Appendix D to Part 50 of the Commission's regulations, additional public hearings before the Atomic Safety and Licensing Board were held in August 1973 to consider the results of the staff's environmental review related to continuation of construction of Units No. 1 and 2. In September 1975, hearings before the Atomic Safety and Licensing Board were held to consider the routing of transmission lines from the North Anna Power Station.

As of October 1976, construction of Unit No. 1 was approximately 94% complete and the reactor is expected to be ready for fuel loading in December 1976. Unit No. 2 was approximately 73% complete and has a tentative fuel-loading date of January 1978. Each unit has a pressurized-water reactor which will produce up to 2900 MWt and a net electrical output of 980 MWe.

A.1.2 PERMITS AND LICENSES

The applicant has provided a status listing of environmentally related permits, approvals, licenses, etc., required from Federal, regional, State, and local agencies in connection with the proposed project. The staff has reviewed that listing. The only significant non-NRC license or permit which has not yet been obtained for the North Anna Power Station, Units Nos. 1 and 2, is the 402 Permit which must be obtained from the Virginia Water Control Board. VEPCO applied for a 402 Permit in October 1973 and provided supplemental information in April 1976. VEPCO anticipates that a 402 Permit will be issued for Units No. 1 and 2 no later than January 1977. The staff is not aware of any other non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the plant.

A.2. THE SITE

A.2.1 RÉSUMÉ

The staff conducted an overflight of the North Anna Station in August 1976 to determine what changes, if any, had occurred at the site since the environmental review in 1972. Since considerable construction had already taken place when the original evaluation was done, much of the environmental impact of construction had already occurred and the site was in a recovery phase. There is still a considerable amount of activity in the immediate vicinity of the station, however, little evidence of the construction activity remains throughout the remainder of the site.

A.2.2 METEOROLOGY

Due to a change in the security requirements of the plant, the original parking lot was relocated. The new location involved the area next to the 150 foot meteorological tower and the supplemental low threshold wind sensor pole. The cars parked in this area along with gravel or asphalt ground cover would create a localized heat island which would affect the wind sensors and the temperature/differential temperature sensors, causing them to be less representative of the area. Temporary construction buildings have been built in the vicinity of the existing tower and produce an influencing effect on the main tower 35 foot wind sensor. These conditions necessitated a change in location. The onsite meteorological measurements program will also be modified to meet the recommendations and intent of Regulatory Guide 1.23, "Onsite Meteorological Programs" (February 1972).

The present onsite meteorological measurements program, initiated in 1971, utilizes a 150-ft tower located about 1000 feet north-northeast of the nearest containment structure, and a 35-ft satellite tower. Both towers are located on a peninsula which projects into the Lake Anna impoundment. On the 150-ft tower, wind speed and direction are measured at the 35-ft and 150-ft levels, and vertical temperature difference measurements are made between the 35-ft and 150-ft levels. A supplemental low-threshold wind instrument is located at the 35-ft level of the satellite tower. The wind sensors on the 150-ft tower do not meet the recommendations of Regulatory Guide 1.23 because this tower was instrumented prior to issuance of these guidelines. However, the low-threshold wind sensor on the 35-ft satellite tower does meet the accuracy recommendations.

The upgraded meteorological measurements program will utilize a 150-ft tower located about 1750 feet east-northeast of the nearest containment structure and about 1000 feet east of the present 150-ft meteorological tower. The new tower will have the same relative proximity to Lake Anna as the existing satellite tower. On the new 150-ft tower, wind speed and direction will be measured at the 33-ft and 150-ft levels, vertical temperature differences will be measured between the 33-ft and 150-ft levels, and ambient dry bulb and dewpoint temperatures will be measured at the 33-ft level. Precipitation will be measured at the base of the tower.

The upgraded meteorological facility is scheduled to be in operation by November 1, 1976, and the current and upgraded meteorological facilities will be operated concurrently for at least one year prior to decommissioning of the existing system.

The staff concludes that the proposed meteorological measurements program meets the recommendations and intent of Regulatory Guide 1.23. The staff will review data from the current and new programs when the first year of concurrent operation has been completed.

A.2.3 GEOLOGY/SEISMOLOGY

As part of its earlier NEPA review, the staff made brief reference in the FES to the geological and seismological characteristics of the North Anna site. This discussion has been considerably expanded during Atomic Safety and Licensing Board (ASLB) hearings which have been held at various times during the past three years. These topics are primarily subjects of the safety review (see Staff Safety Evaluation Report Section 2.5 and Supplement 2 thereto) which has been performed by the staff; consequently, additional discussion of the geology and seismology of the North Anna site has not been included in this FES Addendum.

A.3. THE PLANT

A.3.1 RÉSUMÉ

At the time of this review, construction of the North Anna Power Station is proceeding towards a fuel loading date for Unit No. 1 of December 1976 and for Unit No. 2 of January 1978. Since issuance of the FES there have been minor changes in the service water reservoir and the Reactor and Steam Electric Systems which are discussed in Sections A.3.2.1 and A.3.2.2, respectively. Also, changes in the liquid and solid radioactive waste treatment systems are discussed in Section A.3.2.3. In addition to considering the changes which have been made, the radioactive waste treatment systems have been reassessed using a new and more realistic model to develop expected individual and population doses. This assessment is provided in Section A.5.2.4.

A.3.2 DESIGN AND OTHER SIGNIFICANT CHANGES

A.3.2.1 Land Use

A.3.2.1.1 Service Water Reservoir

The size of the service water reservoir has been increased from 7.5 acres to 9.0 acres. The staff considers the environmental impact of this change to be insignificant.

A.3.2.1.2 Access Road

The access road to Units 1 and 2 was rerouted on site to allow easier access without passing through the heavy construction activity for Units 3 and 4. The land around the road is being used for a spoils area and equipment storage area for Units 3 and 4. The impact of relocating this road has been minimal.

A.3.2.2 Reactor and Steam Electric System

The number of fuel rods has been increased from 204 to 264. The UO_2 content has also been increased from 87.8 tons to 90.6 tons. The enrichments of 2.0% and 3.2% have been changed to 2.1% and 3.1%, respectively.

A.3.2.3 Radioactive Waste Treatment

The Safety Evaluation Report (SER) for the Virginia Electric and Power Company's North Anna Power Station, Unit Nos. 1 and 2, was issued in June 1976.[1] The SER indicated that a detailed assessment to determine conformance with Appendix I to 10 CFR Part 50 would be provided at a later date. The assessment has been extended to include Units 3 and 4 to demonstrate compliance with site-related criteria. The assessment was performed to determine if the proposed North Anna Power Station, Unit Nos. 1, 2, 3, and 4 meet the numerical design objectives specified in Sections II.A, B, C and D of Appendix I of 10 CFR Part 50.[2]

In the case of plants whose applications for construction permits were filed prior to January 2, 1971, Appendix I does not provide specific guidance concerning the need for these plants to submit a detailed cost-benefit analysis to determine conformance with Section II.D of Appendix I. The staff is in the process of determining whether plants for which construction applications were filed prior to January 2, 1971 can be treated in a manner similar to the treatment given plants docketed after January 2, 1971, including the cost-benefit option provided by the Commission's September 4, 1975 amendment to Appendix I. Until this determination has been made, the staff's evaluation of the radwaste systems has been performed to determine conformance with the criteria set forth in the Concluding Statement of Position of the Regulatory Staff, Docket RM-50-2, in lieu of a detailed cost-benefit analysis as required by Section II.D.

The staff has evaluated the radioactive waste management systems proposed for North Anna Power Station, Units No. 1, 2, 3 and 4, to reduce the quantities of radioactive materials released to the environment in liquid and gaseous effluents. These systems have been previously described in Section 3.5 of the FES,[3] and in Chapter 11 of the SER.[1,4] Based on more recent operating data applicable to the North Anna Power Station and on changes in our calculational model, the staff has generated new liquid and gaseous source terms to determine conformance with Appendix I. These values are different from those given in Tables 3.7, 3.8, and 3.11 of the FES.

The chemistry of the secondary-loop has been changed to an all volatile treatment which will require the addition of a full-flow condensate polishing system and a higher blowdown rate than in the original design. The secondary-loop cleanup for Units 1 and 2 will be accomplished by continuously removing as blowdown a fraction of the circulating flow, as required by steam generator chemistry up to a maximum of 200 gpm. The main blowdown will normally be discharged to a flash tank, where part of it will be vaporized and sent to the feedwater heaters. The remainder of the main blowdown will be sent to the condenser and cleaned up by passing the secondary-loop condensate through full-flow resin demineralizers. If required, the depleted resins will be pumped to the solid waste disposal system.

The original 22 gpm blowdown system is available for use when required. This system consists of a collector tank, where part of the blowdown will be vaporized and discharged to the atmosphere and part will condense and be sent to the clarifier package for treatment prior to discharge.

The new source terms, shown in Tables A.3.2-1, A.3.2-2, A.3.2-3 and A.3.2-4 were calculated using the models and methodology described in NUREG-0017, "Calculation of Releases of Radioactive

Table A.3.2-1

Calculated Releases of Radioactive Material in Liquid Effluents from North Anna Power Station, Units No. 1 and 2

Nuclide	Ci/yr/reactor	Nuclide	Ci/yr/reactor
Corrosion & Activation Product		Te-129	1.6(-4)
		I-130	8.6(-4)
Cr-51	3(-4)[a,b]	Te-131m	2.9(-4)
Mn-54	8(-5)	Te-131	5(-5)
Fe-55	2.7(-4)	I-131	1(-1)
Fe-59	2(-4)	Te-132	3.1(-3)
Co-58	2.7(-3)	I-132	3.6(-2)
Co-60	3.9(-4)	I-133	1.5(-1)
Np-239	1.8(-4)	I-134	2.8(-3)
		Cs-134	4.7(-3)
Fission Products		I-135	7.7(-2)
		Cs-136	2.4(-3)
Br-83	1.3(-3)	Cs-137	3.6(-3)
Br-84	3(-5)	Ba-137m	3.1(-3)
Rb-86	2(-5)	Ba-140	3(-5)
Rb-88	2(-5)	La-140	2(-5)
Sr-89	7(-5)	Ce-141	1(-5)
Sr-91	5(-5)	Ce-144	[illegible] 5)
Y-91m	3(-5)		
Zr-95	2(-5)	All Others	5(-5)
Nb-95	3(-5)		
Mo-99	1.2(-2)	Total (except H-3)	4.1(-1)
Tc-99m	9.8(-3)		
Ru-106	2(-5)	H-3	5.8(+2)
Te-127m	3(-5)		
Te-127	8(-5)		
Te-129m	2(-4)		

[a]Exponential notation; 1(-4) = 1×10^{-4}.

[b]Nuclides whose release rates are less than 10^{-5} Ci/yr/reactor are not listed individually, but are in the category "All Others."

Table A.3.2-2

Calculated Releases of Radioactive Material in Liquid Effluents from North Anna Power Station, Units No. 3 and 4

Nuclide	Ci/yr/reactor
Corrosion & Activation Products	
Cr-51	1.2(-4)[a,b]
Mn-54	4(-5)
Fe-55	1.1(-4)
Fe-59	7(-5)
Co-58	1.1(-3)
Co-60	2.1(-4)
Zr-95	1(-5)
Nb-95	2(-5)
Np-239	7(-5)
Fission Products	
Br-83	3(-5)
Sr-89	3(-5)
Sr-91	2(-5)
Y-91m	1(-5)
Mo-99	4.6(-2)
Tc-99m	3(-2)
Ru-106	2(-5)
Te-127m	1(-5)
Te-127	3(-5)
Te-129m	9(-5)
Te-129	6(-5)
I-130	7(-5)
Te-131m	5(-5)
I-131	5.4(-2)
Te-132	1.2(-3)
I-132	1.7(-3)
I-133	1.7(-2)
I-134	2(-5)
Cs-134	2.5(-3)
I-135	4.6(-3)
Cs-136	1.1(-3)
Cs-137	2(-3)
Ba-137m	1.7(-3)
Ba-140	1(-5)
Ce-144	5(-5)
All Others	6(-5)
Total (except H-3)	1.6(-1)
H-3	5.5(+2)

[a]Exponential notation; 1(-4) = 1 x 10^{-4}.

[b]Nuclides whose release rates are less than 10^{-5} Ci/yr/reactor are not listed individually, but are in the category "All Others."

Table A.3.2-3

Calculated Releases of Radioactive Material in Liquid Effluents from North Anna Power Station, Units No. 1 and 2

Ci/yr/reactor

Radio-nuclide[d]	Reactor Building	Auxiliary Building	Turbine Building	Air Ejector	Decay Tanks	Total
Kr-83m	a	4	a	2	a	6
Kr-85m	a	17	a	11	a	2.8(+1)
Kr-85	a	a	a	a	2(+2)	2(+2)
Kr-87	a	1.2(+1)	a	7	a	1.9(+1)
Kr-88	1	3.5(+1)	a	2.1(+1)	a	5.7(+1)
Kr-89	a	1	a	a	a	1
Xe-131m	2	a	a	a	2	4
Xe-133m	5	7	a	4	a	16
Xe-133	3.8(+2)	2.9(+2)	a	1.8(+2)	4	8.5(+2)
Xe-135m	a	3	a	2	a	5
Xe-135	5	3.8(+1)	a	2.4(+1)	a	6.7(+1)
Xe-137	a	2	a	1	a	3
Xe-138	a	1(+1)	a	6	a	1.6(+1)
I-131	3.2(-4)	4.7(-3)	7.8(-4)	2.9(-2)	a	3.5(-2)
I-133	1.4(-4)	9.2(-3)	1.3(-3)	5.8(-2)	a	6.9(-2)
Mn-54	5.8(-5)	1.8(-4)	c	c	4.5(-5)	2.8(-4)
Fe-59	2(-5)	6(-5)	c	c	1.5(-5)	9.5(-5)
Co-58	2(-4)	6(-4)	c	c	1.5(-4)	9.5(-4)
Co-60	7(-5)	2.7(-4)	c	c	7(-5)	4.3(-4)
Sr-89	3.3(-6)	1.3(-5)	c	c	3.3(-6)	2.1(-5)
Sr-90	6(-7)	2.4(-6)	c	c	6(-7)	3.8(-6)
Cs-134	4.5(-5)	1.8(-4)	c	c	4.5(-5)	2.8(-4)
Cs-137	7.5(-5)	3(-4)	c	c	7.5(-5)	4.7(-4)
H-3	5.8(+2)	c	c	c	c	5.8(+2)
C-14	1	a	a	a	7	8
Ar-41	2.5(+1)	c	c	c	c	2.5(+1)

[a] less than 1.0 Ci/yr/reactor for noble gases and carbon-14, less than 10^{-4} Ci/yr/reactor for iodine.

[b] exponential notation; 1.4(-2) = 1.4×10^{-2}.

[c] less than 1% of total for this nuclide.

[d] radionuclides not listed are released in quantities less than those specified in notes a and c from all sources.

Table A.3.2-4

Calculated Releases of Radioactive Material in Gaseous Effluents from North Anna Power Station, Units No. 3 and 4

Ci/yr/reactor

Radio-nuclide[d]	Reactor Building	Auxiliary Building	Turbine Building	Air Ejector	Decay Tanks	Total
Kr-85m	1	2	a	1	a	4
Kr-85	9	a	a	a	1.9(+2)	2(+2)
Kr-88	2	3	a	2	a	7
Xe-131m	1.4(+1)	a	a	a	2	1.6(+1)
Xe-133m	2.2(+1)	2	a	1	a	2.5(+1)
Xe-133	2.4(+3)	1.3(+2)	a	8.3(+1)	4	2.6(+3)
Xe-135	9	5	a	3	a	1.7(+1)
I-131	5(-3)	5.4(-3)	7.7(-4)	3.4(-2)	a	4.5(-2)
I-133	1.3(-3)	6.3(-3)	8.9(-4)	4(-2)	a	4.8(-2)
Mn-54	5.8(-3)	1.8(-4)	c	c	4.5(-5)	6(-3)
Fe-59	2(-3)	6(-5)	c	c	1.5(-5)	2.1(-3)
Co-58	2(-2)	6(-4)	c	c	1.5(-4)	2.1(-2)
Co-60	9(-3)	2.7(-4)	c	c	7(-5)	9.3(-3)
Sr-89	4.5(-4)	1.3(-5)	c	c	3.3(-6)	4.7(-4)
Sr-90	7.9(-5)	2.4(-6)	c	c	6(-7)	8.2(-5)
Cs-134	5.8(-3)	1.8(-4)	c	c	4.5(-5)	6(-3)
Cs-137	1(-2)	3(-4)	c	c	7.5(-5)	1(-2)
H-3	5.5(+2)	c	c	c	c	5.5(+2)
C-14	1	a	a	a	7	8
Ar-41	2.5(+1)	c	c	c	c	2.5(+1)

[a]less than 1.0 Ci/yr/reactor for noble gases and carbon-14, less than 10^{-4} Ci/yr/reactor for iodine

[b]exponential notation; 1.4(-2) = 1.4×10^{-2}

[c]less than 1% of total for this nuclide

[d]radionuclides not listed are released in quantities less than those specified in notes a and c from all sources.

Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976. These source terms were used to calculate the doses as described below. The dispersion of radionuclides in and the deposition of radionuclides from the atmosphere were based on analyses performed by the staff for this evaluation.

As shown in Tables A.3.2-1 and A.3.2-2, the expected quantity of radioactive materials released in liquid effluents from Units No. 1, 2, 3 and 4 will be less than 5 Ci/yr/reactor (0.41 Ci/yr/reactor for Units No. 1 and 2; 0.16 Ci/yr/reactor for Units No. 3 and 4), excluding tritium and dissolved gases, in conformance with the amendment to Section II.D. The liquid effluents released from Units No. 1, 2, 3, and 4 will not result in an annual dose or dose commitment to the total body or to any organ of an individual, in an unrestricted area from all pathways of exposure, in excess of 5 mrem (Table A.5.2-3).

Based on the staff's evaluation of the gaseous radwaste management systems, the total quantity of radioactive materials released in gaseous effluents from Units No. 1, 2, 3, and 4 will not result in an annual gamma air dose in excess of 10 mrads or a beta air dose in excess of 20 mrads at every location near ground level, at or beyond the site boundary, which could be occupied by individuals (Table A.5.2-7). As shown in Tables A.3.2-3 and A.3.2-4, the annual total quantity of iodine-131 released in gaseous effluents will be less than 1 Ci/reactor (0.035 Ci/yr/reactor for Units No. 1 and 2 and 0.045 Ci/yr/reactor for Units No. 3 and 4) in conformance with the amendment to Section II.D. The annual total quantity of radioiodine and radioactive particulates released in gaseous effluents from Units No. 1, 2, 3, and 4 will not result in an annual dose or dose commitment to any organ of an individual in an unrestricted area, from all pathways of exposure, in excess of 15 mrem (Table A.5.2-3).

The staff's evaluation demonstrates that the radwaste treatment systems proposed for Units No. 1, 2, 3, and 4 are capable of maintaining releases of radioactive materials in effluents during normal operation such that the doses will not exceed the design objectives of Sections II.A, B and C of Appendix I of 10 CFR Part 50.

The staff's evaluation also shows that the applicant's proposed design of Units No. 1, 2, 3, and 4 satisfies the design objectives set forth in RM-50-2 specified in the option provided by the Commission's September 4, 1975 amendment to Appendix I and, therefore, meets the requirements of Section II.D of Appendix I of 10 CFR Part 50.

The staff concludes that the liquid and gaseous radwaste treatment systems will reduce radioactive materials in effluents to "as low as is reasonably achievable" levels in accordance with 10 CFR Part 50.34a and, therefore, are acceptable.

A.3.2.3.2 Solid Radwaste Disposal

The original design of Units No. 1 and 2 provided for solidification of liquid waste evaporator bottoms using cement as the agent. This technique typically requires a mixture such that 25 gals of bottoms may be solidified in a 55 gal drum. The current design provides for solidification using chemical agents (ureaformaldehyde and sodium bisulfate). The design provides a 3 to 1 volume ratio of waste to agent, thereby allowing approximately 42 gals of waste per 55 gals of container volume or a 40% reduction in the container volume requirements. It is estimated that 1910 ft^3 of evaporator bottoms will be solidified each year. Using cement would have required the shipment of 572 drums. The use of chemical agents reduces this number to 347, a reduction of 225 drums.

A design change on the treatment of the secondary loop provides for the capability of full flow condensate polishing using resins which are disposed of upon depletion. This design change is to improve the overall performance and reliability of the steam generators. The potential contamination of this resin is a function of steam generator primary to secondary leakage and station operation. If it is conservatively assumed that a resin bed is backwashed every other day and the partially dewatered resin occupies 6.5 ft^3 and that all resin must be treated as radioactive, this would produce 1215 ft^3 of resin for disposal each year. The shipment of 1215 ft^3 will require 261 55-gal drums.

The use of chemical agents instead of cement will reduce the solid radwaste shipment by 225 drums, while the use of condensate demineralizers may increase the shipments by as much as 261 drums. Consequently, the overall impact of these two changes is not significant.

REFERENCES FOR SECTION A.3

A.3.1 Staff of the U.S. Nuclear Regulatory Commission, NUREG-0053, "Safety Evaluation Report Related to Operation of North Anna Power Station, Units No. 1 and 2," Docket Nos. 50-338 and 50-339, Washington, D.C., June 1976.

A.3.2 Title 10, CFR Part 50, Appendix I. Federal Register, V. 40, p. 19442, May 5, 1975.

A.3.3 Staff of the U.S. Nuclear Regulatory Commission, "Final Environmental Statement Related to the Continuation of Construction and the Operation of North Anna Power Station, Units No. 1 and 2, and the Construction of Units No. 3 and 4," Docket Nos. 50-338, 50-339, 50-404, and 50-405, Washington, D.C., April 1973.

A.3.4 Staff of the U.S. Nuclear Regulatory Commission, "Safety Evaluation of the North Anna Power Station, Units No. 3 and 4," Docket Nos. 50-404 and 50-405, Washington, D.C., December 1972.

A.4. STATUS OF SITE PREPARATION AND CONSTRUCTION

A.4.1 RÉSUMÉ AND STATUS OF CONSTRUCTION

As of October 1976, the construction of Unit No. 1 was 94% complete and Unit No. 2 was 73% complete. The impacts on the terrestrial and aquatic environment were as anticipated, and thus the staff assessment presented in the FES remains unchanged.

A.5. ENVIRONMENTAL EFFECTS OF STATION OPERATION

A.5.1 RÉSUMÉ

With few exceptions, the discussions of impacts of operation of the station provided in the FES remain valid. New generic material has been added concerning the transportation of radioactive material and the environmental effects of the uranium fuel cycle. These assessments are discussed in Sections A.5.2.1 and A.5.2.2, respectively. Information on taxes and employment resulting from operation of Units No. 1 and 2, which was not available when the FES was prepared, has been provided by the applicant. The impact of this information is discussed in Section A.5.3. Section A.5.4 corrects the radius of the exclusion area.

A.5.2 RADIOLOGICAL IMPACTS

A.5.2.1 Environmental Effects of the Uranium Fuel Cycle

The environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low level wastes and high level wastes are within the scope of the AEC report entitled, "Environmental Survey of the Uranium Fuel Cycle." The contributions of such environmental effects are summarized in Table A.5.2-1.

The NRC staff may subsequently modify or expand the discussion of environmental effects of the fuel cycle in the light of the Court of Appeals decision in Natural Resources Defense Council v. NRC (CADC Nos. 74-1386 and 74-1586 decided July 21, 1976). On August 13, 1976, in response to the D.C. Circuit Court decision the Commission had directed the staff to produce a revised environmental survey on the probable contribution to the environmental costs of licensing a nuclear power reactor that is attributable to the reprocessing and waste management stages of the uranium fuel cycle. In addition, the Commission intends to reopen the rulemaking proceeding on the Environmental Effects of the Uranium Fuel Cycle, (Docket RM-50-3) for the limited purpose of (1) Supplementing the record on the reprocessing and waste management issues; and (2) Determining whether or not on the basis of the supplemented record, Table S-3 of 10 CFR 51.20(d) should be amended and, if so, in what respect. The revised environmental survey, together with any amendments to Table S-3 that may be proposed as a consequence of that analysis, will be the basis for these reopened proceedings.

A.5.2.2 Environmental Impact of Transportation of Radioactive Material

The transportation of cold fuel to each of the North Anna reactors, of irradiated fuel from each reactor to a fuel reprocessing plant, and of solid radioactive wastes from each reactor to burial grounds is within the scope of the Commission's Transportation Rulemaking decision "Environmental Effects of Transportation of Radioactive Materials to and from Nuclear Power Plants" promulgated as 10 CFR Section 51.20(g). Pursuant to the rule, the environmental effects of such transportation are summarized in Table A.5.2-2. For a detailed discussion of the transportation of radioactive material, see the NRC report entitled, *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*.

A.5.2.3 Radiological Impact on Man

The mathematical models used to perform the dose calculations are contained in Regulatory Guide 1.109.[1]

Included in the analysis are dose evaluations of three effluent categories: 1) pathways associated with liquid effluent releases to Lake Anna, 2) noble gases released to the atmosphere, and 3) pathways associated with radioiodines, particulates, carbon-14 and tritium released to the atmosphere.

The dose evaluation of pathways associated with liquid effluents was based on the maximum exposed individual. The dietary and living habits for an adult individual included the consumption of 21 kg/yr of fish harvested in the immediate vicinity of the discharge from the cooling arm of the

Table A.5.2-1

Summary of Environmental Considerations for the Uranium Fuel Cycle

[Normalized to Model LWR Annual Fuel Requirement]

Natural resource use	Total	Maximum effect per annual fuel requirement of model 1,000-MWe LWR
Land (acres)		
Temporarily committed	63	
Undisturbed area	45	
Disturbed area	18	Equivalent to 90-MWe coal-fired power plant.
Permanently committed	4.6	
Overburden moved (millions of metric tons)	2.7	Equivalent to 90-MWe coal-fired power plant.
Water (millions of gallons)		
Discharged to air	156	≑ 2% model 1000-MWe LWR with cooling tower.
Discharged to water bodies	11,040	
Discharged to ground	123	
Total	11,319	<4% of model 1000-MWe LWR with once-through cooling.
Fossil fuel		
Electrical energy (thousands of MW-hour)	317	<5% of model 1000 MWe LWR output.
Equivalent coal (thousands of metric tons)	115	Equivalent to the consumption of a 45-MWe coal-fired power plant.
Natural gas (millions of scf)	92	<0.2% of model 1000-MWe energy output.
Effluents - chemical (metric tons)		
Gases (including entrainment)[a]		
SO_2	4,400	
NO_2[b]	1,177	Equivalent to emissions from 45-MWe coal-fired plant for a year.
Hydrocarbons	13.5	
CO	28.7	
Particulates	1,156	
Other gases		
F^-	0.72	Principally from UF_6 production enrichment and reprocessing. Concentration within range of state standards - below level that has effects on human health.
Liquids		
SO_4^-	10.3	From enrichment, fuel fabrication, and reprocessing steps. Components
NO_3^-	26.7	that constitute a potential for adverse environmental effect are present
Fluoride	12.9	in dilute concentrations and receive
Ca^{2+}	5.4	additional dilution by receiving bodies
Cl^-	8.6	of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are:
Na^+	16.9	NH_3 - 600 cfs.
NH_3	11.5	NO_3 - 20 cfs.
Fe	0.4	Fluoride - 70 cfs.
Tailings solutions (thousands of metric tons)	240	From mills only - no significant effluents to environment.
Solids	91,000	Principally from mills - no significant effluents to environment.

Table A.5.2-1

Summary of Environmental Considerations for the Uranium Fuel Cycle

[Normalized to Model LWR Annual Fuel Requirement] (cont'd)

Natural resource use	Total	Maximum effect per annual fuel requirement of model 1,000-MWe LWR
Effluents - radiological (curies)		
Gases (including entrainment)		
Rn-222	75	Principally from mills - maximum annual dose rate <4% of average natural background within 5 miles of mill. Results in 0.06 man-rem per annual fuel requirement.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.032	
Tritium (thousand)	16.7	Principally from fuel reprocessing plants - whole body dose is 6 man-rem per annual fuel requirements for population within 50-mile radius. This is <0.007% of average annual background dose to this population. Release from Federal Waste Repository of 0.005 Ci/year has been included in fission products and transuranics total.
Kr-85 (thousands)	350	
I-129	0.0024	
I-131	0.024	
Fission products and transuranics	1.01	
Liquids		
Uranium and daughters	2.1	Principally from milling - included in tailings liquor and returned to ground - no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production - concentration 5% of 10 CFR 20 for total processing of 27.5 model LWR annual fuel requirements.
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants - concentration 10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ru-106	0.15[c]	From reprocessing plants - maximum concentration 4% of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium (thousands)	2.5	
Solids (buried)		
Other than high level	601	All except 1 Ci comes from mills - included in tailings returned to ground - no significant effluent to the environment, 1 Ci from conversion and fuel fabrication is buried.
Effluents - thermal (billions of Btu's)	3,360	<7% of model 1000-MWe LWR.
Transportation (man-rem): exposure of workers and general public.	0.334	

[a] Estimated effluents based upon combustion of equivalent coal for power generation.

[b] 1.2% from natural gas use and process.

[c] Cs-137 (0.075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

Source: Paragraph 51.20(e), 10 CFR 51.

Table A.5.2-2

Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor[a]

NORMAL CONDITIONS OF TRANSPORT

	Environmental Impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr.
Weight (governed by Federal or State restrictions)	73,000 lbs per truck; 100 tons per cask per rail car.
Traffic density:	
Truck	Less than 1 per day.
Rail	Less than 3 per month.

Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals[b] (per reactor year)	Cumulative Dose to Exposed Population (per reactor year)[c]
Transportation workers	200	0.01 to 300 millirem	4 man-rem
General public			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem	

[a]Data supporting this table are given in the Commission's Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plant," WASH-1238, December 1972 and Supp. I. NUREG-75/038, April 1975.

[b]The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[c]Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem in each case would be 1 man-rem.

lake, consumption of 730 ℓ/yr of water from the lake, and recreational use of the lake and its shoreline for 10 hr/yr. For an infant, the diet included consumption of 510 ℓ/yr of water from the lake. These pathways have been addressed in this addendum utilizing the most recent source terms and dose models. For these dose assessments, the critical radionuclides (tritium, cesium-134 and cesium-137) were assumed to reconcentrate in the reservoir water as determined by expected flows, with no significant dilution of the liquid releases prior to downstream use. The maximum dose commitment (all four units operating) resulting from ingestion of water from the lake was estimated to be 0.095 mrem/yr (total body) and 0.61 mrem/yr (thyroid) for an infant.

The dose evaluation of noble gases released to the atmosphere included a calculation of beta and gamma air doses at the site boundary and total body and skin doses at the residence having the highest dose. The maximum air doses at the site boundary were found at 0.85 miles NNE relative to Unit No 1. The location of maximum total body and skin doses was determined to be at a residence 1.09 miles S of the station.

The dose evaluation of pathways associated with radioiodine, particulates, carbon-14 and tritium released to the atmosphere was also based on the maximum exposed individual. One such individual is a child whose diet is assumed to include the consumption of 520 kg/yr of crops, 330 ℓ/yr of milk, and 41 kg/yr of beef and poultry produced at the location of the milk cow having the highest calculated dose from these and two other pathways noted below. This location is 1.86 miles E of the station. Another such individual is a child whose diet is assumed to include the consumption of 520 kg/yr of crops grown at the location of the residence having the highest calculated dose from this and two other pathways noted below. This location is 1.09 miles S of the station. These maximum exposed individuals were also assumed to be exposed to inhaled radionuclides in this category, as well as those deposited on the ground at each of the locations described above.

A comparison of calculated doses from Units No. 1 through 4 with 10 CFR Part 50 Appendix I criteria is provided in Table A.5.2-3.

A.5.3 SOCIO-ECONOMIC IMPACT

In addition to the impacts discussed in the FES, the applicant has provided additional information about employment and taxes resulting from operation of North Anna Power Station, Units Nos. 1 and 2.

The applicant conservatively estimates that the operation of Units No. 1 and 2 will result in the formation of 254 new jobs on site, approximately 10 new jobs in the corporate offices in Richmond, Virginia and approximately 10 new jobs in other departments of the Company that support the operation at North Anna.

In addition to those individuals hired directly by the Company for the operation of Units No. 1 and 2 the station will provide employment for an additional 30 people on the average during a calendar year. This number includes contract mechanics, electricians, laborers, food vendors and office services.

The applicant estimates that for the year 1978, the first full year of operation of both units, the total annual income for these 304 people will be $4,400,000.

The applicant also estimates that these people will pay approximately $1,850,000 in taxes to local counties. Most of this money will be paid in Louisa County, Virginia, the county in which the station is located.

These taxes and the taxes paid by station employees should more than off-set any additional burden on local schools and service facilities resulting from the influx of new residents required as a result of operation of Units No. 1 and 2.

A.5.4 EXCLUSION AREA SIZE

The FES incorrectly states that the exclusion area radius is 1500 m. The correct radius is 1350 m. The applicant owns and controls all the land within the exclusion area. Dose calculations for normal reactor operation are presently calculated at the site boundary, not the exclusion area boundary as discussed in the FES. Dose calculations at the site boundary of the North Anna Power Station have been made as part of the assessment of compliance with 10 CFR 50 Appendix I discussed in Section A.5.2.4 of this Addendum.

Table A.5.2-3

Comparison of North Anna Power Station Unit No. 1, 2, 3, and 4, with Appendix I to 10 CFR Part 50, Sections II.A, II.B and II.C (May 5, 1975)[d] and Section II, D, Annex (September 4, 1975)[b]

Criterion	Appendix I[a] Design Objectives	Annex[b] Design Objectives[c]	Calculated Unit Nos. 1 and 2	Calculated Unit Nos. 3 and 4
Liquid Effluents				
Dose to total body from all pathways (infant)	3 mrem/yr/unit	5 mrem/yr/site	0.025 mrem/yr/unit	0.023 mrem/yr/unit
Dose to any organ from all pathways (infant-thyroid)	10 mrem/yr/unit	5 mrem/yr/site	0.20 mrem/yr/unit	0.11 mrem/yr/unit
Liquid Releases (except tritium and noble gases)	No Limit Specified	5 Ci/yr/unit	0.41 Ci/yr/unit	0.16 Ci/yr/unit
Noble Gas Effluents				
Gamma dose in air	10 mrad/yr/unit	10 mrad/yr/site	0.10 mrad/yr/unit	0.13 mrad/yr/unit
Beta dose in air	20 mrad/yr/unit	20 mrad/yr/site	0.14 mrad/yr/unit	0.34 mrad/yr/unit
Dose to total body of an individual	5 mrem/yr/unit	5 mrem/yr/site	0.030 mrem/yr/unit	0.41 mrem/yr/unit
Dose to skin of an individual	15 mrem/yr/unit	15 mrem/yr/site	0.072 mrem/yr/unit	0.12 mrem/yr/unit
Radioiodines and Other Radionuclides Released to the Atmosphere[e]				
Dose to any organ from all pathways (infant-thyroid)	15 mrem/yr/unit	15 mrem/yr/site	0.78 mrem/yr/unit	1.2 mrem/yr/unit
Releases (I^{131})	No Limit Specified	1 Ci/yr/unit	0.035 Ci/yr/unit	0.045 Ci/yr/unit

[a] Federal Register, V.40, p. 19442, May 5, 1975.

[b] Federal Register, V.40, p. 40816, September 4, 1975.

[c] Design Objectives given on a site basis. Therefore these design objectives apply to 4 units at the site.

[d] Limited to noble gases only.

[e] Carbon-14 and Tritium have been added to this category.

REFERENCES FOR SECTION A.5

A.5.1 Staff of the U.S. Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Average Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Implementing Appendix I," March 1976.

A.6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

A.6.1 PREOPERATIONAL PROGRAMS

A.6.1.1 Ecological

A.6.1.1.1 Terrestrial

No monitoring data on terrestrial ecosystems on or near the plant site have been collected to date. The preoperational program will begin in the fall of 1976. The applicant has supplied a general description of the proposed sampling program. The staff considers this program to be adequate and will review the data collected when it is available.

A.6.1.1.2 Aquatic

Preoperational-preimpoundment studies of the North Anna River basin were conducted in 1971 and construction of Lake Anna was completed in December 1972. This phase of the monitoring program is summarized in Sect. 6.1.1 of the FES.

The preoperational-postimpoundment and operational aquatic monitoring programs are designed to distinguish between the effects of construction and operation of the North Anna Power Station on the Lake Anna and North Anna River systems and the effects of natural ecological variations and cycles. Table A.6.1-1 summarizes the North Anna preoperational-postimpoundment monitoring program; it is based on information in Appendices K and L of the Environmental Report, docketed communications with Vepco 50-338-147 and 50-338-174, and Addendum 1 to Appendix L filed 29 April 1976. At this time, the final baseline report for the monitoring program has not been submitted to NRC. A definitive review of sampling design, methods, and statistical validity of data will have to await receipt of this report. If this review is satisfactory, the aquatic preoperational monitoring program is adequate. The following deficiencies in the preoperational monitoring program were noted and should be considered in the development of any additional preoperational monitoring and/or the development of the operational monitoring program discussed in Section A.6.2.

(1) Measurements of zooplankton productivity:

Because of the potential for entrainment of a significant portion of the zooplankton population and effects of temperature on reproductive parameters, measurements of the zooplankton reproductive rate should be incorporated into the monitoring program along with measurements of zooplankton densities (including immature forms) and species composition. Data on egg ratio and duration of development as described in IBP Handbook No. 17, Sect. 2.6[1] should be adequate.

(2) Quantitative samples of benthic macroinvertebrates in the sediments of Lake Anna:

Artificial substrates, as presently utilized by the applicant, are adequate for bioassay studies with benthic organisms in the lake. However, because of the structural differences between the natural bottom substrates in the lake and the surfaces of artificial substrate samplers, the growth of organisms on artificial substrates does not accurately reflect populations of benthos in the lake. In order to measure actual benthic population changes due to power plant operation, sampling of benthos in bottom habitats in Lake Anna should be incorporated into the monitoring program. Chapter 1.3 of the IBP Handbook No. 17[1] reviews sampling techniques available.

(3) Sampling of periphyton in the North Anna River:

Periphyton should be collected on a regular basis to determine effects of turbidity and temperature increases on primary production in the river.

(4) Aquatic macrophytes:

Distribution of aquatic macrophytes in Lake Anna (particularly on the west bank between the dam and entrance of Contrary Creek) should be mapped each summer.

(5) Collection and identification of ichthyoplankton in the vicinity of the proposed intake structure.

(6) Add a sampling station for physical and chemical, phytoplankton, and zooplankton measurements in Lake Anna near the discharge from Waste Heat Treatment Facility (WHTF) lagoon 3 and associated with benthos and fish sampling stations in the same area.

(7) Increase frequency of sampling in the North Anna River from quarterly to quarterly-plus-once-per-month in summer.

(8) Water quality of feeder streams to Lake Anna (particularly Elk Creek, Millpond Creek, and Coleman Creek) should be measured every 3 to 5 years to evaluate effects of changing land use patterns on reservoir water quality.

A.6.2 OPERATIONAL MONITORING PROGRAMS

The assessments of potential impacts to the ecosystem presented in the FES were based principally on the surveys and experiments listed in Section 6.1 of the FES and on the applicant's and staff's evaluation of the thermal discharge. The staff believes that these assessments should be confirmed by monitoring the thermal plumes and the indigenous biota after Unit No. 1 has begun operation. To a large degree, the biological program will be a continuation of the preoperational surveys and tests as shown in Table A.6.1-1. Updated biological and thermal programs will be finalized by the Environmental Technical Specifications that are currently being developed by the applicant and staff and which will become Appendix B to the Operating License.

Table A.6.1-1

Summary of Preoperational Monitoring Program

Parameter	In Lake Anna	North Anna River below the Dam
Temperature	Continuous recorders established August 1974 at six stations in lake, three in the Waste Heat Treatment Facility embayments (WHTF), recorders (where possible) at surface, mid-depth, and bottom; Quarterly synoptic surveys begun in August 1973 at 17 stations; recorded hourly (sunrise to sunset) at 1 M interval Vertical profiles at 15 stations monthly throughout year and bi-monthly in June, July, and August	Same as lake, three stations
Metals distribution	7 stations; water analyzed for Cu, Pb, Zn, Fe, Na, K, Ca, and Mg quarterly 1972-75 at surface, mid-depth and bottom. Fish (8 species) analyzed in 1975 for Pb, Zn, and Fe. Sediment, benthos, macrophytes, and plankton (seston) analyzed in 1975 for Cu, Pb, Zn, and Fe. In 1976, studies will be continued on metals in the water (15 stations), sediments (9), and bluegills (8 stations). Fish will be analyzed for Cu, Pb, Zn, Cd, and Hg.	Same as lake, 5 stations, quarterly. In 1976, water from 4 river stations are being analyzed quarterly
Other physical-chemical parameters	15 stations sampled monthly for light transmission (Secchi disc and pyrheliometer), dissolved oxygen (vertical profile), alkalinity, nutrients (7 stations only) and pH. Measurements for most parameters at most stations are taken at the surface and at one meter intervals to at least 5 m.	Dissolved oxygen, pH, alkalinity, turbidity, water quality (presumably similar to lake sampling), 5 stations, quarterly.
Algae and thermal productivity	Primary productivity (light-dark bottles C-14 uptake), chlorophyll measurements and phytoplankton collections (ID and density) at 5 stations at surface and 1-m intervals to 5 m, monthly. At 10 other stations, chlorophyll analysis and phytoplankton collections at surface and selected depths (to 6 m) monthly and bi-monthly June-August.	Limited periphyton collections in 1975.
Zooplankton	Monthly collections (Juday trap) at 5 stations, at surface and 1 m intervals to 5 m and 10 additional stations at surface and selected depths. Data on species composition and relative densities of mature and immature zooplankters; occurrence of Cladocerans with eggs.	NONE

Table A.6.1-1 (continued)

Parameter	In Lake Anna	North Anna River below the Dam
Benthic Macroinvertebrates	Monthly samples at 10 stations with artificial substrates (set at 2, 4, and 7 m) and dip nets. ID to at least genus	Quarterly sampling at 5 stations with a D-frame, time sequence collecting net.
Macrophytes	Types or species of macrophytes in Lake have been identified. A more extensive survey is planned for 1976.	NONE
Fish	Monthly collections at 13 stations with gill and hoop nets, seines, and electrofishing. More detailed studies for game species on age, growth, distribution, movements, fecundity, and condition. For largemouth bass and chain pickerel, food habit study and life cycle data (relative condition, gonad cycles, fecundity, and egg size with tine). Cove rotenone studies in 1975 to estimate standing crop.	Quarterly collections at 5 stations, seining and electrofishing.
Terrestrial ecosystems around Lake Anna	No information to date. However, starting in late 1976, 5 representative plots (2 adjacent to WHTF, 2 near lower portion of Lake Anna, and 1 along the river below the dam) will be established and vegetation surveyed annually.	
Land Use	Sections 2.1 and 2.2 of the FSAR (also included in App. K.II) include data on crops, dairy farms, industrial facilities, jails, hospitals, schools, mines, parks, and airports, major recreation and wildlife management areas, and populations within 10 miles of the site (which encompasses most of Lake Anna). In the late fall of 1976, Vepco proposes to make an aerial survey of the periphery of Lake Anna, the WHTF, and for a short distance down the river below the dam. General land use map for these areas would be the output. Biennial land use surveys are planned until the station is fully developed, when a 5-year schedule will be established.	
Well Water	No data presently available. In the summer of 1976, Vepco began analyzing potable water quality (parameters not specified) of wells from 4 locations: Mineral, Wares Crossroads, Arritt's Store, and on-site.	
Groundwater	NONE existing or proposed	

REFERENCES FOR SECTION A.6

A.6.1 W. T. Edmondson and G. G. Winberg, A Manual on Methods for the Assessment of Secondary Productivity in Fresh Waters, IBP Handbook No. 17, Blackwell Scientific Publications, Oxford, England, 1971.

A.7. ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS INVOLVING RADIOACTIVE MATERIAL

The assessment of the impacts of postulated accidents presented in the FES remains unchanged.

A.8 NEED FOR STATION

A.8.1 RÉSUMÉ

When the FES was issued in April 1973, the North Anna Power Station, Units No. 1 and 2, were scheduled to come on line in 1974 and 1975, respectively. Two major events, unforeseen at that time, led to a dramatic decline in the growth of energy and peak demand nationwide as well as in the VEPCO service area as shown in Table A.8.1-1. The first event was the Arab oil embargo in the latter part of 1973 and its effect on fuel prices and fuel availability, and the impetus given energy conservation efforts by these developments. The other unexpected event was the severity of the economic recession which followed shortly thereafter. As a result of these developments, the applicant has revised downward the energy and peak demand forecasts for the late 1970's and early 1980's and has rescheduled the North Anna units to come on line in 1977 and 1978.

A.8.2 APPLICANT'S SERVICE AREA AND REGIONAL RELATIONSHIPS

The applicant reports that there have been no significant changes in its service area or regional relationships since issuance of the FES in April 1973.

A.8.3 BENEFITS OF OPERATING THE STATION

North Anna Power Station has been constructed to provide an economic source of baseload generation energy for 1977 and following years. The station will be utilized primarily to provide electricity for the applicant's service area described in the FES.

A.8.3.1 Minimization of Production Costs

Once a plant is constructed, the capital costs are sunk costs and cannot be recovered. They are not relevant to the question of whether the plant should operate or not. The important decision-variables are fuel costs and operation and maintenance costs because these expenses can be avoided by choosing not to operate the plant. The decision criterion in this situation is to operate the North Anna Power Station if system production expenses are reduced by doing so.

Excluding taxes and investment-related costs, production expenses at a nuclear plant consist of about 75% fuel costs and 25% operating and maintenance (O + M) costs (License Application, Amendment 46, Tables A10.1-1 through A10.1-10). O and M costs at fossil fueled stations are expected to be similar in magnitude but much less on a percentage basis as a result of the higher fossil fuel costs as discussed below. Thus, fuel costs are the dominant factor in the annual production expenses (excluding taxes, depreciation, and return on investment).

Fuel costs of Units No. 1 and 2 are estimated by the applicant to be 3.71 and 4.32 mills/kWhr in 1977 (ER, Appendix L, Addendum 1). The Surry Nuclear Station's fuel cost in 1975 was 3.09 mills/kWhr[1] and in 1977 is expected to be 3.53 and 3.80 mills/kWhr for Units No. 1 and 2, respectively, an increase of 17% in two years (ER, Appendix L, Addendum 1). The lowest cost base-load fossil-fueled plant in the VEPCO system in 1975 was the coal-fired Mt. Storm mine-mouth station with a fuel cost of 9.83 mills/kWhr. With a similar coal cost escalation, the Mt. Storm fuel cost in 1977 would be about 11.5 mills/kWhr. The average fuel cost in 1975 for the coal and oil-fired units in the VEPCO system were 14.19 and 19.38 mills/kWhr, respectively. Since the North Anna units will have one of the lowest fuel costs in the VEPCO system, significant cost savings could be realized by operating North Anna Power Station, Unit Nos. 1 and 2 instead of coal and oil-fired plants. The staff finds the estimates provided by the applicant to be reasonable based on the staff's assessment of generating costs at similar facilities.

Using the estimated 1977 nuclear fuel cost for the North Anna Power Station and system average fossil fuel cost in 1975 (unescalated), and assuming fuel loading dates of November 1976 and July 1977, the staff finds that operation of the North Anna Power Station would have reduced fuel costs by $49 million in 1977 compared to coal and $73 million compared to oil. This assumed a conservative capacity factor of only 60% and was based on the assumption that Unit No. 1 would be operational for about nine months and Unit No. 2 would be operational for only about three months. According to the applicant, operation of the North Anna Power Station would have reduced

Table A.8.1-1

Recent Operating History of the VEPCO Power System

Year	Energy Distributed 10^9 kWhrs	Change From Preceding Year, %	Peak Load MW	Change From Preceding Year, %	Generating Capability(1) MW	Largest Outage(1) MW	Largest Purchase(1) MW
1973	32.7	12.4	6900	10.7	6738	1397	1559
1974	32.8	0.3	6734	-2.5	7298	2201	1637
1975	34.4	4.9	7133	5.9	8753(2)	2204	599

(1) Capability, Outage, and Purchase at Peak Load.

(2) Added Yorktown Unit 3 and Possum Point Unit 5.

net production cost (fuel, operation and maintenance, insurance, taxes, depreciation, and income) by about $60,746,100. The subsequent delay of Unit 1 until December 1976 and Unit 2 until January 1978 will modify the actual savings realized, however, the relative comparison should still be valid.

A.8.3.2 Power Demand

Although savings in system production costs are a sufficient basis to justify operation of Units No. 1 and 2, the station will also be required to meet the expected growth in power demand and will provide important benefits in terms of increased system reliability. Since issuance of the FES, the load forecasts have been revised to reflect changes in the overall energy situation. In line with these changes, peak load forecasts for the late seventies were revised downward by about 30 percent and the North Anna units, planned for 1974 and 1975, were rescheduled accordingly.

Table A.8.3-1 shows the most recent load forecasts for the VEPCO system and the system capability, reserves, and reserve margins assuming North Anna Power Station, Units No. 1 and 2 come on line as scheduled. Reserve margins increase dramatically in 1977 and 1978, reflecting the addition of 1,800 MW to the system. However, Table A.8.1-1 shows that unit outages at peak load have amounted to capacities similar to the two North Anna units. Thus, availability of these units will reduce the need to puchase large quantities of power in case of future outages at peak load.

If Unit No. 1 were delayed beyond the 1977 summer peak, reserve margins for the VEPCO system would be reduced from 30.9 percent to 19.2 percent. Similarly, if both North Anna units were delayed beyond the summer of 1978, reserve margins for the VEPCO system would fall to 12.1 percent.

A.8.4 CONCLUSION

The staff finds that operation of North Anna Power Station, Units Nos. 1 and 2 will benefit the electric power consumers in the VEPCO service area in the following ways:

1) Reduced cost of electric energy compared with operation of existing coal and oil fired units.

2) Increased reserve capacity which increases the power system reliability in case of equipment outages.

3) Lower level of power and energy purchases during equipment outages, also resulting in lower costs and greater reliability.

Therefore, the staff recommends operation of the North Anna units as soon as possible consistent with the environmental and safety review.

Table A.8.3-1

System Peak Load, Capability, Reserves, and Reserve Margins for VEPCO Service Area

Year	Peak Load MW	System Capability MW	Reserves MW	Reserve Margins Percent
1976	7360	9,157	1797	24.4
1977	7680	10,055	2375	30.9
1978	8170	10,953	2783	34.1
1979	8760	11,025	2265	25.9
1980	9310	11,025	1715	18.4

REFERENCES FOR SECTION A.8

A.8.1 1975 Annual Report, Virginia Electric and Power Company, Richmond, Virginia.

A.9 ENVIRONMENTAL EVALUATION OF THE PROPOSED ACTION

A.9.1 ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

The staff has reviewed the physical, social and economic impacts that can be attributed to the North Anna Power Station. Inasmuch as the plant is currently under construction, many of the predicted and expected adverse impacts of the construction phase are evident. The applicant has committed to a program of restoration and redress of the plant site that will begin at the termination of the construction period. The staff has not identified any additional adverse effects that will be caused by construction of the plant. Consequently, the operation phase of the plant will consist of restoration, reparation, and maintenance with the possibility of enhancing the environs as they existed prior to construction.

A.9.2 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The staff's evaluation of the use of land for the site of the North Anna Power Station and associated transmission lines has not changed since the original environmental review. The presence of this plant in Louisa County will continue to influence the future use of other land in its immediate environs as well as the continued removal of county land from agricultural use as the result of any increased industrialization.

A.9.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

There has been no change in the staff's assessment of this impact since the earlier review except that the continuing escalation of costs has increased the dollar values of the materials used for constructing and fueling the plant.

A.9.4 DECOMMISSIONING AND LAND USE

In the long term, beyond the useful life of the proposed generating station, this site may continue to be used for generation of electrical energy. At the termination of such use, the land areas occupied by the nuclear facilities would be removed from productive use unless decommissioning measures included removal of all radioactive equipment. Although the details of decommissioning may not be worked out for several years, the various alternatives should not be diminished by the proposed action of licensing operation. The range of beneficial uses of the site by future generations will not be curtailed, provided the applicant has the capability for removing all radioactively contaminated equipment if and when that step may be desirable.

NRC regulations prescribe procedures whereby a licensee may voluntarily surrender a license and obtain authority to dismantle a facility and dispose of its component parts.[1] Such authorization would normally be sought near the end of the nuclear plant's useful life. In any event, the Commission requires that a qualified licensee maintain valid licenses appropriate to the type of facility and materials involved. Under current regulations, the Commission generally requires that all quantities of source, special nuclear, and by-product materials not exempt from licensing under Parts 30, 40, and 70 of Title 10, Code of Federal Regulations, either be removed from the site or secured and kept under surveillance.

To date, experience has been gained with decommissioning of six nuclear electric generating stations which were operated as part of the Atomic Energy Commission's power reactor development program: Hallam Nuclear Power Facility, Piqua Nuclear Power Facility, Boiling Nuclear Superheat Power Station, Elk River Reactor, Carolinas-Virginia Tube Reactor, and Pathfinder Atomic Power Plant. The last two facilities were licensed under 10 CFR Part 50; the others were Atomic Energy Commission-owned and operated under the provisions of Part 115.

Several alternative modes of decommissioning have been experienced in those cases. They may be summarized generally as four alternative levels of restoration of the plant site, each with a distinct level of effort and cost.

In decommissioning at any level, economically salvageable equipment and all reactor fuel elements would be removed, some equipment would be decontaminated, and wastes of the type normally shipped during operation would be sent to waste repositories. In addition, the respective levels of restoration would involve the following measures:

Lowest level. There would be minimal dismantling and relocation of equipment. All radioactive material would be sealed in containment structures (primarily existing ones), which would require perpetual, continual surveillance for security and effectiveness.

Second level. Some radioactive equipment and materials would be moved into existing containment structures to reduce the extent of long-term contamination. Surveillance as in the lowest level would be required.

Third level. Radioactive equipment and materials would be placed in a containment facility approaching a practically minimum volume. All unbound contamination would have been removed. The containment structure would be designed to need minimal perpetual maintenance, surveillance, and security.

Highest level. All radioactive equipment and materials would be removed from the site. Structures would be dismantled and disposed of onsite by burial or offsite to the extent desired by the tenant. No further Commission license would be required.

Estimated costs of decommissioning at the lowest level are about $1 million plus an annual maintenance charge on the order of $100,000.[2]

Complete restoration, including regrading, has been estimated to cost $70 million.[3] Hence, there is wide variation, arising from differing assumptions as to level of restoration. At present land values, it is not likely that consideration of an economic balance alone would justify a high level of restoration. Planning required of the applicant at this stage will assure, however, that variety of choice for restoration is maintained until the end of useful plant life.

Units 1 and 2 of the North Anna Power Station are designed to operate for about 30 years, and the end of their useful life will be approximately in the year 2007. The applicant has made no firm plans for decommissioning but assumes that the following steps would be taken as minimum precautions for maintaining a safe condition.

1. All fuel would be removed from the facility and shipped offsite for disposition.

2. All radioactive wastes--solid, liquid, and gas--would be packaged and removed from the site insofar as practical.

A decision as to whether the facility would be further dismantled would require an economic study involving the value of the land and scrap value versus the cost of complete demolition and removal of the complex. However, no additional work would be done unless it is in accordance with rules and regulations in effect at the time.

In addition to personnel required to guard and secure the facility, concrete and steel would be used to prevent ingress into any building, particularly the radioactive areas.

A.9.5 HEALTH EFFECTS OF COAL VS. NUCLEAR FUELS

In addition to the environmental costs considered in the FES, the differing health effects from using coal and nuclear fuels should be considered in the environmental balance. In making this balance the entire fuel cycle rather than just the power-generation phase should be considered. For coal, the cycle consists of mining, fuel transportation, processing, and power generation. The nuclear fuel cycle includes mining, milling, fuel preparation, fuel transportation, power generation and waste disposal.

Comar and Sagan[4] recently reviewed the literature (41 references) concerning premature deaths associated with the operation of 1,000 MWe coal and nuclear power plants. The data summarized in Table A.9.6-1 give the highest and lowest estimates of premature deaths for the general public and for occupational employees. Premature deaths include accidental ("prompt") deaths and delayed deaths (e.g., from the long-term effects of exposure to low level radiation or the products of the combustion of coal). Genetic effects resulting in delayed deaths are not included in Table A.9.6-1 but the authors state that for the nuclear fuel cycle, "--there are enough data to indicate the values given (0.01 - 0.16 deaths per year) in Table A.9.6-1 for non-accidental premature deaths would not be increased by more than 50% in the first generation or

Table A.9.6-1

Premature Deaths Per Year Associated with Operation of a 1,000 MWE Power Plant*

GENERAL PUBLIC	COAL	NUCLEAR
Transport	0.5.5-1.3	N.A.
Processing	1-10	N.A.
Power Plant Operation	0.067-100	0.01-0.16**
TOTAL GENERAL PUBLIC	1.6-111	0.01-0.16
OCCUPATIONAL		
Entire Fuel Cycle	0.54-5.0	0.10-0.86
TOTAL OCCUPATIONAL AND PUBLIC	2-116	0.11-1.0

*Extracted from Table 3 of Reference 2.

**Included in Power Plant Operation.

N.A. Indicates no data found; effects, if any, are presumably too low to be observed; and no theoretical basis for prediction.

by more than several fold after hundreds of years." The consideration of the effects of large nuclear accidents would not materially affect these values (see later discussion).

The premature public (non-occupational) deaths per year caused by the transportation of coal (0.55 - 1.3) are primarily deaths occurring at railroad grade crossings.[5] The effects of air pollutants emitted from the combustion of coal in a coal-fired power plant are a matter of considerable uncertainty, as the premature death estimate range of 0.067 to 100 would suggest.

The public death estimates for coal processing (1-10) are attributed to air pollution originating from the oxidation of culm banks (refuse coal screenings).[6] The estimates of premature public deaths resulting from the nuclear fuel cycle (0.01 to 0.16 per year) represents less than one-tenth of the public deaths from the coal cycle (1.6 to 111 per year).

Estimates of premature occupational deaths range from 0.54 to 5.0 per year for the coal fuel cycle and from 0.10 to 0.86 per year for the nuclear fuel cycle. For coal, the largest items are for mining and for transport; for the nuclear cycle, the largest contributors are processing and mining.

In Table A.9.6-2, Comar and Sagan express the estimates of premature deaths in Table A.9.6-1 in terms of the degree of incremental risk to which individuals and populations are exposed. Comar and Sagan also presented (see Table A.9.6-2) (1) values illustrative of the absolute number of premature deaths predicted for the routine operation of 300 plants for their typical lifetime of 30 years, and (2) an estimate, based on the draft WASH-1400 report,[7] that 10 statistical deaths would result from catastrophic nuclear accidents in 30 years from 300 plants. The final WASH-1400 report[8] was available subsequent to the Comar and Sagan article; however, Comar and Sagan note while the numerical values in the final version of WASH-1400 differ from those used by them, they would not materially affect the comparisons made.

An important source of information in the field of industrial health effects is a study[5] by the Council on Environmental Quality. The estimates given in this study were generally within the ranges given in Table A.9.6-1.

In a recent article[9] by Rose et al., the estimates of health effects of power generation are generally within the ranges cited in Table A.9.6-1; predicted deaths per 1000 MWe plant-year are 20-100 for coal and 0.502 for nuclear. The estimate is higher for total incapacitation and premature death owing to black-lung disease in coal miners (10 deaths per year). Recent improvements in mining practices are expected to lower this toll. This paper also discusses

Table A.9.6-2

Summary of Implications of Qualitative Assessments of Health Effects in the General Population Associated with Electricity Production (All Values) Rounded)*

		Coal	Nuclear
Premature deaths/year/1000-MWe plant		2-100	0.01-0.2
Added Risk/year		1 in 10,000	1 in 5,000,000
Age	Normal risk of death/yr	Enchanced risk of death per year because of electricity production[a] Coal	Nuclear
All Ages	1 in 100	1.01 in 100	1.00002 in 100
Number of premature deaths in 30 years associated with routine operations of 300 plants[b]		20,000 to 1,000,000	100 to 2,000
Number of deaths statistically predicted from catastrophic accidents in 30 years from 300 plants (Rasmussen estimate (5))[c]		5	10

[a]Upper estimates.

[b]This represents the total operation for a generation of power plants that would supply about 300 million people.

[c]Based on 1 chance in 10^6 of an accident per reactor-year causing 1000 immediate and delayed casualities.

*Excerpted from Table 7, Reference 2.

deaths to the public from large nuclear accidents. Utilizing the value of 0.0004 "prompt" deaths per reactor-year from the draft WASH-1400 report,[7] Rose et al. estimated delay deaths--from cancers and genetic faults--could increase the total by a factor of 10 to 0.004 deaths.

Applying the factor of 25 suggested by the American Physical Society's critique[10] of the draft WASH-1400 report, Rose et al. arrived at an expectation value of 0.01 deaths per reactor-year. This value is a small fraction of their estimate for the complete nuclear fuel cycle of 0.168 radiation-related deaths and 0.334 accidental deaths not radiation-related.

It was also mentioned by Rose et al. that improvements in methods for scrubbing SO_2 out of the gaseous effluents from coal combustion may reduce the highest figure in Table A.9.6-1, the 100 deaths possibly resulting from the sulfurous effluents. Such a reduction would still leave higher health costs from the coal cycle, but nearer the effects from the nuclear cycle.

The data in Table A.9.6-2 place in perspective the enhancement of risk from both fuel cycles. For the nuclear cycle, the risk of death increases from an original value of 1 per 100 individuals per year to 1.00002 per 100 individuals per year; for the coal cycle, the increase is from 1 to 1.01 per 100 individuals. Providing further perspective regarding the small statistical risk of large nuclear accidents, the Reactor Safety Study[8] finds that "All non-nuclear accidents examined in this study, including fires, explosions, toxic chemical releases, dam failures, airplane crashes, earthquakes, hurricanes and tornadoes, are much more likely to occur and can have consequences comparable to, or larger than, those of nuclear accidents."

Although it might be expected that public acceptance would be governed by risk evaluations of this kind, Comar and Sagan[4] point out that other factors may be involved: "It is a matter of conjecture whether the public would accept the probability, although very small, of a single nuclear event causing an immediate loss of hundreds of lives as preferable to or in place of the loss of a large number of lives from fossil fuel combustion occurring in driblets and therefore unnoticed." This view has been expressed by others.[8,11]

After consideration of the comparative health analyses and results discussed above, which include the risks from improbable nuclear accidents, the staff concludes that the total societal risk of premature deaths from electrical power generation using nuclear fuel is lower than the risk from power generation using coal.

REFERENCES FOR SECTION A.9

A.9.1 Title 10, "Atomic Energy," Code of Federal Regulations, Part 50, Licensing of Production and Utilization Facilities, Section 50.82, "Applications for Terminations of Licenses."

A.9.2 Atomic Energy Clearing House, Congressional Information Bureau, Inc., Washington, D.C., 17(6):42, 17(10):4, 17(18):7, 16(35):12.

A.9.3 "Pacific Gas and Electric Company, Supplement No. 2 to the Environmental Report, Units 1 and 2, Diablo Canyon Site," July 28, 1972.

A.9.4 Comar, C. L. and L. A. Sagan, "Health Effects of Energy Production and Conversion," In J. M. Hollander (ed) Annual Review of Energy, Vol. 1, 1976.

A.9.5 Council on Environmental Quality, "Energy and the Environment," August 1973.

A.9.6 Hamilton, L. S. (ed), "The Health and Environmental Effects of Electricity Generation: A Preliminary Report," Biomedical and Environmental Assessment Group, Brookhaven National Laboratory, July 1974.

A.9.7 U.S. Atomic Energy Commission, 1974. "An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," WASH-1400, draft.

A.9.8 U.S. Nuclear Regulatory Commission, 1975. "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," WASH-1400 (NUREG-75/14), final.

A.9.9 Rose, D. J., P. W. Walsh and L. L. Leskovjan, "Nuclear Power-Compared to What?" American Scientists 74:291-299, May-June 1976.

A.9.10 H. W. Lewis (chmn) et al. 1975. "Report to the American Physical Society by the Study Group on Light Water Reactor Safety." Rev. Mod. Phys. 47 (summer): Suppl. No. 1.

A.9.11 B. Commoner, "The Poverty of Power."

A.10. BENEFIT-COST ANALYSIS

A.10.1 RÉSUMÉ

There have been minor changes in the benefit-cost analysis of station operation discussed in the FES. Local economic costs have been estimated and environmental costs have changed slightly. The economic justification for operation of the station is discussed in detail in Section 8. Table A.10.1-1 summarizes the benefits and costs of plant operation. Detailed discussions of most of the factors remain unchanged from the FES. No new information has been acquired that would alter the staff's previous position related to the overall balancing of the benefits of this plant versus the environmental costs. Consequently, it is the staff's belief that this plant can be operated with only minimal environmental impacts. The staff finds that the primary benefits of minimizing system production costs and/or the addition to the base-load generating capacity greatly outweigh the environmental and social costs. Section 10.2 discusses the materials which will be consumed during plant operation.

A.10.2 MATERIAL RESOURCE COMMITMENT

A.10.2.1 Replaceable Components and Consumable Materials

Uranium is the principal natural resource irretrievably consumed in plant operation. Other materials consumed (see Table A.10.2-1), for practical purposes, are fuel-cladding materials, reactor-control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion-exchanger regeneration, ion-exchanger resins, and minor quantities of materials used in maintenance and operation.

The two reactors in the plant will be fueled with uranium enriched in the isotope U-235 to 4%.

If the two units of this plant operate at 80% of capacity, about 8500 metric tons of contained natural uranium in the form of U_3O_8 must be produced to feed the plant for 40 years. The known U.S. reserves of natural uranium recoverable at a cost of $8 or less per pound of U_3O_8 are 276,700 metric tons.[4]

There is an estimated potential additional 450,000 metric tons U_3O_8 at $8 or less per pound, but this increment will require a major effort in exploration and development to bring it into production (see Ref. 1, p. 5). The long-term uranium resource situation in the U.S. will depend on larger expected reserves of ore recoverable at greater costs and on utilization of breeder reactors.

The 8500 metric tons of mined natural uranium required for this two-reactor plant consist of 61 metric tons of U-235, with the balance of U-238. In the power plant itself, 43 metric tons of U-235 and 39 metric tons of U-238 will be consumed by fission or transmutation. In this process, 13 metric tons of recoverable fissionable plutonium will be produced. Additional irretrievable losses of uranium in other portions of the fuel cycle amount to 1.3 metric tons of U-235 and 101 metric tons of uranium-238. A new residuum of about 8400 metric tons of uranium depleted to about 0.2% of U-235 would remain. In the long-term, this stock of depleted uranium may be used as feed material in other reactor fuel cycles.

A.10.2.2 Uranium Resources Availability

This section reviews information available from the Energy Research and Development Administration (ERDA) on the domestic uranium resource situation and the outlook for development of additional domestic supplies, availability of foreign uranium, and the relationship of uranium supply to planned nuclear generating capacity.

Analysis of uranium resources and their availability has been carried out by the government since the late 1940s. The work was carried out for many years by the Atomic Energy Commission. The activity was made part of the Energy Research and Development Administration (ERDA) when the agency was created in early 1975.

TABLE A.10.1-1

BENEFIT-COST SUMMARY

Primary impact and population or resource affected	Unit of measure	Magnitude of Impact
	Direct Benefits	
Energy	kWh/yr	10.63×10^9
Capacity	kW	1.868×10^6
	Indirect Benefits	
Taxes (local) (1979)	$/year	1,850,000
Employment		
New jobs (1979)	Number	304
New income (1979)	$/yr	4,400,000
	Economic Costs Saving	
Operating		
Production cost	$/year	49,000,000
	Environmental Costs	
1. Impact on water		
1.1 Consumption (evaporation)		
1.1.2 Property	acre-ft/yr	29000
1.2 Heat discharge to natural water body		
1.2.1 Cooling capacity of water body	Btu/hr	13.5×10^9
1.2.2 Aquatic biota		As discussed in the FES (Sec. 5.4.2)
1.2.3 Migratory fish		None
1.3 Chemical discharge to natural water body		
1.3.1 People		Not discernible
1.3.2 Aquatic biota		Not discernible
1.3.3 Water quality		Not discernible
1.3.4 Chemical discharge	lbs/yr	Same as discussed in FES (Sec. 5.4)
1.4 Radionuclide contamination of natural surface water bodies all except tritium	Ci/yr/reactor	0.41
Tritium	Ci/yr/reactor	580
1.5 Chemical contamination of groundwater		
1.5.1 People		Not discernible
1.5.2 Plants		Not discernible
1.6 Radionuclide contamination of groundwater		
1.6.1 People		Not discernible
1.6.2 Plants and animals		Not discernible
1.7 Raising/lowering of groundwater levels		
1.7.1 People		Not expected offsite
1.7.2 Plants		Not expected offsite

TABLE A.10.1-1 (Cont'd)

Primary impact and population or resource affected	Unit of measure	Magnitude of Impact
1.8 Effects on natural water body of intake structure and condenser cooling systems		
1.8.1 Primary producers and consumers		Unknown
1.8.2 Fisheries		Unknown
1.9 Natural water drainage		
1.9.1 Flood Damage		No damage
1.9.2 Erosion Damage		Insignificant
2. Impact on air		
2.1 Chemical discharge to ambient air		
2.1.1 Air quality, chemical		
2.1.1.1 CO_2	lb/yr	None
2.1.1.2 SO_2	lb/yr	None
2.1.1.3 No_x	lb/yr	None
2.1.1.4 Particulates	lb/yr	None
2.1.1.5 Other	lb/yr	None
2.2 Radionuclides discharged to ambient air		
Noble gases	Ci/yr/reactor	1272
Radioiodines	Ci/yr/reactor	0.104
Particulates	Ci/yr/reactor	0.0025
Carbon-14	Ci/yr/reactor	8
Tritium	Ci/yr/reactor	580
2.3 Fogging and icing		
2.3.1 Ground transportation		Negligible
2.3.2 Air transportation		None
2.3.3 Water transportation		Negligible
2.3.4 Plants		Negligible
	Societal Costs	
1. Operational fuel disposition		
1.1 Fuel transport (new)	trucks/yr	8
1.2 Fuel storage		In-building storage
1.3 Waste products (spent fuel)	trucks/yr or rail shipments/yr	100
1.4 Waste products (other)	trucks/yr	10
2. Plant operating force		200

No significant societal costs are anticipated

Table A.10.2-1

Estimated Quantities of Materials Used in Rector Core Replaceable Components of Water Cooled Nuclear Power Plants

Material	Quantity Used in Plant,[a] kg	World Production,[b] metric tons	U.S. Consumption, metric tons	U.S. Reserves,[b] metric tons	Strategic & Critical Material,[c]
Antimony	1.7	65,400	37,800	100,000[d]	Yes
Beryllium	2.8	288	308	72,700	Yes
Boron	3,363	217,000[e]	79,000[e]	33×10^6	No
Cadmium	206	17,000	6,800	86,000	Yes
Chromium	109,000	1,590,000	398,000	2×10^6[d]	Yes
Cobalt	61	20,200	6,980	25,000[d]	Yes
Gadolinium	2,650	8[f]		14,920[g]	No
Iron	443,000	574×10^6[h]	128×10^6[i]	2×10^9[d]	No
Nickel	55,200 314,000	480,000[i]	129,000[i]	181,000[d]	Yes
Tin	24,000	248,000	89,000	57,000[d]	Yes
Tungsten	9.3	35,000	7,300	79,000	Yes
Zirconium	1,106,000	224,000[e]	71,000	51×10^6	No

[a]Quantities used are modified from the final ER for Hope Creek Generating Station, Table 10.1, Docket Nos. 50-354 and 50-355.

[b]Production, consumption, and reserves were compiled, except as noted, from the U.S. Bureau of Mines publications "Mineral Facts and Problems" (1970 ed. Bur. Mines Bull. 650) and the "1969 Minerals Yearbook."

[c]Designated by G. A. Lincoln, "List of Strategic and Critical Materials," Office of Emergency Preparedness; Fed. Regist. 37(39):4123 (Feb. 26, 1972).

[d]World reserves are much larger than U.S. reserves.

[e]Information for 1968.

[f]Production of gadolinium is estimated for 1971 from data for total separated rare earths given by J. G. Cannon, Eng. Mining J. 173(3):187-200 (March 1972). Production and reserves of gadolinium are assumed to be proportional to the ratio of gadolinium to total rare earth content of minerals given in "Comprehensive Inorganic Chemistry," Vol. 4, ed. M. C. Sneed and R. C. Brasted, D. Van Nostrand Co., Princeton, N. J., 1955, p. 153.

[g]Reserves include only those at Mountain Pass, Calif., according to the "1969 Minerals Yearbook."

[h]Excludes quantities obtained from scrap.

[i]Production of raw steel.

[j]Metallic zirconium accounted for 8% of total U.S. consumption in 1968.

U.S. Resource Position

To establish some basic concepts, a review of resource concepts and nomenclature would be worthwhile. Table A.10.2-2 is a chart of resource categories based on varying geologic knowledge and on varying economic availability. Resources designated as ore reserves have the highest assurance regarding their magnitude and economic availability. Estimates of reserves are based on detailed sampling data, primarily from gamma ray logs of drill holes. ERDA obtains basic data from industry from its exploration effort and estimates the reserves in individual deposits. In estimating ore reserves, detailed studies of feasible mining, transportation, and milling techniques and costs are made. Consistent engineering, geologic, and economic criteria are employed. The methods used are the result of over 25 years effort in uranium resource evaluation.

Resources that do not meet the stringent requirements of reserves are classed as potential resources. For its study of resources, ERDA subdivides potential resources into three categories: probable, possible, and speculative.[2] Probable resources are those contained within favorable trends, largely delineated by drilling, within productive uranium districts (i.e., those having more than 10 tons U_3O_8 production and reserves). Quantitative estimates of potential resources are made by considering the extent of the identified favorable areas and by comparing certain geologic characteristics with those associated with known ore deposits.

Possible potential resources are outside of identified mineral trends but are in geologic provinces and formations that have been productive. Speculative resources are those estimated to occur in formations or geologic provinces which have not been productive but which, based on the evaluation of available geologic data, are considered to be favorable for the occurrence of uranium deposits.

The reliability of the estimates of potential uranium resources differs for each of the three potential classes. The reliability of probable potential estimates is greatest in view of the more complete information, a result of the extensive exploration and development in the major uranium districts. It is least for speculative potential for areas with no significant uranium deposits, for which favorability is determined from available knowledge on the characteristics of the geologic environment.

Since any evaluation of resources is dependent upon the availability of information, the estimates themselves are, to a large degree, a score card on the state of development of information. Thus appraisal of United States uranium resources is heavily dependent upon the completeness of exploration efforts and the availability of subsurface geologic data. Since the geology of the United States as it relates to mineral deposits can never be completely known in detail, it will not be possible to produce a truly complete appraisal of domestic uranium resources. Given the nature and current status of ERDA estimates, however, so far as an overall appraisal of the United States is concerned, it is more likely that the total resources eventually will prove larger than present estimates than that they will be less. The key question may be the timeliness with which resources are identified, developed and produced.

Conceptually, a resource, whether uranium or other mineral commodity, would initially be in the potential category. Development of additional data and clarification of production techniques and economics is required until the point is reached that specific ore deposits are delineated and understood to a degree that they can be categorized as reserves.

We can expect that there will be a dynamic balance between anticipated markets and prices and the extent to which exploration and reserve delineation will be done. There is no economic incentive for industry to expand reserves, if the additional uranium will not be needed for many years ahead, especially if the long-term market is uncertain. This has been so for uranium. The mining companies are concentrating on markets for the next 5 to 15 years. The utilities and government are concerned with the outlook for the next 30 to 40 years. Conversion of the presently estimated potential resources into ore reserves will take many years and will cost several billion dollars. It would be difficult to economically justify accelerating such an effort to delineate ore reserve levels equal to lifetime requirements of all planned reactors covering some 30-40 years in the future simply to satisfy planners.

Supply assurance through continued timely additions to reserves and maintenance of a resource base adequate to support production demands, coupled with carefully developed information on potential resources, is considered to be adequate and a more realistic and economic approach. The conversion of potential resources to ore reserves and expansion of production facilities can be accomplished when needed as markets expand and production is needed.

Table A.10.2-2 ERDA Uranium Resource Categories

CUTOFF COST	ORE RESERVES	NURE POTENTIAL			ULTIMATE POTENTIAL
		PROBABLE	POSSIBLE	SPECULATIVE	
		(Known Districts-Identified Trends)	(Productive Provinces, in Productive Formations)	(New Provinces or New Formations)	
$8					
$10					
$15					
$30					
HIGHER COST					

DECREASING KNOWLEDGE AND ASSURANCE →

The vertical dimension in Table A.10.2-2 relates to the impact of increasing production costs on resource availability. Higher prices are needed to produce ores of lower quality and those with more difficult mining or milling characteristics. Such reserves, though well delineated, are not available if prices are too low.

The domestic uranium industry has, over most of its lifetime, been concerned with discovery and production of uranium at costs in the $8-$10/lb. range or less. Average prices for uranium deliveries in 1975 are reported to be $10.50 per pound of U_3O_8.[3] In view of the economic acceptability of higher cost uranium in reactors, resource estimates by ERDA in recent years have included resources that would be available at $15 and $30 production cutoff costs. However, because of the lesser experience with $15 and $30 resources, they are not as fully delineated or as well understood as the $10 resources.

At cost levels above $30 per pound, there has been little effort at appraisal of resources or in exploration. Therefore, these resources are poorly known at present and quantitative estimates are not possible (with the exception of the Chattanooga shale to be discussed later). Such resources are known to exist, and efforts are under way to appraise them.

In Table A.10.2-3 are tabulated ERDA estimates of domestic uranium resources following the conceptual arrangement of Table A.10.2-3. These estimates reflect the results of the preliminary phase of the ERDA National Uranium Resource Evaluation (NURE) program. The resources estimates in the preliminary phase of the NURE program totaled 3.7 million tons up to a production cost of $30. Of this 640,000 tons are in the ore reserve category. An additional estimated 140,000 tons is attributed to byproduct material through the year 2000.

In this evaluation program, the nation has been divided into study areas as shown in Figure A.10.2-1. For comparison, the major known uranium areas in the U.S., such as the Colorado Plateau, Wyoming Basins and Texas Gulf Coastal Plain, are shown in Figure A.10.2-3.

The geographic distribution of estimated potential resources is shown in Figure A.10.2-4.

Only limited data are available for much of the country and estimates for these areas will be largely in the speculative category, or unassessed, for some time. The preliminary phase of the NURE program has identified additional areas with geologic characteristics favorable for the occurrence of uranium deposits, but for which data was inadequate for evaluation of potential resources. The location of areas with estimated potential resources and other favorable areas is shown in Figure A.10.2-5. The NURE program will develop considerable additional basic information, in the next several years, which will lead to a more comprehensive, in-depth evaluation of the U.S. long-term resource outlook.

LAND THAT MEETS THE CENSUS OF AGRICULTURE DEFINITION OF A FARM: ANY PLACE UNDER 10 ACRES IF ESTIMATED SALES OF AGRICULTURAL PRODUCTS EXCEED $250 A YEAR, OR ANY PLACE OVER 10 ACRES IF SALES EXCEED $50. PASTURES AND OTHER LAND INCLUDES FARMSTEADS, ROADS, AND WASTELAND ON THE FARM. LAND IN FARMS IS THE PREDOMINANT LAND USE IN THE 48 CONTIGUOUS STATES, OCCUPYING SLIGHTLY OVER 1 BILLION ACRES IN 1969 - MORE THAN 65 PERCENT OF TOTAL LAND AREA.

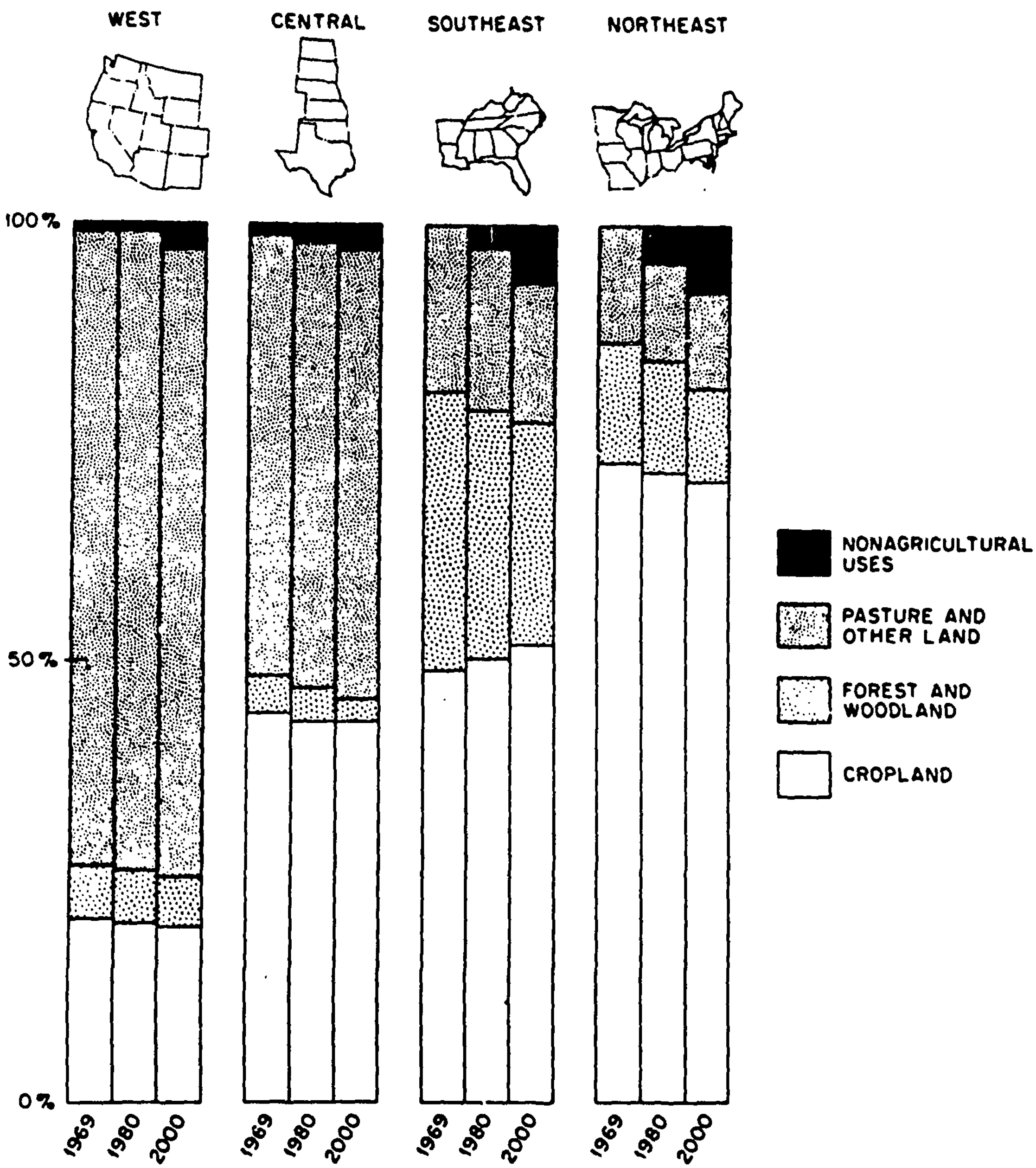


Fig. A.10.2-1. Today's Farmland--How It May Be Used by the Year 2000. Source: U. S. Department of Agriculture, "Our Nation's Land and Water Resources," Economic Research Service, ERS-530, 1973.

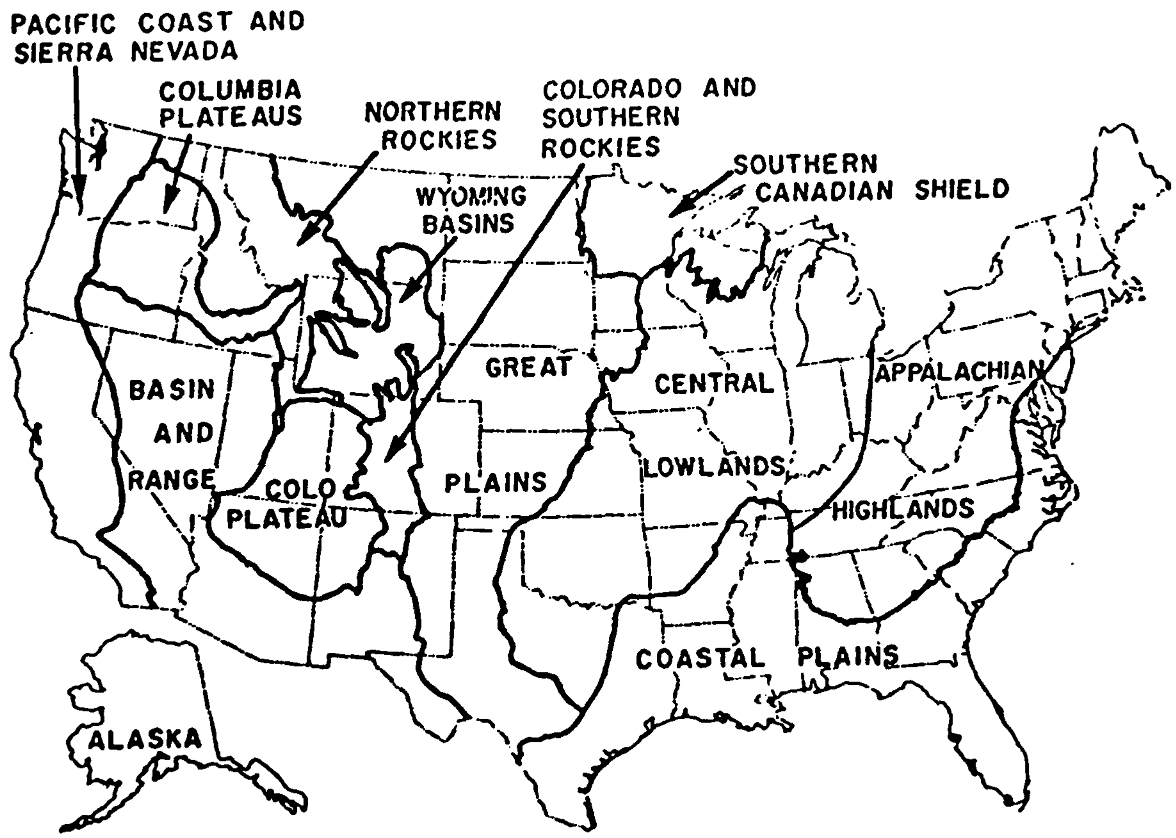


Fig. A.10.2-2. National Uranium Resource Evaluation (NURE) Regions

Fig. A.10.2-3 Principal U.S. Uranium Areas

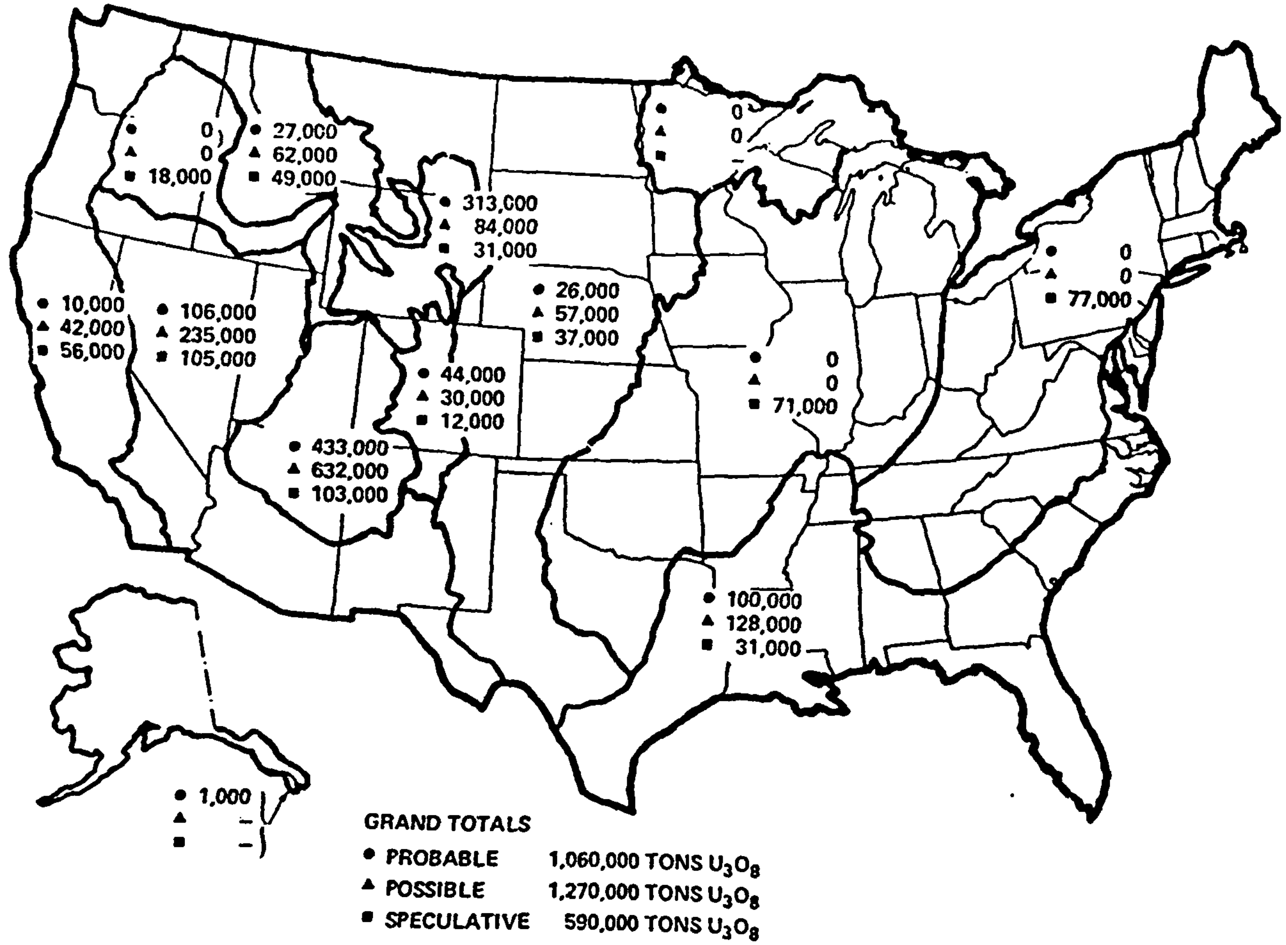


Fig. A.10.2-4 Potential Uranium Resources By Region ($30/lb. U_3O_8)

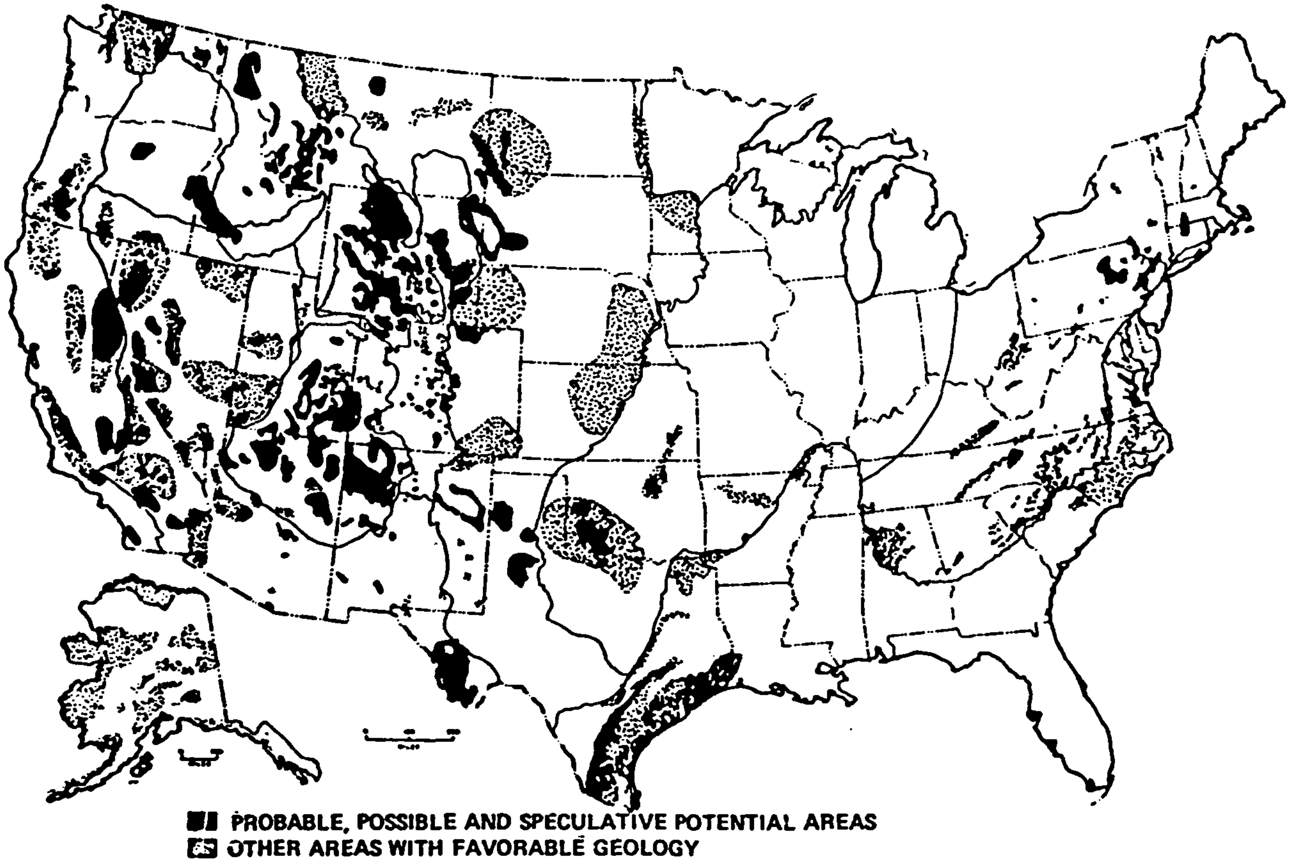


Fig. A.10.2-5 National Uranium Resource Evaluation
Preliminary Potential And Favorable Areas

Table A.10.2-3

U.S. Uranium Resources
Tons U_3O_8

	RESERVES	POTENTIAL PROBABLE	POTENTIAL POSSIBLE	POTENTIAL SPECULATIVE	TOTAL
$10	270,000	440,000	420,000	145,000	1,275,000
$15	430,000	655,000	675,000	290,000	2,050,000
$30	640,000	1,060,000	1,270,000	590,000	3,560,000
	140,000[a]	-	-	-	140,000
	780,000	1,060,000	1,270,000	590,000	3,700,000

[a]Byproduct of phosphate and copper production.

Attainable Production Levels and Reactor Capacity

The domestic industry currently has a production capacity of around 16,000 tons U_3O_8 per year. Plans have been reported to expand capacity to 24,000 tons per year by 1978. Study of attainable production capability from currently estimated $15 U.S. ore reserves and probable potential resources indicates that production levels of 50,000 tons to 60,000 tons U_3O_8 per year can be achieved with agressive resources development and exploitation. While the level may be achievable by use of domestic $15 resources alone, development and utilization of $30 resources would provide added assurance that the levels could be attained and sustained. Considering that some imported uranium will add to supplies, it is considered realistic to plan on the basis that a 60,000 tons per year supply is achievable from currently estimated resources. Such a level could be reached by the early 1990s.

The level of nuclear generating capacity supportable with this amount of uranium, as shown in Figure A.10.2-6, will vary with enrichment tails assay and recycle assumptions. Without recycle of uranium or plutonium and a 0.30% U-235 enrichment tails assay, about 260,000 MWe could be supported. Without recycle, and at 0.20 tails, 310,000 MWe could be supported. With recycle of uranium and plutonium and a 0.20 tails assay, about 520,000 MWe could supported. As shown in Figure A.10.2-6, all the levels of supportable capacity are well above the 237,000 MWe of capacity in operation (40,000 MWe), under construction (88,000 MWe), on order (83,000 MWe), and announced (26,000 MWe) as of January 1, 1976. Thus, presently estimated resources can provide adequate uranium supplies for a sizable expansion to U.S. nuclear generating capacity.

The cumulative lifetime (30 years) uranium requirements for all these reactor cases would be about equal to the 1.8 million tons in $30 ore reserves, byproduct, and probable potential resources. Evaluation of long-term fuel commitments on the basis of ore reserves and probable potential resources is considered a prudent course for planning. The lifetime commitment would be only about half of currently estimated $30 domestic resources, including the possible and speculative categories.

Prospects for Expanding U.S. Supply

The long-range (through the rest of the century and beyond) supply outlook will be largely influenced by the extent to which the present resource position is modified in the decades ahead. There are three prinicpal means by which the supply position can change. First, through the identification of additional resources in the less than $30/lb category; second, through utilization of already identified higher cost resources; and third, through utilization of foreign uranium supplies. These means will be examined separately.

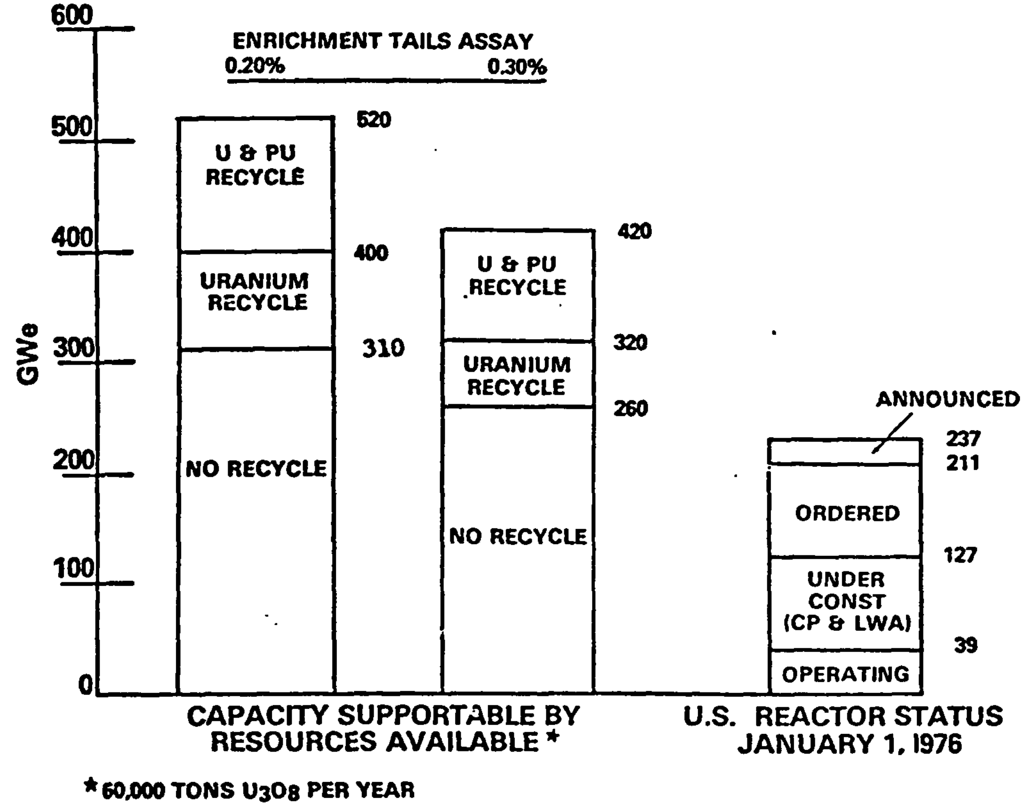


Fig. A.10.2-6 Nuclear Reactor Capacity (GWe)

Domestic Low-Cost Resources

An evaluation of the potential for developing additional domestic low-cost uranium resources beyond those now estimated involves the following considerations:

1. Experience generally has been that mineral resources ultimately prove larger than can be estimated at any time. We are limited by what occurs in nature but also, and perhaps more so, by the degree of our knowledge. Development of information of unknown or poorly explored areas is likely to increase the estimate of resources. As previously noted, there is no complete assessment of the U.S. uranium position. The NURE effort is scheduled to produce a nationwide in-depth assessment in 1981.

   Comparing the U.S. uranium resource position 10 years ago with today's can illustrate the point. In 1966, $10 ore reserves were estimated to be 195,000 tons U_3O_8. Potential resources then estimated, which correspond to the current "probable" potential category plus a portion of the "possible" category, were 325,000 tons U_3O_8. Since then 134,000 tons of U_3O_8 have been produced. The present estimates are 270,000 tons of reserves and 440,000 tons of probable potential. Thus, in the 10 years over 320,00 tons were added to these categories of resources. During the period, the value of the dollar has declined to about 60% of its 1966 value. Since inflation increases costs, moving some material to higher cost categories, the 1976 resource estimates would have been higher measured in 1966 dollars.

2. Expansion of resources will depend on the level of effort expended. Increased exploration activity can be expected to improve the resource position. Exploration success per unit of effort has been less in recent years, but inflation has exaggerated the reduction since increasingly higher grade ores must be found at a given cost of offset inflation. In addition, there has been a trend toward deeper drilling, which increases the effort required. Exploration results in 1975 show improved discovery rates.

   Industry investment activities will be influenced by nuclear power growth and acceptance, uranium demand, and price movements. As is the case of other raw materials commodities, increasing demands and higher prices should lead to increased efforts by industry to expand supplies.

3. Known U.S. uranium resources are in a few comparatively small areas as shown in Figure A.10.2-3. The comparatively small geographic areas of the mining districts within these areas suggests that significant undiscovered districts can be overlooked.

4. Domestic uranium resources in sandstone deposits make-up over 95% of known U.S. low-cost resources. The bulk of resources in other parts of the world are in other types of geologic environments. A listing of significant types of uranium deposits is shown in Table A.10.2-5. The possibility exists for identification of additional types of deposits in the U.S.

Industry Exploration Activity

The major responsibility for discovering new uranium deposits needed in the years ahead is with private industry. The footage drilled in search for uranium deposits in the U.S. for the last several years is shown in Figure A.10.2-7. In the period 1967-69, a sharp increase in exploration occurred. Exploration decreased in the early 1970s due to softening in the uranium market as a consequence of the slippage in uranium demands. In 1973, utilities contracted for 52,000 tons of U_3O_8,[2] a far greater procurement effort than had been previously seen, firming prices and rekindling exploration interest. As a result, exploration began to increase again.

As shown in Figure A.10.2-7 expenditures for land acquisition, drilling and related activities reached a peak of about $59 million in 1969, dropped to $32 million in 1972 but increased to an all time high of $122 million in 1975. Plans to expend $156 million in 1976 and $168 million in 1977 have been reported to ERDA. Although expenditures are increasing, the footage drilled per dollar of expenditure has been decreasing because of higher costs and a trend toward deeper drilling.

The results of drilling are shown at the bottom of Figure A.10.2-7 in terms of annual additions to ore reserves. It should be noted that inflation during this period has been high, therefore, the discovery rate measured in terms of $8 reserves added in 1975 is not directly comparable to those added in 1969 and 1970. The 1969 $8 reserves are comparable in 1975 to reserves at a cost of around $15 per pound. The additions of $10, $15, and $30 reserves in the 1972-1975 period are also shown in Figure A.10.2-7. The additions to $30 reserves increased substantially in 1975 even though not all the data from industry were available and a number of additional deposits are known to have been discovered.

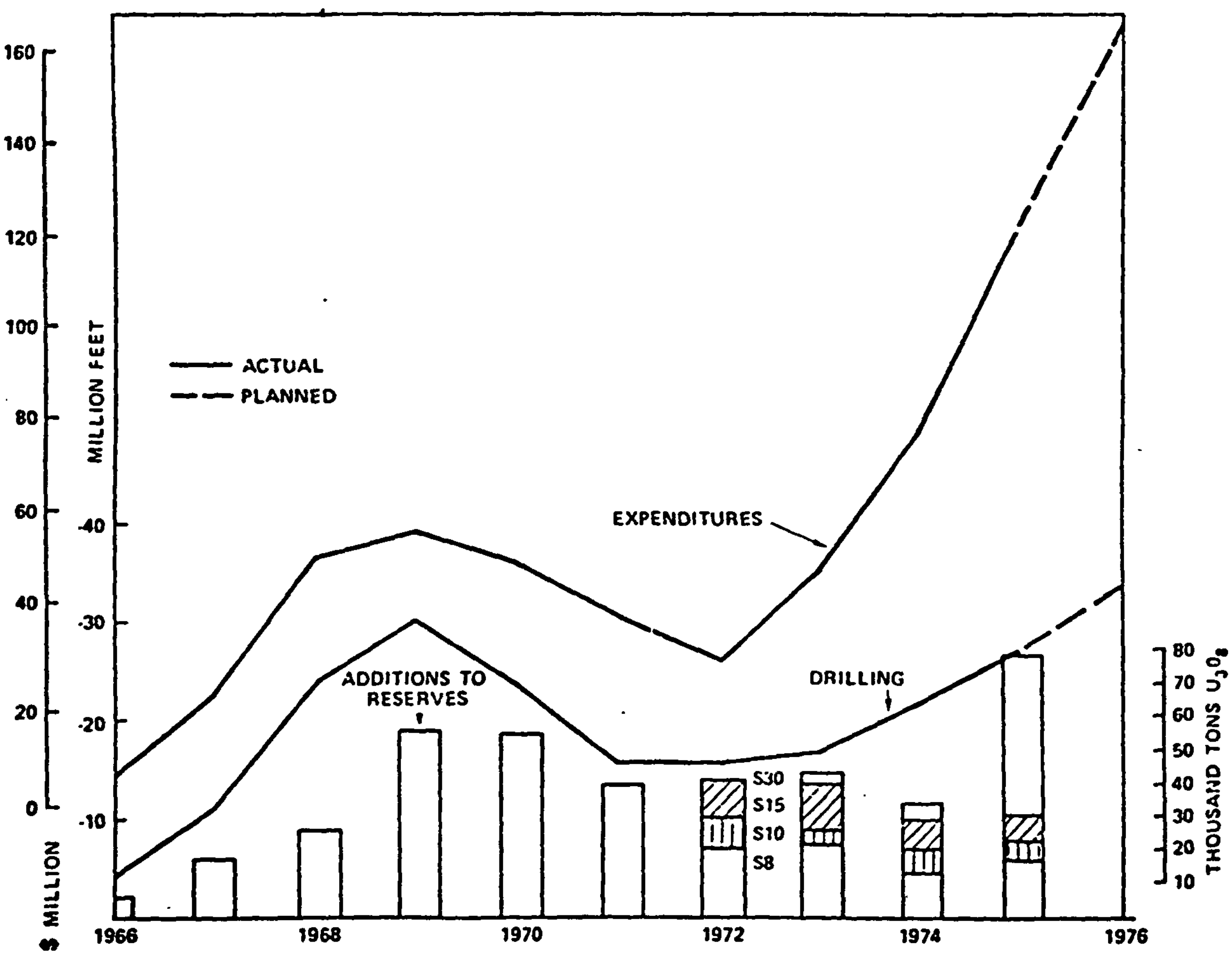


Fig. A.10.2-7 U.S. Exploration Activity and Plans

Expenditures for uranium exploration have not been large in comparison to the expenditures in other phases of nuclear power. For example, the cost of a typical large reactor alone (over $800 million) will be substantially larger than the total of $520 million spent in uranium exploration (including land acquisitions, drilling and related activities) in the entire country over the period 1966 through 1975.

Technology Development

Improved technology has in the past provided a means for expanding available resources of minerals. There have been a number of developments in uranium that are improving the supply situation and others are likely to be developed in the years ahead. Of current interest is the use of in situ leaching methods where the extraction of the uranium is accomplished by pumping leach solutions down drill holes, through the ore zone, and back to the surface for treatment. Such plants are operating in Texas and others are planned.

An additional development is the improved process for recovery of uranium from phosphoric acid. A plant is starting operation in Florida, and several others are planned. If all the phosphoric acid currently produced in the large plants in Florida were treated, about 3,000 tons U_3O_8 per year could be recovered. Production may reach this level by the early 1980s, and future increases will follow as phosphoric acid production expands.

Government Uranium Resource Activities

In view of the need to understand better the long-range prospects for expanded domestic uranium supply for reactor development strategy and planning and to assure adequate uranium supplies to fuel nuclear power growth, the ERDA is carrying out programs to assess more completely domestic resources and to improve technology for discovery, assessment, and production of these resources. The basic elements in the ERDA resource program are illustrated in Figure A.10.2-8.

Starting in the upper left hand corner of the diagram, knowledge about known uranium occurrences will be augmented by gathering and generating new data by use of surface, aerial, subsurface and remote sensing techniques. This will allow improved estimates in known areas and identification of other areas where known types and postulated new types of deposits may exist. This will increase knowledge about uranium occurrences in the United States, improve estimates of the resource position, and expand and solidify the base of nuclear fuel supplies. Information is routinely made available to industry for development of their exploration and mining programs. Industry efforts will generate additional data which will also be used by ERDA in continuing resource studies.

An important part of this strategy is research and development to improve the technology involved in uranium discovery, assessment, mining and milling. ERDA uranium raw materials budgets to carry out this program are increasing. In FY 1976, expenditures will be around $14 million. In fiscal year 1977 $27 million has been requested.

Two activities underway to generate new data systematically are the aerial radiometric reconnaissance program and the national hydrogeochemical survey. Features of the airborne program are highlighted in Table A.10.2-5. This program will involve some 870,000 line miles of aerial surveys flown on an average line spacing of five miles utilizing gamma ray spectrometric techniques. Data generated are being made publicly available upon the completion of individual projects.

The hydrogeochemical survey features are listed in Table A.10.2-6. This will be a systematic national survey of the uranium and associated trace element content of surface and underground waters, being carried out by ERDA laboratories. Data generated will provide a means of identification of areas of favorability particularly when coupled with other available data.

The ERDA programs involve a continuing review of the uranium resource situation, analysis of the activities and success of industry and their relation to the desirable resource levels needed in the years ahead to assure adequate uranium supplies to meet the country's needs. The program is geared to providing information to government and industry so that sound decisions can be made on energy policy.

High-Cost Resources

As previously noted, an alternative to identification of additional low-cost resources is the utilization of higher cost resources. The highest cutoff cost category included in ERDA resources, in Table 10.2-3 is $30/lb. U_3O_8. This level was selected a few years ago as an upper range of what might be of interest for utilization in light water reactors over the next decade or more.

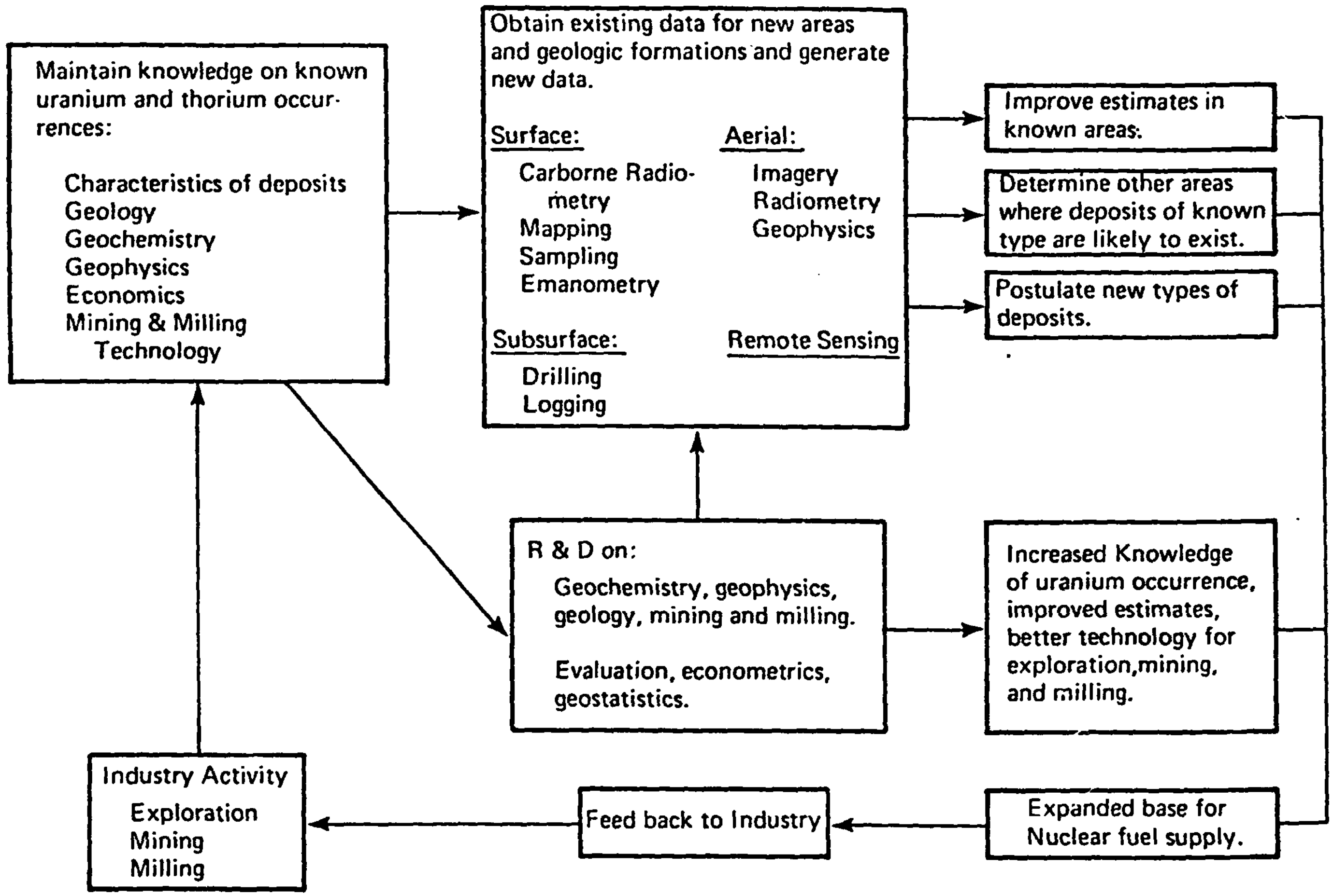


Fig. A.10.2-8 Uranium Resource Strategy

Table A.10.2-4

Uranium Deposits

Type	Average Deposit Grades PPM	Size Range	United States	Foreign
Massive Vein-like	3,000-25,000	10,000-250,000	?	Saskatchewan, Canada; Alligator River, Australia
Vein	1,000-25,000	1,000-40,000	Colorado Washington	Great Bear Lake, Canada; Shinkolobwe, Zaire; France
Sandstone	500-5,000	100-50,000	Colorado Plateau Wyoming, Texas	Niger, Gagon Argentine
Calcrete	1,000-3,000	1,000-50,000	?	Yeelirrie, Australia
Quartz-Pebble Conglomerate	200-1,500	10,000-200,000	?	Elliot Lake, Canada; Witwatersrand, South Africa
Alaskite	300-400	75,000-150,000	?	Rossing, South West Africa
Syenite	100-400	10,000-50,000	?	Illimaussaq, Greenland
Phosphate Rock	60-200	0.5-2.0 million	Florida, Idaho	North Africa
Shale	50-300	1-5 million	S.E. United States	Ranstad, Sweden
Granite	10-200	1-10 million	New Hampshire Colorado	Brazil
Sea Water	.003	4 billion		

Table A.10.2-5

ERDA Aerial Radiometric Reconnaissance Program

GOAL - Complete airborne radiometric survey of U.S., including Alaska, on wide-spaced flight lines, by 1-1-80, to aid in identifying faborable areas.

PROGRAM--Minimum total flight lines miles--conterminous U.S., 760,000; Alaska, 110,000

FLIGHT LINE SPACING--1-12 miles: Average 5 miles

ALTITUDE--200-800 feet above ground level, optimum 400 feet

SYSTEMS--Computerized high-sensitivity gamma-ray spectrometric and magnetic detectors, mounted in fixed-wing and rotary-wing aircraft operated by private firms

OUTPUT--Radiometric equivalent of uranium, thorium, and potassium, and magnetic characteristics of enclosing rock, statistically evaluated by geologic units

DATA HANDLING

PUBLICATION--Open file upon completion of each survey

SUMMARIZED DATA BANK--Los Alamos scientific laboratory

TENTATIVE SCHEDULE

FISCAL YEAR	LINE MILES
1974-76	150,000
1977	147,000
1978	362,000
1979	210,000
	870,000

Table A.10.2-6

Hydrogeochemical and Stream Sediment Reconnaissance Program

GOAL - A systematic determination of the distribution of uranium and associated trace elements in surface and underground waters and in stream sediments in the U.S., including Alaska, to identify areas favorable for uranium mineral occurrence.

PARTICIPANTS: National laboratories; universities; State agencies; U.S.G.S.; E.P.A.

OPERATING PARAMETERS:

SAMPLE SPACING - 10 sq. mi. (wide area) - 1/2 sq. mi. (detailed) depending on geologic homogeneity of area.

ANALYSIS - Field concentration of elements from water; measurement of conductivity and pH; determination of specific elements.

DATA TREATMENT - Statistical analysis.

DATA INTERPRETATION - Relate anomaly data to geologic environments.

OUTPUT - Areas of favorability; open-filing of maps and data; national data bank.

TENTATIVE SCHEDULE:

FISCAL YEAR - 1975 -- Literature search and limited R&D.
1976 -- Pilot studies; statistical methods development; staffing.
1977-1979 -- Large-scale surface and subsurface sampling; data analysis, interpretation, and reporting.

The increased price of oil and coal in the last few years has increased the cost of uranium economically acceptable in light water reactors. This results from the relative insensitivity of nuclear electric power costs to increase in uranium prices. The cost of fuel is only a fraction of the cost of power from a nuclear plant. In turn, the cost of natural uranium is only a fraction of the fuel cost; enrichment, fabrication, reprocessing and carrying charges making up the balance. As a result, large increases in uranium prices result in comparatively small increases in power costs. This is an important advantage for nuclear power and provides additional assurance that uranium supplies will be adequate.

Knowledge of U. S. resources in the above $30 category is meager largely because of the lack of past economic interest. There has been virtually no industry activity to search for or develop such resources. Prospects for discovery of higher cost resources in the U. S., including those types of deposits known elsewhere in the world, such as those listed in Table A.10.2-4, are considered promising at this stage of U. S. exploration. The magnitude of such resources is, however, uncertain. The ERDA assessment program will also consider these types of resources.

There are, in addition, large very low grade deposits which have been studied in some detail in the past. These include shales, granites and phosphates.

The Chattanooga shale in Tennessee is of particular interest because of its large size. This deposit was extensively drilled, sampled, and studied in the 1950s. The higher grade part of the Chattanooga shale has a uranium content of about 60-80 ppm. It contains in excess of 5,000,000 tons of U_3O_8 that may be producible at a cost of $100 or more per pound of U_3O_8. While additional work developing production technology will be needed, it is of interest that plans have been announced to exploit a similar but considerably higher grade deposit (300 ppm) in Sweden. The mining and milling technology has been developed and the deposits are economic. A plant of 20,000 tons of ore per day capacity is planned.

Similar production technology could be used for the Chattanooga shale at higher prices. As an example, if shale were mined to fuel a 1,150 MWe reactor, assuming recycle of uranium but not plutonium and a 0.3% enrichment tail, about 12,600 tons of shale would have to be processed each day, or with uranium and plutonium recycle and 0.20% enrichment tails, about 8,500 tons per day. An average of about 11,300 tons of coal would need to be burned each day if 8,700 Btu/lb. coal were used.

Utilization of the very low-grade resources such as Chattanooga shale would, of course, involve mining and processing very much larger quantities of ore than are currently mined to produce the same amount of uranium. From an environmental as well as from an economic point of view, identification and utilization of additional higher grade ores would be preferable. However, the shales are available if their use should become necessary.

<u>Foreign Uranium</u>

In October 1974, the AEC announced its plan for allowing enrichment of foreign uranium intended for use in domestic reactors.[5] The plan would allow 10% of an enrichment customer's feed to be of foreign origin in 1977. The allowable percentage would increase in subsequent years as shown in Table A.10.2-7. In ~~1984~~, there would be no restriction on use of foreign uranium. Foreign uranium, therefore, will be an additional source of uranium to meet domestic needs. During 1975, 1,100 tons of foreign uranium were delivered to U. S. buyers and 44,000 tons of foreign uranium were under contract at the beginning of 1976 for delivery to U. S. customers through 1990.[9]

Resources of foreign countries, up to the $30/lb. category, are tabulated in Table A.10.2-8. The "reasonably assured" category corresponds closely to the domestic ore reserve category and the "estimated additional" category corresponds to the domestic probable potential. As will be noted in the table, foreign resources are largely contained in five countries: Australia, Canada, South Africa, South West Africa and Sweden. All except Sweden and to some extent Canada will be essentially uranium exporting countries as their own needs will be comparatively small. The Swedish uranium is contained in low-grade shale as previously noted and is not likely to be available for export in significant quantities.

Foreign uranium demand, principally for the countries of Western Europe and Japan, is projected to grow even more rapidly than in the United States. ERDA projections indicate cumulative non-Communist foreign requirements through the year 2000 could be 2,100,000 to 2,800,000 tons of U_3O_8 with annual demand in 1980 of 45,000 tons and in 1990 of 90,000 to 120,000 tons (at 0.3 tails and with recycle).

Table A.10.2-7 Allowable Foreign Uranium Enrichment Feed
(Domestic End Use)

Tons U_3O_8

Calendar Years	Schedule of Percentage of Feed Allowed to be Foreign
1974	0
1975	0
1976	0
1977	10%
1978	15%
1979	20%
1980	30%
1981	40%
1982	60%
1983	80%
1984	No Restriction

Table A.10.2-8 Foreign Resources
Thousand Tons U_3O_8

	Reasonably Assured	Estimated Additional
	$15/lb U_3O_8	
Autralia	430	104
S & SW Africa	242	8
Canada	189	394
Niger	52	26
France	48	33
Algeria	36	--
Gabon	26	6
Spain	13	11
Argentina	12	20
Other	56[a]	26
Total (Rounded)	1,100	630
	$30/lb U_3O_8	
Australia	430	104
Sweden	390	--
S & SW Africa	359	96
Canada	225	887
France	71	52
Niger	65	39
Algeria	36	--
Spain	30	55
Argentina	27	50
Other	150[b]	110
Total (Rounded)	1,780	1,390

[a]Includes Brazil, Central African Republic, Germany, India, Japan, Mexico, Portugal, Turkey, Yugoslavia and Zaire.

[b]Includes, in addition to [a], Denmark, Finland, Italy, Korea and the United Kingdom.

Existing foreign production capacity is about 20,000 tons per year. Considering the magnitude of known foreign uranium resources and production expansion plans, foreign capability could be increased to over 50,000 tons per year in the early 1980s. Although foreign resources are large, there are limitations on attainable production levels from Canadian and South African resources, and continued growth of foreign production capability will require enlargement of the foreign resource base or use of higher cost resources.

The prospects for expansion of foreign uranium supplies from a geologic point of view are good. The experience in Australia where large new resources were identified in just a few years effort is an example. The absence of substantial known resources in South America and in many African and Asiatic countries as seen in Figure A.10.2-9 emphasizes the lack of exploration effort that has been done in these areas. There are, however, political limitations on the degree to which exploration will be accomplished in such places and the degree to which uranium supplies can be exported. Nationalistic policies towards resources has made access to supplies difficult in recent years. The improvement of world prices and markets should assist in opening up new areas to uranium exploration. However, since uranium demand will be low in many countries, material should be available in the world market place in time to make a useful contribution to U. S. needs.

Fuel Cycle Practice

There are a number of management and technical decisions relating to nuclear power utilization which will have significant impact on uranium demand. An important factor relating to operation of light water reactors involves the selection of tails assay at the enrichment plants. For example, enrichment with a 0.2% tails assay instead of the 0.3% reduces uranium demand by about 20%. Recycle of uranium and plutonium would allow more efficient use of fuel and reduce demands for newly mined uranium. Successful development of a commercial breeder reactor would in time reduce growth in uranium demand. This reactor may not require any natural uranium for centuries, being able to use the several hundred thousand tons of depleted uranium which will be accumulating in the next few decades at enrichment plants. In time additional plutonium could also be available from breeders in sufficient quantities that plutonium could become the primary fuel in water reactors.

Finding made by the Federal Energy Resources Council

The subject of uranium availability has been considered by the Federal Energy Resources Council which included participation by the Council on Environmental Quality, the Department of Commerce, Department of Interior (U. S. Geological Survey), Environmental Protection Agency, ERDA, and FEA. A report issued by the Council, "Reserves, Resources and Production," June 15, 1976, states "available data indicates that there are sufficient economically recoverable uranium resources on which to base an expanding national program. The adequacy of uranium to provide fuel (over their 30-year lifetime) for all existing plants and additional reactors which may be placed into service by 1990 is a reasonable planning assumption."

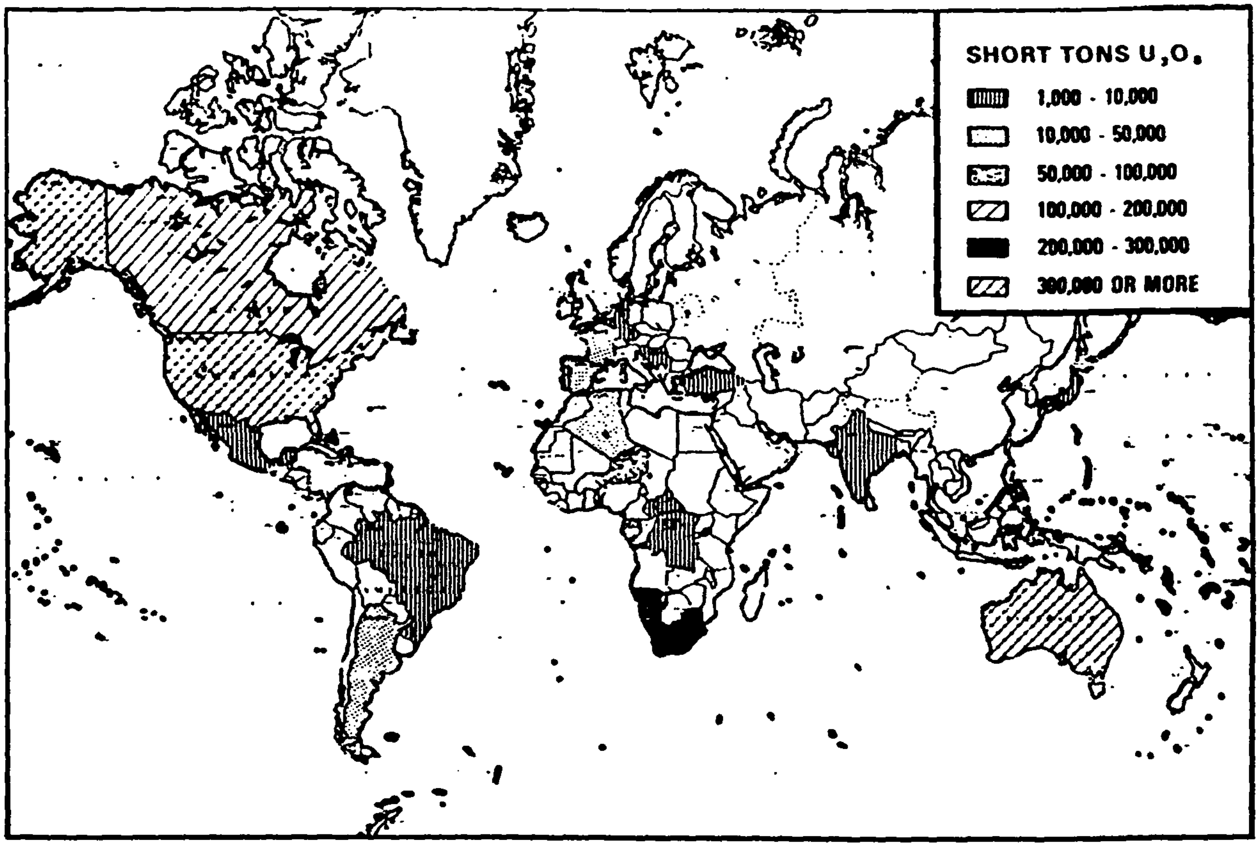
Conclusion

In conclusion, ERDA assessment of uranium resources indicates that currently estimated U. S. resources would be adequate to allow fueling of substantially more nuclear power plants than all those now operable, under construction, on order and announced, without recycle of uranium or plutonium and with high enrichment tails assays. Lower tails assays and recycle could significantly increase the supportable capacity. Further expansion of U. S. uranium supplies is possible by discovery of new low-cost resources, utilization of higher cost resources or importation of foreign uranium. ERDA programs are designed to improve understanding of current resources and to aid in identification of new resources, seeking to assure that uranium supplies will be available when needed.

Prices have increased to levels that make exploration and production economically attractive. Industry exploration and development activities are increasing. Foreign uranium supplies will be available to augment domestic resources. There is a high probability that additional intermediate cost resources can also be identified and there are known domestic high cost resources which could be used if needed.

A.10.3 SUMMARY OF BENEFIT-COST

As the result of this second review of potential environmental, economic, and social impacts, the staff has been able to forecast more accurately the effects of the plant's operation. No new information has been acquired that would alter the staff's previous position related to the overall balancing of the benefits of this plant versus the environmental costs. Consequently, it is the staff's belief that this plant can be operated with only minimal environmental impacts. The staff finds that the primary benefits of minimizing system production costs and/or the addition to base-load generating capacity greatly outweigh the environmental, social and economic costs.



*EXCLUDES PEOPLES REPUBLIC OF CHINA, USSR AND ASSOCIATED STATES OF EASTERN EUROPE

Fig. A.10.2-9 World Uranium Resources Reasonably Assured Reserves @ $15 Per Pound U_3O_8

REFERENCES FOR SECTION A.10

A.10.1 "Nuclear Fuel Supply," U.S. Atomic Energy Commission, Washington, D.C., GPO, May 1973.

A.10.2 "Uranium Industry Seminar," USAEC, Grand Junction, Colorado Office, GJO-108(74), October 1974.

A.10-3 "Survey of U.S. Uranium Marketing Activity," ERDA 76-46, April 1976.

A.10-4 "Survey of U.S. Uranium Marketing Activity," USAEC. WASH-1196(74), April 1974.

A.10-5 USAEC Press Release No. T-517, October 25, 1974.

NUREG-0134
(Errata)

ERRATA

TO ADDENDUM TO THE FINAL ENVIRONMENTAL STATEMENT

RELATED TO THE OPERATION OF

NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2

DOCKET NOS.: 50-338 AND 50-339

ERRATA TO ADDENDUM TO THE FINAL ENVIRONMENTAL STATEMENT RELATED TO THE OPERATION OF NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2

1. On page A-i, paragraph 4.(A), line 2 replace the words "a significant adverse": with "an".

2. On page A.3-4, Table A.3.2-3 in the title of the table change "Liquid" to "Gaseous".

3. On page A.5-5, Section A.5.3, paragraph 5, line 1 replace "these people" with "VEPCO".

4. On page A.5-1 replace section A.5.2.1 with this revision.

A.5.2.1 Environmental Effects of the Uranium Fuel Cycle

On March 14, 1977, the Commission presented in the FEDERAL REGISTER (42 FR 13803) an interim rule regarding the environmental considerations of the uranium fuel cycle. It is effective through September 13, 1978 and revises Table S-3 of 10 CFR Part 51. Final rulemaking proceedings will be conducted so as to allow for additional public comment and specific details with respect to time, place, and format of such proceedings shall be presented in a subsequent FEDERAL REGISTER notice.

The interim rule reflects new and updated information relative to reprocessing of spent fuel and radioactive waste management as discussed in NUREG-0116, Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle and NUREG-0216 which presents staff responses to comments on NUREG-0116. The rule also considers other environmental factors of the uranium fuel cycle including mining and milling, isotopic enrichment, fuel fabrication, and management of low and high level wastes. These are described in the AEC report WASH 1248, Environmental Survey of the Uranium Fuel Cycle.

Specific categories of natural resource use are included in Table S-3 of the interim rule and are reproduced as Table A.5.2-1. These categories relate to land use, water consumption and thermal effluents, electrical energy use, fossil fuel combustion, chemical and radioactive effluents, burial of transuranic and high/low level wastes, and radiation doses from transportation and occupational exposures. The contributions in Table A.5.2-1 for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle which resulted in the greater impact was used.

In accordance with the interim rule, the assessment of the environmental impacts of the fuel cycle as related to the operation of the North Anna Power Station, Unit Nos. 1 and 2 is based upon the values given in Table A.5.2-1. For the sake of consistency, the analyses of fuel cycle impacts have been based on a comparison of each North Anna Unit with one model 1000 MWe LWR. Our conclusions regarding the effects of these impacts would not be altered if the analysis was based on the net 980 MWe electrical power capacity of each North Anna Unit.

The total annual land requirements for the fuel cycle supporting a model 1000 MWe LWR is approximately 100 acres (94 acres temporarily committed and 7.1 acres permanently committed). Over the 30-year operating life of Units 1 and 2, this amounts to about 4200 acres,* which is less than one-fourth of the total land commitment for the entire North Anna Station.

Considering common classes of land use in the United States, the fuel cycle land requirements related to the operation of the North Anna Power Station, Unit Nos. 1 and 2 does not constitute a significant impact.

The annual total water usage and thermal effluents associated with fuel cycle operations to support a 1000 MWe LWR are given in Table A.5.2-1. Since the North Anna Power Station, Units Nos. 1 and 2 will utilize a once-thru cooling system, they can be compared to model 1000 MWe plants with once-thru cooling referenced in Table A.5.2-1. The water use associated

*The temporarily committed land at the reprocessing plant is not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years. (See footnote "2" to Table A.5.2-1).

with fuel cycle operations of each North Anna Unit is less than 4% of the water consumed in the operation of a model 1000 MWe plant with once-thru cooling. Similarly, the quantity of heat discharged in fuel cycle operations associated with each North Anna Unit is less than 4% of the thermal output from a model 1000 MWe LWR. The staff finds these quantities of indirect water consumption and thermal loadings to be acceptable relative to the use of water and thermal discharges associated with operation of North Anna Power Station, Unit Nos. 1 and 2.

Electrical energy and process heat are required during various phases of the fuel cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. As indicated in Table A.5.2-1, electrical energy associated with the fuel cycle represents less than 5% of the annual electrical power production of a typical 1000 MWe nuclear plant. Process heat is primarily generated by the combustion of natural gas. As noted in Table A.5.2-1, this gas consumption if used to generate electricity would be less than 0.3% of the electrical output from a 1000 MWE plant. The staff finds therefore, that both the direct and indirect consumption of electrical energy for fuel cycle operations are small and acceptable relative to the net power production of the power plant.

The quantities of chemical gaseous and particulate effluents associated with fuel cycle processes are given in Table A.5.2-1. The principal species are SO_x, NO_x and particulates. Based upon data in a CEQ Report,* the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison to the same emissions from the stationary fuel combustion and transportation sectors in the U.S., i.e., approximately .02% of the annual (1974 base) national releases for each of these species. The staff believes such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel cycle processes are related to fuel enrichment, fabrication and reprocessing operations and may be released to receiving waters. These effluents are usually present in dilute concentrations such that only small amounts of dilution water are required to reach levels of concentration that are within established standards. Table A.5.2-1 specifies the flow of dilution water required for specific constituents. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel cycle operations will be subject to requirements and limitations set forth in an NPDES permit issued by an appropriate State or Federal regulatory agency.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in significant quantities to create an impact upon the environment.

Radioactive effluents released to the environment estimated to result from reprocessing and waste management activities and other phases of the fuel cycle process are set forth in Table A.5.2-1. It is estimated that the overall gaseous dose commitment to the U.S. population from fuel cycle operations for a 1000 MWe reference reactor would be approximately 370 man-rem per year. This dose is less than 0.002% of the average natural background dose of approximately 20,000,000 man-rem to the U.S. population. Based on Table A.5.2-1 values, the additional dose commitment to the U.S. population from radioactive liquid effluents due to these fuel cycle operations would be approximately 100 man-rem per year for a 1000 MWe reference reactor. Thus, the overall estimated annual involuntary dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle for a 1000 MWe LWR is approximately 470 man-rem. This is higher than the small involuntary annual dose to the public from operating North Anna Station, Units Nos. 1 and 2. The occupational dose from the fuel cycle is 22.6 man-rem per reference reactor year. This represents approximately 5% of the occupational dose associated with operation and maintenance of each unit of North Anna Power Station.

The quantities of buried radioactive material (including low level, high level and transuranic wastes) are specified in Table A.5.2-1. For low level wastes, which are buried at land burial facilities, the Commission notes in Table S-3 of 10 CFR 51.20 that there will be no significant effluent to the environment. For high level and transuranic wastes, the Commission notes that these are to be buried at a Federal Repository and, in accordance with Table S-3 of 10 CFR 51.20, no release to the environment is associated with such disposal. NUREG-0116 which provides background and context for the new values established by the Commission, indicates that these buried wastes, which are placed in the geosphere, are not released to the biosphere and no radiological environmental impact is anticipated from them.

*"The Seventh Annual Report of the Council on Environmental Quality," September 1976, Figures 11-27 and 11-38, pp. 238-239.

The transportation dose to workers and the public is specified in Table A.5.2-1. This dose is small and is not considered significant in comparison to the natural background dose.

The use of a fuel cycle entailing no recycle (neither plutonium nor uranium) would not affect the discussion above, since as described in footnote 1 of Table A.5.2-1, the Commission has considered such a cycle in developing the values given in Table A.5.2-1 with respect to reprocessing, waste management, and transportation of wastes.*

5. On page A.5-2 and A.5-3, replace Table A.5.2-1 with the enclosed revised Table A.5.2-1.

6. On page A.5-6, Table A.5.2-3, in the column entitled "Calculated Unit Nos. 3 and 4", Row 6, replace "0.41 mrem/yr/unit" with "0.041 mrem/yr/unit."

7. Insert the following paragraph before the existing paragraph in A.10.3.

The environmental costs associated with the uranium fuel cycle are summarized in Table A.5.2-1, and described in Section A.5.2.1. Their contribution is sufficiently small so that when they are superimposed upon the other assessed environmental impacts associated with the North Anna Power Station, Unit Nos. 1 and 2, the overall environmental impacts are not appreciably changed. Taking the impacts into account, the staff has concluded that the overall benefit-cost balance is not significantly affected.

*As noted in Table A.5.2-1 the entry for Radon-222 excludes the contributions from mining. Footnote 5 to Table A.5.2-1 indicates a maximum release of about 4800 Ci of Radon-222 when contributions from mining are considered. This in turn, would increase the estimated dose commitment for the total fuel cycle by some 600 man-rem per reference reactor year, maximized for the no recycle case. Although this is larger than the dose commitment due to other elements of the fuel cycle, it is still small compared to the natural background exposure level of some 20,000,000 man-rem per year.

Table A.5.2-1. Summary of environmental considerations for uranium fuel cycle[1]

[Normalized to model LWR annual fuel requirement (WASH 1248) or reference reactor year (NUREG-0116)]

Natural resource use	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Land (acres):		
Temporarily committed[2]	94	
Undisturbed area	73	
Disturbed area	22	Equivalent to 110 MWe coal fired powerplant
Permanently committed	7.1	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal fired powerplant
Water (millions of gallons):		
Discharged to air	159	=2 pct of model 1,000 MWe LWR with cooling tower
Discharged to water bodies	11,090	
Discharged to ground	124	
Total	11,373	4 pct of model 1,000 MWe LWR with once through cooling
Fossil fuel:		
Electrical energy (thousands of megawatt hours)	321	5 pct of model 1,000 MWe LWR output
Equivalent coal (thousands of MT)	117	Equivalent to the consumption of a 45 MWe coal fired powerplant
Natural gas (millions of scf)	124	<0.3 pct of model 1,000 MWe energy output
Effluents—chemical (MT):		
Gases (including entrainment):[3]		
SO_x	4,400	
NO_x[4]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases:		
F	0.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards—below level that has effects on human health.
HCl	0.014	
Liquids:		
SO_4	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are:
NO_3	25.8	NH_3—600 ft^3/s
Fluoride	12.9	NO_3—20 ft^3/s
Ca^{++}	5.4	Fluoride—70 ft^3/s
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	0.4	
Tailings solutions (thousands of MT)	240	From mills only—no significant effluents to environment
Solids	91,000	Principally from mills—no significant effluents to environment
Effluents—radiological (curies):		
Gases (including entrainment):[5]		
Rn-222	74.5	Principally from milling operations and excludes contributions from mining
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	0.14	Principally from fuel reprocessing plants
I-129	1.3	
I-131	0.83	
Fission products and transuranics	0.203	
Liquids:[6]		
Uranium and daughters	2.1	Principally from milling—included in tailings liquor and returned to ground—no effluents; therefore, no effect on environment.
Ra-226	.0034	From UF_6 production
Th-230	.0015	
Th-234	.01	From fuel fabrication plants—concentration 10 pct of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9,100 Ci comes from low-level reactor wastes and 1,500 Ci comes from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. ~60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^7	Buried at Federal repository
Effluents—thermal (billions of British thermal units)	3,462	<4 pct of model 1,000 MWe LWR.
Transportation (person-rem): Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management.

[1] Data supporting this table are given in the "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); and the "Discussion of Comments Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248). The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the 2 fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in table S-4 of sec. 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of table S-3A of WASH-1248.

[2] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services 1 reactor for 1 yr or 57 reactors for 30 yr.

[3] Estimated effluents based upon combustion of equivalent coal for power generation.

[4] 1.2 pct from natural gas use and process.

[5] Gaseous effluents from waste management contribute about 9 person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year for the uranium only recycle option. This contribution for the no recycle option is 170 person-rem. For comparison, all radiological gaseous effluents from fuel cycle operations contribute about 370 person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year. This dose is <0.002 pct of the average natural background radiation dose to this population. Fuel reprocessing contributes about 330 person-rem (total body) of the total of 370 person-rem to offsite U.S. population. Person-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total person-rem dose in each case would be 1 person-rem. The dose to the offsite U.S. population due to average natural background radiation is about 2×10^7 person-rem per year. The Commission's final environmental statement on use of mixed-oxide fuel in LWR's (NUREG-0002) indicates a maximum release of about 4000 Ci of Rn-222 when contributions from mining are included. NUREG-0002 also indicates that mining contributes about 500 person-rem (total body) and that milling contributes about 100 person-rem (total body) of a total of about 610 person-rem (total body) to offsite U.S. population per annual fuel requirement.

[6] Liquid radiological effluents from reprocessing and waste management activities in the fuel cycle contribute 1.4×10^{-4} person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year. For comparison all radiological liquid effluents from fuel cycle operations contribute about 180 person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year. This dose is <0.0008 pct of the average natural background radiation dose to this population.