UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Andrew C. Goodhope, Chairman
Dr. A. Dixon Callihan
Dr. Richard F. Cole

In the Matter of:	
BOSTON EDISON COMPANY ET AL.	Docket No. 50-471
(Pilgrim Nuclear Power Station, Unit 2)	February 2, 1981

PARTIAL INITIAL DECISION
FINDINGS OF FACT AND CONCLUSIONS OF LAW
ON ALL MATTERS EXCEPT EMERGENCY PLANNING
AND TMI-2 RELATED ISSUES

Appearances

For the Applicants
George H. Lewald, Esq., Ropes and Gray,
225 Franklin Street, Boston, Mass.;
Dale G. Stoodley, Esq., 800 Boylston Street,
Boston, Mass.; and Robert H. Culp, Esq.,
Lowenstein, Newman, Reis, Axelrad and Toll,
1025 Connecticut Avenue, N.W., Washington, D.C.

For the NRC Regulatory Staff
Barry H. Smith, Esq., Marcia E. Mulkey, Esq.,
Lawrence J. Chandler, Esq., Geoffrey P. Gitner, Esq.,
Richard Goddard, Esq., Office of the Executive
Legal Director, U.S. Nuclear Regulatory Commission

For the Intervenor, Massachusetts Wildlife
Federation
Henry Herrman, Esq., 151 Tremont Street,
Boston, Mass.

For Intervenors Alan And Marion Cleeton,
22 Mackintosh Street, Franklin, Mass.
William S. Abbott, Esq., 50 Congress Street,
Boston, Mass.

For the Commonwealth of Massachusetts
Laurie Burt, Esq., and Francis S. W. Wright, Esq.
Assistant Attorneys General, and Michael Meyer, Esq.,
Special Assistant Attorney, One Ashburton Place,
Boston, Mass.; and Ellyn R. Weiss, Esq.,
131 Tremont Street, Boston, Mass.

For the Massachusetts Governor's Office of Energy
Resources
Patrick J. Kenny, Esq., General Counsel

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Legal Director, U.S. Nuclear Regulatory Commission

For the Intervenor, Massachusetts Wildlife Federation
Henry Herrman, Esq., 151 Tremont Street,
Boston, Mass.

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I. PRELIMINARY STATEMENT

1. On June 7, 1973, pursuant to § 103 of the Atomic Energy Act of 1954, as amended (the Act), Boston Edison Company (BECo) filed with the Atomic Energy Commission, now the Nuclear Regulatory Commission (NRC or Commission), an application on behalf of itself and ten public utility companies and eleven municipal light departments or plants (the Applicants)[1/] for authorization to construct an 1180 megawatt electric (MWe) pressurized water reactor, designated as Pilgrim Unit 2, (Unit 2) to be located on the western shore of Cape Cod Bay in Plymouth County, Massachusetts. At the same time, BECo filed on its own behalf a similar application for Pilgrim Unit 3, to be built at an adjacent location. After revision, the applications were resubmitted on November 24, 1973, and the Commission docketed them as Nos. 50-471 and 50-472, respectively, on December 21, 1973. A Notice of Hearing on the applications was published at

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1/ Since the filing of the original application the utility systems participating as Applicants have changed. The present fourteen Applicants are Boston Edison Company, The Electric Light Department of the City of Burlington, Central Maine Power Company, Central Vermont Public Service Corporation, Fitchburg Gas and Electric Light Company, Town of Hudson Light and Power Department, Massachusetts Municipal Wholesale Electric Company, Montaup Electric Company, New Bedford Gas and Edison Light Company, New England Power Company, Public Service Company of New Hampshire, The United Illuminating Company, Tauton Municipal Lighting Plant Commission, and Vermont Electric Cooperative, Inc.

39 FR 1786 on January 14, 1974, which ordered a hearing to consider issues pursuant to the Act and to the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. § 4321 et seq.).

2. Pursuant to the Commission's Notice of Hearing, timely petitions to intervene were filed by the Commonwealth of Massachusetts (Commonwealth), the Massachusetts Wildlife Federation (MWF), Daniel F. Ford (Ford), and Alan and Marion Cleeton (Cleetons). A special prehearing conference was held pursuant to 10 CFR § 2.751a on April 19, 1974, to consider these petitions and other matters. By Memorandum and Order of May 30, 1974, the Board admitted as parties to the proceeding the Commonwealth, MWF, Mr. Ford, and Mr. and Mrs. Cleeton in light of their interests and the identification of at least one valid contention.

3. A non-timely petition to intervene was filed on July 15, 1974, by William S. Abbott on behalf of the Plymouth County Nuclear Information Committee. That petition was opposed by both the Applicant and the Staff and was supported by the Commonwealth. On August 30, 1974, the Board denied the late petition to intervene and the Appeal Board thereafter affirmed.[2/]

2/ Boston Edison Company (Pilgrim Nuclear Generating Power Station, Unit 2), ALAB-238, 8 AEC 656 (October 22, 1974).

4. Prehearing conferences were held on July 15, October 3 and December 4, 1974 on the contentions proposed by intervenors. By Memorandum and Order dated February 18, 1975, the Board ruled on the Parties' contentions stated here in summary and in detail in Part V infra. The following contentions of the Commonwealth were admitted:

1(a)-(h).	the effects of operation on the Cape Code ecosystem;
2.	alternative cooling systems;
3.	alternative energy sources;
4.	alternative sites;
5.	financial qualifications;
6.	the need for power;
8.	overstatement of production of electrical energy;
9.	the risk of theft and sabotage;
10.	technical qualifications of the Applicants, Bechtel Corporation, and Combustion Engineering, Inc.;
11.	the inadequacy of the NRC inspection programs; and
12.	alternate siting from a population density and environmental standpoint.

Contentions 13 and 14 were also admitted but were withdrawn by the Commonwealth in a letter dated November 17, 1975. The Board admitted the following MWF contentions:

1(a).	compliance with the Commission's "as low as practicable" standards; and
1(b).	failure to consider alternate sites.

MWF Contentions 2(a), (b), (d), (e) and (f) and 4 were admitted by the Board but were subsequently withdrawn. (Tr. 781, 3679-3680) MWF Contentions 2(c), 3, and 5 were also admitted but were withdrawn as a result of a settlement agreement between the Applicants and MWF. (Tr. 6360-61, 6460) The Board rejected MWF Contentions 6-10 as factual contentions holding that these were more appropriately to be addressed as legal issues.[3/]

The Board accepted the following contentions of the Cleetons:

B. transportation risks;

C. aircraft risks;

E. routine discharges of effluents;

H. the need for power;

I. alternate sources of power; and

K. unavailability of adequate nuclear fuel.

5. Prior to the commencement of the evidentiary hearings, Intervenor Ford informed the Board by letter dated October 15,

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3/ On January 8, 1977, MWF served a Memorandum with respect to its Contentions 6 through 10 in which it announced it would only pursue one legal contention, that of the legality of Sec. II-D of Appendix I to 10 CFR Part 50, which relates to a balancing of a dollar value per man-rem with augments in the radwaste system. In lieu of proposed findings of fact and conclusions of law, and in order to preserve its rights on appeal, MWF served on November 30, 1979 a statement describing its exceptions to a Board Order dated July 14, 1978 concerning the application of Sec. II-D of Appendix I to 10 CFR 50 to this proceeding.

1975, that he did not intend to participate in the evidentiary hearings but that he reserved the right to seek "administrative and judicial review." On October 30, 1975, on motion of the NRC Staff (Staff), the Board issued an Order directing Mr. Ford to show cause why he should not be held in default and why certain of his contentions should not be dismissed from the proceeding. After a response was filed by Mr. Ford on November 14, 1975, the Board issued an Order on February 20, 1976, holding Mr. Ford in default because of his failure to meet the responsibilities of his participation in this proceeding. The Board reviewed the Ford contentions, however, to ensure that his legitimate concerns would be considered at the evidentiary hearings. All except one of his contentions were dismissed because they were included in those of other parties or lacked specificity. The remaining contention on the integrity of steam generator tubes was made the subject of Board inquiry.

6. The decisional record of this proceeding consists of a) the Commission's Notice of Hearing; b) the petitions and pleadings filed by the parties; c) the memoranda and orders of the Board; d) the transcript of the hearing; and e) the exhibits received into evidence. The principal documents filed by the Applicants are the Preliminary Safety Analysis Report (PSAR) as amended (Applicants' Exhibits 1-B through 1-J, 1-N through 1-BB,

23, 24 and 25); the Environmental Report (ER) as amended (Applicants' Exhibits 1-K, 1-L, 1-M and 1-CC). The Staff's principal documents include the Safety Evaluation Report (SER) as amended (Staff's Exhibits 4, 5, 7, 21 and 50); the Draft Environmental Statement (DES); the Final Environmental Statement (FES) (bound following Tr. 897) as amended including the Final Supplement to the FES (received at Tr. 9852 and bound following Tr. 9952), and Staff Exhibits 10, 11-A, 11-B, 11-C, 13, 14, 15, 16, 17, 19, 53 and 66); and the NRC Site Suitability Report (SSR, Staff Exhibit 9).

7. On June 18, 1974, the Staff issued the Draft Environmental Statement (DES) for the proposed Pilgrim Units 2 and 3 which addressed the environmental impacts of construction and operation of the two units. Comments on the statement were received from the Applicants, from a number of federal and state agencies, and from an individual.

8. After the DES had been issued, and prior to the issuance of the Final Environmental Statement (FES), BECo, in June 1974, advised the Commission that construction of Unit 3 was to be deferred until the need for its output was established. BECo submitted a motion on July 1, 1974 requesting withdrawal of Unit 3 since the financial commitment for its construction would not be prudent. On August 9, 1974, the Board found that BECo had demonstrated good cause for withdrawal of the Unit 3 application and imposed no conditions upon the withdrawal.

9. Since most of the environmental impacts of Units 2 and 3 had been addressed in the DES, both separately and collectively, the Staff found an issuance of a draft statement for Unit 2 alone to be unnecessary.

10. Pursuant to the Board's August 9, 1974 Order, the Staff submitted to the Board and the parties on August 20, 1974, a document summarizing the changes in the proposed FES resulting from the Applicants' withdrawal of the application for Unit 3.[4/] After reviewing this document, the Board determined that recirculation of the changes to the appropriate agencies was advisable and directed the Staff accordingly. The Staff's motion for reconsideration of the Board's Order to seek these additional comments was denied.[5/]

4/ "Summary of New or Revised Sections of the Final Environmental Statement for Pilgrim Nuclear Power Station Unit 2 which were Required as a Result of Withdrawal of the Application for Pilgrim Nuclear Power Station Unit 3."

5/ Circulation of the summary of "new and revised sections" to those agencies, organizations and individuals from whom comment on the DES was requested was ordered by the Board under date of September 6, 1974. After denial of a motion for reconsideration, filed by the Staff on September 13, the order was reaffirmed by the Board orally on October 3 at Tr. 243 and by an Order filed October 10, 1974.

11. Pursuant to the Board Order of October 10, 1974, the Staff distributed on November 15, 1974, the "Summary of New and Revised Sections" to various agencies and also requested comments from interested persons in a Federal Register Notice published on November 12, 1974 (39 FR 40881). The Staff published[6/] a response to comments received from several agencies.

12. The FES assessing the benefits and costs of the proposed Unit 2, based on the DES but reflecting the absence of Unit 3, was prepared by the Staff under date of September 1974. The FES and a supplement reporting the Staff's response to the comments on the DES received as a result of the withdrawal of Unit 3 were received at Tr. 897.[7/] Certain additional supplements and corrections to the FES introduced into the proceeding subsequently will be cited later as appropriate.

6/ "Response to Comments on the Summary of New or Revised Sections of the Final Environmental Statement for Pilgrim Nuclear Power Station, Unit 2 which were Required as a Result of Withdrawal of the Application for Pilgrim Nuclear Power Station, Unit 3, Final Version" (May, 1975), following Tr. 897. As noted by the Staff at fn 1, p. 2 of this "Response," some of the comments were directed to the FES and not to the Summary of the New and Revised Sections.

7/ The concurrence of the Environmental Protection Agency with the Staff's decision against reissuing the DES following withdrawal of Unit 3 appears at A-47, FES.

13. On June 27, 1975, the Staff issued its Safety Evaluation Report (SER)[8/] for the proposed Unit 2 containing the Staff's evaluation of the safety aspects of the proposed facility, including Section 2 relating to the characteristics of the proposed site. Supplements Nos. 1, 2, 3 and 4 to the SER, were issued by the Staff[9/] on November 3, 1975, January 27, 1976, August 31, 1977, and January 19, 1979. Comments and recommendations on the Application and SER by the Advisory Committee on Reactor Safeguards (ACRS) were transmitted to the Commission[10/] [11/] on November 14, 1975, and on October 12, 1977.

14. Evidentiary hearings commenced in Plymouth, Massachusetts on October 20, 1975 and continued intermittently until July 1, 1977 when the sessions were adjourned for the filing of proposed findings of fact and conclusions of law on a request by the Applicants for a Limited Work Authorization (LWA) Request for Unit 2 dated October 13, 1976.

8/ Staff Exhibit 4, following Tr. 3717.

9/ Staff Exhibits 5, 7 and 21 respectively, following Tr. 3717, Tr. 5394, Tr. 8921; Staff Exhibit 50 received at Tr. 9509 and bound following Tr. 10046.

10/ Staff Exhibit 7, SER Supplement 2, Appendix B, pp. 1-3, following Tr. 5394.

11/ Staff Exhibit 50, SER Supplement 4, Appendix B at B-1 to B-3, following Tr. 10046.

15. On November 30, 1977, the Board issued a partial initial decision[12/] denying the request on the basis of the an incomplete record on possible alternate sites for Unit 2.

16. Evidentiary sessions resumed on March 6, 1978, and continued from time to time until August 28, 1979 concluding hearings on all of the then-established issues[13/] except emergency planning,[14/] which was deferred indefinitely at the request of the Staff.[15/]

12/ Partial Initial Decision Regarding Request For Limited Work Authorization, 6 NRC 839 (November 1977). Affirmed, Boston Edison Company (Pilgrim Nuclear Generating Station, Unit 2), ALAB-479, 7 NRC 774 (1978).

13/ During this period hearings were held on certain remaining health and safety issues, financial qualifications, alternate site re-review and the reopened need for power issue. Since that time certain additional issues have arisen. All are directly related to NRC task orders resulting from the Three Mile Island (TMI) incident of March 28, 1979.

14/ On April 27, 1978 and April 4, 1979 the Commonwealth by separate motions sought to reopen the issue of "need for power" and to introduce contentions relating to emergency planning. On May 9, 1979, the Board granted Commonwealth's motion to reopen the need for power issue and on May 24, 1979 granted Commonwealth's motion to admit a late-filed contention on emergency planning.

15/ Board Order dated September 13, 1979 granted Staff motion to defer hearings until the Staff has completed its review of emergency planning at the Pilgrim site.

17. During the course of the proceedings the Board heard a number of limited appearance statements from members of the public. These statements have been considered by the Board in this partial initial decision.

18. In preparing the following findings of fact and conclusions of law, the Board reviewed and considered the entire record in this case and the findings of fact and conclusions of law proposed by the parties. Those proposed findings not incorporated directly or inferentially in this Partial Initial Decision are rejected as being unsupported by the record of this case or as being unnecessary to the rendering of this decision.

II. FINDINGS OF FACT - RADIOLOGICAL HEALTH AND SAFETY MATTERS

A. General

19. The Notice of Hearing issued with respect to this proceeding dated January 9, 1974 and published in the Federal Register on January 14, 1974 (39 FR 1786), requires the Board, pursuant to the Atomic Energy Act of 1954, as amended, to consider and decide:

> "1. Whether in accordance with the provisions of 10 CFR § 50.35(a):
>
> (a) The applicants have described the proposed design of the facilities including, but not limited to, the principal architectural and engineering criteria for the design, and have identified the major features or components incorporated therein for the protection of the health and safety of the public;
>
> (b) Such further technical or design information as may be required to complete the safety analysis and which can reasonably be left for later consideration, will be supplied in the final safety analysis report;
>
> (c) Safety features or components, if any, which require research or development have been described by the applicants and the applicants have identified, and there will be conducted a research and development program reasonably designed to resolve any safety questions associated with such features or components; and
>
> (d) On the basis of the foregoing, there is reasonable assurance that (i) such safety questions will be satisfactorily resolved at or before the latest date stated in the applications for completion of construction of the proposed facilities, and (ii) taking into consideration the site criteria contained

in 10 CFR Part 100, the proposed facilities can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

"2. Whether the applicants are technically qualified to design and construct the proposed facilities;

"3. Whether the applicants are financially qualified to design and construct the proposed facilities; and

"4. Whether the issuance of permits for construction of the facilities will be inimical to the common defense and security or to the health and safety of the public."

The notice of hearing further states that..."in the event this proceeding becomes a contested proceeding" [which it is]... "the Board will consider and initially decide, as issues in the proceeding, Items 1-5"...[the above listed four items pertaining to the Act and Item 5 pertaining to implementation of the National Environmental Policy Act of 1969 stated in Section IV of this decision]..."as a basis for determining whether construction permits should be issued to the Applicants."

B. Facility Description and Compliance with 10 CFR § 50.35(a)

20. The proposed facility is described in the Preliminary Safety Analysis Report (PSAR) as amended (Applicants' Exhibits 1-B through 1-J, 1-N through 1-BB), in the Environmental Report (ER) as amended (Applicants' Exhibits 1-K through 1-M, and 1-CC) and in the Staff's SER as amended (Staff Exhibits 4,

5, 7, 21, and 50 and FES (following Tr. 897) as amended by Staff Exhibits 10 through 11-C, 13 through 15, 19 and 53.

21. Pilgrim Unit 2 is proposed to be located on the western shore of Cape Cod Bay in Plymouth, Massachusetts on a 528 acre site adjacent to Pilgrim Unit 1, an operating 655 MWe boiling water reactor. (PSAR §§ 1.1, 1.2.1; SER § 2.0)

22. The nuclear steam supply system (NSSS) will consist of a Combustion Engineering, Inc. (CE) pressurized water reactor and a two loop reactor coolant system rated at a thermal power output of 3473 MW. Each loop of the reactor coolant system will consist of an outlet pipe (hot leg), one steam generator, two inlet pipes (cold legs) and two reactor coolant pumps, one in each cold leg. An electrically heated pressurizer will be connected to one loop to establish and maintain the reactor coolant pressure. The reactor core will be composed of uranium dioxide pellets enclosed in Zircaloy-4 tubes with welded end plugs. Water will serve both as the neutron moderator and the coolant and will be circulated through the reactor vessel and core by four reactor coolant pumps. The heated water will flow through two steam generators where heat will be transferred to the secondary system and ultimately converted to electric energy in the turbine generator. The reactor will be controlled by control

rod movement and regulation of the boric acid concentration in the reactor coolant. The control elements, whose drive mechanisms will penetrate the top of the reactor vessel, will be moved vertically within the core by individual control rod drive mechanisms. A plant protection system which automatically initiates action when preestablished limits are approached will shut down the reactor, close isolation valves and initiate operation of the engineered safety features should they be required. (SER §1.2, PSAR §§ 1.2.5, 1.2.6)

23. The NSSS will be housed in a steel-lined reinforced concrete structure designed and constructed by the Bechtel Corporation (Bechtel) and prestressed by post-tensioned tendons. (SER § 1.2)

24. The reactor core for Unit 2 is similar to the design approved for San Onofre Units 2 and 3. (Docket Nos. 50-361 and 50-362) The Unit 2 core will contain 217 fuel assemblies, each with a 16 x 16 rod array. CE is committed to perform tests to verify the adequacy of the fuel assembly mechanical design, to finalize values for thermal, hydraulic and structural design parameters and to develop analytical models for confirming that the design meets specified criteria. (SER § 4.0) Each fuel assembly will consist of 236 fuel or fuel-poison rods with pellets of about 1.9 to 3.0 percent U-235 enriched uranium oxide at 95 percent theoretical density, sealed in Zircaloy tubes pressurized with helium. (PSAR

Table 1.3-1) The differences from the San Onofre fuel design previously reviewed and approved by the Staff are geometric (San Onofre employs a 14 x 14 array) and will result in a lower linear power density in the Unit 2 fuel rods, thus increasing thermal performance margins. (SER § 4.2.1)

25. The principal components of the reactor coolant system for the facility consist of a reactor vessel, two parallel heat transfer loops, each containing one steam generator and two reactor coolant pumps, and a pressurizer connected to one of the reactor vessel outlet pipes. All components of the system will be located inside the containment building. (SER § 5.1)

26. The containment systems will include the reactor containment structure, heat removal system, air purification and clean up system, isolation system, combustible gas control system and provisions for containment leakage testing. (SER §§ 6.1, 6.2) The containment structure will completely enclose the reactor coolant system, the safety injection system tanks, the containment cooling system's fan coolers and the circulation fans. The containment spray system is designed to reduce rapidly the containment pressure and temperature and to supply chemically treated water to control fission product inventory following a loss-of-coolant accident. The containment combustible gas control system which consists

of redundant hydrogen recombiners located outside of the containment and a backup purge system, is designed to maintain the hydrogen concentration below the flammability limit of 4.0 volume percent following a loss-of-coolant accident. (SER § 6.2.4) The isolation system, consisting of the circuitry and isolation valves, provides appropriate containment isolation following a loss-of-coolant accident. These are the principal means by which plant personnel and the public will be protected from excessive exposure to radioactive materials should a major accident occur in the facility. (PSAR § 1.2.6)

27. The Unit 2 emergency core cooling system (ECCS) is designed to provide cooling for those postulated accident conditions where a failure in the reactor coolant system piping results in a loss of coolant greater than the makeup capacity of normal operation equipment. It will also be designed to protect against the consequences of a main steam line break. (SER § 6.3.1) The ECCS will consist of four safety injection tanks, a high pressure safety injection system and a low pressure safety injection system, with provisions for recirculation of the borated water after injection. (SER § 6.3.2) The system will be designed so that various combinations of the system will assure core cooling for the complete spectrum of postulated break sizes. (Id.)

28. The Atomic Energy Commission (now NRC) on January 4, 1974 issued acceptance criteria for emergency core cooling systems for light water reactors. (39 FR 1004.) The criteria as set forth in 10 CFR §§ 50.34(a)(4), 50.46(a)(1) and Appendix K to 10 CFR Part 50 require evaluation of core cooling in accordance with certain criteria using an acceptable evaluation model. (SER § 6.3.3) The Staff reviewed the information submitted by the Applicants and Combustion Engineering and concluded that the design of the Unit 2 emergency core cooling system is acceptable. (SER § 6.3.3; SER Supplement 1, § 6.3.4; SER Supplement 2, § 6.3.3; SER Supplement 3, § 6.3.3)

29. The proposed design of the protection and control systems for the facility is in several respects similar to that of Calvert Cliffs Units 1 and 2 which was previously reviewed and approved. The design will, however, include core protection calculators (digital mini-computers) which will be utilized to generate a reactor trip signal at a low value of the departure from nucleate boiling ratio (low DNBR) or high local power density. (SER § 7.1) The reactor

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16/ By letter dated April 2, 1979, the Staff advised the Board that it is evaluating new information related to Combustion Engineering's flow blockage model for the Unit 2 Emergency Core Cooling System. The Staff evaluation is ongoing and the Board opines that this matter can abide the operating license review.

protection system will be comprised of four redundant and independent protection channels per trip input. Each channel trip input will deenergize three relays when a trip setpoint is exceeded. The contacts from these relays will be arranged into six independent logic matrices representing all possible two-out-of-four trip combinations for the four protection channels. A trip output from any one of the six logic matrices will interrupt power to the control rod supply breakers and will cause insertion by gravity of all full length control rods and thereby shut down the reactor. The reactor protection and control system will be designed in conformance to the Commission's General Design Criteria and IEEE Standard 279-1971 "Criteria for Protection Systems for Nuclear Power Generating Stations."[17/] (SER § 7.1, 7.2; PSAR § 1.2.7.1)

30. The facility's safety-related instrumentation and controls of the engineered safety features will include (1) the engineered safety feature protective systems which will consist of the electrical and mechanical devices and logic circuitry involved in generating signals that actuate the required engineered safety feature systems, and (2) the arrangement of components that will perform protective actions after receiving a signal from either the engineered safety

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17/ This Standard was reaffirmed in 1978.

feature protective system or the operator. All of the engineered safety feature protective systems will be identical except for the input parameters and include four redundant and independent channels per trip input. (SER § 7.3)

31. Unit 2 will be connected to the New England power grid through two 345 kV and one 115 kV transmission lines. These lines and associated circuits will constitute the two physically independent circuits required by Criterion 17 of the General Design Criteria. (10 CFR Part 50, Appendix A) To maintain independence between the 345 kV and 115 kV circuits, the 115 kV line will be run underground to the facility switchyard from a substation located at Manomet, Mass. (SER § 8.2; PSAR, § 1.2.8) The 345 kV ring bus which currently serves Pilgrim Unit 1 will be modified to accommodate Unit 2. During normal power generation, the auxiliary and safety related a-c power distribution systems will be supplied by the unit a-c power supply via the generator load switch and three unit auxiliary transformers. In the event of turbine or reactor trip the generator load switch will be automatically opened. The 345 kV preferred a-c power supply will remain connected and will provide uninterrupted power to the auxiliary and safety-related a-c power distribution systems via the main and unit auxiliary transformers. In the event that the preferred 345 kV power is lost, 115 kV power will be supplied

to the auxiliary and safety related bus bars by automatic transfer to the reserve transformers. (SER § 8.2)

32. Onsite standby a-c power will be supplied for the facility by two diesel generators. Each diesel generator will supply one of two redundant 4160 V emergency bus bars arranged in a two-division split-bus configuration. Among the design features to be included in the standby diesel generators and their associated a-c power distribution systems are: (a) electrical independence from each other; (b) starting and operation of either diesel will not be conditioned by operation of the other; (c) each diesel will be started by an undervoltage signal from its respective bus bar or by an engineered safety feature actuation signal; (d) separate onsite fuel storage for each diesel sufficient for seven days operation at accident load and (e) each diesel generator and its auxiliary systems will be housed in a separate seismic Category I installation. (SER § 8.3)

33. The d-c power system for the facility will consist of four redundant and independent d-c load groups, each composed of a 125 V battery, a battery charger, distribution bus, distribution panel, interconnecting cables and connected loads. The system is in conformance with General Design Criteria 17 and 18, Regulatory Guide 1.6 and appropriate IEEE standards. (SER § 8.3; PSAR § 1.2.8)

34. The ultimate heat sink for Unit 2 is Cape Cod Bay. Sufficient heat removal capacity will be provided for an indefinite time in conformance with Regulatory Guide 1.27. (SER § 9.2.4)

35. Plant cooling requirements during power operation and shutdown of the facility will be met by the reactor coolant system, the shutdown cooling system and by four segregated water systems consisting of (a) the turbine building cooling water, (b) the component cooling water, (c) the auxiliary building cooling water, and (d) the service water. The last three systems are required for safe shutdown of the plant following a design basis accident. These systems will be designed for 100 percent redundancy with functional and physical separation of each train of redundant components. The systems are interconnected so that functional and physical separation of each train of redundant components will be maintained. (PSAR, § 1.2.9.2) The component cooling system is designed to circulate water through two physically separated seismic Category I closed loops. Each loop will remove heat from the containment, shutdown heat exchangers, spent fuel pool heat exchangers, engineered safety features equipment, boric acid concentrator package and the waste concentrator package. Only one train of these components is required for safe plant shutdown following any postulated accident. (SER 9.2.2) The auxiliary building cooling water will

circulate through two physically separated loops each independently capable of providing the required cooling for the components of the engineered safety features support system. (SER § 9.2.3)

36. The facility's station service system, which will meet Criterion 44 of General Design Criteria, 10 CFR Part 50, Appendix A, will supply water to two identical trains of safety related equipment. Each train will be capable of providing sufficient water for the component, auxiliary building, and diesel generator cooling water systems. The station service water system will be designed so that a single failure of its components or of the onsite power supply will not prevent a safe shutdown. (SER § 9.2.1)

37. The facility's fire protection system and its components will be designed so that a failure or inadvertent operation of the fire protection systems will not result in loss of function of safety related equipment. Sprinklers will be provided in the engineered safety feature pump rooms, the standby diesel generator rooms and the turbine building. Fixed automatic chemical extinguishing systems will be provided for the cable spreading rooms, computer room and unoccupied areas housing electrical equipment. The facility's proposed fire protection system, as currently designed, meets

Criterion 3 of the General Design Criteria. (10 CFR Part 50, Appendix A) (SER Supplement 3, § 9.5.1)

38. The unit 2 steam and power conversion system will be of conventional design and similar to those of previously approved plants. The heat of the reactor coolant will be removed through two steam generators and converted to electrical energy through the turbine driven generator. The condenser will transfer unusable heat in the cycle to the condenser cooling water. (SER § 10.1)

39. The radioactive waste (radwaste) system will consist of solid, liquid and gaseous waste systems. The design objective of each system is to restrict the amount of radioactive material released to the environment to as low as reasonably achievable in conformance with the requirements of 10 CFR § 50.34a and 10 CFR Part 50, Appendix I.[18/]

40. The facility's liquid waste system will process input from decontamination, chemical regenerants, steam generator blowdown, equipment and floor drains. The gaseous waste systems for the facility will provide holdup capacity to allow decay of short-lived noble gases stripped from the primary coolant. Charcoal adsorbers will be used to remove

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18/ Findings of Fact by the Board pertaining to Appendix I are contained in Part II.G.c. *infra*.

radioiodine from the main condenser offgas and from the air purged from the containment building. The solid waste system will provide for the packaging and solidification of low level radioactive wastes generated during station operation. These will be shipped to a licensed disposal facility. (SER § 11.0)

41. The offsite radiological consequences of design basis accidents have been evaluated by the Staff and found to be within the guidelines of 10 CFR Part 100. (SER § 15.0; SER Supplement 3, §§ 15.5, 15.6)

42. The research and development necessary for the safe operation of Unit 2 have been identified by the Applicants and will be performed on a timely schedule. (SER § 1.7)

43. Health and safety issues raised in these proceedings by intervenors are addressed in Part V of this decision. The Staff testified that there are no additional health and safety matters that cannot be favorably resolved prior to completion of construction. (SER § 21.1; SER Supplement 4, § 21.1)

II. C. Technical Qualifications of Applicants

44. Testimony on the technical qualifications of the Applicants and of their principal contractors was prepared and presented by a series of panels. The Staff's testimony was similarily presented. No direct testimony was offered by the intervenors who argued their cases through cross examination of Applicants' and Staff's witnesses.[19/]

19/ The testimony on the technical qualifications of BECo was given by Panelists J.E. Howard, Vice-President Nuclear, R. M. Butler, Manager Nuclear Projects, W. M. Sides, Manager Quality Assurance and V. P. McMahon, Corporate Manager Quality Assurance, Kaiser Engineers, Inc. (Following Tr. 3735)

The Panel on the qualifications of the Bechtel Power Corporation, the architect-engineer, was comprised of F. A. Hollenbach, Manager Project Operations, T. D. Dow, Supervisor QA Program, M. J. Jacobson, QA Engineer, J. D. Blatchford, Project Engineer, G. K. Stavro, Inspection Manager and D. R. Johnson, Field Engineer, Quality Control. (Following Tr. 3987)

The Panelists for Combustion Engineering, Inc., the nuclear steam supplier, were C. R. Waterman, Unit 2 Project Manager, C. W. Hoffman, Director Quality Assurance, W. E. Midinger, Manager, QA Systems and W. K. Couch, Manager Quality Control. (Following Tr. 4185)

The Staff Witnesses were D. L. Caphton, D. M. Sternberg, and R. F. Heishman all of the U.S. Nuclear Regulatory Commission's Office of Inspection and Enforcement. (Following Tr. 4234)

Further evidence by the Staff on this contention was prepared by D. B. Vassallo and M. B. Aycock of the Office of Nuclear Reactor Regulation. (Following Tr. 5534) Still further is the testimony of A. M. Garland, of the NRC Quality Assurance Branch, Division of Reactor Licensing (following Tr. 4425), and by R. H. Vollmer, Office of Nuclear Regulation. (Following Tr. 4464)

45. As described in Paragraph 69 of this Decision the Applicants in this action are a consortium of a number of public utilities and municipalities. The members of this consortium constitute the ownership of the proposed generating station. The lead entity of this group is the Boston Edison Company. In that position, BECo represents and is contractually empowered to act for the other owners on matters of design, procurement, licensing, construction, operation and maintenance of Unit 2.

46. In a similar line of authority, the principal contractors, CE and Bechtel, are contractually responsible to BECo not only for the supply for the steam generating system and construction services, but also for assurance that their product will meet designated specifications and quality in accord with the requirements of 10 CFR 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Facilities." Additionally these contractors are to exercise prudent use of capital funds. To these ends BECo has the ultimate authority to reject completed work and to terminate further work through the use of stop-work orders. (Applicants' Witness Howard at 13 following Tr. 3735)

47. Under 10 CFR 50.40(b) the Staff is obligated to determine that an applicant is technically qualified to engage in the proposed activity in accordance with regulations, yet

"The Staff has no specific quantitative guidelines for determining whether an applicant has the management capability to undertake the construction or operation of a nuclear reactor... A determination on this subject must be subjective and judgemental and each utility must be evaluated individually. The best test is a functional one."[20/] The Pilgrim Unit 1 station has been operated by BECo since 1972. The managerial and operational experience with that was, accordingly, taken as a measure of expectations of Unit 2.

48. This issue was almost exclusively addressed in the testimony through discussions of assurances that the products and services of the suppliers would be of the requisite quality.

49. The corporate structure of BECo includes a Vice-President, Nuclear, reporting to the Office of the President and receiving reports from managers of various functions within the project. One of these is the Quality Assurance (QA) Department Manager to whom reports QA Engineering. The QA Department is responsible for establishing a QA program applicable to all safety related activities performed by BECo and its principal contractors in accord with the established QA program. [At 14 and 47 (BECo Exhibit BE-TQ-1) following

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20/ In the Matter of Carolina Power and Light Company (Shearon Haris Nuclear Power Plant, Units 1, 2, 3 and 4) LBP 79-19; 10 NRC 37 at p. 41 (1979).

Tr. 3735; see also Fig. 1, unnumbered p. 19 following Tr. 5534] All reporting along this chain is independent of other project activities including operations, construction, cost control and engineering.

50. The managers of the QA and the Nuclear Projects Departments (the latter administers engineering and construction) and the Vice-President to whom they report each have more than 20 years experience in nuclear energy. These experiences include responsibilities at commercial power generating stations at production reactors and with naval-propulsion units. (at 2 through 4 following Tr. 3735)

51. Applicants' Witness Sides testified to the stability of the QA Engineering Staff at BECo asserting to the absence of turnover and of any need for disciplinary action. As of February 1976, BECo Staff had accumulated considerable experience in QA matters at Pilgrim Unit 1. (Tr. 3904)

52. The roster of the BECo QA Department is comprised of eight managerial and professional personnel with an enlargement authorized as necessary to the activities required during the construction of Unit 2. Each position requires an academic degree in engineering augmented by up to five years experience in QA, or related activities, in the nuclear industry, the exact amount depending upon the specific position. Within

the Department there must be knowledge of applicable Federal Regulations (10 CFR 50), ASME Codes, American National Standards and NRC Regulatory Guides as well as familiarity with internal programs and activities related to QA. (Applicants' Witness Sides at 38 and 39 following Tr. 3735)

53. In addition to BECo's line organization for QA is the Quality Assurance Review Committee, a staff group, with membership composed of the Vice-President - Nuclear as chairman and four department managers. This Committee provides a continuing review of BECo's QA Program to assess its scope, implementation and effectiveness. There is also the Nuclear Safety Review and Audit Committee, chaired by the QA Manager, which has the responsibility of reviewing the nuclear safety of Unit 1 operating in conformance with NRC-issued technical specifications. (Applicants' Witness Howard at 9 and 10 following Tr. 3735)

54. The organizational relation between BECo and its principal contractors is shown in Applicants' Exhibit BE-TQ-2. (At unnumbered p. 48 following Tr. 3735) By this arrangement the contractors' QA organizations report to the BECo QA manager. Similarly the contractors' project managers report to the BECo Nuclear Project Manager thence, in both instances, to the BECo Vice-President - Nuclear thereby effecting authority and control through an interface established by procedures.

Audits and surveillance of fabrication and construction activities f r safety-related structures, systems, and components are performed by the QA Department. Necessary corrective actions are taken by the contractors through, in the extreme, stop-work orders. (Applicants' Witness Butler at 25 following Tr. 3735; see also Staff Witnesses Vassallo and Aycock at 6 through 8 following Tr. 5534)

55. The Staff concludes from its investigation of the Applicants and their principal contractors that BECo is technically qualified to carry out the responsibilities attendant to the design and construction of Unit 2. In support of its finding, the Staff cites its observation of a favorable attitude of the management of BECo toward safety and environmental characteristics of Unit 2. Further it cites the practice of BECo in seeking advice and guidance from outside experts[21/] on those specialties beyond the ken of its staff. (Staff Witnesses Vassallo and Aycock at 14 through 17 following Tr. 5534)

56. The principal contractors of BECo, Bechtel (architect-engineer, construction service) and CE (nuclear steam system supplier) are large well established organizations with long

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21/ For example, BECo has obtained an independent assessment of its QA program from Kaiser Engineers, Inc., a qualified QA consultant. (Applicants' Witness Howard at 41, following Tr. 3735)

industrial experience. Each has been engaged, in its respective field, in the nuclear industry for upwards of two decades. Additionally, each has great experience in more conventional energy conversion systems, that of CE dating back almost a century. (Applicants' Witness Hollenbach at 9 through 30 following Tr. 3987; Applicant Witness Waterman at 10 through 31 following Tr. 4185, see also testimony of Staff Witness Vollmer following Tr. 4464)

57. Representatives of each of these contractors presented detailed descriptions of its organization including quality assurance activities and responsibilities. Each instance can be typified by the BECo pattern, supra, though differing in details. Worthy of note is the existence of a line of reporting and responsibility of the QA staff to upper-level management entirely independent of segments controlling operations, construction, procurement, etc. [See BECo Exhibit BPC-TQ-1, unnumbered page concluding testimony following Tr. 3987; also Applicants' Witness Hollenbach at 25 following Tr. 3987 and BECo Exhibit CE-TQ-5 (at unnumbered page 35 following Tr. 4185)]

58. Some measure of the qualifications of the Applicants in these proceedings is to be expected from BECo's experience at Unit 1, a boiling water reactor which began operation in 1972. During the hearing a number of reports

derived from inspections of Unit 1 by AEC Division of Compliance (now NRC Inspection and Enforcement) were reviewed.[22/]

59. Intervenor Commonwealth introduced several of these reports for the purpose of illustrating BECo's poor performance at Unit 1 and, consequently, an absence of technical competence to construct and operate Unit 2. Several of these reports concerned procedural matters, interpretation of the results of weld testing, and some design changes.[23/]

60. One consequence of the findings of AEC inspectors was the assessment of three $4000 civil penalties against BECo. One item concerned the qualification rating of an inspector (employed by a secondary contractor of BECo of ultrasonic examination of certain welds in the primary-coolant piping. Another concerned the calibration of the ultrasonic testing equipment; still another had to do with the presence, as allegedly required, of BECo QA personnel as a witness to the ultrasonic testing. The $12,000 fine was paid. (Applicants' Witness Howard at Tr. 3850-3889)

61. There is uncertainty in the bases for the allegations which involve interpretation of Section XI of the

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22/ Inspections are listed in Appendix A of testimony of Staff Witness Caphton following Tr. 4234.

23/ Commonwealth Exhibits 3 through 8 received at Tr. 3847; Exhibits 9 and 10, at Tr. 3860, *et seq*.

American Society of Mechanical Engineers Code on inservice inspection (which references American Society for Nondestructive Testing (ASNT) Recommended Practice SNT-TC-1A, and some apparent conflict in personnel records. At any rate, although there were plans to repeat the inspections such was not required. (Applicants' Witness Howard at Tr. 3874, 4014 and 4016) [Some were, however, repeated. (BECo letter to NRC dated June 18, 1975 appended to Commonwealth Exhibit 11, received at Tr. 3949)]

62. As a consequence of these events BECo increased the frequency of audits, initiated better procedures, clarified its appropriate inspection manual, and advised its contractor to institute more thorough personnel training. (Applicants' Witness Howard at Tr. 3864, 3875; BECo letter to NRC dated June 18, 1975 appended to Commonwealth Exhibit 11)

63. Applicants' Witness Howard testified that the matter of weld inspection had been resolved with the AEC/NRC. (Tr. 3855) Current practice on the specific item of inspection qualification has been accepted by NRC. (Tr. 4003)

64. Summary Staff testimony on the technical qualifications of BECo and its principal contractor was prepared by Messrs. Vassallo and Aycock. (Following Tr. 5534) These and other witnesses recognize the inevitable appearance of

deviations from specifications and procedures in past similar operations of the Applicants. They occurred in varying degree. (See testimony of Staff Witnesses Caphton and Sternberg following Tr. 4234.) Of great importance, however, in the evaluation of the qualifications of the Applicants in future actions is the severity of those infractions in the response and remedial actions of the licensee, and in the reception of them by the regulatory agency. Additional factors for investigation are the Applicants' organizational structure and manpower and the technical qualifications of their principal contractors.

65. On the basis of these several considerations, the Staff concluded, in its overall evaluation, that BECo is technically qualified to enter into the construction of Unit 2 with the support of the principal contractors it has named. (Staff Witnesses Vassallo and Aycock at Tr. 5630-5647)

II. D. Financial Qualifications of Applicants

66. Initial evidential presentations on the financial qualifications of the Applicants were made in February 1976 by the Applicants and the Staff supporting and supplementing their positions contained in the Pilgrim Station License Application, Section VI and in Supplement 1 of the SER, respectively. (Applicants' Witnesses Houston following Tr. 5078, and Kelmon, Mefferman and Mitiguy following Tr. 5103)

67. Subsequent changes in the proposed ownership of Unit 2 and in revised plant costs necessitated additional information from the Applicants and review by the Staff[24/] and further hearing before this Board. The Applicants' supplemental testimony was through BECo Treasurer Kelmon and Assistant Treasurer May. (following Tr. 9234) The Staff presented its further evaluation of the financial qualifications of the Applicants through Witness Karlowicz. (following Tr. 9513) Intervenor Commonwealth's evidence was presented by Witness Levy. (following Tr. 9434)

68. The Commission requires, in 10 CFR § 20.33(f) and 10 CFR 50 Appendix C, that an applicant show it either possesses or has reasonable assurance it can obtain the funds necessary to cover estimate construction and related fuel costs. Guidance was provided by the Commission:

> "..given the history of the present rule and the relatively modest implementing requirements in Appendix C (footnote omitted), a 'reasonable assurance' does not mean a demonstration of near certainty that an applicant will never be pressed for funds in the course of construction. It does mean the applicant must have a reasonable plan in light of relevant circumstances."[25/]

24/ Staff Exhibit 21, SER Supplement 3, p. 1-2 following Tr. 8921; Staff Exhibit 50, SER Supplement 4, p. 20-1 following Tr. 10046.

25/ Public Service Company of New Hampshire (Seabrook Station Units 1 and 2) 7 NRC 1 at p. 18 (1978).

69. The ownership of Unit 2 is presently distributed among investor-owned and non-investor-owned utilities in this proportion:[26/]

a)	Boston Edison Company	59.026 %
b)	The Electric Light Department of City of Burlington	0.330
c)	Central Maine Power Company	2.850
d)	Central Vermont Public Service Corporation	1.780
e)	Fitchburg Gas and Electric Light Company	0.190
f)	Town of Hudson Light and Power Department	0.174
g)	Massachusetts Municipal Wholesale Electric Company	13.240
h)	Montaup Electric Company	2.150
i)	New Bedford Gas and Edison Light Company	1.530
j)	New England Power Company	11.160
k)	Public Service Company of New Hampshire	3.470
l)	The United Illuminating Company	3.300
m)	Tauton Municipal Lighting Plant Commission	0.600
n)	Vermont Electric Cooperative, Inc.	0.200
		100.000 %

26/ Staff Exhibit 50, SER Supplement 4, Appendix C at C-1, following Tr. 10046.

70. "The cost of Pilgrim Unit 2, including site and 'common facilities' (i.e., common to Pilgrim Unit 1), the initial nuclear fuel core, and transmission and switching facilities is estimated to be $1,319 million. With the inclusion of allowance for funds used during construction (AFUDC)," the projected total cost of the facility is $2,037.5 million.[27/]

71. Consistent with Commission requirements the investor-owned applicants filed statements of sources and uses of funds and non-investor-owned applicants filed alternative financial data.[28/] Applicants expect to rely upon a combination of internally generated funds (39 percent of the requirement) and the sale of debt and equity (61 percent) to finance the construction and initial fueling of the facility.[29/]

72. Whereas the commitment of BECo to the overall financial schedule is significant, it is not extraordinarily great relative to that utility's recent experience in construction expenditures.[30/]

27/ License Application, Amendment 9, Applicants' Exhibit 1-00 at V-1, Tr. 9601. Staff Exhibit 50, SER Supplement 4, Appendix C at C-1 following Tr. 10046.

28/ License Application, Amendment 8, Applicants' Exhibits 1-NN (1), (2) and (3), Tr. 9601; Staff Exhibit 50, SER Supplement 4, Appendix C at C-2 following Tr. 10046.

29/ Applicants' Witnesses Kelmon and May at 6 and 7 following Tr. 9234.

30/ Applicants' Witnesses Kelmon and May at 7 and 8 following Tr. 9234.

73. The Staff found to be reasonable BECo's projections of the rate of return on equity, internal cash generation, interest coverage and capital structure.[31/]

74. Applicants other than BECo submitted plans for financing their portion of Unit 2 consisting, primarily, of issuance of general obligation and revenue bonds, with interest and principal to be paid from revenues. The Staff concludes that the members of this group of co-applicants have developed reasonable financing plans, recognizing them not to be necessarily what will actually occur. This demonstration of one possible way of financing the construction suffices Commission requirements.[32/]

75. The portion of Supplement 4 of the Staff Safety Evaluation Report (Exhibit 50), cited above, addressing the financial qualifications of BECo was supported by Staff Witness Karlowicz (Tr. 9514) who had used state-of-the-art techniques of financial analysis, accepted by the financial community, in review of information supplied by BECo with supplements from various investment rating agencies. (Tr. 9519) The testimony of this witness is the Staff's evaluation of

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31/ Staff Exhibit 50, SER Supplement 4, at C-8 through C-14 following Tr. 10046.

32/ Id. at C-15 through C-48.

BECo's financial qualifications.[33/] The conclusion of the Staff review affirms the ability of BECo to assume the financial obligation of a 59 percent ownership of Unit 2.

76. Testimony on behalf of the Commonwealth on the matter of financial qualifications of the Applicants was presented to the Board and the Record by Paul F. Levy.[34/] This witness served in the Massachusetts Energy Policy Office from mid-1974 through 1977. During calendar year 1978 he was a Commissioner of the Commonwealth's Department of Public Utilities. On the basis of these limited experiences and of other statements in the record (Tr. 9414 through 9434) the Board finds the qualification of Mr. Levy to present evidence on the subject matter to be marginal and, hence, accords appropriate weight to his testimony.

77. The testimony of Witness Levy was largely based on two internal BECo memoranda, prepared in mid-1978, and on the testimony presented by Mr. Kelmon at a pending rate case before the (Massachusetts) Department of Public Utilities (DPU-19991).[35/]

33/ Id. at 20-1 and at C-1 through C-15.

34/ Following Tr. 9434. Mr. Levy had testified before this Board in February 1976 on the issue of cost comparison of various future baseload generating stations at Tr. 4990.

35/ Commonwealth Exhibits 100, 101 and 102 at Tr. 9270, 9275 and 9276 respectively.

78. For reasons appearing in his testimony,[36/] Witness Levy stated that BECo would encounter increasing difficulty in issuing debt and equity securities within the construction schedule of Unit 2. One reason was that further stock issuances, if necessary because of the possible high percent of allowance for funds used during construction (AFUDC), will dilute the book value of current stock, thereby reducing the interest of potential investors. Upon cross examination the witness could cite no instance of recent sale of electric utility stock above book value and, in fact, he considered sale of stock below book value not to be unusual. Nonetheless, electric utilities have been successful in marketing stocks. (Tr. 9470-71)

79. On November 1, 1979 the Applicants filed with the Board and all parties in this proceeding a Base and Standby Revolving Credit and Term Loan Agreement, dated July 31, 1979 with an Amendment of October 12, 1979. This Agreement, as amended, was approved by the Department of Public Utilities and the sale of the subject securities was authorized by Order 20145 dated September 17, 1979, as amended by Order 20145-A of October 17, 1979. The Agreement makes available to BECo a principal amount of $500 million in aggregate to be used for the Company's general corporate purposes including capital expenditures.

36/ At 6 and 7 following Tr. 9434.

II. E. Common Defense and Security

80. The activities proposed to be conducted under the construction permit will be within the jurisdiction of the United States and all directors and principal officers of the Applicants are citizens of the United States. The Applicants are not owned, dominated or controlled by an alien, a foreign corporation or a foreign government. Although the activities to be conducted do not depend upon any restricted data, the Applicants have agreed to safeguard any such data in accordance with the requirements of 10 CFR Part 50. The Applicants will obtain fuel as needed from sources available for civilian purposes, so that no diversion of special nuclear material from military sources will occur. (SER § 19.0)

81. Pursuant to Commission regulations and earlier rulings,[37/] consideration of potential sabotage of Unit 2, by armed acts of force both by enemies of the U.S. Government and by other armed personnel regardless of origin and basic

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37/ 10 CFR 50.13. See also, for example, Siegel v. AEC, 400 F.2d 778 (D.C. Cir. 1968); Florida Power and Light Co. (Turkey Point Units 3 and 4) 4 AEC 218 (1969); Long Island Lighting Co. (Shoreham Station) 6 AEC 831 (1973); Consolidated Edison Co. of New York, Inc. (Indian Point Station, Unit 2) 7 AEC 826 (1974); Potomac Electric Power Co. (Douglas Point Station, Units 1 and 2) 8 AEC 79 (1974). Although the Board senses these cited rulings to be at variance with 10 CFR 73.55(a)(1) it has followed the mandates of these decisions pending clarification of an apparent conflict within the Commission's regulations.

intent, were ruled inadmissible into these hearings on the application for a construction permit. Accordingly, deliberations on this contention were limited by the Board to theft and sabotage of radioactive materials during transport to and from the Pilgrim site and to actions within the proposed plant by a few employees or by a small group of outsiders following surreptitious entry. The potential of an armed band, "terrorists," has not been included.

82. Intervenor Commonwealth, the Applicants, and the Staff presented witnesses who testified and were cross-examined on this contention.

83. The testimony of Commonwealth Witness Rathjens (following Tr. 4380) was based on the findings of a Commission charged by the Commonwealth to study "...its role in assuring the safety of nuclear power plants...." chaired by this witness. Although the testimony as filed encompasses security in a nuclear power station as well as in transport, consideration was limited, without prejudice, as stated above.

84. Whereas he testified that the self-damage to a reactor plant resulting from actions by an employee could conceivably be severe, the likelihood of such occurences is low because of the protection afforded by monitoring devices and the dispersal of the information they derive among the

operations staff. To be otherwise would require collusion among a number of employees with similar motivation, a condition controllable by effective screening of personnel. To bring about such an event of sufficient magnitude to grossly affect the public through a large release of radioactivity is even less likely. (at 123 to 126 following Tr. 4380)

85. Staff Witness Sears also testified that the likelihood of theft and industrial sabotage within a nuclear power plant by unarmed persons is very low. His judgment was based on requirements for employee selection, for surveillance and search of employees and visitors upon entry, for fulfillment of physical protection objectives[38/] which require intrusion monitoring and alarm systems and location of vital equipment[39/] within an area encompassed by three barriers representing, progressively, increasing levels of security control, for redundancy in and separation of vital equipment thereby protecting against malicious outages, and for special equipment for diversion of special nuclear materials.[40/]

38/ These objectives are described in part in the Commission's Regulatory Guide 1.70.15 and in 10 CFR 73.55.

39/ Vital equipment is defined as any whose failure could directly or indirectly endanger public health and safety by exposure to radiation.

40/ Irradiated fuel is the sole material within a nuclear power plant designated as special nuclear material.

86. This witness also addressed the cost of anti-sabotage and anti-theft measures at an electric generating station, including downtime and necessary repairs and replacements as a consequence of sabotage, and concluded that such costs were independent of the type of fuel. (Tr. 2226) Further, the cost estimates, $250,000 capital and $200,000/yr operating, are similar for a non-nuclear installation and are insufficient to shift the cost-benefit analysis away from nuclear. He concluded that the risk of theft of special nuclear material from a nuclear power plant is small because of the hazard to the potential thief from the associated highly radioactive substances. Supporting this conclusion is the absence of successful and identified theft and sabotage attempts at any domestic operating nuclear power reactor (following Tr. 2210)

87. In the course of his testimony on the risks associated with the transport of radioactive materials, Commonwealth witness Rathjens pointed out that, although used fuel in transit may be a more attractive target than a reactor for those having extortion or coercion as their goal, the potential for damage to the public is much less. This potential could arise from materialization of a threat to disperse radioactivity were demands not met. Potential concommitant panic due to the public aversion to radiation exposure is also a

consequence. To effect a probable lethal exposure from sabotage, however, would require breaching the container with explosives, the availability of heavy equipment and remote manipulators, and subjecting the contents to temperatures of the order of a thousand degrees to vaporize them preparatory to atmospheric dispersal. (at 128 following Tr. 4380; Tr. 4393, 4419)

88. Diversion of used fuel for fabrication of illicit nuclear weapons is not a viable threat. Witness Rathjens reiterated the necessity of first coping with the activity of the accompanying fission products and of chemically purifying the special nuclear material to arrive finally at an inferior weapon. He concluded that more attractive and practical channels existed for illegally acquiring a nuclear weapon. (Tr. 4410, et seq.)

89. He, however, strongly recommended accompanying these shipments to and from the Pilgrim site with armed escorts retaining constant communication with law-enforcement authorities. (at 129 following Tr. 4380)

90. Applicants' Witnesses Podger and Low testified that the risk of theft and sabotage of low-level wastes is non-existent because of its negative financial value, the absence of a health hazard even if dispersed, and the

deterring legal penalties. These witnesses concluded that the low monetary value of used nuclear fuel, even after costly processes for separation of fission products, was not an incentive for its theft. The radiological consequences of such theft would not be significantly different from those resulting from a transportation accident. (at 8, 13 following Tr. 2024)

91. The testimony of Staff Witness Barker on theft and sabotage in transport (following Tr. 2275)[41/] is summarized in the record as:

> "Based on consideration of the low enrichment of the fuel, the negative value of the waste, criminal laws against theft and sabotage, the type and form of the material, and the size, weight, and designs of the rugged packaging required by the regulatory standards, the probability of such acts causing a release is so small as to not require additional analysis or protection. Although the probability cannot be easily quantified, our lack of such experience indicates it is much less than the probability for very severe accidents.
>
> "Furthermore, in the unlikely event such an accident could cause or did cause a release, principally because of the nature and form of the fuel and waste, the consequences would not be significantly different from those assessed in WASH-1238." (Tr. 2280-81)

92. These conclusions are supported by the witness' observation of the rugged construction of the massive shipping

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41/ Cross-examination of Mr. Barker is continued beginning at Tr. 2458.

containers, the properties of the materials which make handling and purification difficult and expensive, and the proven ability to detect relatively low-intensity radiation by, for example, aerial surveillance, allowing discovery of illegally diverted radioactive materials including used fuel. In his opinion, a saboteur intent upon procurement of explosives or otherwise harming the public can find more readily available, more efficient and economic, and more positively acting materials in commerce. Examples are ordinary explosives, compressed or liquified gases such as chlorine and propane, and biological and etiological agents. (at 9 following Tr. 2275)

93. Staff Witnesses Kasun and Hodge (following Tr. 8459) and Hodge with Sawyer (Staff Exhibit 68 served January 17, 1980 admitted by Board Order December 30, 1980) supplemented the testimony of Barker by sponsoring a Commission study of the radioactive materials.[42/] This recent analysis by the Staff of the consequences of a transport accident to or sabotage of a 10-fuel-element shipping cask assumes the maximum credible breach resulting in the release of 100 percent of the gases and 1 percent of the volatile and non-volatile

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42/ "Calculation of Radiological Consequences from Sabotage of Shipping Casks for Spent Fuel and High-Level Wastes," NUREG-0194, Feb. 1977. This information was not available at the time of Mr. Barker's testimony.

solids[43/] as respirable aerosols. The number of health effects in an area with a population density of 100 persons per square mile and average meteorological conditions are calculated to be less than one early cancer death and approximately 38 latent cancer fatalities. (at 4 following Tr. 8459)

II. F. Generic Issues

94. In the ongoing evolution of nuclear fueled power generating stations the Staff maintains surveillance of advances in technology, of their potential for increasing the safety of operating those stations, and of concerns and safety issues as they may develop from operating experiences. Accordingly, the Staff maintains a list of items which would be potentially benefitted by additional information and investigation. Generally these items concern a type or class of stations rather than a single installation and, hence, are designated as "generic safety issues."

95. The importance of each issue to safety establishes a priority to the effort for its resolution. The issues listed, therefore, change from time-to-time as research, experience, identification, etc. occur.

43/ The more intense emission postulated by Commonwealth Witness Rathjens required subjecting the fuel elements to very high temperatures. (Tr. 4398 et seq.) No analysis of ensuing health effects was offered nor was the credibility of such an event established.

96. It is apparent that solutions to these generic items become important at times more near to the operation of Unit 2 than at this review of a construction permit application. At this time the Board has a responsibility to judge the likelihood of a predictive satisfactory timely solution. An Appeal Board has given some guidance.[44/]

97. In this record the Staff has cited some 133 generic issues of which 28 are judged to be related to plant safety and applicable to Unit 2. Further the Staff has described[45/] each of these issues, summarized the present status of its solution, projected future investigative programs, and evaluated the impact of the issue on the operation of Unit 2.

98. The Staff concluded that none of the 28 issues applicable to Unit 2 is cause for denying the construction permit.

II. G. Additional Health and Safety Issues

a. Steam Generator Tube Integrity

99. On February 20, 1976, the Board issued an Order dismissing intervenor Daniel F. Ford from the proceeding for

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44/ Gulf State Utilities Co. (River Bend Station, Units 1 and 2), ALAB-444, 6 NRC 775 (1977).

45/ Staff Exhibit 50, SER Supplement 4 at D-16 through D-31, following Tr. 10046.

failure to carry out the responsibilities of being an intervenor in this proceeding. The Board reviewed Mr. Ford's contentions and dismissed all of them. Ford Contention K however alleged that the proposed steam generator tubes will not maintain their integrity during a loss of coolant accident. The Board adopted this contention in modified form as its own and directed that evidence regarding the overall integrity of the proposed steam generator tubes be presented. In response to that direction, testimony was presented by Staff and Applicants on May 24 and 25, 1976. In subsequent experiences at certain CE PWR generating stations, damage to tubes in steam generators was observed as deformations in the vicinity of supporting tube plates. This circumstance, called "denting," was addressed by Staff and Applicants in a reopened hearing on March 6 and 7, 1978.

100. The integrity of the steam generator tubes is highly significant from a radiological safety standpoint since they represent an integral part of a major barrier between the radioactive reactor coolant fluid, which circulates inside the tubes at high temperature and pressure, and the secondary two-phased coolant. Rupture of steam generator tubing would result in a release of the radioactive primary fluid into the secondary coolant. Any subsequent releases from the secondary system would result in discharge of radioactivity to

the outside environment. The weakening of these tubes due to service induced tube degradation processes could in the event of a loss of coolant accident (LOCA), result in rupture of tubes and release of the fluid energy from the secondary system into the containment or into the reactor vessel. This in turn could interfere with the emergency core cooling water reflooding rate with major radiological safety implications. (Staff Witness Rajan at 2 following Tr. 5847) The steam generator tubing being an integral part of the reactor coolant pressure boundary is designed to meet Criteria 14, 15, 31 and 32 of Appendix A to 10 CFR Part 50.

101. In order to meet these criteria the Staff requires that the steam generator tubes be designed with sufficiently thick walls so that:

> "1. tubes with detected acceptable defects will not be stressed during the full range of the normal reactor operation beyond the elastic range of the tube material;
>
> "2. a factor of safety of three is maintained against burst of the tubes during normal operation (as required by ASME [Boiler and Pressure Vessel (BPV)] Code, Section III);
>
> "3. available margins to failure under postulated accident conditions are comparable to those margins provided by Appendix F 'Rules for Evaluation of Faulted Conditions' of Section III of the ASME [BPV] Code for such loadings for all other components of the reactor coolant pressure boundary;
>
> "4. crack-type defects that could lead to tube rupture, either during normal operation or

under postulated accident conditions, will not be accepted;

"5. the natural frequencies of the tubes will be sufficiently different from the exciting forcing frequencies during normal operation, as well as during postulated accident conditions, so that the steam generator tubing supports will not experience any damaging vibracions;

"6. the fatigue effects of cyclic loading forces will not cause failure of thinned tubes or tubes with service induced defects during normal operation or postulated accidents. The design transients which produce the cyclic loads, include normal power operation, expected instrument failure, equipment malfunction, and operator errors which result in reactor trips."

In satisfying the above stated six design criteria the Staff believes that the requirements of criteria 14, 15, 31 and 32 of Appendix A to 10 CFR Part 50 are also met. (Staff Witness Rajan at 3 following Tr. 5847)

102. The NRC Staff concluded that the steam generator tubes, tube sheet and other components for the proposed Unit 2 have been designed to meet all requirements of the Staff's design criteria to accommodate the sytem pressures and temperatures obtained under all expected modes of operation including all anticipated transients and to maintain the stresses within applicable limits. It is the Staff's view that this design assures that the steam generator tube integrity will not be reduced below the level acceptable for adequate margins of safety and is also considered adequate for issuance of a construction permit. (Id. at 4 through 18 and at Tr. 5850)

103. Focusing on the safety issues associated with the consequences of postulated loss of tube integrity and the necessary controls and surveillance requirements to provide reasonable assurance that steam generator tube integrity is not reduced below a level for acceptable service, Staff Witness Almeter listed five specific criteria, the meeting of which would demonstrate an adequate margin of safety. The specific criteria are:

> "1. The steam generators shall be of advanced design features with improved secondary water flow chracteristics.
>
> "2. The design of the steam generators shall permit in-service inspection of the tubes by methods that will detect incipient tube degradation. Tubes that could further degrade to marginal conditions shall be taken out of service by plugging.
>
> "3. The secondary system water chemistry shall be compatible with steam generator tube material to minimize the probability of tube degradation.
>
> "4. Provisions for monitoring the secondary water chemistry shall be included. These shall be used to detect the presence of deleterious impurities before significant tube degradation can occur.
>
> "5. Provisions for monitoring reactor coolant leakage to the secondary side shall be included in the design, and the limits on such leakage established to assure that tube degradation, should it occur, will be detected before it develops into serious deterioration of tube integrity." (Staff Witness Almeter at 3 and 4 following Tr. 5847)

104. The steam generator tubes in proposed Unit 2, as a part of the reactor coolant pressure boundary, are designed to Class I requirements of the ASME BPV Code Section III in conformance with 10 CFR Part 50.55(a). Design of the steam generator tubes considers "faulted conditions" (PSAR, § 5.5.2) of which a LOCA is included. (Applicants' Panel at 11 following Tr. 6021.) PSAR §§ 5.5.2 and 5.2.1.2 present the transients for which the reactor coolant system is designed. These events are far in excess, in both number and severity, of those which are anticipated to occur during the life of the facility. (Id.)

105. The steam generator is of an advanced design utilizing an integral economizer to improve secondary circulation. In the economizer design the feed water enters near the bottom of the dary side of the steam generator and flows across the tube sheet, thus minimizing the susceptibility for solids accumulation on the tube sheet. (Applicants' Panel at 13 following Tr. 6021) This design has the potential of minimizing the local concentration of impurities and the deposition of solids carried in by the feed water, thereby providing further protection against tube degradation by stress corrosion cracking and localized tube wall thinning (wastage). Applicants have committed in Amendment 18 to the PSAR, dated April 28, 1975, to conduct a steam generator development program to confirm the adequacy of the integral

economizer design. (Staff Witness Almeter at 5 following Tr. 5847)

106. The chemical treatment of the secondary coolant of Unit 2 will not utilize the phosphate method which has been related to corrosion at some plants. The secondary water will be treated by an all-volatile method (AVT) in conjunction with full flow demineralization to minimize the buildup of caustic-forming impurities and scale-forming solids in the steam generator. (Staff Witness Almeter at 6 following Tr. 5847)

107. The steam generator tubes will be made of Inconel-600, which is resistant to corrosion by chloride impurities, thereby reducing potential degradation from seawater intrusion. (Staff Witness Almeter at 5, following Tr. 5847) Additionally, the design thickness of the tube wall incorporates a general corrosion allowance that will provide for reliable operation over the plant lifetime. (Applicants' panel at 13-14 following Tr. 6021) Inconel-600 is also resistant to degradation by radiation. (Staff Witness Almeter at Tr. 5863)

108. The design of the Unit 2 steam generators permits in-service inspection of the tubes by methods that will detect potential tube degradation. Periodic surveillance in accordance with Regulatory Guide 1.83 will detect tube

degradation in a timely manner to permit plugging. (Staff Witness Almeter at 5 following Tr. 5847)

109. Localized corrosion has lead to steam generator tube leakage in some operating reactor plants through stress assisted caustic cracking and wastage. The caustic stress corrosion type of failure is minimized by controlling bulk-water chemistry to a specification which reduces free caustic in the generator. Wastage has not been a problem when the AVT control was used. (Staff Witness Almeter at Tr. 5889, et seq.) Monitoring of the secondary water chemical properties will detect out-of-specification conditions on a timely basis to minimize buildup of impurities in the steam generators. Maintaining low levels of impurities will decrease the probability of steam generator tube degradation and enhance tube integrity. (Staff Witness Almeter at 6 following Tr. 5847) Witness Almeter stated that he would expect no more corrosion or erosion to occur in the secondary system than occurs in the primary system which he estimated at 0.02 mils per year or less. (Tr. 5891) He also stated that with the program outlined by the Applicant in the PSAR he would not anticipate any problem with stress corrosion. (Tr. 5890)

110. Prior to the May 1976 testimony a phenomenon known as tube denting was observed only in those steam generators

with coolant treated with phosphate secondary water chemistry for some time before conversion to AVT. (Staff Witness Rajan at 2 following Tr. 9044) The subject of denting was not discussed in Applicants' or Staff's earlier testimony. Recently however, denting has been observed at two CE PWR facilities--Maine Yankee and Millstone Unit 2--both of which have operated exclusively on AVT. In this context the Applicants and Staff presented evidence regarding the denting phenomenon in relation to Unit 2. (Applicants' Witness McCracken following Tr. 8903 and Staff's Witness Rajan following Tr. 9044)

111. According to Applicants' Witness McCracken, operating experience and laboratory testing indicate that at least the following conditions must exist simultaneously to produce denting: (a) a region capable of concentrating impurities must exist adjacent to a tube (historically an annulus between a tube and a tube-support plate); (b) a carbon steel tube support plate; and (c) the ingress of impurities that can produce a local acidic environment. Denting is caused by accelerated corrosion of carbon steel in the tube/tube support plate annular regions. The corrosion product magnetite has about half the density of carbon steel. As corrosion proceeds the tube is crushed by an advancing front of hard adherent magnetite. Applicants' Witness McCracken and Staff Witness Rajan

both discussed the conditions necessary to produce denting and the improvements in the mechanical design, the materials of construction and the operating procedures which would eliminate or at least minimize the potential for denting of the steam generator tubes proposed for Unit 2. The improvements are:

(1) Tube support design. The tube bundle will be supported by egg crate structures rather than drilled support plates. These have improved flow characteristics and improved corrosion resistance in the region of contact with the tubes. The resistance to denting in tubes supported by egg crate structures has already been verified in CE plants, whereas denting has been observed at the drilled carbon steel support plates.46/

(2) Flow distribution baffles. These baffles will provide balanced flow through the economizer and boiler region of the tube bundle thereby minimizing areas of low flow velocity where sludge buildup might occur. Additionally, the flow velocities in this region will be sufficiently high that the area between the tube and its support will be swept clean of any suspended corrosion products or low solubility materials.

(3) Tube support materials. The egg crate support structures will be fabricated of type 409 stainless steel. The flow distribution baffles are type 405 stainless steel. Neither of these materials is susceptible to the accelerated corrosion responsible for denting at carbon steel supports. (Rajan testimony following Tr. 9044; McCracken testimony following Tr. 8903)

46/ Denting in the tube sheet region has not been a problem with CE commercial steam generators apparently because of the process used in joining the tubes and tube sheet which virtually eliminates areas where denting might occur. (Applicants' Witness McCracken at 6 and 7 following Tr. 8903)

In addition, improvements in the steam condenser design, the incorporation of full flow demineralization procedures, and the adaption of condenser leakage detection systems will allow better control of the purity of the secondary coolant and will minimize the possibility of producing a local acidic environment--one of the necessary conditions for denting. (Applicants' Witness McCracken at 7 following Tr. 8903; Staff Witness Rajan at Tr. 9046)

112. CE steam generator tube integrity has been identified as one of a group of "generic issues" which the Staff has reviewed. (SER Supplement 4, Appendix D at p. D-16, 17, Task A-4 Combustion Engineering Steam Generator Tube Integrity.) The Staff concluded that based on its review of the measures that will be taken by Applicants to assure that the tubes will not be subjected to conditions that will cause deleterious wastage or cracking, a construction permit for Unit 2 can be issued with reasonable assurance that there will be no undue risk to the health and safety of the public. The Staff further stated: "The efforts under A-3 (Westinghouse Steam Generator Tube Integrity) regarding steam generator tube integrity may result in improved criteria that could provide further assistance in this regard. However, such improvements are likely to be procedural rather than system modifications and their application to the Pilgrim Unit 2 facility is a matter

that can reasonably be left to the operating license stage of review. Accordingly, our previous conclusions in the Pilgrim Unit 2 SER regarding the issuance of a construction permit are unaffected by this on-going generic task." (Id. at D-17)

113. Seawater will cool the condenser at Unit 2 through tubes of a titanium alloy. Titanium also resists chloride attack and will reduce the probability of seawater in-leakage through the condenser system. (Staff Witness Almeter at 5, following Tr. 5847) Titanium has been used very successfully for this purpose in a number of nuclear power plant condensers, for example at San Onofre 1 in California. (Applicants' Witness McCracken at Tr. 8906, 8907)

II. G. b. Adequacy of Regulatory Staff Inspection Practices

114. Staff Witness Reinmuth described the NRC program for the inspection of nuclear power plant manufacturers. He testified that in considering the overall adequacy of the NRC's inspection effort, it is important to note that there are four levels of inspection which follow the defense in depth concept. The first level is the requirement that each individual vendor have a directly employed inspection staff independent of the personnel actually performing the manufacturing work (vendor QA program requirements). The second line of inspection (or defense) is that provided by the buyer's (Applicants or their agent) inspection activity and as specified in Appendix B to

10 CFR Part 50. The third level in the case of ASME coded products, is a third party review of vendor's QA program. Coded product vendors must contract for the services of one or more authorized inspectors. The inspectors are employed by a state or an authorized inspection agency, usually an insurance company. Before a coded product is used in a reactor facility, that product must be stamped with an ASME code symbol and a report prepared certifying that the product meets code requirements. The code inspector as well as the manufacturer (vendor) must sign the certification. The fourth level of inspection is that performed by NRC, which is an audit of each of the other levels and thus provides assurance that the much larger program of the other three levels is effectively carried out. The total nuclear inspection activity is thus pyramided, with each layer of activity verified, inspected and/or audited by those above. (Staff Witness Reinmuth at 8 and 9 following Tr. 4520)

115. Reinmuth described in detail the NRC inspection program directed to vendors. This program utilizes a special technical staff, highly qualified both by education and experience, who inspect vendors on a nationwide basis. Typical vendors inspected included nuclear steam supply systems suppliers, architect-engineering firms and manufacturers of components. The selection of vendors and the frequency of

inspection depends upon the importance of the product or the service to safety, the inspection efforts of others, the past performance of the particular vendor and the necessity of investigating problem cases that may arise. During a typical eleven-month period this process included 149 inspections of 104 vendors including eight team inspections of Bechtel and three of CE. These inspections were conducted by a staff of thirteen. (Staff Witness Reinmuth, at 3 through 6 following Tr. 4520)

116. In response to questioning by Intervenor Cleetons concerning a 1973 task force report alleging deficiencies in the NRC vendor inspection practices, Staff Witness Reinmuth testified that there had been substantial improvement in the vendor inspection effort since 1973 evidenced, in part at least, by a significant increase in inspector manpower. (Tr. 4536 through 4540) The witness, in response to questioning by members of the Board, further ascribed the recent improvement in inspection practices to the growing role and acceptance of quality assurance and the general upgrading and improvement of relevant codes and standards. (Tr. 4559 through 4562)

II. G. c. Compliance with Appendix I

117. Appendix I to 10 CFR Part 50 requires that, in addition to demonstrating compliance with certain numerical

guidelines on design objectives for doses to individuals from radioactive effluents released to unrestricted areas,

> "....the applicant shall include in the radwaste system all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can for a favorable cost-benefit ratio effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. As an interim measure and until establishment and adoption of better values (or other appropriate criteria), the values $1000 per total body man-rem and $1000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be used in this cost-benefit analysis." (10 CFR 50 Appendix I § II.D)

118. Applicants' Witness Larson testified that the procedure used to demonstrate compliance with the numerical guidance of Appendix I, was as follows:

> "We began with a base case system (identified as Alternate A) capable of meeting the liquid effluent numerical design objectives of Appendix I for doses to individuals. Then we added equipment sequentially to this system defining such incrementally augmented systems as alternatives B, C, D, E.....From this radiological and cost information, using values of $1000 per total body-rem and thyroid-rem, it was determined whether or not the system augment was required." (at 10 following Tr. 7248)

119. Descriptions of the Applicants' "base case" radwaste treatment systems are contained in Applicants' FSAR § 11.0 and particularly Figures 11G-1, 11G-7-1, 11G-8, 11G-9, 11G-10, and 11G-11-1. (See also Applicants' testimony following Tr. 7248 and Staff testimony following Tr. 6482 and 7659)

120. The current design of the liquid radwaste system of Unit 2 incorporates Alternates B through E as augments to the base case, Alternate A. An analysis by the Applicants of the effects of these four additions on the basis of the $1000 per manrem guide (10 CFR 50 Appendix I, § II.D) shows that none of these additions (not even B alone) will provide whole-body protection of the population from exposure at a cost of $1000/manrem or less. [The Applicants and the Board have interpreted the language of Appendix I as a total annual cost of $1000 to reduce the exposure by 1 manrem per year. (Applicants' Witness Larson at Tr. 7301)] The addition of the initial augment, leading to Alternate B, is expected to reduce the exposure by 14.1 manrem/year at a total cost of $49,400 per year or $3500/manrem. Similarly, augments leading to Alternate E will reduce the exposure at a cost of $69,000/manrem. (PSAR Table 11G-15 also included in Applicants' Panel testimony following Tr. 7248 as BECo Exhibit RA-1) At this stage of design and review, however, it will not be economic to make alterations removing these augments. (Applicants' Witness Larson at 11 following Tr. 7248)

121. Similar analyses were made of the six separate systems from which gaseous radioactive effluents are expected to derive. These are:

1. gaseous waste management;
2. vent collection;
3. condenser air ejector;
4. containment purge;
5. auxiliary building vent; and
6. turbine building ventilation.

122. The last of these was predicted to release so little activity when designed as Alternate A that no perceived augment would be cost effective and, consequently, no additional analysis was made. Analyses of the remaining five, however, showed that, as in the liquid effluent study, the annual cost of viable augments would be greater than the prescribed $1000/man-rem. It is noted, however, that Item 1, the gaseous waste management system, has been designed to Alternate E, i.e., with four augments, Items 2 and 4 have been designed to Alternate B, while Items 3 and 5 remain in the base case. (PSAR Tables 11G-16, -28, -34, -43, and -49 also included as BECo Exhibits RA-2 through RA-6 attached to Applicants' Panel testimony following Tr. 7248; see also Applicants' Witness Larson at 13 and at 24 through 29 following Tr. 7248)

123. The Staff independently evaluated the Applicants' radwaste systems for conformance with Appendix I requirements. The Staff evaluation consisted of (1) a review of the Applicants' radwaste systems and supplemental information describing

the plant and the environment within a 50 mile radius as described in the PSAR, the ER and information provided by letter in response to Staff requests; (2) independent Staff calculations of expected radioactive release based on PWR operating experience; (3) calculation of individual and population doses out to a 50 mile radius in accordance with standardized methods; (4) evaluation of the cost-benefit ratio for potential radwaste-system additions in accordance with standardized methods. The Staff's standardized methods for evaluating compliance with Appendix I are found in NUREG-0017 and Regulatory Guides 1.109 and 1.110. (Staff Witnesses Weller and Gotchy, at 1 through 4 and Table 3 following Tr. 6482 and following Tr. 7659)

124. The Staff's independent evaluation of the Applicants' design concluded that the release of radioactive materials from Unit 2 will not result in exposure of any individual in an unrestricted area in excess of limits established by 10 CFR § 50.34a and Appendix I. These are specifically:

(1) an annual dose or dose commitment from all radioactive materials released in liquid effluents in excess of 3 mrem to the total body and 10 mrem to any organ;

(2) an annual dose from all radioactive materials in gaseous effluents in excess

of 10 mrad for gamma radiation and 20 mrad for beta radiation; and

(3) an annual dose or dose commitment from radioactive iodines and particulates in excess of 15 mrem to any organ.

(Staff Witnesses Weller and Gotchy at 4, 5 and Table 4 following Tr. 6482 as amended by supplemental testimony at 2, 3 and Table 4 following Tr. 7659)

125. Population dose calculations from liquid and gaseous releases from Applicants' "base case" systems for radwaste handling and treatment demonstrate compliance with Appendix I effluent design objectives. The calculations show less than 1 manrem to the total body and less than 1 man-thyroid-rem from liquid releases and 1.8 manrem to the total body and 3.4 man-thyroid-rem from gaseous releases. (Id. at 5 and Table 5 as amended by p. 3 and Table 5 following Tr. 7659) In accordance with the $1000 per manrem criterion the maximum expenditure that could be required for a radwaste system augment is less than $1000 for liquids and $3400 for gases assuming that augments would reduce the discharge to zero.

126. No evidence was presented to refute the Applicants' demonstration that the design of Unit 2 complies with the ALARA Standards of Appendix I to 10 CFR 50.

III. FINDINGS OF FACT - SITE SUITABILITY

A. Geography and Exclusion Area

127. The proposed site for Unit 2 is a 528-acre tract on the western shore of Cape Cod Bay located in the Town of Plymouth in Plymouth County, Massachusetts, approximately 4.4 miles east-southeast from the center of Town and approximately 38 miles southeast of Boston, Massachusetts. (PSAR § 2.1.1; SER § 2.1, following Tr. 3717)

128. The site is generally rectangular in shape, about 0.45 miles wide, with its long dimension of 1.8 miles roughly parallel to the Bay shore. The elevation varies from sea level to approximately 280 feet. Open water occupies about 60 percent of the area within a 50-mile radius. (PSAR § 2.1.2)

129. BECo owns all of the land and mineral rights within the site boundary except for a triangular tract adjacent to the exclusion area and a portion of the land beneath the proposed Unit 2 structure which is jointly owned as tenants-in-common with the other Applicants. BECo possesses authority to determine activities. (PSAR § 2.1.2; SER § 2.1 and SER Figure 2.2)

130. Applicants can control all activity within the exclusion area except for the use of a public way, Rocky Hill

Road, which provides access to Priscilla Beach. The Plymouth Police Department has agreed with BECo to barricade this road at site boundaries in the event of an emergency. Visitors, at Applicants' discretion, are permitted inside the exclusion area to the station overlook and to the shorefront-breakwater recreational area. (PSAR § 2.1.2 1; SER § 2.1)

131. The Staff has calculated the radiological doses for postulated design basis accidents and has concluded that 10 CFR Part 100 doses will not be exceeded at the boundary of the exclusion area which, at its closest point, is 441 meters from the proposed Unit 2. (PSAR § 2.1.2.1; SER § 2.1 and Table 15.2; Staff Exhibit 9, Report on Site Suitability at 3 following Tr. 7466)

III. B. Demography, Low Population Zone and Population Center Distance

132. Guidance on considerations of the demography of a proposed nuclear generating station site is furnished to the Staff through § 2.1.3 of the Standard Review Plan.[47/] The population density within a 30-mile radius of the proposed installation need not be a factor in comparison of alternative sites if the density at startup and at the end of the projected

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47/ NUREG-75/087, "Standard Review Plan For The Review Of Safety Analysis Reports For Nuclear Power Plants LWR Edition" (September 1975).

life[48/] do not exceed 500 and 1000 persons per square mile, respectively. (Staff Witnesses Grimes and Soffer at 2 following Tr. 1842)

133. On the basis of data from the 1970 census updated by the Applicants to August 1975, the Staff projects the maximum population densities in 1980 and at the conclusion of plant operation to be 370 and 903 persons per square mile, respectively. Accordingly, the Staff concluded that no special consideration of demography was necessary in the review of alternate sites. (at 3 following Tr. 1842)

134. Since the proposed site of Unit 2 is coastal, an area of a 30-mile radius[49/] centered at the site encompasses both land and water areas. The Staff determined the population density to be the ratio of the population within the circle of 30-mile radius to its area regardless of the topography. (Tr. 1903, 1920)

135. In a rationale of this method Staff Witness Grimes pointed out that the dispersal of air-borne contaminants is

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48/ The most recent schedule for Pilgrim 2 establishes commercial operation during December 1985. (Applicants' Exhibit 22 served September 25, 1980, at 20) The population density lies commensurate with this revised schedule will be considered in the forthcoming hearings on emergency planning.

49/ The 30-mile distance was established as the limit within which the effects of a major accident may be significant. (Grimes Tr. 1904)

distributed in a manner characteristic of a wind-rose regardless of the population distribution. During onshore winds, exposures may occur; during offshore winds, there would be few if any exposures. The Staff's method, therefore, provides a suitable averaging process. (Staff Witnesses Grimes and Soffer at Tr. 1921)

136. The area adjacent to the Pilgrim site is attractive to vacationers and tourists. The present permanent population of Plymouth is 29,000; additionally, there are 14,000 seasonal residents for periods of three to four months. An estimated 300,000 transients are in the area in the course of a year, most for only a few hours. In determining the population density the Staff considered a weighted average of these three components (Staff Witnesses Grimes and Soffer at 3 following Tr. 1842; Tr. 8446, Tr. 8453)

137. The testimony of Cleeton Witness Frieden on the population density in the vicinity of the proposed Unit 2 does not disagree with that of the Staff.[50/] He presented the findings of two local regional planning groups including some projected population statistics. (Tr. 8417) A detailed comparison of these data with the Staff's values was not satisfactory because the boundaries of the several areas considered did not coincide.

50/ Mr. Frieden's oral testimony begins at Tr. 8406. No written testimony was submitted.

138. Witness Frieden estimated the population density of Plymouth would be 310 persons per square mile in 1980; 400 persons per square mile in 1990; and 450 persons per square mile in 1995. In these determinations he "did not consider water areas." (Tr. 8434, 8436) Presumably the densities will be less by the Staff's method. He judged that an area of a 30-mile radius around Unit 2 would have a population density in 1986 less than 500 persons per square mile were the salt water regions included. (Tr. 8448, 8452) He also concluded that the population projections appearing in the Staff's Site Suitability Report (Staff Exhibit 9 following Tr. 7466) are not grossly in error. (Tr. 8438)

139. In accordance with Commission Regulations [10 CFR § 100.11(a)] the Applicants and the Staff established a low population zone (LPZ) and a population center distance.[51/] These entities are related by the requirement that the distance from a reactor to a population center shall be at least one and one-third times the radius of the LPZ.

140. Investigations by the Staff of the distribution of population and of community institutions in and near central

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51/ Absent a specific description, Applicants and Staff chose as a population center an area enclosing 25,000 individuals with a density of 2,000 persons per square mile at any time during the lifetime of the reactor. (SER Supplement 1 at 2-1 and 2-2 following Tr. 3717)

Plymouth lead to the identification of an area encompassing those institutions and other parts of Plymouth as the population center. The corresponding distance from the Pilgrim Site is about 3.1 miles. Accordingly, the radius of the LPZ was set by the Staff at 2.3 miles, maximum. A Staff evaluation of the potential radiological consequences at a distance of 2.3 miles from a design basis accident concludes that they will be within the guidelines of 10 CFR Part 100. (SER Supplement 3 at 2-5 following Tr. 8921)

141. Although the record does not support the acceptance by the Applicants of an LPZ of this size, Revision 38 of the PSAR describes an LPZ of 2.3 mile radius. (PSAR at 2.1-5, Staff Witness Licitra at Tr. 8927; see also discussion at Tr. 9087)

C. Nearby Industrial, Transportation and Military Facilities

142. Except as noted in the following paragraph, there are no nearby industrial, transportation or military facilities which would affect the suitability of the proposed Unit 2 site. (PSAR § 2.2.1; SER § 2.2) There are no airports within five miles of the proposed site and no aircraft flight patterns within two miles. State Highway No. 3A (a 2-lane undivided paved road) is approximately 0.7 miles west of the site and State Highway No. 3 (a 6-lane divided road) is approximately

three miles west of the proposed site. Boats which use Plymouth Harbor pass two to three miles north of the station, and ships which use Cape Cod Canal pass about four or more miles east of the station. (PSAR §§ 2.2.1, 2.2.2; SER § 2.2)

143. A witness for Intervenors Cleeton testified that contrary to PSAR § 2.2.1 there is a petroleum products storage facility (fuel tank farm) within five miles of the proposed site. (Frieden Tr. 8422) Following that testimony the Applicants determined that such a facility is located about one-half mile south of Route 3 in Plymouth at a point about 4.1 miles from the proposed Unit 2. The Facility is licensed to store 30,000 gallons of diesel fuel, 250,000 gallons of No. 2 fuel oil, 120,000 gallons of gasoline, and 75,000 gallons of propane. Applicants have assumed that at a time when the wind is blowing from the propane tank toward Unit 2 the tank ruptures when its content is the licensed maximum, and thereafter all the propane boils within a very short time, forming an initial puff which moves through adverse meterological diffusion condition and ignites at the worst possible location. Under these assumptions, the over-pressure at Unit 2 due to the propane explosion would be less than 0.1 psi. The Applicants further calculated that the over-pressure to be expected from a gasoline vapor-air mixture under similar conditions would be significantly less

than those caused by a propane release and that releases of diesel fuel or No. 2 fuel oil would not result in explosions at locations away from the storage tanks. Safety-related structures at the proposed Unit 2 are designed to withstand about 2.3 psi over-pressure. The Staff has reviewed the Applicants' analysis of the risk potential of releases from the fuel tank farm and finds them conservative. (SER, Supplement 3 at 2-5, following Tr. 9821) A comparison with an earlier independent analysis by the Staff of a similar risk potential (Wolf Creek Generating Station, Docket STN 50-482) confirms the Staff's current findings. (Id. at 2-6)

144. The impact of aircraft using Boston's Logan Airport on the Pilgrim site was considered by Applicants' Witnesses W. Wade Larson and Robert J. Merlino. (following Tr. 4577) That testimony was to the effect that there are no airways or airports close enough to the Pilgrim site to require an analysis of aircraft hazards to the proposed plant (Id. at 5 and 6) The nearest airway (V-141) is 3.6 miles distant and Logan Airport is 36 miles away. Airways more than two miles away and airports further than five miles away generally need not be analyzed under Regulatory Guide 1.70. The exception is that airports having a large number of operations must be considered, under the Guide, if a formula relating distance from the site and the number of annual

operations yields certain results. Considering the number of operations at Logan, it does not need analysis under the Regulatory Guide. (Id.)[52/]

145. Applicants analyzed the effect on the Unit 2 site of Logan Airport traffic and Airway V-141. In 1974, Logan had 295,000 aircraft movements and the Airway had a daily average of about 70 flights, ranging from 100 in the summer to 40 to 50 flights in the winter. Applicants' witnesses testified that the probability of an aircraft using Airway V-141 crashing at the Pilgrim site, calculated according to Section 3.5.1.6, Aircraft Hazards, of the NRC Standard Review Plan (NUREG-75/087), would be less than one in 10 million per year. Aircraft landing and taking off from Logan, except when on Airway V-141, do not generally approach the Pilgrim site. (Id. at 3 through 10)

146. On cross-examination by Mrs. Cleeton, Applicants' witnesses testified that the calculations of crash probability assumed that the aircraft always flew on course. (Tr. 4583)

52/ Exempted are airports where projected operations are less than 1000 d^2 where d, the distance in miles between the airport and the site, is greater than 10. In this instance the number of operations limiting the analysis is greater than 1,000,000. The Applicants and the Staff, however, did address the subject because it was a contention of one of the intervenors. (Staff Witness Fontecilla following Tr. 4654)

Absent knowledge by the witnesses of an established width of this, or any airway, a value equal to twice the distance from the center of the airway to the site of Unit 2 was assumed in the probability calculation. (Tr. 4627) This selection effectively abuts, in a vertical plane, the airway and the plant. It was further elicited by Mrs. Cleeton that aircraft movements at Logan were 316,744 in 1971; 306,202 in 1972; and 307,257 in 1973. (Tr. 4584) The Applicants have not projected Logan movements in 1985 or beyond but it was the judgment of the witness that considering the possibilities for expansion of Logan, the movements in the future will not significantly vary from the present number. (Tr. 4584) Private aircraft deviate from the airways. (Tr. 4594, 4595)

147. Staff Witness Fontecilla testified that the Pilgrim site is outside the Logan Airport controlled airspace. It is also outside an area within five miles of the runways at Logan and accident rates are highest within that distance of runways (At 1 following Tr. 4654) Commercial traffic approaches Boston on Airways V-16, V-139 and V-141. V-16 is at least 40 miles from the Pilgrim location and V-139 passes about 20 miles away. The center of V-141 passes about 3.5 miles east of Pilgrim. (Id. at 8) There are about 100 to 150 flights at altitudes from 2000 to 5000 feet on V-141 in the summer of which 40 to 50 are scheduled flights of an airline running between Boston and Hyannis and the balance are unscheduled

light craft. These flights, as they pass Pilgrim, are not on descending flight paths. (Id. at 2) The Staff calculated a probability of less than one in 30 million per year of an aircraft crashing into Unit 2 from V-141 and resulting in radiological consequences in excess of those defined in 10 CFR Part 100. (Id. at 1)

148. On cross-examination by Mrs. Cleeton, Witness Fontecilla said that airplanes frequently fly off-course and sometimes descend when not landing. (Tr. 4663) He said further that the difference in his calculation of a damaging crash probability and that of the Applicants, is that he considered only commercial and military flights and assumed that the other aircraft on V-141 were private or general aviation aircraft too small to cause significant damage to Unit 2 in a crash. (Tr. 4664) The witness thought there would be little reason for military traffic from Boston to Hyannis. (Tr. 4665)

149. The Plymouth Airport is nearby but cannot handle aircraft of more than 12,500 pounds; a plane of that size could not cause significant damage to the plant but it could start a small fire. (Tr. 4666) This was expanded upon in response to a Board inquiry and Witness Fontecilla said that a nuclear plant in the Pilgrim area would be designed to

withstand tornadoes of 360 miles per hour and associated missiles as well as seismic events and for that reason it could withstand a crash by a light aircraft. (Tr. 4672)

150. Witness Frieden testified that the airport at Plymouth is not within five miles of the Pilgrim site and that he was not knowledgeable of the landing pattern. He said the Planning Board of Plymouth reported 25,000 annual operations with light unscheduled aircraft at Plymouth Airport in 1972 and that an operation is either a landing or a takeoff or a touch-and-go procedure. The Planning Board predicted 75,000 operations by 1982 and 141,000 in 1992. (Tr. 8424-8439)

151. The aircraft activity at Weymouth Naval Air Station, located nearly 25 miles northeast of the Pilgrim Site, and its potential effect on Unit 2 was analyzed by neither the Applicants nor the Staff. The Weymouth air traffic is sufficiently low to place an analysis under the distance exemption of Regulatory Guide 1.70. (Staff Witness Merlino at Tr. 4602)

D. Hydrology

152. Cape Cod Bay is a broad, open-mouthed body of water facing northward, having a surface area of approximately 365,000 acres. The Unit 2 Site, adjacent to the shore, is in

a rectangular drainage basin the long axis of which runs approximately parallel to the shoreline. The immediate plant area of 50 acres is flat and gently slopes toward Cape Cod Bay. This area will be drained by a system of catch basins and culverts will flow directly into the Bay. The western section of the basin drains in a northerly direction to a marshy area which flows into a peat bog south of the existing switchyard and parking area. (PSAR §§ 2.4.1.1, 2.4.1.2; SER § 2.4.1; Staff Exhibit 9 at 5 and 6)

153. The grade elevation at the site of the proposed structures is approximately 22.5 feet above mean sea level (MSL). Except for the intake structure, all of the exterior accesses to safety-related structures are at or above the elevation of 23 feet MSL. (PSAR § 2.4.1.1; SER § 2.4.1; Staff Exhibit 9 at 5 and 6)

154. The Applicants and the Staff have evaluated the potential for flooding the safety-related structures. The probable maximum precipitation at the site would result in water levels of 23.5 feet MSL. This is about 0.5 feet above the floor grade on the turbine building side. If such flooding were to occur, there might be water seepage around a small door in the auxiliary building and around four doors leading into the turbine building. This leakage could be discharged by the

the in-plant drainage system, including the sump pumps located in the turbine building basement. (PSAR § 2.4.10.1; SER § 2.4.2) The proposed plant grade elevation of 22.5 feet above MSL for Unit 2 will provide adequate protection against the potential for flooding from the maximum probable precipitation.

155. The Applicants and the Staff have analyzed the potential for flooding due to a maximum probable hurricane. In such a case, waves could reach a height of about 3 feet on the northernly face of the auxiliary building. It will be waterproofed to protect against possible damage. The maximum leakage around each of its closed doors is estimated to be 20 gpm; this will be handled by the floor drain system and will be well within the capacity of the sump pumps. (PSAR § 2.4.10.2; SER § 2.4.1.1; Staff Exhibit 9 at 5 and 6) The proposed plant grade elevation of 22.5 feet above MSL for Pilgrim Unit 2 will provide adequate protection against the potential for flooding from the maximum probable hurricane and its wind and wave effects.

156. The intake structure, protected by breakwaters, is designed for a Bay-water surge level of 14.7 feet above MSL. A reinforced concrete substructure and the superstructure which houses the service water pumps will be designed for the static and dynamic effects of these waves. (PSAR § 2.4.10.2)

The safety-related equipment in the intake structure will be protected against the maximum probable flood. Drawdown of water at the intake structure may occur due to the stress of offshore winds. The Applicants and the Staff agree that the probable maximum drawdown of water at the intake structure due to a hurricane will be 10.1 feet below MSL. (PSAR § 2.4.11.2; SER § 2.4.3) This predicted minimum low water level will be about 13 feet above the suction bell of each pump, located 23 feet below MSL, thereby assuring a dependable water supply to safely shut down Unit 2.

157. The hydraulic gradient of the groundwater under the Unit 2 site slopes toward Cape Cod Bay. Because of this flow pattern, there is little likelihood of contamination of public or private wells caused by accidental releases of radioactive materials into the groundwater. The Applicants will not use any groundwater for the operation of proposed Unit 2. (PSAR § 2.4.13.1; SER § 2.4.4)

158. The Applicants intend to use water from the Bay during shutdown of the proposed facility under normal and emergency conditions. The Bay will provide an adequate supply of water for safety-related purposes. (SER § 2.4.3) 53/

53/ By letter of July 5, 1979 Staff Counsel informed the Board of a report on break-water damage at Pilgrim Unit No. 1. Since this breakwater will be used by the proposed Unit 2, the (footnote continued on next page)

III. E. Meteorology

159. Eastern Massachusetts experiences various types of storms including intense thundershowers, snow and ice storms, hurricanes, and northeasters. Northeasters are coastal cyclones which occur during the winter and are characterized by high winds and intense rainfall. Hurricanes with high winds and intense rainfall occur occasionally. Maximum sustained five-minute wind speeds at Logan Airport in Boston since 1933 have been between 52 and 87 mph. The latter speed was during the September 1938 great hurricane which registered sustained winds of 121 mph and gusts of 183 mph at Blue Hill Observatory, Milton, Massachusetts. Between 1886 and 1970, coastal Massachusetts experienced 18 tropical cyclones (sustained winds of 40 mph or more), 6 hurricanes (winds of over 74 mph), and the 1938 hurricane (wind speeds of over 125 mph). Toronados are not common; those that occur are not severe. (PSAR §§ 2.3.1, 2.3.2, Table 2.3-4; SER §§ 2.3.1, 2.3.2) Safety-related

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53/ (footnote continued) report was relevant to this case. The report indicated that the Applicants have committed to submit the final design of the Unit 2 intake structure for review and approval by the Staff prior to commencement of its construction. (SER § 2.4.2) Also as stated on p. 5 of this report, "....the Unit 2 intake structure can be designed to withstand the design basis flood without credit for the effects of the breakwater." The Board is of the opinion that this potential problem regarding the stability of the breakwater can be resolved and concurs with the procedure recommended by the Staff and committed to by the Applicants.

structures proposed for Unit 2 are designed to withstand tornados having a maximum wind speed of 360 mph. (PSAR § 3.3.2.1)

160. Local meteorological data have been collected at the Pilgrim site since May 1968, when a 200-foot-high meteorological tower was placed in operation. In April 1974, new equipment was placed on this tower and, in addition, a new 160-foot high tower was erected in order to collect the necessary data for the proposed facility. (PSAR § 2.3.3; SER § 2.3.3)

161. Estimation of radiation doses at the boundary of the exclusion area which might arise as a consequence of a release of radioactive materials during a design basis accident requires knowledge of atmospheric dispersion at the site. Necessary is an evaluation of the relative concentration of emissions (X/Q). Staff has recently[54/] supplied a value of X/Q equal to 5.6×10^{-4} sec/(meter)^3 expected to occur at the 441-meter exclusion radius in a direction towards Cape Cod Bay. This is the highest value of X/Q during the time interval up to two hours, following the

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54/ Staff Exhibit 67 dated November 19, 1980 and served on the Board and all parties. This exhibit was received into the record by Board Order dated December 16, 1980.

162. To counter the potential for exposure of water borne individuals where X/Q has a higher value [5.6×10^{-4} sec/(meter)^3, maximum], the Applicants have established an arrangement with the U.S. Coast Guard whereby offshore areas will be evacuated as necessary to limit the exposure of boaters to no more than that of onshore personnel. (Staff Exhibit 67 at 2)

III. F. Geology and Seismology

163. As required by the provisions of the Commission's regulations set forth in 10 CFR, §§ 50.34(a)(1), 100.11(c)(1), and Appendix A to Part 100, the Applicants have submitted information to the Staff on the geology and seismology of the proposed site and on foundation engineering for the proposed facility.

164. There are no identifiable faults or other geological structures in the immediate vicinity of the site which might be expected to localize earthquakes there. The nearest fault which has been mapped is located about 17 miles from the site, although the Staff indicates that a possibility of faulting exists about 10 miles away. (PSAR § 2.5.1.2.3; SER Supplement 3 at 2-9) So far as is known, the earthquake that has occurred closest to the site was 6 miles distant; this happened in 1881 and had a Modified Mercalli (MM) intensity of II. Twelve

earthquakes of MM intensity V to VI have occurred within 50 miles of the site, the nearest of which was about 15 miles to the southwest. There is no indication of faulting in the vicinity which would affect the suitability of the proposed site.

165. The Applicants' submittal has combined earlier data with information from recent investigations including original field explorations and theoretical studies to comprehensively explore the correlation of the larger New England earthquakes to identifiable tectonic structures. The program was designed to review historical New England seismicity together with the results of both earlier field investigations and recent onshore and offshore geophysical research including aerial, land and marine magnetic surveys, land gravity observations, and seismic reflection and refraction data. These results were correlated with integrative theoretical models. (Applicants Witness Famiglietti at 4 following Tr. 8830) According to the Applicants, the proposed Unit 2 site is located in the southeastern New England platform. (PSAR Figure 2.5-4A) No earthquake of intensity greater than MM VI has been recorded in the tectonic province within which the Site is located. (Applicants' Witness Famiglietti at 2 following Tr. 8830)

166. The analysis centered around an intense earthquake (Modified Mercalli VIII) which occurred off Cape Ann,

emission, that will prevail for more than five percent of the time. Consideration only of the periods of onshore winds reduces X/Q to 2.3×10^{-4} sec/(meter)^3, all other conditions remaining. The corresponding value reported earlier[55/] (PSAR § 2.3.4; SER § 2.3.4, SSR at 5) is 4.0×10^{-4} sec/(meter)^3. This reduction in X/Q stems from relatively recent meteorological data obtained during a year following May 1974 from improved monitors together with the use of a direction-dependent model which considers a) plume characteristics that deviate from theory under stable conditions with light winds, b) the existence of variable exclusion boundaries, and c) directional dependence of dispersion conditions. This modified methodology is embodied in Regulatory Guide 1.145. The recent value of X/Q [2.3×10^{-4} sec/(meter)^3] represents a greater dilution factor than does the value in the PSAR. Consequently, this lower value makes the Pilgrim Site even more attractive than formerly believed.

55/ Traditionally a distinction has been made between inland and coastal sites when evaluating atmospheric conditions. The calculation of X/Q at inland sites has been based on consideration of dispersion conditions for winds in all directions whereas for coastal sites only onshore winds were included. This distinction at the Pilgrim Site, on the shore of the Bay, resulted in elimination of about 38 percent of the meteorological data. The impact of the different assumptions for the two types of sites on the value of X/Q has only recently been recognized. ("Differences in Procedures for Estimating Atmospheric Dispersion Conditions at Inland and Coastal Sites," Board Notification dated April 4, 1979)

Massachusetts, in 1755. Applicants' position is that the Cape Ann quake, as well as others in New England, are associated with particular mafic plutons[56/] and with their setting in anomalous-faulted[57/] rock of the middle Cretaceous Age. Recent studies by the Applicants and their contractors have defined the southern boundary of the Cape Ann tectonic structure as 35 miles from proposed Unit 2. (Applicants' Witness Famiglietti at Tr. 8858) While neither Staff nor its consultant, U.S. Geological Survey (USGS), are in complete agreement with Applicants' position that the larger New England earthquakes (in particular the 1755 Cape Ann earthquake) are directly associated with a unique tectonic model of cylindrical mafic plutons and tangential faults, both Staff and USGS agree that the zone of high earthquake activity extends no closer than 35 miles from the Pilgrim Site. (SER Supplement No. 3 at 2-15 and Appendix B at B-2) The differences then become academic since the end result as regards seismic design would be identical, i.e., an Intensity VIII quake at a distance of 35 miles from the Site as the basis for seismic design. Accordingly, the Pilgrim Site, being within a different seismic

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56/ A pluton is a large body of once-liquid rock that rose to the earth's crust and solidified. The term mafic refers to the composition of the rock. (Tr. 8863) Cape Ann is some 50 miles north of the Pilgrim site. No mafic pluton has been discovered within 50 miles of the site. (Applicants' Witness Famiglietti at 39 following Tr. 8830)

57/ An anomalous structure is one mapped on land and inferred offshore by aeromagnetic studies. (Applicants' Witness Famiglietti at Tr. 8864)

region than Cape Ann, is considered not to be susceptible to such extremes of tectonic activity.

167. The analysis consisted of, first, an assumption that an Intensity VIII quake would occur within the Cape Ann structure at a location most proximate to the Pilgrim Site; second, an empirical extrapolation of that intensity a distance of 35 miles to the Site; and, lastly, a conversion, also empiric, to a horizontal ground acceleration. The results of this analysis lead to the conservative specification, at the Site, of a disturbance of effective intensity MM VII producing a ground acceleration having a horizontal component equal to 0.20 g.[58/] (Applicants' Witness Famiglietti at 5 following Tr. 8830)

168. Accordingly, the Applicants propose MM VII as the Safe Shutdown Earthquake (SSE)[59/] and assign 0.20 g as the

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58/ Conservatism is incorporated in these values in the following ways. MM VIII is an upper limit on the Cape Ann intensity [MM VII is indicated by some observations, (at 9 following Tr. 8830)]; the proposed MM VIII is placed in the Cape Ann structure at a point nearest the Pilgrim Site; the extrapolation resulted in an equivalent MM VI at the Site corresponding to an acceleration 0.13 g. (At 5 and 16 following Tr. 8830) MM VII and 0.20 g were, however, specified; the latter incorporates a soil amplification factor.

59/ The magnitude of the SSE is conservatively estimated to be 6.0 on the Richter scale. (Applicants' Witness Holt at 10 following Tr. 8830)

horizontal component of the corresponding ground acceleration. The Staff concurs in these values.[60/] (SER Supplement 3 at 2-15 following Tr. 8921; Staff Witnesses Bennett, Jackson and Kane at 6 following Tr. 8945; Tr. 8995)

169. Applicants purpose a horizontal ground acceleration of 0.1 g (one-half of the value for SSE) for the operating basis earthquake (OBE). The probability of experiencing an OBE during the 40-year operating life of the plant is estimated to be 0.1. (PSAR 3.71 and Figure 3.7-3) The Staff considers the horizontal acceleration of 0.1 g for the OBE to be acceptable and in accordance with the requirements of Appendix A to 10 CFR Part 100. (SER Supplement 4 at 2-2 following Tr. 10046)

170. The Applicants and their contractors testified to their testing and analyses of the soil at the Pilgrim Site and the assessment of the margin of safety against potential soil liquefaction[61/] during a safe shutdown earthquake. (Witnesses Famiglietti, Ferris, Seed and Poulos following Tr. 8881)

60/ In a recent finding the Appeal Board associated a ground acceleration of 0.15 g with a MM VII event. [Consolidated Edison Company of New York, Inc. (Indian Point, Units 1, 2 and 3) ALAB-436, 6 NRC 547 at 624 (1977)] The larger acceleration in the instant proceeding arises, in part, from the local soil conditions.

61/ Soil liquefaction is the potential for development of strain deformations when sand, under load and saturated with water, is subjected to strong earthquake motion.

171. The Applicants have investigated the subsurface materials at the proposed Unit 2 Site with 51 borings and by excavating two test pits below foundation level. The purpose of Applicants' investigation was to measure the in situ density of the soils and to determine from undisturbed samples the properties of the soils for the purpose of further evaluation. These investigations have shown that the soil consists of about 90 feet of dense, poorly-graded to well-graded sands and gravelly sands. The upper 20 to 30 feet of this soil contains layers of silt, silty clay, and sandy clay. Stratified sandy glacial outwash, which is the main load-bearing stratum at the site, overlies bedrock. Over the outwash is a complex mass of glacial till which is about 20 feet thick. Bedrock consists of contemporaenous igneous rocks, known as the Dedham granodiorite. Bedrock surface under the foundation area lies between 58 and 80 feet below MSL. (PSAR §§ 2.5.1.3.1, 2.5.1.3.3.1 and 2.5.1.3.3.2; SER at 8)

172. Liquefaction potential of sand is affected by its density, grain structure, history of subjection to sustained pressures, lateral earth forces, and prior seismic or other shear experience. A measure of resistance to liquefaction is the resistance to penetration. (Applicants' Witness Seed at 26 following Tr. 8881)

173. Although the density of the foundation soils, measured in the field, ranged between 80 and 130 lb/ft^3, it was not possible to determine the relative density[62/] because of stratification. The gross density is consistent with the 15 ton/ft^2 glacial loading estimated from topographic evidence of the 600-foot-thick glacial layer. Preparatory to determining liquefication characteristics, minimally disturbed soil samples were vibratory compacted in the laboratory in a manner comparable to that to which the soil underlaying the structures will be subjected. Laboratory samples so treated are considered representative of field properties. (Id. at 28 through 32)

174. From laboratory and field data, soil was characterized by a relation between penetrability, measured in blowcounts,[63/] and the corresponding cyclic stress ratio.[64/]

62/ Relative density, an important property in soil mechanics, rates a sample on a scale bounded by the actual density in the loosest condition (zero) and in the most tightly packed configuration (100%). (Applicants' Witness Seed at Tr. 8891)

63/ Blowcount is a measure of penetration being the number of impacts of a 140-lb mass, after a 30-in. free fall, necessary to drive a cylindrical annulus 12 in. into a sample. The high blowcount (<100) and the behavior of the adjacent Unit 1 foundation ("small settlement") point to the high preconsolidation pressure of the soil.

64/ The stress ratio is defined as the ratio of the average horizontal shear stress (induced by an earthquake) to the effective overburden pressure. (PSAR at 2A-79)

An empirical relation between these properties derived from historical earthquakes, of magnitude comparable to the SSE, defines a boundary between instances of liquefication and no liquefication. Data from soils at the Pilgrim Site lie in the "no liquefaction" region. [Applicants' Witness Ferris at 13 and unnumbered p. 42 (BECo Exhibit SL-2) following Tr. 8881]

175. The characteristics of the Pilgrim Site soil establish a vertical gradient in the horizontal ground acceleration arising from seismic activity. These characteristics led the Applicants to set 0.15 g at foundation level corresponding to 0.20 g at the surface. (Applicants' Witness Ferris at 5 following Tr. 8881) The Staff does not disagree. (Staff Witness Bennett at Tr. 9024)

176. For each of many locations under and around proposed Unit 2 structures a factor of safety was determined.[65/] These safety factors are 2.0 or more for a ground surface acceleration of 0.25 g. [Applicants' Witness Ferris at 17 and unnumbered p. 47 (BECo Exhibit SL-5) following Tr. 8881]

177. On the basis of MM VII as the SSE and of the properties of the Pilgrim Site soil, the Applicants conclude that an adequate margin of safety against disruptive seismic

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65/ A factor of safety is the ratio of the available soil strength to the (expected earthquake) induced stress. (Applicants' Witness Ferris at 11 following Tr. 8881)

forces exists at the Site without special preparation.[66/] The Staff concurs. (Staff Panel at 6 following Tr. 8945; Staff Witness Kane following Tr. 8948)

178. The Staff concludes, based on past experience with the design of nuclear power plants, that reactors of the general type and size proposed can be, and have been, safely designed to withstand an event of intensity as great as MM VIII. (Staff Exhibit 9 at 8 following Tr. 7466)

66/ Had the results of the investigations and analyses been different the Applicants were prepared to incorporate a procedure for permanently dewatering the Unit 2 foundation. (See Testimony of Applicants' Witness Poulos at 13 following Tr. 8207 and Staff Witness Kane following Tr. 7470)

IV. FINDINGS OF FACT - ENVIRONMENTAL MATTERS

A. General

179. Pursuant to the National Environmental Policy Act of 1969 (NEPA), the Notice of Hearing in this proceeding[67/] requires this Board to consider and decide:

> "5. Whether in accordance with the requirements of Appendix D of 10 CFR Part 50 [now 10 CFR 51], the construction permits should be issued as proposed."[68/]

The Notice of Hearing further stated the following: "With respect to the Commission's responsibilities under NEPA, and regardless of whether the proceeding is contested or uncontested, the Board will, in accordance with Section A.11 of Appendix D of 10 CFR Part 50: (1) determine whether the requirements of Section 102(2)(C) and (D) of NEPA[68A/] and Appendix D of 10 CFR Part 50 [now 10 CFR 51] have been complied with in this proceeding; (2) independently consider the final balance among conflicting factors contained in the record of the proceeding with a view to determining the appropriate action to be taken; and (3) determine whether the construction permits should be issued, denied, or appropriately conditioned to protect environmental values."

67/ 39 Fed. Reg. 1786, (January 14, 1974).

68/ Items 1 through 4 are issues pursuant to the Atomic Energy Act of 1954 (as amended). Those are listed within paragraph 19 supra.

68A/ In 1975, Subsection D was lettered as Subsection E. The wording of the Subsection was not changed by that amendment.

IV. B. Compliance with Sections 102(2), (C) and (E) of the National Environmental Policy Act of 1969 (as amended) and 10 CFR Part 51

a. Need for Power

180. In its deliberations on this "need for power" the Board is cognizant of the substantial margin of uncertainty attendant to any quantitative prediction of energy consumption in even the near future, to say nothing of the requirement nearly a decade hence when Unit 2 is proposed to operate. In the course of these hearings several witnesses approached the problem through estimates of the anticipated growth rates of both energy requirements and peak-power demands during the last part of this century with the realization that most of the predictive analyses were fraught with uncertainties. Some estimates were based primarily on judgmental extrapolations of past energy sales modified by economic trends, home building activity, plans of major commercial and industrial developers, etc., and tempered by national reports from Electrical World and the Edison Electric Institute. (Applicants' Witness Sweeney at 21 following Tr. 7927) More sophisticated methods, utilizing price elasticity[69/] and econometric equations, were employed by others.

69/ Price elasticity is defined as the ratio of the fractional change in the quantity demanded to the fractional change in price.

181. Applicants and Staff witnesses addressed the issue of price and demand elasticities as a forecast mechanism. Applicants' Witness Guth stated that "[o]ne detects an implicit argument made by supporters of economic models of energy demand for forecasting purposes, namely, that such forecasts represent an objective non-judgmental alternative to traditional methods. But this position is simply erroneous." The witness further observed that there is very little that is objective or non-judgmental about forecasts of future economic activity, populations, price levels of fuels, prices of electricity, and capital costs. Conclusions from econometric models will reflect these uncertainties. (at 37 through 39 following Tr. 2647)

182. Staff Witness Nash pointed out that the derivation of elasticities is very complex and by its nature rather inexact. A partial analysis relating only price and electricity use can be expected to give erroneous results since the demand for electricity is determined by complex interactions of economic, social and political factors. The advantage of econometric methods over others can be questioned since models predicting electricity demand, no matter how mathematically complex, are not free from subjective factors. (at 3 through 5 following Tr. 3110)

183. Recognition must also be made of the legal responsibilities imposed upon a public utility to provide to the public it serves a continuing and reliable product with attendant severe consequences in failure to so do. It is, therefore, incumbent upon the utility to be reasonable in its forecast. [Kansas Gas and Electric Company, et al. (Wolf Creek Generating Station, Unit No. 1), ALAB-462, 7 NRC 320 (1978); Carolina Power and Light Company (Shearon Harris Nuclear Power Plant, Units 1, 2, 3 and 4), CLI-79-5, 9 NRC 607 at 609 (1979)]

184. For these reasons this Board turns to the concept that, absent a firmly established "need" for the energy output of Unit 2, its operation will be favorable in the national interest because of the traditional dependence of New England on oil in the production of electrical energy. This concept has been termed "substitution."

185. It is public policy that oil, particularly imported oil, either in short supply or invaluable for other uses as in the petrochemical industry, be replaced as a fuel in steam generating plants by coal, uranium, etc. Additional uranium-fueled units may allow retirement or restricted use of fossil fueled plants unable to meet pollution control requirements

without extraordinary expense and difficulty.[70/]

186. Applicants' Witness Weiner testified to the fundamental bases for the need of Unit 2. One is the substitution concept, supra; another is achievement of predicted energy requirements discussed, infra. The third is the cost savings expected to accrue to New England electrical energy consumers directly from the output of Unit 2 and indirectly from the retirement of older, less efficient and more costly fossil plants. (At 3 following Tr. 10430; Tr. 10940)

187. During the course of the hearing, however, much attention was accorded the prognostications on the energy requirements of New England towards the end of this century. Thirty witnesses were presented on this aspect of the need for Unit 2: 15 by the Applicants; four by the Staff; eight by the Commonwealth Attorney General; two by the Commonwealth Governor and one by the Board from the then Federal Power Commission (FPC). The growth rates expected in the requirements for energy and for peak power were projected independently by witnesses of several parties.

70/ Power Plant and Industrial Fuel Use Act of 1978, P.L. 96-620, 92 Stat. 3289. [Public Service Company of New Hampshire, et al. (Seabrook Station, Units 1 and 2), ALAB-422, 6 NRC 33 at 90 et seq. (1977); Public Service Company of Indiana, Inc. (Marble Hill Nuclear Generating Station, Units 1 and 2), ALAB-459, 7 NRC 179 at 186 (1978); Dairyland Power Cooperative (La Crosse Boiling Water Reactor), ALAB 617, 12 NRC ___ (1980), affirming the Licensing Board decision on substitution at 11 NRC 44 at 77 (1980).]

188. Applicants presented their assessment of the need for Unit 2 through its ER[71/] and through two panels of witnesses nesses.[72/]

71/ Environmental Report, Applicants' Exhibit 1(k), Volume 1 at 1-1 through 1-36.

72/ The duration of these proceedings was such as to require updating some early testimony. The Applicants' first panel testified in December 1975 (following Tr. 2647) and consisted of: John H. Ferguson, Director of Rate Research and Forecasting Department, BECo; Donald V. Bourcier, Senior Load Analyst, NEPLAN; Abraham Gerber, Vice President, National Economic Research Associates, Inc. (NERA); Louis A. Guth, Vice President, NERA; Moshe Weiss, Senior Consultant, NERA; Kenneth O. Sten, Manager of Research and Planning Department, BECo; and Benjamin H. Weiner, Vice President, Power Supply Administration, BECo. The Applicants' second panel of witnesses testified on June 20, 1977 (following Tr. 7927) and consisted of: Robert O. Bigelow, Vice President and Director of Planning and Power Supply, New England Power Service Company and member of the New England Power Pool (NEPOOL) Planning Committee; Stephen J. Sweeney, Vice President, Steam Operations, Environmental Affairs, Planning and Research Organization, BECo; Cameron H. Daley; Manager of the Research and Planning Department, BECO; Louis A. Guth, NERA; Moshe Weiss, NERA; and Abraham Gerber, NERA. The Applicants' third panel was comprised of: B. H. Weiner, BECo; Philip A. Legrow, Generation Planning Engineer, BECo; Donald V. Bourcier, BECo; Arthur W. Barstow, Manager of Generation Planning, New England Power Planning. Its fourth panel consisted of F. Cort Turner, Vice President, Arthur D. Little, Inc.; and Niegel Godley and David Hanna both of the Energy Economics Section, Arthur D. Little, Inc. The testimony of the fourth panel was presented on July 16, 1979 (following Tr. 10430); that of the third panel on July 18, 1979 (Tr. 10730) except that of Mr. Barstow which was presented on August 27, 1979. (Tr. 11356) The written testimony of both the third and fourth panels is Applicants' Exhibit 19 bound following Tr. 10430.

189. Applicants are members of NEPOOL, formed in late 1974 for the purpose of enhancing the adequacy, reliability and economy of the power systems in New England. NEPOOL is responsible for planning bulk power facilities in New England. NEPOOL members serve over 95 percent of the electric power load in New England. (ER, Volume I, at 1-1; FES at 8-1)

190. NEPOOL, through its New England Power Planning Division (NEPLAN), forecasts regional load requirements as well as the type of generating capacity needed: base-load, intermediate, or peaking. Individual utility members or consortia of utilities, as in the case of proposed Unit 2, however, have the responsibility of selecting and installing new generating facilities. (FES at 8-1)

191. The interdependence and interconnection among the suppliers of electrical energy throughout a region together with the differences in seasonal demands and in other characteristics of the individual consituent utilities within the region, make imperative a close cooperative relation among those constituents. Accordingly, the unified areal projections and resources of NEPOOL are important to good business administration.

192. The need for Unit 2 in this context, as advanced by NEPOOL, is based on periodic load and capacity projections developed by the NEPLAN staff. The most recent of the series

of reports of these projections introduced in this record forecasts need for the period 1980-1995.[73/]

193. In its most recent report NEPOOL has forecast for 1979 through 1995 a 2.6 percent annual compound growth rate in energy, a 2.0 percent growth rate in summer peak power demand, and a 2.7 percent rate for winter demand. These estimates are about one percentage point less than the values of April 1, 1979.

194. Forecasts of the electrical energy and power demands within the BECo service area have also been presented. The most recent value for the 1979 to 1989 interval is an annual compounded growth rate of 2.0 percent in energy and 2.4 percent in peak power.[74/] These values are significantly reduced from earlier predictions.[75/]

73/ "NEPOOL Forecast for New England 1980-1995," April 1, 1980; New England Power Planning, West Springfield, MA, Applicants' Exhibit 22, served on the Board and all parties, September 25, 1980, admitted by Board Order dated October 2, 1980. The earliest report in the record is for the 1976-1987 interval taken from "New England Load and Capacity Report 1976-1987" introduced by Daley at 31, following Tr. 7927. The second forecast introduced is "New England Load and Capacity Report 1978-1989," Applicants' Exhibit 20-C, introduced by Barstow, a NEPOOL employee, at Tr. 10740 (see Tr. 11360 for correction to exhibit numbers).

74/ "Long-Range Forecast of Electric Power Needs and Requirements" Volume 1, p. 3, Applicants' Exhibit 21-A served September 25, 1980 admitted October 2, 1980.

75/ See, for example, the 1976 energy growth estimates of 3.7 to 5.8 percent for the period 1974-1980 and 3.3 to 5.1 percent for 1980-1986, Applicants' Witness Guth at 38 and BECO Exhibit NP-27 at unnumbered p. 67 following Tr. 7927; see also BECo Exhibit NP-21 at unnumbered p. 57 following Tr. 7927 for a series of 1976-1986 comparative forecasts.

195. The Northeast Power Coordinating Council has established a system reliability criterion whereby the area's electric generating power supply shall be less than the area load no more than one day in ten years. To fulfill this condition, a reserve of 23 percent of the peak-power load is required by NEPOOL. (FES at 8-9)

196. NEPOOL capacity and reserve-margin projections[76/] based on predicted winter-peak power loads with Unit 2 coming on line in December 1985 are given in the following table.

197. Experience indicates that slippage will occur in some of the startup schedules factored into the above predictions. Consequently, the required NEPOOL reserve margin, 23 percent, may not be available as early as the lace 1980s in the additional absence of Unit 2. (Applicants' Witness Weiner at 10, following Tr. 10430)

198. Further, the required reserve margin increases with increased average size of the units within the system to which the margin applies. The trend in NEPOOL to more generating stations of large capacity, such as the present 1150 MW variety, together with decommissioning older and smaller plants will require NEPOOL to increase its reserve margin above the present 23 percent. (Staff Witness Feld, Tr. 10647)

76/ Applicants' Exhibit 22 at 20 served on the Board and all parties September 25, 1980 admitted on October 2, 1980.

With Unit 2:

Winter of	1984/85	1985/86	1988/89	1990/91	1991/92	1992/93	1993/94	1995/96
Capacity (MW)	23692	25790	26596	27166	27166	27122	27120	27120
Reserve Margin (%)	36.2	44.3	36.4	31.6	27.7	23.7	19.9	12.2

Without Unit 2:

Reserve Margin (%)		37.9	30.5	26.0	22.3	18.4	14.8	11.6

Notes: a. The capacities assume the addition of two Stony Brook Units (510 MW oil turbine) in 1981 and 1982; Seabrook Unit 1 (1150 MW nuclear) in April 1983, Seabrook Unit 2 (1150 MW nuclear) in February 1985, Pilgrim Unit 2 (1150 MW nuclear) in December 1985, Millstone Unit 3 (1150 MW nuclear) in May 1986, and Sears Island (568 MW, coal) in November 1987, together with a number of smaller stations.

b. Data are given for winter peak power because power demand within NEPOOL peaks in the winter period. Power in the BECo service area peaks during the summer months.

199. Staff Witness Feld[77/] reviewed the NEPOOL load forecast and was in essential agreement with the anticipated schedule for Unit 2 to meet the minimum reserve.[78/]

200. The Staff in collaboration with the Oak Ridge National Laboratory (ORNL) independently developed forecasting capability and applied it to the future electrical energy requirements of New England. A conclusion of this analysis, based on a 3.4 percent energy-requirement annual growth rate established for a median fuel price, is the need for Unit 2 output during the 1988/89 winter to conform with NEPOOL reserve requirements. All planned and authorized additions are assumed to have come on line. This date is not grossly inconsistent with 1993/94 reported in paragraph 196 supra, recognizing the

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77/ Throughout the course of these hearings the Staff offered four witnesses on the need for Unit 2: H. L. Thompson (Tr. 2939); Daryl Nash (Tr. 3102); Sidney Feld (Tr. 8150 and 10499); and W. S. Chern (Tr. 11231). The Commonwealth District Attorney offered eight: H. Houthakker (Tr. 2330); Carl Stein (Tr. 3297); J. H. Neely (Tr. 3518); Henry Lee and Paul Levy (Tr. 4959); Nancy Boxer (Tr. 8583); Paul Chernick and Susan Geller (Tr. 10952). The Massachusetts Governor's Office of Energy Resources presented J. G. Buckley (Tr. 10370) and J. S. Fitzpatrick (Tr. 10656). E. N. Fields of the Federal Power Commission appeared for the Board (Tr. 6080).

78/ The continually changing and complex pattern of energy requirements over the four-year interval of hearings on this topic has made much of the earlier testimony moot. No party has responded to the most recent filing of the Applicants, on September 25, 1980, on which much of the above is based. Apart from considerations given by the Board to that NEPOOL-BECo information, greater weight has been afforded to the next most recent presentation than to the older data.

reduced growth rate (2.7 percent vs 3.4 percent) factored into the latter. (Staff Witness Feld at 6 et seq. admitted at 10501 bound following Tr. 10651)

201. The Staff/ORNL forecast utilized a regional econometric model, the ORNL model, built around a system of non-linear simultaneous equations and containing submodels for the various types of electrical service. (Chern et al., Staff Exhibit 60 at 1-3 through 1-5) The energy demands in these types of service are assumed to be functions of such entities as the population, the cost of various fuels, the per capita personal income, the number of residential customers, weather data and the value added in manufacturing. (Id. at 1-3) The model adjusts to a range of fuel prices. (Feld at 6 following 10651) The codes are continually updated recognizing changes in cost indices, in technological developments at generating stations, in operating and maintenance costs, etc. (Feld at Tr. 11321) During its development, the model has been validated against historical data for the period 1955 to 1974 and was again tested against more recent information obtained in 1975 and 1976. In each comparison the demand forecast, with 1955 as the base year, varied from experience by no more than three percent. (Staff Exhibit 60 at 6-1 et seq.; Chern at Tr. 11238, 11301 et seq.)

202. In the most recent sessions of this hearing the Commonwealth District Attorney presented witnesses Chernick and Geller, each being employed by that office as a rate analyst. In their prepared testimony, these witnesses offer extensive criticisms of both the NEPOOL and the ORNL models for forecasting energy demands. (Commonwealth Witnesses Chernick and Geller at 5 through 45, following Tr. 11224) The criticisms[79/] of NEPOOL were principally those of inadequate documentation and errors arising from incorrect concepts and input. (Tr. 10968) Further there was assertion of inadequate consideration of the effects of conservation. In the ORNL model the price elasticities were considered to be too low, natural gas was not considered as a substitute fuel, profit margins were implausible, and the model is based on a faulty understanding of how demand for electricity works. (Tr. 11165)

203. Witness Chernick predicted an approximate 1 percent annual growth rate of peak demand in New England over the next decade. More specifically, he set the value between 95 percent confidence bounds of -0.5 and 2.5 percent. This prediction was subjective without basis on any particular model. (Tr. 11162, 11192 through 11196)

204. Witness Geller, the principal critic of the ORNL method, was unable to revise the growth rate forecast so that

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79/ Although the prepared testimony was filed jointly by the two witnesses, Mr. Chernick made the criticisms of NEPOOL and Ms. Geller criticized ORNL. (Tr. 10990, 11180)

its value would reflect the alleged shortcomings of the model. Her position was that the "equations don't make any sense." (Tr. 1165)

205. The Massachusetts Governor's Office of Energy Resources presented testimony by Witness J. G. Buckley (received Tr. 10372, bound following Tr. 10947) and by J. S. Fitzpatrick (received Tr. 10659, bound following Tr. 10947). Mr. Buckley is the Vice President of Northeast Petroleum Industries, Inc.; he is currently the chairman of the Fuel Oil Marketing Committee of the U.S. Department of Energy. Mr. Fitzpatrick is Director, Massachusetts Office of Energy Resources.

206. These witnesses testified to the severity and potential consequences to the national economy of recent practices necessitating importing large quantities of oil. There are two principal effects of this importation. It imposes a tremendous drain on this country's international balance of payments which is reflected in the domestic economy. (Tr. 10386) Second, imported oil is a very insecure source of energy on which the domestic economy and livelihood so strongly depend. (Witness Buckley at 9 following Tr. 10947; Witness Fitzpatrick at 2, 3 following Tr. 10947)

207. Witness Buckley directed his testimony to an expected future increase in the cost of oil and to the prudence of

IMAGE EVALUATION
TEST TARGET (MT-3)

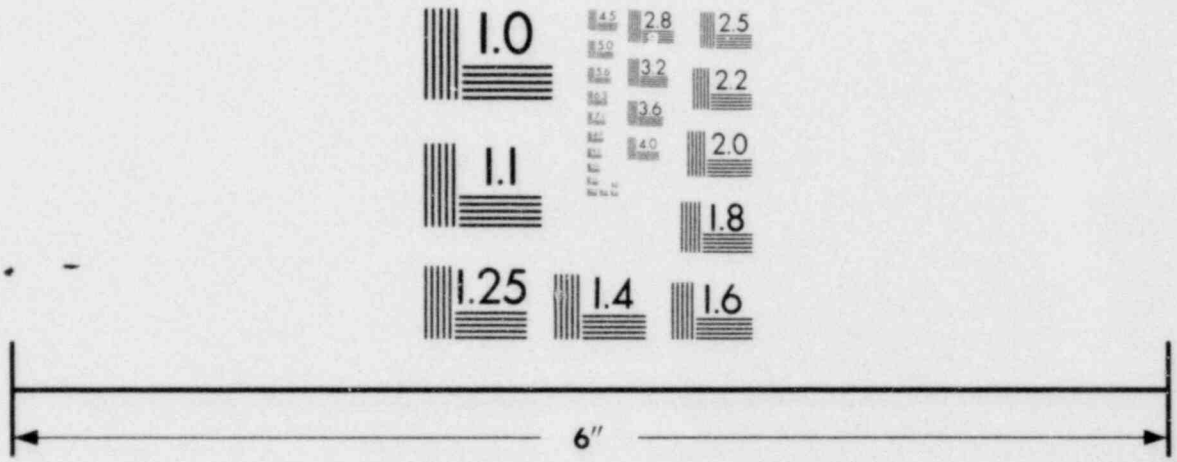
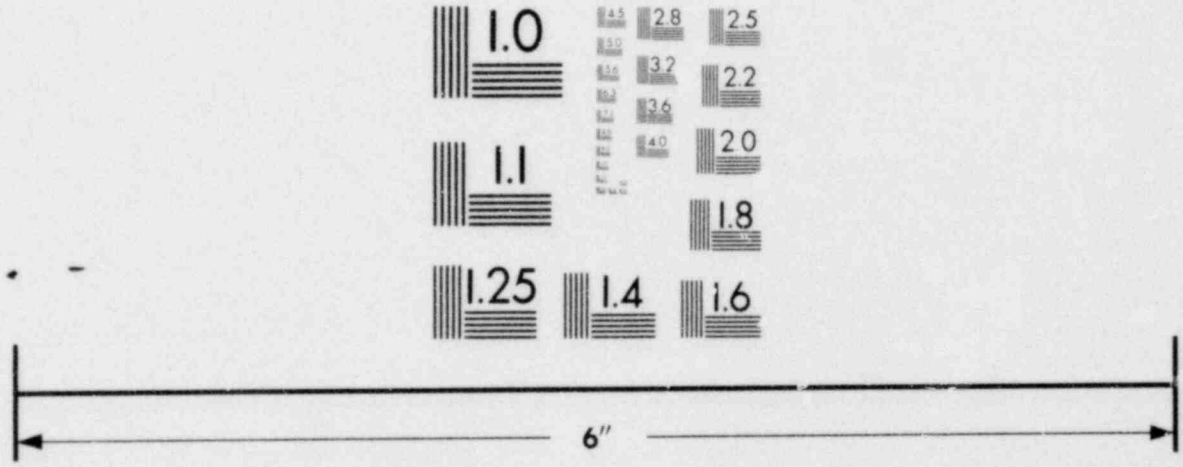


IMAGE EVALUATION
TEST TARGET (MT-3)



encouraging alternate sources of energy. (Tr. 10410) Witness Fitzpatrick reported the policy of the Commonwealth to "discourage new uses of oil and encourage the reduction of present levels of use." (at 2 following 10947) He attributed a 27 percent decrease in oil imports between 1973 and 1977 primarily to the installation of 2800 MWe of nuclear-fueled generating capacity. (at 6 following Tr. 10947) Activation of Unit 2 would advance the oil conservation policy of the Executive Department of the Commonwealth. (at 7 following Tr. 10947)

208. The Massachusetts Governor's Office of Energy Resources has estimated the oil-equivalent cost saving of operation of Unit 2, that is the cost of oil to produce the same electrical energy, over the 35-year life, to be the order of 10 billion dollars. (Fitzpatrick at 8, 9 following Tr. 10947)

209. It was the opinion of both of these witnesses that the forecasts of future oil prices by Applicants' witnesses were conservatively low. (Tr. 10374, 10712)

210. The Applicants' position on this matter of oil-import reduction was discussed by Witness Weiner. (at 19 through 24 following Tr. 10430) An advance of the operation of Unit 2 to 1985 from 1988 would reduce oil consumption over that period by about 30 million barrels. (BECo Exhibit NP-42, at unnumbered p. 34 following Tr. 10430)

211. As noted above the presentation of testimony on "need for power" spanned nearly four years and some extremes

in economic conditions. Consequently many of the earlier data became outmoded and were replaced by more current values of expected behavior of the economy. A few topics, however, even though discussed relatively early in the hearing, were not reheard in recent sessions. Some of them are addressed now.

212. The effect of "conservation of energy" on the projected future need for electricity was addressed by Applicants' Witness Weiss.[80/] (at 81 through 104 following Tr. 2647, and at 42 through 49 following Tr. 7927)

213. This witness assessed the impact of conservation by applying an econometric model to the sale of electricity in the Boston Edison service area to account for the effects of price and income and then considering any unaccounted for residual reduction to be attributable to conservation. He concluded that conservation was responsible for a significant portion of the decline of electricity consumption experienced after the 1973/74 oil embargo but that this non-price related conservation was a short-lived phenomenon and would not affect electricity consumption in the future. (at 82 et seq. following Tr. 2647) Later he judged that the non-price or "patriotic" conservation

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80/ Conservation was defined as a reduction in sales over and above that attributed to the effect of price and income. Elsewhere it was similarly defined "as a curtailment which results from a decision by a member of the public to use less energy . . . which is not influenced by economic pressures." (Tr. 2968)

observed in 1974 had no effect on the 1976 growth of electricity sales and that an examination of those economic factors affecting sales revealed patterns which could be accounted for solely by economics and that regulations will be required to effect true conservation. (at 42 through 49 following Tr. 7927; also Tr. 8131, 8132)

214. Witness Weiss commented on the potential of future government action for slowing the growth of electrical consumption, i.e., financial incentives for increasing home insulation and installation of equipment to utilize solar energy but stated that the extent to which such actions would affect electricity consumption will depend on some government activity. He did, however, indicate that the Administration has a target to reduce growth rates in electrical energy requirements in 1985 by about 10 percent. This impact, while not insignificant, is clearly not of the magnitude necessary to modify substantially the need for additional base-load capacity (at 44 and 45 following Tr. 7927)

215. The Staff presented evidence on the effects of "voluntary" conservation and estimated the potential impact of all "voluntary" conservation actions to be "much less than 1 percent of the total energy consumption." (Thompson at 4, following Tr. 2968)

216. Staff Witness Thompson also examined the potential for conservation of electricity as a result of new standards for

improved building insulation, heating, lighting, and air conditioning and concluded that the maximum potential reduction in the residential and commercial consumption of electricity in 1970 would have been 17.5 percent and 15 percent, respectively. (Tr. 2969) Reviewing the results of the Federal Power Commission's study[81/] on reduction in the growth rate of effective energy demand due to conservation and other methods, the witness concluded that a reduction of 7 percent in the historic rate could be achieved. This reduction would account for about one-half the reduction anticipated by the Staff due to the combination of energy shortage, higher costs and conservation. (at 45 and 47 following Tr. 2968)

217. Commonwealth Witness Houthakker presented an econometric equation that illustrated price and income elasticities for residential electricity sales in New England and showed that increases in marginal prices (Tr. 2346) would lead to a decrease in sales and that increases in real income would lead to increases in sales. (Houthakker testimony at 2)[82/]

218. The model does not include cost of competing fuels (Tr 2361, 2386) and fuel substitutions. (Tr. 2362) The

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81/ "FPC News' August 7, 1975, No. 21622 p. 45.

82/ The testimony was admitted at Tr. 2330, was prepared in mid-1974 and was not updated. (Tr. 2335) It was received into the record as Commonwealth Exhibit 18 by Board Order dated July 14, 1978.

effect of the then-current recession had not been analyzed. (Tr. 2425) The witness further stated that the thrust of his testimony was "to show that consumption of electric power, by residences, is sensitive to the prices charged . . . rather than to project the consumption in particular years. These projections are made on assumptions which I do not claim to be realistic." (Tr. 2374) In response to a question whether, as a utility company, he would rely on his econometric equation to make demand forecasts, he responded "certainly not." (Tr. 2386) The quantitative results of this testimony have been superceded by more recent offerings.

219. Commonwealth Witness Neely questioned Applicants' forecasts of the need for Unit 2, the Federal Power Commission reliability criteria and the resultant reserve margin requirements, and whether adequate consideration was given to alternate energy systems such as solid waste. (Neely testimony at 1 through 4)[83/]

220. This witness in his critique of Applicants' forecasting recommended, inter alia, consideration of price elasticity and the state of the New England economy. (Id. at 10 and 11) He mentioned the failures of the utility demand forecasts in 1974 but proposed no substitute methodology,

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83/ The Neely testimony was received at Tr. 3542. Contrary to a statement there, it was not bound into the record. It was designated as Commonwealth Exhibit 17 and was again received into the record by Board Order dated July 14, 1978.

stating that poor forecasting methods are likely to lead to under-capacity or over-capacity and there are adverse consequences of each. For example, under-forecasting leads to blackouts and adverse economic effects, over-forecasting diverts capital and entails unnecessary land-use diversion. (Id. at 3 through 8) He did, however, opine that there is not sufficient information for adequate review, the demand forecast is probably too high, and the supply forecast is probably too low." (Id. at 9)

221. In his criticism of the FPC reliability criterion of a one-day loss of load due to insufficient capacity every 10 years, Witness Neely did not perform a complete cost-benefit analysis to justify lesser reserve margins but argued instead that, "since most blackouts result from equipment failure, a doubling or tripling of the number of blackouts from insufficient generating capacity would mean only a modest increase in the total ...." and that the economic benefits from not paying the carrying costs of "excess" reserve capacity would outweight the economic costs of more frequent losses of load. (Id. at 4 and 5)

222. Commonwealth Witness Stein, an architect and specialist in energy conservation projects, testified to the magnitude of reductions in electrical energy demands which could be achieved by conservation in residential and commercial buildings.

(following Tr. 3299) He stated that, at present, savings of about 11 percent and 36 percent in residential and non-residential buildings, respectively, are attainable. Future new commercial structures could be designed to require 50 percent less energy. Applying these projected savings to the New England area, he predicted that the demand for electrical energy in New England would remain virtually unchanged or would be reduced by the year 2000 even with a 40 percent growth in the residences in the service area. (Tr. 3300)

223. Commonwealth Witnesses Lee and Levy presented a report[84/] addressed primarily to future relative costs of energy derived in New England from various fuels. It touched briefly on the matter of necessary growth of production facilities. A position of the report is the adoption of "policies and price structures that discourage the growth in electricity demand[85/] and that promote a more efficient use of both existing and new generation capacity." (at 3 following Tr. 4962)

224. Achievement of a reduced electric generation growth rate could be by reducing wastage of energy and by increasing the efficiency of its use. (Tr. 4967) A reduction of growth by these means could better the economy of New England by

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84/ "The Economics of Nuclear Power: A New England Perspective," Energy Policy Office, Commonwealth of Massachusetts, December 1975. (following Tr. 4962)

85/ In this context "demand" connotes energy. (Tr. 4966)

removing the burden to residents and industry of the high costs of unnecessary plant construction. (Tr. 5054)

225. The witnesses, nonetheless, believe the projected growth rate to be finite, pointing out that a Ford Foundation study[86/] used a 3 percent annual rate, doubling consumption by the year 2000, in an extremely conservative projection. (at 7 following Tr. 4962)

226. Although Board Witness Fields, of the FPC (now FERC), did not address directly the question of electric power and energy requirements in the BECo service area, he did testify on the reliability of bulk power supplies and on the justification of the 23 percent reserve margin established by NEPOOL.[87/] A FPC analysis for 1982/83 disclosed that the 23 percent margin[88/] would not be maintained if the annual load growth exceeds 6 percent. (at 11 following Tr. 6080) He concluded that the NEPOOL system would be much more stable and reliable with the Unit 2 capacity available. (at 12 following Tr. 6080)

86/ Energy Policy Project of the Ford Foundation, "A Time to Choose: America's Energy Future," p. 508 (1974)

87/ The FPC analysis referred to NEPEX which performs dispatching and planning functions for NEPOOL. (Tr. 6202)

88/ Whereas the genesis of the 23 percent margin is a projected system reliability no less than a one-day outage each 10 years, the witness translated it into 0.5 hours per week (an order of magnitude greater) when applied to a span as short as one week. (Tr. 6210 et sec.)

227. Applicants and Staff witnesses testified that peak-load pricing would not reduce the need for Unit 2, contending that peak-load pricing would likely increase base-load requirements thereby further justifying increased base-loaded capacity, such as by nuclear units, at the expense of installing peak-load units. They also indicated the possibility that electric energy consumption would increase as usage is shifted from peak to off-peak periods. (Applicants' Witness Guth at 6 to 8 following Tr. 2647; Staff Witness Nash at 23 following Tr. 3110)

228. Both Applicants and Staff further contend that implementation of peak-load pricing would be difficult and would require regulatory actions, and modifications of current metering systems and of other equipment to take advantage of off-peak power. (Nash at 23 following Tr. 3110; Tr. 3243; Guth at 6 to 8 following Tr. 2647; Ferguson at 32 following Tr. 2647)

229. A significant amount of evidence introduced in these proceedings on the propriety of construction of Unit 2 supports the thesis that a benefit of principal importance is the value of the Unit in replacing older, less economic, potentially polluting generating stations which in many instances consume oil to the disadvantage of this country's international economy and of the use of that natural resource in industries where it is a unique raw material.

230. The Applicants have most recently forecast, for the NEPOOL area, an annual compound growth rate in winter-season peak power of 2.7 percent. Other parties have not taken exception to this value. Assuming all planned additions to the generating system are effected on present schedule, retention of the 23 percent reserve margin, required by NEPOOL, will require operation of Unit 2 in advance of the 1993/94 winter season.

IV. B. b. Impacts of Construction

231. The Applicants have identified and described and the Staff has reviewed the environmental impacts associated with construction of the facility. (ER §§ 4 and 11; FES § 4)

i. Impact on Land Use, Terrestrial Ecology and Fresh Water Resources

232. The construction of the proposed Unit 2 will have some adverse impacts on land use and on the terrestrial biota. About 49 additional acres of the site, including areas for the water tank and meteorological tower, the construction personnel parking lot and access road, and the construction laydown and batch plant will be cleared for the construction of Unit 2. (ER § 4.11; FES § 4.1.1, following Tr. 897 as revised in Staff Exhibit 16 following Tr. 8542) In order to reduce construction impacts on certain wetlands, 47 of these 49 acres to be cleared are located south of Rocky Hill Road. Although clearing will

remove the mixed-oak forest, no more than 2 percent of the mixed-oak habitat in this region will be affected. (Staff Exhibit 16 at 2, 3 following Tr. 8542) Such a loss is acceptable, particularly since it is compensated by the protection of the regional wetland resources. Further, much of the cleared area not subsequently occupied by permanent structures will be landscaped or allowed to return to its natural state. (FES at 4-7)

233. The major expected adverse terrestrial ecology effects are those associated with long-term loss of biological productivity through the removal of forest community acreage and replacement by buildings and pavement. The construction, however, is not expected to result in the elimination of any existing population of plants or animals. (FES at 4-4)

234. There are no historical, cultural, archaelogical or architectural resources which will be affected by construction of Unit No. 2. (FES § 2.3.2)

235. The existing transmission corridor from the Site, including the towers, which was established for Unit 1, will also serve Unit 2 (FES § 3.7) The installation of transmission lines will have a minimal impact on the land in the vicinity of the facility and along the transmission corridor.

The Staff recommends, however, that replanting portions of the transmission corridor with a vegetative screen be a condition of the issuance of permits.

236. Water required during construction, at a maximum flow of 500 gpm, will be furnished by the Town of Plymouth and will not affect the local water supply. (FES at 4-2)

237. The construction of Unit 2 will have no effect on the quality of surface run-off water or groundwater used by others because the Unit 2 site is on the downstream edge of the basin, and all drainage from the site discharges directly to the Bay. (FES at 4-2)

ii. Impact on Cape Cod Bay

238. The construction of the proposed Unit 2 will have some adverse impacts on Cape Cod Bay water and on the aquatic biota. The major impacts on the water of the Bay were incurred when the intake and discharge channels for Unit 1 were constructed although some modification of those channels is now required together with dredging and construction of a barge unloading facility. There will result slight temporary impacts such as increased turbidity in the immediate area of construction and at nearby beaches. (ER § 4.1.4; FES at 4-3) The Applicants have estimated that, in addition to the destruction by construction of Unit 1 of 11 percent of the total area from

which Irish moss is harvestable, another 3.5 percent will be destroyed during construction of Unit 2. Indications are, however, that recolonization will occur. Further, there will be some displacement of marine life from about two acres of the Bay bottom. (ER § 4.1.2.3; FES at 4-5)

239. Dredged spoils will be barged to an off-shore disposal area in accordance with U.S. Army Corps of Engineer regulations. Other surplus material removed by land-based equipment will be disposed of in an existing borrow area in accordance with specifications of the Massachusetts Departments of Natural Resources and of Public Works. (FES at 4-3)

240. Staff Witness Parsont testified on the effect of temperature on the uptake and elimination of radionuclides by aquatic organisms. Experience has shown a two- or three-fold increase in concentration factors and, hence, in radiation exposure, at elevated temperature. (These observations were made, however, in radiation fields orders of magnitude greater than any expected in the Bay near the Pilgrim site.) Even a three-fold increase in the exposure of organisms in the Bay will not result in radiologic doses causing observable somatic effects. In general, induction of genetic effects is independent of temperature. The witness concluded that at the temperature and in the low radiation field characteristics of the proposed site no observable adverse somatic or genetic

effects will be caused by radiation and by thermal-radiation interaction. ("Supplemental Testimony of M. A. Parsont Relative to Massachusetts Wildlife Foundation Contention 2(c)," Staff Exhibit 7A, identified at Tr. 6431 as Staff Exhibit 7 and received at Tr. 6432)

iii. Impact on the Community

241. Vehicular traffic and the general noise will increase due to construction. At peak construction about 1000 cars will transport workers to and from the site resulting in some traffic congestion. Noise during site preparation and construction will arise from trucks, earthmoving equipment, rock drills, pneumatic machinery, and pile-driving rigs. The noise at the nearest residence may reach 75 dB corresponding to that of a busy street. The Applicants will ameliorate these conditions by installing traffic controls, utilizing mufflers on vehicles, and minimizing truck usage of Rocky Hill Road. (ER § 4.1.1.5; FES at 4-5, 4-6)

242. Only 7 percent of the construction labor force is expected to reside in the Plymouth area and will be the cause of a small demand for housing and an increase of about 6 percent in the local school enrollment, both temporary and absorbable into existing facilities. The 160 permanent operating employees can be similarly accommodated. (ER §§ 8.2.2.1 and 8.2.2.3; FES at 5-4)

iv. Impact of Pilgrim Unit 1 on Construction Personnel

243. During construction of Unit 2 the labor force will experience an estimated radiation exposure of 100 man-rem arising from the operation of Unit 1. The main sources of this exposure are the gaseous effluents and air-scattered radiation from nitrogen-16 in the turbine. The Applicant is committed to limiting this exposure to as low as reasonably achievable.[89/]

v. Proposed Measures to Mitigate Construction Impacts

244. The Applicants have proposed measures, broadly applicable to construction activities, intended to limit adverse environmental effects of the Unit 2 project. The Staff concludes from its evaluation of those anticipated measures that they, when supplemented by more specific items appearing elsewhere in this decision, will limit the impact to a practical minimum. The Applicants' proposals as stated by the Staff follow. (FES at v)

245. The Applicants will take the necessary mitigating actions (including those summarized in §§ 4.5.1 and 4.5.2 of the FES) during construction of the plant and of the associated transmission lines to avoid unnecessary adverse environmental impacts from construction.

89/ Staff Exhibit 11A following Tr. 7828. This is § 4.6 of the FES filed as an addendum.

246. Moreover, the Applicants will establish a program which will include written procedures and instructions to control all construction activities prescribed in the FES and by this decision and to provide periodic management audits to determine that all conditions are adequately implemented. The Applicants will maintain records showing compliance with all of the environment-related conditions imposed by this decision.

247. The Applicants will prepare and record an environmental evaluation before engaging in any construction activity not previously considered by the Staff. When that evaluation indicates that the activity may result in an adverse environmental impact not previously considered or in an impact considered in the FES to be less severe, the Applicants shall describe the activity in writing and shall obtain prior approval of the Director of the Office of Nuclear Reactor Regulation.

248. If unexpected harmful effects or evidence of serious damages are detected during construction, the Applicant will provide to the Staff an analysis of the problem and a plan to eliminate or significantly reduce those effects.

IV. B. c. Impacts of Operation

249. The Applicants have identified and described and the Staff has reviewed the environmental impacts associated with operation of Unit 2. (ER §§ 5, 8 and 11; FES § 5)

i. Terrestrial Impacts

250. The operation of proposed Unit 2 will have slight impact on land use. The Site is now occupied by Unit 1 and operation of both units with related facilities will permanently require about 45 acres out of a total site area of more than 500 acres. Although the major structures will be quite visible from the Bay, there will be no unusual visual impacts from the land side because the property surrounding the station is heavily wooded and is at a lower elevation than the surrounding countryside. Availability of portions of the site to the public for recreational and educational purposes will continue. (FES § 5.1.1)

251. The impact of the operation of Unit 2 on terrestrial wildlife is expected to be negligible. (FES at 5-23)

252. Effects of operation and maintenance along the transmission corridors will be minimized by the utilization of helicopters for inspection and the retention of existing roads, built during construction, to provide access for maintenance.

Brush control will be by selective application of herbicides in accord with Commonwealth regulations. (FES at 5-24)

ii. Aquatic Impact, Nonradiological

253. The operation of proposed Unit 2 will have some impact on the Bay, on terrestrial water, and on the aquatic biota. The aquatic biota of the Bay is typical of that found in north temperate climates and is more representative of a marine than an estuarine environment.

254. The flow rate of Bay water required for the once-through cooling system of both Units 1 and 2 when operating at full power is nearly 3000 cfs with return through a common discharge channel at about 22°F above the intake temperature. The only loss of water is through evaporation. Although wind and tidal patterns make a description of a discharge plume difficult, the estimated area in which the surface temperature will be 15 or more degrees Fahrenheit above ambient is one acre whereas the area of the Bay is about 365,000 acres. Correspondingly, the area of the plume encompassed by the 5°F above-ambient isotherm is 64 acres. (FES at 5-4, 5-30 et seq.)

255. Certain species of fish have congregated in the vicinity of the Unit 1 coolant discharge and, although no mortalities have been attributable directly to the increased temperature in that area, fish have died as a consequence of the supersaturation of nitrogen in the discharge. The ailment,

called gas bubble disease, has, on two reported occasions, killed a quantity of menhaden equivalent to the order of 0.1 percent of the annual harvest from the Bay. (Staff Witness Froelich at Tr. 2194 et seq.; FES at 5-36; ER § 5.1.2.4)

256. Mortality of fish acclimated to warm water then suddently exposed to a cold shock, as might result following a plant shutdown, has not been a problem at Unit 1. Even though the area of heated water will be larger with two units operating, the impact of shutting down one will be considerably reduced. The frequency of simultaenous shutdown of both Units 1 and 2 is estimated at seven per year, normally occurring during spring or fall months when ambient water temperatures are not extreme. The Applicants must make every effort to insure that simultaneous shutdown of both units does not occur during the winter months. (ER § 5.1.2.5; FES at 5-36)

257. The National Pollutant Discharge Elimination System permit, issued to the Applicants, will require installation of a barrier near the terminal of the discharge canal to prevent entry of fish. Additional precautions are required if the barrier is not successful. (Staff Exhibit 18C at 15 following Tr. 8801)

258. Trash racks and traveling screens are provided in the cooling-water intake system to reduce the passage

of fish and of debris into the condensers. Although the water speed in this screening system is about 1 fps, a value believed easily sustained by many species common to Cape Cod Bay, fish are expected to impinge on the screens. In spite of provision of a return path for fish thusly caught to return to the Bay, a loss is expected. Observations at Unit 1 over a period of one year reported collection of fish on the screens at a rate of 1.4 per hour, 60 percent being from the herring family and 27 percent smelt and silversides. Impingement with both units operating is expected to be 3.4 times greater.

259. Spores, eggs, larvae, small fish and other plankton will be entrained in the intake waters and will pass through the plant condensers. These organisms will be subject to mechanical and chemical stresses and to a thermal shock of as much as 22°F. Assuming 100 percent mortality of such organisms passing through the plant, the Staff has estimated that with both units operating at capacity up to 15 percent of the planktonic forms in a one-square-mile area of the Bay adjacent to the plant will be killed each day. (FES at 5-27)

260. The principal chemical contaminant of the water discharged into the Bay will be chlorine, from sodium hypochlorite, serving as a biocide in treatments, separately, of each half of the Unit 2 condenser. The chlorine concentration in the

discharge from the canal is expected to be less than 0.2 ppm achieved by dilution with water from Unit 1 and from the half of Unit 2 not undergoing treatment. Chlorination will occur about one hour per day during two-thirds of the year. (FES at 3-28 and 5-4)

261. No evidence of expected violation of the current high quality of the local coastal waters (Class SA of the Massachusetts Water Quality Standards) was presented. Hence, operation of Unit 2 will not be cause for restriction of any water sports at nearby beaches. The high surface speed of the coolant discharge will provide a potential risk to small boats. (FES at 5-7)

262. Consideration was given to the impact of plant operation on commercial fishing, including bottom trawling for flounder, cod, haddock, etc., and harvesting lobster and Irish moss. No significant nonradiological impacts of the operation of Unit 2 on the fish and lobster are expected. In addition to the loss of 3.5 percent of the productive area for Irish moss due to Unit 2 construction,[90/] the thermal effects of operation will reduce the crop by 11 percent. (FES at 5-8) Recent fluctuations in Irish moss crops, attributable to natural causes, may obscure the predicted effects of thermal discharges. (FES at 5-40 and Tr. 10,010)

90/ Paragraph 238, supra.

263. The maximum annual requirement for fresh water from the Plymouth municipal water supply has been set at 30 million gallons (~ 60 gpm, average). (FES at 5-7, ER at 3-15) All drainage from the Pilgrim Site is directly into the Bay, thereby precluding any effect of the installation on potable water supplies. (FES at 5-7)

iii. Impacts on the Community

264. The social and economic impacts of the operation of Unit 2 on the community are expected to be mainly beneficial Benefits will derive from an increased tax base either as increased revenue or as a decreased tax rate. Eighty-five additional permanent personnel will be employed bringing about 100 additional children into the Plymouth schools, corresponding to a one percent increase in enrollment. No problems are anticipated in meeting the need for housing and for medical, transportation, and other municipal services. Noise from station operation is not expected to have any impact beyond the site boundary. (FES at 5-41; ER at 8-22 through 8-27)

iv. Radiological Impacts

265. Releases of radioactivity from nuclear power plants are subject to Commission regulations which, among other things, require the Applicants to "make every reasonable effort to maintain radiation exposures, and releases of radioactive

materials in effluents to unrestricted areas, as low as reasonably achievable . . . taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest." [10 CFR § 20.1(c)]

266. The Cleetons introduced the direct testimony of Witnesses Tamplin (following Tr. 6959A), Bertell (following Tr. 7044) and Caldicott (following Tr. 7150). The testimony proffered by Martha Drake was ruled inadmissible on the grounds of relevance. It reported health effects near two boiling water reactors located in the mid-west and near one on the West Coast. The statement is included in the record as a limited appearance. (following Tr. 7138)

267. None of these witnesses addressed the impact on the Cleetons of the specific releases of radioactive materials from Unit 2 and no evidence was presented to show that the Cleetons would be at any greater risk from the doses of radiation resulting from the routine operation of Unit 2 than are other similarly situated members of the public. None disputed the validity of the Staff's radiation dose estimates. (Tr. 7007, 7118, 7119)

268. Witness Tamplin addressed generally the assessment of risk from exposure to low-level radiation[91/] with particular reference to the assessment presented in the BEIR Report.[92/] His major point was that "the estimates of the biological effects of radiation that are in current use most likely significantly underestimate both the somatic and genetic effects on both populations and individuals." (at 8 following Tr. 6959A) Reference was made to the work of Bross[93/] who has shown a variation of several orders of magnitude in the sensitivity of individuals to radiation. The Witness opined that risk to individuals may be as much as 1000 times the upper limit of the range given in the BEIR Report. (Tr. 6965) To make this judgment, however, requires information on the individual's medical history and genetic background and those of members of his family. He further has no information upon which to base a judgment whether the Cleeton family could be among the group of individuals whose relative risk to radiation effects could be 1000 times worse than the average of the population. (Tr. 6969)

91/ In this testimony "low-level" denotes radiation of intensity at or near that of natural background. (Tr. 6995)

92/ NAS BEIR Report, Report to the National Academy of Sciences, National Research Council Committee on the Biological Effects of Ionizing Radiation, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", Washington, D.C., November, 1972. This report was revised in 1980.

93/ Bross, Irwin D. J., "Leukemia from Low-Level Radiation," New England Jour. of Medicine, Vol. 287, No. 3, 20 July 1972, pp. 107-110.

269. Cleeton Witness Bertell testified that the estimated discharges of radioactivity from Unit 2 have not been adequately tested against reality, that they are most probably not conservative, and that uncertainties involved in present monitoring are such that only a rough approximation of the possible radiation exposure to an individual is possible. (at 1 following Tr. 7044) She, however, had no specific information about Unit 2 other than its size and that it was a light-water reactor. When questioned about the estimated discharges from Unit 2 and the proposed monitoring program, the witness referred to a nation-wide "release" of 0.003 mrem from the entire nuclear industry presented before the EPA in 1976 by Roger Madsen, not otherwise identified, who also reported that radiation monitoring equipment was not available for nuclear plants. (Tr. 7052, 7055) She had no knowledge of the monitoring plan proposed for Unit 2 (Tr. 7056, 7059) and had not examined the estimates made by Staff and Applicants of the expected emissions from it nor had she read the PSAR, the SER or other documents supplied by the Applicants and the Staff describing radiological discharges and dose rates associated with the proposed Unit 2. (Tr. 7055, 7094, 7104) She believed the calculations by Staff Witness Gotchy were correct though based on outdated information in the BEIR Report. Further, in the Gotchy testimonies, only mortality was considered, not total health effects. (Tr. 7118-19) She stated that any discharge above zero would be unacceptable. (Tr. 7107)

270. Witness Bertell stated that the purpose of her testimony was to "... set forth some of the scientific evidence for my conclusion that the Cleeton family, and particularly Mrs. Cleeton and three grandchildren, ... would be exposed to an unreasonable risk to health and safety if the proposed Pilgrim 2 were to be constructed and operated." She referred to her research that has revealed classes of children with as much as 50 times the average susceptibility to leukemia and adults with demonstrated immuno-incompetency or already damaged genetic mechanisms making them several times more susceptible to further damage than are healthy persons. (at 3 following Tr. 7044) She concluded that Mrs. Cleeton's history of arrested tuberculosis and of cancer in her family places her and her family at a greater relative risk than if there were no such history. (Tr. 7063) Without quantification the additional risk from Unit 2 was stated to be unreasonable. (Tr. 7065) The witness had not determined whether the Cleeton grandchildren, now (1977) of age less than ten, were in the more-susceptible-than-average category. (Tr. 7084)

271. Witness Bertell criticized the proposed Unit 2 monitoring program, stating that it was inadequate to give early warning of a deterioration of human health (at 3 following Tr. 7044) and, in oral testimony, stated that the failure to measure health effects is the result of an outmoded public health system where morbidity is not included and the "public health measuring devices are not to the level of sophistication to handle the pollution problems from radiation, PCB's

[polychlorinated biphenyls] and all the rest of the industrial pollution which is being put into our environment and our food." (Tr. 7074-75) She further testified that this is a generic problem and not peculiar to radiation or to Unit 2 and that the monitoring she proposes is not being done for any industrial pollutant. (Tr. 7076)

272. Witness Bertell implied but did not provide any probative evidence that Mrs. Cleeton or any member of her family, including the grandchildren, would be at greater-than-average risk of injury due to radiation from proposed Unit 2. It is her position that no amount of radiation is acceptable and that exposure to any radiation would constitute an unreasonable risk to the health and safety of the Cleeton family. (Tr. 7107)

273. Cleeton Witness Caldicott testified that " ... Mrs. Cleeton with her medical history, is at great risk if exposed to any additional radiation" and "The Cleeton grandchildren, like all children, are more susceptible than adults to damage from radiation." (at 2 following Tr. 7150, also Tr. 7152) She did not, however, provide any probative evidence to demonstrate that the estimated incremental radiation from Unit 2 would have a synergistic effect over and above what might be predicted from the linear non-threshold theory espoused in the 1972 BEIR Report. She identified several inherited diseases which she alleged make persons more susceptible than others to the effects of radiation and identified groups with alleged radiation sensitivity including fetuses, infants and young

children, children with allergies, and fair-skinned people, stressing that it is the young who are extremely sensitive. (Tr. 7181-82) The witness had very limited knowledge of the proposed radioactive releases and radiation dose rates associated with Unit 2 and could provide no estimate of the magnitude of the risk except to say that any radiation additional to the natural background is unacceptable. (Tr. 7153, 7180, and at 2 following Tr. 7150)

274. Applicants' Witnesses Larson and Cehn testified on the release of radioactive materials from liquid and gaseous effluents from the proposed Unit 2. Applicants' assessment of the liquid and gaseous effluents during normal operation of Unit 2, determined in accordance with 10 CFR 50 Appendix I, gives annual radiologic whole-body doses to the "maximum exposed" individual at the site boundary of 0.004 and 0.282 mrem, respectively, and are no more than 6 percent of the exposure limits established by Appendix I. The single-organ doses are correspondingly lower than the Appendix I limits. The gaseous effluent doses assume 0.1 percent of the fuel pins are defective. The predicted total annual dose to the population within 50 miles of the reactor resulting from both liquid and gaseous effluents is 1.9 person-rem and may be compared to 720,000 person-rem/yr arising in that area from natural radiation. (at 9 et seq. following Tr. 7352 as revised by updated Supplemental Testimony, also following Tr. 7352)

275. Applicants' Witness Larson testified that individuals residing 40 miles west of the Pilgrim site, as do the Cleetons, would experience radiation exposures estimated to be three orders of magnitude less than those predicted at the site boundary. Consumption of food originating near Unit 2 and utilization of Cape Cod recreational facilities could increase this factor to two orders of magnitude or the dose to 0.003 mrem/yr. (at 7 et seq. following Tr. 7352)

276. Applicants' Witness Cehn estimated 125 deaths per year within the 50-mile radius population attributable to background radiation exposure, 720,000 person-rem/yr. Superposition of the exposure expected from Unit 2 operation, 1.9 person-rem/yr, would, by the linear dose model of the 1972 BEIR Report, cause an additional 0.003 cancer deaths per year, an increase of 1 in 4×10^5 events, due to radiation and of 1 in 3.8×10^7 cancer deaths from all causes. (at 16 following Tr. 7352 as revised)

277. Although the analyses by the Staff evaluating the health effects of routine radioactive emissions during operation of Unit 2 utilized models and assumptions different from those of the Applicants, the results show variances considered to be not unreasonable. (Tr. 7432, 7814) The Applicants' values of the annual dose to the "maximum exposed" individual and of the 50-mile population dose, 0.28 mrem and 1.9 person-rem, compare to those of the Staff, 3.6 mrem (at 3 following Tr. 7654) and 1.81 person-rem. (Tr. 7819; at 3, Staff Exhibit 8A following Tr. 7820)

The Staff recognized that dose calculations may be uncertain by as much as an order of magnitude because of inadequacies in both model and input data. The practice, however, is to achieve conservatism in the result through introduction of data from the high-risk limits of the uncertainties and through "worst-case" assumptions. (Tr. 6625) Further, the Staff integrated the expected dose over the projected 30-year lifetime of Unit 2 and, additionally, extended the consideration for 50 more years to assure taking into account the whole lifetime exposure experience of an infant at the time of plant startup. (Tr. 6535) There is presently before the National Committee on Radiation Protection and Measurement a recommendation reducing the risk from low-dose rate exposure by a factor of five from that utilized by the Staff. (Tr. 6625)

278. In the evaluation of the annual dose to the "maximum-exposed" individual, Staff Witness Gotchy assumed a family residing near the site boundary, procuring all its food from nearby land and water and utilizing an adjacent beach for recreation. The source term in the evaluation was taken from the testimony of Staff Witness Weller. (Table 2 following Tr. 7659) The resulting whole-body dose for a child is 3.6 mrem/yr, shown to be greater than that for any individual organ and greater than that for any other age group. Accordingly, this value was used in subsequent dose evaluations.

279. From this exposure and the analysis proposed in the 1972 BEIR Report, the added lifetime risk, to this maximum exposed individual, of cancer mortality because of the operation of Unit 2 is 2.1×10^{-5}, or a mortality risk of 1 in 4.7×10^{4}. The risk 40 miles distant is orders of magnitude less. (at 6 following Tr. 7654) Extending the evaluations to the population exposure within 50 miles of the site resulted in the following. The dose from the combined liquid and gaseous effluents is calculated to be 1.81 person-rem/yr and to cause 7.4×10^{-3} cancer deaths over the 30-year life of the plant. The incremental life-time risk of mortality from radiogenic cancer is 1.8×10^{-9} or 1 chance in 550 million. (Staff Exhibit 8A following Tr. 7820 correcting both Tr. 6721-2 and Gotchy affidavit dated April 5, 1977)

280. For comparison, statistics[94/] describing common lifetime risks are tabulated:

94/ These 1973 statistics were taken from "Statistical Abstract of the United States - 1975", U.S. Department of Commerce, Bureau of the Census.

Cause of Death	Individual Lifetime Risk		
Cardiovascular disease	0.526	or 1 in	1.9
Cancer	0.178	or 1 in	5.6
Influenza and Pneumonia	0.0317	or 1 in	32
Motor Vehicle Accidents[95/]	0.0281	or 1 in	35
Suicide	0.0127	or 1 in	79
Homicide	0.0104	or 1 in	96
Peptic Ulcer	0.0039	or 1 in	256
Drowning	0.0026	or 1 in	380
Poison	0.0016	or 1 in	630
Air Travel	0.00062	or 1 in	1,600
Electrocution	0.0004	or 1 in	2,500
Lightning	0.000056	or 1 in	18,000
Tornadoes	0.000041	or 1 in	24,000
Hurricanes	0.000032	or 1 in	32,000

281. The Staff assessed the radiological impact of the operation of Unit 2 by determining radiation dose commitments to various segments of the population. The analysis begins with the anticipated liquid and gaseous effluents as source terms,[96/]

95/ This value corresponds to about 4.3×10^{-8} deaths per driving mile.

96/ The source terms initially determined by the Staff appeared as Tables 3.4 and 3.5 of FES. (at 3-20, 3-26) Models and parameters provided in "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)", NUREG-0017 (April 1976) required modification of the source terms to conform to Appendix I of 10 CFR Part 50. Additionally, changes (footnote continued on next page.)

their migration along various pathways and culminate in expected doses. Doses are, in some instances, translated into health effects and, ultimately, into a segment of the cost-benefit analysis.

282. The gaseous effluents determined by the Staff (Table 2 following Tr. 7659) were compared with the effluents calculated independently by the Applicants using a different model and different input data. A comparison of the two sets of results by Witness Weller (Tr. 7766) showed those of the Staff to be generally higher.[97/]

96/ (footnote continued) in the design of the gaseous radwaste system were proposed by the Applicants. Tables 1 and 2 of testimony by Staff Witnesses Weller and Gotchy (following Tr. 6482) resulted. This version reflects in the testimony of Staff Witness Gotchy. (following Tr. 6494) Still another revision was necessitated by a subsequent design change in March 1977. The latest results appear in testimony of Witnesses Weller and Gotchy (following Tr. 7659), where the updated source term appears as Table 2, and in the testimony of Witness Gotchy (following Tr. 7654). This evaluation is concluded and summarized at 11-1 et seq. Staff Exhibit 21 following Tr. 8921. See also Tr. 9083.

97/ In the Board's view this comparison may not be strictly proper. At the time of the testimony, the Staff's values included the March 1977 changes in the design of the gaseous radwaste system while the Applicants' values were taken from PSAR Table 11.3-9, Amendment 25, June 15, 1976 and could not reflect the March 1977 design change. Amendment 37 of the PSAR, issued August 1, 1977 (Applicants' Exhibit 24 admitted by Board Order dated December 16, 1980), included a revision of Table 11.3-9 listing source term components more properly comparable to the Staff's. Whereas between the latter there is general agreement, no trend is established.

283. The annual radiation doses averaged over the projected 30-year operating life of Unit 2 to a "maximum individual"[98/] arising from liquid and gaseous radioactive effluents were determined by the Staff to be less than the design objective doses stated in 10 CFR Part 50, Appendix I, by amounts ranging from 13 percent to more than 99 percent. Accordingly, the Staff concluded that the maximum individual would be subjected to an annual radiation dose of not more than 10 mrad from beta radiation, and 15 mrem from the iodines and particulate matter.

284. As a basis for judgment on a requirement for augments to the gaseous radwaste system, the Staff determined the annual population dose within a 50-mile radius of the reactor to be 1.8 man-rem total body and 3.4 man-rem thyroid. The annualized cost of the most effective augment considered is $11,500 which exceeds the cost-assessment value of $3,400 assigned to the thyroid dose in 10 CFR 50, Appendix I, Section II.D.

285. Translation by Witness Gotchy of anticipated exposures to health effects resulted in a conclusion that an individual living for 30 years at the Unit 2 site boundary,

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98/ A "maximum individual" is defined as one occupying any location, near ground level in an unrestricted area, where the expected radiation exposure is maximum. (Applicants' Exhibit 24 admitted by Board Order December 16, 1980)

subsisting entirely on locally produced foods, and engaging in recreational activities nearby, would encounter an incremental risk of one in 47,000 of dying of cancer induced by radiation from Unit 2. (at 6 following Tr. 7654)

286. This probability of a fatality from Unit 2 radiation-induced cancer was extended to the population within an area of 50-mile radius centered at the reactor. The result is an incremental risk of one chance in 550×10^6 of such a fatality among nearly 6×10^6 residents over the 30-year plant life. (at 5 following Tr. 7820)

287. The transport of nuclear fuel to an electric power producing plant and of radioactive materials, including the fuel after use, from the plant is an operation common to all nuclear-power reactor installations and its anticipated impact on the environment is the subject of a regulation.[99/]

288. The Applicants, through Witness Rosen, affirmed that the planned design and operation of Unit 2 are within the requirements and limitations established as requisites[100/] for application of the regulation, and that all shipments of nuclear

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99/ 10 CFR 51.20(g), particularly Summary Table S-4.

100/ 10 CFR 51.20(g)(2).

materials would conform to all applicable regulations.[101/] (at 5 following Tr. 3651, Tr. 3657)

289. The Staff presented Witness Barker who sponsored several AEC/NRC documents[102/] containing information and conclusions on which the referenced NRC regulation is based. The testimony and the response by the witness to cross-examination present the conclusions of WASH-1238 on the risk of radiological exposure due to accidents during transportation. These conclusions derive from specifications of the design of containers and the quality to be assured in their construction, of permissible radiation at the outer surface of the containers arising from their contents, of permissible quantities of contaminating substances on the outer surface, of necessary and informative labels, and of the monitoring necessary to establish compliance with the regulations. (following Tr. 2536; Tr. 2552 et seq.)

101/ Packaging standards and criteria are found in the regulations of the Nuclear Regulatory Commission (10 CFR Part 71) and the regulations of the U.S. Department of Transportation (49 CFR Parts 170 through 179).

102/ The documents sponsored by Witness Barker are a) an excerpt from the Federal Register, Volume 40, pp. 1005-1009 (Staff Exhibit 1); b) "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants," WASH-1238, December 1972 (Staff Exhibit 2); c) "Supplement One to WASH-1238," NUREG-75/038 (Staff Exhibit 3). These exhibits together with Witness Barker's testimony were received at Tr. 2537. The testimony was bound following Tr. 2536 in some but not all copies of the transcript. As a remedy of this omission the testimony was again received as Staff Exhibit 23 by Board Order dated July 14, 1978.

290. At the request of the Board, the Staff presented as evidence the updated findings of an ongoing research program investigating the integrity of used-fuel shipping containers under severe potential-accident conditions. In the tests the truck, on which used-fuel containers loaded with unirradiated fuel were mounted, was subjected to collision with another truck or with a railroad locomotive in a simulated grade-crossing mishap. In an additional test a container impacted hard soil at speeds up to 250 mph equivalent to free fall through a distance of 2000 feet. In these tests the containment provided by the containers was either not breached or a trivial quantity of its liquid contents was lost through a leaking gasket. (Staff Witness Hodge at 2 following Tr. 8459) The results of these tests show a massive rupture of a spent-fuel cask to be essentially impossible.

v. Impact of the Uranium Fuel Cycle

291. Tables S-3 and S-4 in 10 CFR § 51.20(e) and (g), respectively, summarize the environmental effects of the uranium fuel cycle including the impact of transportation of radioactive materials to and from the plant.[103/]

103/ "Table S-3 does not include the health effects from the effluents described in the Table, or estimates of the releases of radon-222 from the uranium fuel cycle or estimates of technetium-99 releases from waste management or reprocessing activities." Excerpt from footnote 1, Table S-3.

292. The issue of radon-222 releases and effects was included in this proceeding by the Board's adoption (Tr. 9127) of the record of the Perkins' proceeding and the findings of the Perkins' licensing board.[104/]

293. Viewing radon discharges of mining and milling operations as causing fractional increases in natural background radiation, "the increase . . . is so small compared with background and so small in comparison with the fluctuations in background as to be completely undetectable. Under such a circumstance, the impact cannot be significant." (from finding of fact 51, LBP-78-25, 8 NRC 100; see fn 103 supra.)

294. The health effects of the effluents described in Table S-3 are considered to have insignificant effect on the overall cost-benefit balancing of Unit 2.

104/ Partial Initial Decision, Environmental Consequences of the Uranium Fuel Cycle, (Perkins Nuclear Station, Units 1, 2, and 3) LBP-78-25, 8 NRC 87 (1978). As pointed out by the Appeal Board, the use of Perkins as a "lead case" in the generic radon issue would result in large savings in time and effort yet not foreclose further pursuit of the issue by any litigants who might believe it warranted." Philadelphia Electric Company et al, ALAB-480, 7 NRC 796 (1978).

vi. Availability of Fuel and Waste Disposal Facilities

295 Applicants' and Staff witnesses addressed the following topics: (1) the availability of uranium at an acceptable cost as a resource over an interval corresponding to the projected life-time of Unit 2; (2) the effect on that availability of recycling the uranium residue in used fuel elements into a supply for new elements; (3) the monetary gain to be derived from that recycle; (4) the monetary and environmental costs of prolonged used fuel storage at the Pilgrim Site including its indirect consequences on transportation effects.

296. The testimony of Applicants' Witness Stoller (at 46 et seq. following Tr. 955) based on early information concluded that U.S. uranium resources were adequate to fulfill the projected needs of 223 electric generating plants then projected. This witness later testified on the matter of utilizing uranium and plutonium obtained by recycle of used reactor fuel as an energy resource. The uranium-235 content of the uranium in used fuel, about 0.9 percent, enhances its value over that of natural (0.7 percent uranium-235) uranium as a raw material about 25 percent. That is, use of one part of recycled uranium would replace 1.25 parts of virgin material. Use of the salvable plutonium from recycle would further reduce the demand for uranium as fuel by about 20 percent. (at 3 et seq. following Tr. 4692)

297. Staff Witness Nash testified that 1.5 million tons of U_3O_8 would be required to fuel 236 nuclear power reactors now operating, under construction, and planned, comprising a capacity of 242,000 MWe, throughout their projected 30-year lifetime. This estimate is based on a 0.3 percent uranium-235 content of uranium tails from gaseous diffusion separation plants and on the assumption of no light-water reactor fuel recycle. (at 3 following Tr. 4853) The resource available at acceptable costs to fill this need, as determined by the U.S. Energy Research and Development Administration, was reported by Staff Witnesses Nash and Fisher to be 3.0 million tons of U_3O_8 including 1.1 million tons having possible potential. (at 7 following Tr. 8304)

298. Commonwealth Witness Lee foresaw no shortage of fuel required for the operation of Unit 2. (Tr. 5030)

299. One of the limits of options conceived for the disposal of used fuel is permanent storage of the intact fuel elements, under the jurisdiction of U.S. Government, with no recovery of the value of the constituents of the materials contained. This scheme is called the "throwaway" fuel cycle and will, of course, entail a cost to the utility. The Applicants' estimate that this alternative will increase the 1988 cost of nuclear-produced energy by an amount equivalent

to 1 mill/kWh or 3 percent of the generating cost. (Applicants' Witnesses Stoller and Muckerheide at 5, 6, 13 following Tr. 4692 and Seery at 22 following Tr. 8207)

300. Staff Witnesses Nash and Fisher place this fuel cycle cost differential between recycle and no recycle at 2.3 mills/kWh. (at 21 following Tr. 8304)

301. The absence of used-fuel reprocessing, per se, and of regulatory decision on any alternate ultimate "backend" of the fuel cycle will require temporary accommodation of fuel elements being continually discharged from operating reactors. A typical capacity of the used-fuel storage facility in a reactor complex is one and one-third cores established by a discharge schedule of one-third core per year and a requirement for the capability to receive the core-in-operation were a need for complete unloading to arise. Staff Witness Miller described means of increasing the capacity of existing storage pools by the introduction of neutron-absorbing chemical elements to permit more compact arrays of the fuel elements.[105/] The neutron absorber may be included in the structural supports or may be dissolved in the cooling-shielding water. The witness predicted that the capacity of the Unit 2 pool could thereby be doubled

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105/ The structures for such configurations are sometimes referred to as "high-density racks."

to provide adequate space for operation for about 10 years.[106/] Additional storage capacity could be provided by newly constructed facilities both at the reactor site or elsewhere. (following Tr. 4778)

302. Applicants' Witnesses Stoller and Muckerheide estimate the effective cost of the "high-density" storage racks to be 0.6 mill/kWh. Their cost, however, is included in the current estimated capital investment. (at 13 following Tr. 4692)

303. The potential impact on the environment of increased and prolonged storage of used fuel at the Pilgrim site through greater exposure of the public was analyzed by Staff Witness Parsont who concluded that an insignificant increment to an already low exposure would occur. Radiation from the pool is comprised of (a) a component from the used fuel and the irradiated structural materials of the elements, and (b) a component from the cooling water arising from activity induced in water itself and in dissolved impurities and from radioactive materials that have leaked from defective fuel tubes. The design capacity of the Unit 2 storage pool is 300 fuel assemblies. The minimum depth of the cooling water above the radioactive portion of the assemblies is 26 feet. Calculations by validated

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106/ The availability of the one-core reserve-storage capability during these 10 years is not clear from the testimony. (at 3 following Tr. 4778)

methods have shown the dose rate 3 feet above the surface of the pool to be 10^{-7} mrem/hr from radiation arising in the fuel. By similar means the dose rate at that elevation from the activity in the water is 1.8 mrem/hr. The corresponding dose rate to an individual located 1900 feet above the pool from both sources would be 0.02 mrem/hr.[107/] An increase in the inventory of used fuel by several-fold necessary to accommodate the discharge from the reactor over an extended period will increase this impact proportionally at most. (Staff Witness Parsont following Tr. 4906)

304. Applicants' Witness Muckerheide arrived at the same conclusion through considerations of the quantities of thermal energy to be dissipated by the pool coolant as a function of the inventory and its age. There is additional conservatism in the result because the spectrum of the emissions from "old" fuel elements softens with age. Further, the retention of used fuel at the Pilgrim site reduces still further the small radiological environmental effects associated with normal transport. (at 9 through 11 following Tr. 4692)

107/ The residence nearest the proposed storage is 1900 ft distant. (ER at 2-66) Calculation at a vertical distance of 1900-ft is conservative through neglect of radiation shielding effected by structures and other objects encountered in a 1900-ft ground level path. Vertically emitted radiation must be air-scattered to ground level. (Staff Witness Parsont at 2, 3 following Tr. 4906)

IV. B. d. Consideration of Alternatives

i. Alternate Energy Sources

305. The witnesses collectively addressed the utilization of fossil and solid-waste fuels, both directly or after conversion, in conventional steam-electric generating plants, and the reliance upon solar, wind, and oceanic temperature-differential energies.

306. Plant operational reliability is an important consideration in determining both absolute and relative costs of power and energy derived from various sources. Reliability was discussed by a number of witnesses. The quantitative measure addressed was the capacity factor defined as the ratio of the actual energy output to the expected net energy output. The availability factor is the ratio of the maximum energy that could have been supplied to the expected net energy output. The capacity factor and the availability factor are equal for a fully loaded base-load generating station.

307. Applicants' and Staff's testimony[108/] on nuclear and coal as alternate sources of energy was first presented to the

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108/ See, for example, the testimony of Applicants' Panel comprised of Messrs. Sten, Weiner, Butler, Maroni, Hechling, Stoller, Godley, Smith, Gerber, Irving and White following Tr. 955. Also Staff's Final Environmental Statement following Tr. 897 and testimony of Witness Vetrano following Tr. 1409.

Board in October 1975. Rapidly changing economic conditions throughout the United States in the ensuing period have made moot those early cost-benefit analyses and many were updated[109/] in mid-1977. Accordingly, the Board has attached greater weight to the later testimony.

308. The Commonwealth presented the testimony of three panels of witnesses relating to the economics of electric power generation from nuclear and coal energy. Witnesses Lee and Levy sponsored a report[110/] which discusses required generating capacity and the narrow choice between nuclear and coal sources. (bound following Tr. 4962)

309. Commonwealth Witnesses MacDonald and Madden (following Tr. 5690, Tr. 6220) and Boxer (following Tr. 8587) addressed primarily the expected capacity factor of future nuclear generating stations. Both studies derived from a statistical analysis of past performances of generating plants. The former compared anticipated operations of coal and nuclear plants and the latter presented the results of an historical study of nuclear power plant performance.

109/ See Applicants' panel comprised of Messrs. Maroni, Madsen, Leery, Dunlap and Gibbons following Tr. 8207. Also testimony of Staff Witnesses Nash and Fischer following Tr. 8304.

110/ "The Economics [illegible] Power: A New England Perspective," En[illegible]y Office, Commonwealth of Massachusetts (Decem[illegible]).

310. The decision of NEPOOL on the need for power in the immediate future is to expand the base-load generation capacity through the addition of nuclear fueled plants to achieve an approximate 55 percent nuclear component of the total NEPOOL capacity. Although NEPOOL expects its nuclear units to operate at about 70 percent capacity factor,[111/] its study shows an economic benefit of nuclear at an operation at even 50 percent capacity factor.[112/] Unit 2 is considered to be an integral part of the NEPOOL plan.

311. Applicants' Witness Maroni (at 6 following Tr. 8207) presented comparative generating costs in 1988 by nuclear and coal units. The nuclear-energy costs apply to the 1150 MW Unit 2 plant then expected to be in service for four years and the coal-energy costs apply to two 590 MW units expected to have come on line in 1984 and 1985. The nuclear projections are by BECo and its consultants; the coal-plant capital costs are based on a 1977 Bechtel Power Corporation study prepared for the

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111/ The 30 percent operating penalty in the projected capacity factor results from both scheduled and unexpected down times. For example, a normal 6-week refueling reduces the capacity factor by 12 percent. Additional reductions stem from regulatory actions, equipment malfunctions, and economic dispatch of energy. (Applicants' Witness Henchling at Tr. 1350)

112/ Applicants' Witnesses Sten at 18 following Tr. 955; Maroni at Tr. 1330; Sten at 109 following Tr. 2647; Bigelow at 8 following Tr. 7929.

Electric Power Research Institute.[113/] The estimated coal-fuel costs were prepared by Boston Edison Company consultants.

312. The projected total generating costs are 50.2 and 68.1 mills/kWh, the 17.9 mills/kWh differential favoring the nuclear plant.[114/] A 70 percent capacity factor was applicable in both instances. Further capital investment, comprising 72 percent of the nuclear plant generating cost, is no longer subject to escalation after commencement of operation. The nuclear-coal differential may, accordingly, increase with time.

313. For comparison with the estimates of the Applicants the bases selected by the Staff in recent testimony (Staff Witness Nash at 25 following Tr. 8304) are, as for the Applicants' values, a nominal generating capacity of 1000 MW, no recycle of used nuclear fuel, no requirement for exceptional nuclear-plant site preparation on account of seismic requirements, and a 70 percent capacity factor of both nuclear and coal

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113/ Bechtel Power Corp. "Coal-Fired Plant Capital Cost Estimates," EPRI-AF-342, January 1977. (following Tr. 8207) The basic conditions of this report were adjusted to those unique to coal-fired plants proposed by Boston Edison for construction in the south-of-Boston area.

114/ The estimated 50.2 mills/KWh is based on a "throwaway" fuel cycle, i.e., the residual uranium-235 and the byproduct plutonium are not recovered from used fuel, rather the fuel is put into the custody of the Government at a prescribed cost to the owners, the utility, which is included in the estimate.

generating stations. On these bases the projected 1984 electro-nuclear energy cost is 47.3 mills/kWh and that from a coal-fueled plant is 63.6 mills/kWh representing a differential of 16.3 mills/kWh favorable to nuclear comparable to the Applicants' value of 17.9.

314. The estimates of the cost of generating electrical energy is strongly dependent upon the capacity factor expected. The Applicants based the 1984 cost on a value of 70 percent for both the nuclear and coal plants. The Commonwealth challenged that basis through three panels of witnesses as being atypical.

315. Commonwealth Witnesses Lee and Levy testified that nuclear and coal electric power plants will be competitive in the 1980's and justify their conclusion with qualitative statements of expectations at selected capacity factors for both types of plants. (at 38 following Tr. 4962) No numerical cost estimates, or of their construction, are given. Coal is said to be advantageous when coal capacity factors are large (75 percent) and nuclear capacity factors are small (50 percent), and vice versa. These witnesses pointed out that coal capacity factors, in recent times, have become 60 percent and less as plant size has increased. The report concludes that a nuclear choice should be made by a utility provided a "65 or 70 percent" capacity can be realized.

316. Commonwealth Witnesses MacDonald and Madden (following Tr. 5690) offered the results of a statistical analysis purporting to show (1) that an increase in the output of a generating unit, either coal or nuclear, results in a decrease in the cumulative capacity factor; and (2) that, with increasing age, the capacity factor of a nuclear unit decreases while that of a coal plant increases.

317. The study was by the method of regression analysis with the cumulative capacity factor as the dependent variable and the duration of plant operation and its design power as the independent variables. Operational data from 28 nuclear plants and 31 coal plants were analyzed. The design power of the nuclear units, which had operated up to 15 years, ranged from 175 to 1085 MW. The coal-fired plants had operated up to 17 years and ranged in power from 114 to 1150 MW.

318. During cross-examination of these witnesses (Tr. 6220 et seq.) the data and results originally presented were, in many instances, altered severely.[115/] The results of the analysis were supplemented by addition of confidence intervals at the 95 percent level.[116/] The confidence level on values of

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115/ See, for example, Applicants' Exhibits 11 and 12, identified at Tr. 6226 and 6228. These exhibits were admitted at Tr. 6329.

116/ These data were supplied by the Commonwealth to the Applicants under date of July 26, 1976 and were received and bound into the record on July 1, 1977 following Tr. 8798.

the expected cumulative capacity factor are observed to span as much as six orders of magnitude.[117/]

319. The witnesses calculated[118/] expected generating costs for both nuclear and coal units utilizing the above capacity factors. Considering the many combinations of assumed input parameters, no dramatic differences between the two types of fuel are discernible. No confidence limits are stated. Also, no consideration of societal costs of coal operations, such as black-lung disease and fatalities arising from accidents, were included. (Tr. 6325)

320. Witness MacDonald seemed not to value highly some of the results for, in response to a query about the initial absence of an assignment of standard errors, he stated "Basically because the number of data points is small, the statistics are not good. I refer to the large uncertainty associated with the data points, and what I was trying to demonstrate is that given the data as they were, this is the kind of answers that

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117/ For example, the expected cumulative capacity factor of a 600 MW nuclear plant after 5 years operation is reported by Witnesses MacDonald and Madden to be 72.8 percent within a 95 percent confidence range of 27600 percent to 0.0510 percent. For a 1150 MW plant similar to Unit 2 the expected capacity factor after 15 years operation is 23.6 percent within the range 121.6 percent to 3.7 percent. For a 1200 MW coal-fired plant after 15 years the factor is 61.8 within the range of 159.3 to 23.7 percent. (Tables 3B, 3C and 4b following Tr. 8798)

118/ Table 5 of "Statistical Analysis of the Capacity Factors of Base Load Nuclear and Coal Plants" following Tr. 5690 as amended by Applicants' Exhibit 12 following Tr. 6329.

you come up with. I'm not making any supposition that these have - are highly significant in a strict sense, statistical sense." (Tr 6293 et seq.)

321. The Commonwealth added further to its rebuttal of the Applicants' expected 70 percent capacity factor through the testimony of Witness Boxer (following Tr. 8587) which statistically predicted the capacity factor of Unit 2 in 1988 to be in the range 17.63 to 77.87 percent with an expected value equal to 47.75 percent. The limits are at a 95 percent confidence level.[119/] This analysis was also by a multiple regression method with plant age and size as the independent variables.

322. The witness applied the analysis which predicted a Unit 2 capacity factor of 47.75 percent to operating pressurized water reactors supplied by CE. The analysis included empirical constants derived from the history of all operating pressurized water reactors. The difference between statistically predicted capacity factors and those actually observed ranged from -33 to + 20 percent. (Tr. 8614)

323. In the analysis by Witness Boxer only 20 percent of the variability is accounted for by plant age and size, the independent variables studied. (Tr. 8693) Correspondingly,

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119/ These final results were transmitted to the Board on August 1, 1977 and were accepted into the record as Commonwealth Exhibit 16 by Board Order dated July 14, 1978.

80 percent of the variability is unexplained or unexplainable. Were these unknowns introduced, their effects could influence the expected capacity factor either way.

324. Although the Staff originally utilized a capacity factor in the range 60 to 80 percent in determining benefits from the proposed Unit 2 plant (FES Table 10.1 at 10-6), Staff Witness Nash proposed a value between 55 and 65 percent near an estimated break point below which the total production cost from fossil fuel is more favorable than from a comparable nuclear-fueled plant. This value of the capacity factor was derived from the recorded 1964-1973 experience of the operation in the United States of nearly 900 fossil plants (capacity factor 68.9 percent) and of 20 nuclear plants (factor 64.2 percent). In 1974, 41 nuclear plants operated at a capacity of 57.2 percent. (at 27 following Tr. 3110)

325. Methods of analyzing and evaluating the environmental and societal impacts, including those on man, of the coal-fuel cycle have not matured to the degree characteristic of nuclear effects. Nonetheless, the Staff attempted a comparative evaluation of the health effects of nuclear- and coal-fuel cycles. The absence of data and the shortcomings of its interpretation introduce uncertainties of as much as two orders or magnitude in these conclusions. The results reported are expressed as the annual mortality within the population in the 1980's attributable

to the respective fuels of a 800 MW generating station.[120/] The estimated mortality as a consequence of the operation of a coal-fuel system is 30 to 240 times greater than that estimated from the operation of an all-nuclear cycle. (Gotchy, Table 1, following Tr. 8358)

326. Staff Witness Gotchy testified to the relative impacts on the environment of the nuclear and coal cycles with emphasis on the developing recognition of the effects of pollutants from coal, and the attendant uncertainties were energy requirements from that source to increase at the rate anticipated assuming that gas, oil, and nuclear fuels do not meet the demands of the future. On the other hand, the hazard potential of the nuclear cycle has been recognized since its inception and very conservative estimates of its effects have been assigned. Major pollutants from the coal cycle demanding study and evaluation of their environmental effects include:

(a) particulates of respirable size containing metals;

(b) hydrocarbons of carcinogenic character;

(c) oxides of sulfur and nitrogen;

120/ This is a 1000 MW plant operating at 80 percent capacity factor.

(d) ozone, radon, carbon monoxide and dioxides and other gases;

(e) carbon dioxide[121/] in its special consideration as an increasing atmospheric constituent affecting the transmission of radiant energy, the "greenhouse" effect;

(f) acids and acidic solutions as rainout and as discharges from coal mines;

(g) flyash and other solid products of combustion, including the SO_2 absorbers. (Gotchy at 3 and 6 to 11 following Tr. 8358)

327. The annual requirement of a fully operating 1180 MWe electric generating plant will be about 4 million tons of coal, 16 million barrels of fuel oil, or 40 tons of nuclear fuel. The annual particulate and gaseous effluents from the three plants are, respectively, 1.4×10^5 tons, 3×10^4 tons, and a negligible amount. (FES at 9-7)

328. In a discussion of the removal and disposition of products of the generation of electricity from a coal source,

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121/ A favorable effect of the discharge of carbon containing little ^{14}C is a dilution of that radioisotope.

it was pointed out by Applicant Witness Hechling (Tr. 1318 et seq.) that the solid constituent is comprised of pit-ash, fly-ash and the absorbent utilized in the SO_2 cleanup system, usually a calcium salt. About 90 percent of the ash is collected from flue gases. Disposition of solids at present is by landfill, a practice currently under review by the Environmental Protection Agency (EPA) with emphasis on seepage of toxic metals naturally present in coal into groundwater supplies. The past casual treatment of this apparent innocuous material is now due for a more careful assessment.

329. The creation and shipment of radioactive materials to and from Unit 2 is less an adverse effect on the environment than the transportation and on-site storage of the large amounts of fuel required for a fossil plant. A half-million tons of coal or a quarter-million tons of oil is required to provide a 60-day reserve. (FES at 9-7)

330. Evidence was received from the Applicants and from the Staff on the availability and viability of other, less common sources of energy. Included were coal gasification, solar, winds, solid wastes from population centers, and oceanic temperature differentials.

331. Successful gasification of coal requires a resource of low-sulfur content and large quantities of water, needs

incompatible with their geographic distribution in the United States. That is, low-sulfur coal is mainly in the west with adequate water supplies at the Mississippi River and points east. (Applicants' Witness White at 75 following Tr. 955)

332. The generation of electric energy from solar sources is in development. With an availability factor in New England estimated at 12.5 percent (3 hrs/day), large efficient collectors and hugh thermal storage capacities are required. A source of 1100 MW would employ 300 square miles of collector plus storage space. Home heating and home-water heating is a more viable undertaking and, in fact, is underway on a limited scale. Present costs of a solar unit for home heating are relatively high (10 percent of the cost of a 3-bedroom home to supply 50 percent of the average seasonal heating requirements) and a backup system, preferably electric, would be required. Demonstration installations have shown a need for further materials research to cope with observed deterioration of collectors. This use of solar energy would reflect on the demand for oil, the principal heating source, rather than for electricity. (White at 76 et seq. following Tr. 955)

333. Commonwealth Witness Converse testified to the technological feasibility of using solar energy for space heating in New England as an economically competitive supply.

Since space heating accounts for 40 percent of all the energy requirements in New England and solar is a viable source, he concluded that, with progressive development, solar energy could supply 10 percent of that requirement by the end of this century. In his experience, an experimental solar space heating installation, at a capital cost of $12,000, in a 1.5 story structure occupied by shops and having a floor area of 2300 ft^2, is supplemented by heat pumps and resistance heating. Although some heat panels have lost effectiveness through opacity of covers and some have been removed from service for other reasons, a not unusual experience in a developing technology, the solar installation provided about 40 percent of the heat required in the winter and spring of 1975. (Commonwealth Exhibit 2 admitted at Tr. 1540; Tr. 1606, 1615, 1544 et seq.)

334. In cross-examination it was established that only about 1 percent of the space heating in New England is electrically supplied. (Tr. 1560) Since some of the required backup systems to solar power installations would be electrical, the electrical energy requirement might even increase.

335. Staff Witness Vetrano stated that the production of electricity from steam generated from solar energy has not been shown to be feasible; that production of electricity through photovoltaic action is not presently feasible because

of low efficiency and undependable equipment (an energy density of 0.1 W/cm^2 and a 10 percent collector efficiency results in a requirement of 2500 acres for the generation of the Unit 2 design power output); that the potential of solar energy for domestic water heating and for home heating and cooling is viable. He concluded that increasing fuel costs and the expected decrease in the cost of improved solar collectors would make solar home heating and cooling an economical option in the 1985-1990 period; and, with respect to wind power, he estimated that 2000 windmills off the Massachusetts shore would be required to produce the electrical output of Unit 2. This number is derived from an annual average wind power of 800 W/m^2, 200-ft blades and 20 percent efficiency. (following Tr. 1409)

336. Applicants' Witness White considered the production of useful energy from wind power to be a likely supply from small units with present capacity being limited to about 5 kW/unit. Research projects directed toward a 100 kW unit are underway. (Following Tr. 955) In cross-examination Witness White emphasized the variability of the wind, and hence, of power availability and the need for energy storage. He considered wind not to be a source of bulk electrical energy although it has promise for home application. (Tr. 1394)

337. The temperature differential of 20 Celsius degrees required for production of ocean-thermal power is not available in the New England shore areas; the effects on aquatic biota of transporting the required large quantities of seawater and the underwater transmission of the energy are considerations in areas where the method is technically viable; and the estimated cost is 50 mills/kWh in 1974 dollars for a 100 MWe plant not including electrical transmission costs. (Vetrano at 41 following Tr. 1409; White at Tr. 1395)

338. The production of useful energy from burning trash and other solid wastes was discussed by witnesses representing the Applicants, the Commonwealth and the Staff. Applicants' Witness White stated that solid wastes would be most useful as a supplement to the combustion of fossil fuels. Possibly as much as 100 MWe could be obtained from the waste produced in the Boston area. Even if direct use of waste as a fuel were developed, a generating capacity equal to that of Unit 2 would require a transportation system to collect solids from a population greater than that of Massachusetts. (White at 81 following Tr. 955)

339. Commonwealth Witness Cousins described the beneficial recovery of energy from solid wastes as a developing technology and stated that, by statutory requirement, the

Commonwealth is conducting research and development on improved methods of disposal including recycling. A plant consuming 1200 tons of trash per day for the generation of process steam is in operation in Massachusetts. The trash is not mixed with other fuel. A second plant, underway for 1979 operation, is expected to produce 60 MW of electric power from burning 3000 tons of mixed refuse per day, probably without fossil fuel addition. The electrical energy generating potential from combustion of all the solid waste produced in Massachusetts is 470 MW. Further, however, the witness testified that the use of solid waste as a fuel "will not replace Unit 2." (following Tr. 5411, particularly fn. 1 at 3; also Tr. 5463, 5439 and 5452)

340. The commitment of the Commonwealth to support the technology of electric power generation from solid wastes was confirmed by Witness Neely. (Commonwealth Exhibit 17 at 17)

341. Staff Witness Vetrano noted that the expected generating cost at Boston area plants is an attractive 8 mills/kWh with pickup a major cost component. Location of such facilities near urban areas is therefore desirable. Also, the combustion of trash combined with coal is a preferable method. Trash burning is susceptible to problems of particulate and gaseous-contaminant emissions similar to those of coal. Scrubbers or other decontaminating devices are required. (at 35 following Tr. 1409)

342. The Staff considered other processes, all requiring research and/or development to establish their economic or practical applicability. These include pyrolysis and hydrogenation, anaerobic digestion and coal gasification. (at 24 et seq. following Tr. 1409)

343. No viable source of geothermal power is known to exist in New England. (FES 9-2)

i. Alternate Sites for Unit 2

344. As stated in the Preliminary Statement of this Decision (para. 15 supra), this Board rejected in a prior Partial Initial Decision the analysis of alternate sites by the Staff. The Board found the Staff's analysis"...to be couched in generalities." The Board further found"...no record of a careful examination, either physically or by review of proffered descriptions of other than [the Applicants' proposed] Rocky Point." The Board concluded that"...the Staff's evaluation of alternate sites is inadequate, and...this deficiency requires the denial of the Applicants' application for a Limited Work Authorization." [6 NRC 839 at 845 (1977)] In upholding this decision the Appeal Board[122/] rejected the Staff's "generalized" review process which led to the elimination of all other potential sites without a detailed examination of specific sites, including site visits.

122/ Boston Edison Company (Pilgrim Nuclear Generating Station, Unit 2, ALAB-479, 7 NRC 774 (1978).

345. Licensing the construction of a nuclear power plant is a "major federal action" within the meaning of Section 102(2) (C) of the National Environmental Policy Act of 1969 (NEPA). This section of NEPA requires the Commission to "...consider whether reasonable alternatives less harmful to the environment exist before allowing a utility to proceed with construction." (Id. at 778) To satisfy NEPA, the agency must identify, study and compare alternative sites for the location of the proposed facility. In determining whether a proposed site is environmentally acceptable, the Board must find that after giving each alternative site a "hard look" none is found "obviously superior" to the one proposed by the Applicant. Public Service Company of New Hampshire (Seabrook Stations Units 1 and 2), CLI-77-8, 5 NRC 503 (1977).

346. Subsequent to the Board's decision (LBP-77-66) and the Appeal Board's affirmation (ALAB-479), the Staff undertook to remedy the alternate site review deficiencies. To assist the Staff in its review, BECo submitted on January 26, 1978, a draft siting study entitled "Boston Edison Company Siting Study for Long-Term Capacity Expansion - 1975 to 2000" [the 1974 siting study, Applicants' Exhibits 14(A), (B) and (C)]. The 1974

siting study was not prepared for the purpose of supporting the construction of Unit 2 at the Rocky Point Site but rather for the purpose of identifying current and future generating options and other sites for the Boston Edison Co. to the year 2000. The study assumed that the Rocky Point Site was planned for three nuclear plants, and further utilization of the site was not considered. The 1974 siting study was updated by BECo on May 30, 1978. (Staff Exhibit 53 at vii bound following Tr. 9852)

347. The 1974 siting study conducted by United Engineers and Constructors, Inc. (UE&C) used a radial approach. The review started with the center of the BECo service district and moved radially outward along resource areas (water bodies) until a decision was made that a sufficient number of sites had been identified. After examination of over 100 parcels of land in eastern Massachusetts, a total of 24 fossil and nuclear sites were identified, of which 10 were deemed satisfactory as possible nuclear plant sites. (Applicants' Witness Griffin at 6 following Tr. 9608 and Staff Exhibit 53 at 3-2) The 1974 siting study was limited to eastern portions of Massachusetts and did not include the largest fresh water resource in the state--the Connecticut River. The Staff considered this to be a major deficiency of the 1974 siting study and in its comparison of alternative sites the Staff

included Montague as a representative site from the Connecticut River Valley to compare with the Applicants' proposed Rocky Point Site. (Staff Exhibit 53 at 4-1)

348. After its initial evaluation of the 1974 siting study the Staff requested additional information. BECo supplied the requested additional information in 1978, including responses to Staff questions and reconnaissance level information obtained from various sources. The Applicants reviewed and updated the description of nine potential nuclear sites identified in the 1974 site study and provided similar information for existing sites in New England, including Charlestown, Seabrook, Montague, and Millstone. (Applicants Exhibit 15 received at Tr. 9637) The Staff supplemented Applicants' further information with data gathered independently, including site visits by each member of the team responsible for preparing supplements to the FES. (Staff Witness Scaletti at 2 following Tr. 9852)

349. During the course of their review, the Staff visited 19 sites, including among others Millstone, Seabrook, Montague, Pilgrim and each of the 10 candidate nuclear sites listed in the Applicants' 1974 siting study. (Id.) Millstone and Seabrook are both located outside the State of Massachusetts and even though Applicants might have legal problems locating power plants outside the Commonwealth, Staff included them in its evaluation. (Staff Exhibit 53 at 4-1)

350. The Staff analysis of the 1974 siting study was divided into (1) an assessment of the site selection process and (2) and assessment of the candidate sites. Their assessment of the site selection process resulted in the addition of three sites (Montague, Millstone and Seabrook) to the list of candidate nuclear sites of the 1974 study. The Staff's final assessment included Montague, Millstone, Seabrook and 9 sites from the 1974 study (3 located within 20 km of the Merrimack River, 4 within the town of Plymouth, and 2 located in the Buzzard Bay area) for a total of 12 alternates for comparison with the Rocky Point Site.

351. Twenty-three characteristics of each of the 12 sites were evaluated and compared directly with Rocky Point. The comparison includes: water availability, terrestrial ecology and land use, socioeconomics, demography, hazards, aquatic ecology and water quality, geology and seismology, and meteorology. Characteristics of the sites were rated as superior, equal or inferior to Rocky Point. (Id.)

352. The Staff conclusion after comparing the environmental attributes and site characteristics of each of the 12 alternate sites is that none of the candidate sites is superior to the Rocky Point site. (Id. at viii and 4-60)

353. As regards underground siting, BECo's 1974 siting study addressed the issue and, although indicating certain possible advantages, did not recommend the underground siting concept. (Applicants' Exhibit 14 at III-29, 30 and 72, 73) Both Applicants and Staff testified that underground siting for Unit 2 is not a practical alternative within the current schedule for construction. (Applicants' Witness White at 65 et seq. following Tr. 1656; Staff Witness Harbour at 9 following Tr. 1493) No general designs currently exist for plants to be built underground and technical problems such as potential flooding and assuring the stability of the site have to be resolved. (White at 66 following Tr. 1656; Harbour at 4, 5 following Tr. 1493) Underground siting would also entail substantially higher plant costs. (Applicants' Exhibit 14 at III-29; Harbour at 5, 6 following Tr. 1493) Both Applicant and Staff witnesses testified that offshore siting is not a reasonable alternative for Unit 2 at this time since most of the coastal areas of Massachusetts are protected ocean sanctuaries. The design and feasibility of offshore plants are currently under Staff review and no plants have been licensed to date. The record shows that Applicants have evaluated inland sites along the Merrimack, Concord, Nashua and Taunton Rivers. (Applicants Exhibit 14, Figure V-1 and page VI-3) Both Applicants and Staff agree that the only available fresh

water source in Eastern Massachusetts capable of supporting a large power plant is the Merrimack River. (Id.; Applicants' Witness Griffin at 5 following Tr. 9607; Staff Exhibit 53 at 4-1 and 4-6 through 4-19 bound following Tr. 9952) The Staff also considered the Montague site, an inland site located on the Connecticut River in Western Massachusetts. (Staff Exhibit 53 at 4-44 through 4-52)

iii. Alternate Condenser Cooling

354. The condenser cooling systems considered by the Applicants and reviewed by the Staff included: open-cycle, "once-through" cooling, utilizing Bay water with a temperature increase up to 29°F; cooling ponds; spray canals; mechanical-draft saltwater cooling towers; natural-draft saltwater cooling towers; combinations of various open-cycle/closed-cycle systems; and dry-cooling towers. (ER § 10.1.1; FES at 9-7 to -16) The system selected by Applicants based upon technical, economic and environmental consideration is a once-through cooling system with a condenser temperature rise of 22°F across the condensers. The two alternatives considered feasible for detailed consideration were mechanical-draft and natural-draft cooling towers utilizing saltwater because less than 10 percent of the freshwater required is available. A summary comparison of these three systems is in ER Table 10-1.

355. A mechanical-draft saltwater cooling system would require three towers approximately 50 x 400 by 75 feet high. Compared to a once-through installation, this method would discharge less heat to the Bay and would require 65 percent less cooling water, thereby reducing the loss of aquatic biota through impingement and entrainment.[122/] It would, however, result in serious problems of salt drift and noise. The Staff estimates that up to 2.5 tons of salt per day could be deposited on surrounding land resulting in property damage and impacts on terrestrial vegetation. (FES 9-10) Further, noise levels due to operation of motors and fans in the towers would be substantial. Applicants have estimated that fog from towers might adversely affect local boat navigation an average of 160 hours per year. (ER 10-33) Applicants further estimate that a mechanical-towers cooling system would result in an annual average generating capacity 2.5 to 3 percent less than with a once-through system, with a maximum of 5 percent during peak summer temperatures. (ER 10-7)

356. A natural-draft cooling tower system would include a single tower 370 feet high by 310 feet base diameter and would be more costly than mechanical towers. While impacts

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122/ Applicants presented some evidence on the survival of aquatic organisms upon passage through a condenser cooling system (ER 5-24 et seq.) and estimate that perhaps as few as 10 percent, excluding fish eggs and larvae, will be killed whereas essentially none would survive in a cooling tower. Accordingly, the mortality in a once-through cooling system may be less, overall, than in one employing towers. (ER 10-44)

from salt drift and noise would be slightly less than from mechanical-draft towers, these impacts would, nevertheless, be substantial. Further, the natural-draft tower and its plume would be much more visible to the surrounding area. (ER 10-7; FES 9-11) The water requirements would be approximately 40 percent of the proposed once-through cooling system. Average generating capacity is estimated to be 2.5 percent less than with a once-through system, with maximum of 6 percent during summer peak ambient temperatures. (ER 10-7A)

357. Both Applicants and Staff concluded from their evaluations that none of the alternatives was environmentally preferable to the system or treatment proposed by the Applicants.

IV. B. e. Environmental Monitoring

358. The Applicants' preoperational monitoring for Unit 2 is based upon their experience with Unit 1 and is described at ER § 6.1 Studies were made of the characteristics of Cape Cod Bay and of the marine ecology in the vicinity of the Pilgrim Station. Meteorological observations include continuous wind velocity, temperature, and vertical temperature gradients. The Staff concurs generally with the proposed Unit 2 preoperational program and recommends the addition and/or intensification of a number of studies on aquatic biota. (FES at 6-4) The Staff also recommends additional determination of concentrations of copper and nickel in nearby seawater and in organisms that

concentrate these elements and that chlorine demand studies be made of Unit 1 intake water as a function of temperature and season. (FES at 6-7)

359. A comprehensive preoperational environmental radiological monitoring program for Unit 2 was established through agreement between the Applicants and one of the Intervenors. It was entered into the record as a stipulation.[123/]

360. Staff witnesses testified (Tr. 6452) to the acceptability of the monitoring program described in the stipulation and to its adequacy under NRC regulations.[124/]

361. Applicants' Witness Wrenn (Tr. 6419) and Staff Witness Bores (Tr. 6457) stated that the requirements of the monitoring program were within the capability of existing techniques and instrumentation.

362. The specifications of the stipulation constituted a revision to the FES, Section 6.1.4.1, thereby becoming the Unit 2 preoperational monitoring program[125/] and will also become a part of the technical specifications of Unit 1

123/ Massachusetts Wildlife Federation Exhibit MWF-1A and MWF-1B at Tr. 6460. At Tr. 7633 the Board established that agreement existed on the stipulation among the parties, and dismissed the MWF contentions made moot by the stipulation.

124/ At and near Tr. 6450 the stipulation MWF-1B is referenced as Exhibit B.

125/ Staff Exhibit 11C following Tr. 7828.

(Tr. 6454) and of the Unit 1 operating license. (Staff Exhibit 11C)

IV. B. f. Environmental Effects of Postulated Accidents

363. The environmental effects of postulated accidents have been assessed by the Applicants. (ER § 7) The Staff has reviewed this assessment, has made independent calculations, and has concluded that the environmental risks of the accidents are extremely small. (FES at 7-1) The radiological effects of accidents on the environment have been assessed using the standard assumptions and guidance issued by the Commission as a proposed amendment to Appendix D to 10 CFR Part 50 on December 1, 1971 (36 FR 22851).[126/] The Applicants' analysis considered accidents of a wide range of severity including some of those of Class 8 in the Commission's assumptions, such as those arising from the ejection of a control rod and from a break in the reactor coolant piping.

126/ On June 9, 1980, the Commission issued a Statement of Interim Policy on Nuclear Power Plant Accident Considerations Under NEPA. This statement withdraws the proposed annex to Appendix D to Part 50 and announces the Commission's "position that its Environmental Impact Statements shall include considerations of the site-specific environmental impacts attributable to accident sequences, that lead to releases of radiation and/or radioactive materials, including sequences that can result in inadequate cooling of reactor fuel and to melting of the reactor core." This policy applies to all cases in which a Final Environmental Impact Statement has not been prepared. Since the FES for Unit 2 had already been prepared and issued, this policy requirement does not apply to Pilgrim Unit 2.

364. Both the Applicants' and Staff's calculations show that the radiological exposures to a member of the public at the site boundary will be no more than 35 percent of the limit specified in 10 CFR Part 20, that the year 2020 population dose within an area of 50-mile radius about the site, will be no more than 2300 man-rem. In general, the exposure resulting from any of the postulated events will be a small fraction of the exposure due to natural background radiation and will be, in fact, well within naturally occurring variations in the natural background.

IV. B. g. Unavoidable Adverse Environmental Effects

365. In an assessment of unavoidable environmental effects the Staff finds (FES at 10-1) that 28 acres of land in addition to that already committed to an existing electric generating station will be removed from productive use for the life of Unit 2.

366. Noise, typical of construction, may be objectional for the public during early stages of the project.

367. The operation of Unit 2 will require the discharge of about 2000 ft^3 of water per second into Cape Cod Bay at a temperature about 22°F above ambient. Accordingly, the quality of the water will have been somewhat degraded by this usage. Additionally, the water may contain dissolved gases to near saturation.

368. Although the thermal and chemical discharges are expected not to have an adverse effect on the biota of the Bay, there will be some loss through entrainment in the water stream and impingement upon the equipment. These losses are within the recuperative capability of the Bay.

369. Amounts of radiation and radioactive materials, insignificant compared to those present from natural sources, will be released to the environment during routine operation of Unit 2.

IV. B. h. Relationships Between Local Short-Term Use of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

370. Long-term competition among such uses of coastal sites as seaports, power plants, industrial facilities, commercial and sport-fishing and commercial and individual housing developments, may be expected to continue and increase. The particular site in question here is, however, already dedicated to a power plant and other uses are either already excluded by virtue of site incompatability or they are not affected by the plant and can continue. The construction and operation of Unit 2 is consistent with the long-term objective of coastal zone management. The presence of Unit 1 has not inhibited commercial or recreational uses of Cape Cod Bay and the addition of Unit 2 will not change that situation.

IV. B. i. Irreversible and Irretrievable Commitments of Resources

371. The Staff identified (FES at 10-3) material and other resources which would be consumed or otherwise lost from the environment, in their present form, as a result of the construction and operation of Unit 2.

372. Included in this identification are the usual materials of construction, constituents of the reactor and other items unique to the generation of electric power from nuclear energy, chemicals consumed in process operations, aquatic biota destroyed when carried in the coolant, uranium transformed into other uranium isotopes, plutonium and fission products. In the opinion of the Staff the consumption of these material resources will have negligible effect on their reserves. (FES at 10-4)

IV. C. Compliance with Federal Water Pollution Control Act (as Amended)

373. The current status of the Federal and the State permits necessary for the discharge of condenser coolant water and other liquids from Unit 2 is not entirely clear to the Board since appeals on the issuance of these permits have been taken. However, the present record shows the following.

374. National Pollutant Discharge Elimination System (NPDES) Permit No. MA 0025 135 was issued to BECo on March 11, 1977.[127/]

375. The Massachusetts Division of Water Pollution Control (MDWPC) by letter to the Applicants dated June 20, 1977, (Staff Exhibit 18A) stated that the proposed discharges of coolant from Unit 2 will not violate §§ 301, 306 and 307 of the Federal Water Pollution Control Act (FWPCA) and expressed the Division's intent to issue a certification provided the discharge will be conducted in a manner which will not violate the conditions stated in the NPDES Permit MA 0025 135.

376. The Applicants and the Staff state that NPDES Permit MA 0025 135 constitutes a certification under § 401 of FWPCA and that the MDWPC letter of intent commits the Commonwealth to a certification. The Staff stated that "Both units [Pilgrim 1 and 2] have received the necessary approvals and permits from the Environmental Protection Agency . . ." (At 4-2 Staff Exhibit 53)[128/] Staff Witness Lehr supported this FES conclusion. (Tr. 9965)

127/ Staff Exhibits 18A-D admitted at Tr. 8801. Exhibit 18A is the 401 State Water Quality Certification; 18B is the letter transmitting the NPDES permit to the Applicants; 18C is the Federal Permit MA 0025 135; 18D is an amendment to that Permit.

128/ Staff Exhibit 53 is the Final Supplement to the Final Environmental Statement received at Tr. 9852, bound following Tr. 9952.

377. Counsel for Intervenors Cleetons and others have challenged the authority of these permits and have appealed their issuance. (Tr. 9965) This issue has been through an adjudicatory hearing before the EPA.

378. There is no evidence in the record to the effect that the Commonwealth has exercised its authority to stay the certification represented by the permits during the appeal [30A Mass. Ann. Laws § 14(3)].

IV. D. Cost-Benefit Analysis

379. The Staff has carried out a cost-benefit analysis of the construction and operation of the proposed Unit 2 by an established methodology and through the application of judgemental factors. The analysis has led to environmental and monetary costs which are compared with the benefits to be gained. (FES § 10.4)

380. The basis of the Staff's analysis, in addition to the impact of the generating station itself, included the impact of the uranium fuel cycle as specified in 10 CFR 51.20(E) and set forth in Table S-3.[129/] It also included the environmental

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129/ See also Section IV.B.c.v. supra which summarizes the Board's findings on the impact of radon-222 and technetium-99 which were also considered.

effects of transportation of fuel and of solid radioactive wastes to and from the facility as specified in 10 CFR § 51.20(g) and in Table S-4.

381. The principal benefit of the plant is the production of electrical energy to fulfill the requirements of the Applicants' customers and to replace presently operating oil-fired generating stations. The consequences of these replacements have been extensively discussed in ¶ 184 et seq. supra. Based on a 60 percent capacity factor, the generation of electricity will be approximately 6.2 billion kilowatt hours per year. (FES § 10.4.2, revised in Staff Exhibit 13 following Tr. 8308)

382. The economic costs for constructing, operating and maintaining Unit 2 over its 30-year projected life will be $2.227 million. (FES Table 10.2, revised in Staff Exhibit 13 following Tr. 8308)

383. The principal environmental costs identified are those which have been described previously in this Decision and include impacts during construction and operation of Unit 2, minor radiological exposures to the population from both Unit 2 and the segment of the national nuclear fuel cycle attributable to Unit 2, and a small risk potential in the transport of radioactive materials.

384. The costs and benefits of emergency planning and TMI-related issues have not been factored into this cost-benefit analysis. After evidentiary hearings on those issues are completed the Board will reassess its cost-benefit balance.

V. CONTENTIONS ADDRESSED IN THESE PROCEEDINGS

385. A number of issues were introduced into these proceedings through contentions filed by the Intervenors and accepted[130/] by the Board in a Memorandum and Order dated February 18, 1975. Each Party was offered the opportunity to present evidence on the surviving contentions. The findings by the Board appear in Parts II, III and IV *supra*. This Part contains a statement of each contention and its disposition by the Board based on the findings.

A. Need for the Power to be Generated by Unit 2

386. Statement of Contentions:

> Commonwealth 6 "The need for the electrical generating capacity of Pilgrim 2 has not been properly established because the Applicants have not developed a model adequately considering the effects of the following on demand:
>
> (a) Voluntary curtailment of consumption of electricity by the public;
>
> (b) Elasticity of demand;
>
> (c) Peak load pricing to flatten demand; and
>
> (d) New standards for improved building insulation, heating, lighting and air conditioning."

130/ Of the contentions originally filed, a number were rejected by the Board before the onset of the hearing. Some of those accepted were later withdrawn by their originators and some were modified. These actions are summarized in the Preliminary Statement, ¶ 4, *supra*.

Cleeton H "Applicants and Staff have not adequately demonstrated the need for additional power in that the projected needs are inaccurate and conservation has not been seriously examined."

387. At Part IV.B.a. supra (¶ 180 through ¶ 230) detailed findings of fact by this Board on the need for Unit 2 have been made. These findings, based on the evidence submitted by the Parties, lead the Board to conclude that while it is difficult to predict future need with any degree of certainty, the record clearly shows that a positive growth rate in the electrical requirements of the New England region exists. The electric utilities have a continuing legal duty to provide an adequate supply of electrical power to their customers and this requirement dictates conservative planning. The Board therefore concludes that Unit 2 is needed to meet these future requirements. The Board also finds that the operation of Unit 2 will be in regional and national interests by substituting for the consumption of oil which has been and may be in short supply or better utilized for other purposes. Further, the Board opines that substitution alone constitutes an adequate basis for Unit 2.

V. B. Overstatement of Production of Electrical Energy

388. Statement of Contention:

Commonwealth 8 "The benefits of the proposed facility have been overstated with respect to projected production of electrical energy."

389. This contention is addressed in large degree in the more broad topics of Part V.A. supra and in Part V.E. infra, the discussion of contentions of the need for power and of alternate [to Unit 2] sources of energy, respectively. The relevant findings of fact on those issues are at least implicitly in Parts IV.B.a. (¶ 180 through ¶ 230) and IV.B.d.i. (¶ 305 through ¶ 343). Those broad citations can be reduced to ¶ 305 through ¶ 324 as the principal reference to the issue. The basic concept here is the reliability of Unit 2 once operating and is measured by the capacity factor. The values of the capacity factor predicted for Unit 2 vary widely among the several witnesses and the uncertainties attached to those values have an even greater compass. The absence of statistical reliability in the testimony of witnesses presented by Intervenor Commonwealth leaves the Board unpersuaded by their arguments. Accordingly the Board sees no reason not to accept the expected performance envisaged by the Applicants and the Staff. It is observed that the Staff reduced its prediction during the course of this hearing. Translation into the context of this contention leads to the judgment that it lacks foundation.

V. C. Financial Qualifications Of Applicants

390. Statement of Contention:

Commonwealth 5 "The Applicants are not financially qualified to design and construct the proposed facility."

391. Part II.D.c. supra (¶ 66 through ¶ 79) are findings of fact by the Board on the financial qualifications of the Applicants. Based upon these findings the Board concludes that the Applicants have made an adequate showing of their financial ability to construct the proposed facility.

V. D. Technical Qualifications of Applicants

392. Statement of Contention:

> Commonwealth 10 "The Applicants and their architect engineer, Bechtel Corporation, and nuclear steam system supplier, Combustion Engineer, are not technically qualified to engage in the proposed activities and cannot provide an adequate quality assurance program based upon their previous records in similar ventures."

393. At Part II.C. supra (¶ 44 through ¶ 65) are findings of fact by the Board on the technical qualifications of the Applicants and their principal contractors. No evidence was presented by the Commonwealth in support of this contention other than cross-examination of Applicants and Staff witnesses. Based upon the findings, the Board concludes that the Applicants and their principal contractors are qualified to construct the proposed facility.

V. E. Alternate Energy Sources

394. Statement of Contentions:

Commonwealth 3 "The Applicants and Staff have not given adequate or accurate consideration to solar power, wind power, the use of fossil fuels, the use of fuel derived from solid waste, or the high temperature gas-cooled reactor as alternative sources of power."131/

Cleeton I "Applicants have not adequately considered alternate sources of power in that they have not considered: methods of thermonuclear fusion; wind power; solar energy, utilization of ocean temperature differences; gasification of coal; production of low sulfur oil from garbage, animal waste and coal; or cultivation of high energy algae for conversion to methane or for direct power plant combustion."

395. At IV.B.d. supra (¶ 306 through ¶ 343) are findings of fact by the Board on possible alternative methods of producing energy by the use of other types of fuel or other technologies. The Commonwealth presented a number of witnesses supporting its contention and cross-examined the Applicants' and the Staff witnesses. Intervenors Cleeton offered no witnesses but did cross-examine Applicants' and Staff witnesses. Upon consideration of the environmental, economic, technological and practical factors presented by the various witnesses, the Board concludes

131/ On motion by the Commonwealth dated September 25, 1975, its originally stated contention was modified by the Board to include solid waste as a potential fuel. (Tr. 832)

that Unit 2 will be a source of electrical energy, over the span of its expected life, superior to other proposed sources. The choice between nuclear and coal cycles is tipped toward nuclear by present-day economics and the uncertainty in the future effect of the restrictions and regulations expected to be applied to reduce the environmental impact of the combustion of coal. Evaluations of that impact are only now beginning. Their consequence is expected to further worsen the economy of the coal fuel cycle. The Board expresses confidence and faith in the technical community in its pursuit of acceptable alternates. Of greater promise among those considered, it seems to the Board, are solar energy and the combustion of municipal solid wastes. The first is strikingly free of pollutants; the second, though fraught with the decontamination problems of other combustion processes, will provide a sorely needed reduction in a continuing and aggravating disposal problem and, at the same time, will recover energy otherwise destined for landfills at an ever-increasing rate. Additional sources show promise but their perfection will occur on a schedule well beyond the requirement Unit 2 is intended to fill. The Board concludes that there are at present no viable alternative energy sources.

V. F. Alternate Sites for Unit 2

396. Statement of the Contentions:

Commonwealth 4 "The Applicants and the Staff have not given adequate consideration to underground siting, off-shore siting and inland siting using closed-cycle cooling systems, as alternate types of sites."

Commonwealth 12 "Neither Applicants nor Staff have adequately considered the alternative of locating the proposed plant at a site more suitable from a population density and environmental standpoint."

MWF 1(b) "To the extent that the practicability of such additional or alternative means [of complying with ALARA standards] is site-dependent, including without limitation factors relating to transportation, the Applicants and Staff have failed to consider adequately alternate sites in light of the desirability of such additional or alternative means."

397. At Part III. and Part IV.B.d.ii. supra (¶ 127 through ¶ 178 and ¶ 344 through ¶ 353) are findings of fact by this Board on the existence of obviously superior alternate sites for the proposed facility. The Board finds that Applicants and Staff have adequately considered the alternatives of underground siting, off-shore siting and inland siting, including those which would employ closed cycle cooling systems. Based on the record the Board concludes that the Staff has adequately evaluated and compared

in detail a sufficient number of diverse and potentially licensable alternate sites to meet the requirements of NEPA and the Commission's regulations. The Board concludes that the population density estimated for the area contiguous to the site proposed for the Unit 2 nuclear generating station throughout its projected life is within guides established by the Commission and, accordingly, that the projected density is not cause, in itself, for selecting other sites. The Board concurs with the conclusions of both Applicants and Staff in that none of the alternate sites considered in this proceeding is "obviously superior" to Rocky Point, the Applicants' preferred site. The Board finds that the predicted radiological effects of the gaseous and liquid discharges from Unit 2 are so small as to make any comparisons with other sites on the basis of estimated population dose unnecessary.[132/] With respect to the suitability

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132/ Subsequent to the admission of MWF contention 1(b), the Commission promulgated (40 Fed. Reg. 19439 dated May 5, 1975) Appendix I to 10 CFR Part 50, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as Reasonable Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents." Compliance with Appendix I is discussed in Part II.G.c. supra. For the purposes of assessing the validity of MWF's contention one need only take notice of the calculated population doses from liquid and gaseous releases (summarized in ¶ 125 supra). In accordance with the $1000 per manrem criterion established by Appendix I § II.D. the maximum expenditures that could be required for a radwaste system augment are less than $1000 for liquids and $3400 for gases assuming that the augments would reduce the discharge to zero. The Board considers this potentially required expenditure by the Applicants to be de minimis and as such would not be a factor upon which an alternative site would be selected.

of Rocky Point, Board findings (¶ 127 through ¶ 178 supra) indicate that the site is suitable. Specifically, the Board finds that the population center selected by Staff establishes an LPZ conforming to the Commission's regulations and, from geographic and population viewpoints, the proposed Unit 2 site is suitable for the location of a nuclear plant of the general type and size proposed by the Applicants. The Board further finds that there are no nearby industrial, military, or commercial facilities which would cause the site to be unsuitable. The atmospheric dispersion conditions at the proposed Unit 2 Site are better than at 70 percent of some 80 sites which have been proposed for other reactors throughout the country. The Board finds the site suitable based on meteorological considerations. The Board also finds the Site suitable from hydrologic, geologic and seismic viewpoints. The Category I structures shall be designed to withstand a horizontal seismic-induced ground acceleration of 0.20 g and the existing soil is suitable for that purpose.

V. G. Impact of Aircraft on Pilgrim Site

398. Statement of Contention:

> Cleeton C "Neither Applicants nor Staff have adequately considered the health, safety and environmental risks originating as a consequence of locating Pilgrim Unit 2 in the proximity of a major descending flight path to Logan Airport and the potential impact of descending aircraft on the Unit 2 site. A consideration of such risks would lead to the selection of a site more suitable from a health, safety and/or environmental viewpoint."

399. At Part III.C. supra (¶ 142 through ¶ 151) are findings of fact by the Board on the potential impact of aircraft on the Pilgrim Site. The Board concludes that the probability of an impact on vulnerable portions of the site is so small as not to be credible.

V. H. Alternate Condenser Cooling

400. Statement of Contention:

> Commonwealth 2 "Alternative cooling systems employing towers at the proposed site are available but have not been adequately assessed by the Applicants or Staff."

401. Part IV.B.d.iii. supra (¶ 354 through ¶ 357) are findings of fact on this contention. The Board finds that Applicants and Staff have adequately evaluated alternative condenser cooling methods including their intake and discharge systems and further finds that no significant environmental advantages would be realized by the use of either

mechanical or natural draft saltwater cooling towers over the proposed Unit 2 once-through cooling system.

V. I. Adverse Effects of Unit 2 on Cape Cod Bay

402. Statement of Contention:

Commonwealth 1 "The Applicants and the Staff have not adequately or accurately considered the potential adverse effects on the Cape Cod Bay ecosystem of:

a. Entrapment and impingement of fish and other biota in the intake structure.

b. Entrainment of ichthyoplankton and larvae in the condenser cooling system.

c. Supersaturation of ambient atmospheric gas entrained in cooling water with possible resultant fish mortality.

d. The loss of Irish moss vegetation due to entrainment of spores, thermal effects and bottom scouring.

e. The use of biocides as an anti-fouling mechanism.

f. The use of heat treatment to control mussels.

g. The attraction of certain fish, including menhaden and pollock, to the heated water in the vicinity of the discharge.

h. The recirculation of heated water into the cooling system."

403. At Part IV.B.b.ii. supra (¶ 238 through ¶ 240) and in IV.B.c.ii supra (¶ 253 through ¶ 263) the impact on Cape Cod Bay from both construction and operation are the subject of findings of fact by the Board. Commonwealth offered no testimony

on this contention but cross-examined Applicants' and Staff witnesses. Based on the Board's findings cited above it is concluded that the Applicants and Staff have adequately considered the potential adverse effects of the proposed facility on the Cape Cod ecosystem and found them to be within acceptable limits.

V. J. Environmental Impact of Routine Releases of Radioactive Material

404. Statement of Contention:

> Cleeton E "The routine discharges of radioactive materials and/or attendant routine doses of radiation caused by the operation of Pilgrim Unit 2 constitute an unreasonable threat to the health and safety of the Intervenors' family."

405. At Part IV.B.c.iv supra (¶ 265 through ¶ 286) findings of fact by the Board appear. Although this contention was admitted only for the limited purpose of "....[permitting] the Cleetons to demonstrate, if they could, the specific environmental impact, if any, on the health and safety of Intervenors' family by routine releases of radioactive materials caused by the operation of Pilgrim Unit 2," (Board Order dated April 2, 1975), the Applicants, the Staff and the Cleetons presented extensive evidence. The contention was not admitted as a generic item or as a challenge to Commission regulations. The testimony of the Cleetons' witnesses failed to show unusual

circumstances whereby the Cleeton family is inordinately susceptible to the effects of radiation. Absent a showing of such circumstances, Commission rules and regulations governing releases of radioactive material and radiation exposures apply. The record shows that Unit 2 is designed to operate in conformance with these rules. Accordingly the Board accepts the testimony of witnesses of the Applicants and the Staff stating that radiologic effects of routine releases from Unit 2 will be small compared to those attributable to background sources and hence negligible.

V. K. Theft and Sabotage

406. Statement of Contention:

> Commonwealth 9 "The Applicants and the Staff overstate the advantage of the nuclear option as opposed to alternative methods of electrical generation by understating the risk of theft and sabotage attendant on nuclear generation, the costs of which, if considered in the cost-benefit analysis for Pilgrim 2 would cause the overall costs of the facility to outweigh its benefits."

407. At Part II.E. supra (¶ 81 through ¶ 93) are findings of fact by the Board on the risks of theft and sabotage of the proposed facility. The Board finds that the potential risk of sabotage and of theft of radioactive materials, including used fuel, from within Unit 2 or in transport, by unarmed persons is

sufficiently small in the overall cost-benefit analysis not to affect a conclusion that alternative generation options are inferior to nuclear energy.

V. L. Transportation Risks

408. Statement of Contention:

> Cleeton B "Applicants and Staff have not properly assessed the radiological risk to Intervenors' health and safety caused by possible future accidents of vehicles used in the transportation of nuclear fuels and nuclear wastes to and from the Pilgrim 2 site."

409. At Part IV.B.d. supra (¶ 287 through ¶ 290) are findings of fact by the Board on the question of risks in the transportation of nuclear fuels and wastes. The Intervenors presented no direct testimony in support of their contention on the risks arising from accidents during such transport. The Intervenors cross-examined witnesses presented by the Applicants and the Staff. Upon review of this record discussing accidents involving vehicles transporting nuclear materials, the Board observes no evidence of unusual traffic risks. Accordingly, the Board concludes that the transport of nuclear materials to and from Unit 2 does not constitute an unacceptable risk to the health and safety of the public or of the Intervenors in excess of that engendered by day-by-day commercial activity on highways and railroads.

V. M. Effect of Unavailability of Reprocessing and Waste Disposal Facilities on Costs and the Environmental Assessment of Increased Spent Fuel Storage

410. Statement of Contention:

> Cleeton K "The delay in the licensing of reprocessing facilities and in the availability of long term waste disposal and storage facilities will preclude the availability of sufficient fuel for Pilgrim 2. In addition, it will require longer storage of spent fuel at the Pilgrim 2 site, thereby increasing the radiological environmental impact of the facility. These factors will tend to increase the cost of fresh fuel and cause additional storage expenses for the Applicants, which will make the nuclear option more expensive than comparable fossil facilities. Proper consideration of these matters in this proceeding would cause the cost-benefit balance to shift in favor of alternatives to nuclear fueled generation capacity for Pilgrim 2."

411. At Part IV.B.c.vi. supra (¶ 295 through ¶ 304) are findings of fact by the Board on this contention. The Board concludes that sufficient fuel for Unit 2 is assured throughout its lifetime even absent the recovery of resources by reprocessing used fuel from operating nuclear reactors. Further, the additional fuel cost entailed by that absence is acceptably small. The impact on the environment of storage of used fuel at the Pilgrim site is solely an increase in the nearby radiation field. That increase, however, is negligible compared to the natural radiation background.

V. N. Compliance with ALARA Standards

412. Statement of Contention:

> MWF 1(a) "The Applicants' plant design does not comply with the Commission's 'as low as practicable' standards since the releases of radioactive materials in liquid and gaseous effluents may be further reduced through the use of alternative or additional means such as, for example, additional solidification and filtration systems."

413. At Part II.G.c. supra (¶ 117 through ¶ 126) are findings of fact by the Board on this contention. The Board finds that Applicants' plant design is in compliance with the Commission's regulations imposed to assure releases of radioactive materials in liquid and gaseous effluents are "as low as reasonably achievable."

V. O. Adequacy of Regulatory Staff Inspection Practices

414. Statement of Contention:

> Commonwealth 11 "The Nuclear Regulatory Commission Regulatory Staff has not demonstrated that its inspection practices are adequate in terms of the frequency and scope of inspection to monitor the quality assurance programs of nuclear power plant manufacturers. Absent more stringent inspection of such quality assurance programs, the issuance of a construction permit for the proposed Pilgrim 2 facility will be inimical to the health and safety of the public."

415. At Part II.G.b. supra (¶ 114 through ¶ 116) are findings of fact by the Board on this contention. The Board

agrees that the adequacy of the Staff inspection program must be measured in conjunction with the overall inspection and quality assurance effort which is applied to the manufacture of nuclear power plants and individual plant components. Viewed in that context the Board finds that the inspection practices of the NRC Staff are adequate in terms of frequency and scope to monitor the quality assurance programs of nuclear power plant manufacturers and that the health and safety of the public are adequately protected by such actions.

V. P. Steam Generator Tube Integrity

416. Statement of Issue:

> Board Issue "Evidence regarding the overall integrity of the proposed steam generator tubes will be taken."

417. At Part II.G.a. supra (¶ 99 through ¶ 116) are the Board's findings on steam generator tube integrity. The Board finds that there exists the requisite reasonable assurance that the public health and safety will not be endangered as a consequence of tube failure during the operation of Unit 2.

VI. CONCLUSIONS OF LAW

418. The Board makes the following conclusions of law based upon the entire record and all the evidence in this proceeding, including our consideration and evaluation of the Application for Permit and supporting documents submitted by Applicants, the Staff's Safety Evaluation Report and Final Environmental Statement; the written and oral testimony of all of the witnesses; the exhibits admitted into evidence; the Rules and Regulations of the Commission; the Atomic Energy Act of 1954, as amended; the National Environmental Policy Act, as amended; and relevant NRC decisions and case law.

1. In accordance with the provisions of 10 CFR 50.35(a):

   (a) the Applicants have described the proposed design of the facilities including, but not limited to, the principal architectural and engineering criteria for the design, and have identified the major features or components incorporated therein for the protection of the health and safety of the public;

   (b) such further technical or design information as may be required to complete the safety analysis and which can reasonably be left for later consideration, will be supplied in the final safety analysis report;

(c) safety features or components, if any, which require research and development have been described by the Applicants. Further the Applicants have identified, and there will be conducted, a research and development program reasonably designed to resolve any safety questions associated with such features or components; and

(d) on the basis of the foregoing, there is reasonable assurance that (i) such safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility, and (ii) taking into consideration the site criteria contained in 10 CFR Part 100, the proposed facility can be constructed and operated at Rocky Point without undue risk to the health and safety of the public.

2. The Applicants are technically qualified to design and construct the proposed facility.

3. The Applicants are financially qualified to design and construct the proposed facility.

4. The issuance of a permit for construction of the facility will not be inimical to the common defense and security or to the health and safety of the public.

5. The provisions of Section 102(2)(C) and (E) of NEPA and 10 CFR Part 51 of the Commission's regulations have been complied with in this proceeding. In particular the Board has independently considered the benefits and costs of the proposed facility and concludes that the benefits to be derived from Unit 2 outweigh its costs. This consideration has included the impacts of construction and operation on both the terrestrial and aquatic environments as well as of the uranium fuel cycle including transportation of fuel and other radioactive materials to and from the Site.

VII. ORDER

419. The record of these proceeding includes a number of items derived during discussions among the Parties. They constitute commitments by the Applicants to effect various actions. These actions, listed below, are made conditions to any construction permit issued as a result of this Order.

1. The FES, at v, enumerates five conditions designed to protect the environment. These include: a) twenty-one items detailed at FES § 4.5.1 and 4.5.2 intended to minimize the environmental impacts of construction; b) a preoperational monitoring program, described in FES § 6.1 and in MWF Exhibits 1(A) and 1(B), comprised of ecological, water, meteorological, and radiological observations and evaluations; c) the establishment and maintenance of a control program to review conformance of the construction with the conditions set forth in the permit; d) communication to the Commission on construction activities deviating from the conditions of the permit; and e) transmittal to the Staff of analyses of and solutions for any unexpected harmful effects detected during construction.

2. The Applicants shall establish written procedures and instructions to control all construction activities prescribed in the FES and in this Decision and shall provide periodic management audits to determine that all conditions are implemented. They shall maintain records showing compliance with all of the environment-related conditions.

3. The Applicants shall possess and shall prudently exercise their authority to control at any time all activities within the exclusion area e[illegible] on Rocky Hill Road. Th[illegible]ority shall include the [illegible] of personnel and property. During any emergency the Applicants shall additionally have control of Rocky Hill Road through appropriate law enforcement officials.

4. To minimize exposures of aquatic biota to cold shock the Applicants shall make every effort to avoid simultaneous shutdown of both Units 1 and 2 during winter months.

420. A construction permit to build Pilgrim Unit 2 should be issued subject to the above conditions and subject to the favorable completion of hearings on emergency planning and Three Mile Island 2 related issues.

In accordance with 10 CFR 2.760, 2.762, 2.785 and 2.786, this Partial Initial Decision shall constitute the final action of the Commission on the matters considered herein thirty (30) days after issuance, subject to any review pursuant to the above-cited Rules of Practice.[133/] Exceptions to this Partial Initial Decision may be filed by any Party within ten (10) days after its service. A brief in support of the exceptions shall be filed within thirty (30) days thereafter, forty (40) days in the case of the NRC Staff. Within thirty (30) days of the filing and service of the brief of the appellant, forty (40) days in the case of the NRC Staff, any other Party may file a brief in support of, or in opposition to, the exceptions.

133/ In accordance with 10 CFR Part 2, Appendix B, the Board has reviewed the issues decided herein and has determined that none presents serious, close questions which may be crucial to whether a license should become effective before full appellate review is completed. Further, the Board has found no issues on which prompt Commission policy guidance is required.

IT IS SO ORDERED.

THE ATOMIC SAFETY AND
LICENSING BOARD

A. Dixon Callihan
Administrative Judge

Richard F. Cole
Administrative Judge

Andrew C. Goodhope, Chairman
Administrative Judge

Dated at Bethesda, Maryland
this 2nd day of February 1981.

APPENDIX

No.	Applicants' Exhibits	Identified	Admitted Into Evidence
A	Applicants' Direct Testimony on Alternate Sources of Power	899	955
B	Qualifications of Abraham Gerber	919	955
C	Applicants' Direct Testimony on Alternate Sites	1636	1656
1-A	Application	901	906
1-B	PSAR, Volume I	901	906
1-C	PSAR, Volume II	901	906
1-D	PSAR, Volume III	901	906
1-E	PSAR, Volume IV	901	906
1-F	PSAR, Volume V	901	906
1-G	PSAR, Volume VI	901	906
1-H	PAAR, Volume VII	901	906
1-I	PSAR, Volume VIII	901	906
1-J	PSAR, Volume IX	901	906
1-K	ER, Volume I	901	906
1-L	ER, Volume II	901	906
1-M	ER, Volume III	901	906
1-N	PSAR Amendment 21	7586	7595
1-O	PSAR Amendment 22	7587	7595
1-P	PSAR Amendment 23	7587	7595
1-Q	PSAR Amendment 24	7588	7595

No.	Applicants' Exhibits	Identified	Admitted Into Evidence
1-R	PSAR Amendment 25	7588	7595
1-S	PSAR Amendment 26	7589	7595
1-T	PSAR Amendment 27	7589	7595
1-U	PSAR Amendment 28	7590	7595
1-V	PSAR Amendment 29	7590	7595
1-W	PSAR Amendment 30	7591	7595
1-X (1)	PSAR Amendment 31	7592	7595
1-X (2)	Report on Fire Protection	7592	7595
1-Y	PSAR Amendment 32	7592	7595
1-Z	PSAR Amendment 33	7593	7595
1-AA	PSAR Amendment 34	7593	7595
1-BB	PSAR Amendment 35	7594	7595
1-CC	ER Amendment 6	7594	7595
1-EE	Correspondence between BECO and the NRC	9229	9379
1-FF	Letter dated 5/23/79 from BECo to O.D.Parr	9233	9379
1-KK	Financial Amendment No. 5	9599	9601
1-LL (1), (2) and (3)	Financial Amendment No. 6 (in 3 volumes)	9600	9601
1-MM	Financial Amendment No. 7	9600	9601
1-NN (1), (2) and (3)	Financial Amendment No. 8 (in 3 volumes)	9600	9601

No.	Applicants' Exhibits	Identified	Admitted Into Evidence
1-00	Financial Amendment No. 9	9600	9601
3	Letter of 11/28/75 re NRC Inspection Report	3919	3919
5	Report: "Events Affecting the Availability of Pilgrim 1 During January - July, 1974"	3964	3964
6	Letter re BECo's Response to Notice of Violation in Commonwealth Exhibit 10	4375	4375
10	UEC Report: "Rocky Point (Pilgrim) Site - An Evaluated Comparison of Site Alternatives	5916	5916
11	Letter of 6/29/76 re Testimony of Commonwealth Witness MacDonald	6226	6328
12	Letter of 6/30/76 re Testimony of Commonwealth Witness MacDonald	6228	6328
13	AFUDC over 90% earnings one sheet: "Salomon Brothers" (formerly Exhibit 1-HH)	9346	9379
14 A, B and C	Boston Edison Co. siting study for Long Range Generating Capacity Expansion, 1975-2000 (in 3 volumes)	9610	9610
15	Letters and Attachments from Boston Edison Co. to the NRC Concerning Alternate Siting, 1978	9637	9637
16	Letter from Boston Edison Co. to the NRC and attachment (formerly Staff Exhibit 51)	9672	9676
17-A	Letter from Boston Edison Co. to Averill Laundon, Esq. (6/20/78)	10,350	10,353

No.	Applicants' Exhibits	Identified	Admitted Into Evidence
17-B	Letter from Boston Edison Co. to Peter V. Lacouture, Esq., Tillinghast, Collins and Graham (6/21/78)	10,350	10,353
17-C	Letter from Boston Edison Co. to Lewis Segal, Esq., Murtha, Cullina, Richter and Pinney (6/22/78)	10,350	10,353
17-D	Letter from Boston Edison Co. to Joseph Ransmeier, Sulloway, Hollis, Godfrey and Soden (8/2/78)	10,351	10,353
18	Package of letters attached to letter to Mr. Regan of the NRC (8/2/78)	10,352	10,353
19	Applicants' Revised Supplemental Testimony on the Need for Pilgrim 2	10,427	10,430
20-A	NEPOOL Forecast for New England, 1979 - 1989	10,740	10,740
20-B	Report of the NEPOOL Load Forecasting Task Force on the NEPOOL Model-Based Forecast of New England Electricity and Energy and Peak Load, 1979 - 1989	10,740	10,740
20-C	New England Load and Capacity Report, 1978 - 1989	10,740	10,740
21-A, -B	Annual Supplement 1-D, 1980-1989 to BECo's "Long Range Forecast of Electric Power Needs and Requirements" - Volumes I and II dated May 1, 1980	-	Board Order 10/2/80
22	NEPOOL Forecast for New England, 1980-1995	-	Board Order 10/2/80
23	PSAR Amendment 36	-	Board Order 12/16/80

No.	Applicants' Exhibits	Identified	Admitted Into Evidence
24	PSAR Amendment 37	-	Board Order 12/16/80
25	PSAR Amendment 38	-	Board Order 12/16/80

No.	Staff's Exhibits	Identified	Admitted Into Evidence
1	Attachment A to Testimony of Staff Witness Barker: "Environmental Effects of Transportation of Radioactive Materials To and From Nuclear Power Plants"	2535	2537
2	Attachment B to Testimony of Staff Witness Barker: WASH-1238, December 1972, "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants"	2536	2537
3	Attachment C to Testimony of Staff Witness Barker: NUREG-75/038, Supplement One to WASH-1238, "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants"	2536	2537
4	Safety Evaluation Report (SER)	3717	3717
5	SER, Supplement No. 1	3717	3717
6	NRC Letter of 3/5/1975 re Findings of the Inspection of the In-Service Inspection Program	4237	4250
6-A	Inspection Report No. 50-293/75-05	4237	4240
6-B	BECo Letter of 6/19/75 Responding to NRC Inspection Findings	4237	4240
6-C	NRC Letter of 7/10/75 re BECo Position re NRC Inspection Findings	4237	4240
7-A	SER, Supplement No. 2	5393	5394
7-B	Supplemental Testimony of M. A. Parsont re MWF Contention 2(C)	6431	6432
8	Affidavit of Dr. R. L. Gotchy	7436	7437
8-A	Corrected Affidavit of Dr. R. L. Gotchy	7818	7820

No.	Staff's Exhibits	Identified	Admitted Into Evidence
9	NRC Site Suitability Report	7462	7466
10	FES Revised Section 5.5 and Revised Table S-3	7603	7607
11-A	FES Section 4.6: "Radiological Effects:	7822	7828
11-B	FES Section 5.3: "Radiological Impacts"	7822	7828
11-C	FES Section 6.1.4.1: "Preoperational Programs	7823	7828
12	Affidavit of M. Parsont	7834	7835
13	FES Section 10.4.2: "Economic Costs"	8307	8308
14	FES Section 6.1.4: "Radiological"	8537	8538
15	FES Section 6.2: "Operational Programs"	8359	8540
16	Staff's "Environmental Analysis of Proposed Modified Site Utilization Plan for Pilgrim Unit 2"	8542	8542
17	Fig. 1 of Wetland Identification and Mapping Study	8542	8542
18-A	401 Certificate	8801	8801
18-B	Letter of 3/11/77 Transmitting NPDES Permit to Applicants, as modified by Letter of 3/25/77	8801	8801
18-C	Federal Permit No. MA0025135	8801	8801
18-D	Amendment to Permit No. MA0025135	8801	8801
19	FES Table 10.4: "Summary Environmental Costs"	8803	8803
21	SER, Supplement No. 3	8921	8921

No.	Staff's Exhibits	Identified	Admitted Into Evidence
22	Letter, ACRS to Hon. Joseph M. Hendrie, 10/12/77; subject: "Report on Pilgrim Nuclear Generating Station, Unit No. 2	8922	8922
50	SER, Supplement No. 4	9509	9509
52	Letters from Mr. Butler to Mr. Regal dated 4/13/78 with attachment; 5/20/78 with attachment; 8/2/78 without attachment; 8/11/78 with attachment and 8/18/78 with attachment	9622	9622
53	Supplemental Testimony to FES	9847	9852
60	A document entitled "Regional Econometric Model for Forecasting Electricity Demand by Sector and by State"	11,232	11,234
66	4 Tables and Text	11,444	11,451
67	Affadavit of Joseph Levine concerning updated X/Q analysis	-	Board Order 12/16/80
68	Supplemental testimony of Carl B. Sawyer and C. Vernon Hodge on Commonwealth 9	-	Board Order 12/30/80

No.	Commonwealth of Massachusetts' Exhibits	Identified	Admitted Into Evidence
2	Resume and Testimony of A. O. Converse	1540	1540
3	AEC Letter of 4/23/71 to BECo	3845	3846
4	AEC Letter of 7/6/71 to BECo	3845	3846
5	AEC Letter of 1/7/72 to BECo	3845	3846
6	AEC Letter of 10/18/73 to BECo	3846	3846
7	AEC Letter of 1/31/74 to BECo	3846	3846
8	NRC Letter of 3/6/75 to BECo	3846	3846
9	AEC Letter of 3/29/74 to BECo	3858	3860
11	Documents re Ultransonic Reading Violation	3949	3950
12	AEC Letter of 4/18/72	4296	4299
14	"BECO's Supplement to Long-range Forecast, 1977 through 1986"	7908	7911
16	Report "Nuclear Plant Performance/Update"	8754	8755
100	BECo Pilgrim 2 Financial Analysis of Comparative Studies, 7/17/78	9268	9270
101	BECo Board of Directors Meeting, 7/27/78, Report on Pilgrim 2 Project	9275	9275
102	Testimony R. M. Kelmon, BECo, Exhibit No. BE-100	9276	9276
103	Pilgrim 2, Current Est., 1/31/79	9319	9327
104	Pilgrim 2, Detailed Capital Cost Chronology, 1/31/79, p. 1 of 2	9320	9389

No.	Commonwealth of Massachusetts' Exhibits	Identified	Admitted Into Evidence
105	DPU 19494, Inf. Request, 1/31/79, p. 2 of 2	9321	9389
106	Pilgrim 2, Estimate No. 4	9323	9389
109	USGS 7.5 min. quadrangel on set, MA, dated 1967	10,112	10,113
110	Letter from W. E. Gordon, NOAA, to USNRC, 11/28/77	10,158	10,159
110*	The New England Energy Policy Alternative Study, dated October 1978, Final Report, (Admitted for Impeachment Purposes Only)	10,698	10,708
111	Letter from Mr. Landry, EPA, to N. E. Utilities Service Co., to Mr. B. Fox (undated	10,161	10,161
112	SECY 78-137 from E. G. Case dated 3/7/78	11,537	11,539

*This document was also marked as Commonwealtn Exhibit 110.

No.	Cleetons' Exhibits	Identified	Admitted Into Evidence
1	Map of Massachusetts	8414	8457, 8557
2	NPDES Permit Hearing Notice	8801	8801

No.	Massachusetts Wildlife Federation Exhibits	Identified	Admitted Into Evidence
1-A	Settlement Agreement Between MWF and Applicants	6460	6460
1-B	Proposed Technical Specifications for Pilgrim 1 Monitoring Program	6460	6460