PILGRIM NUCLEAR POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
REPORT NO. 21

JANUARY 1 THROUGH DECEMBER 31, 1988

ISSUED: MAY 1989

BY: PLANT SUPPORT DEPARTMENT
RADIOLOGICAL SECTION

BOSTON EDISON COMPANY

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January 1, 1988 through December 31, 1988

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Boston Edison Company
Pilgrim Nuclear Power Station
Radiological Environmental Monitoring Program
Report
January 1, 1988 through December 31, 1988

INTRODUCTION

This report summarizes the results of the Boston Edison Company's Radiological Environmental Monitoring Program (REMP) conducted in the vicinity of Pilgrim Nuclear Power Station (PNPS) during the period from January 1 to December 31, 1988. This document has been prepared in accordance with the requirements of PNPS Technical Specifications section 6.9.C.2.

The REMP has been established to monitor the radiation and radioactivity released to the environment as a result of Pilgrim Station operation. This program, initiated in August, 1968, includes the collection, analysis, and evaluation of radiological data in order to assess the impact from the operation of Pilgrim Station on the environment and general public.

SAMPLING AND ANALYSIS

The environmental sampling media collected in the vicinity of PNPS and at distant locations include air particulate filters, charcoal cartridges, soil, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation and beef forage.

During 1988, there were over 1300 samples collected from the atmospheric, aquatic, and terrestrial environments. In addition, over 376 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs) and six exposure rate measurements were performed using a high pressure ion chamber. These 1300 samples and 376 monitoring devices were collected by Boston Edison Company and Massachusetts Division of Marine Fisheries personnel.

All samples were collected as required by the PNPS Technical Specifications with the following exceptions: 6 out of 572 (1%) of the air particulate and charcoal cartridge samples, and 4 out of 376 (1%) of the TLD measurements were missed. Of the TLD required by PNPS Technical Specifications, there was one TLD which was found missing from its posted location during the quarterly retrieval. The missing TLD and cage was relocated to be inconspicuous and less accessible, where possible.

There were more than 1,500 analyses performed on the environmental media samples. All analyses were performed by the Yankee Atomic Electric Company Environmental Laboratory in Westboro, Mass.

All samples were analyzed as required by the PNPS Technical Specifications with the following exceptions: 2 out of 566 of the analysis results for air particulate and charcoal filters were deleted due to questionable sample volume.

GARDEN AND MILK-PRODUCING ANIMAL CENSUS

The 1988 annual Garden and Milk-Producing Animal Census was performed as required by the PNPS Technical Specifications. Twelve new gardens and two new milk animals were located. Of the twelve new gardens, two (0.5 miles SE and 2.2 miles S) were added to the program in accordance with Technical Specifications. The two new milk animals were not added to the sampling program since neither of the goats were used for milk. In addition, the Town of Plymouth's Animal Inspector indicated that she was not aware of any new milking animals within a five mile radius of PNPS subsequent to her last census dated March 1988.

RADIOLOGICAL IMPACT TO THE ENVIRONMENT

During 1988, all samples (except charcoal cartridges) collected as part of the REMP at Pilgrim Station continued to contain detectable amounts of naturally-occurring and man-made radioactive materials. Shellfish (mussels), Irish moss (Chondrus crispus), sediment, and soil were the only sampling media collected offsite which showed radioactivity which could be attributable to Pilgrim Station operation.

None of the radioactivity analysis results exceeded the reporting levels specified in the PNPS Technical Specifications. Furthermore, the detectable radioactivity which could be attributable to Pilgrim Station operation was only a small percentage of the naturally-occurring and other man-made amounts of radioactivity. In addition, offsite direct radiation measurements using environmental TLDs and a high pressure ion chamber ranged between 51 and 86 mR/year. This range of radiation levels is consistent with natural background radiation levels for Massachusetts as determined by the Environmental Protection Agency (EPA).

RADIOLOGICAL IMPACT TO THE GENERAL PUBLIC

During 1988, radiation doses to the general public as a result of Pilgrim Station operation continued to be well below the federal limits and much less than the dose due to other man-made and naturally-occurring sources of radiation.

The maximum estimated total body dose to the general public from radioactive effluents released by PNPS operations during 1988 was less than 0.1 mrem. This conservative estimate is well below the EPA's annual dose limit to any member of the general public and less than 0.03 percent of natural and man-made radiation levels.

In addition to dose calculations based on radioactive effluent releases during 1988, four special studies were initiated to determine the dose contribution from radioactivity that was detected in mussels, Irish moss, sediment, and soil samples. Results of these studies showed that the radioactivity accumulated in these media from previous years' operations would result in a maximum dose to a member of the general public of less than five mrem, using extremely conservative assumptions.

CONCLUSIONS

The 1988 Radiological Environmental Monitoring Program for Pilgrim Station included the collection and analysis of hundreds of environmental samples and measurements. The data obtained were used to determine the impact of Pilgrim Station operation on the environment and general public.

An evaluation of direct radiation measurements, environmental sample analyses, and dose calculations showed that all applicable federal criteria were met. Furthermore, radiation levels and resulting doses were a small fraction of those which are normally present due to natural and man-made background radiation.

Based on this information, there is no evidence of any significant radiological impact on the environment or the general public due to Pilgrim Station operation.

1.0 INTRODUCTION

The Radiological Environmental Monitoring Program for 1988 performed by Boston Edison Company for the Pilgrim Nuclear Power Station (PNPS) is discussed in this report. Since the operation of a nuclear power plant results in the routine release of small amounts of radioactivity and low levels of radiation, the Nuclear Regulatory Commission (NRC) requires that a program be established to monitor radiation and radioactivity in the environment.[1] This report, which is required to be published annually by Pilgrim Station's Technical Specifications section 6.9.C.2, summarizes the results of measurements of radiation and radioactivity in the environment in the vicinity of Pilgrim Station and at distant locations during the period January 1, 1988 to December 31, 1988.

The Radiological Environmental Monitoring Program consists of taking radiation measurements and collecting samples from the environment, analyzing them for radioactivity content, and interpreting the results. With emphasis on the critical radiation exposure pathways to humans, samples from the aquatic, atmospheric, and terrestrial environments are collected. These samples include, but are not limited to: air, soil, seawater, shellfish, lobster, fishes, milk, cranberries, vegetables, and forage. Thermoluminescent dosimeters (TLDs) are placed in the environment to measure gamma radiation levels. The TLDs are processed and the environmental samples are analyzed to measure the very low levels of radiation and radioactivity present in the environment as a result of PNPS operation. These results are reviewed by BECo's radiological staff and have been reported semi-annually or annually to the Nuclear Regulatory Commission and others since 1972.

In order to more fully understand how a nuclear power plant impacts humans and the environment, background information on radiation and radioactivity, natural and man-made sources of radiation, reactor operations, radioactive effluent controls and radiological impact on humans is provided. It is believed that this information will assist the reader in understanding the radiological impact on the environment and humans from the operation of Pilgrim Station.

1.1 RADIATION AND RADIOACTIVITY

All matter is made of atoms. An atom is the smallest part into which matter can be broken down and still maintain all its chemical properties. Nuclear radiation is energy, in the form of waves or particles, that is given off by unstable, radioactive atoms.

Radioactive material exists naturally and has always been a part of our environment. The earth's crust, for example, contains radioactive uranium, radium, thorium and potassium. Some radioactivity is a result of nuclear weapons testing. Examples of radioactive fallout which is normally present in environmental samples are cesium-137 and strontium-90. Some examples of radioactive materials released from a nuclear power plant are cesium-137, iodine-131, strontium-90 and cobalt-60.

Radiation dose is measured in units of millirem, much like temperature is measured in degrees. A millirem is a measure of the biological effect of the quantity called dose. The natural and man-made radiation dose received in one year by the average American is 420 mrem.[2,3,4]

Radioactivity is measured in curies. A curie is that amount of radioactive material needed to produce 37,000,000,000 nuclear disintegrations per second. This is an extremely large amount of radioactivity in comparison to environmental radioactivity measurements. That is why radioactivity in the environment is measured in picocuries. One picocurie is equal to one trillionth of a curie.

1.2 SOURCES OF RADIATION

As mentioned previously, naturally occurring radioactivity has always been a part of our environment. Table 1.2-1 shows the sources and doses of radiation from natural and man-made sources.

Table 1.2-1

Sources and Doses of Radiation

NATURAL[2]		MAN-MADE[4]	
Source	Radiation Dose (millirem/year)	Source	Radiation Dose (millirem/year)
Cosmic rays	40	Medical/Dental Exposure	90
Building materials	40	Weapons testing fallout	5-8
Internal	30	Releases from nat. gas, phosphate mining, burning of coal, etc.	5
Ground (Soil)	10	Consumer products	Less than 1
*Radon/Thoron[3]	200	Nuclear power plants	Less than 1
APPROXIMATE TOTAL	320	APPROXIMATE TOTAL	100

*Radiation dose from radon/thoron was recently published by the National Council on Radiation Protection in their Report No. 93.

Radiation from outer space and from the sun penetrates the earth's atmosphere and continuously bombards us with cosmic radiation. This results in the average person in the United States receiving about 40 millirem per year.

The buildings we live in also emit radiation. The average American receives about 40 millirem per year from building materials.

Additionally, natural radioactivity is in the food we eat (about 30 millirem/yr), the ground we walk on (about 10 millirem/yr) and the air we breathe (about 200 millirem/yr). All these sources contribute to a total dose of 320 mrem per year from natural sources of radiation.

Radon and thoron levels vary greatly with location. Many newspaper articles have recently appeared concerning elevated levels of radon/thoron at some locations in Colorado, New York, Pennsylvania and New Jersey. Residents of these areas have a higher annual dose as a result of higher levels of radon/thoron gases in these areas.

In addition to natural radiation, we are normally exposed to radiation from a number of man-made sources. The single largest doses from man-made sources result from therapeutic and diagnostic applications of x-rays and radiopharmaceuticals. The annual dose to an individual in the U.S. from medical and dental exposure is about 90 mrem. Much smaller doses result from weapons testing fallout (about 5-8 mrem/yr); exposures from burning natural gas and coal (about 5 mrem/yr); consumer products like televisions and smoke detectors (less than 1 mrem/yr); and nuclear power plants (less than 1 mrem/yr). Basically, the average person in the United States receives about 100 mrem per year from man-made sources.

Summing the doses from the natural and manmade sources of radiation yields a total dose to an average American of 420 mrem each year.

1.3 NUCLEAR REACTOR OPERATIONS

Pilgrim Station generates about 670 megawatts of electricity when at full power, which is enough electricity to supply the entire city of Boston, Massachusetts. Pilgrim Station is a boiling water reactor whose nuclear steam supply system was provided by General Electric Co. The nuclear station is located on a 1600 acre site about five miles east-southeast of Plymouth Center. Commercial operation began in December, 1972.

Pilgrim Station was shutdown for refueling, maintenance, safety enhancement and modifications during the period from January 1 to December 30, 1988. The reactor at Pilgrim Station was critical for only a 20 minute period on December 30, 1988. However, the average capacity factor for the entire year was effectively zero. Monthly capacity factors are given in Table 1.3-1.

Nuclear-generated electricity is produced at Pilgrim Station by many of the same techniques used for conventional oil and coal-generated electricity. Both systems use heat to boil water to produce steam. The steam turns a turbine which turns a generator, producing electricity. In both cases, the steam passes through a condenser where it changes back into water and recirculates back through the system. The cooling water source for Pilgrim Station is the Cape Cod Bay.

The key difference between Pilgrim's nuclear power and conventional power is the source of heat used to boil the water. Conventional plants burn fossil fuels in a boiler, while nuclear plants make use of uranium in a nuclear reactor.

Table 1.3-1

PNPS-1 Capacity Factors

1988

OPERATING PERCENT CAPACITY

(Based on 670 MWe)

Pilgrim Nuclear Power Station was shut down* during 1988 and all monthly capacity values were zero.

* The reactor was critical for approximately 20 minutes on December 30, 1988.

Inside the reactor, a nuclear reaction called fission takes place. Particles, called neutrons, strike the nucleus of a uranium-235 atom, causing it to split into fragments called radioactive fission products. The splitting of the atoms releases both heat and more neutrons. The newly-released neutrons then collide with and split other uranium atoms, thus making more heat and releasing even more neutrons, and on and on until the uranium fuel is depleted or spent. This process is called a chain reaction.

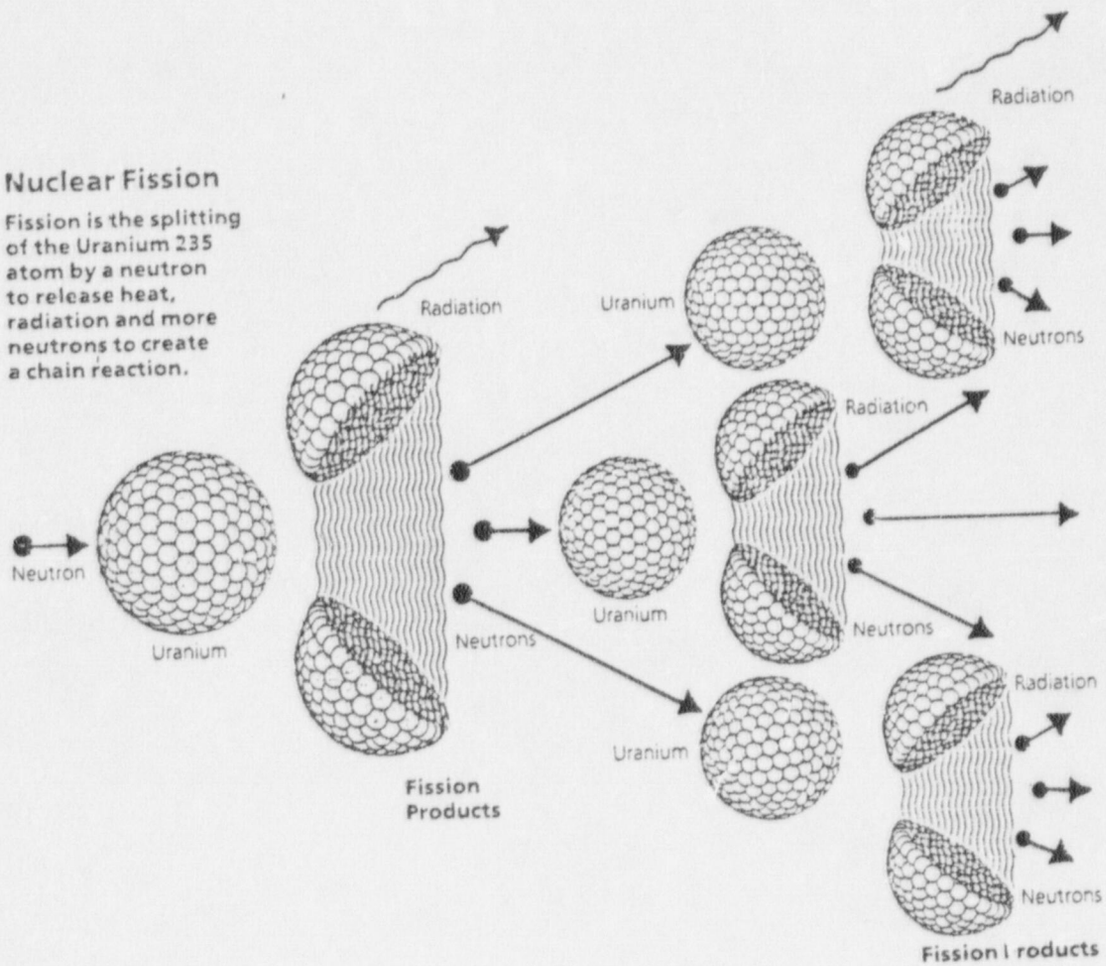


Figure 1.3-1
Radioactive Fission Products

The operation of a nuclear reactor results in the release of small amounts of radioactivity and low levels of radiation. The radioactivity originates from two major sources, radioactive fission products and radioactive activation products.

Radioactive fission products (see Figure 1.3-1)[5], originate from the fissioning of the nuclear fuel. These fission products get into the reactor coolant as they are released by minute amounts of uranium on the outside surfaces of the fuel cladding, by diffusion through the fuel pellets and cladding and, on occasion, through defects or failures in the fuel cladding. These fission products circulate along with the reactor coolant water and some of these particles deposit on the internal surfaces of pipes and equipment. The radioactive fission products on the pipes and equipment emit radiation. Examples of some fission products are cesium-137, iodine-131, strontium-90, xenon-133 and krypton-85.

Radioactive activation products (see Figure 1.3-2), on the other hand, originate from two sources. The first is by neutron bombardment of the hydrogen, oxygen and other gas (helium, argon, nitrogen) molecules in the reactor cooling water. The second is a result of the fact that the internals of any piping system or component are subject to minute yet constant corrosion from the reactor cooling water. These minute metallic particles (for example: nickel, iron, cobalt, or magnesium) are transported through the reactor core into the fuel region, where neutrons may react with the nuclei of these particles, producing radioactive products. So, activation products are nothing more than ordinary naturally occurring atoms that are made unstable or radioactive by neutron bombardment. These activation products circulate along with the reactor coolant water and some of these particles will deposit on the internal surfaces of pipes and equipment. The radioactive activation products on the pipes and equipment emit radiation. Examples of some activation products are cobalt-60, cobalt-58, iron-59, manganese-54 and zinc-65.

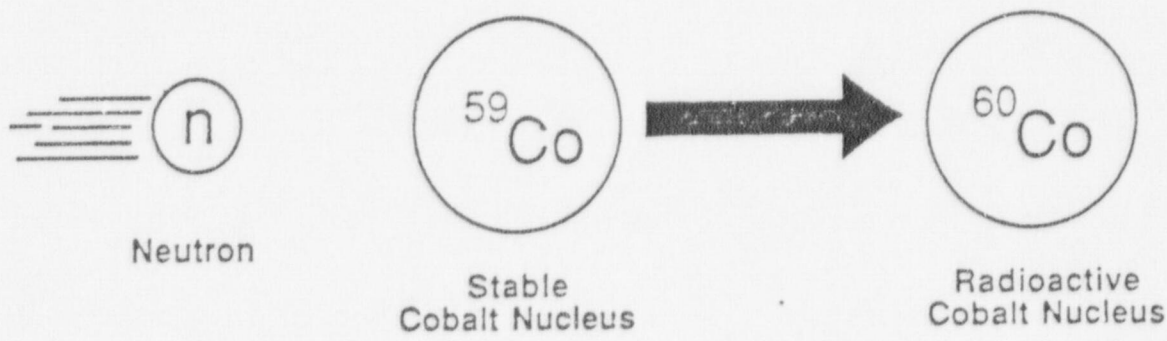


Figure 1.3-2
Radioactive Activation Product

At Pilgrim Nuclear Power Station there are five independent protective barriers that confine these radioactive materials. These five barriers, which are shown in Figure 1.3-3, are: 1) fuel pellets; 2) fuel cladding; 3) reactor vessel and piping; 4) primary containment (drywell and torus); and 5) secondary containment (reactor building).

The ceramic uranium fuel pellets provide the first barrier. Most of the radioactive fission products are either physically trapped or chemically bound between the uranium atoms, where they will remain. However, a few fission products which are volatile or gaseous may diffuse through the fuel pellets into small gaps between the pellets and the fuel cladding.

The second barrier, the fuel cladding, consists of zirconium alloy tubes that confine the fuel pellets. The small gaps between the fuel and the cladding contain the noble gases and volatile iodines which are types of radioactive fission products. This radioactivity can diffuse to a small extent through the fuel cladding into the reactor coolant water.

The third barrier consists of the reactor pressure vessel, steel piping, and equipment that confines the reactor cooling water. The reactor pressure vessel, which holds the reactor fuel, is a 65 foot high by 19 foot diameter tank with steel walls about nine inches thick. This provides containment for radioactivity in the primary coolant and the reactor core. However, during the course of operation and maintenance, small amounts of radioactive fission and activation products are released into the primary containment through valve leaks or upon breaching the primary coolant system.

The fourth barrier is the primary containment. This consists of the drywell and the torus. The drywell is a steel lined enclosure that is shaped like an inverted light bulb. The drywell's steel pressure vessel is enclosed by an approximately five foot thick concrete wall. The torus is a donut shaped pressure suppression chamber. The torus tunnel is 30 feet in diameter, with the donut itself having an outside diameter of about 130 feet. Small amounts of radioactivity may be released from primary containment during maintenance.

The fifth barrier is the secondary containment or reactor building. The reactor building is the concrete building that surrounds the primary containment. This barrier is an additional safety feature to contain radioactivity which may escape from the primary containment. The reactor building is equipped with a filtered ventilation system that is used, when needed, to reduce the radioactivity that escapes from the primary containment.

Most of the radioactive fission and activation products are confined by the five barriers. However, small amounts of radioactivity are released via mechanical failures and maintenance on valves, piping, and equipment associated with the reactor cooling water system. The small amounts of radioactive liquids and gases that do escape the various containment systems are further controlled by the liquid purification and ventilation filtration systems. Also, prior to a release to the environment, control systems exist to collect and purify the radioactive effluents in order to reduce releases to the environment to as low as is reasonably achievable. The control of radioactive effluents at Pilgrim Station will be discussed in more detail in the next section.

SIMPLIFIED DIAGRAM OF PILGRIM NUCLEAR POWER STATION

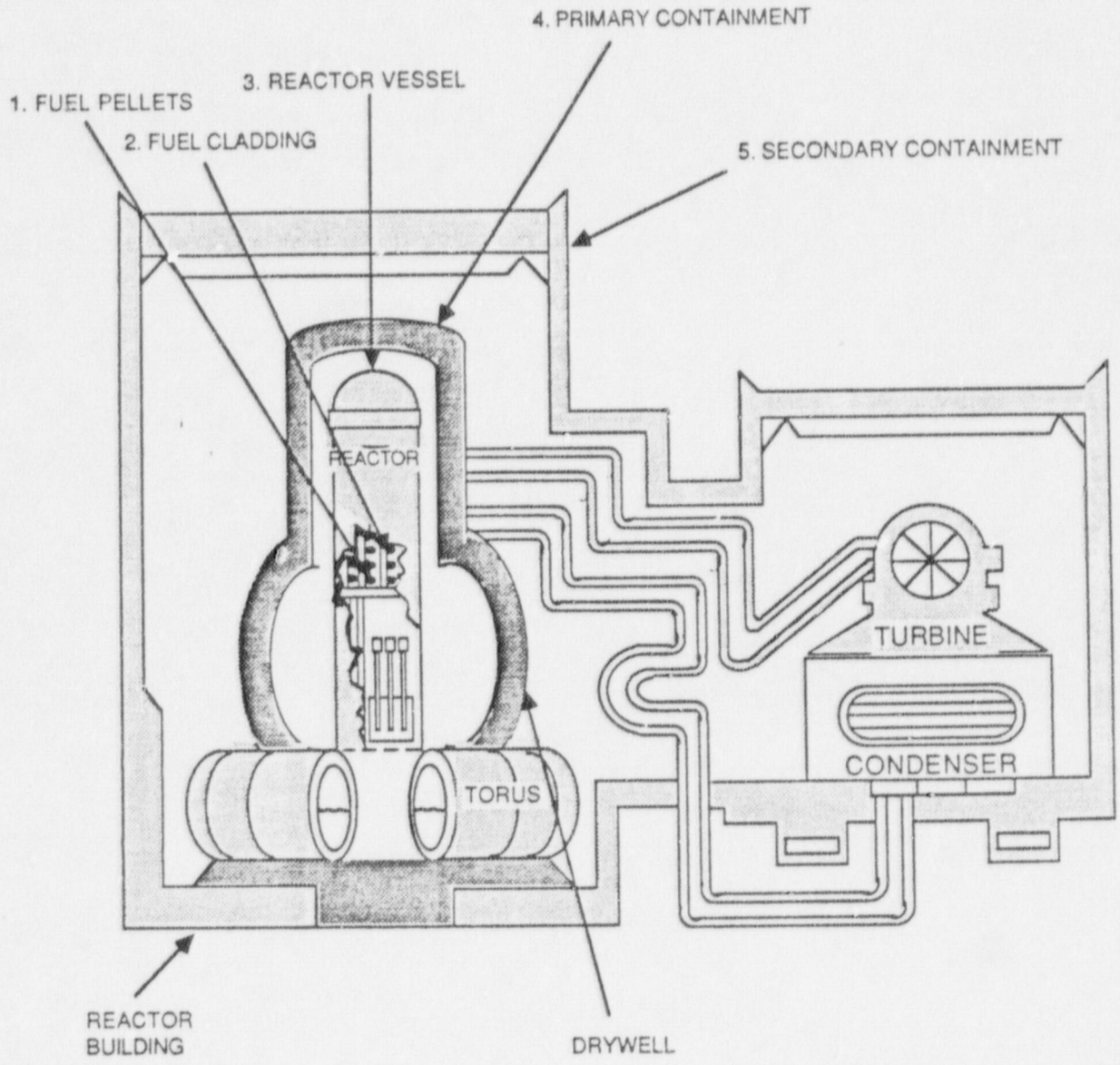


Figure 1.3-3
Five Barriers That Confine Radioactive Materials

1.4 RADIOACTIVE EFFLUENT CONTROL

Small amounts of radioactivity are released into liquid and gaseous streams from operation of Pilgrim Station. These waste streams are processed in the appropriate treatment systems prior to release and are monitored in accordance to PNPS Technical Specifications. The limits set forth in the technical specifications are established to conform with release and dose limits set forth by the Nuclear Regulatory Commission.

In order to ensure that all radioactive liquid effluents are released according to ALARA concepts, the following systems and practices are utilized:

- Reactor water cleanup system
- Radwaste treatment system
- Sampling and analyses of radwaste tanks.

The reactor water cleanup system maintains reactor water purity by means of a filtering and demineralizing process. This system provides a means of removing radioactive water-borne materials which are generated by the fission and corrosion process. The removal of these impurities limits the secondary sources of radiation and consequently reduces the amount of radioactive material which might be released from the system.

Such releases of radioactive liquids are directed to the liquid radwaste treatment system. This treatment system consists of a flatbed filter and ion exchange demineralizer to further purify this water. A small quantity of this treated water may be selected to be released as a radioactive liquid effluent. However, this liquid is sampled and analyzed prior to release to determine the specific level of radioactivity. As a result of this analysis, a discharge flow rate will be determined in conjunction with the available dilution flow provided by the sea water pumps to ensure that the federal limits for radionuclide concentrations are not exceeded.

Radioactive releases from the radioactive gaseous effluent systems to the environment are limited, controlled, and monitored by a variety of systems:

- Off-gas radiation monitoring system
- Augmented off-gas system
- Main stack ventilation system
- Main stack effluent radioactivity monitor and sampling system.
- Reactor building ventilation system
- Reactor building vent effluent radioactivity monitor and sampling system
- Standby gas treatment system.

The off-gas radiation monitoring system actually consists of two monitoring systems, the main steam line process radiation monitor (PRM) and the air ejector off-gas PRM. These detectors measure gross radiation levels in both the main steam lines and off-gases from the main condenser. Both of these monitoring systems are provided with alarm and trip functions which are actuated when preset radiation level limits are exceeded. These alarms are set in accordance to limits specified in the PNPS Technical Specifications.

The augmented off-gas system is downstream of these monitoring systems and provides a treatment function whereby, through delay and filtration processes, off-gas radiation levels are drastically reduced. Furthermore, the radioactive gaseous effluents from this treatment system are continuously monitored. As in the previous monitoring systems, alarm and trip functions are set in accordance with PNPS Technical Specifications.

The main stack ventilation system is the final treatment and monitoring system whereby radioactive gaseous effluents are assured to be "As Low As Reasonably Achievable". This system accepts flow from systems such as the main condenser, standby gas treatment, drywell purge, radwaste and turbine building ventilation, and main condenser mechanical vacuum pump. This flow is directed through high efficiency particulate (HEPA) filters and then to the stack where it is diluted by a large volume of air prior to exiting the 310 foot stack. The main stack monitoring system draws a representative gaseous sample through an isokinetic probe. This sample is directed through a particulate and iodine filter and then to two shielded chambers where the radiation levels of the noble gases are measured by two redundant detectors. The particulate and iodine filters are routinely analyzed in a chemistry laboratory in accordance with PNPS Technical Specifications.

The noble gas detectors continuously monitor the effluent of the main stack and are equipped with an audible alarm and a recorder which provides a permanent record of the effluent releases. The alarm for the main stack is set in accordance to limits specified in the PNPS Technical Specifications.

Air from areas containing potential sources of radioactive contamination such as the reactor building, radwaste building basement, and turbine building basement are discharged through the reactor building exhaust vent. The gaseous effluents from the reactor building ventilation system are continuously monitored by a sampling system similar to that for the main stack. An isokinetic sample is drawn from the vent and directed through a particulate and iodine filter and then to two shielded chambers where the radiation levels of the noble gases are measured. The analysis frequencies and alarm set points are also similar to those for the main stack.

Should elevated radiation levels exist at the reactor building vent, the standby gas treatment system is automatically initiated and the reactor building vent isolated. The standby gas treatment system (SBGT) provides a method to remove particulates and gaseous contaminants from the reactor building exhaust system. The SBGT has two identical, parallel air filtration assemblies separated by a concrete block wall. Each train has 100% capacity and draws air through a filter unit containing a set of pre-treatment HEPA filters, two charcoal beds, and a final set of post-treatment HEPA filters. The air drawn through this system is then monitored and discharged to the main stack.

Therefore, the radioactive effluent control systems, which exist for treating and monitoring all liquid and gaseous effluents, ensure that all effluent releases are handled in accordance with PNPS Technical Specifications. The dose and release limits set forth in the technical specifications are established to conform with federal limits imposed by the Nuclear Regulatory Commission. In addition, these systems are designed and operated to assure that all releases are as low as reasonably achievable (ALARA).

1.5 RADIOLOGICAL IMPACT ON HUMANS

The final effluent control is the determination of the radiological dose impact on humans and comparison with the federal dose limits to the public. As mentioned previously, the purpose of the continuous radiation monitoring and the periodic sampling and analysis is to measure the quantities of radioactivity being released to determine if the radioactivity release limits are met. This is the first stage for assessing releases to the environment.

The second stage is to calculate the dose impact to the general public from Pilgrim Station radioactive effluents. The purpose of these calculations is to periodically assess the doses to the general public resulting from radioactive effluents to ensure that these doses are being maintained as far below the federal dose limits as is reasonably achievable.

The types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during 1988 were reported to the Nuclear Regulatory Commission semi-annually. The 1988 Radioactive Effluents are provided in Appendix B and will be discussed in more detail in Part IV of this report. These liquid and gaseous effluents were well below the federal release limits and were a small percentage of the PNPS Technical Specifications limits and operational objectives.

Measurements of the physical and chemical nature of the effluents are used to determine how the radionuclides will interact with the environment and how they can result in radiation exposure to humans. The environmental interaction mechanisms depend upon factors such as the hydrological (water) and meteorological (atmospheric) characteristics in the area. Information on the water flow, wind speed, wind direction and atmospheric mixing characteristics is used to estimate how radioactivity will distribute and disperse in the ocean and the atmosphere.

The most important type of information that is used to evaluate the radiological impact on humans is data on the use of the environment. Information on fish and shellfish consumption, boating usage, beach usage, locations of cows and goats, locations of residences, locations of gardens, and other usage information are utilized to estimate the amount of radiation and radioactivity received by the general public.

The radiation exposure pathway to humans is the path radioactivity takes from its release point at Pilgrim Station to its impact on man. The movement of radioactivity through the environment and its transport to humans is portrayed in Figure 1.5-1.

Examples of Pilgrim Station's Radiation Exposure Pathways

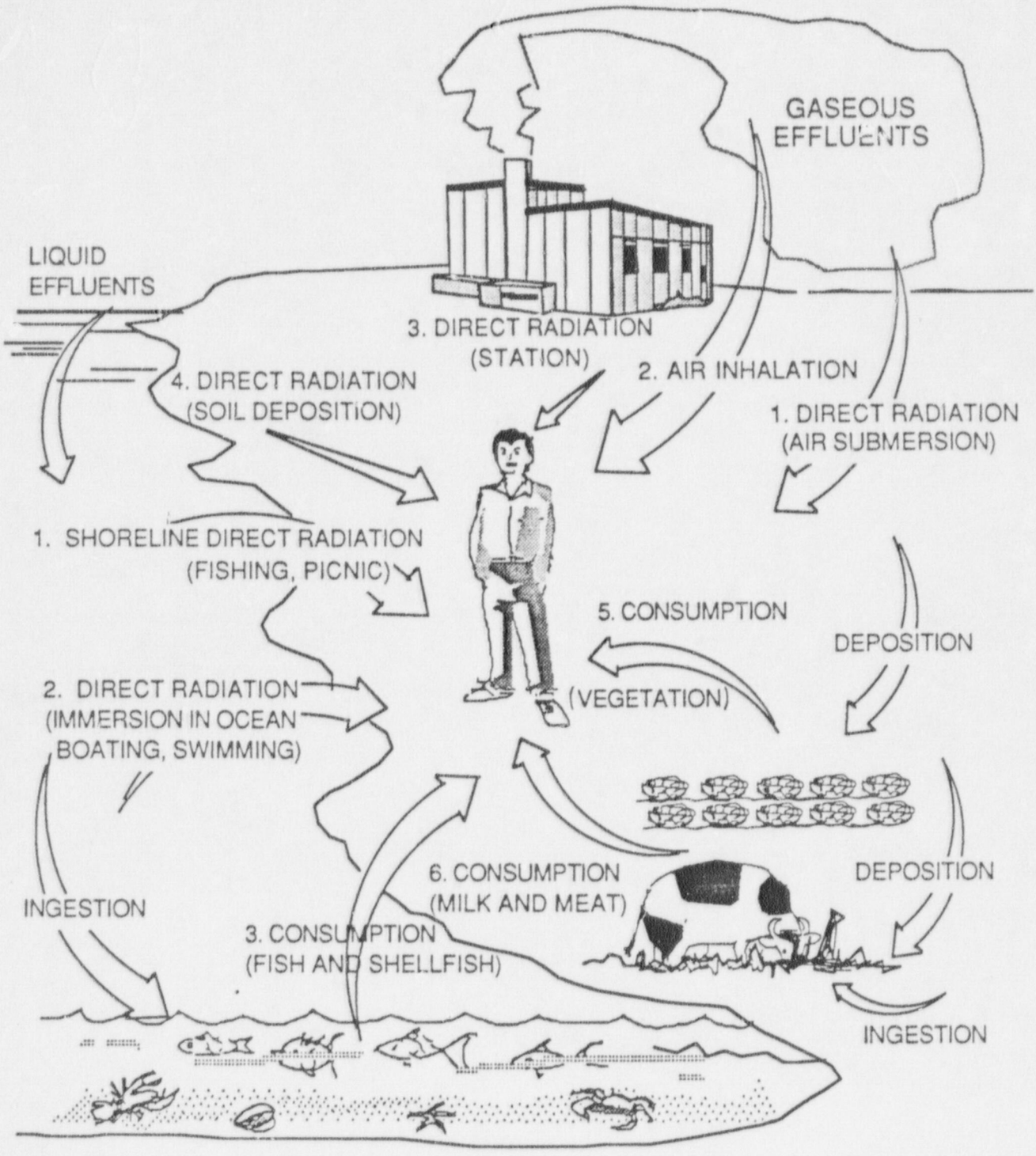


Figure 1.5-1
Generalized Radiation Exposure Pathways to Humans

There are six major ways in which gaseous effluents impact humans:

1) external radiation from exposure to airborne radioactivity;

2) internal radiation from inhalation of airborne radioactivity;

3) direct radiation emitted from the radioactivity contained in Pilgrim Station;

4) external radiation from deposition of radioactive effluents on soil;

5) internal radiation from consumption of vegetation containing radioactivity absorbed from the soil due to ground deposition of radioactive effluents; and,

6) internal radiation from consumption of milk and meat containing radioactivity deposited on forage which is eaten by cows and cattle.

There are three major ways in which liquid effluents impact humans:

1) external radiation from liquid effluents that deposit on the shoreline;

2) external radiation from immersion in ocean water containing radioactive liquids; and,

3) internal radiation from consumption of fish and shellfish containing radioactivity absorbed from the liquid effluents.

To the extent possible, the radiological dose impact on humans is based on direct measurements of radiation and radioactivity in the environment (see Appendix A). The operation of Pilgrim Nuclear Power Station results in releases of only small amounts of radioactivity. However, as a result of dilution in the atmosphere and ocean, even the most sensitive radioactivity measurements and analysis techniques often cannot detect these small amounts of radioactivity in the environment above that which is naturally present. Therefore, radiation doses are routinely calculated using radioactivity release data and computerized dose calculations that are based on very conservative (over-estimated) NRC-recommended models.[7] These computerized dose calculations are performed by Yankee Atomic Electric Co. or Boston Edison Co. personnel. The dose calculations are documented and described in detail in the Pilgrim Nuclear Power Station Off-site Dose Calculation Manual[8] which has been reviewed and found to be acceptable by the NRC.

Dose calculations are routinely performed by Boston Edison Co. personnel on a weekly and monthly basis. Dose calculations are also performed for Boston Edison Co. by Yankee Atomic Electric Co., using their "YODA" computer program, on an annual basis. It should be emphasized that because of the very conservative assumptions made in the computer code calculations, the maximum calculated hypothetical dose to an individual is considerably higher than the dose that would actually be received by a real individual.

Following calcuations of the maximum hypothetical doses, the results are compared to the federal dose limits for the public. The two federal agencies that are charged with the responsibility of protecting the public from radiation and radioactivity are the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA).

The NRC, in 10CFR 20.105,[9] limits the levels of radiation to unrestricted areas resulting from the possession or use of radioactive materials such that they limit any individual to a dose of:

- less than or equal to 500 mrem per year to the total body.

In addition to this dose limit, the NRC has established design objectives for nuclear plant licensees. Conformance to these guidelines ensures that nuclear power reactor effluents are maintained as far below the legal limits as is reasonably achievable.

The NRC, in 10CFR 50 Appendix I,[10] establishes design objectives for the dose to a member of the general public from radioactive material in liquid effluents released to unrestricted areas to be limited to:

- less than or equal to 3 mrem per year to the total body

-and-

- less than or equal to 10 mrem per year to any organ.

The air dose due to release of noble gases in gaseous effluents is restricted to:

- less than or equal to 10 mrad per year for gamma radiation

-and-

- less than or equal to 20 mrad per year for beta radiation.

The dose to a member of the general public from iodine-131, tritium, and all particulate radionuclides with half-lives greater than 8 days in gaseous effluents is limited to:

- less than or equal to 15 mrem per year to any organ.

The EPA, in 40CFR190.10 Subpart B,[11] sets forth the environmental standards for the uranium fuel cycle. During normal operation, the annual dose to any member of the public shall be limited to:

- less than or equal to 25 mrem per year to the total body
- less than or equal to 75 mrem per year to the thyroid

-and-

- less than or equal to 25 mrem per year to any other organ.

It should be noted that the EPA limits are based on the dose that a real individual might receive, as opposed to the NRC's limits which are based on the maximum hypothetically exposed individual. Also, the EPA limits include dose from direct radiation, whereas the NRC limits in 10CFR50, Appendix I, are based only on doses resulting from effluent releases.

The summary of the 1988 radiological dose impact to the general public from Pilgrim Station and comparison with the EPA dose limits and guidelines, as well as a comparison with natural/man-made radiation levels, is presented in Part 3.0 of this report.

The third stage of assessing releases to the environment is the Radiological Environmental Monitoring Program (REMP). The description and results of the environmental monitoring program conducted at Pilgrim Nuclear Power Station during 1988 will be discussed in Part 2.0 of this report.

2.0 SUMMARY OF RADIOLOGICAL IMPACT ON THE ENVIROMENT

2.1 DESCRIPTION OF THE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The Radiological Environmental Monitoring Program (REMP) at Boston Edison Company's Pilgrim Nuclear Power Station was initiated in August of 1968. The purpose of the pre-operational environmental monitoring program was to:[12]

1) measure background levels and their variations in the environment surrounding Pilgrim Station; and,

2) evaluate procedures, equipment, and techniques for sampling and measurement.

The pre-operational program continued for approximately three and a half years, from August 1968 to March 1972.[13] Examples of background radiation and radioactivity levels measured during this time period are as follows:

- Airborne Radioactivity Particulate Concentration (gross beta): 0.25 pCi/m^3
- Direct Radiation (TLDs): 13 micro-R/hr
- Seawater Radioactivity Concentrations (gross beta): 20 pCi/kg
- Fish Radioactivity Concentrations (gross beta): 3,850 pCi/kg
- Milk Radioactive Cesium-137 Concentrations: 17 pCi/kg
- Milk Radioactive Strontium-90 Concentrations: 9 pCi/kg
- Cranberries Radioactive Cesium-137 Concentrations: 170 pCi/kg

This information from the pre-operational phase is used as a basis for evaluating changes in radiation and radioactivity levels in the vicinity of the plant following plant operation. In April 1972, just prior to initial reactor startup (June 12, 1972), Boston Edison Co. implemented a comprehensive operational environmental monitoring program at Pilgrim Nuclear Power Station. This program provides information on radioactivity and radiation levels in the environment for the purpose of:[14]

1) demonstrating that doses to the general public and levels of radioactivity in the environment are within established limits and legal requirements;

2) monitoring the transfer and long-term buildup of specific radionuclides in the environment to revise the monitoring program and environmental models in response to changing conditions;

3) checking the condition of the Station operation, the adequacy of operation in relation to the adequacy of containment, and the effectiveness of effluent treatment, so as to provide a mechanism of determining unusual or unforseen conditions and, where appropriate, to trigger additional radioactive effluent treatment systems and special environmental monitoring studies;

4) assessing the dose equivalent to the general public and the behavior of radioactivity released during the unlikely event of an accidental release; and

5) determining whether the radiological impact on the environment and humans is significant.

The Nuclear Regulatory Commission requires that Boston Edison Company provide monitoring of the plant environs for radioactivity that will be released as a result of normal operations, including anticipated operational occurrences, and postulated accidents. The NRC has established guidelines which specify an acceptable monitoring program.[15] The Boston Edison Company's Radiological Environmental Monitoring Program was designed to meet and exceed these guidelines. Guidance contained in the NRC's Radiological Assessment Branch Technical Position on Environmental Monitoring[16] has been used to improve the program. In addition, the program has incorporated the provisions of an agreement made with the Massachusetts Wildlife Federation.[17] The program was supplemented by including improved analysis of shellfish and sediment at substantially higher sensitivity levels to verify the adequacy of effluent controls at Pilgrim Station.

Sampling locations have been established by considering meteorology, population distribution, hydrology, and land use characteristics of the Plymouth area. The sampling locations are divided into two classes: indicator and control. Indicator locations are those which are expected to show effects from PNPS operations, if any exist. These locations were primarily selected on the basis of where the highest predicted environmental concentrations would occur. While the indicator locations are typically within a few miles of the plant, the control stations are generally located so as to be outside the influence of Pilgrim Station. They provide a basis on which to evaluate fluctuations at indicator locations relative to natural background radiation, natural radioactivity, fallout from prior nuclear weapons tests, and fallout from accidents such as the one at Chernobyl.

The environmental sampling media collected in the vicinity of Pilgrim Station during 1988 include air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation and beef forage. The medium, station number, description, and distance from the reactor for indicator and control samples are listed in Table 2.1-1. These sampling locations are also displayed on the maps shown in Figures 2.1-1 through 2.1-4. The terrestrial and aquatic sampling and measurement control locations are shown in Figure 2.1-5.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.1-1 through 2.1-3. The frequency of collection and types of radioactivity analysis are described in Appendix C, Table 8.1-1.

The land-based samples and monitoring devices are collected by Boston Edison personnel from the Electrical Engineering and Station Operation Department's Environmental Laboratory. The aquatic samples are collected by the Massachusetts Division of Marine Fisheries Pilgrim Station Project personnel. The direct radiation measurements and soil radioactivity measurements are conducted by Yankee Atomic Electric Co. Radiological Engineering Group and Environmental Laboratory personnel. The radioactivity analysis of samples and the processing of the environmental TLDs is performed by Yankee's Environmental Laboratory personnel.

Table 2.1-1

Pilgrim Nuclear Power Station
1988 Sampling Locations

Medium	No.	Code	Description	Dist.*	Dir.*
Air Particulate	00	WS	Warehouse	0.11 mi	SSE
Filters/	01	ER	E. Rocky Hill Road	0.65 mi	SE
Charcoal Cartridges/	03	WR	W. Rocky Hill Road	0.48 mi	WNW
Soil	06	PL	Property Line	0.32 mi	NW
	07	PB	Pedestrian Bridge	0.13 mi	N
	08	OA	Overlook Area	0.09 mi	W
	09	EB	East Breakwater	0.33 mi	ESE
	10	CR	Cleft Rock	0.86 mi	SSW
	15	PC	Plymouth Center	4.1 mi	W
	17	MS	Manomet Substation	2.3 mi	SSE
	21	EW	East Weymouth Control	24 mi	NW
Seawater	11	DIS	Discharge Canal	0.13 mi	N
	17	BP	Barlett Pond	1.7 mi	SE
	23	PP	Powder Point Control	7.9 mi	NNW
Shellfish	11	DIS	Discharge Canal	0.21 mi	N
	12	Ply-H	Plymouth Harbor	2.8 mi	W
	15	MP	Manomet Point	3.0 mi	ESE
	13	Dux-Bay	Duxbury Bay Control	7.8 mi	NNW
	23	PP	Powder Point Control	9.9 mi	NNW
	24	MS	Green Harbor Control	10 mi	NNW
Irish Moss	11	DIS	Discharge Canal	0.21 mi	N
	15	MP	Manomet Point	2.2 mi	ESE
	22	EL	Ellisville	7.9 mi	SSE
	34	BR	Brant Rock Control	10 mi	NNW
American Lobster	11	DIS	Discharge Canal	0.21 mi	N
	89	Dux-B	Duxbury Beach Control	5.8 mi	NNW
Fishes	11	DIS	Discharge Canal	0.21 mi	N
	14	PLB	Plymouth Beach	2.5 mi	W
	30	JR	Jones River Control	7.8 mi	WNW
	98	CC-Bay	Cape Cod Bay Control	15 mi	ESE
Sediment	11	DIS	Discharge Canal	0.21 mi	N
	14	PLB	Plymouth Beach	2.5 mi	W
	12	Ply-H	Plymouth Harbor	3.0 mi	W
	15	MP	Manomet Point	2.5 mi	ESE
	13	Dux-Bay	Duxbury Bay Control	8.7 mi	NNW
	24	MS	Green Harbor Control	10 mi	NNW
Milk	11	CF	Plymouth County Farm	3.5 mi	W
	21	WF	Whitman Farm Control	20 mi	WNW

Table 2.1-1 (continued)

Pilgrim Nuclear Power Station
1988 Sampling Locations

Medium	No.	Code	Description	Dist.*	Dir.*
Cranberries	13	MR	Manomet Pt. Bog	2.4 mi	SE
	14	BR	Bartlett Rd. Bog	2.7 mi	SSE
	23	PS	Pine St. Bog Control	16 mi	WNW
Vegetation	78	HR	Hall Residence	0.5 mi	SE
	60	AF	Alden Road Farm	0.77 mi	SE
	76	JG	Jenkins Residence	1.3 mi	WSW
	43	WH	Whipple House	1.8 mi	SW
	77	MG	Moon Residence	2.1 mi	WSW
	80	MF	Minahan Farm	2.2 mi	S
	11	CF	Plymouth County Farm	3.5 mi	W
	27	BF	Bridgewater Farm Cont.	20 mi	W
Beef Forage	11	CF	Plymouth County Farm	3.4 mi	W
	12	WF	Whitman Farm Control	20 mi	WNW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.1-1
Pilgrim Nuclear Power Station

Environmental Thermoluminescent
Dosimeter and Air Sampling Locations Within Exclusion Area

ENVIRONMENTAL TLD LOCATIONS

No.	Code	Description	Dist.*	Dir.*
B10	A	Station A	1300 ft	W
B24	B	Station B	1300 ft	SSW
B28	C	Station C	1700 ft	SE
B05	D	Station D	1700 ft	NNW
B26	EB	East Breakwater	1800 ft	SE
B04	F	Station F	1400 ft	NW
B11	G	Station G	1700 ft	WNW
B02	I	Station I	1600 ft	NW
B27	L	Station L	1400 ft	ESE
B09	OA	Overlook Area	500 ft	W
B55	P01	Sec H Shore	720 ft	NNW
B56	P02	Fence Shore	440 ft	NW
B57	P03	Fen L Screenh	330 ft	NW
B58	P04	Fen R Screenh	220 ft	N
B59	P05	Fen Water Tank	260 ft	NE
B60	P06	Fen Culvert	280 ft	ENE
B61	P07	Fen Intake	400 ft	E
B62	P08	Fen New Admin	300 ft	E
B63	P09	Fen TCF Side	450 ft	E
B64	P10	Fen Intake TCF	740 ft	ESE
B65	P11	Gate Wh to TCF	620 ft	SE
B66	P12	Fen Wh Con Gate	660 ft	SSE
B67	P13	Fen Con & RHR	740 ft	S
B68	P14	Fen Butler B	750 ft	S
B69	P15	Fen Unit #9	740 ft	SSW
B70	P16	Fen Swy M Gate	560 ft	SW
B71	P17	Fen Shf M Gate	350 ft	WNW
B72	P18	I&C N Admin	290 ft	S
B73	P19	Compliance Area	280 ft	S
B74	P20	Dosimetry Window	220 ft	SSE
B75	P21	WW Admin & Turb	170 ft	SE
B76	P22	QA/QC Area	450 ft	SE
B77	P23	CMG Area	400 ft	SSE
B78	P24	Old Admin Bld 2nd	190 ft	W
B79	P25	First Aid Trailer	250 ft	WNW
P26	P26	Fence Warhouse	490 ft	SE
P27	P27	TCF Boat Launch	640 ft	ESE
P28	P28	TCF Cont. Lot	800 ft	ESE
B06	PA	Parking Area	1200 ft	NNW
B07	PB	Pedestrian Bridge	700 ft	N
B03	PL	Property Line	1700 ft	NW
B53	TC	Training Center	520 ft	W
B12	WR	W. Rocky Hill Road	2600 ft	WNW
B01	WS	Warehouse	600 ft	SSE
B08	PMT	Plymouth Met Tower	1400 ft	NW
B29	HB	Halls Bog	2000 ft	SSE
B89	CT	Contractor Lot	1100 ft	SSE

AIR SAMPLE LOCATIONS

No.	Code	Description	Dist.*	Dir.*
09	EB	East Breakwater	0.33 mi	ESE
08	OA	Overlook Area	0.09 mi	W
07	PB	Pedestrian Bridge	0.13 mi	N
06	PL	Property Line	0.32 mi	NW
03	WR	W. Rocky Hill Road	0.48 mi	WNW
00	WS	Warehouse	0.11 mi	SSE

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.1-1 (cont.)

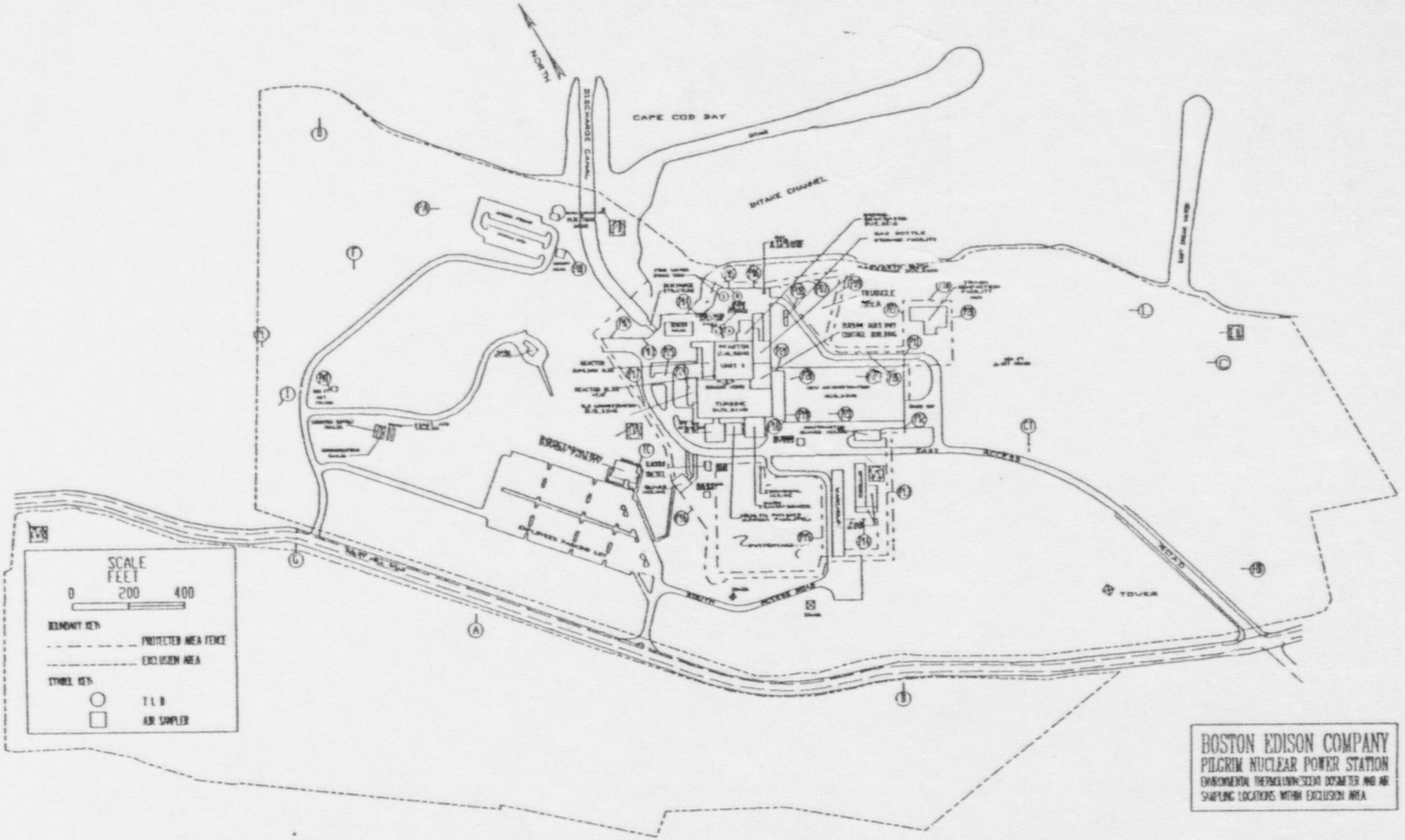


Figure 2.1-2

Pilgrim Nuclear Power Station

Environmental Thermoluminescent Dosimeter and
Air Sampling Locations Outside Exclusion Area to About Two Miles

ENVIRONMENTAL TLD LOCATIONS

No.	Code	Description	Dist.*	Dir.*
B23	AR	Access Road	0.92 mi	S
B90	BB	3A & Bartlett Rd	2.1 mi	SSE
B13	BD	Bayshore Drive	0.81 mi	WNW
B14	BS	Bayshore	1.3 mi	W
B36	BW	Beachwood Road	2.5 mi	SE
B18	CR	Cleft Rock	0.86 mi	S
B16	DR	Dirt Road	0.94 mi	SW
B20	E	Station E	1.2 mi	S
B31	EM	Emerson Road	1.1 mi	SSE
B86	EP	Emer Rd & Pris	1.1 mi	SE
B30	ER	E Rocky Hill Rd	0.65 mi	SE
B54	GH	Greenwood Hse	0.57 mi	SE
B83	GN	Goodwin Property	1.4 mi	SW
B25	H	Station H	0.57 mi	SW
B21	J	Station J	1.3 mi	S
B84	JG	John Gauley	1.1 mi	W

ENVIRONMENTAL TLD LOCATIONS

No.	Code	Description	Dist.*	Dir.*
B22	K	Station K	1.4 mi	SSE
B34	ME	Manoment Elm	2.1 mi	SE
B35	MP	Manomet Pt	2.3 mi	SE
B19	MR	Manomet Road	0.98 mi	S
B33	MS	Manomet Subst	2.3 mi	SSE
B17	MT	Micro Tower	0.58 mi	SSW
B43	PT	Pines Estate	2.7 mi	SSW
B15	RC	Rec Pool	1.3 mi	WSW
B82	RW	Right of Way	1.7 mi	S
B40	SP	S Ply. Sub	2.8 mi	W
B88	TP	Taylor & Pearl	1.9 mi	SE
B87	TT	Taylor&Tom Ave	1.5 mi	SE
B92	VR	Valley Road	1.8 mi	SSW
B91	WC	Warren&Clifford	2.1 mi	W
B32	WH	White Horse Rd	1.3 mi	SSE
B85	YV	Yankee Village	1.4 mi	WSW

AIR SAMPLE LOCATIONS

No.	Code	Description	Dist.*	Dir.*
10	CR	Cleft Rock	0.36 mi	SSW
17	MS	Manomet Substation	2.3 mi	SSE
01	ER	East Rocky Hill Rd	0.65 mi	SE

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.1-2 (cont.)

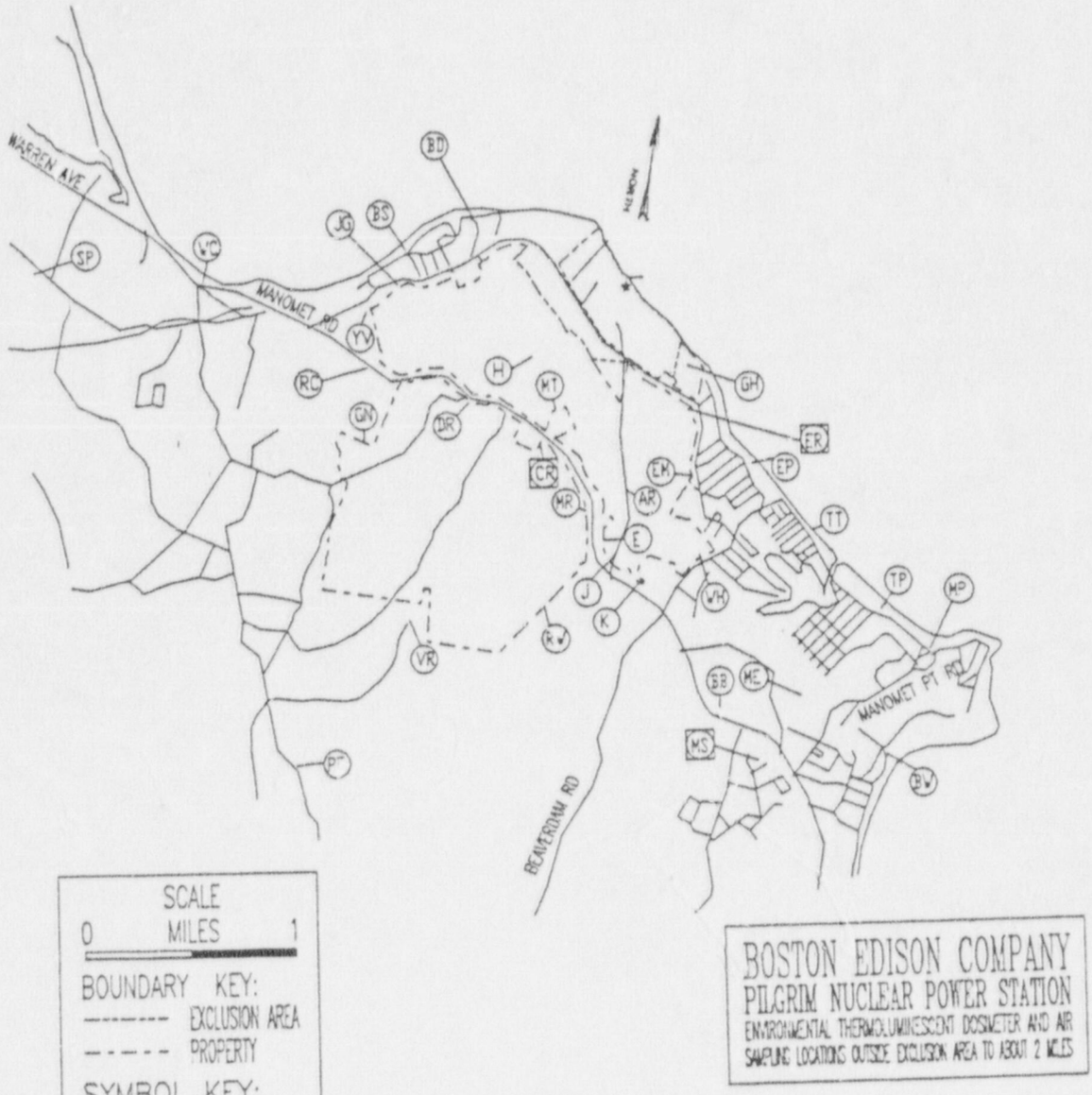


Figure 2.1-3

Pilgrim Nuclear Power Station

Environmental Thermoluminescent Dosimeter and
Air Sampling Locations Outside Property Boundary

ENVIRONMENTAL TLD LOCATIONS

No.	Code	Description	Dist.*	Dir.*
B90	BB	3A & Bartlett	2.1 mi	SSE
B13	BD	Bayshore Drive	0.81 mi	WNW
B96	BE	Bourne Road	8.4 mi	SSW
B42	BR	Beaver Dam Road	3.5 mi	S
B14	BS	Bayshore	1.3 mi	W
B36	BW	Beachwood Road	2.5 mi	SE
B18	CR	Cleft Rock	0.86 mi	S
B38	CS	Cedarville Sub	10 mi	S
B39	CP	College Pond	4.8 mi	SW
BA1	CW	Church & West	10 mi	NW
B95	DMF	Div. Mar. Fish.	14 mi	SSE
BA0	DW	Deep Water	5.3 mi	W
B41	EA	Earl Road	3.0 mi	SSE
B94	EL	Ellisville Road	7.2 mi	SSE
B86	EP	Emer. Rd & Pris	1.1 mi	SE
B52	EW	E. Weymouth Sub	24 mi	NW
B46	HD	Hilldale Road	3.1 mi	W
B93	HR	Hyannis Road	4.8 mi	SSE
B84	JG	John Gauley	1.1 mi	W
BA4	KC	King Ceasar Road	8.1 mi	NNW
B50	KS	Kingston Subst.	10 mi	WNW
B98	LD	Long & Drew Road	4.5 mi	WSW
B97	LP	Long Pond Road	5.7 mi	SSW
BA5	LR	Landing Road	10 mi	NNW

ENVIRONMENTAL TLD LOCATIONS

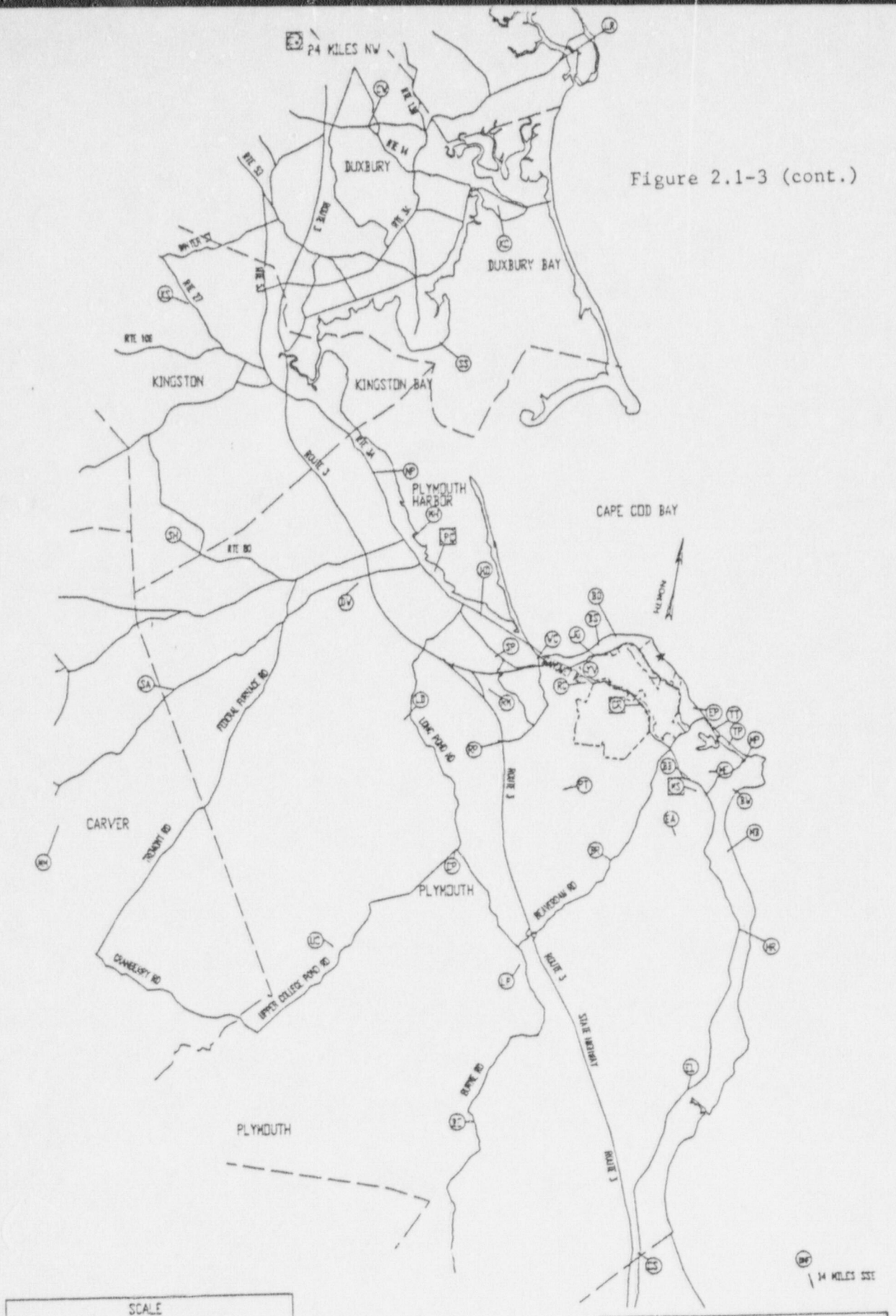
No.	Code	Description	Dist.*	Dir.*
B37	MB	Manomet Beach	3.4 mi	SSE
B34	ME	Manomet Elem	2.1 mi	SE
B32	MH	Memorial Hall	4.7 mi	WNW
BA2	MH	Main & Meadow	11 mi	WSW
B35	MP	Manomet Point	2.3 mi	SE
B33	MS	Manomet Subst	2.3 mi	SSE
B49	NP	North Plymouth	5.8 mi	WNW
B47	PC	Plymouth Center	4.1 mi	W
B43	PT	Pine Estates	2.7 mi	SSW
B15	RC	Rec Pool	1.3 mi	WSW
B45	RH	Russel Hill	3.0 mi	WSW
B44	RP	Rt 3 Overpass	3.0 mi	SW
B48	SA	Sherman Airport	8.4 mi	WSW
BA3	SH	Sacred Heart	8.1 mi	W
B51	SS	Standish Shores	6.5 mi	NW
B40	SP	S. Plymouth Sub	2.8 mi	W
B88	TP	Taylor & Pearl	1.9 mi	SE
B87	TT	Taylor & Thomas	1.5 mi	SE
B99	UC	Up Coll. Pnd.Rd	7.4 mi	SW
B91	WC	Warren&Clifford	2.1 mi	W
B85	YV	Yankee Village	1.4 mi	WSW

AIR SAMPLE LOCATIONS

No.	Code	Description	Dist.*	Dir.*
10	CR	Cleft Rock	0.86 mi	SSW
21	EW	East Weymouth	24 mi	NW
17	MS	Manomet Subst	2.3 mi	SSE
15	PC	Plymouth Center	4.1 mi	W

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.1-3 (cont.)



SCALE
MILES
0 3

BOUNDARY KEY:
PROPERTY
COUNTY

SYMBOL KEY:
TLD
AIR SAMPLER

BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER AND AIR SAMPLING LOCATIONS OUTSIDE PROPERTY BOUNDARY

Figure 2.1-4
Pilgrim Nuclear Power Station

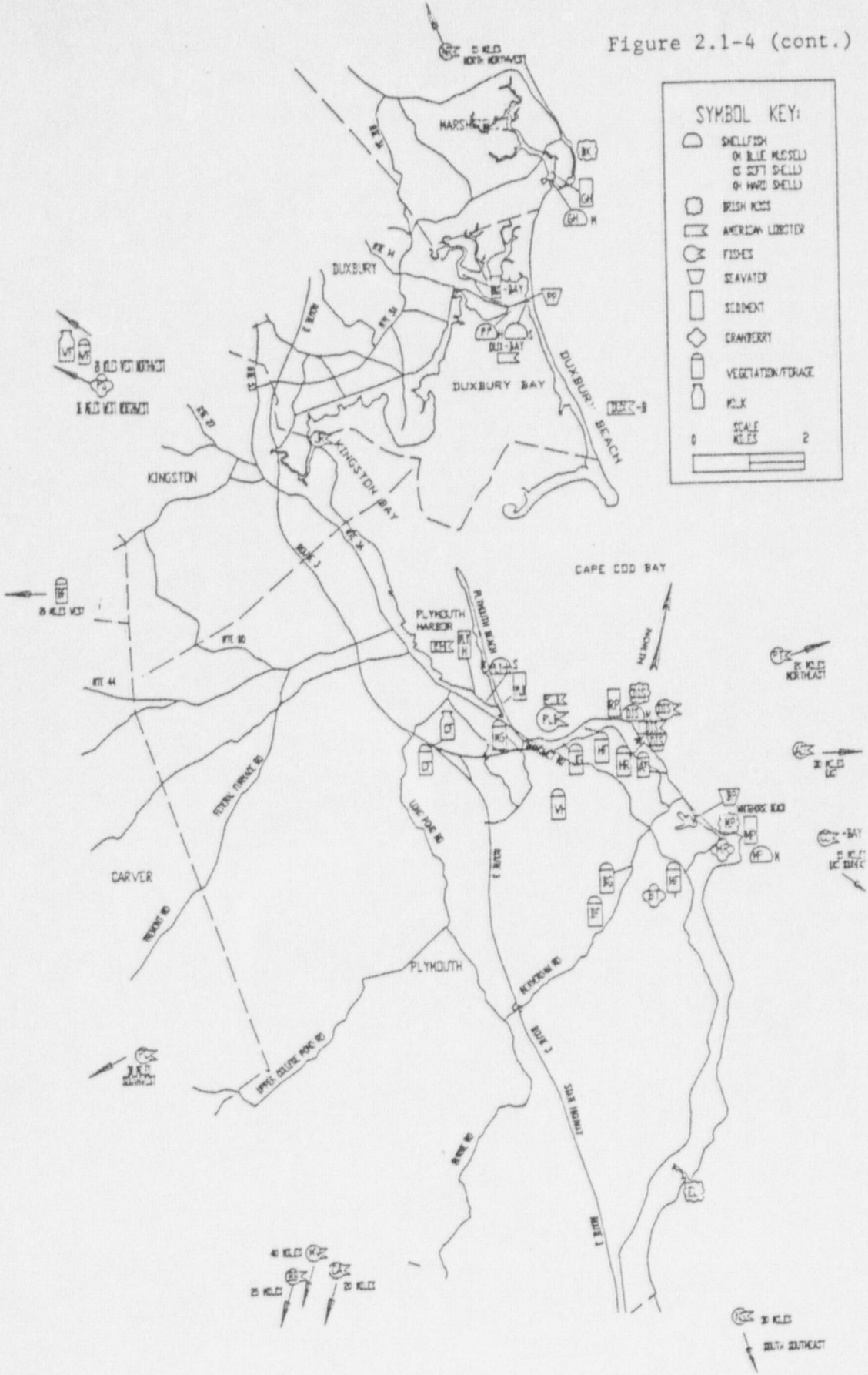
Terrestrial and Aquatic Sampling Locations

No.	Code	Description	Dist.*	Dir.*
		SEAWATER		
11	DIS	Discharge Canal	0.13 mi	N
17	BP	Bartlett Pond	1.7 mi	SE
23	PP	Powder Point Control	7.9 mi	NNW
		SHELLFISH		
11	DIS	Discharge Canal	0.21 mi	N
12	PLY-H	Plymouth Harbor	2.8 mi	W
15	MP	Manomet Point	3.0 mi	ESE
13	DUX-BAY	Duxbury Bay Control	7.8 mi	NNW
23	PP	Powder Point Control	8.0 mi	NNW
24	GH	Green Harbor Control	9.9 mi	NNW
		IRISH MOSS		
11	DIS	Discharge Canal	0.21 mi	N
15	MP	Manomet Point	2.2 mi	ESE
22	EL	Ellisville	7.9 mi	SSE
34	BK	Brant Rock Control	10 mi	NNW
		AMERICAN LOBSTER		
11	DIS	Discharge Canal	0.21 mi	N
12	PLY-H	Plymouth Harbor	4.0 mi	WNW
89	DUX-B	Duxbury Beach Control	5.8 mi	NNW
13	Dux-Bay	Duxbury Bay Control	7.1 mi	NNW
14	PLB	Plymouth Beach	2.5 mi	W
		FISHES		
11	DIS	Discharge Canal	0.21 mi	NNW
14	PLB	Plymouth Beach	2.5 mi	W
30	JR	Jones River Control	7.8 mi	WNW
98	CC-BAY	Cape Cod Bay Control	15 mi	ESE
96	NR	N River-Hanover Control	15 mi	NNW
28	CA	Cataumet Control	20 mi	SSW
99	PT	Provincetown Control	20 mi	NE
90	BB	Buzzards Bay Control	25 mi	SSW
49	PC	Priest Cove Control	30 mi	SW
97	NS	Nantucket Sound Control	30 mi	SSE
94	AO	Atlantic Ocean Control	30 mi	E
92	MV	Vinyard Sound Control	40 mi	SSW

No.	Code	Description	Dist.*	Dir.*
		SEDIMENT		
11	RP	Rocky Point	0.21 mi	N
12	PLY-H	Plymouth Harbor	3.0 mi	W
14	PLB	Plymouth Beach	2.5 mi	W
15	MP	Manomet Point	2.5 mi	ESE
13	DUX-BAY	Duxbury Bay Control	8.7 mi	NNW
24	GH	Green Harbor Control	10 mi	NNW
		MILK		
11	CF	Plymouth County Farm	3.5 mi	W
21	WF	Whitman Farm Control	20 mi	WNW
		CRANBERRIES		
13	MR	Manomet Pt. Bog	2.4 mi	SE
14	BT	Bartlett Rd. Bog	2.7 mi	SSE
23	PS	Pine St. Bog Control	16 mi	WNW
		VEGETABLES		
78	HR	Hall Residence	0.5 mi	SE
60	AF	Alden Road Farm	0.77 mi	SE
79	HF	Hanlon Farm	0.9 mi	W
76	JG	Jenkins Residence	1.3 mi	WSW
43	WH	Whipple House	1.8 mi	SW
77	MG	Moon Residence	2.1 mi	WSW
80	MF	Minahan Farm	2.2 mi	S
81	BG	Beaverdam Rd. Garden	2.5 mi	S
11	CF	Plymouth County Farm	3.5 mi	W
27	BF	Bridgewater Farm Control	20 mi	W
		FORAGE		
11	CF	Plymouth County Farm	3.5 mi	W
12	WF	Whitman Farm Control	20 mi	WNW
31	DF	Davis Farm (DF)	3.1 mi	S

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.1-4 (cont.)



BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
TERRESTRIAL AND AQUATIC
SAMPLING LOCATIONS

Figure 2.1-5
Pilgrim Nuclear Power Station

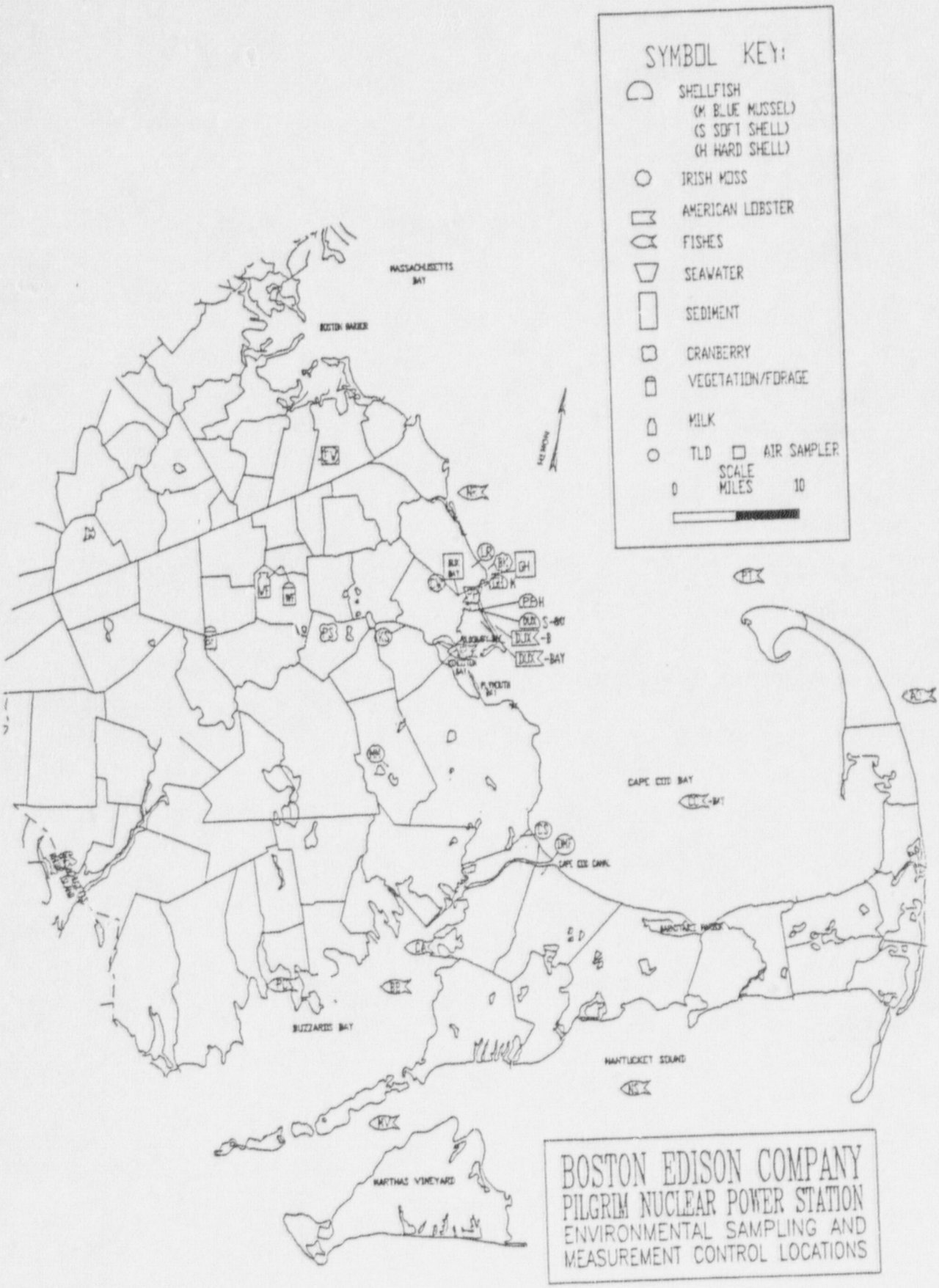
Environmental Sampling And Measurement Control Locations

No.	Code	Description	Dist.*	Dir.*
		AIR SAMPLE		
21	EW	East Weymouth	24 mi	NW
		SEDIMENT		
24	GH	Green Harbor Control	10 mi	NNW
13	Dux-Bay	Duxbury Bay Control	8.7 mi	NNW
		SEAWATER		
23	PP	Powder Point Control	7.9 mi	NNW
		SHELLFISH		
13	DUX-BAY	Duxbury-Bay Control	7.8 mi	NNW
23	PP	Powder Point Control	8.0 mi	NNW
24	GH	Green Harbor Control	9.9 mi	NNW
		IRISH MOSS		
34	BK	Brant Rock Control	10 mi	NNW
		AMERICAN LOBSTER		
89	DUX-B	Duxbury Beach Control	5.8 mi	NNW
13	Dux-Bay	Duxbury Bay Control	7.1 mi	NNW
		FISHES		
30	JR	Jones River Control	7.8 mi	WNW
98	CC-Bay	Cape Cod Bay Control	15 mi	ESE
96	NR	N. River Hanover Control	15 mi	NNW
28	CA	Cataumet Control	20 mi	SSW
99	PT	Provincetown Control	20 mi	NE
90	BB	Buzzards Bay Control	25 mi	SSW
29	PC	Priest Cove Control	30 mi	SW
97	NS	Nantucket Sound Control	30 mi	SSE
94	AO	Atlantic Ocean Control	30 mi	E
92	MV	Vineyard Sound Control	40 mi	SSW

No.	Code	Description	Dist.*	Dir.*
		TLD		
B50	KS	Kingston Subst	10 mi	WNW
BA5	LR	Landing Road	10 mi	NNW
B38	CS	Cedarville Sub	10 mi	S
BA1	CW	Church & West	10 mi	NW
BA2	MM	Main & Meadow	11 mi	WSW
B95	DMF	Div. Mar. Fish	14 mi	SSE
B52	EW	East Weymouth Sub	24 mi	NW
		MILK		
21	WF	Witman Farm Control	20 mi	WNW
		CRANBERRIES		
23	PS	Pine St. Bog Control	16 mi	WNW
		VEGETABLES		
27	BF	Bridgewater Farm Control	20 mi	W
21	WF	Whitman Farm Control	20 mi	WNW
		FORAGE		
21	WF	Whitman Farm Control	20 mi	WNW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.1-5 (cont.)



The frequency, type, minimum number of samples and maximum lower limits of detection (LLD) for the analytical measurements are specified in the PNPS Technical Specifications (see Appendix C, Table 8.1-1 and Table 8.1-4).

Upon receipt of the analysis results from Yankee Atomic Electric Co., the Boston Edison staff reviews the results. Reporting levels for radioactivity concentrations in environmental samples are specified in the PNPS Technical Specifications (see Appendix C, Table 7.1-1). If the radioactivity concentrations are above the reporting levels, the NRC must be notified within 30 days. For radioactivity which is detected that is attributable to Pilgrim Station operation, calculations are performed to determine the cumulative dose contribution for the current year. Depending upon the circumstances, a special study may also be completed (see Appendix A for the 1988 special studies). Most importantly, if radioactivity levels in the environment become elevated as a result of the station operation, an investigation is performed and corrective actions are recommended to reduce the amount of radioactivity to as far below the legal limits as is reasonably achievable.

The radiological environmental sampling locations are reviewed annually, and modified if necessary. A garden and milk animal census is performed every year to identify changes in the use of the environment in the vicinity of the station to permit modification of the monitoring and sampling locations. The results of the 1988 Garden and Milk Animal Census are reported in Appendix D. Two discrepancies were identified during the course of the 1988 census. These are described in Appendix E in accordance with Section 7.1.A of PNPS Technical Specifications.

The accuracy of the data obtained through Boston Edison Company's Radiological Environmental Monitoring Program is ensured through a comprehensive Quality Assurance (QA) program. BECo's QA program has been established to ensure confidence in the measurements and results of the radiological monitoring program through:

- Regular audits of the sampling and monitoring program
- An annual audit of the analytical laboratory by the sponsor companies
- Participation in the United States Environmental Protection Agency cross-check program
- Use of blind duplicates for comparing separate analyses of the same sample

- Spiked sample analyses by the analytical laboratory
- Boston Edison Company's TLD QA Program and YAEL's TLD QA Program

QA audits and inspections of the Radiological Environmental Monitoring Program are performed by the US NRC, American Nuclear Insurers and by Boston Edison Company's Quality Assurance Department.

The blind duplicates, split samples, and spiked samples are analyzed by Boston Edison Company, Yankee Atomic Electric Company's Environmental Laboratory, and four other sponsor companies. The 1988 results of this QA program are summarized in Appendix F. These results indicate that the analyses and measurements which were performed during 1988 exhibited acceptable precision and accuracy.

2.2 RESULTS OF RADIOMETRIC ANALYSES AND MEASUREMENTS

The following pages summarize the analytical results of the environmental samples which were collected during 1988. All samples were collected and measurements were performed as required by PNPS Technical Specifications (see Appendix C, Table 8.1-1) with the exception of those sampling deficiencies noted in the following environmental media sections. As of December 15, 1988, all enviromental monitoring surveillances are tracked by the PNPS computerized Master Surveillance Tracking Program (MSTP). Following implementation of the MSTP, it was noted that some past samples had been collected on a calendar basis rather than being collected in accordance with the strict definition of the surveillance frequency specified in PNPS Technical Specifications. A description of this event and corrective actions taken are documented in Appendix E.

Data for each environmental medium are included in a separate section. A discussion of the sampling program and results is followed by a table which summarizes the year's data for each type of medium. The tables were generated by the Yankee Atomic Electric Company's ERMAP computer program. The unit of measurement for each medium is listed at the top of each table. The left hand column contains the radionuclides which are being reported, total number of analyses of that radionuclide, and the number of measurements which exceed ten times the yearly average for the control station(s). The latter are classified as "non-routine" measurements. The next column lists the Lower Limit of Detection (LLD) for those radionuclides which have detection capability requirements as specified in the PNPS Technical Specifications (see Appendix C, Table 8.1-4).

Those sampling stations which are within the range of influence of Pilgrim Station and which could conceivably be affected by its operation are called "indicator" stations. Distant stations, which are beyond plant influence, are called "control" stations. Direct radiation monitoring stations are broken down into four geographical zones to aid in data analysis.

For each sampling medium, each radionuclide is presented with a set of statistical parameters. This set of statistical parameters includes separate analyses for (1) indicator stations, (2) the station having the highest annual mean, and (3) control stations. For each of these three groups of data, the Yankee Atomic Electric Company's "ERMAP" computer program calculates:

- The mean value of all concentrations including negative values and values below LLD.
- The standard error of the mean.
- The lowest and highest concentrations.
- The number of positive measurements (activity which is three times greater than the standard deviation) divided by the total number of measurements.

Each single radioactivity measurement datum is based on a single measurement and is reported as a concentration plus or minus one standard deviation. The quoted uncertainty represents only the random uncertainty associated with the measurement of radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the sampling and analysis process. Radioactivity is considered to be present in a sample when the concentration exceeds three times its associated standard deviation.

2.2.1 Air Particulate Filters

A type A/E glass fiber particulate filter, a charcoal cartridge and an air sampling vacuum pump were used to collect radioactive airborne particulates. The eleven locations sampled during 1988 are listed in Table 2.1-1. Analyses of the air particulate filters for gross beta radiation are performed weekly. In addition, quarterly composites of the particulate samples for each sampling location were analyzed for gamma-emitting nuclides.

There were a total of 6 air particulate filters out of the required 572 which were not collected and analyzed during 1988. The air samples at station 09 - East Breakwater were missed on week 5 (1/19 - 1/26), week 6 (1/26 - 2/2), and week 7 (2/2 - 2/9) and again on week 32 (7/25 - 8/1), week 33 (8/1 - 8/10), and week 34 (8/10 - 8/16) due to a loss of power. The loss of power was caused by a faulty electrical splice which was repaired in August 1988.

During 1988, there were several instances of low sample volume due to power failures, pump failures and crimped sampling lines, yet despite this, all particulate filter analyses met the maximum LLD during 1988. However, the analysis results for station 00-Warehouse for week 17 (2/2 - 2/9) and station 08 - Overlook Area for week 18 (4/19 - 4/26) were disregarded. The validity of these results was questionable because of physical damage of the inlet lines which resulted in some air bypassing the filter. The cracked intake nozzle at the Warehouse station and leaking hose on the Overlook Area station were replaced.

The summary of the radioactivity analysis results for air particulates for 1988 is presented in Table 2.2.1-1. The station identification numbers correspond to the locations identified in Table 2.1-1. Naturally occurring potassium-40 was observed at one indicator station. Naturally occurring beryllium-7 was observed in all indicator and control station air particulate filters. No radioactive isotopes which could be attributable to Pilgrim Station operation were detected on quarterly composite air samples.

Trend plots of the gross beta activity vs. time for the on-site, property boundary, and offsite stations are provided in Figure 2.2.1-1, Figure 2.2.1-2, and Figure 2.2.1-3, respectively. These graphs indicate that on-site gross beta concentrations were no different than weekly gross beta concentrations at the distant control station, with the exception of the air sample results for the Pedestrian Bridge station for week 9 in February. An isotopic analysis on this filter indicated that no radioactivity was present that could be attributable to Pilgrim Station operation.

Therefore, analysis of air particulate samples collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.1-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results for Air Particulate Filters - 1988

MEDIUM: AIR PARTICULATE

UNITS: PCI/CU. M

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
GR-B (564)	.01	(2.1 ± 0.0)E -2	21	(2.2 ± 0.1)E -2	(2.2 ± 0.1)E -2
(0)		(4.5 - 81.9)E -3		(6.0 - 47.1)E -3	(6.0 - 47.1)E -3
		(510/512)		*(52/ 52)*	*(52/ 52)*
BE-7 (44)		(4.6 ± 0.1)E -2	15	(5.4 ± 0.6)E -2	(4.5 ± 0.4)E -2
(0)		(2.8 - 6.4)E -2		(4.3 - 6.4)E -2	(3.8 - 5.4)E -2
		(40/ 40)		*(4/ 4)*	*(4/ 4)*
K-40 (44)		(4.5 ± 1.0)E -3	00	(8.9 ± 3.0)E -3	(5.4 ± 2.6)E -3
(0)		(-9.7 - 16.4)E -3		(3.5 - 142.0)E -4	(-3.8 - 123.0)E -4
		(1/ 40)		*(0/ 4)*	*(0/ 4)*
MN-54 (44)		(4.3 ± 5.7)E -5	10	(2.3 ± 0.6)E -4	(5.5 ± 8.2)E -5
(0)		(-9.6 - 9.4)E -4		(1.2 - 3.9)E -4	(-1.2 - 2.7)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CO-58 (44)		(-2.6 ± 7.2)E -5	06	(3.2 ± 3.0)E -4	(1.3 ± 0.6)E -4
(0)		(-1.2 - 1.2)E -3		(-7.2 - 122.0)E -5	(2.7 - 25.7)E -5
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
FE-59 (44)		(-2.2 ± 1.4)E -4	08	(6.2 ± 2.2)E -4	(-2.7 ± 47.9)E -5
(0)		(-2.3 - 1.5)E -3		(2.5 - 12.4)E -4	(-7.9 - 13.7)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CO-60 (44)		(5.2 ± 74.1)E -6	01	(4.7 ± 3.6)E -4	(1.8 ± 0.5)E -4
(0)		(-1.3 - 1.4)E -3		(-3.5 - 13.9)E -4	(5.2 - 27.8)E -5
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
ZN-65 (44)		(6.5 ± 14.4)E -5	21	(1.6 ± 0.4)E -3	(1.6 ± 0.4)E -3
(0)		(-2.5 - 2.0)E -3		(8.2 - 22.5)E -4	(8.2 - 22.5)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
ZR-95 (44)		(-1.4 ± 1.2)E -4	06	(5.8 ± 5.6)E -4	(-4.3 ± 2.9)E -4
(0)		(-2.2 - 2.2)E -3		(-3.6 - 21.9)E -4	(-1.1 - 0.3)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.1-1 (Continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Air Particulate Filters - 1988

MEDIUM: AIR PARTICULATE

UNITS: PCI/CU. M

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-103 (44)		(-1.1 ± 0.9)E -4	01	(4.9 ± 1.6)E -4	(-4.5 ± 22.2)E -5
(0)		(-1.6 - 0.9)E -3		(8.9 - 85.3)E -5	(-4.1 - 5.4)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
RU-106 (44)		(-3.5 ± 4.6)E -4	21	(2.4 ± 0.8)E -3	(2.4 ± 0.8)E -3
(0)		(-8.7 - 7.3)E -3		(5.4 - 44.2)E -4	(5.4 - 44.2)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CS-134 (44)	.01	(-1.5 ± 0.7)E -4	03	(1.3 ± 14.7)E -5	(-1.0 ± 2.7)E -4
(0)		(-1.5 - 0.6)E -3		(-2.9 - 4.0)E -4	(-7.6 - 4.4)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CS-137 (44)	.01	(2.5 ± 48.4)E -6	21	(2.5 ± 0.5)E -4	(2.5 ± 0.5)E -4
(0)		(-8.8 - 6.5)E -4		(9.7 - 34.8)E -5	(9.7 - 34.8)E -5
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
BA-140 (44)		(-5.8 ± 3.6)E -4	03	(1.5 ± 0.8)E -3	(-2.8 ± 17.9)E -4
(0)		(-9.1 - 4.6)E -3		(3.4 - 39.5)E -4	(-5.1 - 3.6)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CE-141 (44)		(5.1 ± 10.4)E -5	01	(3.7 ± 5.0)E -4	(5.4 ± 60.8)E -5
(0)		(-1.1 - 2.0)E -3		(-6.1 - 17.6)E -4	(-1.3 - 1.6)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CE-144 (44)		(-3.2 ± 3.5)E -4	07	(2.0 ± 1.2)E -3	(9.2 ± 73.7)E -5
(0)		(-6.2 - 5.3)E -3		(-5.7 - 52.6)E -4	(-1.1 - 2.0)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
TH-232 (44)		(6.0 ± 2.5)E -4	07	(2.0 ± 1.0)E -3	(4.3 ± 9.1)E -4
(0)		(-2.3 - 4.9)E -3		(5.1 - 453.0)E -5	(-1.7 - 2.7)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Figure 2.2.1-1
Pilgrim Nuclear Power Station

Radioactivity Measurements of Air Sample Filters
Taken On-site Locations and Distant Location - 1988

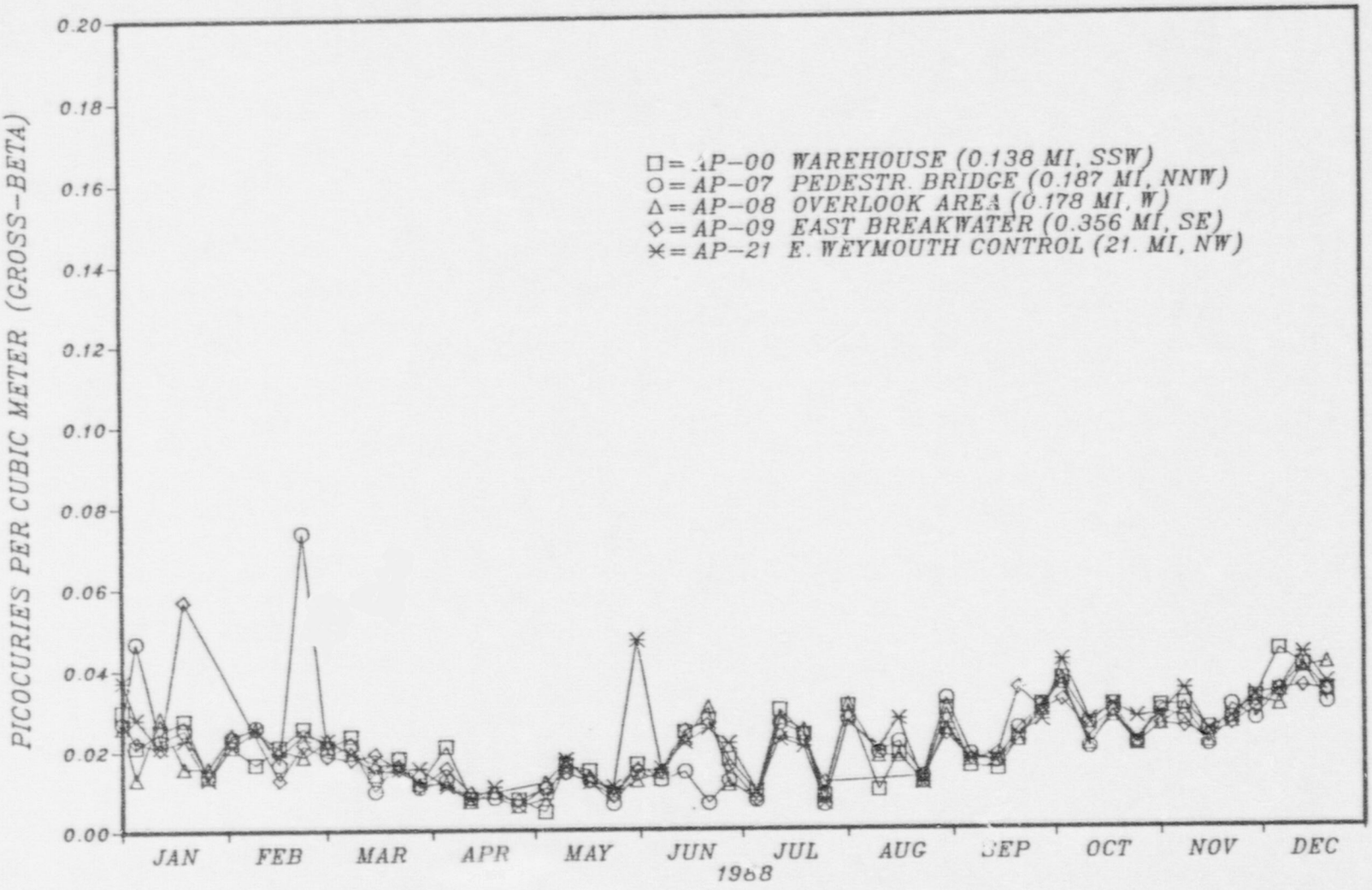


Figure 2.2.1-2
Pilgrim Nuclear Power Station

Radioactivity Measurements of Air Sample Filters
Taken at Property Boundary Locations and Distant Location - 1988

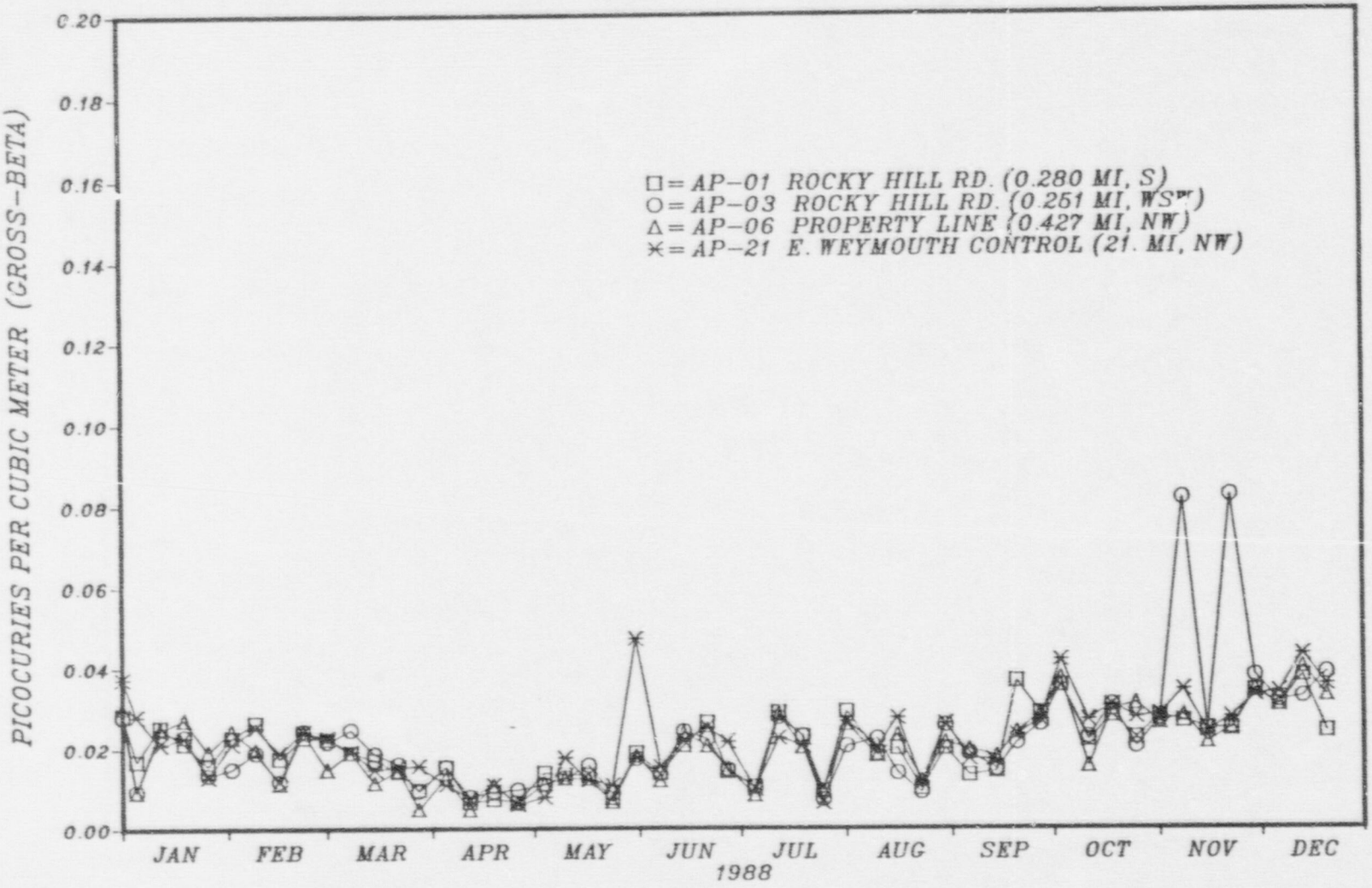
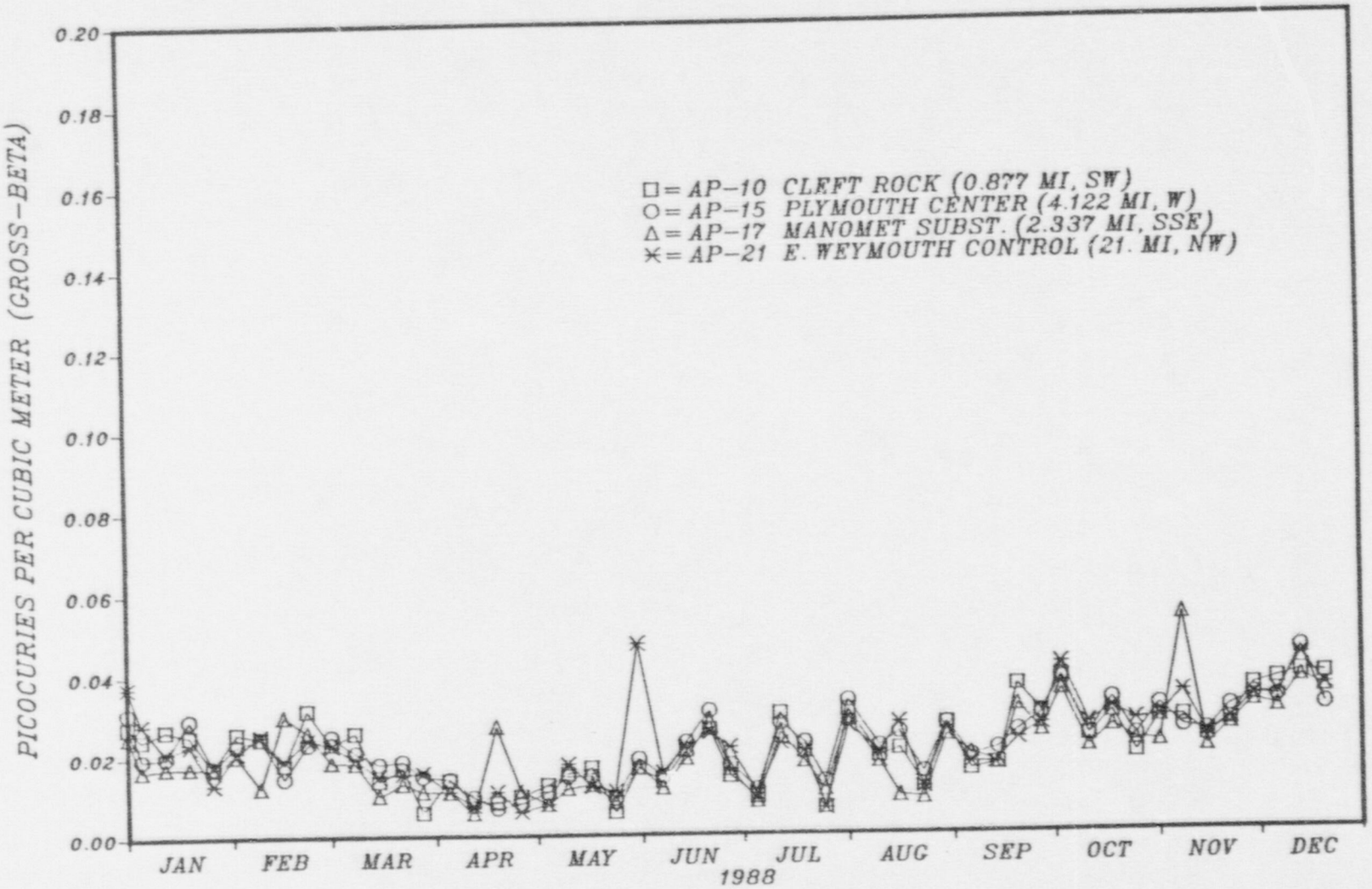


Figure 2.2.1-3
Pilgrim Nuclear Power Staion

Radioactivity Measurements of Air Sample Filters
Taken at Off-site Locations and Distant Location - 1988



2.2.2 Charcoal Cartridges

The same sample collection systems which were used to collect airborne particulates were also used to collect gaseous iodine on charcoal cartridges. The Nucon Level A charcoal cartridges were analyzed weekly for gaseous iodine-131. The eleven locations sampled during 1988 are indicated on Table 2.1-1.

There were a total of 6 charcoal cartridges out of the required 572 which were not collected and analyzed during 1988. The iodine air samples at station 09 - East Breakwater were missed on week 5 (1/19 - 1/26), week 6 (1/26 - 2/2), and week 7 (2/2 - 2/9) and again on week 32 (7/25 - 8/1), week 33 (8/1 - 8/10), and week 34 (8/10 - 8/16) due to a loss of power. The loss of power was caused by a faulty electrical splice which was repaired in August 1988.

The maximum value for the LLD for iodine-131 was achieved for all charcoal cartridges analyzed during 1988. However, as indicated previously the analysis results for station 00-Warehouse for week 17 (2/2 - 2/9) and station 08 - Overlook Area for week 18 (4/19 - 4/26) were disregarded. The validity of these results was questionable because of physical damage of the inlet lines which resulted in some air bypassing the cartridge. The cracked intake nozzle at the Warehouse station and leaking hose on the Overlook Area station were replaced.

The summary of the radioactivity analysis results for charcoal cartridges collected during 1988 is provided in Table 2.2.2-1. The results indicate that the mean value of the gaseous iodine-131 concentrations for the indicator stations is statistically no different than the mean value for the distant control station; that is, none of the results showed a positive measurement of iodine-131.

The graphical trends of gaseous iodine-131 measurements on charcoal cartridges for the on-site, property boundary and off-site stations are shown in Figures 2.2.2-1, 2.2.2-2, and 2.2.2-3, respectively. These graphs indicate that the weekly iodine-131 concentrations measured at on-site, property boundary, and off-site indicator stations were no different than the weekly iodine-131 concentrations at the distant control station. It should be noted that iodine-131 was not detected on any of the charcoal cartridges collected during 1988.

Therefore, analysis of charcoal cartridges collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.2-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results for Charcoal Cartridges - 1988

MEDIUM: CHARCOAL CARTRIDGE UNITS: PCI/CU. M

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
I-131 (566)	.07	(1.1 ± 0.4)E -3	07	(2.7 ± 1.4)E -3	(2.1 ± 1.7)E -3
(0)		(-3.7 - 3.4)E -2		(-2.3 - 2.4)E -2	(-2.9 - 3.5)E -2
		(0/514)		*(0/ 52)*	*(0/ 52)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Figure 2.2.2-1
Pilgrim Nuclear Power Station

Radioactivity Measurements of Charcoal Cartridge Samples
Taken at On-site Locations and Distant Location - 1988

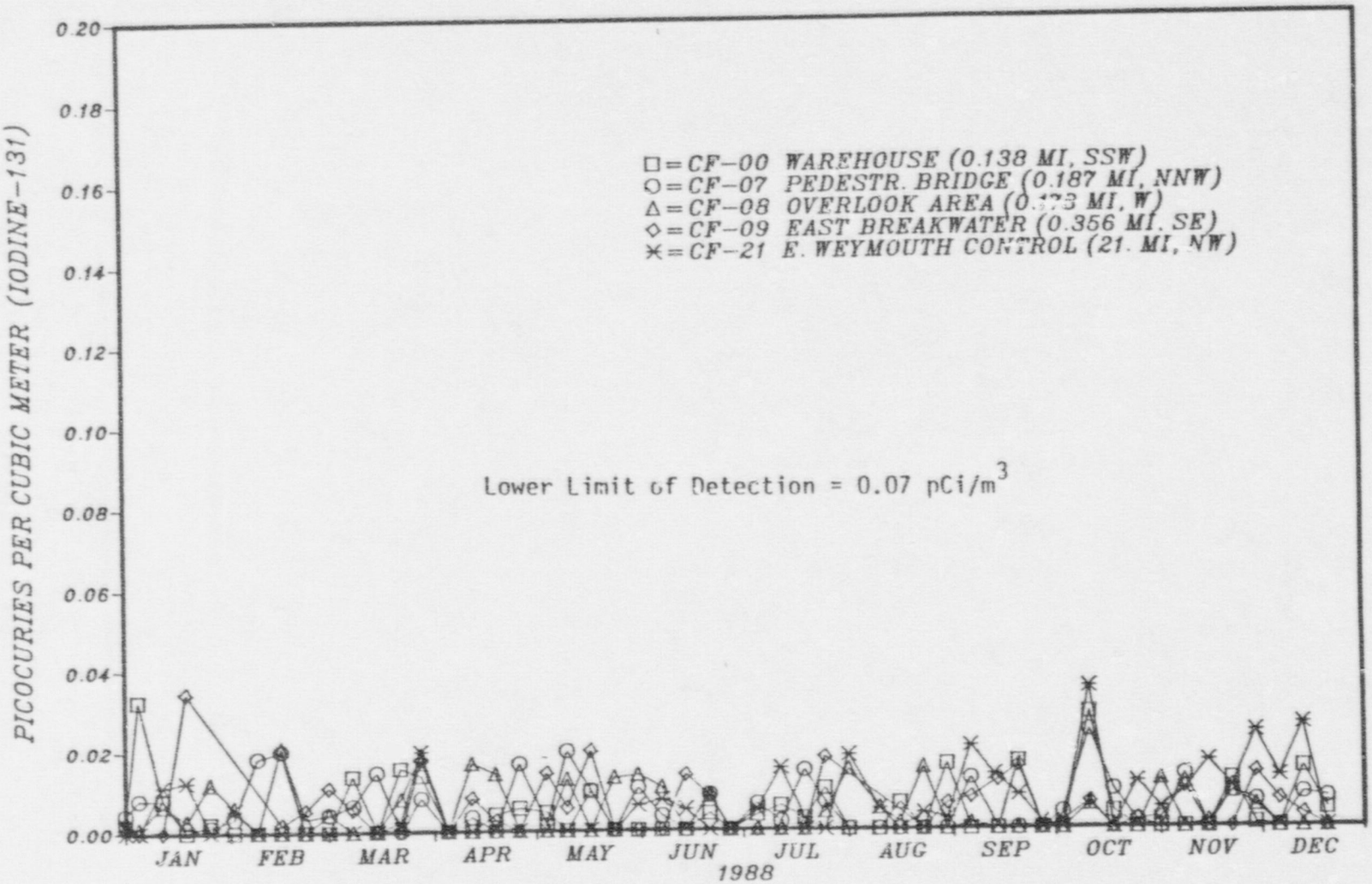


Figure 2.2.2-2
Pilgrim Nuclear Power Station

Radioactivity Measurements of Charcoal Cartridge Samples
Taken at Property Boundary Locations and Distant Location - 1988

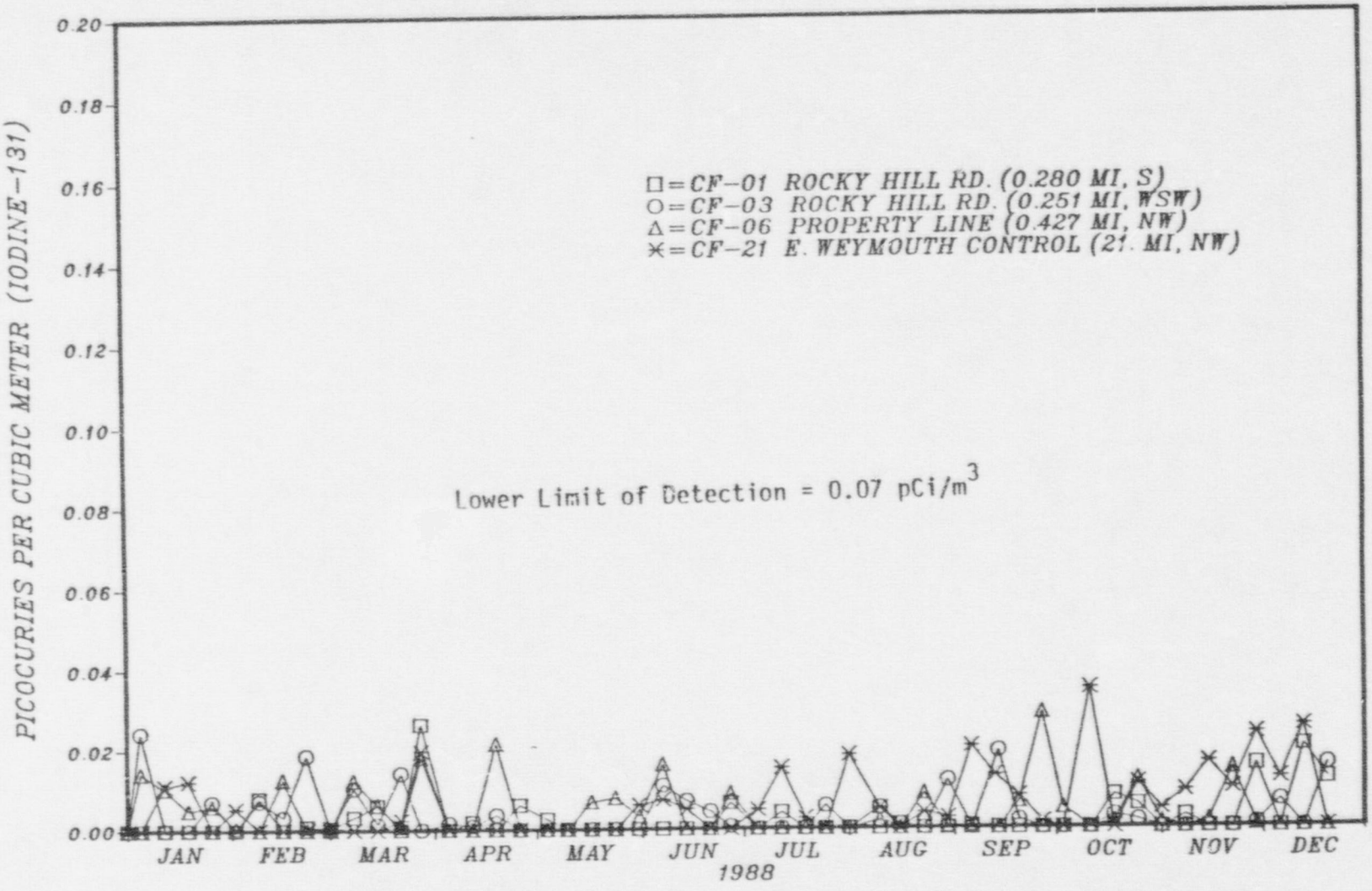
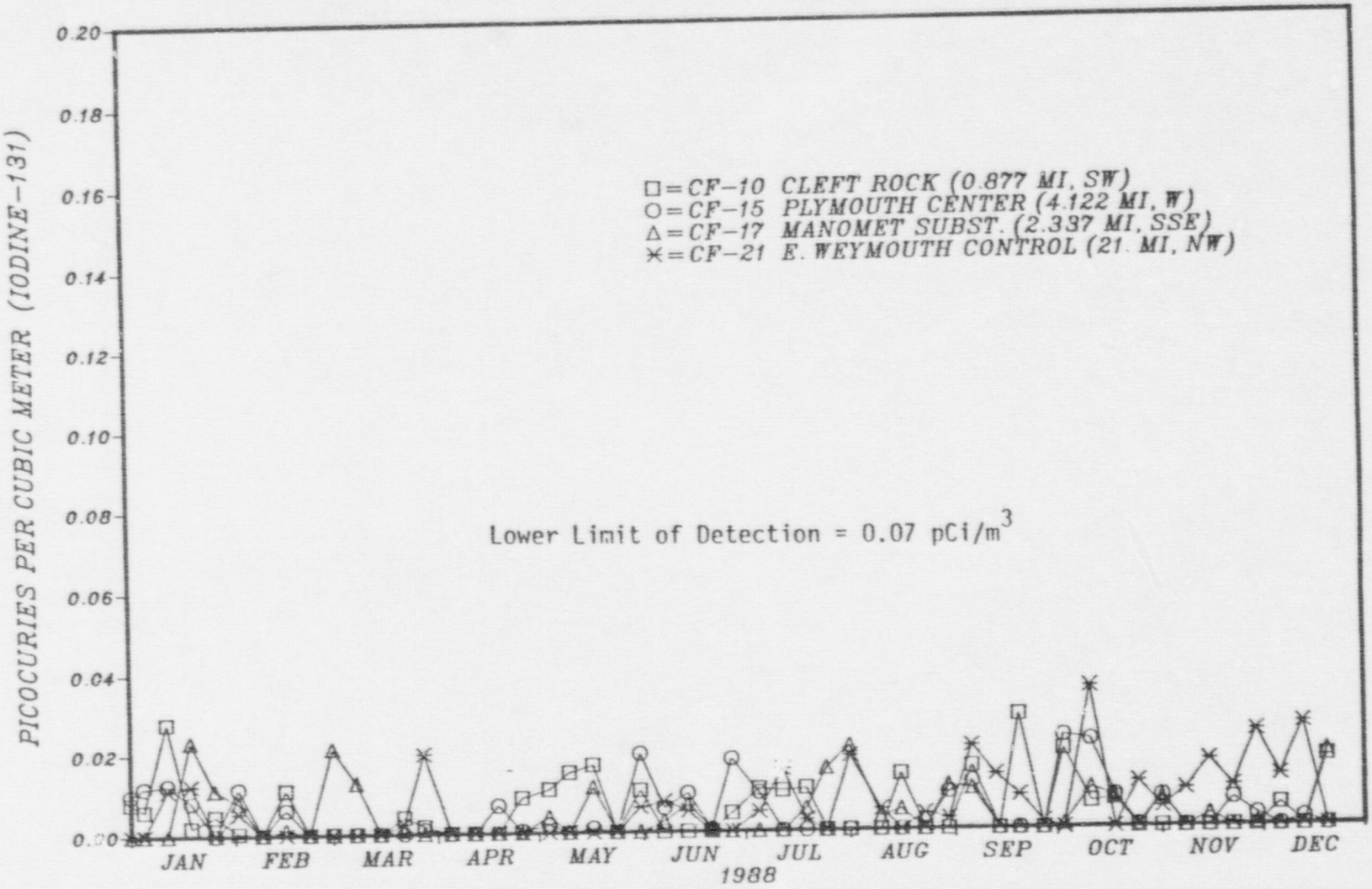


Figure 2.2.2-3
Pilgrim Nuclear Power Station

Radioactivity Measurements of Charcoal Cartridge Samples
Taken at Off-site Locations and Distant Location - 1988



2.2.3 Soil

Soil surveys are routinely performed at eleven locations (see Table 2.1-1) once every three years. These routine surveys were performed in 1988 during the months of April and May. In addition to the normal survey locations, surveys were conducted at 12 other locations around Pilgrim Nuclear Power Station during April, May and June of 1988. These surveys included collection of topsoil and soil core samples for gamma spectrum analysis and in situ measurements with a germanium detector and a pressurized ion chamber. Results of these surveys are presented in Appendix G of this report.

In addition to naturally-occurring levels of potassium-40, thorium-232, and uranium-238, detectable levels of cobalt-60 and cesium-137 were also observed. Cesuim-137 was detected at 20 locations at levels consistent with fallout from past nuclear weapons testing. At three locations, the elevated levels of cesium-137 were similar to those attributed to wind blown dust, which was documented in the 1987 Radiological Environmental Monitoring Program Report No. 20, issued in May 1988. Cobalt-60 was detected at five of the normal survey locations and two of the additional locations, all of which were located on Boston Edison property. These levels were also consistent with the cobalt-60 levels attributed to the wind blown dust. Cesium-134 was detected at one of the additional survey locations. The absence of any detectable levels of cobalt-60 or cesium-137 activity in airborne particulate samples collected at the eleven normal survey locations indicates that deposition of these nuclides in windblown dust did not occur during 1988. The activity observed during the 1988 soil surveys was likely due to residual activity remaining from the pre-1988 deposition that led to the observations documented in the 1987 REMP Report.

Cesium-137 activities measured at the location which yielded the detectable cesium-134 were similar to normal fallout levels and did not indicate any elevation in cesium-137 or other radionuclides which would be attributable to emissions from Pilgrim Station. The cesium-134 concentrations observed in the single topsoil sample was 1/3 of that observed in vegetation collected from Plymouth County Farm during 1986 as a result of the accident at the Chernobyl Reactor during that year. The small level of activity observed is likely residual activity remaining from the Chernobyl accident.

Based on the positive survey results for cobalt-60, cesium-134, and cesium-137, the maximum dose to a hypothetical individual was calculated assuming the highest concentrations of each of the radionuclides that were observed at off-site locations during 1988 surveys. This calculation is presented in Part IV of Appendix A. The conservative assumptions used in the calculations yielded a maximum total body dose of 3.9 mrem/yr, which is a small percentage of the annual dose normally received from natural and man-made radiation.

Therefore, evaluation of soil survey data collected during 1988 showed no evidence of any significant radiological impact due to Pilgrim Station operations.

2.2.4. Direct Radiation Exposure

Exposure rates from external radiation sources were measured quarterly at about 103 locations (only 40 required by PNPS Technical Specifications) in the vicinity of Pilgrim Station (and at distant locations) using thermoluminescent dosimeters (TLDs), and annually at six nearby beach locations using a high pressure ion chamber system. Indicator TLDs were placed in the vicinity of Pilgrim Station as shown in Figures 2.1-1 through 2.1-3. Control TLDs were placed in locations so as to be outside the influence of Pilgrim Station and are shown in Figure 2.1-5.

Only one (1) out of the forty TLD measurements required by Technical Specifications each quarter were missed during the year of 1988. The TLD measurement that was missed is noted in Table 2.2.4-1. The TLD located at College Pond was found missing from it's posted location during the first quarterly retrieval. The missing TLD and cage was relocated to be inconspicuous and less accessible.

2.2.4.1 Environmental Thermoluminescent Dosimeters

A new thermoluminescent dosimeter program (Panasonic UD-801AS1 and UD-814AS1 combination) was implemented in 1987. Thermoluminescence is a process in which ionizing radiation, upon interacting with the sensitive material of the TLD (the phospor or 'element'), causes some of the energy deposited in the phosphor to be stored in stable electron 'traps' in the TLD material. These TLD traps are so stable that the energy that is deposited does not change appreciably over the course of months or even years. This provides an excellent method of determining the amount of radiation exposure received over a period of time. The energy stored in the TLDs as a result of interactions with radiation is removed and measured by a controlled heating process in a calibrated light reading system. As the TLD is heated, the phosphor releases the stored energy as light. The amount of light given off is directly proportional to the radiation exposure the TLD received. The reading process 're-zeros' the TLD and prepares it for re-use. The TLDs in use for environmental monitoring at Pilgrim Station are provided and processed by Yankee Atomic Electric Co. These highly sensitive TLDs are capable of accurately measuring exposures between 1 mR (well below normal environmental levels for the quarterly monitoring periods) and 200,000 mR.

Table 2.2.4.1-1 shows quarterly average exposure rates and annual exposure from direct gamma radiation at the TLD stations. The off-site exposure rates ranged from approximately 5 micro-R/hr to 9 micro-R/hr whereas the annual exposures ranged from about 50 mR to 80 mR. It should be noted that station No. B81-Memorial Hall had an annual exposure of 99.5 mR. This station was not within the expected exposure range because of the location of this TLD near stone building material. As noted previously, Pilgrim Station was not operating for essentially the entire year.

In addition to average exposures for each TLD for each quarterly period, average exposures were calculated for four geographic zones. Figure 2.2.4.1-1 shows environmental radiation levels that are consistent with past trends.

2.2.4.2 Beach Surveys

Sensitive radiation detection surveys using a high pressure ion chamber were performed at Plymouth Beach, White Horse Beach and Duxbury Beach during October of 1988.[20] These measurements were performed by personnel from Yankee Atomic Electric Company's Radiological Engineering Group.

The purpose of this survey is to detect differences in the external exposure rate encountered at beaches near the plant (Plymouth and White Horse) and at a control location (Duxbury). The detector's calibration was checked before each measurement. The data in Table 2.2.4.2-1 indicate that the exposure rates at Plymouth Beach and White Horse Beach are not significantly different from the exposure rates measured at the distant control station in Duxbury. As noted previously Pilgrim Station was not operating for essentially the entire year.

This survey indicates that the natural background exposure rate at beaches near Pilgrim Station is 6-9 uR/hr. These results are in close agreement with similar measurements performed in Maine[21], where the natural background exposure rate at shoreline locations was found to vary between 6.6 and 14.5 uR/hr. These exposure rates were also found to vary directly with the size and proximity of granite outcroppings.

Granite beach stones and gravel are present at three locations. It has been demonstrated that proximity to beach stones results in higher exposure rates than in sandy areas (see Annual Report No. 10).

The results of this most recent survey are in agreement with the previous beach surveys conducted annually from 1977 through 1987. The graphical trend of the radiation levels at these beaches in Figure 2.2.4.2-1 shows very little change in the exposure rate over this twelve year period.

2.2.4.3 Summary

The direct radiation (TLD) measurements and beach survey results for 1988 are within the range of natural background exposure rates in the northeastern part of the United States. Therefore, analysis of direct radiation data collected during 1988 showed no evidence of any significant radiological impact on the environment or on the general public due to Pilgrim Station.

Table 2.2.4.1-1
Pilgrim Nuclear Power Station

Environmental Thermoluminescent Dosimeter Results - 1988

TLD STATION			LOCATION*		QUARTERLY EXPOSURE RATE AT TLD LOCATION - mR/quarter (VALUE ± STD.DEV.)				ANNUAL AVERAGE** EXPOSURE RATE
NO.	CODE	DESCRIPTION	DIST.	DIR.	FIRST	SECOND	THIRD	FOURTH	mR/yr
B01	WS	WAREHOUSE	600 ft.	SSE	14.5 ± 0.5	14.2 ± 0.9	14.0 ± 0.7	15.0 ± 1.0	57.7
B02	I	STATION I	0.30 mi.	WNW	15.6 ± 0.6	16.0 ± 0.8	17.5 ± 0.8	18.0 ± 1.3	67.1
B03	PL	PROPERTY LINE	0.32 mi.	NW	17.3 ± 0.9	17.2 ± 1.1	17.5 ± 0.6	18.4 ± 1.3	70.3
B04	F	STATION F	0.27 mi.	NW	17.1 ± 0.7	17.6 ± 1.2	16.9 ± 0.5	18.3 ± 1.3	70.1
B05	D	STATION D	0.32 mi.	NNW	21.1 ± 0.7	22.1 ± 1.2	22.4 ± 0.8	23.0 ± 1.4	88.6
B06	PA	PARKING AREA	0.23 mi.	NNW	17.2 ± 0.7	18.0 ± 1.1	17.9 ± 0.7	18.5 ± 1.2	71.6
B07	PB	PEDESTRIAN BRID	0.13 mi.	NNW	29.4 ± 0.8	30.6 ± 1.8	27.6 ± 0.8	28.2 ± 1.5	115.9
B08	PMT	PLYMOUTH MET TR	0.27 mi.	WNW	14.5 ± 0.6	15.5 ± 1.0	15.8 ± 0.8	15.6 ± 1.0	61.4
B09	OA	OVERLOOK AREA	0.09 mi.	W	18.0 ± 0.8	18.7 ± 1.2	19.4 ± 0.8	18.2 ± 0.9	74.3
B10	A	STATION A	0.25 mi.	WSW	15.4 ± 0.6	16.3 ± 0.9	16.1 ± 0.7	17.7 ± 1.0	65.5
B11	G	STATION G	0.32 mi.	W	16.1 ± 0.6	17.0 ± 1.0	17.3 ± 0.8	16.5 ± 0.9	66.8
B12	WR	W ROCKY HILL RD	0.45 mi.	WNW	20.2 ± 0.6	20.0 ± 1.0	21.2 ± 0.8	21.5 ± 1.2	82.9
B13	BD	BAYSHORE DR	0.81 mi.	WNW	17.4 ± 0.5	18.0 ± 0.9	18.0 ± 1.1	19.5 ± 2.0	72.9
B14	BS	BAYSHORE	1.3 mi.	W	18.5 ± 0.7	18.5 ± 1.0	18.1 ± 0.7	19.9 ± 1.8	75.1
B15	RC	REC.POOL	1.3 mi.	WSW	Missing	16.6 ± 0.9	16.5 ± 0.6	17.0 ± 1.0	66.9
B16	DR	DIRTROAD	0.94 mi.	SW	15.1 ± 0.6	15.1 ± 1.0	15.5 ± 0.4	15.7 ± 0.9	61.4
B17	MT	MICRO TOWER	0.58 mi.	SSW	17.1 ± 0.8	17.6 ± 1.0	17.7 ± 0.7	17.6 ± 1.1	70.8
B18	CR	CLEFT ROCK	0.86 mi.	S	16.1 ± 0.7	16.1 ± 1.0	16.8 ± 1.0	16.2 ± 0.8	65.2
B19	MR	MAHONET ROAD	0.98 mi.	S	16.0 ± 0.7	16.3 ± 1.1	16.3 ± 0.5	17.3 ± 2.0	65.9
B20	E	STATION E	1.2 mi.	S	15.4 ± 0.7	16.0 ± 0.8	15.8 ± 0.8	17.7 ± 2.3	64.9
B21	J	STATION J	1.3 mi.	S	15.4 ± 0.6	15.4 ± 0.9	15.7 ± 1.2	15.8 ± 0.9	62.2
B22	K	STATION K	1.4 mi.	SSE	14.2 ± 0.7	15.5 ± 1.0	14.8 ± 0.7	15.4 ± 0.9	59.8
B23	AR	ACCESS ROAD	0.92 mi.	S	15.2 ± 0.5	15.4 ± 1.0	15.3 ± 0.6	16.1 ± 0.8	62.0
B24	B	STATION B	0.25 mi.	S	17.5 ± 1.0	18.5 ± 1.1	18.3 ± 0.8	18.5 ± 1.3	72.7
B25	H	STATION H	0.57 mi.	SW	18.7 ± 0.9	19.6 ± 1.4	19.6 ± 0.8	19.3 ± 1.3	77.2
B26	EB	EAST BREAKWATER	0.34 mi.	ESE	18.4 ± 0.8	18.8 ± 1.0	18.9 ± 0.7	17.6 ± 1.3	73.6
B27	L	STATION L	0.27 mi.	ESE	16.1 ± 0.9	16.6 ± 1.1	16.4 ± 0.8	16.2 ± 0.9	65.3
B28	C	STATION C	0.32 mi.	ESE	16.2 ± 0.8	16.7 ± 1.1	17.0 ± 0.7	16.5 ± 0.8	66.3
B29	HB	HALLS BOG	0.38 mi.	SE	17.2 ± 0.7	16.9 ± 1.2	17.3 ± 0.6	16.4 ± 0.9	67.9
B30	ER	E ROCKY HILL RD	0.65 mi.	SE	15.0 ± 0.8	15.5 ± 1.0	15.8 ± 0.8	15.3 ± 0.8	61.6
B31	EM	EMERSON RD	1.1 mi.	SSE	15.8 ± 0.8	15.8 ± 0.9	16.1 ± 0.6	17.3 ± 1.5	65.0
B32	WH	WHITE HORSE RD	1.3 mi.	SSE	15.4 ± 0.6	15.8 ± 1.3	15.9 ± 0.9	16.2 ± 1.4	63.4
B33	MS	MAHONET SUBST	2.3 mi.	SSE	18.7 ± 1.0	19.0 ± 1.1	19.7 ± 0.7	20.8 ± 1.2	78.3
B34	ME	MAHONET ELEM	2.1 mi.	SE	14.2 ± 0.5	14.2 ± 0.8	14.5 ± 0.7	14.5 ± 0.8	57.4
B35	MP	MAHONET PT	2.3 mi.	SE	15.7 ± 0.6	16.0 ± 0.9	15.9 ± 0.7	17.0 ± 1.0	64.6

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

** Annual average value is based on arithmetic mean of the observed quarterly values multiplied by 4.0 quarters/year.

Table 2.2.4.1-1 (continued)
Pilgrim Nuclear Power Station

Environmental Thermoluminescent Dosimeter Results - 1988

TLD STATION			LOCATION*	QUARTERLY EXPOSURE RATE AT TLD LOCATION - mR/quarter (VALUE ± STD.DEV.)				ANNUAL AVERAGE** EXPOSURE RATE
NO.	CODE	DESCRIPTION	DIST. DIR.	FIRST	SECOND	THIRD	FOURTH	mR/yr
B36	BW	BEACHWOOD RD	2.5 mi. SE	15.4 ± 0.7	17.3 ± 1.0	16.5 ± 0.5	17.1 ± 1.2	66.3
B37	MB	MANOMET BEACH	3.4 mi. SSE	14.7 ± 0.7	14.7 ± 1.0	15.3 ± 0.5	16.5 ± 1.3	61.2
B38	CS	CEDARVILLE SUB	10 mi. S	16.1 ± 0.7	18.2 ± 1.1	16.8 ± 0.8	16.3 ± 0.8	67.5
B39	CP	COLLEGE POND	4.8 mi. SW	Missing	15.0 ± 0.8	15.9 ± 0.7	16.7 ± 0.9	63.4
B40	SP	S PLYMOUTH SUB	2.8 mi. W	15.4 ± 0.8	16.4 ± 1.0	16.2 ± 0.8	15.8 ± 0.8	63.8
B41	EA	EARL RD	3.0 mi. SSE	13.4 ± 0.6	13.5 ± 0.7	13.4 ± 0.5	13.9 ± 0.8	54.1
B42	BR	BEAVERDAM RD	3.5 mi. S	13.3 ± 0.4	13.6 ± 0.8	13.2 ± 0.6	13.0 ± 0.9	53.1
B43	PT	PINES ESTATE	2.7 mi. SSW	14.2 ± 0.6	14.4 ± 0.9	14.8 ± 0.4	14.2 ± 1.1	57.6
B44	RP	RT. 3 OVERPASS	3.0 mi. SW	15.8 ± 0.9	16.1 ± 1.1	15.9 ± 0.6	16.4 ± 0.9	64.2
B45	RM	RUSSELL MILL RD	3.0 mi. WSW	14.5 ± 0.6	14.6 ± 0.9	14.9 ± 0.6	14.8 ± 0.7	58.8
B46	MD	MILLDALE RD	3.1 mi. W	15.9 ± 0.6	16.3 ± 1.1	16.3 ± 0.6	16.0 ± 0.9	64.5
B47	PC	PLYMOUTH CENTER	4.1 mi. W	12.0 ± 0.5	12.1 ± 0.7	11.5 ± 0.5	15.2 ± 1.5	50.8
B48	SA	SHERMAN AIRPORT	8.4 mi. WSW	14.8 ± 0.9	15.1 ± 0.8	14.8 ± 0.5	14.7 ± 0.9	59.3
B49	NP	NORTH PLYMOUTH	5.8 mi. WNW	18.7 ± 0.6	18.7 ± 1.0	18.0 ± 1.0	17.9 ± 0.9	73.3
B50	KS	KINGSTON SUBST	10 mi. WNW	15.1 ± 0.6	16.5 ± 1.1	15.2 ± 0.6	15.9 ± 1.1	62.7
B51	SS	STANDISH SHORES	6.5 mi. NW	13.8 ± 0.6	17.1 ± 3.7	14.6 ± 0.4	14.2 ± 1.4	59.8
B52	EW	E WEYMOUTH SUB	24 mi. NW	16.6 ± 0.6	17.5 ± 1.1	17.6 ± 0.7	17.0 ± 1.1	68.6
B53	TC	TRAINING CTR	0.10 mi. WSW	13.6 ± 0.6	14.0 ± 0.7	13.2 ± 0.4	13.2 ± 0.7	53.9
B54	GH	GREENWOOD NSE	0.59 mi. SE	16.4 ± 0.8	16.7 ± 1.0	16.7 ± 0.6	16.6 ± 0.9	66.3
B55	P01	SEC N SHORE	0.14 mi. NNW	18.1 ± 0.7	18.2 ± 1.2	21.0 ± 0.8	18.5 ± 0.9	75.8
B56	P02	FENCE SHORE	440 ft. NNW	20.6 ± 0.9	21.4 ± 1.3	20.9 ± 0.7	21.3 ± 1.2	84.2
B57	P03	FEN L SCREENH	330 ft. NW	25.8 ± 1.2	26.4 ± 1.4	26.6 ± 1.8	25.3 ± 1.7	104.1
B58	P04	FEN R SCREENH	220 ft. N	130.7 ± 4.7	119.1 ± 6.5	122.1 ± 4.2	115.1 ± 6.3	487.0
B59	P05	FEN WATER TANK	260 ft. NE	50.7 ± 2.2	46.8 ± 2.2	49.5 ± 1.8	34.3 ± 1.8	181.3
B60	P06	FEN CULVERT	280 ft. ENE	55.3 ± 2.3	42.1 ± 2.5	62.1 ± 4.4	50.0 ± 3.9	209.6
B61	P07	FEN INTAKE	400 ft. E	87.7 ± 3.1	110.9 ± 6.5	114.1 ± 4.6	103.2 ± 6.5	415.9
B62	P08	FEN NEW ADMIN	300 ft. E	60.5 ± 2.9	53.1 ± 2.9	58.8 ± 2.0	67.8 ± 4.1	240.3
B63	P09	FEN TCF SIDE	450 ft. E	110.3 ± 5.3	109.5 ± 6.1	109.6 ± 3.1	97.9 ± 4.7	427.3
B64	P10	FEN INTAKE TCF	740 ft. ESE	29.8 ± 1.1	33.4 ± 0.8	35.3 ± 0.9	38.7 ± 2.3	137.3
B65	P11	GATE NH TO TCF	620 ft. SE	48.2 ± 1.5	39.2 ± 2.3	42.8 ± 4.0	37.9 ± 2.1	168.2
B66	P12	FEN NH CON GATE	660 ft. SSE	20.2 ± 0.8	20.7 ± 1.5	19.6 ± 0.7	20.5 ± 1.2	81.0
B67	P13	FEN CON & RHR	740 ft. S	17.9 ± 0.6	18.2 ± 1.3	18.1 ± 0.8	18.9 ± 1.2	73.2
B68	P14	FEN BUTLER B	750 ft. S	17.5 ± 0.5	17.8 ± 1.2	17.4 ± 1.1	16.7 ± 0.8	69.4
B69	P15	FEN UNIT #9	729 ft. SSW	17.1 ± 0.7	17.0 ± 0.9	16.8 ± 0.7	17.1 ± 1.0	68.0
B70	P16	FEN SWY M GATE	560 ft. SW	19.4 ± 0.7	19.6 ± 1.1	19.8 ± 0.6	19.4 ± 1.4	78.2

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

** Annual average value is based on arithmetic mean of the observed quarterly values multiplied by 4.0 quarters/year.

Table 2.2.4.1-1 (continued)
Pilgrim Nuclear Power Station

Environmental Thermoluminescent Dosimeter Results - 1988

TLD STATION			LOCATION*		QUARTERLY EXPOSURE RATE AT TLD LOCATION - mR/quarter (VALUE ± STD.DEV.)				ANNUAL AVERAGE** EXPOSURE RATE
NO.	CODE	DESCRIPTION	DIST.	DIR.	FIRST	SECOND	THIRD	FOURTH	mR/yr
B71	P17	FEN SNF N GATE	350 ft.	WNW	22.3 ± 1.2	22.5 ± 1.2	23.2 ± 0.7	22.0 ± 1.0	90.0
B72	P18	I&C N ADMIN	290 ft.	S	33.1 ± 1.2	25.4 ± 1.5	18.9 ± 0.6	19.2 ± 1.4	96.6
B73	P19	COMPLIANCE AREA	280 ft.	S	29.5 ± 1.6	23.7 ± 1.2	17.5 ± 0.6	17.3 ± 1.0	88.1
B74	P20	RP WINDOW	220 ft.	SSE	19.8 ± 0.6	18.7 ± 0.9	19.8 ± 0.5	19.1 ± 0.9	77.4
B75	P21	WW ADMIN & PROC	170 ft.	SE	24.3 ± 0.8	23.7 ± 1.8	24.3 ± 1.0	22.9 ± 1.1	95.2
B76	P22	QA/QC CORNER	450 ft.	SE	22.4 ± 0.8	21.7 ± 1.2	21.0 ± 0.9	21.8 ± 1.2	86.1
B77	P23	CMG CORNER	400 ft.	SSE	13.9 ± 0.6	13.8 ± 0.9	13.6 ± 0.8	14.1 ± 0.7	55.3
B78	P24	OLD ADMIN BLDG	190 ft.	W	27.4 ± 1.6	27.5 ± 1.8	27.8 ± 1.7	25.7 ± 1.2	108.5
B79	P25	FIRST AID TRAIL	250 ft.	WNW	17.8 ± 0.7	20.4 ± 1.4	18.8 ± 0.5	18.5 ± 0.9	75.6
B81	MM	MEMORIAL HALL	4.7 mi.	WNW	24.2 ± 0.8	25.3 ± 1.4	25.3 ± 0.9	24.9 ± 1.4	99.6
B82	RW	RIGHT OF WAY	1.7 mi.	S	13.2 ± 0.9	16.3 ± 0.7	14.1 ± 0.6	13.7 ± 1.0	57.3
B83	GB	GOODWIN PROPERT	1.4 mi.	SW	11.4 ± 0.8	12.8 ± 1.2	12.5 ± 0.5	12.0 ± 0.8	48.8
B84	JG	JOHN GAULEY	1.1 mi.	W	15.8 ± 1.2	16.6 ± 1.2	16.6 ± 0.8	16.5 ± 0.8	65.6
B85	YV	YANKEE VILLAGE	1.4 mi.	WSW	15.9 ± 1.2	18.0 ± 2.1	17.2 ± 0.7	18.0 ± 1.6	69.2
B86	EP	EMER RD & PRIS	1.1 mi.	SE	Locations Established 3rd Quarter		16.0 ± 0.7	16.1 ± 3.0	64.1
B87	TT	TAYLOR & TOM AV	1.5 mi.	SE			15.7 ± 0.7	17.0 ± 1.3	65.5
B88	TP	TAYLOR & PEARL	1.9 mi.	SE			15.8 ± 1.3	15.0 ± 0.9	61.5
B89	CT	CONTR. PARK. LO	0.21 mi.	SE			19.0 ± 0.7	19.6 ± 1.7	77.1
B90	BB	JA & BARTLETT R	2.1 mi.	SSE			16.1 ± 0.5	17.2 ± 1.4	66.5
B91	WC	WARREN & CLIFFO	2.1 mi.	W			15.1 ± 0.7	14.9 ± 0.8	60.1
B92	VR	VALLEY ROAD	1.8 mi.	SSW			14.3 ± 0.5	14.4 ± 1.0	57.4
B93	HR	HYANNIS ROAD	4.8 mi.	SSE			13.8 ± 0.4	13.5 ± 0.8	54.7
B94	EL	ELLISVILLE RD	7.2 mi.	SSE			14.8 ± 0.6	14.4 ± 0.9	58.4
B95	DMF	DIV. MAR. FISH	14 mi.	SSE			21.0 ± 0.6	20.6 ± 1.0	83.2
B96	BE	BOURNE ROAD	8.4 mi.	SSW			Missing	14.3 ± 1.0	57.3
B97	LP	LONG POND RD.	5.7 mi.	SSW			13.8 ± 0.4	14.8 ± 1.4	57.3
B98	LD	LONG & DREW RD	4.5 mi.	WSW			13.5 ± 0.5	14.8 ± 0.9	56.6
B99	UC	UP COLL. PND. R	7.4 mi.	SW			13.7 ± 0.6	13.7 ± 0.8	54.8
BA0	DW	DEEP WATER POND	5.3 mi.	W			18.9 ± 0.5	18.8 ± 0.9	75.4
BA1	CW	CHURCH&WEST ST	10 mi.	NW			14.0 ± 0.5	13.9 ± 1.0	55.7
BA2	MM	MAIN & MEADW ST	11 mi.	WSW			15.7 ± 0.5	16.0 ± 1.2	63.5
BA3	SH	SACRED HEART SC	8.1 mi.	W			15.8 ± 0.5	16.2 ± 1.0	64.1
BA4	KC	KING CAESAR RD.	8.1 mi.	NNW			Missing	14.3 ± 0.9	57.1
BA5	LR	LANDING RD.	10 mi.	NNW			15.3 ± 0.6	14.5 ± 0.7	59.6

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

** Annual average value is based on arithmetic mean of the observed quarterly values multiplied by 4.0 quarters/year.

Figure 2.2.4.1-1
Pilgrim Nuclear Power Station

Environmental Radiation Level Trends
for Environmental TLD Measurements - 1988

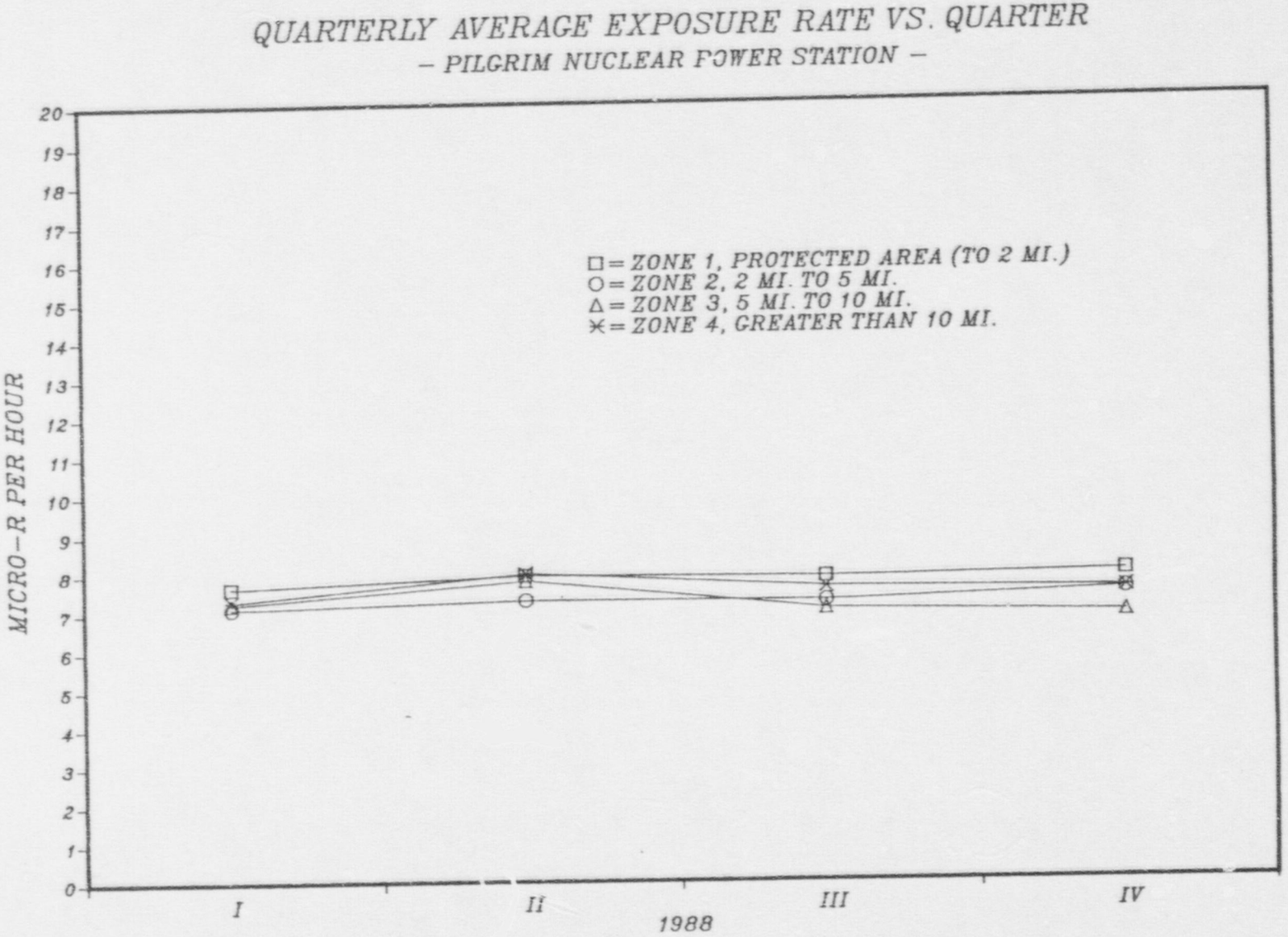


Table 2.2.4.2-1
Pilgrim Nuclear Power Station

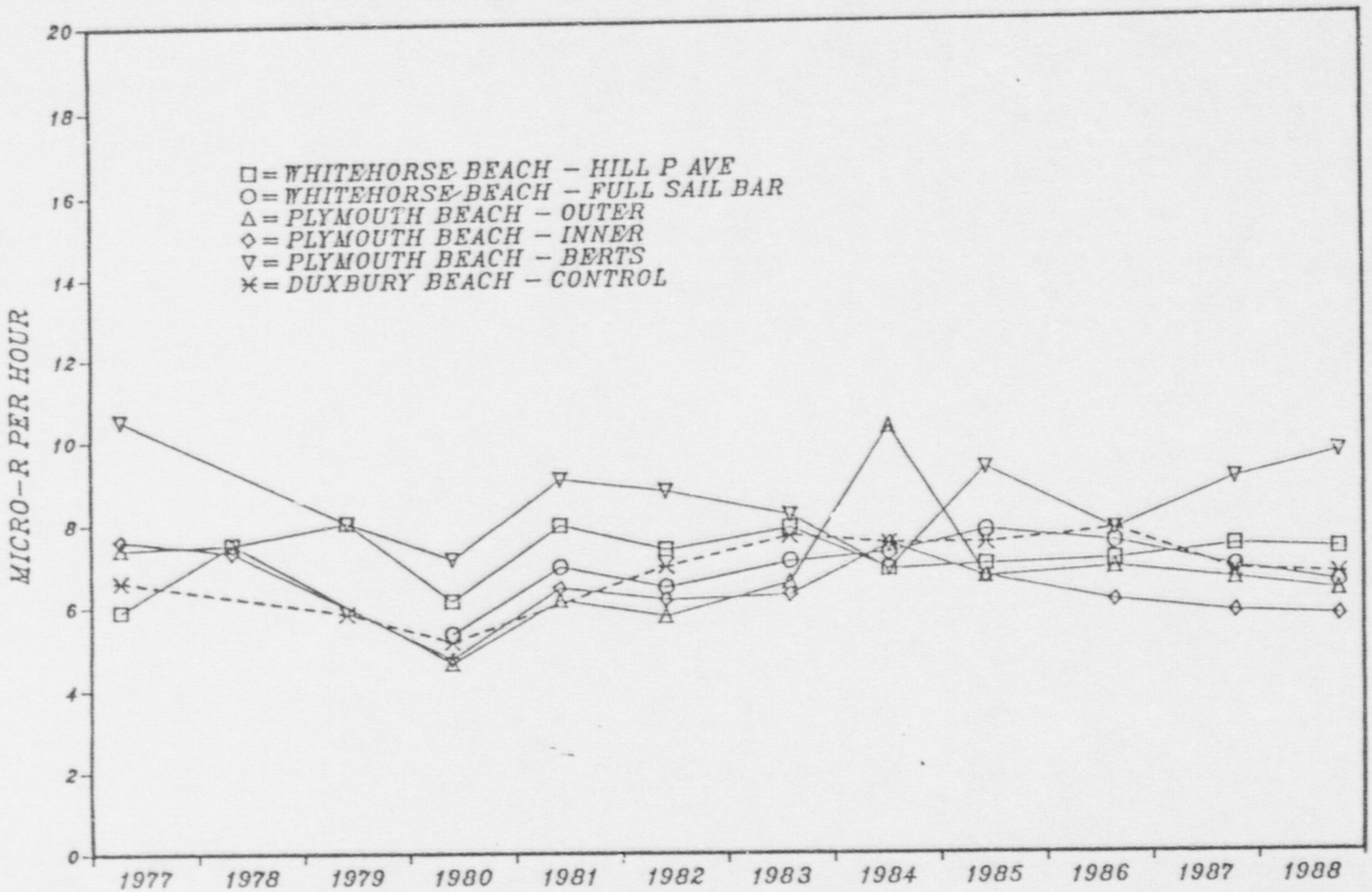
Beach Survey Exposure Rate Results - 1988

Radiation Survey
October 5, 1988

Location	Exposure Rate Mean ± SD (uR/hr)	Beach Terrain
White Horse Beach (Near Hill P Ave)	7.2 ± 0.4	Sandy with small amounts of gravel.
White Horse Beach (In Back of Full Sail Bar)	6.4 ± 0.4	Sandy with small amounts of gravel.
Plymouth Beach (Outer Beach)	6.2 ± 0.4	Sandy.
Plymouth Beach (Inner Beach)	5.6 ± 0.4	Sandy.
Plymouth Beach (Behind Bert's Restaurant)	9.5 ± 0.5	Rocky. Approximately 30 feet from seawall.
Duxbury Beach	6.6 ± 0.5	Sandy with coarse gravel.

Figure 2.2.4.2-1
Pilgrim Nuclear Power Station

Environmental Radiation Level Trends
at Beaches Near Pilgrim Station and a Distant Beach - 1988



2.2.5 Seawater

Samples of seawater were collected at three locations: the Discharge Canal, Bartlett Pond and Powder Point (control). The Discharge Canal sample was collected by a continuously compositing sampler which extracts a sample of about 20 ml of water from the Discharge Canal every twenty minutes. Grab samples were collected weekly from each of the other two locations. Seawater samples were analyzed monthly for gamma isotopes with a quarterly composite analyzed for tritium. All seawater samples were collected and analyzed as required during 1988.

The summary of radioactivity analysis results for seawater samples collected during 1988 is presented in Table 2.2.5-1. There were no positive measurements of nuclides characteristic of Pilgrim Station's operation observed at any of the three sampling locations. The only positive radioactivity measurements observed were due to naturally-occurring radioactivity (potassium-40).

Therefore, analysis of seawater samples collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.5-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results For Seawater - 1988

MEDIUM: SEAWATER

UNITS: PCI/KG

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (36)		(3.3 ± 16.3)E -1	11	(1.3 ± 2.3)E 0	(-1.7 ± 3.2)E 0
(0)		(-1.1 - 1.9)E 1		(-1.0 - 1.3)E 1	(-1.4 - 2.1)E 1
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
K-40 (36)		(1.5 ± 0.3)E 2	11	(3.0 ± 0.1)E 2	(2.8 ± 0.1)E 2
(0)		(-2.5 - 34.2)E 1		(2.7 - 3.4)E 2	(2.1 - 3.8)E 2
		(12/ 24)		*(12/ 12)*	*(12/ 12)*
MN-54 (36)	15.	(-1.4 ± 2.4)E -1	11	(-1.2 ± 2.5)E -1	(-2.8 ± 3.0)E -1
(0)		(-3.2 - 1.6)E 0		(-1.8 - 1.6)E 0	(-2.0 - 1.6)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
CO-58 (36)	15.	(-9.9 ± 20.7)E -2	11	(4.6 ± 322.7)E -3	(-1.7 ± 21.4)E -2
(0)		(-2.1 - 1.9)E 0		(-2.1 - 1.9)E 0	(-1.4 - 0.9)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
FE-59 (36)	30.	(-2.9 ± 3.4)E -1	23	(3.4 ± 3.8)E -1	(3.4 ± 3.8)E -1
(0)		(-3.9 - 2.2)E 0		(-1.1 - 2.8)E 0	(-1.1 - 2.8)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
CO-60 (36)	15.	(-4.1 ± 2.5)E -1	23	(-2.1 ± 3.0)E -1	(-2.1 ± 3.0)E -1
(0)		(-3.3 - 1.7)E 0		(-1.9 - 1.8)E 0	(-1.9 - 1.8)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
ZN-65 (36)	30.	(-2.3 ± 3.5)E -1	23	(2.2 ± 6.9)E -1	(2.2 ± 6.9)E -1
(0)		(-3.9 - 3.0)E 0		(-4.4 - 4.3)E 0	(-4.4 - 4.3)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
ZR-95 (36)	15.	(1.3 ± 3.4)E -1	23	(5.8 ± 7.3)E -1	(5.8 ± 7.3)E -1
(0)		(-2.3 - 3.7)E 0		(-3.3 - 5.3)E 0	(-3.3 - 5.3)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
RU-103 (36)		(-7.8 ± 2.3)E -1	17	(-7.0 ± 3.8)E -1	(-7.7 ± 4.4)E -1
(0)		(-3.2 - 1.3)E 0		(-3.2 - 1.3)E 0	(-2.8 - 1.9)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.5-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
For Seawater - 1988

MEDIUM: SEAWATER UNITS: PCI/KG

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
RU-106 (36)		(-1.6 ± 1.8)E 0	17	(2.3 ± 1.4)E 0	(1.9 ± 3.3)E 0
(0)		(-2.4 - 1.0)E 1		(-6.6 - 9.0)E 0	(-1.7 - 2.3)E 1
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
I-131 (36)	1.	(6.4 ± 2.9)E -2	17	(7.9 ± 3.9)E -2	(6.4 ± 3.6)E -2
(0)		(-1.5 - 4.0)E -1		(-8.8 - 34.0)E -2	(-2.1 - 1.8)E -1
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
CS-134 (36)	15.	(-6.0 ± 1.6)E -1	23	(-1.2 ± 2.9)E -1	(-1.2 ± 2.9)E -1
(0)		(-2.7 - 0.6)E 0		(-1.7 - 1.9)E 0	(-1.7 - 1.9)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
CS-137 (36)	18.	(3.7 ± 285.5)E -3	11	(2.5 ± 45.5)E -2	(-2.3 ± 2.3)E -1
(0)		(-2.3 - 3.1)E 0		(-2.3 - 3.1)E 0	(-2.0 - 0.8)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
BA-140 (36)	15.	(-8.5 ± 3.9)E -1	11	(-2.6 ± 6.6)E -1	(-1.3 ± 0.9)E 0
(0)		(-5.8 - 3.1)E 0		(-5.8 - 3.1)E 0	(-7.7 - 3.5)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
CE-141 (36)		(-5.9 ± 49.5)E -2	23	(2.5 ± 5.9)E -1	(2.5 ± 5.9)E -1
(0)		(-5.6 - 3.6)E 0		(-3.5 - 3.6)E 0	(-3.5 - 3.6)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
CE-144 (36)		(-1.0 ± 1.2)E 0	17	(6.9 ± 15.4)E -1	(-1.4 ± 1.5)E 0
(0)		(-1.4 - 1.1)E 1		(-9.2 - 10.9)E 0	(-1.2 - 1.2)E 1
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
TH-232 (36)		(4.5 ± 6.9)E -1	23	(1.4 ± 0.9)E 0	(1.4 ± 0.9)E 0
(0)		(-6.2 - 10.2)E 0		(-4.7 - 7.6)E 0	(-4.7 - 7.6)E 0
		(0/ 24)		*(0/ 12)*	*(0/ 12)*
H-3 (12)	3000.	(1.4 ± 0.6)E 2	23	(2.4 ± 0.5)E 2	(2.4 ± 0.5)E 2
(0)		(-1.4 - 3.4)E 2		(1.0 - 3.4)E 2	(1.0 - 3.4)E 2
		(0/ 8)		*(0/ 4)*	*(0/ 4)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*

2.2.6 Shellfish

Shellfish samples, which include soft shell clams, quahogs, and blue mussels, were collected quarterly from six locations: the Discharge Canal outfall, Manomet Point, Plymouth Harbor, Duxbury Bay (control), Powder Point (control) and Green Harbor (control). Shells and bodies were analyzed quarterly for gamma-emitting isotopes. All shellfish samples were collected and analyzed as required during 1988.

The summary of radioactivity analysis results for shellfish collected during 1988 is presented in Table 2.2.6-1. This table shows positive measurements of beryllium-7, cesium-127, cobalt-60, thorium-232, and potassium-40 at the indicator stations. In addition, there were positive measurements of beryllium-7, potassium-40, and thorium-232 at the control stations. There were slight positive measurements of cobalt-60 in blue mussels (bodies and shells) taken from the discharge canal outfall during 1988. There was one other positive measurement of cobalt-60 in blue mussel bodies taken at Manomet Point during January 1988. The observed concentrations of beryllium-7, thorium-232 and potassium-40 are due to the natural occurrence of these radionuclides, whereas the observed concentrations of cesium-137 (above expected fallout levels) and cobalt-60 were the result of Pilgrim Station's radioactive liquid releases. It should be noted that no soft shell clams or quahogs showed any detectable levels of radioactivity that could be attributable to the operation of Pilgrim Station.

A special study was conducted to evaluate the dose impact of the radioactivity in the blue mussels. Part I of Appendix A presents the findings and results of this special study. It was shown that if a person were to consume the maximum annual quantity of seafood (9 kilograms/year) with the highest concentrations of the above radionuclides (as found in the mussels in the discharge canal), he would receive a dose of 0.008 mrem to the total body and 0.03 mrem to the most restrictive organ (adult, GI-LLI). This study noted that blue mussels, due to their filtration effect, concentrate the radioactivity in the water thereby making them a sensitive biological indicator.

Therefore, analysis of shellfish samples collected during 1988 showed no evidence of any significant radiological impact on the environment or on the general public due to Pilgrim Station.

Table 2.2.6-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results for Shellfish - 1988

MEDIUM: SHELLFISH

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (46)		(3.2 ± 1.0)E 1	12	(4.5 ± 1.9)E 1	(-1.2 ± 1.2)E 1
(8)		(-4.9 - 17.7)E 1		(-4.9 - 17.7)E 1	(-1.6 - 0.5)E 2
		(8/ 24)		*(3/ 12)*	*(6/ 22)*
K-40 (46)		(9.4 ± 1.0)E 2	15	(1.3 ± 0.1)E 3	(8.4 ± 1.5)E 2
(0)		(7.8 - 159.0)E 1		(1.2 - 1.5)E 3	(8.3 - 254.0)E 1
		(22/ 24)		*(4/ 4)*	*(17/ 22)*
MN-54 (46)	130.	(1.7 ± 0.9)E 0	23	(5.9 ± 6.9)E 0	(2.1 ± 2.0)E 0
(0)		(-8.8 - 12.5)E 0		(-9.6 - 37.3)E 0	(-9.6 - 37.3)E 0
		(0/ 24)		*(0/ 6)*	*(0/ 22)*
CO-58 (46)	130.	(-3.2 ± 13.0)E -1	23	(4.0 ± 4.0)E 0	(-2.3 ± 14.0)E -1
(0)		(-1.5 - 2.0)E 1		(-1.2 - 1.3)E 1	(-1.2 - 1.3)E 1
		(0/ 24)		*(0/ 6)*	*(0/ 22)*
FE-59 (46)	260.	(-2.1 ± 1.6)E 0	23	(8.3 ± 6.2)E 0	(1.7 ± 3.8)E 0
(0)		(-1.8 - 2.2)E 1		(-1.1 - 2.4)E 1	(-5.9 - 2.5)E 1
		(0/ 24)		*(0/ 6)*	*(0/ 22)*
CO-60 (46)	5.	(9.0 ± 3.3)E 0	11	(2.6 ± 0.6)E 1	(-1.2 ± 1.4)E 0
(0)		(-6.2 - 56.1)E 0		(7.6 - 56.1)E 0	(-1.5 - 2.4)E 1
		(9/ 24)		*(8/ 8)*	*(0/ 22)*
ZN-65 (46)	5.	(1.2 ± 2.1)E 0	13	(2.4 ± 8.6)E 0	(-1.9 ± 35.8)E -1
(0)		(-2.7 - 2.2)E 1		(-2.4 - 4.1)E 1	(-3.2 - 4.1)E 1
		(0/ 24)		*(0/ 8)*	*(0/ 22)*
ZR-95 (46)	5.	(8.0 ± 20.9)E -1	13	(3.0 ± 5.7)E 0	(5.8 ± 26.0)E -1
(0)		(-3.0 - 2.9)E 1		(-2.7 - 2.8)E 1	(-2.7 - 2.8)E 1
		(0/ 24)		*(0/ 8)*	*(0/ 22)*
RU-103 (46)		(-7.1 ± 8.9)E -1	13	(2.4 ± 2.7)E 0	(7.4 ± 12.1)E -1
(0)		(-1.1 - 1.1)E 1		(-9.1 - 17.8)E 0	(-9.1 - 17.8)E 0
		(0/ 24)		*(0/ 8)*	*(0/ 22)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.6-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Shellfish - 1988

MEDIUM: SHELLFISH

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (46)		(-4.4 ± 6.8)E 0	13	(2.0 ± 3.0)E 1	(9.5 ± 11.1)E 0
(0)		(-8.1 - 10.0)E 1		(-6.0 - 19.2)E 1	(-6.0 - 19.2)E 1
		(0/ 24)		*(0/ 8)*	*(0/ 22)*
I-131 (46)		(-1.5 ± 3.9)E 0	24	(1.7 ± 6.5)E -1	(-6.3 ± 5.0)E 0
(0)		(-4.1 - 6.5)E 1		(-1.6 - 3.0)E 0	(-7.4 - 2.6)E 1
		(0/ 24)		*(0/ 8)*	*(0/ 22)*
CS-134 (46)	5.	(-2.0 ± 1.4)E 0	24	(-2.8 ± 1.4)E -1	(-5.5 ± 1.5)E 0
(0)		(-2.0 - 1.3)E 1		(-7.7 - 3.3)E -1	(-2.2 - 0.6)E 1
		(0/ 24)		*(0/ 8)*	*(0/ 22)*
CS-137 (46)	5.	(1.7 ± 0.8)E 0	12	(3.2 ± 1.5)E 0	(4.9 ± 11.6)E -1
(0)		(-2.6 - 15.5)E 0		(-2.6 - 15.5)E 0	(-8.3 - 16.7)E 0
		(1/ 24)		*(1/ 12)*	*(0/ 22)*
BA-140 (46)		(8.6 ± 18.8)E -1	12	(2.6 ± 3.7)E 0	(-5.2 ± 4.1)E 0
(0)		(-1.5 - 2.8)E 1		(-1.5 - 2.8)E 1	(-5.7 - 3.8)E 1
		(0/ 24)		*(0/ 12)*	*(0/ 22)*
CE-141 (46)		(2.6 ± 1.2)E 0	23	(1.1 ± 0.4)E 1	(2.9 ± 2.3)E 0
(0)		(-7.7 - 21.4)E 0		(-3.1 - 249.0)E -1	(-1.9 - 2.9)E 1
		(0/ 24)		*(0/ 6)*	*(0/ 22)*
CE-144 (46)	15.	(-2.4 ± 3.7)E 0	11	(-2.5 ± 9.9)E -1	(-2.3 ± 6.9)E 0
(0)		(-4.7 - 4.0)E 1		(-4.7 - 3.5)E 0	(-9.4 - 7.4)E 1
		(0/ 24)		*(0/ 8)*	*(0/ 22)*
TH-232 (46)		(2.6 ± 0.6)E 1	23	(6.7 ± 2.7)E 1	(4.5 ± 1.2)E 1
(0)		(9.6 - 944.0)E -1		(-4.3 - 13.7)E 1	(-4.3 - 13.9)E 1
		(7/ 24)		*(2/ 6)*	*(8/ 22)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.2.7 Irish Moss (Chondrus crispus)

Irish moss (Chondrus crispus) samples were collected quarterly at four (4) locations: the Discharge Canal outfall, Manomet Point, Ellisville and Brant Rock (control). Irish moss samples were analyzed quarterly for gamma-emitting isotopes. All Irish moss samples were collected and analyzed as required during 1988.

The summary of radioactivity analysis results for Irish moss collected during 1988 is presented in Table 2.2.7-1. This table shows positive measurements of beryllium-7, cobalt-60, potassium-40, and thorium-232. There were positive measurements of naturally occuring beryllium-7, thorium-232 and potassium-40 at the indicator locations, and at the control location in Brant Rock.

The observed concentrations of cobalt-60 at the Discharge Canal outfall were the result of Pilgrim Station's liquid releases. The prevailing surface currents along the shoreline in the Plymouth area are in the southerly direction. There were no positive measurements of Pilgrim Station related nuclides at Manoment Point, Ellisville, or at the control station in Brant Rock which is approximately twelve miles away in the north northwest direction.

A special study was performed to evaluate the dose impact from ingestion of cobalt-60 in Irish Moss. The dose calculations are discussed in detail in Part II of Appendix A. It is important to note that, due to processing and market dilution of the Irish moss, the presence of the cobalt-60 concentrations do not represent a significant potential source of dose to the general public. However, direct human consumption of Irish moss (which to our knowledge, does not occur) with the highest concentrations would result in a dose rate of about 0.01 mrem/yr to the total body and approximately 0.08 mrem/yr to the most restrictive organ.

Therefore, analysis of Irish moss samples collected during 1988 showed no evidence of any significant radiological impact on the environment or on the general public due to Pilgrim Station.

Table 2.2.7-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Irish Moss (Chondrus crispus) - 1988

MEDIUM: IRISH MOSS

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (16)		(1.4 ± 0.2)E 2	22	(1.9 ± 0.1)E 2	(7.4 ± 3.4)E 1
(0)		(3.8 - 26.8)E 1		(1.8 - 2.1)E 2	(1.3 - 16.2)E 1
		(8/ 12)		*(4/ 4)*	*(1/ 4)*
K-40 (16)		(6.2 ± 0.5)E 3	11	(7.4 ± 0.9)E 3	(3.9 ± 0.3)E 3
(0)		(3.9 - 9.3)E 3		(5.1 - 9.3)E 3	(3.2 - 4.5)E 3
		(12/ 12)		*(4/ 4)*	*(4/ 4)*
MN-54 (16)		(1.4 ± 1.6)E 0	22	(3.6 ± 3.5)E 0	(9.4 ± 7.0)E -1
(0)		(-7.5 - 10.2)E 0		(-3.4 - 10.2)E 0	(-9.0 - 22.9)E -1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
CO-58 (16)		(-1.8 ± 1.1)E 0	34	(-7.9 ± 23.6)E -1	(-7.9 ± 23.6)E -1
(0)		(-8.6 - 4.4)E 0		(-7.3 - 3.9)E 0	(-7.3 - 3.9)E 0
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
FE-59 (16)		(-8.4 ± 33.1)E -1	22	(2.0 ± 5.5)E 0	(-5.9 ± 12.2)E 0
(0)		(-2.6 - 1.3)E 1		(-9.9 - 12.6)E 0	(-3.9 - 1.8)E 1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
CO-60 (16)		(3.2 ± 1.8)E 1	11	(8.7 ± 4.5)E 1	(4.6 ± 26.6)E -1
(4)		(-1.1 - 219.0)E 0		(2.8 - 21.9)E 1	(-6.6 - 6.4)E 0
		(4/ 12)		*(4/ 4)*	*(0/ 4)*
ZN-65 (16)		(1.2 ± 3.6)E 0	22	(9.6 ± 6.1)E 0	(2.1 ± 76.0)E -1
(0)		(-2.1 - 1.9)E 1		(-8.3 - 19.0)E 0	(-8.7 - 22.9)E 0
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
ZR-95 (16)		(2.5 ± 2.4)E 0	15	(6.6 ± 3.5)E 0	(1.1 ± 4.8)E 0
(0)		(-1.3 - 1.7)E 1		(8.7 - 169.0)E -1	(-9.4 - 13.1)E 0
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
RU-103 (16)		(-6.7 ± 16.5)E -1	22	(4.4 ± 2.3)E 0	(-1.4 ± 2.2)E 0
(0)		(-9.6 - 9.5)E 0		(-1.2 - 9.5)E 0	(-5.3 - 4.5)E 0
		(0/ 12)		*(0/ 4)*	*(0/ 4)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.7-1 (continued)

Pilgrim Nuclear Power Station
Summary of Radioactivity Analysis Results
for Irish Moss (Chondrus crispus) - 1988

MEDIUM: IRISH MOSS

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (16)		(-2.5 ± 1.3)E 1	34	(2.7 ± 14.9)E 0	(2.7 ± 14.9)E 0
(0)		(-1.1 - 0.3)E 2		(-2.5 - 3.7)E 1	(-2.5 - 3.7)E 1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
I-131 (16)		(1.8 ± 0.8)E 1	11	(2.5 ± 1.2)E 1	(-5.8 ± 5.7)E 0
(0)		(-2.5 - 6.0)E 1		(-2.8 - 53.8)E 0	(-2.0 - 0.5)E 1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
CS-134 (16)		(-2.8 ± 1.2)E 0	22	(-3.4 ± 26.5)E -1	(-4.5 ± 2.5)E 0
(0)		(-8.8 - 5.6)E 0		(-7.3 - 5.6)E 0	(-1.0 - 0.2)E 1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
CS-137 (16)		(4.1 ± 1.6)E 0	11	(9.6 ± 1.1)E 0	(9.0 ± 17.4)E -1
(0)		(-6.4 - 11.6)E 0		(6.9 - 11.6)E 0	(-3.2 - 4.9)E 0
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
BA-140 (16)		(-1.7 ± 2.5)E 0	15	(9.4 ± 39.5)E -1	(-4.6 ± 3.5)E 0
(0)		(-1.8 - 1.2)E 1		(-8.2 - 7.9)E 0	(-1.1 - 0.4)E 1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
CE-141 (16)		(-2.9 ± 1.8)E 0	15	(-1.4 ± 3.7)E 0	(-3.3 ± 2.9)E 0
(0)		(-1.4 - 0.6)E 1		(-1.1 - 0.6)E 1	(-8.2 - 4.5)E 0
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
CE-144 (16)		(5.9 ± 70.3)E -1	11	(1.5 ± 1.6)E 1	(9.1 ± 16.4)E 0
(0)		(-3.5 - 5.4)E 1		(-2.3 - 5.4)E 1	(-3.0 - 5.0)E 1
		(0/ 12)		*(0/ 4)*	*(0/ 4)*
TH-232 (16)		(2.8 ± 0.9)E 1	15	(5.0 ± 1.9)E 1	(1.6 ± 1.1)E 1
(2)		(-1.6 - 9.3)E 1		(1.6 - 9.3)E 1	(-2.7 - 46.6)E 0
		(2/ 12)		*(2/ 4)*	*(0/ 4)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.2.8 American Lobster (Homarus americanus)

Lobster samples were collected four times per season in the vicinity of the discharge canal and annually at a distant point offshore. Lobsters collected from the vicinity of the discharge canal were analyzed quarterly for gamma-emitting isotopes. Lobsters collected offshore were analyzed annually for gamma-emitting isotopes. All lobster samples were collected and analyzed as required during 1988.

The summary of the radioactivity analysis results for American lobsters collected during 1988 is presented in Table 2.2.8-1. These results indicate that there were no positive measurements of any radioactivity other than potassium-40 in either the indicator or the control samples (potassium-40 is a naturally-occurring nuclide).

Therefore, analysis of lobster samples collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.8-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for American Lobster (Homarus americanus) - 1988

MEDIUM: AMERICAN LOBSTER

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (5)		(-2.7 ± 3.9)E 1	89	(-1.1 ± 9.5)E 1	(-1.1 ± 9.5)E 1
(0)		(-1.0 - 0.8)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
K-40 (5)		(2.5 ± 0.3)E 3	11	(2.5 ± 0.3)E 3	(1.9 ± 0.3)E 3
(0)		(1.9 - 3.1)E 3		(1.9 - 3.1)E 3	
		(4/ 4)		*(4/ 4)*	*(1/ 1)*
MN-54 (5)	130.	(1.5 ± 5.9)E 0	89	(6.7 ± 12.0)E 0	(6.7 ± 12.0)E 0
(0)		(-1.4 - 1.5)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CO-58 (5)	130.	(-3.4 ± 9.0)E 0	11	(-3.4 ± 9.0)E 0	(-2.7 ± 1.3)E 1
(0)		(-2.5 - 1.2)E 1		(-2.5 - 1.2)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
FE-59 (5)	260.	(6.8 ± 10.5)E 0	89	(1.8 ± 2.5)E 1	(1.8 ± 2.5)E 1
(0)		(-1.6 - 3.1)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CO-60 (5)	130.	(4.2 ± 5.5)E 0	89	(2.3 ± 1.7)E 1	(2.3 ± 1.7)E 1
(0)		(-1.0 - 1.3)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
ZN-65 (5)	260.	(-2.1 ± 1.5)E 1	89	(2.3 ± 2.7)E 1	(2.3 ± 2.7)E 1
(0)		(-5.6 - 1.5)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
ZR-95 (5)		(8.6 ± 5.9)E 0	89	(2.9 ± 2.2)E 1	(2.9 ± 2.2)E 1
(0)		(-1.9 - 24.2)E 0			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
RU-103 (5)		(6.2 ± 76.0)E -1	11	(6.2 ± 76.0)E -1	(-1.1 ± 1.2)E 1
(0)		(-2.2 - 1.0)E 1		(-2.2 - 1.0)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.8-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis
Results for American Lobster
(Homarus americanus) - 1988

MEDIUM: AMERICAN LOBSTER

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (5)		(2.3 ± 4.0)E 1	89	(1.1 ± 1.2)E 2	(1.1 ± 1.2)E 2
(0)		(-8.1 - 8.9)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
I-131 (5)		(-1.1 ± 1.7)E 1	11	(-1.1 ± 1.7)E 1	(-2.5 ± 5.4)E 1
(0)		(-5.1 - 1.8)E 1		(-5.1 - 1.8)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
CS-134 (5)	130.	(-1.3 ± 0.1)E 1	89	(1.8 ± 1.3)E 1	(1.8 ± 1.3)E 1
(0)		(-1.6 - -1.1)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CS-137 (5)	130.	(1.0 ± 0.7)E 1	11	(1.0 ± 0.7)E 1	(-1.1 ± 11.6)E 0
(0)		(-9.1 - 23.5)E 0		(-9.1 - 23.5)E 0	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
BA-140 (5)		(-1.4 ± 1.6)E 1	89	(3.5 ± 30.5)E 0	(3.5 ± 30.5)E 0
(0)		(-4.8 - 2.4)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CE-141 (5)		(3.5 ± 6.4)E 0	11	(3.5 ± 6.4)E 0	(-1.4 ± 2.0)E 1
(0)		(-5.4 - 22.2)E 0		(-5.4 - 22.2)E 0	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
CE-144 (5)		(3.2 ± 4.6)E 1	11	(3.2 ± 4.6)E 1	(2.7 ± 5.9)E 1
(0)		(-4.4 - 15.6)E 1		(-4.4 - 15.6)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
TH-232 (5)		(1.9 ± 0.8)E 1	11	(1.9 ± 0.8)E 1	(-1.3 ± 5.3)E 1
(0)		(-3.4 - 29.9)E 0		(-3.4 - 29.9)E 0	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.2.9 Fishes

Fish samples of bottom-oriented (Group I)* and near-bottom (Group II)** species were collected quarterly (when available) in the vicinity of the Discharge Canal. In addition, samples of anadromous (Group III)*** and coastal migratory (Group IV)**** species were collected (when in season) in this same area. Lastly, a sample from each group was collected at a distant location offshore. Fish samples collected from the vicinity of the discharge canal were analyzed quarterly for gamma-emitting isotopes and fish samples collected offshore were analyzed annually. During 1988, Group I and II samples were unavailable in the first quarter, and Group I samples were unavailable during the fourth quarter due to the species not being found in the general area of the Discharge Canal. Fish samples from all other groups of fishes were collected and analyzed as required during 1988.

The summary of the radioactivity analysis results for fishes collected during 1988 is presented in Table 2.2.9-1. There were positive measurements of potassium-40 from all samples collected at indicator and control stations. The potassium-40 is naturally-occurring. Analysis results for two fish samples obtained from the outfall of the discharge canal indicated the presence of cesium-137. The low levels of cesium-137 observed are indicative of fallout due to previous atmospheric nuclear weapons testing.

Therefore, analysis of fish samples collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

*Group I - Bottom Oriented: Winter flounder and Yellowtail flounder.

**Group II - Near Bottom Distribution: Tautog, Cunner, Atlantic cod, Pollock, and Hakes.

***Group III - Anadromous: Alewife, Rainbow smelt, and Striped bass.

****Group IV - Coastal Migratory: Bluefish, Atlantic herring, Atlantic menhaden, and Atlantic mackerel.

Table 2.2.9-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results for Fishes - 1988

MEDIUM: FISHES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (28)		(-1.1 ± 1.5)E 1	30	(1.7 ± 1.1)E 2	(-3.4 ± 5.3)E 1
(0)		(-1.8 - 1.2)E 2			(-2.0 - 1.7)E 2
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
K-40 (28)		(3.2 ± 0.1)E 3	14	(3.8 ± 0.3)E 3	(3.2 ± 0.2)E 3
(0)		(2.3 - 3.8)E 3			(2.5 - 3.7)E 3
		(21/ 21)		*(1/ 1)*	*(7/ 7)*
MN-54 (28)	130.	(1.1 ± 1.8)E 0	98	(7.0 ± 3.0)E 0	(6.3 ± 2.6)E 0
(0)		(-2.3 - 1.5)E 1		(-3.7 - 14.0)E 0	(-3.7 - 14.0)E 0
		(0/ 21)		*(0/ 6)*	*(0/ 7)*
CO-58 (28)	130.	(8.1 ± 17.5)E -1	98	(4.9 ± 3.7)E 0	(2.4 ± 4.0)E 0
(0)		(-1.4 - 2.3)E 1		(-9.1 - 15.9)E 0	(-1.2 - 1.6)E 1
		(0/ 21)		*(0/ 6)*	*(0/ 7)*
FE-59 (28)	260.	(-2.9 ± 4.2)E 0	11	(-2.9 ± 4.4)E 0	(-2.2 ± 0.8)E 1
(0)		(-4.0 - 3.4)E 1		(-4.0 - 3.4)E 1	(-5.5 - 0.4)E 1
		(0/ 21)		*(0/ 20)*	*(0/ 7)*
CO-60 (28)	130.	(-3.8 ± 2.0)E 0	14	(8.2 ± 14.9)E 0	(-1.1 ± 1.9)E 0
(0)		(-2.0 - 2.1)E 1			(-8.5 - 7.5)E 0
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
ZN-65 (28)	260.	(6.6 ± 4.2)E 0	14	(4.2 ± 2.1)E 1	(-4.9 ± 68.2)E -1
(0)		(-2.0 - 4.2)E 1			(-3.8 - 1.7)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
ZR-95 (28)		(3.6 ± 25.5)E -1	30	(2.7 ± 2.1)E 1	(1.1 ± 0.6)E 1
(0)		(-1.9 - 2.5)E 1			(-9.0 - 27.6)E 0
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
RU-103 (28)		(-2.8 ± 2.1)E 0	14	(6.0 ± 10.4)E 0	(-5.3 ± 4.7)E 0
(0)		(-1.7 - 1.8)E 1			(-2.7 - 0.8)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.9-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Fishes - 1988

MEDIUM: FISHES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
RU-106 (28)		(-1.2 ± 1.5)E 1	14	(5.6 ± 8.7)E 1	(-1.3 ± 2.3)E 1
(0)		(-1.5 - 1.0)E 2			(-6.9 - 11.5)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
I-131 (28)		(-3.5 ± 7.[illegible])E -1	30	(8.8 ± 88.7)E 0	(-10.0 ± 19.4)E 0
(0)		(-4.4 - 10.5)E 1			(-9.1 - 7.4)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
CS-134 (28)	130.	(-6.4 ± 1.6)E 0	98	(-4.0 ± 3.9)E 0	(-5.5 ± 3.7)E 0
(0)		(-1.9 - 0.2)E 1		(-1.5 - 0.7)E 1	(-1.5 - 0.7)E 1
		(0/ 21)		*(0/ 6)*	*(0/ 7)*
CS-137 (28)	130.	(5.4 ± 3.7)E 0	14	(1.2 ± 1.0)E 1	(5.9 ± 1.9)E 0
(2)		(-2.4 - 4.9)E 1			(-1.3 - 10.7)E 0
		(2/ 21)		*(0/ 1)*	*(0/ 7)*
BA-140 (28)		(-6.5 ± 3.9)E 0	98	(-4.6 ± 97.4)E -1	(-3.9 ± 8.9)E 0
(0)		(-5.1 - 3.1)E 1		(-3.7 - 3.5)E 1	(-3.7 - 3.5)E 1
		(0/ 21)		*(0/ 6)*	*(0/ 7)*
CE-141 (28)		(4.3 ± 2.7)E 0	14	(1.4 ± 1.5)E 1	(-1.9 ± 7.7)E 0
(0)		(-1.8 - 3.2)E 1			(-4.0 - 2.0)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
CE-144 (28)		(1.1 ± 0.9)E 1	14	(6.9 ± 4.6)E 1	(1.7 ± 1.1)E 1
(0)		(-7.7 - 6.9)E 1			(-2.5 - 6.0)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*
TH-232 (28)		(2.4 ± 0.8)E 1	14	(6.8 ± 4.1)E 1	(2.7 ± 1.4)E 1
(0)		(-5.2 - 8.8)E 1			(-3.5 - 6.2)E 1
		(0/ 21)		*(0/ 1)*	*(0/ 7)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.2.10 Sediment

Sediment samples were collected semi-annually at five indicator stations including: the Discharge Canal outfall, Plymouth Harbor, Duxbury Bay, Plymouth Beach and Manomet Point, and at a control station in Green Harbor. There is a detailed procedure for sub-dividing individual sediment cores in which samples are sectioned into 2-cm increments during the first half of the year (this applies to all locations except Plymouth Beach), and samples are sectioned into 5-cm increments during the second half of the year. The surface and alternate sections were analyzed for gamma-emitting nuclides semi-annually. In addition, the surface section from each core and a mid-depth section from Rocky Point and Plymouth Harbor were analyzed annually for Pu-238, Pu-239, and Pu-240. All sediment samples were collected and analyzed as required during 1988.

The summary of radioactivity analysis results for sediment collected during 1988 is presented in Table 2.2.10-1. This table shows that positive measurements of potassium-40 and thorium-232 were observed at all indicator and control stations. Positive measurements of beryllium-7 were detected on a sediment sample from an indicator station and two control stations samples. The beryllium-7, potassium-40, and thorium-232 are all naturally-occurring radionuclides. Cobalt-60 was detected in one sediment sample taken from the outfall of the Pilgrim Station discharge canal. The cobalt-60 is attributable to Pilgrim Station radioactive liquid releases. Positive measurements of cesium-137 were detected on 24 sediment samples taken from indicator and control stations. The levels of cesium-137 observed were similar to those expected from fallout from nuclear weapons testing.

The analysis of potential dose attributable to the positive cobalt-60 sample result is presented in a special study in Part III of Appendix A. The maximum external radiation dose calculated for an individual spending 67 hr/yr[8] in the vicinity of the Discharge Canal is 0.0003 mrem.

The results of plutonium analyses for the 1988 samples are presented in Table 2.2.10-2. When the 1988 analysis results were compared to results from previous years' analyses, there was no apparent trend to indicate that Pilgrim Station is contributing measurably to levels of Pu-238, 239, or 240 in the environment.

Therefore, analysis of sediment samples collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.10-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Sediment - 1988

MEDIUM: SEDIMENT

UNITS: PCI/KG DRY

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (61)		(2.7 ± 1.3)E 1	13	(8.2 ± 4.6)E 1	(4.6 ± 2.5)E 1
(0)		(-1.2 - 4.6)E 2		(-5.8 - 45.6)E 1	(-5.8 - 45.6)E 1
		(1/ 39)		*(2/ 11)*	*(2/ 22)*
K-40 (61)		(9.1 ± 0.2)E 3	14	(1.1 ± 0.0)E 4	(9.3 ± 0.2)E 3
(0)		(6.9 - 11.3)E 3		(9.7 - 11.3)E 3	(7.7 - 11.1)E 3
		(39/ 39)		*(6/ 6)*	*(22/ 22)*
MN-54 (61)		(-3.2 ± 0.7)E 0	14	(-4.7 ± 17.0)E -1	(-2.2 ± 0.8)E 0
(0)		(-1.3 - 0.8)E 1		(-7.2 - 4.1)E 0	(-8.3 - 7.3)E 0
		(0/ 39)		*(0/ 6)*	*(0/ 22)*
CO-58 (61)	50.	(-3.0 ± 0.7)E 0	15	(-1.1 ± 1.6)E 0	(-4.8 ± 1.0)E 0
(0)		(-1.1 - 0.8)E 1		(-1.0 - 0.8)E 1	(-1.3 - 0.2)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
FE-59 (61)		(-1.3 ± 2.1)E 0	12	(4.8 ± 2.9)E 0	(-4.5 ± 3.1)E 0
(0)		(-3.8 - 2.2)E 1		(-1.2 - 2.2)E 1	(-2.8 - 2.8)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CO-60 (61)	50.	(2.3 ± 0.8)E 0	11	(7.3 ± 1.4)E 0	(-1.3 ± 1.0)E 0
(1)		(-8.1 - 13.0)E 0		(-2.1 - 13.0)E 0	(-10.0 - 7.5)E 0
		(1/ 39)		*(1/ 11)*	*(0/ 22)*
ZN-65 (61)	50.	(1.0 ± 1.9)E 0	13	(4.4 ± 4.4)E 0	(-10.0 ± 28.4)E -1
(0)		(-2.0 - 2.5)E 1		(-1.5 - 3.0)E 1	(-2.3 - 3.0)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
ZR-95 (61)	50.	(3.0 ± 1.5)E 0	24	(5.9 ± 2.6)E 0	(4.7 ± 1.6)E 0
(0)		(-2.0 - 2.1)E 1		(-4.9 - 22.9)E 0	(-9.6 - 22.9)E 0
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
RU-103 (61)		(-1.0 ± 0.7)E 0	15	(-4.9 ± 115.0)E -2	(-9.7 ± 12.3)E -1
(0)		(-1.3 - 0.6)E 1		(-8.0 - 4.3)E 0	(-1.1 - 1.0)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.10-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Sediment - 1988

MEDIUM: SEDIMENT

UNITS: PCI/KG DRY

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (61)		(-1.0 ± 0.7)E 1	14	(9.9 ± 189.8)E -1	(-1.2 ± 0.7)E 1
(0)		(-1.2 - 0.9)E 2		(-4.3 - 8.7)E 1	(-8.6 - 6.5)E 1
		(0/ 39)		*(0/ 6)*	*(0/ 22)*
I-131 (61)		(4.7 ± 6.0)E 0	14	(3.5 ± 2.1)E 1	(1.4 ± 0.6)E 1
(0)		(-1.2 - 1.4)E 2		(-5.8 - 138.0)E 0	(-3.4 - 7.7)E 1
		(0/ 39)		*(0/ 6)*	*(0/ 22)*
CS-134 (61)	50.	(-9.6 ± 6.8)E -1	13	(4.1 ± 1.3)E 0	(2.3 ± 1.0)E 0
(0)		(-7.2 - 10.5)E 0		(-3.0 - 10.4)E 0	(-7.8 - 10.4)E 0
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CS-137 (61)	50.	(1.1 ± 0.3)E 1	12	(3.0 ± 0.6)E 1	(1.1 ± 0.2)E 1
(0)		(-7.4 - 52.3)E 0		(-3.8 - 52.5)E 0	(-1.8 - 29.5)E 0
		(11/ 39)		*(9/ 11)*	*(13/ 22)*
BA-140 (61)		(-5.1 ± 3.2)E 0	24	(1.2 ± 2.5)E 1	(-1.9 ± 128.2)E -1
(0)		(-4.0 - 5.0)E 1		(-3.8 - 25.7)E 1	(-5.3 - 25.7)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CE-141 (61)		(6.7 ± 1.4)E 0	11	(1.1 ± 0.2)E 1	(7.0 ± 1.4)E 0
(0)		(-2.0 - 2.5)E 1		(-1.7 - 18.8)E 0	(-5.6 - 21.8)E 0
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CE-144 (61)	150.	(-1.5 ± 0.5)E 1	14	(-2.9 ± 13.3)E 0	(-9.3 ± 6.1)E 0
(0)		(-7.0 - 6.7)E 1		(-3.8 - 5.4)E 1	(-6.2 - 3.7)E 1
		(0/ 39)		*(0/ 6)*	*(0/ 22)*
TH-232 (61)		(3.2 ± 0.1)E 2	11	(3.7 ± 0.2)E 2	(3.1 ± 0.1)E 2
(0)		(1.8 - 5.3)E 2		(2.9 - 5.3)E 2	(2.0 - 4.1)E 2
		(39/ 39)		*(11/ 11)*	*(22/ 22)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.10-2
Pilgrim Nuclear Power Station

Radioactivity Analysis Results for Plutonium in Sediment-1988

Location	Core Depth (cm)	Concentration ± SD (pCi/kg dry)	
		Plutonium 238	Plutonium 239 and 240
Rocky Point	0-2	0.06 ± 0.19	3.39 ± 0.39
Rocky Point	12-14	-0.56 ± 0.25	2.51 ± 0.33
Plymouth Harbor	0-2	0.26 ± 0.25	9.85 ± 0.62
Plymouth Harbor	12-14	0.22 ± 0.21	11.66 ± 0.76
Plymouth Beach	0-2	0.38 ± 0.40	1.09 ± 0.27
Manomet Point	0-2	0.97 ± 0.54	2.52 ± 0.50
Duxbury Bay	0-2	0.16 ± 0.40	8.47 ± 0.80
Green Harbor-Control	0-2	0.09 ± 0.36	0.91 ± 0.20

2.2.11 Milk

Milk samples were collected at two locations during 1988: the Plymouth County Farm and the Whitman Farm control station. Thus, the only dependable indicator station (for milk) within 5 miles of PNPS-1 during 1988 was the Plymouth Country Farm. When available, samples were collected semi-monthly when animals were on pasture (generally May through October) and monthly at other times. Milk samples were analyzed for iodine-131, strontium-89 and 90, and gamma-emitting isotopes semi-monthly during grazing season and monthly otherwise. All milk samples were collected and analyzed as required during 1988.

The summary of the radioactivity analysis results for the milk collected during 1988 is presented in Table 2.2.11-1. The results of radioactivity analyses for cesium-137, strontium-90 and iodine-131 are presented graphically in Figures 2.2.11-1 through 2.2.11-3, respectively.

Positive measurements of potassium-40, cesium-137, and strontium-90 were detected at both sampling locations. No iodine-131 was detected in milk during 1988. The presence of potassium-40 is due to naturally-occurring radioactivity. The cesium-137 and strontium-90 is considered to be attributable to fallout from previous atmospheric nuclear weapons testing, since cesium-134 and strontium-89 were not present. In addition, the pre-operational environmental monitoring program indicate the presence of strontium-90 and cesium-137 in milk at levels of 9 pCi/kg and 17 pCi/kg, respectively. As can be seen in Figures 2.2.11-1 and 2.2.11-2, the levels of cesium-137 and strontium-90 detected in milk samples collected during 1988 were lower than the pre-operational levels.

Therefore, analysis of milk samples collected during 1988 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.11-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Milk - 1988

MEDIUM: MILK

UNITS: PCI/KG

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
SR-89 (36)		(-2.5 ± 3.3)E -1	21	(4.4 ± 225.1)E -3	(4.4 ± 225.1)E -3
(0)		(-3.5 - 1.4)E 0		(-2.5 - 1.9)E 0	(-2.5 - 1.9)E 0
		(0/ 18)		*(0/ 18)*	*(0/ 18)*
SR-90 (36)		(3.0 ± 0.4)E 0	11	(3.0 ± 0.4)E 0	(2.5 ± 0.3)E 0
(0)		(6.7 - 58.2)E -1		(6.7 - 58.2)E -1	(1.5 - 43.7)E -1
		(14/ 18)		*(14/ 18)*	*(13/ 18)*
BE-7 (36)		(1.9 ± 1.4)E 0	11	(1.9 ± 1.4)E 0	(-2.3 ± 24.4)E -1
(0)		(-8.4 - 12.4)E 0		(-8.4 - 12.4)E 0	(-2.0 - 1.9)E 1
		(0/ 18)		*(0/ 18)*	*(0/ 18)*
K-40 (36)		(1.4 ± 0.0)E 3	11	(1.4 ± 0.0)E 3	(1.4 ± 0.0)E 3
(0)		(1.3 - 1.5)E 3		(1.3 - 1.5)E 3	(1.2 - 1.5)E 3
		(18/ 18)		*(18/ 18)*	*(18/ 18)*
MN-54 (36)		(-3.5 ± 2.3)E -1	21	(-9.2 ± 23.8)E -2	(-9.2 ± 23.8)E -2
(0)		(-2.3 - 1.0)E 0		(-1.4 - 2.3)E 0	(-1.4 - 2.3)E 0
		(0/ 18)		*(0/ 18)*	*(0/ 18)*
CO-58 (36)		(9.5 ± 262.9)E -3	11	(9.5 ± 262.9)E -3	(-6.1 ± 2.7)E -1
(0)		(-1.8 - 2.1)E 0		(-1.8 - 2.1)E 0	(-2.4 - 2.1)E 0
		(0/ 18)		*(0/ 18)*	*(0/ 18)*
FE-59 (36)		(4.2 ± 3.7)E 0	11	(4.2 ± 3.7)E 0	(2.9 ± 7.4)E -1
(0)		(-5.8 - 66.2)E 0		(-5.8 - 66.2)E 0	(-5.9 - 5.5)E 0
		(0/ 18)		*(0/ 18)*	*(0/ 18)*
CO-60 (36)		(-3.1 ± 34.4)E -2	21	(3.2 ± 317.1)E -3	(3.2 ± 317.1)E -3
(0)		(-2.8 - 2.9)E 0		(-2.6 - 2.6)E 0	(-2.6 - 2.6)E 0
		(0/ 18)		*(0/ 18)*	*(0/ 18)*
ZN-65 (36)		(-1.3 ± 0.6)E 0	21	(3.4 ± 5.7)E -1	(3.4 ± 5.7)E -1
(0)		(-5.1 - 3.3)E 0		(-5.2 - 3.7)E 0	(-5.2 - 3.7)E 0
		(0/ 18)		*(0/ 18)*	*(0/ 18)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.11-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Milk - 1988

UNITS: PCi/KG		INDICATOR STATIONS	STATION WITH HIGHEST MEAN	CONTROL STATIONS
		**********	**********	**********
RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	MEAN RANGE NO. DETECTED**	STA. NO.	MEAN RANGE NO. DETECTED**
ZR-95 (36)		(-7.4 ± 4.6)E -1	21	(3.0 ± 51.9)E -2
(0)		(-4.1 - 2.5)E 0		(-5.7 - 5.1)E 0
		(0/ 18)		*(0/ 18)*
RU-103 (36)		(-1.2 ± 0.3)E 0	21	(-1.0 ± 0.3)E 0
(0)		(-2.8 - 1.3)E 0		(-3.2 - 1.5)E 0
		(0/ 18)		*(0/ 18)*
RU-106 (36)		(1.8 ± 2.6)E 0	11	(1.8 ± 2.6)E 0
(0)		(-2.4 - 2.3)E 1		(-2.4 - 2.3)E 1
		(0/ 18)		*(0/ 18)*
I-131 (36)	1.	(6.8 ± 4.1)E -2	11	(6.8 ± 4.1)E -2
(0)		(-1.8 - 5.1)E -1		(-1.8 - 5.1)E -1
		(0/ 18)		*(0/ 18)*
CS-134 (36)	15.	(-4.9 ± 2.9)E -1	11	(-4.9 ± 2.9)E -1
(0)		(-3.0 - 1.4)E 0		(-3.0 - 1.4)E 0
		(0/ 18)		*(0/ 18)*
CS-137 (36)	15.	(1.7 ± 0.3)E 0	11	(1.7 ± 0.3)E 0
(0)		(-4.5 - 32.6)E -1		(-4.5 - 32.6)E -1
		(1/ 18)		*(1/ 18)*
BA-140 (36)	15.	(3.7 ± 4.8)E -1	11	(3.7 ± 4.8)E -1
(0)		(-4.7 - 3.2)E 0		(-4.7 - 3.2)E 0
		(0/ 18)		*(0/ 18)*
CE-141 (36)		(1.0 ± 0.4)E 0	11	(1.0 ± 0.4)E 0
(0)		(-2.7 - 4.2)E 0		(-2.7 - 4.2)E 0
		(0/ 18)		*(0/ 18)*
CE-144 (36)		(1.5 ± 1.3)E 0	11	(1.5 ± 1.3)E 0
(0)		(-9.7 - 11.0)E 0		(-9.7 - 11.0)E 0
		(0/ 18)		*(0/ 18)*
TH-232 (36)		(2.2 ± 0.7)E 0	11	(2.2 ± 0.7)E 0
(0)		(-5.7 - 6.9)E 0		(-5.7 - 6.9)E 0
		(0/ 18)		*(0/ 18)*

		CONTROL STATIONS
		**********
		MEAN RANGE NO. DETECTED**
		(3.0 ± 51.9)E -2
		(-5.7 - 5.1)E 0
		(0/ 18)
		(-1.0 ± 0.3)E 0
		(-3.2 - 1.5)E 0
		(0/ 18)
		(-2.9 ± 3.3)E 0
		(-2.2 - 3.4)E 1
		(0/ 18)
		(6.0 ± 2.9)E -2
		(8.9 - 44.0)E -2
		(0/ 15)
		(-9.8 ± 2.3)E -1
		(-2.7 - 0.8)E 0
		(0/ 18)
		(1.3 ± 0.4)E 0
		(-2.0 - 4.5)E 0
		(2/ 18)
		(-6.7 ± 5.3)E -1
		(-3.4 - 3.2)E 0
		(0/ 18)
		(3.4 ± 5.2)E -1
		(-5.0 - 3.3)E 0
		(0/ 18)
		(-1.5 ± 1.4)E 0
		(-1.3 - 1.4)E 1
		(0/ 18)
		(1.6 ± 1.0)E 0
		(-6.8 - 10.7)E 0
		(0/ 18)

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Figure 2.2.11-1
Pilgrim Nuclear Power Station

Radioactive Cesium-137 in Milk Samples
Taken near Pilgrim Station and at a Distant Location - 1988

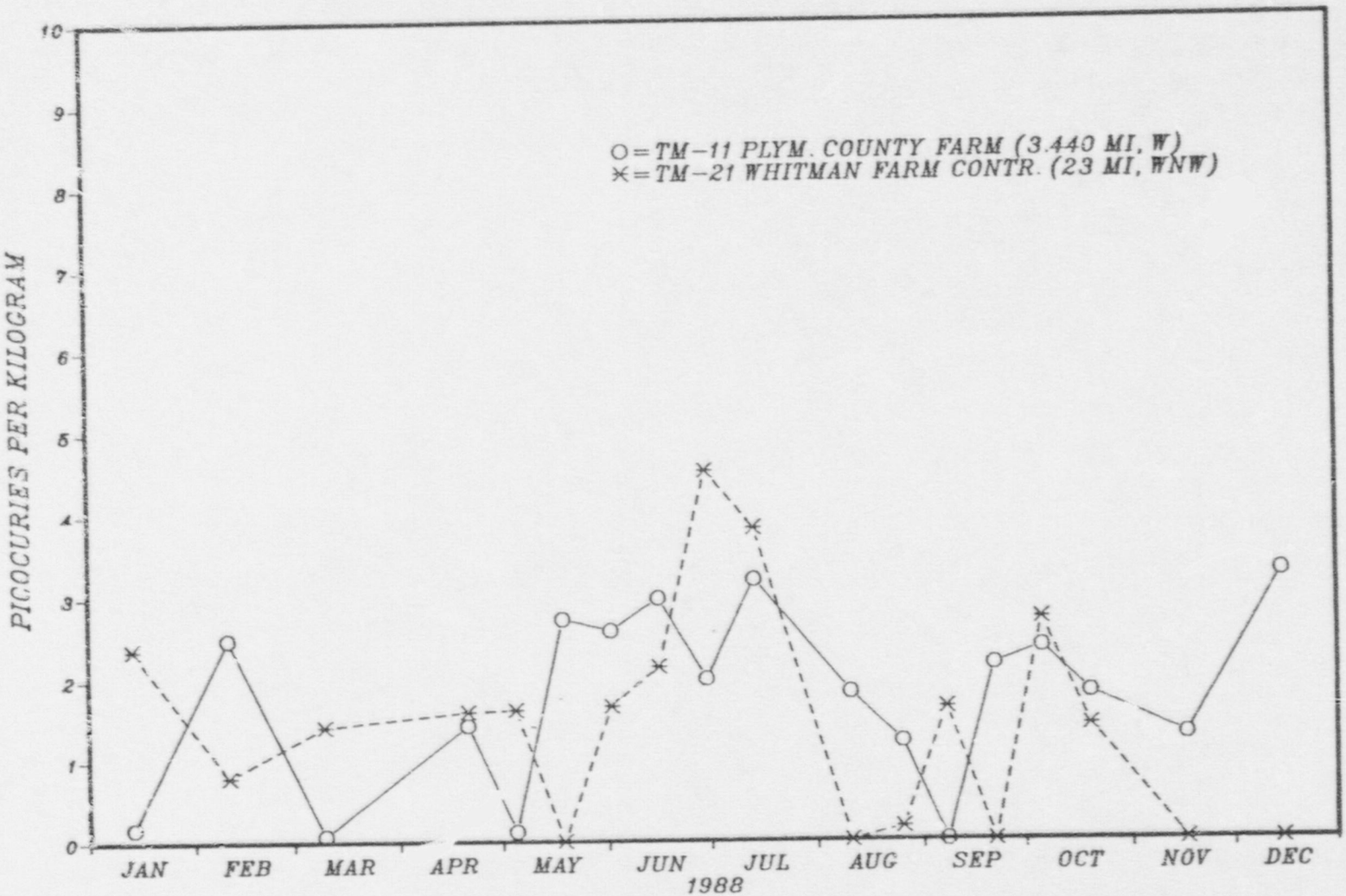


Figure 2.2.11-2
Pilgrim Nuclear Power Station

Radioactive Strontium-90 in Milk Samples
Taken near Pilgrim Station and at a Distant Location - 1988

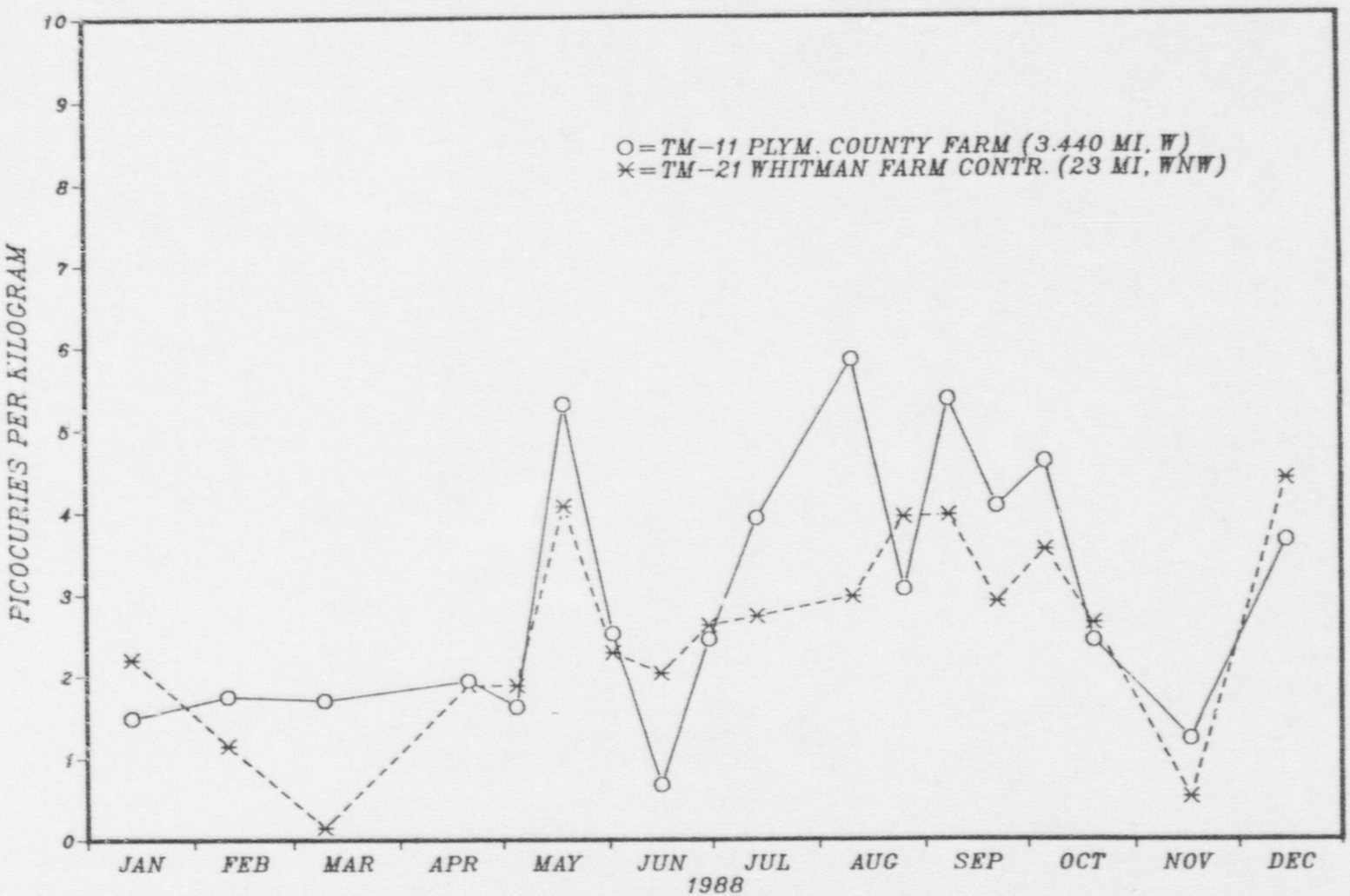
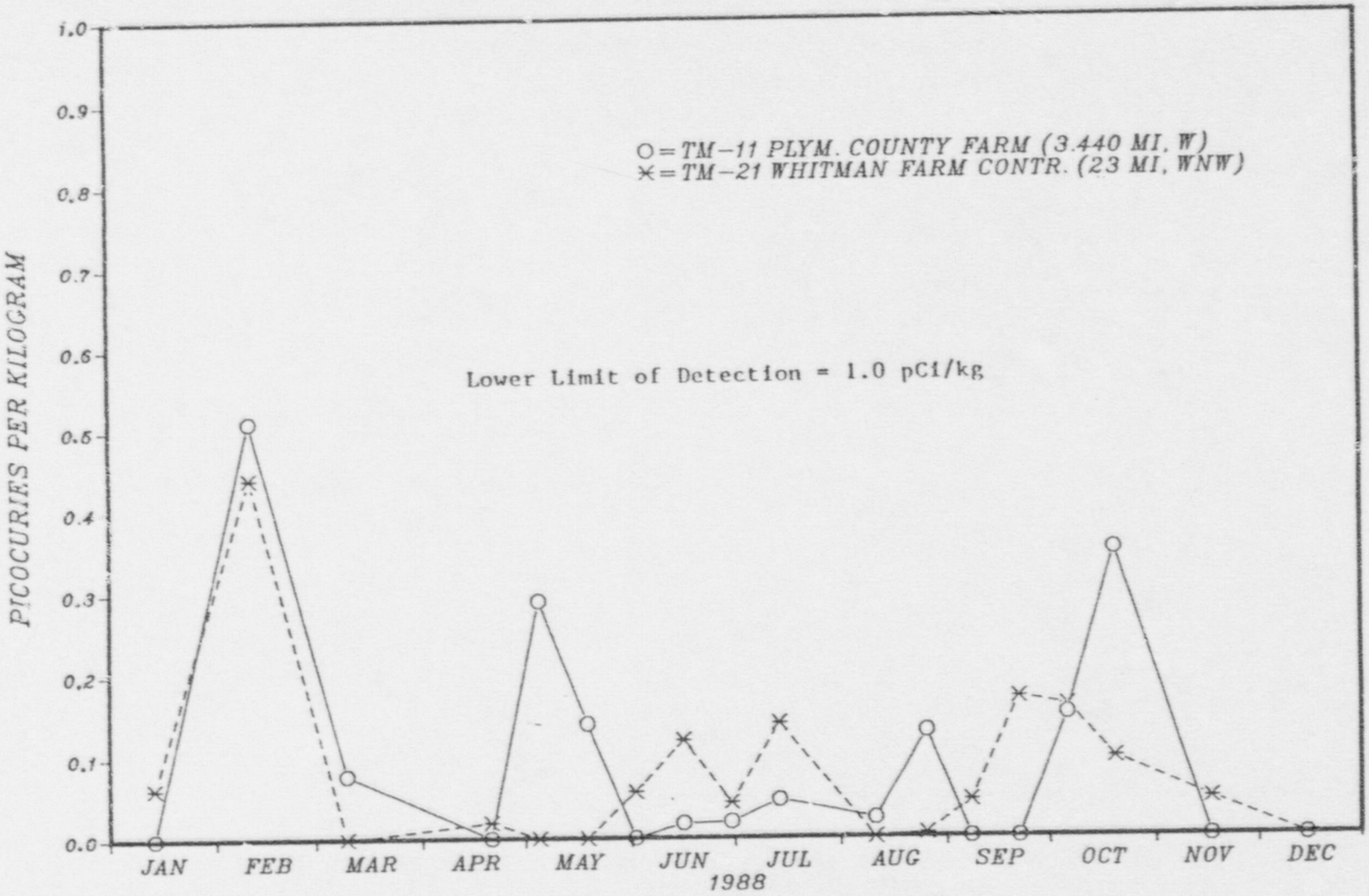


Figure 2.2.11-3
Pilgrim Nuclear Power Station

Radioactive Iodine-131 in Milk Samples
Taken near Pilgrim Station and at a Distant Location - 1988



2.2.12 Cranberries

Cranberries were collected from three locations during 1988 at the time of harvest: Manomet Point Bog, Bartlett Road Bog, and Pine Street Bog (control station). Cranberries were analyzed at harvest time for gamma-emitting isotopes in edible portions. All cranberry samples were collected and analyzed as required during 1988.

The summary of the radioactivity analysis results for cranberries collected during 1988 is presented in Table 2.2.12-1. Naturally-occurring potassium-40 was observed in all three cranberry samples. The only man-made radionuclide detected was cesium-137, which appeared in one sample. However, the detected concentration of cesium-137 is less than the average pre-operational concentrations of 170 pCi/kg. A comprehensive study of cesium uptake in cranberries was performed by Yankee Atomic Electric Co. during 1978,[22] and the results of this study are published in the 1978 Environmental Radiation Monitoring Program Report No. 11. This report identified fallout from previous atmospheric nuclear weapons testing as the primary source of cesium in cranberries. In addition, this report indicates that cesium uptake in cranberries can be enhanced when conditions of low soil potassium occur, as cesium is a chemical congener of potassium.

Therefore, analysis of cranberry samples collected during 1988 show no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.12-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Cranberries - 1988

MEDIUM: CRANBERRIES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (3)		(-4.2 ± 0.3)E 1	23	(2.4 ± 8.3)E 1	(2.4 ± 8.3)E 1
(0)		(-4.5 - -4.0)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
K-40 (3)		(8.3 ± 1.4)E 2	13	(9.7 ± 1.1)E 2	(6.7 ± 2.0)E 2
(0)		(6.9 - 9.7)E 2			
		(2/ 2)		*(1/ 1)*	*(1/ 1)*
MN-54 (3)		(-6.3 ± 37.3)E -1	23	(9.0 ± 8.6)E 0	(9.0 ± 8.6)E 0
(0)		(-4.4 - 3.1)E 0			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CO-58 (3)		(-2.2 ± 3.4)E 0	13	(1.1 ± 5.2)E 0	(-5.5 ± 9.6)E 0
(0)		(-5.6 - 1.1)E 0			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
FE-59 (3)		(-2.3 ± 0.6)E 1	23	(1.7 ± 2.0)E 1	(1.7 ± 2.0)E 1
(0)		(-2.9 - -1.8)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CO-60 (3)		(-5.3 ± 10.2)E 0	13	(4.9 ± 7.3)E 0	(-9.1 ± 13.2)E 0
(0)		(-1.5 - 0.5)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
ZN-65 (3)		(-4.5 ± 1.8)E 0	23	(3.7 ± 1.7)E 1	(3.7 ± 1.7)E 1
(0)		(-6.3 - -2.8)E 0			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
ZR-95 (3)		(8.4 ± 27.0)E 0	14	(3.5 ± 2.4)E 1	(-2.0 ± 1.9)E 1
(0)		(-1.9 - 3.5)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
RU-103 (3)		(-4.4 ± 8.4)E 0	13	(4.0 ± 4.8)E 0	(0.0 ± 9.6)E 0
(0)		(-1.3 - 0.4)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.12-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Cranberries - 1988

MEDIUM: CRANBERRIES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (3)		(7.9 ± 11.3)E 1	14	(1.9 ± 1.0)E 2	(-5.5 ± 6.5)E 1
(0)		(-3.4 - 19.2)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
I-131 (3)		(-3.7 ± 3.8)E 1	23	(5.6 ± 3.7)E 1	(5.6 ± 3.7)E 1
(0)		(-7.5 - 0.2)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CS-134 (3)	60.	(-3.9 ± 13.0)E 0	13	(9.0 ± 5.4)E 0	(-7.9 ± 8.6)E 0
(0)		(-1.7 - 0.9)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CS-137 (3)	60.	(8.3 ± 19.8)E 0	13	(2.8 ± 0.6)E 1	(1.4 ± 0.8)E 1
(0)		(-1.1 - 2.8)E 1			
		(1/ 2)		*(1/ 1)*	*(0/ 1)*
BA-140 (3)		(5.8 ± 1.9)E 0	14	(7.7 ± 25.7)E 0	(-1.7 ± 2.0)E 1
(0)		(3.8 - 7.7)E 0			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CE-141 (3)		(-1.7 ± 2.6)E 1	13	(9.1 ± 6.7)E 0	(-1.6 ± 1.5)E 1
(0)		(-4.4 - 0.9)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CE-144 (3)		(-4.4 ± 3.9)E 1	13	(-5.5 ± 24.6)E 0	(-5.8 ± 4.7)E 1
(0)		(-8.3 - -0.6)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
TH-232 (3)		(9.7 ± 37.5)E 0	13	(4.7 ± 2.1)E 1	(9.6 ± 42.8)E 0
(0)		(-2.8 - 4.7)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.2.13 Vegetation

Samples of tuberous and green leafy vegetables were collected at the time of harvest at six (6) locations: Whipple Farm, Alden Road Farm, Plymouth County Farm, Jenkins garden, Moon residence and Bridgewater Farm (control station). Vegetation samples were analyzed at the time of harvest for gamma-emitting isotopes in edible portions. All vegetation samples were collected and analyzed as required during 1988.

The summary of the radioactivity analysis results for vegetation collected in 1988 is presented in Table 2.2.13-1. Positive measurements of beryllium-7, potassium-40 and cesium-137 were observed in some samples. The beryllium-7 and potassium-40 are naturally-occurring, whereas the cesium-137 is a result of fallout from previous atmospheric nuclear weapons testing.

Therefore, analysis of vegetation samples collected during 1988 show no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.13-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Vegetation - 1988

MEDIUM: VEGETATION

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (18)		(4.8 ± 2.0)E 1	97	(1.8 ± 0.5)E 2	(-5.4 ± 6.0)E 1
(1)		(-6.8 - 17.9)E 1			(-1.5 - 0.6)E 2
		(1/ 15)		*(1/ 1)*	*(0/ 3)*
K-40 (18)		(2.5 ± 0.3)E 3	77	(3.9 ± 0.4)E 3	(2.0 ± 0.5)E 3
(0)		(4.3 - 41.0)E 2			(9.8 - 26.3)E 2
		(15/ 15)		*(1/ 1)*	*(3/ 3)*
MN-54 (18)		(-2.7 ± 2.4)E 0	27	(8.0 ± 3.3)E 0	(8.0 ± 3.3)E 0
(0)		(-2.2 - 1.3)E 1		(2.3 - 13.7)E 0	(2.3 - 13.7)E 0
		(0/ 15)		*(0/ 3)*	*(0/ 3)*
CO-58 (18)		(2.5 ± 1.9)E 0	96	(1.9 ± 1.1)E 1	(-5.7 ± 3.6)E 0
(0)		(-1.4 - 1.9)E 1			(-1.3 - -0.1)E 1
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
FE-59 (18)		(-5.9 ± 4.5)E 0	76	(1.0 ± 1.3)E 1	(-1.1 ± 0.3)E 1
(0)		(-3.4 - 2.5)E 1		(-2.5 - 22.6)E 0	(-1.7 - -0.6)E 1
		(0/ 15)		*(0/ 2)*	*(0/ 3)*
CO-60 (18)		(-4.0 ± 2.5)E 0	96	(2.0 ± 2.0)E 1	(9.8 ± 4.7)E 0
(0)		(-1.7 - 2.0)E 1			(9.6 - 168.0)E -1
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
ZN-65 (18)		(-5.3 ± 4.3)E 0	98	(1.1 ± 1.5)E 1	(-7.1 ± 7.4)E 0
(0)		(-4.8 - 2.5)E 1		(-4.2 - 25.5)E 0	(-2.1 - 0.4)E 1
		(0/ 15)		*(0/ 2)*	*(0/ 3)*
ZR-95 (18)		(-4.5 ± 4.4)E 0	76	(9.4 ± 0.7)E 0	(-3.4 ± 15.4)E 0
(0)		(-3.5 - 2.4)E 1		(8.8 - 10.1)E 0	(-3.4 - 1.2)E 1
		(0/ 15)		*(0/ 2)*	*(0/ 3)*
RU-103 (18)		(-1.2 ± 2.7)E 0	77	(1.3 ± 1.1)E 1	(-1.8 ± 4.1)E 0
(0)		(-2.5 - 1.3)E 1			(-1.0 - 0.3)E 1
		(0/ 15)		*(0/ 1)*	*(0/ 3)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.13-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Vegetation - 1988

MEDIUM: VEGETATION

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (18)		(-4.9 ± 2.7)E 1	60	(2.0 ± 1.2)E 1	(-3.3 ± 9.5)E 1
(0)		(-2.5 - 1.8)E 2		(8.4 - 32.1)E 0	(-1.9 - 1.4)E 2
		(0/ 15)		*(0/ 2)*	*(0/ 3)*
I-131 (18)		(-6.7 ± 4.6)E 0	77	(2.9 ± 2.1)E 1	(-1.9 ± 3.6)E 0
(0)		(-4.0 - 2.9)E 1			(-8.9 - 2.8)E 0
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
CS-134 (18)	60.	(-8.4 ± 3.4)E 0	77	(1.2 ± 1.5)E 1	(-6.9 ± 3.2)E 0
(0)		(-2.8 - 1.2)E 1			(-1.0 - 0.0)E 1
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
CS-137 (18)	60.	(2.4 ± 1.5)E 1	60	(1.1 ± 1.1)E 2	(1.8 ± 2.0)E 0
(2)		(-6.8 - 224.0)E 0		(0.0 - 2.2)E 2	(-1.9 - 4.7)E 0
		(2/ 15)		*(1/ 2)*	*(0/ 3)*
BA-140 (18)		(-4.4 ± 5.2)E 0	43	(3.0 ± 1.5)E 1	(1.0 ± 10.1)E 0
(0)		(-4.0 - 3.0)E 1			(-1.6 - 1.9)E 1
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
CE-141 (18)		(1.4 ± 3.4)E 0	77	(2.2 ± 1.6)E 1	(2.8 ± 1.8)E 0
(0)		(-2.5 - 2.2)E 1			(0.0 - 6.2)E 0
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
CE-144 (18)		(-1.2 ± 1.4)E 1	96	(6.4 ± 5.1)E 1	(3.0 ± 2.0)E 1
(0)		(-9.5 - 8.7)E 1			(-1.9 - 67.7)E 0
		(0/ 15)		*(0/ 1)*	*(0/ 3)*
TH-232 (18)		(1.8 ± 1.0)E 1	11	(5.7 ± 2.6)E 1	(-2.7 ± 1.8)E 1
(0)		(-3.7 - 10.8)E 1		(2.2 - 10.8)E 1	(-5.6 - 0.6)E 1
		(0/ 15)		*(0/ 3)*	*(0/ 3)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.2.14 Forage

Beef forage was collected from two (2) locations annually: Plymouth County Farm and Whitman Farm (control station). Forage samples were analyzed annually for gamma-emitting isotopes. All forage samples were collected and analyzed as required during 1988.

The summary of radioactivity analysis results for the forage collected during 1988 is presented in Table 2.2.14-1. Positive measurements of beryllium-7 and potassium-40 were detected at both stations. These radionuclides are both naturally-occurring. Cesium-137 was detected in the forage sample collected at the Plymouth County Farm. The cesuim-137 is a result of fallout from previous atmospheric weapons testing.

Therefore, analysis of forage samples collected during 1988 show no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2.14-1
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results for Forage - 1988

MEDIUM: FORAGE

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (2) (0)		(1.8 ± 0.2)E 3 *(1/ 1)*	11	(1.8 ± 0.2)E 3 *(1/ 1)*	(1.4 ± 0.3)E 3 *(1/ 1)*
K-40 (2) (0)		(5.8 ± 0.5)E 3 *(1/ 1)*	21	(1.1 ± 0.1)E 4 *(1/ 1)*	(1.1 ± 0.1)E 4 *(1/ 1)*
MN-54 (2) (0)	130.	(1.1 ± 1.9)E 1 *(0/ 1)*	11	(1.1 ± 1.9)E 1 *(0/ 1)*	(5.9 ± 24.6)E 0 *(0/ 1)*
CO-58 (2) (0)	130.	(1.8 ± 23.1)E 0 *(0/ 1)*	11	(1.8 ± 23.1)E 0 *(0/ 1)*	(-6.5 ± 2.8)E 1 *(0/ 1)*
FE-59 (2) (0)	260.	(-3.4 ± 4.6)E 1 *(0/ 1)*	11	(-3.4 ± 4.6)E 1 *(0/ 1)*	(-8.6 ± 5.9)E 1 *(0/ 1)*
CO-60 (2) (0)	130.	(-1.7 ± 2.8)E 1 *(0/ 1)*	21	(-1.4 ± 3.7)E 1 *(0/ 1)*	(-1.4 ± 3.7)E 1 *(/ 1)*
ZN-65 (2) (0)	260.	(1.6 ± 3.9)E 1 *(0/ 1)*	11	(1.6 ± 3.9)E 1 *(0/ 1)*	(-1.2 ± 5.8)E 1 *(0/ 1)*
ZR-95 (2) (0)		(1.2 ± 4.0)E 1 *(0/ 1)*	11	(1.2 ± 4.0)E 1 *(0/ 1)*	(-7.8 ± 5.1)E 1 *(0/ 1)*
RU-103 (2) (0)		(1.1 ± 2.2)E 1 *(0/ 1)*	21	(3.8 ± 2.8)E 1 *(0/ 1)*	(3.8 ± 2.8)E 1 *(0/ 1)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.2.14-1 (continued)
Pilgrim Nuclear Power Station

Summary of Radioactivity Analysis Results
for Forage - 1988

MEDIUM: FORAGE

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (2) (0)		(1.2 ± 1.6)E 2 *(0/ 1)*	11	(1.2 ± 1.6)E 2 *(0/ 1)*	(-3.0 ± 2.0)E 2 *(0/ 1)*
I-131 (2) (0)		(-8.2 ± 9.6)E 1 *(0/ 1)*	21	(1.6 ± 1.7)E 2 *(0/ 1)*	(1.6 ± 1.7)E 2 *(0/ 1)*
CS-134 (2) (0)	130.	(-2.2 ± 17.5)E 0 *(0/ 1)*	11	(-2.2 ± 17.5)E 0 *(0/ 1)*	(-5.3 ± 24.5)E 0 *(0/ 1)*
CS-137 (2) (1)	130.	(6.2 ± 1.5)E 1 *(1/ 1)*	11	(6.2 ± 1.5)E 1 *(1/ 1)*	(6.8 ± 24.5)E 0 *(0/ 1)*
BA-140 (2) (0)		(-1.1 ± 0.5)E 2 *(0/ 1)*	21	(1.5 ± 1.0)E 2 *(0/ 1)*	(1.5 ± 1.0)E 2 *(0/ 1)*
CE-141 (2) (0)		(5.9 ± 3.2)E 1 *(0/ 1)*	11	(5.9 ± 3.2)E 1 *(0/ 1)*	(-4.0 ± 4.0)E 1 *(0/ 1)*
CE-144 (2) (0)		(-1.6 ± 0.9)E 2 *(0/ 1)*	21	(-5.5 ± 10.2)E 1 *(0/ 1)*	(-5.5 ± 10.2)E 1 *(0/ 1)*
TH-232 (2) (0)		(7.9 ± 8.6)E 1 *(0/ 1)*	11	(7.9 ± 8.6)E 1 *(0/ 1)*	(3.3 ± 9.1)E 1 *(0/ 1)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASUREMENTS WHICH WERE GREATER THAN TEN (10) TIMES THE AVERAGE BACKGROUND FOR THE PERIOD OF THE REPORT.

** THE FRACTION OF SAMPLE ANALYSES YIELDING DETECTABLE MEASUREMENTS (I.E. >3 STD DEVIATIONS) IS INDICATED WITH *( )*.

3.0 SUMMARY OF RADIOLOGICAL IMPACT ON HUMANS

3.1 DESCRIPTION OF THE RADIOLOGICAL IMPACT ON HUMANS

The radiological impact to humans from the Pilgrim Station radioactive liquid and gaseous releases has been estimated using two methods:

1) calculations based on measurements of plant effluents, and

2) calculations based on measurements of environmental samples.

The first method utilizes data from the radioactive effluents (measured at the point of release) together with conservative models that calculate the dispersion and transport of radioactivity through the environment to humans.[7] The second method is based on actual measurements of radioactivity in the environmental samples and on dose conversion factors recommended by the Nuclear Regulatory Commission. The measured types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during 1988 were reported to the Nuclear Regulatory Commission, copies of which are provided in Appendix B. The measured levels of radioactivity in the environmental samples that required dose calculations are described in the special studies in Appendix A.

The maximum individual dose from liquid effluents was calculated using the following radiation exposure pathways (see Figure 1.5-1):

1) shoreline direct radiation during fishing and picnicing at the Pilgrim Station shorefront;

2) direct radiation from the ocean during boating and swimming; and

3) ingestion of fish and shellfish.

For gaseous effluents, the maximum individual dose was calculated using the following radiation exposure pathways:

1) direct radiation from submersion in gaseous effluents (not applicable during 1988);

2) inhalation of airborne radioactivity;

3) direct radiation from Pilgrim Station;

4) direct radiation from soil deposition;

5) consumption of vegetables; and

6) consumption of milk and meat.

3.2 RESULTS OF DOSE ASSESSMENTS

The results from the dose assessments based on radioactive effluents are compared with the federal radiation limits and natural/man-made radiation levels in Table 3.2-1. The dose assessment data was taken from the Annual Dose Assessment to the General Public from Radioactive Effluents Report for the period January 1, through December 31, 1988.[24]

Table 3.2-1
Pilgrim Nuclear Power Station

Comparison of 1988 Maximum Estimated Doses from PNPS Effluents to Federal Dose Limits and Natural/Man-Made Radiation Levels

Body Part	1988 Liquid Dose (mrem)	1988 Gaseous Dose (mrem)	1988 Total Dose* (mrem)	EPA Limit (mrem)	NRC Limit (mrem)	Natural/ Man-made (mrem)
Total Body	<0.003	<0.094	<0.097	25	500	420
Skin	<0.002	<0.110	<0.112	-	-	-
Thyroid	<0.002	<0.094	<0.096	75	-	-
Organ	<0.004	<0.105	<0.109	25	-	-

*Dose due to direct radiation from Pilgrim Station was not included in total dose, as the value for near-plant measurements was not statistically different than that for control locations.[24]

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (eg. diagnostic X-rays) sources of radiation. The typical American receives 420 mrem/yr from such sources.

As can be seen from the doses resulting from releases of radioactive effluents during 1988, all values are well within the federal limits specified by the NRC and EPA. In addition, the calculated doses from effluents represent only a fraction of a percent of doses from natural and man-made radiation.

A second method of dose estimation involves calculations based on radioactivity detected in environmental media. During 1988, four special studies were performed to determine the dose impact associated with radionuclides detected in blue mussels, Irish moss, sediment, and soil. These calculations are discussed in detail in Appendix A of this report.

Internal radiation doses associated with ingestion of radioactivity in blue mussels and Irish moss are discussed in Part I and Part II of Appendix A, respectively. The estimated maximum total body dose associated with the hypothetical ingestion of blue mussels taken from the Pilgrim Station Discharge Canal was 0.008 mrem/yr.[25] A similar calculation performed for ingestion of Irish moss, yielded a maximum hypothetical total body dose of 0.009 mrem/yr.[25]

External radiation doses associated with radioactivity detected in sediment and soil are discussed in Part III and Part IV of Appendix A, respectively. The maximum total body dose associated with recreation along the discharge canal from exposure to contaminated sediment was 0.0004 mrem/yr.[27] Finally, the maximum total body dose calculated from hypothetical exposure to radionuclides deposited on the soil surface was 3.9 mrem/yr.[26]

All of the doses calculated from environmental media results, whether considered individually or collectively, are well within federal dose limits specified by the NRC and EPA. In addition, the cumulative dose from such hypothetical exposures represents less than one percent of the typical annual dose received from natural and man-made sources.

Therefore, the radiological impact from Pilgrim Station operation is of insignificant consequence to public health.

V. References

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26. BECo Calulation No. PNPS-1-RTSD-III.A-3-0, "Dose Assessment for Soil Analysis Results for 1988 REMP Report," April 1989.

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APPENDIX A

SPECIAL STUDIES

APPENDIX A

SPECIAL STUDIES

PART I: BLUE MUSSELS

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part I: Blue Mussels

I. Introduction

As a part of the routine radiological environmental sampling program at PNPS, blue mussels are sampled and analyzed on a quarterly basis. During 1988, as in previous years, samples from the outfall of the PNPS discharge canal exhibited measurable quantities of cobalt-60. A special study similar to that performed in 1987, was conducted wherein mussels were taken from the inlet, middle and outlet of the discharge canal. This special study documents the radiological analysis results as well as the dose calculations to evaluate the radiological impact to a hypothetical member of the general public.

II. Background

Blue mussels (*Mytilus edulis*) are harvested from the Cape Cod Bay area and sold on the commercial market. Although mussels are not as popular a seafood as lobster or clams, they are eaten regularly by certain ethnic groups (estimated maximum ingestion rate of 9 kg/yr per capita). The uptake and elimination rates of radionuclides discharged by nuclear power plants by these filter feeding molluscs has been studied and documented.

The uptake rate can be described by the bioaccumulation factor which indicates how many times higher the concentration in the mussel will be than the radioactivity concentration in the water. The biological accumulation factors documented in the literature for cobalt-60, cesium-134, cesium-137 and manganese-54 range from 300-50,000 units.[1-4] This filtration or concentration effect by shellfish makes them a good indicator of radionuclide effects on the aquatic food chain because it is possible to detect radionuclides in the edible portions, even though the concentrations released into the discharge canal are well within the Nuclear Regulatory Commission's 10CFR20[5] permissible concentrations.

Since the present population of mussels did not release from the canal during the past two summers due to the station outage, and because of the lack of full dilution flow, they have been soaking and feeding in water that has relatively high radioactive concentrations (but less than NRC maximum permissible concentrations) for over two years. A reassessment of the radiological impact was determined to be prudent.

The following sections of this document will describe:

1) the recent radioactivity concentration measurements on the mussels in the discharge canal,

2) the estimated internal dose from the ingestion of these mussels, and

3) how these levels compare with existing regulatory limits and proposed guides or guidelines.

III. Mussel Radioactivity Measurements and Estimated Maximum Internal Dose From Ingestion

On June 28, 1988 Boston Edison's Company Senior Radiological Environmental Engineer and personnel from the Massachusetts Division of Marine Fisheries collected blue mussel samples from the Pilgrim Station discharge canal. Representative samples were collected at the inlet, middle and outlet of the discharge canal. The mussel bodies were removed from the shells to obtain approximately a half a kilogram sample from each location. The bodies and shells were analyzed by the Yankee Atomic Electric Co. Environmental Laboratory on July 15 - 22, 1988 (see Exhibit I-A). All samples were counted on a lithium drifted germanium detector using standard procedures.[10] The radioactivity concentrations reported in picocuries per kilogram (wet weight) are shown below:

Radioactivity Concentration of Blue Mussels Collected at the Inlet Middle and Outlet of the Pilgrim Station Discharge Canal

	Activity Concentration Bodies (pCi/kg)			Activity Concentration Shells (pCi/kg)		
Isotopes	Inlet	Middle	Outlet	Inlet	Middle	Outlet
Co-60	65.0 ± 2.9	92.1 ± 2.6	59.3 ± 2.4	88.5 ± 3.0	72.1 ± 3.9	72.1 ± 3.7
Cs-137	5.3 ± 1.3	6.2 ± 1.2	< MDC	< MDC	< MDC	< MDC

< MDC indicates that the measured concentration was less than the minimum detectable concentration.

Comparison of these concentrations to the concentrations for the mussels collected from the outfall of the discharge canal from March 1986 to October 1988 indicates that the present cobalt-60 concentrations for the mussels in the discharge canal are comparable to those observed in mussels collected from the discharge canal outfall over the past years.

Based on the maximum observed concentration in the mussel bodies (i.e., middle of canal) an estimate of the maximum internal dose from the ingestion of these mussels was calculated. This was based on the conservative assumption that the general public would ingest mussels that were raked from the discharge canal. The calculations were performed in accordance with the Pilgrim Nuclear Power Station Off-site Dose Calculation Manual.[13] The results shown in the following table indicate that the internal dose from the ingestion of mussel bodies harvested from the Pilgrim Nuclear Power Station discharge canal would be much less than 1 mrem/yr.

Estimated Maximum Internal Dose from Ingestion of Blue Mussels taken from Pilgrim Station Discharge Canal[14]

Organ	Adult (mrem/yr)	Teenager (mrem/yr)	Child (mrem/yr)
Total Body	0.008	0.005	0.005
Maximum Organ (GI)	0.03	0.02	0.008

IV. Comparison of Estimated Dose to Federal Dose Limits and Normal Radiation Levels

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (eg. diagnostic X-rays) sources of radiation. The typical American receives 420 mrem/yr from such sources.

When the maximum estimated total body dose of 0.008 mrem/yr was compared to the federal dose limits, such an exposure is well within established guidelines. In addition, the maximum dose calculated was a fraction of a percent of the radiation levels typically received each year by members of the general public.

V. Conclusions

In conclusion, the total radiological impact associated with slightly contaminated mussels present in the Pilgrim Nuclear Power Station discharge canal outfall is insignificant. This conclusion is based on the fact that the dose resulting from ingestion of these mussels would be much less than 1 mrem/yr to the exposed individual, which is well below federal radiation limits to the general public set forth by the Environmental Protection Agency and the Nuclear Regulatory Commission. In addition, the maximum estimated dose was much less than one percent of the natural/man-made radiation levels received annually by the average American.

VI. REFERENCES

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Exhibit I-A

MAILED

AUG 02 1988

YAEC
ENVIRONMENTAL LAB.

Yankee Atomic Electric Company
Environmental Laboratory

Initial Analysis Report

RECD REVD AND STATUS UPDATED
DATE: 8/4/88
INITIALS: KB

Customer: Boston Edison Company
Attention: Ms. Christine E. Bowman
Mr. Edward Cumming

Report Date: 07/28/88
Analysis Date: 07/15/88
Receipt Date: 07/08/88
Reference Date: 06/28/88

Mussel body

Station No: 93 Inlet of Discharge Canal

Sample Amount: 0.311 Kg
Elapsed Time: 18.9271 days
Comment:

Lab Sample #: G73582
Sample Code: PMU 93B2788
Analyses Req: G

	Nuclide	Decay Correction	Activity Conc. ± σ [Pico Curie / Kilogram]	MDC
x	Np-239	3.76E-03	(-33 ± 61)E-02	18E-01
	Co-57	9.53E-01	(-42 ± 46)E-01	14E 00
	Ce-144	9.55E-01	(-29 ± 15)E-01	45E-01
	Ce-141	6.68E-01		
x	Mo-99	8.92E-03	(-16 ± 11)E-01	34E-01
	Se-75	8.97E-01	(-12 ± 10)E 00	31E 00
	Cr-51	6.22E-01	(-48 ± 41)E-01	12E 00
	I-131	1.96E-01	(269 ± 94)E-01	27E 00
	Be-7	7.81E-01	(17 ± 12)E-01	33E-01
	Ru-103	7.17E-01		
x	I-133	3.08E-07	(-51 ± 30)E-01	10E 00
	Ba-140	3.59E-01	(-20 ± 13)E-01	48E-01
	Cs-134	9.83E-01	(-8 ± 10)E 00	32E 00
	Ru-106	9.65E-01	(53 ± 13)E-01	42E-01
*+	Cs-137	9.99E-01	(-3 ± 16)E-01	51E-01
	Ag-110M	9.49E-01	(-5 ± 23)E-01	72E-01
	Zr-95	8.17E-01	(-20 ± 13)E-01	41E-01
	Co-58	8.31E-01	(21 ± 12)E-01	37E-01
	Mn-54	9.59E-01	(54 ± 55)E-01	21E 00
	AcTh228	10.0E-01	(-47 ± 41)E 01	13E 02
	TeI-132	1.77E-02	(-22 ± 30)E-01	97E-01
	Fe-59	7.48E-01	(41 ± 29)E-01	99E-01
	Zn-65	9.48E-01	(650 ± 29)E-01	64E-01
*+	Co-60	9.93E-01	(1755 ± 39)E 00	61E 00
*+	K-40	10.0E-01	(-43 ± 30)E-01	10E 00
	Sb-124	8.04E-01		

Approved by

E. L. Laurenzo

Notes:
* Activity greater than 3 standard deviations
+ Peak is found
x Decay correction is less than .01
@ Activity exceeds reporting level

MAILED

AUG 09 1988

YAEC
ENVIRONMENTAL LAB.

RECEIVED AND STATUS UPDATED
DATE: 8/12/88
INITIALS: [illegible]

Yankee Atomic Electric Company
Environmental Laboratory

Initial Analysis Report

Customer: Boston Edison Company
Attention: Ms. Christine E. Bowman
Mr. Edward Cumming

Report Date: 08/05/88
Analysis Date: 07/15/88
Receipt Date: 07/08/88
Reference Date: 06/28/88

Mussel body

Station No: S3 Middle of Discharge Canal

Sample Amount: 0.350 Kg
Elapsed Time: 18.7361 days
Comment:

Lab Sample #: G73584
Sample Code: PMU 93C2788
Analyses Req: G

	Nuclide	Decay Correction	Activity Conc. ± σ [Pico Curie / Kilogram]	MDC
x	Np-239	3.98E-03		21E-01
	Co-57	9.53E-01	(-8[illegible] ± 69)E-02	19E 00
	Ce-144	9.55E-01	(135 ± 59)E-01	52E-01
	Ce-141	6.71E-01	(19 ± 12)E-01	
x	Mo-99	9.36E-03		38E-01
	Se-75	8.98E-01	(-31 ± 13)E-01	34E 00
	Cr-51	6.25E-01	(-3 ± 11)E 00	13E 00
	I-131	1.99E-01	(49 ± 44)E-01	21E 00
*+	Be-7	7.83E-01	(367 ± 83)E-01	36E-01
	Ru-103	7.19E-01	(23 ± 13)E-01	
x	I-133	3.58E-07		11E 00
	Ba-140	3.63E-01	(-42 ± 29)E-01	40E-01
	Cs-134	9.83E-01	(-9 ± 12)E-01	25E 00
	Ru-106	9.65E-01	(-194 ± 81)E-01	35E-01
*+	Cs-137	9.99E-01	(62 ± 12)E-01	49E-01
	Ag-110M	9.50E-01	(-20 ± 15)E-01	70E-01
	Zr-95	8.19E-01	(-10 ± 22)E-01	38E-01
	Co-58	8.32E-01	(-7 ± 12)E-01	43E-01
	Mn-54	9.59E-01	(12 ± 13)E-01	17E 00
+	AcTh228	10.0E-01	(99 ± 47)E-01	12E 02
	TeI-132	1.84E-02	(-36 ± 38)E 01	88E-01
	Fe-59	7.50E-01	(7 ± 28)E-01	94E-01
	Zn-65	9.48E-01	(38 ± 28)E-01	59E-01
*+	Co-60	9.93E-01	(921 ± 26)E-01	46E 00
*+	K-40	10.0E-01	(1674 ± 31)E 00	81E-01
	Sb-124	8.06E-01	(-25 ± 24)E-01	

Notes:
* Activity greater than 3 standard deviations
+ Peak is found
x Decay correction is less than .01

Reporting level ratio: 0.000

Approved by

Estella Lawrence

MAILED

AUG 02 1988

YAEC
ENVIRONMENTAL LAB.

Yankee Atomic Electric Company
Environmental Laboratory

Initial Analysis Report

DATA REVD AND STATUS UPDATED
DATE: 8/4/88
INITIALS:

Customer: Boston Edison Company
Attention: Ms. Christine E. Bowman
Mr. Edward Cumming

Report Date: 07/28/88
Analysis Date: 07/15/88
Receipt Date: 07/08/88
Reference Date: 06/28/88

Mussel body

Station No: 93 Outlet of Discharge Canal

Sample Amount: 0.330 Kg
Elapsed Time: 19.0342 days
Comment:

Lab Sample #: G73580
Sample Code: PMU 93A2788
Analyses Req: G

	Nuclide	Decay Correction	Activity Conc. ± σ [Pico Curie / Kilogram]	MDC
x	Np-239	3.65E-03		
	Co-57	9.52E-01	(12 ± 68)E-02	22E-01
	Ce-144	9.55E-01	(-104 ± 51)E-01	17E 00
	Ce-141	6.66E-01	(8 ± 17)E-01	56E-01
x	Mo-99	8.69E-03		
	Se-75	8.96E-01	(4 ± 12)E-01	41E-01
	Cr-51	6.21E-01	(9 ± 11)E 00	36E 00
	I-131	1.94E-01	(46 ± 45)E-01	15E 00
	Be-7	7.80E-01	(34 ± 12)E 00	39E 00
	Ru-103	7.15E-01	(-14 ± 15)E-01	52E-01
x	I-133	2.83E-07		
	Ba-140	3.57E-01	(38 ± 35)E-01	13E 00
	Cs-134	9.83E-01	(-7 ± 13)E-01	44E-01
	Ru-106	9.65E-01	(-1 ± 11)E 00	38E 00
	Cs-137	9.99E-01	(-5 ± 12)E-01	42E-01
	Ag-110M	9.49E-01	(-15 ± 17)E-01	61E-01
	Zr-95	8.16E-01	(60 ± 23)E-01	79E-01
	Co-58	8.30E-01	(-16 ± 13)E-01	47E-01
	Mn-54	9.59E-01	(20 ± 12)E-01	41E-01
+	AcTh228	10.0E-01	(-44 ± 46)E-01	18E 00
	TeI-132	1.73E-02	(-8 ± 48)E 01	17E 02
	Fe-59	7.46E-01	(30 ± 34)E-01	12E 00
	Zn-65	9.47E-01	(9 ± 31)E-01	11E 00
*+	Co-60	9.93E-01	(543 ± 24)E-01	67E-01
*+	K-40	10.0E-01	(1691 ± 34)E 00	75E 00
	Sb-124	8.03E-01	(10 ± 35)E-01	13E 00

Notes:
* Activity greater than 3 standard deviations
+ Peak is found
x Decay correction is less than .01
@ Activity exceeds reporting level

Approved by

E. L. Laurenzo

MAILED

AUG 02 1988

YAEC
ENVIRONMENTAL LAB.

Yankee Atomic Electric Company
Environmental Laboratory

Initial Analysis Report

RECD REVD AND STATUS UPDATED
DATE: 8/4/88
INITIALS: TJD

Customer: Boston Edison Company
Attention: Ms. Christine E. Bowman
Mr. Edward Cumming

Report Date: 07/28/88
Analysis Date: 07/22/88
Receipt Date: 07/08/88
Reference Date: 06/28/88

Mussel shell

Station No: S3 Inlet of Discharge Canal

Sample Amount: 0.947 Kg
Elapsed Time: 24.8214 days
Comment:

Lab Sample #: G73581
Sample Code: PMUsS3B2788
Analyses Req: G

	Nuclide	Decay Correction	Activity Conc. ± σ [Pico Curie / Kilogram]	MDC
x	Np-239	6.61E-04		
	Co-57	9.38E-01	(-77 ± 69)E-02	21E-01
	Ce-144	9.41E-01	(-7 ± 50)E-01	19E 00
	Ce-141	5.89E-01	(-28 ± 19)E-01	58E-01
x	Mo-99	2.05E-03		
	Se-75	8.67E-01	(-4 ± 12)E-01	37E-01
	Cr-51	5.37E-01	(-16 ± 12)E 00	36E 00
	I-131	1.18E-01	(95 ± 69)E-01	20E 00
*+	Be-7	7.24E-01	(88 ± 11)E 00	27E 00
	Ru-103	6.46E-01	(9 ± 13)E-01	36E-01
x	I-133	2.89E-09		
	Ba-140	2.61E-01	(22 ± 37)E-01	13E 00
	Cs-134	9.77E-01	(-15 ± 13)E-01	46E-01
	Ru-106	9.54E-01	(50 ± 99)E-01	31E 00
	Cs-137	9.98E-01	(18 ± 11)E-01	34E-01
	Ag-110M	9.34E-01	(4 ± 15)E-01	48E-01
	Zr-95	7.67E-01	(8 ± 22)E-01	69E-01
	Co-58	7.84E-01	(-10 ± 13)E-01	41E-01
	Mn-54	.46E-01	(35 ± 12)E-01	34E-01
+	AcTh228	10.0E-01	(139 ± 47)E-01	16E 00
x	TeI-132	5.02E-03		
	Fe-59	6.83E-01	(44 ± 29)E-01	88E-01
	Zn-65	9.32E-01	(35 ± 27)E-01	90E-01
*+	Co-60	9.91E-01	(885 ± 30)E-01	61E-01
*+	K-40	10.0E-01	(405 ± 24)E 00	59E 00
	Sb-124	7.51E-01	(5 ± 26)E-01	85E-01

Approved by

Notes:
* Activity greater than 3 standard deviations
+ Peak is found
x Decay correction is less than .01

Reporting level ratio: 0.000

E. L. Laurenzo

MAILED

AUG 02 19[illegible]

YAEC
ENVIRONMENTAL LAB.

Yankee Atomic Electric Company
Environmental Laboratory

Initial Analysis Report

RECD REV'D AND STATUS UPDATED
DATE: 8/4/88
INITIALS: [illegible]

Customer: Boston Edison Company
Attention: Ms. Christine E. Bowman
Mr. Edward Cumming

Report Date: 07/28/88
Analysis Date: 07/20/88
Receipt Date: 07/08/88
Reference Date: 06/28/88

Mussel shell

Station No: S3 Middle of Discharge Canal

Sample Amount: 0.740 Kg
Elapsed Time: 22.6685 days
Comment:

Lab Sample #: G73583
Sample Code: PMUs93C2788
Analyses Req: G

	Nuclide	Decay Correction	Activity Conc. ± σ [Pico Curie / Kilogram]	MDC
x	Np-239	1.25E-03	(-4 ± 10)E-01	34E-01
	Co-57	9.44E-01	(12 ± 79)E-01	26E 00
	Ce-144	9.46E-01	(-46 ± 27)E-01	91E-01
	Ce-141	6.17E-01		
x	Mo-99	3.51E-03	(-5 ± 18)E-01	60E-01
	Se-75	8.78E-01	(13 ± 17)E 00	57E 00
	Cr-51	5.67E-01	(38 ± 85)E-01	28E 00
	I-131	1.42E-01	(56 ± 14)E 00	37E 00
*+	Be-7	7.44E-01	(-5 ± 18)E-01	61E-01
	Ru-103	6.71E-01		
x	I-133	1.59E-08	(-25 ± 50)E-01	18E 00
	Ba-140	2.93E-01	(-27 ± 19)E-01	67E-01
	Cs-134	9.79E-01	(-2 ± 15)E 00	52E 00
	Ru-106	9.58E-01	(38 ± 17)E-01	55E-01
	Cs-137	9.99E-01	(-8 ± 24)E-01	85E-01
	Ag-110M	9.39E-01	(-37 ± 34)E-01	12E 00
	Zr-95	7.85E-01	(-9 ± 18)E-01	65E-01
	Co-58	8.01E-01	(47 ± 17)E-01	55E-01
	Mn-54	9.51E-01	(59 ± 70)E-01	26E 00
	AcTh228	10.0E-01		
x	TeI-132	7.95E-03	(-32 ± 40)E-01	14E 00
	Fe-59	7.06E-01	(-53 ± 35)E-01	13E 00
	Zn-65	9.38E-01	(783 ± 39)E-01	89E-01
*+	Co-60	9.92E-01	(218 ± 30)E 00	96E 00
*+	K-40	10.0E-01	(6 ± 37)E-01	13E 00
	Sb-124	7.70E-01		

Approved by

Notes:
. Activity greater than 3 standard deviations
* Peak is found
x Decay correction is less than .01

Reporting level ratio: 0.000

E. L. Laurenzo

MAILED

AUG 02 1988

YAEC
ENVIRONMENTAL LAB

Yankee Atomic Electric Company
Environmental Laboratory

Initial Analysis Report

RECD REV'D AND STATUS UPDATED
DATE: 8/4/88
INITIALS: [illegible]

Customer: Boston Edison Company
Attention: Ms. Christine E. Bowman
Mr. Edward Cumming

Report Date: 07/28/88
Analysis Date: 07/21/88
Receipt Date: 07/08/88
Reference Date: 06/28/88

Mussel shell

Station No: 93 Outlet of Discharge Canal

Sample Amount: 0.958 Kg
Elapsed Time: 23.5549 days
Comment:

Lab Sample #: G73579
Sample Code: PMUs93A2788
Analyses Req: G

	Nuclide	Decay Correction	Activity Conc. ± σ [Pico Curie / Kilogram]	MDC
x	Np-239	9.61E-04		25E-01
	Co-57	9.42E-01	(-200 ± 85)E-02	24E 00
	Ce-144	9.44E-01	(6 ± 72)E-01	69E-01
	Ce-141	6.05E-01	(0 ± 24)E-01	
x	Mo-99	2.81E-03		47E-01
	Se-75	8.73E-01	(-31 ± 15)E-01	44E 00
	Cr-51	5.54E-01	(-0 ± 15)E 00	24E 00
	I-131	1.31E-01	(-73 ± 80)E-01	35E 00
	Be-7	7.36E-01	(28 ± 13)E 00	47E-01
	Ru-103	6.61E-01	(-19 ± 15)E-01	
x	I-133	7.88E-09		15E 00
	Ba-140	2.79E-01	(5 ± 42)E-01	55E-01
	Cs-134	9.79E-01	(18 ± 16)E-01	36E 00
	Ru-106	9.57E-01	(9 ± 12)E 00	42E-01
	Cs-137	9.99E-01	(-8 ± 13)E-01	59E-01
	Ag-110M	9.37E-01	(6 ± 19)E-01	81E-01
	Zr-95	7.78E-01	(34 ± 27)E-01	48E-01
	Co-58	7.94E-01	(-6 ± 15)E-01	51E-01
	Mn-54	9.49E-01	(23 ± 16)E-01	30E 00
*+	AcTh228	10.0E-01	(270 ± 85)E-01	
x	TeI-132	6.58E-09		98E-01
	Fe-59	6.96E-01	(63 ± 34)E-01	11E 00
	Zn-65	9.35E-01	(24 ± 32)E-01	86E-01
*+	Co-60	9.92E-01	(721 ± 37)E-01	75E 00
*+	K-40	10.0E-01	(282 ± 28)E 00	12E 00
	Sb-124	7.62E-01	(-13 ± 35)E-01	

Notes:
* Activity greater than 3 standard deviations
+ Peak is found
x Decay correction is less than .01

Reporting level ratio: 0.000

Approved by

E. L. Laurenzo

APPENDIX A

SPECIAL STUDIES

PART II: IRISH MOSS

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part II: Irish Moss

I. Introduction

As part of the routine environmental sampling program at PNPS, Irish moss (algae) is sampled and analyzed on a quarterly basis. During 1988, as in previous years, samples from the outfall of the PNPS discharge canal exhibited measurable quantities of cobalt-60. This special study documents the dose calculations that have been performed to evaluate the radiological impact to a hypothetical member of the general public.

II. Background

Irish moss (Chondrus crispus) is a marine red algae (seaweed) that is common to temperate waters. Irish moss is a commercially valuable resource in western Cape Cod Bay, especially in the vicinity of PNPS. Irish moss has been harvested for over a century from the waters from Scituate to Plymouth.[1]

This seaweed grows naturally attached to rocks, boulders, ledges, and shells for support, and is distributed a few feet from shore to about a mile seaward. Greatest concentrations are usually within 20 feet below mean low water level.[1]

Irish moss is harvested by independent fishermen (called mossers) who use specially-designed long-handled rakes that scrape the moss off the rocky surfaces on which it grows. Typically, harvesting of Irish moss in the Plymouth area is carried out from the end of May to September, only 7,000 to 8,000 pounds of Irish moss was harvested in the Plymouth area in 1988.[2]

Once harvested, the Irish moss is eventually processed into a fine white powder called carrageenan, a starch-like extract used as an additive in foods and other commercial products. Carrageenan serves as a food stabilizer, thickener, and gelling agent. Products containing carrageenan include: pudding, jello, cocoa mix, chocolate milk and syrup, ice cream, non-dairy coffee creamer, salad dressing, milk of magnesia, air deodorizers, shampoo, toothpaste, and hand lotion.[1]

III. Radioactivity Measurements

The following table summarizes the positive results that were obtained from Irish moss samples taken in 1988. Measurable quantities of cobalt-60 were observed, but no other radioactive isotopes were measured that could be attributed to PNPS (see Exhibit II-A).

Although there is no specific regulatory guidance relating to the permissible concentrations of radioisotopes in Irish moss, it will be shown that, even with conservative assumptions, projected doses to any member of the general public from consumption of Irish moss is a small fraction of the annual dose limit.

1988 Irish Moss Samples Showing Detectable Levels Of Cobalt-60

Station Description	Date Collected	Concentration ± SD (pCi/kg wet)
		Cobalt-60
Discharge Canal Outfall	3/02/88	219 ± 12
Discharge Canal Outfall	5/11/88	65 ± 10
Discharge Canal Outfall	7/26/88	38.2 ± 8.0
Discharge Canal Outfall	10/17/88	27.8 ± 7.0

IV. Dose Calculations

NRC Regulatory Guide 1.109[3] provides the methodology for projecting doses to the public from ingestion of aquatic foods. As discussed previously, Irish moss is not eaten directly, but is processed and used as a food additive. A reliable value for a usage factor (i.e., the amount of Irish moss ultimately consumed per year) could not be found in the literature, as Irish moss is utilized in so many different products. As an extremely conservative alternative, the usage factors for "other seafood" were used (R. G. 1.109, Table E-5).

In addition to assuming a conservative value for the usage factor, it is also assumed that the peak concentrations of cobalt-60 (observed in the sample collected on 3/2/88) existed in all Irish moss that was consumed by the hypothetical maximum exposed individual.

The results, summarized in the table below, indicate that the internal dose from the ingestion of Irish moss harvested in the vicinity of the Pilgrim Nuclear Power Station would be less than 1 mrem/year. This amount of internal dose is not likely to cause any health effects, and is well below the dose that is normally received by naturally-occurring radionuclides (e.g., potassium-40) that are present in most foods.

Estimated Maximum Internal Dose from the Ingestions of Irish Moss Harvested in the Vicinity of the Pilgrim Nuclear Power Station

Organ	Adult (mrem/yr)	Teenager (mrem/yr)	Child (mrem/yr)
Total Body	0.009	0.008	0.01
Maximum Organ (GI)	0.08	0.05	0.02

V. Comparison of Estimated Dose to Federal Dose Limits and Normal Radiation Levels

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (eg. diagnostic X-rays) sources of radiation. The typical American receives 420 mrem/yr from such sources.

When the maximum estimated total body dose of 0.01 mrem/yr was compared to the federal dose limits, such an exposure is well within established guidelines. In addition, the maximum dose calculated was only about one percent of the radiation levels typically received each year by members of the general public.

VI. Conclusions

In conclusion, the total radiological impact of slightly contaminated Irish moss in the vicinity of Pilgrim Nuclear Power Station is insignificant. This conclusion is based on the fact that the dose resulting from ingestion of the Irish moss would be less than 1 mrem/yr to the exposed individual, which is well below the regulatory limits set forth by the Nuclear Regulatory Commission and EPA. Further, the additional dose represents only a fraction of a percent of typical background radiation doses received each year by an individual.

VII. References

1. Division of Marine Fisheries Newsletter, November - December 1984.

2. Mando Borgatti letter to Bruce Dionne, dated March 28, 1989.

3. U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I," Regulatory Guide 1.109, October 1977.

4. United States of America, Code of Federal Regulations, Title 10, Part 50, Appendix I.

5. United States of America, Code of Federal Reglations, Title 10, Part 20.

6. United States of America, Code of Federal Regulations, Title 40, Part 190.

7. Boston Edison Company, Pilgrim Nuclear Power Station, Docket No. 50-297, Facility Operating License (FOL), No. DPR-35 Appendix A.

8. BECo Calculation No. PNPS-1-RTSD-III.A-1-0, "Dose Assessment from Blue Mussels and Irish Moss Analysis Results for 1988 REMP Report," April 1989.

MAILED
MAY 02 19
YAEC
ENVIRONMENTAL LAB.

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

RECEIVED AND STATUS UPDATED
DATE: 5/88
INITIALS: TBS

Customer : Boston Edison Company
Attention: MS. CHRISTINE E. BOWMAN
MR. EDWARD CUMMING

Report Date: 04/28/88
Analysis Date: 4 /21/88
Date Received: 3 /28/88
Reference Date: 3 /22/88

Irish Moss

Sample Amount: 1.04 Kg.
Lab Sample No.: G71624
Sample Submission Code: PALI11 1388
Elapsed Time : 30.19 days
Other Analysis Requested: None

Station No.: 11 Rocky Point-Discharge Canal Outfall

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram]	MDC [ ]
xNp-239	1.36E-04	----	----
Co-57	9.26E-01	(-8 +- 31) E-1	100 E-1
Ce-144	9.29E-01	(4 +- 22) E 0	73 E 0
Ce-141	5.25E-01	(-91 +- 93) E-1	310 E-1
xMo-99	5.38E-04	----	----
Se-75	8.40E-01	(-63 +- 51) E-1	170 E-1
Cr-51	4.70E-01	(-47 +- 50) E 0	170 E 0
I -131	7.41E-02	(-3 +- 42) E 0	140 E 0
Be-7	6.75E-01	(68 +- 44) E 0	150 E 0
Ru-103	5.88E-01	(-96 +- 56) E-1	190 E-1
xI -133	4.12E-11	----	----
Ba-140	1.95E-01	(12 +- 10) E 0	35 E 0
Cs-134	9.73E-01	(-21 +- 36) E-1	120 E-1
Ru-106	9.45E-01	(23 +- 34) E 0	110 E 0
Cs-137	9.98E-01	(116 +- 46) E-1	150 E-1
Ag-110M	9.20E-01	(-38 +- 85) E-1	280 E-1
Zr-95	7.25E-01	(-4 +- 10) E 0	35 E 0
Co-58	7.44E-01	(-9 +- 60) E-1	200 E-1
Mn-54	9.35E-01	(32 +- 52) E-1	170 E-1
AcTh228	1.00E 00	(-16 +- 19) E 0	71 E 0
xTeI-132	1.60E-03	----	----
Fe-59	6.29E-01	(5 +- 17) E 0	57 E 0
Zn-65	9.18E-01	(15 +- 13) E 0	43 E 0
*+ Co-60	9.89E-01	(219 +- 12) E 0	24 E 0
*+ K -40	1.00E 00	(693 +- 19) E 1	13 E 1
Sb-124	7.06E-01	(-45 +- 88) E-1	290 E-1

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

D.E.McCurdy.

APPENDIX A

SPECIAL STUDIES

PART III: SEDIMENT

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part III: Sediment

I. Introduction

As a part of the routine radiological environmental sampling program at PNPS, sediment samples are collected along the coast on a semi-annual basis. During 1988, cobalt-60 was detected in a sediment sample collected at the outfall of the Pilgrim Station discharge canal. This special study documents the radiological analysis results as well as dose calculations to evaluate the radiological impact to a hypothetical member of the general public.

II. Background

Sediment in the vicinity of the discharge canal receives deposition of radioactivity from Pilgrim Station liquid effluents. The jetty along the discharge canal is a popular fishing ground used by the general public. The estimated maximum dose from external radiation from shoreline deposits along the discharge canal of Pilgrim Station will be determined.

III. Sediment Radioactivity Measurements and Estimated Maximum External Dose from Shoreline Deposits

On May 11, 1988, the Massachusetts Division of Marine Fisheries personnel collected sediment samples from the outfall of the Pilgrim Station discharge canal. The 30cm long cores were segmented into 2cm slices and analyzed by the Yankee Atomic Electric Company Environmental Laboratory on June 16, 1988 (See Exhibit III-A). The radioactivity concentration for cobalt-60 for the 12-14 cm segment was 11.2 ± 2.6 pC/kg. It should be noted that cobalt-60 levels in the 0-2cm, 4-6cm and 8-10cm segments were below the minimum detectable concentration.

Dose calculations were performed in accordance with the Pilgrim Nuclear Power Station Offsite Dose Calculation Manual (ODCM)[1]. The observed cobalt-60 concentration was assumed to be uniformly distributed along the edge of the discharge canal to a depth of 15cm. The usage factors for recreational activities along the discharge canal from the PNPS ODCM are: adult 12 hr/yr, teen 67 hr/yr, and child 14 hr/yr. The results shown in the following table indicate that the external dose from shoreline deposits of cobalt-60 at the Pilgrim Station discharge canal are insignificant.

Estimated Maximum External Dose From
Shoreline Deposits Along Pilgrim Station Discharge Canal[2]

Organ	Adult (mrem/yr)	Teen (mrem/yr)	Child (mrem/yr)
Total Body	0.00005	0.0003	0.00006
Skin	0.00006	0.0004	0.00007

IV. Comparison of Estimated Dose to Federal Dose Limits and Normal Radiation Levels

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (eg. diagnostic X-rays) sources of radiation. The typical American receives 420 mrem/yr from such sources.

When the maximum estimated total body dose of 0.0003 mrem/yr was compared to the federal dose limits, such an exposure is well within established guidelines. In addition, the maximum dose calculated was negligible compared to the radiation levels typically received each year by members of the general public.

V. Conclusions

In conclusion, the total radiological impact of slighly contaminated sediment in the vicinity of Pilgrim Nuclear Power Station discharge canal is insignificant. This conclusion is based on the fact that the dose resulting from external radiation from the sediment along the discharge canal would be less than 1 mrem/yr to the exposed individual, which is well below the regulatory limits set forth by the Nuclear Regulatory Commission and EPA. Further, the additional dose represents a fraction of a percent of typical background radiation doses received by an individual each year.

VI. References

1. Boston Edison Company, Pilgrim Nuclear Power Station, Offsite Dose Calculation Manual, Revision 2, September 1988.

2. BECo Calculation No. PNPS-1-RTSD-III.A-2-0, "Dose Assessment for Sediment along Discharge Canal Analysis Results for 1988 REMP Report," April 1989.

MAILED

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

RECEIVED AND CHECKED IN LAB
DATE: 6-23-88
INITIALS: TJS

Customer : Boston Edison Company
Attention: MS. CHRISTINE E. BOWMAN
MR. EDWARD CUMMING

Report Date: 06/20/88
Analysis Date: 6 /16/88
Date Received: 5 /20/88
Reference Date: 5 /11/88

Sediment, 4th section

Sample Amount: 0.58 Kg.
Lab Sample No.: G72661
Sample Submission Code: PSE411 2088
Elapsed Time : 37.44 days
Other Analysis Requested: P
Comment: 12-14CM
Station No.: 11 Rocky Point-Discharge Canal Outfall

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram]	MDC]
xNp-239	1.60E-05	----	----
Co-57	9.09E-01	(-18 +- 19) E-1	63 E-1
Ce-144	9.13E-01	(-19 +- 14) E 0	48 E 0
Ce-141	4.50E-01	(121 +- 66) E-1	220 E-1
xMo-99	8.83E-05	----	----
Se-75	8.06E-01	(-7 +- 30) E-1	100 E-1
Cr-51	3.92E-01	(-52 +- 37) E 0	120 E 0
I -131	3.96E-02	(1 +- 45) E 0	150 E 0
Be-7	6.14E-01	(-5 +- 24) E 0	79 E 0
Ru-103	5.18E-01	(-18 +- 34) E-1	110 E-1
xI -133	1.32E-13	----	----
Ba-140	1.32E-01	(26 +- 12) E 0	37 E 0
Cs-134	9.66E-01	(-15 +- 23) E-1	77 E-1
Ru-106	9.32E-01	(-14 +- 21) E 0	70 E 0
Cs-137	9.98E-01	(21 +- 24) E-1	79 E-1
Ag-110M	9.02E-01	(-7 +- 34) E-1	110 E-1
Zr-95	6.71E-01	(-13 +- 57) E-1	190 E-1
Co-58	6.93E-01	(-11 +- 30) E-1	99 E-1
Mn-54	9.20E-01	(-54 +- 23) E-1	80 E-1
*+ AcTh228	1.00E 00	(352 +- 12) E 0	31 E 0
xTeI-132	3.41E-04	----	----
Fe-59	5.62E-01	(-2 +- 77) E-1	260 E-1
Zn-65	8.99E-01	(-66 +- 69) E-1	230 E-1
*+ Co-60	9.87E-01	(112 +- 26) E-1	91 E-1
*+ K -40	1.00E 00	(8512 +- 86) E 0	130 E 0
Sb-124	6.50E-01	(94 +- 54) E-1	180 E-1

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

APPENDIX A

SPECIAL STUDIES

PART IV: SOIL

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part IV: Soil

I. Introduction

Topsoil and soil core samples and in situ radioactivity measurements are routinely collected at eleven locations around Pilgrim Station every three years. In addition to the routine surveys performed in 1988, a number of additional off-site locations were surveyed as followup measurements to special surveys conducted in 1987. During the 1988 surveys, cobalt-60 (Co-60), cesium-134 (Cs-134), and cesium-137 (Cs-137) were detected in soil in the vicinity of Pilgrim Station. This special study describes the radiological analyses results and corresponding radiological impact.

II. Background Information

As reported in the 1987 annual Radiological Environmental Monitoring Program (REMP) report,[1] soil containing radioactive material was transported outside of the Pilgrim Station protected area by wind action. The most probable transport mechanisms were determined to be:

1. Wind-blown dust generated during excavation work associated with the blackout diesel and hydrogen injection facility, Appendix R trenchwork, and security perimeter modifications.

2. Wind-blown dust generated during unloading of soil and asphalt from radwaste shipping boxes.

3. Wind-blown dust and siltation from the soil stored near the upper contractor parking lot.

Special soil surveys were conducted in 1987 in response to elevated levels of radioactivity on air particulate filters collected from on-site sampling stations. These soil surveys indicated detectable levels of cesium-137 (Cs-137) and cobalt-60 (Co-60) at seven on-site locations. Although all stations surveyed in 1987 yielded detectable levels of Cs-137, most concentrations were comparable to levels attributable to fallout from nuclear weapons testing. Any elevated levels of Cs-137 or detectable Co-60 concentrations observed in 1987 surveys were attributed to deposition of wind-blown dust.

III. Soil Radioactivity Measurements and Estimated Maximum External Dose From Ground Deposition

Cesium-137 was detected at all eleven routine survey locations and twelve special survey locations measured in 1988.[2,3] Results of these surveys can be found in Appendix G of this report. Four of these surveys, all on Boston Edison Company property, yielded Cs-137 concentrations greater than expected fallout levels. Cobalt-60 was also detected at six of the locations surveyed, all of which were on Boston Edison Company property. None of the locations beyond Boston Edison Company property which were surveyed yielded detectable Co-60 or elevated Cs-137 concentrations in 1988.

None of the air particulate samples yielded detectable activities of Cs-137 or Co-60 during 1988, indicating that suspension and deposition of wind-blown dust was not occurring as in previous years. In addition, 1988 soil survey results were similar to those obtained in the 1987 measurements. These two factors indicate that the Co-60 and elevated Cs-137 levels observed in 1988 were likely to be residual activity remaining from previous years' deposition. Since there are no major removal mechanisms (i.e. erosion) of topsoil at the survey locations, radionuclide activites would not be expected to change appreciably between the surveys conducted in October of 1987 and April-May of 1988.

The highest concentrations of both Co-60 and Cs-137 were measured at the East Rocky Hill Road airborne sampling station, approximately 0.3 miles southeast of Pilgrim Station. This location yielded a concentration of 2340 pCi/kg and a corresponding Co-60 concentration of 49 pCi/kg in topsoil scraped from the upper inch of the soil profile. These levels were comparable to those measured at this location in 1987. Results of soil core analyses and in situ radioactivity measurements at this location yielded concentration estimates that were considerably lower than those of the 1" topsoil sample.

A single topsoil sample collected at an off-site location in Manomet yielded detectable levels of cesium-134 (Cs-134). However, no Cs-134 was detected in either the soil core samples or the in situ measurements collected at this location. Also, no other radionuclides (e.g. Co-60) were detected at the survey location and levels of Cs-137 were similar to fallout levels.

The probable source of the Cs-134 is the Chernobyl Reactor incident. Cesium-134 was detected in vegetation samples collected at Plymouth County Farm in 1986 following the accident at the Chernobyl reactor. The levels of 48 pCi/kg observed in pasture vegetation samples in 1986 were three times higher than the topsoil concentration of 15 pCi/kg observed in Manomet in 1988. The Cs-134 activity detected in the single topsoil sample could be residual activity remaining from the Chernobyl incident. Any deposition of Cs-134 resulting from operation of Pilgrim Station would be expected to be accompanied by additional radionuclides such as Co-60, which were not detected.

Releases of radionuclides in airborne effluents (see Appendix B) from Pilgrim Station during 1988 were minimal due to the plant being shut down during the year. Although the detectable levels of Co-60, Cs-134, and Cs-137 do not appear to be attributable to effluent releases from Pilgrim Station operations during 1988, the associated radiological impact to a member of the general public was assessed. The external radiation dose resulting from the maximum observed concentrations of these radionuclides deposited on the ground surface was determined.

Although the Cs-134 was detected at a location different than that which yielded the maximum Co-60 and Cs-137 levels, the observed concentrations were asssumed to be present at the same location. A hypothetical individual was assumed to be exposed to the external irradiation, or "ground shine", resulting from the surface-deposited radionuclides. The exposure was assumed to occur for the entire year and no shielding/attenuation of radiation was assumed to be provided by building materials. In addition, the Cs-137 concentration was not corrected for the amount expected to be present from nuclear weapons testing. Doses were calculated according to methods outlined in the Pilgrim Station Off-site Dose Calculation Manual[4]. The resulting dose are presented in the table below.

Estimated Maximum Dose From External Irradiation
From Surface Deposited Radioactivity[5]

Organ	Resulting External Dose (mrem/yr)			
	Co-60	Cs-134	Cs-137	Total
Total Body	0.3	0.1	3.5	3.9
Skin	0.3	0.1	4.1	4.5

IV. Comparison of Estimated Dose to Federal Dose Limits and Normal Radiation Levels

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (eg. diagnostic X-rays) sources of radiation. The typical American receives 420 mrem/yr from such sources.

When the maximum estimated total body dose of 3.9 mrem/yr was compared to the federal dose limits, such an exposure was well within established guidelines. In addition, the maximum dose calculated was only about one percent of the radiation levels typically received each year by members of the general public.

V. Conclusions

Detectable levels of cobalt-60 and cesium-137 were measured in soil at a number of the locations surveyed during 1988. All of these locations were on Boston Edison Company property and the activity levels observed appeared to be residual activity remaining from deposition of wind-blown dust from previous years. Operations of Pilgrim Station during 1988 did not appear to contribute additional activity. Cesium-134 was observed at low levels in a single topsoil sample collected at an off-site location. However, other measurements at the same location did not detect Cs-134 or other radionuclides attributable to Pilgrim Station operations, indicating the Cs-134 may be residual activity remaining from the Chernobyl incident in 1986.

Conservative calculations of doses resulting from such nuclides deposited on the soil surface were performed. The radiological impact associated with the observed levels of cobalt-60, cesium-134, and cesium-137 which could be attribted to Pilgrim Station was relatively minor. The resulting maximum dose of 3.9 mrem/yr was well below federally established limits and represents only a small portion of an individual's annual radiation exposure from both natural and man-made sources.

VI. References

1. Boston Edison Company, Pilgrim Nuclear Power Station, "Radiological Environmental Monitoring Program Report No. 20", May 1988.

2. Yankee Atomic Electric Company, Letter EL 346/88, dated May 25, 1988.

3. Yankee Atomic Electric Company, Letter EL 469/88, dated July 29, 1988.

4. Boston Edison Company, Pilgrim Nuclear Power Station, Offsite Dose Calculation Manual, Revision 2, September 1988.

5. BECo Calculation No. PNPS-1-RTSD-III.A-3-0, "Dose Assessment for Soil Analysis Results for 1988 REMP Report", April 1989.

APPENDIX B

1988 RADIOACTIVE EFFLUENTS

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information

January - June 1988

Facility Pilgrim Nuclear Power Station License DPR-35

1. Regulatory Limits

   a. Fission and activation gases: ≤500 mrem/yr total body and 3000 mrem/yr for skin at Site Boundary

   b. Iodines
   c. Particulates, half-lives >8 days } ≤1500 mrem/yr to any organ at Site Boundary
   d. Liquid effluents: <0.06 mrem/month for total body and 0.20 mrem/month for any organ without Radwaste Treatment

2. Maximum Permissible Concentration

   Provide the MPCs used in determining allowable release rates or concentrations.

   a. Fission and activation gases: } 10 CFR 20
   b. Iodines: } Appendix B
   c. Particulates, half-lives >8 days: } Table II
   d. Liquid effluents: H - 3 = 1 X 10^{-3} μCi/ml; all rest, 10 CFR 20, Appendix B, Table II

3. Average Energy

   Provide the average energy ($\bar{E}$) of the radionuclide mixture in releases of fission and activation gases, if applicable. $\bar{E}$ = 1 Mev

   13(Qs x 1.84E4 + Qv x 1.8E5)≤ 1

4. Measurements and Approximations of Total Radioactivity

   Provide the methods used to measure or approximate the total radioactivity in effluents and the methods used to determine radionuclide composition.

   a. Fission and activation gases: } GeLi
   b. Iodines: } Istopic
   c. Particulates: } Analysis
   d. Liquid effluents: }

5. Batch Releases

   Provide the following information relating to batch releases of radioactive materials in liquid and gaseous effluents.

   a. Liquid

1. Number of batch releases:	78		
2. Total time period for batch releases:	5825 min or	97.08 hrs	
3. Maximum time period for a batch release:	385 min or	6.42 hrs	
4. Average time period for batch releases:	74 min or	1.23 hrs	
5. Minimum time period for a batch release:	15 min or	.25 hrs	
6. Average stream flow during periods of release of effluent into a flowing stream:			1.23E5 GPM

   b Gaseous (Not Applicable)

6. Abnormal Releases

   a. Liquid - N/A
   b. Gaseous - N/A

TABLE 1A

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

January - June 1988

	Unit	1st Quarter 1988	2nd Quarter 1988	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	*	*	*
2. Average release rate for period	μCi/sec	*	*	
3. Percent of Technical Specification limit	%	*	*	
B. Iodines				
1. Total iodine-131	Ci	NDA	NDA	30
2. Average release rate for period	μCi/sec	NDA	NDA	
3. Percent of Technical Specification limit	%	-	-	
C. Particulates				
1. Particulates with half-lives > 8 days	Ci	3.52E-4	1.11E-5	30
2. Average release rate for period	μCi/sec	4.47E-5	1.41E-6	
3. Percent of Technical Specification limit	%	-	-	
4. Gross alpha radioactivity	Ci	< 2.45E-7	NDA	
D. Tritium				
1. Total release	Ci	5.15E-2	3.61E-2	42
2. Average release rate for period	μCi/sec	6.54E-3	4.58E-3	
3. Percent of Technical Specification limit	%	-	-	

* Plant Shutdown 1st & 2nd quarters 1988

LLD's for all isotopes listed as NDA in Section B are $< 1 \times 10^{-12}$ uci/ml

Section C are $< 1 \times 10^{-11}$ uci/ml

Percent of Technical Specification limit in Sections C.3 and D.3 to be provided in the Dose Assessment supplement to the July-December Semi-Annual Report (see PNPS Technical Specification's Section 6.9.C.1 Amendment Number 116).

TABLE 1B

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

GASEOUS EFFLUENTS – ELEVATED RELEASE

January - June 1988

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	1st Quarter	2nd Quarter	Quarter	Quarter
1. Fission gases					
krypton-85	Ci	NA	NA	NA	NA
krypton-85m	Ci	NA	NA	NA	NA
krypton-87	Ci	NA	NA	NA	NA
krypton-88	Ci	NA	NA	NA	NA
xenon-133	Ci	NA	NA	NA	NA
xenon-135	Ci	NA	NA	NA	NA
xenon-135m	Ci	NA	*	NA	NA
xenon-138	Ci	NA	*	NA	NA
xenon-131m	Ci	NA	*	NA	NA
xenon-137	Ci	NA	*	NA	NA
xenon-133m	Ci	NA	*	NA	NA
Total for period	Ci	NA	*	NA	NA
2. Iodines					
iodine-131	Ci	NDA	NDA	NA	NA
iodine-133	Ci	NDA	NDA	NA	NA
iodine-135	Ci	NDA	NDA	NA	NA
Total for period	Ci	NDA	NDA	NA	NA
3. Particulates					
strontium-89	Ci	NDA	NDA	NA	NA
strontium-90	Ci	NDA	NDA	NA	NA
cesium-134	Ci	NDA	NDA	NA	NA
cesium-137	Ci	NDA	NDA	NA	NA
barium-lanthanum-140	Ci	NDA	NDA	NA	NA
chromium-51	Ci	NDA	NDA	NA	NA
manganese-54	Ci	NDA	NDA	NA	NA
cobalt-58	Ci	NDA	NDA	NA	NA
iron-59	Ci	NDA	NDA	NA	NA
cobalt-60	Ci	1.06E-6	1.01E-6	NA	NA
zinc-65	Ci	NDA	NDA	NA	NA
zirconium-niobium-95	Ci	NDA	NDA	NA	NA
cerium-141	Ci	NDA	NDA	NA	NA
cerium-144	Ci	NDA	NDA	NA	NA
ruthenium-103	Ci	NDA	NDA	NA	NA
ruthenium-106	Ci	NDA	NDA	NA	NA

TABLE 1C

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

GASEOUS EFFLUENTS - GROUND LEVEL RELEASE

January - June 1988

Nuclides Released	Unit	CONTINUOUS MODE		BATCH MODE	
		1st Quarter	2nd Quarter	Quarter	Quarter
1. Fission gases					
krypton-85	Ci	NA	NA	NA	NA
krypton-85m	Ci	NA	NA	NA	NA
krypton-87	Ci	NA	NA	NA	NA
krypton-88	Ci	NA	NA	NA	NA
xenon-133	Ci	NA	NA	NA	NA
xenon-135	Ci	NA	NA	NA	NA
xenon-135m	Ci	NA	NA	NA	NA
xenon-138	Ci	NA	NA	NA	NA
Total for period	Ci	NA	NA	NA	NA
2. Iodines					
iodine-131	Ci	NDA	NDA	NA	NA
iodine-133	Ci	NDA	NDA	NA	NA
iodine-135	Ci	NDA	NDA	NA	NA
Total for period	Ci	NDA	NDA	NA	NA
3. Particulates					
strontium-89	Ci	NDA	NDA	NA	NA
strontium-90	Ci	NDA	NDA	NA	NA
cesium-134	Ci	NDA	NDA	NA	NA
cesium-137	Ci	4.22E-5	NDA	NA	NA
barium-lanthanum-140	Ci	NDA	NDA	NA	NA
manganese-54	Ci	NDA	NDA	NA	NA
cobalt-58	Ci	NDA	NDA	NA	NA
iron-59	Ci	NDA	NDA	NA	NA
cobalt-60	Ci	3.09E-4	1.01E-5	NA	NA
zinc-65	Ci	NDA	NDA	NA	NA
zirconium-niobium-95	Ci	NDA	NDA	NA	NA
cerium-141	Ci	NDA	NDA	NA	NA
ruthenium-103	Ci	NDA	NDA	NA	NA
ruthenium-106	Ci	NDA	NDA	NA	NA

LLD'S for all isotopes listed as "NDA" in section (2) are less than 1×10^{-12} uci/ml and in section (3) are less than 1×10^{-11} uci/ml

TABLE 2A

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

January - June 1988

	Unit	1st Quarter 1988	2nd Quarter 1988	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	1.14E-2	9.74E-3	30
2. Average diluted concentration during period	μCi/ml	6.09E-6	1.16E-5	
3. Percent of applicable limit	%			
B. Tritium				
1. Total release	Ci	2.08E-1	9.05E-2	30
2. Average diluted concentration during period	μCi/ml	1.11E-4	1.08E-4	
3. Percent of applicable limit	%			
C. Dissolved and entrained gases				
1. Total release	Ci	*	*	*
2. Average diluted concentration during period	μCi/ml	*	*	
3. Percent of applicable limit	%	*	*	
D. Gross alpha radioactivity				
1. Total release	Ci	NDA	NDA	40
E. Volume of waste released (prior to dilution)	liters	1.80E+6	7.67E+5	20
F. Volume of dilution water used during period	liters	1.87E+9	8.40E+8	20

* Plant shutdown 1st and 2nd quarters 1988

LLD's for all isotopes listed as NDA in Section D are $< 1 \times 10^{-7}$ uci/ml

Percent of applicable limit in Sections A.3 and B.3 to be provided in the Dose Assessment supplement to the July-December Semiannual Report (see PNPS Technical Specifications Section 6.9.C.1 Amendment Number 116).

TABLE 2B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

LIQUID EFFLUENTS

January - June 1988

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter	Quarter	1st Quarter	2nd Quarter
strontium-89	Ci	NA	NA	NDA	NDA
strontium-90	Ci	NA	NA	3.45E-6	3.11E-6
cesium-134	Ci	NA	NA	1.52E-5	1.54E-4
cesium-137	Ci	NA	NA	1.20E-3	5.54E-3
iodine-131	Ci	NA	NA	NDA	NDA
cobalt-58	Ci	NA	NA	NDA	NDA
cobalt-60	Ci	NA	NA	4.08E-3	1.52E-3
iron-59	Ci	NA	NA	NDA	NDA
zinc-65	Ci	NA	NA	NDA	NDA
manganese-54	Ci	NA	NA	1.91E-5	4.42E-6
chromium-51	Ci	NA	NA	NDA	NDA
zirconium-niobium-95	Ci	NA	NA	NDA	NDA
molybdenum-99 technetium-99m	Ci	NA	NA	NDA	NDA
barium-lanthanum-140	Ci	NA	NA	NDA	NDA
cerium-141	Ci	NA	NA	NDA	NDA
Fe-55		NA	NA	3.21E-4	1.60E-4
iodine-133	Ci	NA	NA	NA	NA
cerium-144	Ci	NA	NA	NA	NA
silver-110m	Ci	NA	NA	NA	NA
iron-55	Ci	NA	NA	NA	NA
unidentified	Ci	NA	NA	5.74E-3	2.36E-3
Total for period (above)	Ci	NA	NA	1.14E-2	9.74E-3
xenon-133	Ci	NA	NA	NDA	NDA
xenon-135	Ci	NA	NA	NDA	NDA

LLD's for all isotopes listed as NDA are as follows:

Sr-89 < 5 x 10^{-8} uci/ml Fe-59 < 5 x 10^{-7} uci/ml ZrNb-95 < 5 x 10^{-7} uci/ml
I-131 < 1 x 10^{-6} uci/ml Zn-65 < 5 x 10^{-7} uci/ml Mo99 Tc99m < 5 x 10^{-7} uci/ml
Co-58 < 5 x 10^{-7} uci/ml Cr-51 < 5 x 10^{-7} uci/ml BaLa 140 < 5 x 10^{-7} uci/ml
Ce 141 < 5 x 10^{-7} uci/ml

BOSTON EDISON COMPANY

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information

July - December 1988

Facility Pilgrim Nuclear Power Station License DPR-35

1. Regulatory Limits

a. Fission and activation gases ≤ 500 mrem/yr total body and ≤ 3000 mrem/yr for skin at Site Boundary

b. Iodines
c. Particulates, half-lives >8 days
d. Liquid effluents } ≤ 1500 mrem/yr to any organ at Site Boundary

≤ 0.06 mrem/month for total body and ≤ 0.20 mrem/month for any organ

2. Maximum Permissible Concentration

Provide the MPC's used in determining allowable release rates or concentrations.

a. Fission and activation gases:
b. Iodines:
c. Particulates, half-lives >8 days:
} 10 CFR 20 Appendix B Table II

d. Liquid effluents: H-3 = 3×10^{-3} μCi/ml; entrained gases = 2×10^{-4} μCi/ml; and all other nuclides MPC_w from 10 CFR 20, Appendix B, Table II.

3. Average Energy

Provide the average energy ($\bar{E}$) of the radionuclide mixture in releases of fission and activation gases, if applicable. $\bar{E}$ = 1 Mev

Not Applicable

4. Measurements and Approximations of Total Radioactivity

Provide the methods used to measure or approximate the total radioactivity in effluents and the methods used to determine radionuclide composition.

a. Fission and activation gases:
b. Iodines:
c. Particulates:
d. Liquid effluents:
} GeLi Isotopic Analysis and scintillation detection

5. Batch Releases

Provide the following information relating to batch releases of radioactive materials in liquid and gaseous effluents.

a. Liquid

1. Number of batch releases:	97		
2. Total time period for batch releases:	4545 min	or	75.75 hrs
3. Maximum time period for a batch release:	125 min	or	2.08 hrs
4. Average time period for batch releases:	47 min	or	0.78 hrs
5. Minimum time period for a batch release:	10 min	or	0.17 hrs
6. Average stream flow during periods of release of effluent into a flowing stream:	1.55E5 GPM		

b. Gaseous (Not Applicable)

6. Abnormal Releases

a. Liquid - N/A
b. Gaseous - N/A

Pilgrim Nuclear Power Station

TABLE 1A

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

	Unit	Quarter 3rd	Quarter 4th	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	*	*	*
2. Average release rate for period	μCi/sec	*	*	
3. Percent of Technical Specification limit	%	*	*	
B. Iodines				
1. Total iodine-131	Ci	NDA	NDA	30
2. Average release rate for period	μCi/sec	NDA	NDA	
3. Percent of Technical Specification limit	%	---	---	
C. Particulates				
1. Particulates with half-lives > 8 days	Ci	NDA	7.28 E-6	30
2. Average release rate for period	μCi/sec	NDA	9.25 E-7	
3. Percent of Technical Specification limit	%	---	---	
4. Gross alpha radioactivity	Ci	NDA	NDA	
D. Tritium				
1. Total release	Ci	3.78E-2	3.48 E-2	42
2. Average release rate for period	μCi/sec	4.80E-3	4.42 E-3	
3. Percent of Technical Specification limit	%	---	---	

*Plant not operating 3rd and most of 4th quarter, 1988.

NDA - No detectable activity at or above the lower limit of detection (LLD).

LLD's for all isotopes listed in section B are $< 1X10^{-12}$ uCi/ml.

section C are $< 1X10^{-11}$ uCi/ml.

Percent of Technical Specification limit in Section C.3 and D.3 to be provided in the Dose Assessment supplement to the July-December Semi-Annual Report to be issued prior to April 1, 1989.

PILGRIM NUCLEAR POWER STATION
TABLE 1B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)
GASEOUS EFFLUENTS – ELEVATED RELEASE

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	3rd Quarter	4th Quarter	3rd Quarter	4th Quarter
1. Fission gases					
krypton-85	Ci	*	*	N/A	N/A
krypton-85m	Ci	*	*	N/A	N/A
krypton-87	Ci	*	*	N/A	N/A
krypton-88	Ci	*	*	N/A	N/A
xenon-133	Ci	*	*	N/A	N/A
xenon-135	Ci	*	*	N/A	N/A
xenon-135m	Ci	*	*	N/A	N/A
xenon-138	Ci	*	*	N/A	N/A
xenon-131m	Ci	*	*	N/A	N/A
xenon-137	Ci	*	*	N/A	N/A
xenon-133m	Ci	*	*	N/A	N/A
Total for period	Ci	*	*	N/A	N/A
2. Iodines					
iodine-131	Ci	NDA	NDA	N/A	N/A
iodine-133	Ci	NDA	NDA	N/A	N/A
iodine-135	Ci	NDA	NDA	N/A	N/A
Total for period	Ci	NDA	NDA	N/A	N/A
3. Particulates					
strontium-89	Ci	NDA	NDA	N/A	N/A
strontium-90	Ci	NDA	NDA	N/A	N/A
cesium-134	Ci	NDA	NDA	N/A	N/A
cesium-137	Ci	NDA	NDA	N/A	N/A
barium-lanthanum-140	Ci	NDA	NDA	N/A	N/A
chromium-51	Ci	NDA	NDA	N/A	N/A
manganese-54	Ci	NDA	NDA	N/A	N/A
cobalt-58	Ci	NDA	NDA	N/A	N/A
iron-59	Ci	NDA	NDA	N/A	N/A
cobalt-60	Ci	NDA	NDA	N/A	N/A
zinc-65	Ci	NDA	NDA	N/A	N/A
zirconium-niobium-95	Ci	NDA	NDA	N/A	N/A
cerium-141	Ci	NDA	NDA	N/A	N/A
cerium-144	Ci	NDA	NDA	N/A	N/A
ruthenium-103	Ci	NDA	NDA	N/A	N/A
ruthenium-106	Ci	NDA	NDA	N/A	N/A

* Plant not operating 3rd quarter and most of 4th quarter of 1988.

LLD's for all isotopes listed as NDA in Section (2) are $< 1X10^{-12}$ uCi/ml.
Section (3) are $< 1X10^{-11}$ uCi/ml.

PILGRIM NUCLEAR POWER STATION

TABLE 1C

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

GASEOUS EFFLUENTS - GROUND LEVEL RELEASE

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	3rd Quarter	4th Quarter	3th Quarter	4th Quarter
1. Fission gases					
krypton-85	Ci	*	*	N/A	N/A
krypton-85m	Ci	*	*	N/A	N/A
krypton-87	Ci	*	*	N/A	N/A
krypton-88	Ci	*	*	N/A	N/A
xenon-133	Ci	*	*	N/A	N/A
xenon-135	Ci	*	*	N/A	N/A
xenon-135m	Ci	*	*	N/A	N/A
xenon-138	Ci	*	*	N/A	N/A
Total for period	Ci	*	*	N/A	N/A

* Plant not operating 3rd quarter and most of 4th quarter of 1988.

2. Iodines					
iodine-131	Ci	NDA	NDA	N/A	N/A
iodine-133	Ci	NDA	NDA	N/A	N/A
iodine-135	Ci	NDA	NDA	N/A	N/A
Total for period	Ci	NDA	NDA	N/A	N/A
3. Particulates					
strontium-89	Ci	NDA	NDA	N/A	N/A
strontium-90	Ci	NDA	NDA	N/A	N/A
cesium-134	Ci	NDA	NDA	N/A	N/A
cesium-137	Ci	NDA	7.28E-6	N/A	N/A
barium-lanthanum-140	Ci	NDA	NDA	N/A	N/A
manganese-54	Ci	NDA	NDA	N/A	N/A
cobalt-58	Ci	NDA	NDA	N/A	N/A
iron-59	Ci	NDA	NDA	N/A	N/A
cobalt-60	Ci	NDA	NDA	N/A	N/A
zinc-65	Ci	NDA	NDA	N/A	N/A
zirconium-niobium-95	Ci	NDA	NDA	N/A	N/A
cerium-141	Ci	NDA	NDA	N/A	N/A
ruthenium-103	Ci	NDA	NDA	N/A	N/A
ruthenium-106	Ci	NDA	NDA	N/A	N/A

LLD's for all isotopes listed as NDA in Section (2) are $< 1X10^{-12}$ uCi/ml.

and in Section (3) are $< 1X10^{-11}$ uCi/ml.

PILGRIM NUCLEAR POWER STATION
TABLE 2A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

	Unit	Quarter 3rd	Quarter 4th	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	1.27E-2	1.81E-3	30
2. Average diluted concentration during period	µCi/ml	7.46E-9	1.86E-9	
3. Percent of applicable limit	%	---	---	
B. Tritium				
1. Total release	Ci	1.72E-1	1.02E-1	30
2. Average diluted concentration during period	µCi/ml	1.01E-7	1.05E-7	
3. Percent of applicable limit	%	---	---	
C. Dissolved and entrained gases				
1. Total release	Ci	*	*	*
2. Average diluted concentration during period	µCi/ml	*	*	
3. Percent of applicable limit	%	*	*	
D. Gross alpha radioactivity				
1. Total release	Ci	NDA	NDA	40
E. Volume of waste released (prior to dilution)	liters	1.43E6	7.71E5	20
F. Volume of dilution water used during period	liters	1.70E9	9.70E8	20

* Plant not operating 3rd quarter and most of 4th quarter 1988.
NDA - no detectable activity at or above the lower limit of detection (LLD).
LLD's for all isotopes listed as NDA in Section D are $< 1X10^{-7}$ uCi/ml.

Percent of applicable limit in Sections A.3 and B.3 to be provided in the Dose Assessment supplement to the July-December Semiannual Report to be issued prior to April 1, 1989.

PILGRIM NUCLEAR POWER STATION

TABLE 2B

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1988)

LIQUID EFFLUENTS

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	3rd Quarter	4th Quarter	3rd Quarter	4th Quarter
strontium-89	Ci	N/A	N/A	NDA	NDA
strontium-90	Ci	N/A	N/A	4.27E-6	3.64E-6
cesium-134	Ci	N/A	N/A	2.09E-4	1.76E-7
cesium-137	Ci	N/A	N/A	8.90E-3	2.59E-4
iodine-131	Ci	N/A	N/A	NDA	NDA
cobalt-58	Ci	N/A	N/A	NDA	NDA
cobalt-60	Ci	N/A	N/A	2.18E-3	1.04E-3
iron-59	Ci	N/A	N/A	NDA	NDA
zinc-65	Ci	N/A	N/A	NDA	NDA
manganese-54	Ci	N/A	N/A	9.36E-5	2.02E-5
chromium-51	Ci	N/A	N/A	NDA	NDA
zirconium-niobium-95	Ci	N/A	N/A	NDA	NDA
molybdenum-99/ technetium-99m	Ci	N/A	N/A	NDA	NDA
barium-lanthanum-140	Ci	N/A	N/A	NDA	NDA
cerium-141	Ci	N/A	N/A	NDA	NDA
cerium-144	Ci	N/A	N/A	NDA	NDA
iron-55	Ci	N/A	N/A	1.29E-3	4.89E-4
unidentified	Ci	N/A	N/A	—	—
Total for period (above)	Ci	N/A	N/A	1.27E-2	1.81E-3
xenon-133	Ci	N/A	N/A	NDA	NDA
xenon-135	Ci	N/A	N/A	NDA	NDA

LLD's for all isotopes listed as NDA are as follows:

Sr-89 $< 5 \times 10^{-8}$ uCi/ml
I-131 $< 1 \times 10^{-6}$ uCi/ml
Co-58 $< 5 \times 10^{-7}$ uCi/ml
Xe-133 $< 1 \times 10^{-5}$ uCi/ml
Fe-59 $< 5 \times 10^{-7}$ uCi/ml
Zn-65 $< 5 \times 10^{-7}$ uCi/ml
Cr-51 $< 5 \times 10^{-7}$ uCi/ml
Xe-135 $< 1 \times 10^{-5}$ uCi/ml
ZrNb-95 $< 5 \times 10^{-7}$ uCi/ml
Mo99/Tc99m $< 5 \times 10^{-7}$ uCi/ml
BaLa-140 $< 5 \times 10^{-7}$ uCi/ml
Ce-141 $< 5 \times 10^{-7}$ uCi/ml
Ce-144 $< 5 \times 10^{-7}$ uCi/ml

APPENDIX C

RADIOLOGICAL ENVIRONMENTAL TECHNICAL SPECIFICATIONS

OPERATIONAL OBJECTIVES

7.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

7.1 Monitoring Program

Applicability:

At all times.

Specification:

A. ENVIRONMENTAL MONITORING

An environmental monitoring program shall be conducted to evaluate the effects of station operation on the environs and to verify the effectiveness of the source controls on radioactive materials.

The radiological environmental monitoring program shall be conducted as specified in Table 8.1-1.

Action:

1. With the radiological environmental monitoring program not being conducted as specified in Table 8.1-1, prepare and submit to the Commission, in the Annual Radiological Environmental Monitoring Report required by Specification 6.9.C.2, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence.

2. With the level of radioactivity as the result of plant effluents in an environmental sampling medium at a specified location exceeding the reporting levels of Table 7.1-1 when averaged over any calendar quarter, prepare and submit to the Commission within 30 days, a special report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken

SURVEILLANCE REQUIREMENTS

8.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

8.1 Monitoring Program

Specification:

A. ENVIRONMENTAL MONITORING

The radiological environmental monitoring samples shall be collected pursuant to Table 8.1-1 from the specific locations given in the table and figure(s) in the Offsite Dose Calculation Manual (ODCM) and shall be analyzed pursuant to the requirements of Table 8.1-1 and the detection capabilities required by Table 8.1-4.

1. Cumulative dose contributions for the current calendar year from radionuclides detected in environmental samples shall be determined in accordance with the methodology and parameters in the ODCM. These results will be reported in the Annual Radiological Environmental Monitoring Report.

OPERATIONAL OBJECTIVES

SURVEILLANCE REQUIREMENTS

7.1.A ENVIRONMENTAL MONITORING (Continued)

to reduce radioactive effluents so that the potential annual dose to a member of the public is less than the calendar year limits of Specifications 7.2, 7.3, and 7.4. When more than one of the radionuclides in Table 7.1-1 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (1)}} + \ldots \geq 1.0$$

When radionuclides other than those in Table 7.1-1 are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to a member of the public is equal to or greater than the calendar year limits of Specifications 7.2, 7.3, and 7.4. This report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Monitoring Report.

3. With milk or fresh leafy vegetable samples unavailable from one or more of the sample locations required by Table 8.1-1, identify locations for obtaining replacement samples and add them to the Radiological Environmental Monitoring Program within 30 days. The specific locations from which samples were unavailable may then be deleted from the monitoring program.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.1.A ENVIRONMENTAL MONITORING (Continued) Pursuant to Specification 6.9.C.2, identify the cause of the unavailability of samples and identify the new location(s) obtaining replacement samples in the next Annual Environmental Radiation Monitoring Report and also include in the report the table for the ODCM reflecting the new location(s).	
B. LAND USE CENSUS A land use census shall be conducted and shall identify, within a distance of 8 km (5 miles), the location in each of the 16 meteorological sectors of the nearest milk animal, the nearest residence and the nearest garden of greater than 50 m^2 (500 ft^2) producing broad leaf vegetation. (For elevated releases as defined in Regulatory Guide 1.111, Revision 1, July 1977, the land use census shall also identify, within a distance of 5 km (3 miles), the locations in each of the 16 meteorological sectors of all milk animals and all gardens of greater than 50 m^2 producing broad leaf vegetation. Action 1. With a land use census identifying a location(s) that yields a calculated dose or dose commitment greater than the values currently being calculated in Specification 8.4.A, identify the new location(s) in the next Annual Environmental Radiological Monitoring Report.	B. LAND USE CENSUS The land use census shall be conducted during the growing season, at least once per 12 months using that information that will provide the best results, such as by a door-to-door survey, aerial survey, or by consulting local agriculture authorities. The results of the land use census shall be included in the Annual Radiological Environmental Monitoring Report. Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the site boundary in each of the two different direction sectors with the highest predicted D/Qs, in lieu of the garden census. Specifications for broad leaf vegetation sampling in Table 8.1-1 shall be followed, including analysis of control samples.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.1.B LAND USE CENSUS (Continued) 2. With a land use census identifying a location(s) that yields a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained in accordance with Specification 7.1, add the new location(s) to the Radiological Environmental Monitoring Program within 30 days. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment(s), via the same exposure pathway, may be deleted from this monitoring program after October 31 of the year in which this land use census was conducted. Identify the new location(s) in the next Annual Environmental Radiological Monitoring Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).	
7.2 Dose - Liquids	8.2 Dose - Liquids
Applicability: At all times.	Specification: A. Dose Calculations - Cumulative dose contributions from liquid effluents shall be determined in accordance with the ODCM for each calendar month during which releases occurred.
Specification: A. The dose or dose commitment to a member of the public from radioactive materials in liquid effluents released at and beyond the site boundary shall be limited: 1. During any calendar quarter to $\leq$ 1.5 mrem to the total body and to $\leq$ 5 mrem to any organ, and 2. During any calendar year to $\leq$ 3 mrem to the total body and to $\leq$ 10 mrem to any organ.	

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7.2 Dose - Liquids (Continued)

Action

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, a special report that identifies the cause(s), corrective actions taken, and corrective actions to be taken.

7.3 Dose - Noble Gases

Applicability:

At all times.

Specification:

A. The air dose in areas at and beyond the site boundary due to noble gases released in gaseous effluents shall be limited to the following:

1. During any calendar quarter, to ≤ 5 mrad for gamma radiation and ≤ 10 mrad for beta radiation; and

2. During any calendar year, to ≤ 10 mrad for gamma radiation and ≤ 20 mrad for beta radiation.

Action

With the calculated air dose from radioactive noble gases in gaseous effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, a special report which identifies the cause(s), the corrective actions taken, and corrective actions to be taken.

8.3 Dose - Noble Gases

Specification:

A. Dose Calculations - Cumulative dose contributions for the total time period shall be determined in accordance with the ODCM for each calendar month during which releases occurred.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.4 Dose - Iodine-131, Iodine-133, Radioactive Material in Particulate Form, and Tritium	8.4 Dose - Iodine-131, Iodine-133, Radioactive Material in Particulate Form, and Tritium
Applicability:	Specification:
At all times	A. Dose Calculations - Cumulative dose contributions for the total time period shall be determined for iodine-131, iodine-133, radioactive material in particulate form with half-lives greater than 8 days, and tritium in accordance with the ODCM for each calendar month during which releases occurred.
Specification:	
A. The dose to a member of the public from iodine-131, iodine-133, radioactive materials in particulate form with half-lives greater than 8 days, and tritium in gaseous effluents released to areas at and beyond the site boundary shall be limited to the following: 1. During any calendar quarter to ≤ 7.5 mrem to any organ, and 2. During any calendar year to ≤ 15 mrem to any organ. Action With the calculated dose from the release of iodine-131, iodine-133, radioactive materials in particulate form, and tritium in gaseous effluents exceeding any of the above limits; prepare and submit to the Commission within 30 days, a special report which identifies the cause(s), corrective actions taken, and the corrective actions to be taken.	
7.5 Total Dose	8.5 Total Dose
Applicability:	Specification:
At all times.	A. Dose Calculations - Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Specifications 7.2.A, 7.3.A, and 7.4.A; and in accordance with the ODCM.
Specification:	
A. The dose or dose commitment to any member of the public from Pilgrim Station sources is limited to ≤ 25 mrem to the total body or any organ (except the thyroid, which	

7.5 Total Dose (Continued)

is limited to ≤ 75 mrem) over a period of any calendar year.

Action

With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Specifications 7.2.A, 7.3.A, or 7.4.A; prepare and submit a special report to the Commission and limit the subsequent releases such that the dose or dose commitment to any member of the public from all uranium fuel cycle sources is limited to ≤ 25 mrem to the total body or any organ (except thyroid, which is limited to ≤ 75 mrem) over any calendar year. This special report shall include an analysis which demonstrates that radiation exposures to all members of the public from all uranium fuel cycle sources (including all effluent pathways and direct radiation) are less than the 40 CFR, Part 190 standard. Otherwise, obtain a variance from the Commission to permit releases which exceed the 40 CFR, Part 190 standard.

TABLE 7.1-1

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Reporting Levels				
	Water (pCi/L)	Airborne Particulate or Gases (pCi/M³)	Fish (pCi/kg, wet)	Milk (pCi/l)	Vegetables (pCi/kg, wet)
H-3	2×10^4				
Mn-54	1×10^3		3×10^4		
Fe-59	4×10^2		1×10^4		
Co-58	1×10^3		3×10^4		
Co-60	3×10^2		1×10^4		
Zn-65	3×10^2		2×10^4		
Zr-95	4×10^2				
I-131	2	0.9		3	1×10^2
Cs-134	30	10	1×10^3	60	1×10^3
Cs-137	50	20	2×10^3	70	2×10^3
Ba-140	2×10^2			3×10^2	

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TABLE 8.1-1

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway or Sample Type	Locations (Direction-Distance) from Reactor	Sampling and Collection Frequency	Type and Frequency of Analysis
AIRBORNE			
Particulates	11 Locations (See Table 8.1-2)	Continuous sampling over one week	Gross beta radioactivity ≥4 hours or more after filter change[1]
Quarterly	11 Locations (See Table 8.1-2)		Composite (by location) for gamma isotopic[1]
Radioiodine	11 Locations (See Table 8.1-2)	Continuous sampling with canister collection weekly	Analyze weekly for I-131
DIRECT[3]	40 Locations (See Table 8.1-3)	Quarterly	Gamma exposure quarterly
	Plymouth Beach and Priscilla/White Horse Beach	Annually	Gamma exposure survey[3]
WATERBORNE (Surface Waters)	Discharge Canal	Continuous composite sample	Gamma isotopic[2] monthly, and composite for H-3 analysis quarterly[1]
	Bartlett Pond (SE-1.7 mi)	Weekly grab sample	
	Powder Point (NNW-7.8 mi)[4]	Weekly grab sample	
AQUATIC			
Shellfish (clams, mussels or quahogs as available)	Discharge outfall Duxbury Bay Manomet Point Plymouth or Kingston Harbor Marshfield[4]	Quarterly (at approximate 3-month intervals)	Gamma isotopic[2,6]

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TABLE 8.1-1 (Continued)
OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway or Sample Type	Locations (Direction-Distance) from Reactor	Sampling and Collection Frequency	Type and Frequency of Analysis
Lobster	Vicinity of discharge point	Four times per season	Gamma isotopic[2] on edible portions
	Offshore[6]	Once per season	
Fish	Vicinity of discharge point	Quarterly (when particular species available) for Groups I and II[5], in season for Groups III and IV[5], annually for each group	Gamma isotopic[2] on edible portions[5]
	Offshore[6]		
Sediments	Rocky Point Plymouth Harbor Duxbury Bay Plymouth Beach Manomet Point Marshfield	Semiannually	Gamma isotopic[2,3,7]
INGESTION (Terrestrial)			
Milk	Plymouth County Farm, when available (W-3.5 mi)[8]	Semimonthly during periods when animals are on pasture, otherwise monthly	Gamma isotopic[2], radio-iodine analysis all samples
	Whitman Farm (NW-21 mi)[4]		
Cranberries	Manomet Point Bog (SE-2.6 mi)	At time of harvest	Gamma isotopic[2] on edible portions
	Bartlett Rd. Bog (SSE/S-2.8 mi)		
	Pine St. Bog (WNW-17 mi)[4]		

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TABLE B.1-1 (Continued)
OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway or Sample Type	Locations (Direction-Distance) from Reactor	Sampling and Collection Frequency	Type and Frequency of Analysis
Tuberous and green leafy vegetables	Plymouth County Farm (W-3.5 mi)[3] Bridgewater Farm (W-20 mi)[4]	At time of harvest	Gamma Isotopic[2] on edible portions
Beef Forage	Plymouth County Farm (W-3.5 mi)[3] Whitman Farm (NW-21 mi)[4]	Annually	Gamma Isotopic[2]

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TABLE 8.1-1 (Continued)
NOTES

[1] If gross beta radioactivity is greater than 10 times the control value, gamma isotopic will be performed on the sample.

[2] Gamma isotopic means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

[3] If integrated gamma activity (less K-40) is greater than 10 times the control value (less K-40), strontium-90 analysis will be performed on the sample.

[4] Indicates control location.

[5] Fish analyses will be performed on a minimum of 2 sub-samples, consisting of approximately 400 grams each from each of the following groups:

I. Bottom Oriented	II. Near Bottom Distribution	III. Anadromous	IV. Coastal Migratory
Winter flounder	Tautog	Alewife	Bluefish
Yellowtail founder	Cunner	Rainbow smelt	Atlantic herring
	Atlantic cod	Striped bass	Atlantic menhaden
	Pollock		Atlantic mackerel
	Hakes		

[6] Mussel samples from four locations (immediate vicinity of discharge outfall, Manomet Point, Plymouth or Kingston Harbor, and Green Harbor in Marshfield) will be analyzed quarterly as follows:

One kilogram wet weight of mussel bodies, including fluid within shells will be collected. Bodies will be reduced in volume by drying at about 100°C. Sample will be compacted and analyzed by Ge(Li) gamma spectrometry or alternate technique, if necessary, to achieve a sensitivity of 5 pCi/kg for Cs-134, Cs-137, Co-60, Zn-65, and Zr-95; and 15 pCi/kg for Ce-144. Sensitivity values are to be determined in accordance with a 95% confidence level on k_α and a 50% confidence level on k_α (See HASL-300 for definitions).

The mussel shell sample from one location will be analyzed each quarter. One additional mussel shell sample will be analyzed semiannually. Unscrubbed shells to be analyzed will be dried, processed, and analyzed similarly to the mussel bodies.

TABLE B.1-1 (Continued)
NOTES

Because of the small volume reduction in pre-processing of shells, sensitivities attained will be less than that for mussel bodies. The equipment and counting times to be employed for analyses of shells will be the same or comparable to that employed for mussel bodies so that the reduction in sensitivities (relative to those for mussel bodies) will be strictly limited to the effects of poorer geometry related to lower sample volume reduction. Shell samples not scheduled for analysis will be reserved (unscrubbed) for possible later analysis.

If radiocesium (Cs-134 and Cs-137) activity exceeds 200 pCi/kg (wet) in mussel bodies, these samples will be analyzed by radiochemical separation, electrodeposition, and alpha spectrometry for radioisotopes of plutonium, with a sensitivity of 0.4 pCi/kg.

[7] Sediment samples from four locations (Manomet Point, Rocky Point, Plymouth Harbor, and head of Duxbury Bay) will be analyzed once per year (preferably early summer) as follows:

Cores will be taken to depths of 30-cm, minimum depth, wherever sediment conditions permit, by a hand-coring sampling device. If sediment conditions do not permit 30-cm deep cores, the deepest, cores achievable with a hand-coring device will be taken. In any case, core depths will not be less than 14-cm. Core samples will be sectioned into 2-cm increments; surface and alternate increments will be analyzed, all others will be reserved. Sediment sample volumes (determined by core diameter and/or number of individual cores taken from any single location) and the counting technique will be sufficient to achieve sensitivities of 50 pCi/kg dry sediment for Cs-134, Cs-137, Co-60, Zn-65, and Zr-95 and 150 pCi/kg for Ce-144. In any case, individual core diameters will not be less than 2 inches.

The top 2-cm section from each core will be analyzed for Pu isotopes (Pu-238, Pu-239, and Pu-240) using radiochemical separations, electrodeposition, and alpha spectrometry with target sensitivity of 25 pCi/kg dry sediment. Two additional core slices per year (mid-depth slice from two core samples) will be similarly analyzed.

[8] These locations may be altered in accordance with results of surveys discussed in Specification B.1.B.

[9] Minimum sensitivities for gamma exposure measurements are as follows:

Gamma exposure - 1 μR/hr average exposure rate.
Gamma exposure survey - 1 μR/hr exposure rate.

TABLE B.1-2

AIR PARTICULATES, GASEOUS RADIOIODINE, AND SOIL SURVEILLANCE STATIONS

Sampling Location (Sample Designation)	Distance and Direction from Reactor
Offsite Stations	
East Weymouth (EW) (Control Station)	21 miles NW
Plymouth Center (PC)	4.0 miles W-WNW
Manomet Substation (MS)	2.5 miles SE
Cleft Rock Area (CR)	0.9 miles S
Onsite Stations	
Rocky Hill Road (ER)	0.8 miles SE
Rocky Hill Road (WR)	0.3 miles W-WNW
Overlook Area (OA)	0.03 miles W
Property Line (PL)	0.34 miles NW
Pedestrian Bridge (PB)	0.14 miles N
East Breakwater (EB)	0.35 miles ESE
Warehouse (WS)	0.03 miles SSE

TABLE 8.1-3
EXTERNAL GAMMA EXPOSURE SURVEILLANCE STATIONS'

Dosimeter Location (Designation)	Distance and Direction from Station
ONSITE STATIONS	
Property Line (D)	0.17 miles NNW
Property Line (F)	0.12 miles NW
Property Line (I)	0.14 miles W
Property Line (G)	0.20 miles WSW
Rocky Hill Road (A)	0.12 miles SW
Property Line (H)	0.21 miles SSW
Public Parking Area (PA)	0.07 miles N-NNE
Pedestrian Bridge (PB)	0.1 miles NE
Overlook Area (OA)	0.03 miles W
East Breakwater (EB)	0.26 miles ESE
Property Line (C)	3.3 miles ESE-SE
Property Line (HB)	0.34 miles SE
Rocky Hill Road (B)	0.26 miles SSE
Microwave Tower (MT)	0.38 miles S
Emerson Road (EM)	0.68 miles SE-SSE
White Horse Road (WH)	0.89 miles SE-SSE
Property Line (E)	0.75 miles SSE-S
Rocky Hill Road (WR)	0.3 miles W-WNW
Property Line (J)	1.36 miles SSE-S
Property Line (K)	1.42 miles SSE-S
Rocky Hill Road (ER)	0.8 miles SE
Property Line (L)	0.40 miles E

TABLE B.1-3 (Continued)
EXTERNAL GAMMA EXPOSURE SURVEILLANCE STATIONS[1]

Dosimeter Location (Designation)	Distance and Direction from Station
ONSITE STATIONS (Continued)	
Warehouse (WS)	0.1 miles SE
Property Line (PL)	0.3 miles W
OFFSITE STATIONS	
Duxbury (SS)	6.25 miles SSW-SW
Kingston (KS)	10 miles WNW
North Plymouth (NP)	5.5 miles WNW
Plymouth Center (PC)	4.0 miles W-WNW
South Plymouth (SP)	3 miles WSW
Bayshore Drive (BD)	0.7 miles W-WNW
Cleft Rock Area (CR)	0.9 miles S
Manomet (MP)	2.25 miles ESE-S
Manomet (ME)	2.5 miles SE
Manomet (MS)	2.5 miles SSE
Manomet (MB)	3.5 miles SE-SSE
College Pond (CP)	6.5 miles SSW-SW
Sagamore (CS)	10 miles SSE-S
Plymouth Airport (SA)	8 miles WSW
East Weymouth (EW)[2]	21 miles NW
Saquish Neck (SN)[3]	4.6 miles NNW

1 Thermal Luminescent Dosimeters (TLDs)
2 Control Station
3 TLDs for this loration will be provided to a third party and will be analyzed for gamma exposure whenever returned to Boston Edison Company.

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TABLE 8.1-4

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD)[a]

Analysis	Water (pCi/kg)	Airborne Particulate or Gas (pCi/M³)	Wet Solids (pCi/kg, wet)	Milk (pCi/g)	Food Products (pCi/kg, wet)	Dry Solids (pCi/kg, dry)
gross beta	4[b]	1×10^{-2}				
^{3}H	2000[d]					
^{54}Mn	15		130			
^{59}Fe	30		260			
$^{58,60}Co$	15		130			50
^{65}Zn	30		260			50
^{95}Zr	15					50
^{131}I	1	7×10^{-2}		1	60[c]	
$^{134,137}Cs$	15, 18	1×10^{-2}	130	15	60	50
^{140}Ba	15			15		
^{144}Ce						150

[a] Refer to ODCM for LLD definition.

[b] LLD for surface water.

[c] LLD for leafy vegetables.

[d] If no drinking water pathway exists, a value of 3000 pci/l may be used.

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BASES

7/8.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

7/8.1 Monitoring Program

7/8.1.A ENVIRONMENTAL MONITORING

An environmental radiological monitoring program is conducted to verify the adequacy of in-plant controls on the release of radioactive materials. The program is designed to detect radioactivity concentrations to ensure that radiation doses to individuals do not exceed the levels set forth in 10 CFR 50, Appendix I.

A supplemental monitoring program for sediments and mussels has been incorporated into the basic program (see Notes 6 and 7 to Table 8.1-1) as a result of an agreement with the Massachusetts Wildlife Federation. This supplemental program is designed to provide information on radioactivity levels at substantially higher sensitivity levels in selected samples to verify the adequacy (or, alternatively, to provide a basis for later modifications) of the long-term marine sampling schedules. As part of the supplemental program, analysis of mussels for isotopes of plutonium will be performed if radiocesium activity should exceed 200 pCi/kg in the edible portions.

The 200 pCi/kg radiocesium "action level" is based on calculations which show that if radiocesium from plant releases reached this level, plutonium could possibly appear at levels of potential interest.[1] The calculations also show that the dose delivered from these levels of plutonium would not be a significant portion of the total dose attributable to liquid effluents.

The program was also designed to be consistent, wherever applicable, with NUREG 0473.

Groundwater flow at the plant site is into Cape Cod Bay; therefore, terrestrial monitoring of groundwater is not included in this program.

Detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLD). The LLD in Table 8.1.4 is considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as an *a priori* (before the fact) limit representing the capability of a measurement system and not as an *a posteriori* (after the fact) limit for a particular measurement.

Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), curie, L.A.; "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry", Anal. Chem. 40, 586-93 (1968); and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

[1] In measurable quantities having a potential dose (human food chain) significance comparable to other nuclides if present at their detection limits.

Amendment No. 89

BASES

7/B.1.B LAND USE CENSUS

This section is provided to ensure that changes in the use of areas at and beyond the site boundary are identified and that modifications to the radiological environmental monitoring program are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey, or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of 10CFR50, Appendix I, Section IV.B.3. Restricting the census to gardens of greater than 50 m^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored, since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: 1) 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and 2) a vegetation yield of 2 kg/m^2.

7/B.2 DOSE - LIQUID

This section is provided to implement the requirements of Sections II.A, III.A, and IV.A of 10CFR50, Appendix I, to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Because Pilgrim is not a site where plant operations can conceivably affect drinking water, none of these requirements are intended to assure compliance with 40 CFR 141. The dose calculations in the ODCM implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents will be consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977. NUREG-0133 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.113.

BASES

7/8.3 DOSE - NOBLE GASES

This section is provided to implement the requirements of 10CFR50, Appendix I, Sections II.B, III.A, and IV.A to ensure that the releases of radioactive material in gaseous effluents will be kept "as low as is reasonably achievable." The surveillance requirements implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a member of the public through the appropriate pathways is unlikely to be substantially underestimated. The dose calculations established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977. The ODCM equations provided for determining the air doses at and beyond the site boundary will be based upon the historical average atmospheric conditions. NUREG-0133 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.111.

7/8.4 DOSE - IODINE-131, IODINE-133, RADIOACTIVE MATERIAL IN PARTICULATE FORM, AND TRITIUM

This section is provided to implement the requirements of Sections II.C, III.A and IV.A of 10 CFR50, Appendix I, to assure that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." The ODCM calculational methods specified in the surveillance requirements implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methods approved by the NRC for calculating the doses due to the actual release rates of the subject materials are required to be consistent with the methodology provided in Regulatory Guides 1.109 and 1.111. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate specifications for iodine-131, radioactive material in particulate form with half-lives greater than 8 days, and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in areas at and beyond the site boundary. The pathways which are examined in the development of these calculations are: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

BASES

7/8.5 TOTAL DOSE

This section is provided to meet the dose limitations of 40CFR190 that have now been incorporated into 10CFR20 by 46 FR 18525. The specification requires the preparation and submittal of a special report whenever the calculated doses from plant radioactive effluents exceed twice the design objective doses of 10CFR50, Appendix I. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a member of the public will exceed the dose limits of 40CFR190 if the individual reactors remain within the reporting requirement level. The special report will describe a course of action that should result in the limitation of the annual dose to a member of the public to within the 40CFR190 limits. For the purposes of the special report, it may be assumed that the dose commitment to the member of the public from other uranium fuel cycle sources is negligible, except dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any member of the public is estimated to exceed the limits of 40CFR190, a request for a variance in a special report in accordance with 40CFR190.11 and 10CFR20.405C is considered to be a timely request and fulfills the requirements of 40CFR190 until NRC staff action is completed. This is provided that the release conditions resulting in violation of 40CFR190 have not already been corrected. The variance only relates to the limits of 40CFR190, and does not apply in any way to the other requirements for dose limitation of 10CFR20. An individual is not considered a member of the public during any period in which he/she is engaged in any operation that is part of the nuclear fuel cycle.

APPENDIX D

1988 GARDEN AND MILK ANIMAL CENSUS RESULTS

OFFICE MEMORANDUM

Boston Edison Company

RMG Control Number

To: J. P. Jens

From: C. E. Bowman

Record Type A4.08
Non-Safety Related

Date: October 27, 1988

Dept. Doc. RED 88-124

Subject: 1988 Garden and Milk Producing Animal Census

Distribution:

B. J. Dionne
T. L. Sowdon
E. Robinson
RED Files
D. Tarrentino

References: 1) Boston Edison Company, Station Instruction, "Garden Census", SI-RP.8020, Rev. 0
2) Boston Edison Company, Station Instruction, "Milk Producing Animal Census", SI-RP.8025, Rev. 0.

As required by the PNPS Technical Specifications, section 7.1.B, and 10CFR50 Appendix I, the 1988 Land Use Census was conducted by the Radiological Engineering Division (RED). The garden and milk animal census was performed in accordance with station instruction SI-RP.8020 and SI-RP.8025, (References 1 and 2) respectively, with the exception that the street by street survey was conducted out to 3 miles as it was determined the procedures did not conform to PNPS Technical Specifications Section 7.1.B. Revision to both procedures have been initiated such that they will conform to PNPS Technical Specifications 7.1.B.

The results of the garden census are indicated in Attachment A. The garden census revealed that a previously reported garden (Malmgren residence) no longer exists. In addition, twelve gardens greater than 500 ft^2 were identified that had not been previously reported. These gardens are located on: Clay Hill Road (0.9 mi, W); 2 on Rocky Hill Road (0.5 mi, SE and 1.3 mi, SE); Doten Road (1.7 mi, SW); Farmhurst Road (0.9 mi, SSE); Arlington Road (2.0 mi, SE); Manomet Pt. Rd. (2.3 mi, SE); Holmes Ave. (2.6 mi, SE); Bartlett Rd. (2.7 mi, SSE); 2 on Beaverdam Rd. (2.2 mi, S and 2.5 mi, S); and Jordon Rd. (2.5 mi, SW). Vegetation samples were collected at all previously reported gardens and at four of the twelve new gardens. Samples were not collected from the remaining eight gardens as the samples were unavailable.

The 1988 census identified two garden location (0.5 miles SE and 2.2 miles S) that yield a calculated dose commitment that is twenty percent greater than the locations which were currently being sampled. At the present time, the Nuclear Information Division is in the process of contacting these individuals to inquire about their desire to participate in the vegetation sampling program. If agreeable, these locations will be added to the routine sampling program.

The results of the milk animal census are indicated in Attachment B. The street by street survey out to three miles from PNPS was also used for locating milk producing animal or farm barns. Two goats located 0.5 miles southeast of PNPS were identified. The Nuclear Information Division was requested to inquire as to whether the individual would also be willing to participate in the milk sampling program.

BJD/clc/1439

Dept. Doc. No. RED 88-124
To: J. P. Jens Date: October 27, 1988
Subject: 1988 Garden and Milk Producing Animal Census

In addition to the street by street survey, the results of the 1987 Town of Plymouth Animal Census conducted in February and March of 1988 was reviewed. The Town of Plymouth's Animal Inspector was contacted on September 27, 1988 by a representative from the Nuclear Information Division. The animal inspector indicated that she was not aware of the addition of any new milking animal within a 5 mile radius of PNPS subsequent to her last census dated March 1988.

In summary, the garden and milk animal census has been conducted as required. Twelve new gardens and 2 new milk animals were located. Attachment C lists the location of the nearest receptors. This table, which was originally published in the Pilgrim Station Unit 1 Appendix I Evaluation, has been updated based on the 1988 census. The information in this table will be used to perform dose assessments at these locations and will be reported in the annual Dose Assessment to the General Public Report. The annual Dose Assessment to the General Public Report is submitted to the NRC within 90 days after January 1 per Technical Specification section 6.9.C.1.a.

GARDEN SURVEY FORM

NUMBER OF STREETS WITH OBSERVABLE GARDENS 7

DATE 9/14-15/88

STREET NAME	HOUSE NUMBER	GARDEN 500 FT^2	LEAFY VEGETABLES	DISTANCE AND AZIMUTH	INITIALS
Rocky Hill Road	Jenkins	640 Ft^2	carrots greens	1.3 WSW	BJD
Rocky Hill Road	640	2500 Ft^2	unavailable	0.5 SE	BJD
Rocky Hill Road	808	1056 Ft^2	leek, krenshay	1.3 SE	BJD
Bayshore Drive	-	none	-	-	BJD
Cross Road	-	none	-	-	BJD
Gate Road	-	none	-	-	BJD
Terrace Lane	-	none	-	-	BJD
Entrance Road	-	none	-	-	BJD
Donald Road	-	none	-	-	BJD
Clay Hill Road	10	640 Ft^2	swiss chard, lettuce, org, basil	0.9 W	BJD
Beach Road	-	none	-	-	BJD
Tower Road	-	none	-	-	BJD
Driftwood Lane	-	none	-	-	BJD
Manomet Road	-	none	-	-	BJD
Clifford Road	-	none	-	-	BJD
S. River Street	Moon	1700 Ft^2	broccoli	2.1 WSW	BJD
Doten Road	11	> 500 Ft	corn	1.8 SW	BJD
Doten Road	57	2150 Ft^2	cabbage	1.7 SW	BJD
Warren Dale Road	-	none	-	-	BJD
John Alden Road	Work	800 Ft^2	chinese mustard lettuce,	0.8 SE	BJD

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NUMBER OF STREETS WITH OBSERVABLE GARDENS 7 DATE 9/14-15/88

STREET NAME	HOUSE NUMBER	GARDEN 500 FT^2	LEAFY VEGETABLES	DISTANCE AND AZIMUTH	INITIALS
Farmhurst Road	3	500 Ft^2	lettuce, chard, celery	0.9 SSE	BJD
Charlemont Road	-	none	-	-	BJD
Cochituate Road	-	none	-	-	BJD
Emerson Road	-	none	-	-	BJD
Arlington Road	44	1950 Ft^2	lettuce, kale	2.0 SE	BJD
Quaker Road	-	none	-	-	BJD
Wellington Road	-	none	-	-	BJD
Priscilla Road	-	none	-	-	BJD
Whitehouse Road	-	none	-	-	BJD
Court Avenue	-	none	-	-	BJD
St. Charles Avenue	-	none	-	-	BJD
Centre Avenue	-	none	-	-	BJD

GARDEN CENSUS FORM

NUMBER OF STREETS WITH OBSERVABLE GARDENS 6

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	GARDEN 500 FT^2	LEAFY VEGETABLES	DISTANCE AND AZIMUTH	INITIALS
Pearl	-	None	-	-	BJD
Hilltop	-	None	-	-	BJD
Elm	-	None	-	-	BJD
Spruce	-	None	-	-	BJD
Pine	-	None	-	-	BJD
Hemlock	-	None	-	-	BJD
Diamond	-	None	-	-	BJD
Anderson Way	-	None	-	-	BJD
Manomet Pt. Rd	126	500 Ft^2	Unavailable	2.3 mi SE	BJD
Scott Dr.	-	None	-	-	BJD
Highland Terrace	-	None	-	-	BJD
Victoria Ave.	-	None	-	-	BJD
Valley Rd.	-	None	-	-	BJD
Arnold Ave.	-	None	-	-	BJD
Bancroft Landing	-	None	-	-	BJD
Montrose Ave.	-	None	-	-	BJD
Manomet Ave.	-	None	-	-	BJD
Beechwood Ave.	-	None	-	-	BJD
Stand Ave.	-	None	-	-	BJD
Circuit Ave.	-	None	-	-	BJD

NUMBER OF STREETS WITH OBSERVABLE GARDENS 6

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	GARDEN 500 FT^2	LEAFY VEGETABLES	DISTANCE AND AZIMUTH	INITIALS
Samsoset Ave.	-	None	-	-	BJD
Cheryl Ave.	-	None	-	-	BJD
Cushing Dr.	-	None	-	-	BJD
Brook Rd.	-	None	-	-	BJD
Wilson	-	None	-	-	BJD
President	-	None	-	-	BJD
Beacon	-	None	-	-	BJD
Birchwood	-	None	-	-	BJD
Fitzgerald	-	None	-	-	BJD
Eisenhower	-	None	-	-	BJD
Hoover	-	None	-	-	BJD
Kennedy	-	None	-	-	BJD
Truman	-	None	-	-	BJD
Savin	-	None	-	-	BJD
Heather Rd.	-	None	-	-	BJD
Johnson	-	None	-	-	BJD
Valley Rd.	-	None	-	-	BJD.
Raymond Brook Rd.	-	None	-	-	BJD
Rock Rd.	-	None	-	-	BJD
Jordon Rd.	242	> 500 Ft^2	Unavailable	2.5 mi, SW	BJD

GARDEN SURVEY FORM

NUMBER OF STREETS WITH OBSERVABLE GARDENS 6

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	GARDEN 500 FT^2	LEAFY VEGETABLES	DISTANCE AND AZIMUTH	INITIALS
Av. A	-	None	-	-	BJD
Av. B	-	None	-	-	BJD
Av. C	-	None	-	-	BJD
Avington Ave.	-	None	-	-	BJD
Thomas Ave.	-	None	-	-	BJD
Taylor Ave.	-	None	-	-	BJD
Albert Rd.	-	None	-	-	BJD
Jean Rd.	-	None	-	-	BJD
Brentwood Dr.	-	None	-	-	BJD
Arboretum Rd.	-	None	-	-	BJD
Fare Oaks Rd.	-	None	-	-	BJD
Peterson Ave.	-	None	-	-	BJD
Pond Ave.	-	None	-	-	BJD
Brine Brook Rd.	-	None	-	-	BJD
Brians Way	-	None	-	-	BJD
Williams Rd.	-	None	-	-	BJD
Homer Rd.	-	None	-	-	BJD
Short Rd.	-	None	-	-	BJD
Beach Rd.	-	None	-	-	BJD
Asiaf Way	-	None	-	-	BJD

GARDEN CENSUS FORM

NUMBER OF STREETS WITH OBSERVABLE GARDENS 6

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	GARDEN, 500 FT^2	LEAFY VEGETABLES	DISTANCE AND AZIMUTH	INITIALS
Russil Mill Rd.	-	None	-	-	BJD
Old Sandwich Rd.	-	None	-	-	BJD
Warren Ave.	-	None	-	-	BJD
Cliff	-	None	-	-	BJD
Holmes Ave.	35	800 Ft^2	asparagus rhubard	2.6 mi, SE	BJD
Bartlett Rd	-	1419 Ft^2	lettuce asparagus	2.7 mi, SSE	BJD
Beaver Dam Rd.	96	1800 Ft^2	broccoli	2.2 mi, S	BJD
Beaver Dam Rd	138	800 Ft^2	broccoli cabbage spinach	2.5 mi, S	BJD

NUMBER OF STREETS WITH OBSERVABLE MILK PRODUCING ANIMALS OR FARM BARNS 1

DATE 9/14-15/88

STREET NAME	HOUSE NUMBER	NUMBER OF ANIMALS	TYPE OF ANIMALS	OWNER	DISTANCE AND AZIMUTH	INITIALS
Rocky Hill Road	640	2	goats	Hall	0.6 SE	BJD
Bayshore Drive	-	none	-	-	-	BJD
Cross Road	-	none	-	-	-	BJD
Gate Road	-	none	-	-	-	BJD
Terrace Lane	-	none	-	-	-	BJD
Entrance Road	-	none	-	-	-	BJD
Donald Road	-	none	-	-	-	BJD
Clay Hill Road	-	none	-	-	-	BJD
Beach Road	-	none	-	-	-	BJD
Tower Road	-	none	-	-	-	BJD
Driftwood Lane	-	none	-	-	-	BJD
Manomet Road	-	none	-	-	-	BJD
Clifford Road	-	none	-	-	-	BJD
S. River Street	-	none	-	-	-	BJD
Dotem Road	-	none	-	-	-	BJD
Warren Dale Road	-	none	-	-	-	BJD
John Alden Road	-	none	-	-	-	BJD
Farmhurst Road	-	none	-	-	-	BJD
Charlemont Road	-	none	-	-	-	BJD
Emerson Road	-	none	-	-	-	BJD

MILK ANIM CENSUS FORM

NUMBER OF STREETS WITH OBSERVABLE MILK PRODUCING ANIMALS OR FARM BARNS 1

DATE 9/14-15/88

STREET NAME	HOUSE NUMBER	NUMBER OF ANIMALS	TYPE OF ANIMALS	OWNER	DISTANCE AND AZIMUTH	INITIALS
Quaker Road	-	none	-	-	-	BJD
Arlington Road	-	none	-	-	-	BJD
Wellington Road	-	none	-	-	-	BJD
Priscilla Road	-	none	-	-	-	BJD
Whitehouse Road	-	none	-	-	-	BJD
Court Avenue	-	none	-	-	-	BJD
St. Charles Avenue	-	none	-	-	-	BJD
Centre Avenue	-	none	-	-	-	BJD

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MILK ANIMAL CENSUS FORM

NUMBER OF STREETS WITH OBSERVABLE MILK PRODUCING ANIMALS OR FARM BARNS 0

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	NUMBER OF ANIMALS	TYPE OF ANIMALS	OWNER	DISTANCE AND AZIMUTH	INITIALS
Pearl	-	None	-	-	-	BJD
Hilltop	-	None	-	-	-	BJD
Elm	-	None	-	-	-	BJD
Spruce	-	None	-	-	-	BJD
Pine	-	None	-	-	-	BJD
Hemlock	-	None	-	-	-	BJD
Diamond	-	None	-	-	-	BJD
Anderson Way	-	None	-	-	-	BJD
Manomet Pt. Rd.	-	None	-	-	-	BJD
Scott Dr.	-	None	-	-	-	BJD
Highland Terrace	-	None	-	-	-	BJD
Victoria Ave.	-	None	-	-	-	BJD
Valley Rd.	-	None	-	-	-	BJD
Arnold Ave.	-	None	-	-	-	BJD
Bancroft Landing	-	None	-	-	-	BJD
Montrose Ave.	-	None	-	-	-	BJD
Manomet Ave.	-	None	-	-	-	BJD
Beechwood Ave.	-	None	-	-	-	BJD
Stand Ave.	-	None	-	-	-	BJD
Circuit Ave.	-	None	-	-	-	BJD

MILK ANIMALS SURVEY FORM

NUMBER OF STREETS WITH OBSERVABLE MILK PRODUCING ANIMALS OR FARM BARNS 0

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	NUMBER OF ANIMALS	TYPE OF ANIMALS	OWNER	DISTANCE AND AZIMUTH	INITIALS
Samsoset Ave.	-	None	-	-	-	BJD
Cheryl Ave.	-	None	-	-	-	BJD
Cushing Dr.	-	None	-	-	-	BJD
Brook Rd.	-	None	-	-	-	BJD
Wilson	-	None	-	-	-	BJD
President	-	None	-	-	-	BJD
Beacon	-	None	-	-	-	BJD
Birchwood	-	None	-	-	-	BJD
Fitzgerald	-	None	-	-	-	BJD
Eisenhower	-	None	-	-	-	BJD
Hoover	-	None	-	-	-	BJD
Kennedy	-	None	-	-	-	BJD
Truman	-	None	-	-	-	BJD
Savin	-	None	-	-	-	BJD
Heather Rd.	-	None	-	-	-	BJD
Johnson	-	None	-	-	-	BJD
Valley Rd.	-	None	-	-	-	BJD
Raymond Brook Rd.	-	None	-	-	-	BJD
Rock Rd.	-	None	-	-	-	BJD
Jordon Rd.	-	None	-	-	-	BJD

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NUMBER OF STREETS WITH OBSERVABLE MILK PRODUCING ANIMALS OR FARM BARNS 0

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	NUMBER OF ANIMALS	TYPE OF ANIMALS	OWNER	DISTANCE AND AZIMUTH	INITIALS
Av. A	-	None	-	-	-	BJD
Av. B	-	None	-	-	-	BJD
Av. C	-	None	-	-	-	BJD
Avington Ave.	-	None	-	-	-	BJD
Thomas Ave.	-	None	-	-	-	BJD
Taylor Ave.	-	None	-	-	-	BJD
Albert Rd.	-	None	-	-	-	BJD
Jean Rd.	-	None	-	-	-	BJD
Brentwood Dr.	-	None	-	-	-	BJD
Arboretum Rd.	-	None	-	-	-	BJD
Fare Oaks Rd.	-	None	-	-	-	BJD
Peterson Ave.	-	None	-	-	-	BJD
Pond Ave.	-	None	-	-	-	BJD
Brine Brook Rd.	-	None	-	-	-	BJD
Brians Way	-	None	-	-	-	BJD
Williams Rd.	-	None	-	-	-	BJD
Homer Rd.	-	None	-	-	-	BJD
Short Rd.	-	None	-	-	-	BJD
Beach Rd.	-	None	-	-	-	BJD
Asiaf Way	-	None	-	-	-	BJD

NUMBER OF STREETS WITH OBSERVABLE MILK PRODUCING ANIMALS OR FARM BARNS 0

DATE 10/19-20/88

STREET NAME	HOUSE NUMBER	NUMBER OF ANIMALS	TYPE OF ANIMALS	OWNER	DISTANCE AND AZIMUTH	INITIALS
Russil Mill Rd.	-	None	-	-	-	BJD
Old Sandwich Rd.	-	None	-	-	-	BJD
Warren Ave.	-	None	-	-	-	BJD
Cliff	-	None	-	-	-	BJD
Holmes Ave.	-	None	-	-	-	BJD
Bartlett Rd.	-	None	-	-	-	BJD
Beaver Dam Rd.	-	None	-	-	-	BJD
Beaver Dam Rd.	-	None	-	-	-	BJD

TABLE C.2-1

Rev. 2
September, 1988

NEAREST RECEPTORS

from

PNPS APPENDIX I EVALUATION

(Distance in Miles From Center of PNPS Reactor)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Nearest Milk Cow*													2.4			
Nearest Meat Animal*									3.1				3.5			
Nearest Milk Goat*							0.5						2.4			
Nearest Residence*							0.5	0.8	1.4	0.8	1.2	0.8	0.8	0.5	0.4	
Nearest Vegetable Garden greater than 500 ft^2*							0.5	0.9	2.2	2.9	1.7	2.1	0.9			
Nearest Site Boundary	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.7	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2

*Within 5 miles

APPENDIX E

PNPS ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES DURING 1988

F&M ROOT CAUSE/CORRECTIVE ACTION RESPONSE

F&M No. 88-252

1. Event Description: Section 7.1.B of PNPS Technical Specifications requires that "For elevated releases as defined in Regulatory Guide 1.111, Rev. 1, July 1977, the land use census shall identify, within a distance of 5 km (3 miles) the location in each of the 16 meteorological sectors all milk and gardens of greater than 50 m^2 producing broad leaf vegetation". Contrary to this PNPS Technical Specification 8.1.3 Surveillance requirement the land use census since March 1, 1986 (Amendment 89 implementation date) have only been conducted out to a distance of 1 mile.

2. Root Cause: The responsible group failed to make the needed procedural changes and necessary training prior to the effective date of PNPS Technical Specification implementation of Amendment No. 89. Station Instruction SI-RP 8020 entitled "Garden Census," dated 6/11/87, states "Using a detailed map of the Rocky Point area within one mile of PNPS travel along each residential portion of the street and record on the Garden Census Form." The one mile radius was consistent with the previous PNPS Technical Specification (Amendment No. 23) requirement.

3. Corrective Action:

   a) Taken:

      1) The remainder of the 1988 land use census was conducted out to a distance of 3 miles on 10/21/88.

   b) Necessary to preclude recurrence:

      1) Station Instructions SI-RP .8020 entitled "Garden Census" and SI-RP. 8025 entitled "Milk-Producing Animal Census" have been revised to extend the door-to-door survey of gardens and milk-producing animals out to a distance of 3 miles (approved by Radiological Section Manager on 12/15/88).

F&M Root Cause/Corrective Action Response
F&M No. 88-339

1. Event Description (Synopsis Verification): Technical Specification 7.1.B.2 requires that a new garden be added to the radioloigcal environmental monitoring program within 30 days if it yields a dose commitment 20% greater than gardens currently being sampled. The new gardens were not added to the Offsite Dose Calculation Manual within 30 days.

2. Root Cause:

   a) Personnel error in that gardens were not added to the REMP within 30 days since personnel assumed that owner's permission was necessary prior to adding the garden to the program.

   b) Personnel failed to submit a written request to the Nuclear Information Division asking them to obtain owner's permission, and did not adequately follow-up on the verbal request.

   c) Failure to adequately pursue alternative approaches to adding gardens to the program (e.g., add location to ODCM with a footnote such as "pending owner's permission").

   d) Failure to have a procedure that described alternative approaches to the garden census and the mechanism to add new gardens to the program.

3. Corrective Action:

   a) Taken

      i. Obtained verbal permission from Mr. Hall (0.5 mi, SE) to obtain garden samples (completed 12/14/88).

      ii. Obtained verbal permission from Mrs. Minahan (2.2 mi, S) to obtain garden samples (completed 12/20/88).

      iii. The above garden locations have been added to the proposed ODCM, Revision 3. In addition, the alternative method of performing the garden census described in PNPS Technical Specification 8.1.B has been added to the proposed ODCM, Revision 3. This draft Revision 3 was initially presented to ORC on 12/21/88, but subsequent to its issuance, several errors were identified. The final review of the ODCM final revision 3 will be performed by ORC pending the resolution of the identified errors.

      iv. Will report the new gardens that were added to the ODCM in the next semi-annual Radioactive Effluent and Waste Disposal Report. (See item 3.b)iii - planned for August 29, 1989).

b) Necessary to preclude recurrence:

i) Technical Specification surveillance requirement 8.1.B provides for an alternative method for the garden census. The proposed Revision 3 of the ODCM has added the two locations with the highest predicted D/Q to the sampling program. The Radiological Section is resonsible for obtaining ORC approval of Rev. 3 once the identified errors are corrected (see item 3.a.iii).

ii) PNPS Station Instruction SI-RP .8020 will be revised to proceduralize 1) the use of an alternative approach for the garden census surveillance, 2) the mechanism to determine if a new garden requires addition to the program, and 3) the mechanism to add a new garden to the Radiological Environmental Program. (Radiological Section - second quarter 1989).

iii) An MSTP record has been created to track the addition of changes to the ODCM and the subsequent reporting of the ODCM revision in the semi-annual Radioactive Effluent and Waste Disposal Report. (Radiological Section - completed 12/22/88).

F&M Root Cause/Correction Action Response
F&M No. 89-23

1. Event Description (Synopsis Verification): Technical Specification Section 8.1 requires that the radiological environmental monitoring samples be collected pursuant to the frequencies specified in Table 8.1-1. Although the samples were collected, some samples during the period of March 1986 - December 1988 were not collected within the allowable grace period for the specified surveillance frequency. As of January 1, 1989, all samples have been taken at the appropriate surveillance frequency.

2. Root Cause:

   Environmental samples were not collected at the required frequency since personnel were not aware that the environmental sample collection needed to conform to the strict surveillance frequency defined in definition "u" of the PNPS Technical Specification.

3. Corrective Action:

   a) Taken:

      i. Collection of radiological environmental samples is now being controlled by the Master Surveillance Tracking Program (MSTP). (Initiated 12/15/88)

      ii. Station Procedure 6.2-013 "Administration of the Radiological Environmental Monitoring Program" has been reviewed by ORC. This procedure describes how environmental sampling will be conducted and controlled by MSTP. (Reviewed by ORC 12/16/88)

      iii. Station Instruction RP.8095 "Assuring Proper Sampling Schedule is Maintained" has been revised. This instruction was revised to describe how sample collection will be scheduled and tracked using MSTP. (Approved by the Radiological Section Manager 12/14/88)

      iv. Report the failure to perform surveillances at the specified frequencies in the 1988 Annual Radiological Environmental Monitoring Program Report. (planned for April 28, 1989)

      v. Conduct training for the sample collection personnel to inform them of the new procedure changes (See item 3.a)ii and 3.a)iii above) as well as the importance of collecting samples in strict conformance to the surveillance frequencies required by the Technical Specifications. (Radiological Section - completed January 25 & 27, 1989)

   b) Necessary to preclude recurrence:

      i. Revise SI-RP.8095 to clearly define surveillance frequencies, intervals, and grace periods. (Radiological Section - first quarter 1989)

APPENDIX F

QUALITY ASSURANCE FOR THE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM DURING 1988

APPENDIX F

QUALITY ASSURANCE FOR THE RADIOLOGICAL
ENVIRONMENTAL MONITORING PROGRAM DURING 1988

I. Introduction

The accuracy of the data obtained through Boston Edison Company's Radiological Environmental Monitoring Program (REMP) is ensured through a comprehensive Quality Assurance Program. This appendix addresses those aspects of quality assurance that deal with the accuracy and precision of the analytical sample results and the environmental TLD measurement results that are obtained by Boston Edison from the Yankee Atomic Electric Company's Environmental Laboratory (YAEL). Much of the information contained herein has been summarized from the YAEL "Semi-Annual Quality Assurance Status Report: January - June 1988," and the YAEL "Semi-Annual Quality Assurance Status Report: July - December 1988."

II. Laboratory Analyses

The quality control programs that were performed during 1988 to demonstrate the validity of laboratory analyses by YAEL include the following:

1) YAEL participation in the Environmental Protection Agency (EPA) Interlaboratory Comparison (cross-check) program for those types of samples routinely analyzed by the laboratory. This provides an independent check of accuracy and precision of the laboratory analyses. When the results of the cross-check analysis fall outside of the control limit, an investigation is made to determine the cause of the problem, and corrective measures are taken, as appropriate.

2) YAEL interlaboratory quality control program to assure the validity and reliability of the data. This program includes quality control of laboratory equipment, use of reference standards for calibration, and analysis of blank and spiked samples. The records of the quality control program are reviewed by the responsible cognizant individual, and corrective measures are taken, as appropriate.

3) A blind duplicate program is maintained in which paired samples from the five sponsor companies, including Boston Edison, are prepared from homogeneous media and sent to the laboratory for analysis. The results from this blind duplicate program are used to check for precision in laboratory analyses.

The results of these studies are discussed below.

A. YAEL Intralaboratory and EPA Interlaboratory Results

Results of the Quality Assurance Program are reported in two separate categories based upon YAEL acceptance criteria. The first criterion concerns accuracy, which is defined as the deviation of any one result from the assumed known value. The second criterion concerns precision, which deals with the ability of the measurement to be faithfully replicated by a comparison of an individual result to the mean of all results for a given sample set. In addition to evaluating all individual samples against the YAEL acceptance criteria, if the mean result of an EPA cross-check analysis exceeds the 3-sigma control limit (as defined by the EPA in their known value summary report) an investigation is conducted by YAEL personnel to determine the reason for the deviation.

The Quality Assurance Program implemented at the analytical laboratory indicated good precision and accuracy in reported values. Table 1 shows the cumulative results of accuracy and precision for laboratory analyses in 1988 for YAEL intralaboratory analyses and EPA interlaboratory cross-check analyses. For accuracy, 65 and 87 percent of the results were within 5 and 10 percent of the known values, respectively, with 97 percent of all results falling within the laboratory criterion of 15 percent. For precision, 85 and 97 percent of the results were within 5 and 10 percent of the mean, respectively, with 99.8 percent of all results meeting the laboratory criterion of 15 percent.

The results of the EPA Interlaboratory Comparison program, when considered apart from the remainder of the Quality Assurance program, were satisfactory with respect to accuracy and precision in 1988. Two hundred and nineteen analyses were performed on air particulate filters, milk, food, urine, and water. Based upon this sample analysis total, 206 analyses (i.e., 94 percent) met the EPA's definition of mean value criteria.

TABLE 1

INTRALABORATORY AND EPA INTERLABORATORY RESULTS - 1988

Category	Total Number of Measurements	Number of Measurements within deviation range* 0-5%	0-10%	0-15%**
	YAEL INTRALABORATORY ANALYSES			
Accuracy	435	312 (71.7%)	395 (90.8%)	426 (97.9%)
Precision	414	373 (90.1%)	406 (98.1%)	413 (99.8%)
	EPA INTERLABORATORY ANALYSES			
Accuracy	219	113 (51.6%)	171 (78.1%)	206 (94.1%)
Precision	219	163 (74.4%)	206 (94.1%)	219 (100.0%)
	TOTAL COMBINED ANALYSES			
Accuracy	654	425 (65.0%)	566 (86.5%)	632 (96.6%)
Precision	633	536 (84.7%)	612 (96.7%)	632 (99.8%)

* Values in parentheses indicate percentage of analysis results within the deviation range.

** This category also contains those samples having a verified zero concentration which were analyzed and found not to contain detectable levels of the nuclide of interest.

B. Blind Duplicate Program

A total of 51 paired samples were submitted by the five sponsor companies for analysis during 1988. The database used for the duplicate analysis consisted of paired measurements of 26 gamma-emitting nuclides, H-3, Sr-89, Sr-90, low-level I-131, and gross beta. The sample media included milk, groundwater, sea/river water, food crops, marine algae, and mussel meat.

A dual level criteria for agreement was established: if the paired measurements fall within ± 15 percent of their average value, then agreement between the measurements has been met. If the value falls outside of the ± 15 percent, then a two standard deviation range (95 percent confidence level) is established for each of the analyses. If the ranges overlap, agreement is obtained.

From the 51 paired samples, 1317 paired duplicate measurements were analyzed for 1988. A total of 1311, or 99.5 percent, of all measurements fell within the established criteria discussed above. No trend was evident with respect to repeated failings of measurements for the listed radionuclides and media.

III. Environmental TLD Measurements

Two separate quality control programs were performed during 1988 to demonstrate the performance of the routine environmental TLD processing by YAEL. The quality of the dosimetric results is evaluated relative to independent third party testing and internal performance testing. These tests were performed independent of the processing of environmental TLDs at YAEL. In all of these tests, dosimeters were irradiated to known doses and submitted to YAEL for processing as unknowns. The quality control programs provide a statistical measure of accuracy, precision and consistency of the processing against a reliable standard, which in turn points out any trends or changes in performance.

YAEL began performance testing of the Panasonic environmental TLDs in July 1987. The testing included internal performance testing and testing by an independent third party. Boston Edison conducted quarterly tests on the environmental TLDs via an independent third party during 1988.

A. Intralaboratory and Independent Third Party Results

A ± 30 percent accuracy acceptance standard under field conditions is recommended by ANSI 545-1975, "American National Standard Performance, Testing and Procedural Specifications for Thermoluminescent Dosimetry (Environmental Applications)." Acceptance criteria for accuracy and precision to be used in 1988 was adopted by the Laboratory Quality Control Audit Committee (LQCAC) on November 13, 1987. Recognizing the inherent variability associated with each dosimeter type, control limits for both accuracy and precision of ± 3 sigma plus 5 percent (for bias) were set by the LQCAC. The actual magnitude of the 3 sigma plus 5 percent control limits depends on the historical performance of each type of dosimeter, with each response being indicative of random and systematic uncertainties, combined with any deviation attributable to TLD operation.

The results of the TLD quality control programs are reported in the categories of accuracy and precision. Accuracy was calculated by comparing each discrete reported dose to the known or delivered dose. The deviation of individual results relative to the mean reported dose in used as a measure of precision.

The quality control program implemented for dosimetry processing indicated good precision and accuracy in the reported values. In 1988, there were 46 quality control tests. All 34 environmental TLDs tested during January - June 1988 were within the control limits for both accuracy and precision. The comparisons yielded a mean accuracy of 3.3 percent, with an associated standard deviation of 7.4 percent. The comparisons exhibited a precision value with an overall standard deviation of 2.2 percent. The 12 TLDs tested in July - December 1988 showed a mean accuracy of 0.3 percent with an associated standard deviation of 2.6 percent. TLDs measured during the second semi-annual period exhibited a precision value with a standard deviation of 1.5 percent, well within the acceptance criteria.

B. Boston Edison's TLD QA Program

Boston Edison Company personnel evaluate the accuracy of the environmental TLDs on a quarterly basis, per PNPS Station Instruction RP.8010, "Environmental TLD Quality Assurance Program." This instruction establishes acceptance criteria of: 1) the average of the percentage differences must be within ± 10%; and, 2) no one result can be greater than ± 15%. For the 72 environmental TLDs tested during 1988, calculated averages of the percentage differences were within the 10% acceptance criterion, and no individual result exceeded the 15% criterion (see Exhibit F-1).

IV. Conclusions

Laboratory analysis results for the EPA Interlaboratory Comparison program, the YAEL intralaboratory quality control program, and the sponsor companies blind duplicate program met the laboratory criterion of less than 15% deviation in 99.8% of all cases.

The environmental TLD measurements for intralaboratory and independent third party comparisons resulted in both mean accuracy and precision within 3 percent deviation.

Therefore, the quality assurance programs for the Boston Edison Company's Radiological Environmental Monitoring Program indicated that the analysis and measurements which were performed by Yankee Atomic Environmental Laboratory during 1988 exhibited acceptable accuracy and precision.

OFFICE MEMORANDUM

Boston Edison Company

To: L. E. Whittenberger | From: K. J. Sejkora | Record Type A4.08

Date: April 19, 1989 | Dept. Doc. RTS 89-61 | Non-Safety Related

Subject: **Results of the Environmental TLD Quality Assurance Program Tests for 1988**

Distribution:

B. J. Dionne
P. A. Robinson
Webster/file
S. Reilly Landahl
T. L. Sowdon
J. P. Jens
B. A. McDonald

Environmental TLD QA Program: Summary of 1988 Test Results

In accordance with PNPS Station Instruction SI-RP.8010, "Environmental TLD Quality Assurance Program," the accuracy of the TLDs used in the Radiological Environmental Monitoring Program is evaluated on a quarterly basis. This memo describes the QA Testing Program and addresses the results of the quarterly tests. All quarterly results were within the acceptance criteria established in the above procedure.

The procedure for implementation of the TLD QA program involved submission of 20 sets of TLDs (each quarter) to Atlan-Tech Incorporated, Roswell, Georgia, where a pre-determined radiation exposure was delivered to each set of badges from a Cs-137 source. Each "set" consisted of one Panasonic UD-801 TLD and one Panasonic UD-814 TLD. In each group of TLDs, two sets served as controls and were not irradiated.

Following irradiation, the TLDs were returned to Boston Edison's Braintree office. At the end of each quarter, the badges were forwarded to the Yankee Atomic Environmental Laboratory (YAEL) for processing along with the TLDs that had been retrieved from around the plant. The QA TLDs were processed with the routine end-of-quarter environmental TLDs to ensure that the QA TLDs were processed in the same manner. The reported exposures were compared to the delivered exposures and the percentage difference was calculated. These calculations are documented on the Attachment 1 forms from SI-RP.8010, "Environmental TLD QA Exposure Record" (see Attachment A). The acceptance criteria are: 1) the average of the percentage differences must be within ±10%; and, 2) no one result can be greater than ±15%. If the acceptance criteria are not met, then the discrepancy and its resolution must be documented on Attachment 2 of SI-RP.8010, "Environmental TLD QA Discrepancy Record." No discrepancy reports were required during 1988.

KJS/jmw
2099

Dept. Doc No. RTS 89-61

For the 1988 Environmental TLD QA program quarterly tests, all percentage difference means were within the 10% acceptance criteria. Additionally, no single value exceeded the 15% criteria. The QA test results of quarterly environmental TLDs are listed in the table below.

ENVIRONMENTAL TLD QUALITY ASSURANCE PROGRAM
SUMMARY OF QUARTERLY RESULTS FOR 1988

QUARTER	# Of TLD SETS IRRADIATED	DELIVERED EXPOSURE (mR)	PERCENTAGE DIFFERENCES	
			AVERAGE	HIGHEST INDIVIDUAL
First	18	100	+1.64	+ 5.00
Second	18	41	+4.41	+13.5
Third	18	68	+3.34	+ 7.90
Fourth	18	123	+5.95	+10.2
TOTAL	72	--	+3.84	+13.5

If you have any questions concerning the above please contact me at PNPS extension 8469.

ATTACHMENT 1

ENVIRONMENTAL TLD QA EXPOSURE RECORD

QUARTER YEAR: 1ST, 1988

Date of Irradiation: 3/23/88 Source: Cs-137

Distance of TLDs from source: 1.0 meters.

Configuration: free in air

Exposure Level: 0.100 R Irradiation Time: 400 sec.

Calibrated source strength and date: 899 mR/hr on 3/3/88

Qty.	TLD No.	TLD Designation	Delivered Exposure mR	Delivered Exposure mR/HR	Reported Exposure mR	% Diff.	Comments
1	655/655	881B1	100	899	1.05E+2	+5.00	All deviations
2	656/656	881B2	100		9.98E+1	-0.20	within ± 15%
3	657/657	881B3	100		9.87E+1	-1.30	
4	658/658	881B4	100		1.03E+2	+3.00	
5	659/659	881B5	100		1.03E+2	+3.00	
6	660/660	881B6	100		1.00E+2	0.00	
7	661/661	881B7	100		1.05E+2	+5.00	
8	662/662	881B8	100		1.04E+2	+4.00	
9	663/663	881B9	100		9.90E+1	-1.00	
10	664/664	881B10	100		9.80E+1	-2.00	
11	665/665	881B11	100		9.99E+1	-0.10	
12	667/667	881B12	100		9.92E+1	-0.80	
13	668/668	881B13	100		1.01E+2	+1.00	
14	669/669	881B14	100		1.04E+2	+4.00	
15	670/670	881B15	100		1.02E+2	+2.00	
16	671/671	881B16	100		1.03E+2	+3.00	
17	672/672	881B17	100		1.03E+2	+3.00	
18	673/673	881B18	100		1.02E+2	+2.00	
19	674/674	881TA0	-0- Control		6.54E-2	-	
20	676/676	881TB0	-0- Control		-8.46E-2	-	
		AVERAGE	100		1.02E+2	+1.64	AVERAGE DEV. WITHIN ±10%

Date Reported Exposure Received: 03 May 1988

Completed by: Bruce J. Thomas
Sr. Radiological Engineer

Date: June 15, 1988

Reviewed by: Bowman
Rad. Eng. ~~Group Leader~~ Division Manager

Date: 7/12/88

ATTACHMENT 1

ENVIRONMENTAL TLD QA EXPOSURE RECORD

REC'D REV'D AND STATUS UPDATED
DATE: 6-23-88
INITIALS: XJS

QUARTER YEAR: 2nd / 1988

Date of Irradiation: 6/13/88 Source: Cs-137

Distance of TLDs from source: 100 meters.

Configuration: free in air

Exposure Level: 0.041 R Irradiation Time: 2 min. 48 sec

Calibrated source strength and date: 879 mR/hr @ 6/3/88

Qty.	TLD No.	TLD Designation	Delivered Exposure mR	Reported Exposure mR	% Diff.*	Comments
1	231/231	882B1	41.0	45.4	10.76	
2	232/232	882B2		46.5	13.54	All individual
3	253/253	882B3		41.6	1.46	deviations
4	254/254	882B4		41.0	0.07	within ±15%
5	256/256	882B5		44.6	8.83	
6	258/258	882B6		41.7	1.68	
7	267/267	882B7		40.8	-0.54	
8	268/268	882B8		42.6	3.90	
9	269/269	882B9		42.2	2.83	
10	270/270	882B10		42.2	3.02	
11	274/274	882B11		42.7	4.07	
12	276/276	882B12		43.7	6.54	
13	277/277	882B13		42.9	4.68	
14	278/278	882B14		42.0	2.32	
15	279/279	882B15		42.7	4.07	
16	282/282	882B16		44.1	7.46	
17	283/283	882B17		41.8	1.90	
18	284/284	882B18		42.1	2.80	
19	285/285	882TA0	-0- Control	0.16	-	Average
20	286/286	882TB0	-0- Control	-0.16	-	Deviation
		AVERAGE		42.8	+4.41%	within ±10%

Date Reported Exposure Received: 22 July 1988

Completed by: Bruce J. Devine
Sr. Radiological Engineer

Reviewed by: [signature]
Rad. Eng. Group Leader

Date: 7/22/88

Date: 11/30/88

* % Difference values are calculated using reported exposure values with four significant figures.

ATTACHMENT 1

ENVIRONMENTAL TLD QA EXPOSURE RECORD

QUARTER YEAR: 3rd / 1988

Date of Irradiation: 10-10-88 Source: 3 Ci Cs-137

Distance of TLDs from source: 1 (one) meters.

Configuration: Free in air

Exposure Level: 0.068 R Irradiation Time: 4 min. 39 sec.

Calibrated source strength and date: 878 mR/hr. on 9-13-88

Qty.	TLD No.	TLD Designation	Delivered Exposure mR	Reported Exposure mR	% Diff.*	Comments
	801/814					
1	51/51	B883B1	68.0	68.1	+0.16	All individual
2	52/52	B883B2	68.0	67.8	-0.29	deviations
3	53/53	B883B3	68.0	69.2	+1.74	are within
4	54/54	B883B4	68.0	69.9	+2.74	± 15%
5	55/55	B883B5	68.0	71.0	+4.46	
6	62/62	B883B6	68.0	69.8	+2.68	
7	65/65	B883B7	68.0	69.1	+1.68	
8	71/71	B883B8	68.0	69.2	+1.71	
9	75/75	B883B9	68.0	70.0	+2.91	
10	76/76	B883B10	68.0	71.0	+4.49	
11	88/95	B883B11	68.0	71.0	+4.34	
12	94/110	B883B12	68.0	71.9	+5.71	
13	97/159	B883B13	68.0	70.5	+3.60	
14	98/182	B883B14	68.0	73.4	+7.90	
15	99/197	B883B15	68.0	70.3	+3.44	
16	104/198	B883B16	68.0	71.3	+4.79	
17	111/204	B883B17	68.0	70.0	+2.97	
18	113/208	B883B18	68.0	71.5	+5.19	
19	132/213	B883TAO	-0-	-0.21	+	
20	135/219	B883TBO	-0-	+0.20		
		AVERAGE	68.0	70.3	+3.34	Average deviation within ± 10%

Date Reported Exposure Received: 10/27/88

Completed by: Bruce J. Rooney
Sr. Radiological Engineer

Reviewed by: [signature]
Rad. Eng. Group Leader

Date: 11/15/88

Date: 11/30/88

* % Difference values calculated using reported exposure values with four significant figures.

ATTACHMENT 1

ENVIRONMENTAL TLD QA EXPOSURE RECORD

QUARTER YEAR: 4th / 1988

Date of Irradiation: 12/9/88 Source: 3 Ci Cs-137

Distance of TLDs from source: 1.00 meters.

Configuration: Free in Air

Exposure Level: 0.123 R Irradiation Time: 8 min. 24 sec.

Calibrated source strength and date: 878 mR/hr. on 9/13/88

Qty. TLD No.	TLD Designation	Delivered Exposure mR	Reported Exposure mR	% Diff.*	Comments
801/814					
1 504/663	884B01	123	132	+7.48	All individual deviations are within ± 15%
2 510/664	884B02		132	+7.32	
3 512/666	884B03		131	+6.59	
4 530/690	884B04		134	+8.62	
5 535/725	884B05		133	+7.72	
6 536/732	884B06		134	+8.86	
7 544/733	884B07		136	+10.2	
8 551/734	884B08		131	+6.83	
9 552/735	884B09		131	+6.50	
10 553/748	884B10		125	+1.22	
11 554/749	884B11		127	+3.33	
12 555/762	884B12		130	+5.93	
13 556/792	884B13		128	+4.07	
14 557/793	884B14		133	+7.97	
15 558/794	884B15		127	+3.25	
16 559/795	884B16		129	+4.88	
17 560/796	884B17		130	+6.02	
18 561/798	884B18	↓	123	+0.33	
19 562/799	884BTA	Transit A	0.039	—	
20 566/800	884BTB	Transit B	-0.037	—	
	AVERAGE	123	130	+5.95	Average deviation within ± 10%

Date Reported Exposure Received: 20 January 1989

Completed by: [signature] Sr. Radiological Engineer

Date: 09 March 1989

Reviewed by: Susan M. Reilly Rad. Eng. Group Leader

Date: 3/9/89

* % Difference values calculated using reported exposure values with four significant figures.

APPENDIX G

1988 SOIL SURVEY RESULTS

This appendix includes tables of the analytical results obtained from the soil surveys performed by Yankee Atomic Electric Company (YAEC) Environmental Laboratory personnel in April, May, and June of 1988. The first nineteen tables present the results of the first series of surveys performed in April and May, as documented in YAEC letter EL 346/88, dated May 25, 1988. The subsequent five tables include the results of a followup series of surveys conducted in June, 1988, as described in YAEC letter EL 469/88, dated July 29, 1988. Full details regarding the survey procedures and results can be found in these two YAEC letters.

TABLE 1

BOSTON EDISON ROUTINE AND SPECIAL IN-SITU STATIONS
APRIL-MAY, 1988

Station Number	Description	Distance/Direction From Plant (Miles)	Comment
00	Warehouse	0.1 SE	a
01	East Rocky Hill Road	0.3 WNW	a,b
03	West Rocky Hill Road	0.85 E	a,b,c
06	Property Line	0.34 NW	a
07	Pedestrian Bridge	0.14 N	b
08	Overlook	0.03 W	b,d
09	East Breakwater	0.35 ESE	a,b
10	Cleft Rock	0.9 S	a
17	Manomet Substation	2.5 SE	a
15	Plymouth Center	4.5 WNW	-
21	East Weymouth Control	2.3 NW	a
85	Main Stack	0.12 W	b
90	Access Road & 3A	1.4 S	a,b
91	Manomet Little League	1.4 SSW	a,b
92	Rocky Hill Road Poles 119/120	1.2 W	a,b
93	Plymouth YMCA	0.95 W	a,b
99	First Aid Trailer	0.06 W	a

a = Topsoil sample collected
b = Soil cores obtained
c = 250 feet west of air sampler.
d = Moved to behind I & S building on lawn closer to air sampler.

TABLE 2

WAREHOUSE PTS 00
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72039	Top Soil	56 ± 4	147 ± 7	16
In-Situ[a]	0-10"	100 ± 15	362 ± 14	27
In-Situ[b]	0-10"	30 ± 5	112 ± 4	9

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 3

EAST ROCKY HILL ROAD PTS 01
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ Cs-137	Co-60	Co-60 MDC
G72044	Top Soil	2340 ± 27	49 ± 8	23
G72045	0-2"	1280 ± 22	23 ± 10	39
G72046	2-4"	140 ± 10	-6 ± 8	31
G72047	4-6"	63 ± 7	4 ± 6	24
In-Situ[a]	0-10"	963 ± 28	2 ± 2	8
In-Situ[b]	0-10"	287 ± 8	2 ± 2	8

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 4

WEST ROCKY HILL ROAD PTS 03
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72040	Top Soil	130 ± 4	3 ± 3	12
G72041	0-2"	1051 ± 16	2 ± 7	26
G72042	2-4"	111 ± 7	-6 ± 6	25
G72043	4-6"	-1 ± 11	-15 ± 15	58
In-Situ[a]	0-10"	155 ± 17	1 ± 2	9
In-Situ[b]	0-10"	46 ± 5	1 ± 2	9

a - α/ρ = 0.206; exporential depth distribution assumed
b - α/ρ = infinity; pancer surface distribution assumed

TABLE 5

PROPERTY LINE PTS 06
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72055	Top Soil	76 ± 3	3 ± 2	8
In-Situ[a]	0-10"	228 ± 18	-2 ± 2	8
In-Situ[b]	0-10"	68 ± 5	-2 ± 2	8

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 6

PEDESTRIAN BRIDGE PTS 07
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72052	0-2"	303 ± 13	48 ± 11	36
G72053	2-4"	65 ± 6	-7 ± 6	25
G72054	4-6"	74 ± 6	-6 ± 7	26
In-Situ[a]	0-10"	158 ± 13	48 ± 6	20
In-Situ[b]	0-10"	47 ± 4	15 ± 2	7

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 7

OVERLOOK PTS 08
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ Cs-137	Co-60	Co-60 MDC
G72048	0-2"	93 ± 8	11 ± 8	29
G72049	2-4"	91 ± 9	-1 ± 7	28
G72050	4-6"	60 ± 7	12 ± 8	29
In-Situ[a]	0-10"	83 ± 11	31 ± 4	14
In-Situ[b]	0-10"	25 ± 3	10 ± 1	5

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE B

EAST BREAKWATER PTS 09
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ Cs-137	Co-60	Co-60 MDC
G72034	Top Soil	97 ± 5	10 ± 2	7
G72035	0-2"	82 ± 6	6 ± 6	21
G72036	2-4"	38 ± 7	3 ± 6	23
G72037	4-6"	5 ± 6	-3 ± 8	29
In-Situ[a]	0-10"	43 ± 11	-2 ± 3	11
In-Situ[b]	0-10"	13 ± 3	-2 ± 3	11

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 9

CLEFT ROCK PTS 10
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ Cs-137	Co-60	Co-60 MDC
G72297	Top Soil	317 ± 9	11 ± 6	21
In-Situ[a]	0-10"	268 ± 17	5 ± 2	8
In-Situ[b]	0-10"	80 ± 5	5 ± 2	8

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 10

PLYMOUTH CENTER PTS 15
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ Cs-137	Co-60	Co-60 MDC
In-Situ[a]	0-10"	499 ± 19	1 ± 3	11
In-Situ[b]	0-10"	134 ± 6	1 ± 3	11

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 11

MANOMET SUBSTATION PTS 17
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ Cs-137	Co-60	Co-60 MDC
G72166	Top Soil	343 ± 5	2 ± 3	10
In-Situ[a]	0-10"	451 ± 20	1 ± 3	10
In-Situ[b]	0-10"	134 ± 6	1 ± 3	10

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 12

EAST WEYMOUTH CONTROL PTS 21
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72298	Top Soil	148 ± 9	-3 ± 6	22
In-Situ[a]	0-10"	232 ± 25	5 ± 3	12
In-Situ[b]	0-10"	69 ± 8	5 ± 3	12

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 13

MAIN STACK PTS 85
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72299	0-2"	142 ± 10	6 ± 10	38
G72300	2-4"	89 ± 8	-4 ± 9	35
G72301	4-6"	72 ± 10	17 ± 15	55
In-Situ[a]	0-10"	106 ± 12	3 ± 2	8
In-Situ[b]	0-10"	32 ± 4	3 ± 2	8

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 14

EDISON ACCESS ROAD AND ROUTE 3A PTS 90
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72064	Top Soil #1[c]	823 ± 14	21 ± 5	13
G72051	Top Soil #2[d]	470 ± 6	3 ± 3	11
G72065	0-2"	1204 ± 23	47 ± 12	42
G72066	2-4"	814 ± 19	-11 ± 10	39
G72067	4-6"	292 ± 14	8 ± 10	40
In-Situ[a]	0-10"	405 ± 17	34 ± 4	9
In-Situ[b]	0-10"	121 ± 5	11 ± 1	3

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed
c - Under high voltage tower.
d - Under detector.

TABLE 15

MANOMET LITTLE LEAGUE PTS 91
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ			Co-60 MDC
		Cs-134	Cs-137	Co-60	
G72068	Top Soil	15 ± 2	383 ± 6	2 ± 3	12
G72069	0-2"	16 ± 7	241 ± 11	-7 ± 8	31
G72070	2-4"	-8 ± 6	87 ± 7	12 ± 7	25
G72071	4-6"	-1 ± 5	26 ± 5	-1 ± 5	19
In-Situ[a]	0-10"	c	136 ± 18	-3 ± 3	12
In-Situ[b]	0-10"	c	41 ± 6	-3 ± 3	12

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed
c - Nuclide not identified in spectrum.

TABLE 16

ROCKY HILL ROAD BETWEEN EDISON
POLES 119 AND 120 PTS 92
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72056	Top Soil	388 ± 15	2 ± 11	40
G72057	0-2"	597 ± 14	-1 ± 7	28
G72058	2-4"	477 ± 15	3 ± 9	32
G7059	4-6"	236 ± 15	-4 ± 10	41
In-Situ[a]	0-10"	227 ± 16	2 ± 2	8
In-Situ[b]	0-10"	68 ± 5	2 ± 2	8

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 17

PLYMOUTH YMCA PTS 93
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72060	Top Soil	56 ± 5	2 ± 4	16
G72061	0-2"	110 ± 10	2 ± 8	30
G72062	2-4"	54 ± 6	8 ± 7	26
G72063	4-6"	62 ± 6	-8 ± 7	27
In-Situ[a]	0-10"	109 ± 14	4 ± 3	9
In-Situ[b]	0-10"	32 ± 4	4 ± 3	9

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 18

FIRST AID TRAILER PTS 98
UNITS: pCi/kg WET

LSN	Soil Depth	Concentration ± 1σ		Co-60 MDC
		Cs-137	Co-60	
G72038	Top Soil	37 ± 2	22 ± 3	10
In-Situ[a]	0-10"	81 ± 12	61 ± 6	20
In-Situ[b]	0-10"	24 ± 4	19 ± 2	6

a - α/ρ = 0.206; exponential depth distribution assumed
b - α/ρ = infinity; plancer surface distribution assumed

TABLE 19

BOSTON EDISON IN-SITU RESULTS

COMPARISON OF GERMANIUM SYSTEM AND HIGH PRESSURE IONIZATION CHAMBER (HPIC)

Description	Positive Germanium Results (μR/h-1 ± 1σ)					Total[a] (μR/h^{-1})	HPIC (μR/h^{-1})
	U-238	Th-232	K-40	Cs-137	Co-60		
Warehouse	1.09 ± 0.06	1.66 ± 0.10	1.44 ± 0.06	0.55 ± 0.08	1.17 ± 0.04	9.01 ± 0.17	9.38 ± 0.22
E. Rocky Hill Rd.	1.12 ± 0.05	1.78 ± 0.08	1.24 ± 0.04	0.53 ± 0.15	b	8.27 ± 0.10	8.20 ± 0.49
W. Rocky Hill Rd.	1.05 ± 0.05	2.40 ± 0.12	2.62 ± 0.06	0.08 ± 0.01	b	9.75 ± 0.14	10.49 ± 0.37
Property Line	0.77 ± 0.04	1.72 ± 0.07	1.73 ± 0.05	0.12 ± 0.01	b	7.94 ± 0.10	8.46 ± 0.43
Pedestrian Bridge	0.74 ± 0.04	1.53 ± 0.07	1.45 ± 0.05	0.87 ± 0.01	0.16 ± 0.02	7.55 ± 0.10	8.85 ± 0.47
Overlook	0.94 ± 0.04	1.58 ± 0.07	1.86 ± 0.04	0.04 ± 0.01	0.10 ± 0.01	8.12 ± 0.09	8.73 ± 0.44
East Breakwater	0.99 ± 0.04	1.96 ± 0.09	2.23 ± 0.06	0.02 ± 0.01	b	8.80 ± 0.12	9.78 ± 0.46
Cleft Rock	1.15 ± 0.05	2.77 ± 0.10	2.86 ± 0.06	0.15 ± 0.01	b	10.51 ± 0.12	10.84 ± 0.61
Manomet Substation	1.17 ± 0.05	2.69 ± 0.09	2.77 ± 0.06	0.25 ± 0.01	b	10.47 ± 0.12	0.26 ± 0.51
Plymouth Center	1.82 ± 0.06	2.51 ± 0.09	2.49 ± 0.06	0.25 ± 0.01	b	10.66 ± 0.12	11.25 ± 0.51
E. Weymouth Control	1.09 ± 0.06	1.73 ± 0.10	2.22 ± 0.07	0.13 ± 0.01	b	8.76 ± 0.14	9.24 ± 0.38
Main Stack	0.93 ± 0.05	1.76 ± 0.08	1.70 ± 0.05	0.06 ± 0.01	b	8.03 ± 0.10	9.08 ± 0.39
Access Road & 3A	0.97 ± 0.04	1.91 ± 0.07	1.29 ± 0.04	0.22 ± 0.01	0.11 ± 0.01	8.10 ± 0.10	8.80 ± 0.45
Manomet L. League	0.90 ± 0.05	1.90 ± 0.10	1.86 ± 0.07	0.08 ± 0.01	b	8.33 ± 0.14	8.61 ± 0.41
Rocky Hill Road (Poles 119/120)	1.25 ± 0.05	2.29 ± 0.08	2.00 ± 0.05	0.12 ± 0.01	b	9.26 ± 0.11	9.36 ± 0.36
Plymouth YMCA	0.95 ± 0.05	2.13 ± 0.09	2.33 ± 0.06	0.06 ± 0.01	b	9.05 ± 0.12	8.80 ± 0.49
First Aid Trailer	0.76 ± 0.05	1.50 ± 0.12	2.06 ± 0.05	0.05 ± 0.01	0.20 ± 0.02	8.16 ± 0.14	11.22 ± 0.46

a = Total of portable germanium system plus 3.59 μR/hr cosmic contribution.
b = Nuclide not identified in spectrum.

TABLE 1

PILGRIM STATION SOIL ANALYSIS LOCATIONS

Station Number	Sampling Location	Distance/Direction from Station
84	Intersection (Rocky Hill Road & Edison Access Road)	0.25 S
83	Edison Access Road	1.2 S
82	Boneyard (Edison Access Road)	0.8 S
91A	Manomet Little League - North	1.4 SSE
91B	Manomet Little League - South	1.4 SSE
80	High Tension Line Tower - SW from Rt. 3A	1.6 S
81	Greenwood Estates	0.5 SE

Table 2

Pilgrim Station - In-Situ Soil Summary for Alpha/Rho = Infinity

Station Code	Location	Concentration (pCi/Kg) Cs-137	1sig	LLD	Co-60	1sig	LLD	K-40 .	1sig	LLD
B4	Rocky Hill & Edison Rd.	80.5	4.9	11	4.9	2.5	9	10650	290	310
B3	Access Rd	66.1	4.5	10	-0.3	2.5	9	8940	280	270
B2	Boneyard	62.3	6.2	20	0.1	2.7	10	15600	330	390
B1	Greenwood Estates	101.0	5.2	12	-1.2	2.5	10	11710	290	330
91A	Manomet LL - North	25.4	3.5	10	2.0	2.2	8	12050	290	290
91B	Manomet LL - South	43.1	3.7	9	-0.3	2.2	8	10930	270	260
B0	R. 3A - Power Line	92.4	4.5	9	2.0	2.1	8	7720	230	210

Table 3

Pilgrim Station - In-Situ Soil Summary for Alpha/Rho = .206

Station Code	Location	Concentration (pCi/Kg) Cs-137	1sig	LLD	Co-60	1sig	LLD	K-40	1sig	LLD
84	Rocky Hill & Edison Rd.	271	16	39	4.9	2.5	9	10650	290	310
83	Access Rd	222	15	32	-0.3	2.5	9	8940	280	270
82	Boneyard	209	21	68	0.1	2.7	10	15600	330	390
81	Greenwood Estates	339	17	41	-1.2	2.5	10	11710	290	330
91A	Manomet LL - North	85	12	32	2.0	2.2	8	12050	290	290
91B	Manomet LL - South	145	12	29	-0.3	2.2	8	10930	270	260
80	Rt 3A - Power Line	310	15	31	2.0	2.1	8	7720	230	210

Table 4

Pilgrim Station - Top Soil & Soil Core Summary

LSN	Station	Depth(in)	Sample Wt(Kg)	Concentration (pCi/Kg) Cs-134	1sig	MDC	Cs-137	1sig	MDC	Co-60	1sig	MDC	K-40	1sig	MDC
G73340	Rocky Hill & Edison Rd.	Top	1.53	-1.3	2.8	9	169	5	12	3.2	3.6	13	8440	110	140
G73341		0 - 2	0.21	-3.9	9.4	31	594	20	42	21.0	12.0	45	8410	280	490
G73342		2 - 4	0.25	-15.0	8.7	29	367	15	31	-9.0	11.0	45	11030	290	460
G73343		4 - 6	0.28	-3.5	8.8	29	264	13	28	-5.0	10.0	39	8580	250	430
G73344	Access Rd	Top	0.39	-8.0	6.2	21	537	14	24	5.4	8.0	31	8830	210	340
G73345		0 - 2	0.23	7.9	9.5	32	388	17	42	7.0	10.0	40	8070	250	440
G73346		2 - 4	0.27	0.3	8.1	27	159	11	26	9.8	8.3	31	8820	220	230
G73347		4 - 6	0.27	-7.7	8.1	27	114	10	27	-8.0	9.3	37	8620	230	350
G73348	Boneyard	Top	0.76	2.0	7.0	23	66	10	33	3.2	7.4	28	12630	210	270
G73349	Manomet LL - South	Top	0.60	-7.0	8.3	28	147	9	22	11.6	8.6	32	11210	220	290
G73350		0 - 2	0.24	-7.4	9.1	30	183	12	31	1.0	12.0	45	12810	300	440
G73351		2 - 4	0.26	1.5	8.5	28	190	14	43	-1.4	9.2	36	11250	270	410
G73352		4 - 6	0.27	-7.1	7.6	25	150	91	28	7.5	7.8	30	10600	200	400
G73353	Rt 3A - Power Line	Top	0.57	-3.3	4.6	15	399	9	15	-0.2	5.2	20	6350	130	150
G73354		0 - 2	0.26	0.8	5.4	18	271	9	20	7.1	6.8	26	6690	160	290
G73355		2 - 4	0.34	1.6	4.6	15	108	6	15	2.9	5.4	21	8250	140	220
G73356		4 - 6	0.32	-1.7	4.0	13	121	6	14	-0.5	5.3	21	6520	130	240
G73357	Greenwood Estates	Top	0.58	2.8	8.2	27	230	13	36	14.3	8.3	31	7010	180	300
G73358		0 - 2	0.21	-7.8	7.3	25	263	10	20	-7.6	7.7	30	10720	200	220
G73359		2 - 4	0.26	-3.4	8.7	29	238	13	32	-16.0	11.0	44	13120	290	410
G73360		4 - 6	0.28	-1.5	8.9	30	253	13	36	10.1	9.8	37	12400	270	400
G73361	Manomet LL - North	Top	0.66	1.7	7.3	24	34	6	14	0.2	7.2	28	10240	200	280
G73362		0 - 2	0.28	4.2	8.3	28	125	9	19	-1.1	8.5	33	10520	240	260
G73363		2 - 4	0.31	5.5	6.9	23	97	10	30	9.7	8.7	33	10420	240	340
G73364		4 - 6	0.12	10.0	12.0	41	115	13	32	-4.0	16.0	62	10320	350	640

Table 5

Pilgrim Station - Observed vs Predicted Values for K-40

Location	<----- Observed ----> Conc(pCi/Kg) +/- 1sig	<----- Predicted ----> Conc(pCi/Kg) +/- 1sig	% Deviation from Observed
Rocky Hill & Edison Rd.	9340 +/- 1466	10650 +/- 290	14.03
Access Rd	8503 +/- 388	8940 +/- 280	5.14
Greenwood Estates	12080 +/- 1232	11710 +/- 290	-3.06
Manomet LL - North	10420 +/- 100	12050 +/- 290	15.64
Manomet LL - South	11553 +/- 1136	10930 +/- 270	-5.39
Rt 3A - Power Line	7153 +/- 954	7720 +/- 230	7.93

PNPS Technical Specifications
Section 6.9.C.2

BOSTON EDISON

Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, Massachusetts 02360

K. L. Highfill
Station Director

BECo 89- 063
April 28, 1989

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

License DPR-35
Docket #50-293

ANNUAL ENVIRONMENTAL RADIATION MONITORING REPORT

Dear Sir:

In accordance with the Pilgrim Nuclear Power Station Technical Specification Section 6.9.C.2, the Boston Edison Company submits the Annual Environmental Radiation Monitoring Program Report for 1988 (Report #21).

K. L. Highfill

BPL/bal

Attachment

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