BOSTON EDISON
Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, Massachusetts 02360

PNPS Technical Specifications
Section 6.9.C.2

E. Thomas Boulette, PhD
Vice President Nuclear Operations
and Station Director

April 30 , 1992
BECo Ltr. 92-53

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

Docket No. 50-293
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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 1991 (Report #24).

E. T. Boulette

WJM/dmc

Attachment

cc: Mr. Thomas T. Martin
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Rd.
King of Prussia, PA 19406

Sr. NRC Resident Inspector - Pilgrim Station

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PILGRIM NUCLEAR POWER STATION

Radiological Environmental Monitoring Program Report No. 24

January 1 through December 31, 1991

BOSTON EDISON

BOSTON EDISON COMPANY

PILGRIM NUCLEAR POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

REPORT NO. 24

January 01 through December 31, 1991

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January 1 through December 31, 1991

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, 1991. 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's operation. This program, initiated in August, 1968, includes the collection, analysis, and evaluation of radiological data in order to assess the impact of Pilgrim Station on the environment and on the general public.

SAMPLING AND ANALYSIS

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

During 1991, there were 1,424 samples collected from the atmospheric, aquatic and terrestrial environments. In addition, 417 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs) and six exposure rate measurements were performed using a high pressure ion chamber. These 1,424 samples and 417 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: 3 out of 160 of the TLD measurements were missed, samples of Group I and II fishes were not collected during the second quarter, several air samples were not collected due to power losses, and some problems with the composite water sampler at the discharge canal were also experienced. Of the TLDs required by PNPS Technical Specifications, three were missing from their posted locations during the quarterly retrievals. The missing TLDs and cages were relocated to be inconspicuous and less accessible, where possible. In addition, Group I and II (bottom and near-bottom distribution) fishes were not available in the vicinity of the discharge canal between April and June. Therefore, samples of fish from these categories were not collected for the second quarter of the year. A complete explanation of all the missed samples during 1991 is provided in Appendix D.

There were 1,600 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.

LAND USE CENSUS

The annual land use census in the vicinity of Pilgrim Station was conducted as required by Technical Specifications between September 11 and October 1, 1991. A total of 45 gardens having an area of more than 500 square feet were identified within three miles of PNPS. No new milk or meat animals were located during the census. Of the 45 garden locations identified, seven were sampled as part of the environmental monitoring program.

RADIOLOGICAL IMPACT TO THE ENVIRONMENT

During 1991, 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. Soil, shellfish (mussels), and Irish Moss were the only sampling media which showed radioactivity which could be attributable to Pilgrim Station's operation.

None of the radioactivity analyses exceeded reporting levels specified in the PNPS Technical Specifications. Furthermore, detectable radioactivity which could be attributable to Pilgrim Station's operation was only a small percentage of the naturally-occurring and other man-made amounts of radioactivity. In addition, off-site direct radiation measurements using environmental TLDs and a high pressure ion chamber ranged between 43 and 93 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 1991, radiation doses to the general public as a result of Pilgrim Station's 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 calculated total body dose to the maximally-exposed member of the general public from radioactive effluents and direct radiation resulting from PNPS operations for 1991 was about 1.2 mrem for the year. This conservative estimate is well below the EPA's annual dose limit to any member of the general public and is a fraction of a percent of the typical dose received from natural and man-made radiation.

In addition to dose calculations based on radioactive effluents, special studies were initiated to determine the dose contribution from radioactivity that was detected in soil, mussels and Irish Moss. Results of these studies showed that radioactivity in shellfish, Irish moss and soil would result in a dose to a maximally-exposed member of the general public of much less than one mrem, using conservative assumptions.

CONCLUSIONS

The 1991 Radiological Environmental Monitoring Program for Pilgrim Station resulted in the collection and analysis of hundreds of environmental samples and measurements. The data obtained were used to determine the impact of Pilgrim Station's operation on the environment and on the 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 on the general public due to Pilgrim Station's operation.

1.0 INTRODUCTION

The Radiological Environmental Monitoring Program for 1991 performed by Boston Edison Company for Pilgrim Nuclear Power Station (PNPS) is discussed in this report. Since the operation of a nuclear power plant results in the release of small amounts of radioactivity and low levels of radiation, the Nuclear Regulatory Commission (NRC) requires a program to 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 the Pilgrim Station and at distant locations during the period January 1 to December 31, 1991.

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 and other natural and man-made sources. These results are reviewed by BECo's radiological staff and have been reported semiannually 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 is measured in units of millirem, much like temperature is measured in degrees. A millirem is a measure of the biological effect of the energy deposited in tissue. The natural and man-made radiation dose received in one year by the average American is 300 to 400 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. 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

Radiation Sources and Corresponding Doses

NATURAL		MAN-MADE	
Source	Radiation Dose (millirem/year)	Source	Radiation Dose (millirem/year)
Cosmic/cosmogenic	30	Medical/Dental X-rays	39
Internal	40	Nuclear Medicine	14
Terrestrial	30	Consumer Products	10
Radon/Thoron	200	Weapons Fallout	About 1
		Nuclear Power Plants	About 1
APPROXIMATE TOTAL	300	APPROXIMATE TOTAL	60

Cosmic radiation from the sun and outer space penetrates the earth's atmosphere and continuously bombards us with rays and charged particles. Some of this cosmic radiation interacts with gases and particles in the atmosphere, making them radioactive in turn. These radioactive byproducts from cosmic ray bombardment are referred to as cosmogenic radionuclides. Isotopes such as beryllium-7 and carbon-14 are formed in this way. Exposure to cosmic and cosmogenic sources of radioactivity results in about 30 mrem of radiation dose per year.

Additionally, natural radioactivity is in our body and in the food we eat (about 40 millirem/yr), the ground we walk on (about 30 millirem/yr) and the air we breathe (about 200 millirem/yr). All these sources contribute to a total dose of about 300 mrem per year from all natural sources of radiation.

The majority of a person's annual dose results from exposure to radon and thoron in the air we breath. These gases and their radioactive decay products arise from the decay of naturally occurring uranium, thorium and radium in the soil and building products such as brick, stone and concrete. Radon and thoron levels vary greatly with location, primarily due to changes in the concentration of uranium and thorium in the soil. Residents at some locations in Colorado, New York, Pennsylvania and New Jersey 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 50 mrem. Consumer products, such as televisions and smoke detectors, contribute about 10 mrem/yr. Much smaller doses result from weapons fallout (less than 1) and nuclear power plants (less than 1 mrem/yr). Basically, the average person in the United States receives about 60 mrem per year from man-made sources.

1.3 Nuclear Reactor Operations

Pilgrim Station generates about 670 megawatts of electricity 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 maintenance and refueling from April 29 through August 17, 1991. The station was fully operational during the rest of the year. 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 OPERATING CAPACITY FACTOR DURING 1991

OPERATING PERCENT CAPACITY

(Based on 670 MWe)

Month	Percent Capacity
January	95.4
February	88.9
March	84.6
April	92.7
May*	0
June*	0
July*	0
August	28.5
September	96.4
October	94.2
November	23.7
December	98.1
Average	58.4

* Forced plant shutdown on April 29, 1991 due to unidentified leakage in the Drywell in excess of Tech Spec limits. Refueling Outage No. 8 commenced on May 4, 1991. Operation was resumed on August 17, 1991.

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.

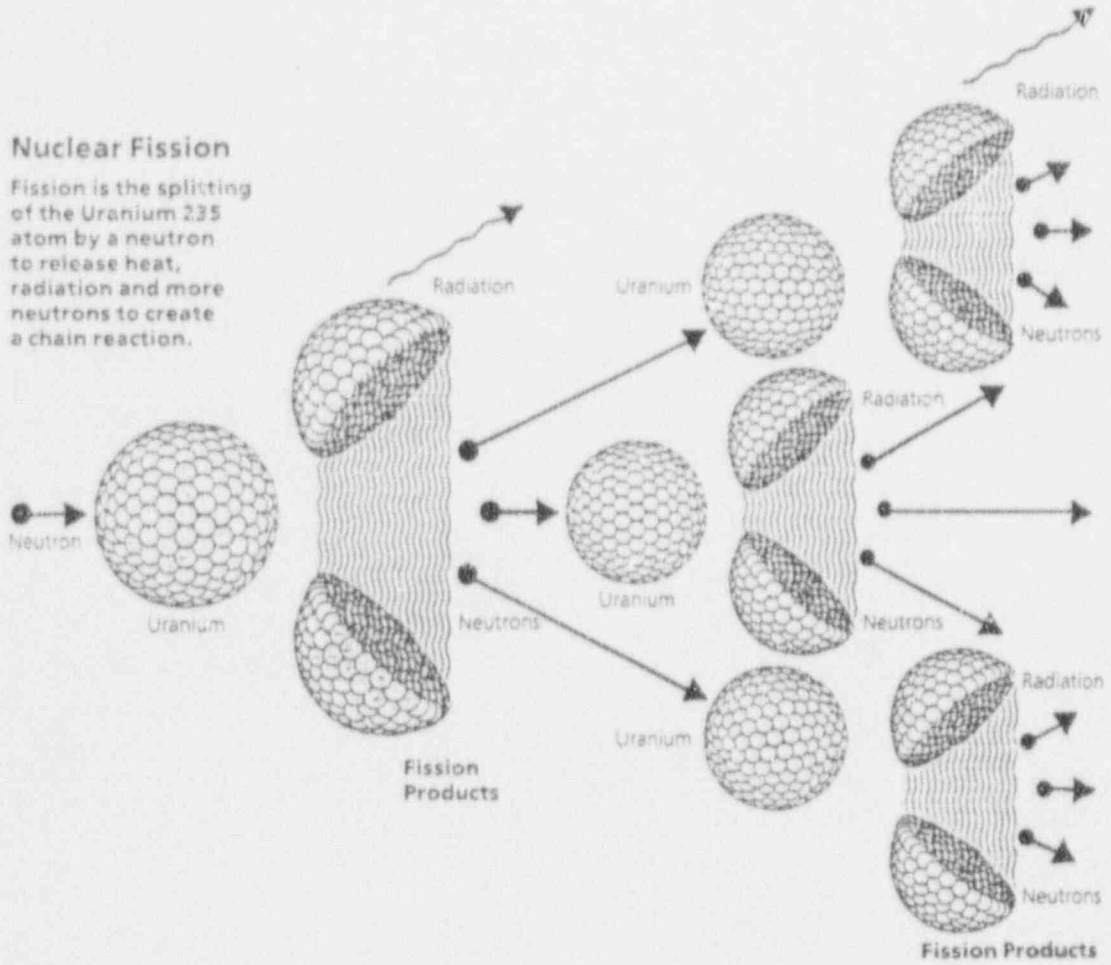


Figure 1.3-1
Radioactive Fission Product Formation

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 from their release 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 will 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 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.

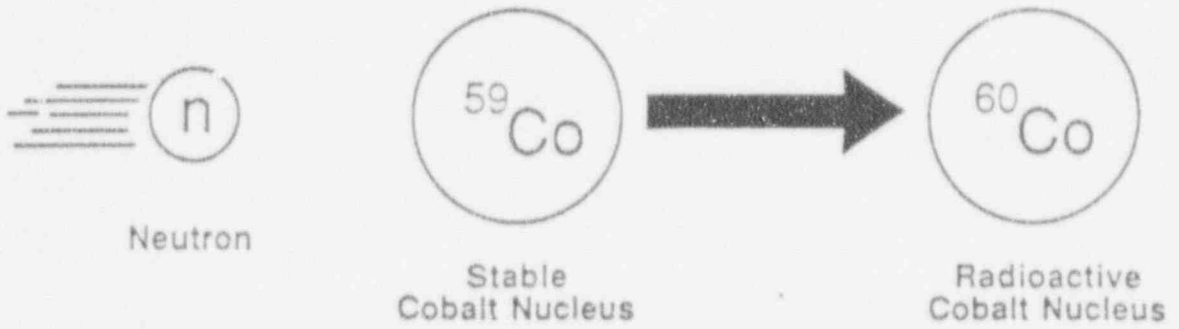


Figure 1.3-2
Radioactive Activation Product Formation

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,[5] 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 operations and maintenance small amounts of radioactive fission and activation products can escape through valve leaks or upon breaching of the primary coolant system for maintenance.

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 steel walls of the torus are nine 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. This 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 do escape 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

SIMPLIFIED DIAGRAM OF PILGRIM NUCLEAR POWER STATION

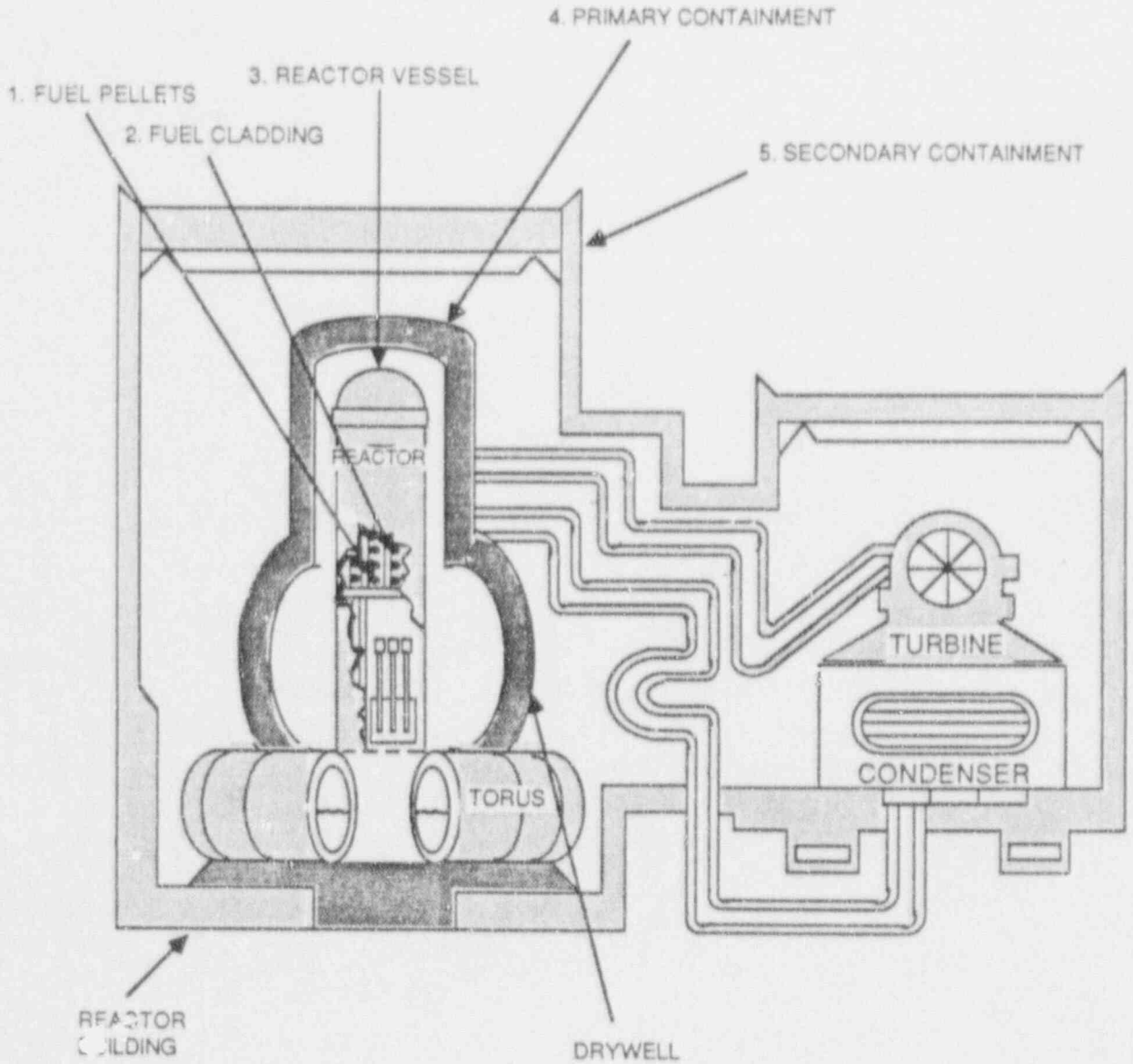


Figure 1.3-3
Barriers To Confine Radioactive Materials

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.

1.4 Radioactive Effluent Control

The small amounts of radioactive liquids and gases that might escape the five barriers are purified in the liquid and gaseous waste treatment systems, then monitored for radioactivity, and released only if the radioactivity levels are below the federal release limits.

Radioactivity released from the liquid effluent system to the environment is limited, controlled, and monitored by a variety of systems and procedures which include:

- reactor water cleanup system;
- liquid radwaste treatment system;
- sampling and analysis of the liquid radwaste tanks;
- liquid waste effluent discharge header radioactivity monitor.

The purpose of the reactor water cleanup system is to continuously purify the reactor cooling water by removing radioactive atoms and non-radioactive impurities that may become activated by neutron bombardment. A portion of the reactor coolant water is diverted from the primary coolant system and is purified by a high efficiency filter that removes radioactive particles suspended in the water. Subsequent to that, the flow is directed through ion exchange resins where radioactive elements, diluted in the water, are removed through chemical processes. The net effect is a drastic reduction of the radioactive material that is present in the primary coolant water and consequently the amount of radioactive material that might escape from the system.

Reactor cooling water that might escape the primary cooling system and other radioactive water sources is collected in floor and equipment drains. These drains direct this radioactive liquid waste to large holdup tanks. The liquid waste collected in the tanks is purified again using the liquid radwaste treatment system, which consists of a filter and ion exchange resins.

Processing of liquid radioactive waste results in large reductions of radioactive liquids discharged into Cape Cod Bay. Of all wastes processed through liquid radwaste treatment, 90 to 95 percent of all wastes are purified and the processed liquid re-used in plant systems.

Prior to release, the radioactivity in the liquid radwaste tank is sampled and analyzed to determine if the level of radioactivity is below the release limits and to quantify the total amount of radioactive liquid effluent that would be released. If the levels are below the federal release limits, the tank is drained to the liquid effluent discharge header.

This liquid waste effluent discharge header has a shielded radioactivity monitor located on it. This detector is connected to a radiation level meter and a strip chart recorder in the Control Room. The radiation alarm is set so that the detector will alarm before radioactivity levels exceed the release limits. The liquid effluent discharge header has an isolation valve. If an alarm is received, the liquid effluent discharge valve will automatically close, thereby terminating the release to the Cape Cod Bay and preventing any liquid radioactivity from being released that may exceed the release limits. An audible alarm notifies the Control Room operator that this has occurred.

Another means for adjusting liquid effluent concentrations to be below federal limits is by mixing plant cooling water from the condenser with the liquid effluents in the discharge canal. This larger volume of cooling water further dilutes the radioactivity levels far below the release limits.

The preceding discussion illustrates that many controls exist to reduce the radioactive liquid effluents released to the Cape Cod Bay to as far below the release limits as is reasonably achievable.

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

- reactor building ventilation system;
- reactor building vent effluent radioactivity monitor;
- sampling and analysis of reactor building vent effluents;
- standby gas treatment system;
- main stack effluent radioactivity monitor and sampling;
- sampling and analysis of main stack effluents;
- augmented off-gas system;
- off-gas radiation monitor.

The purpose of the reactor building ventilation system is to collect and exhaust reactor building air. Air collected from contaminated areas is filtered prior to combining it with air collected from other parts of the building. This combined airflow is then directed to the reactor building ventilation plenum which is located on the side of the reactor building. This plenum, which vents to the atmosphere, has a shielded radiation detector located on it. The radiation level meter and strip chart recorder for the reactor building vent effluent radioactivity monitor is located in the Control Room. To supplement the information continuously provided by the detector, air samples are taken periodically from the reactor building vent and are analyzed to quantify the total amount of radioactive gaseous and particulate effluent released.

If air containing elevated amounts of noble gases is routed past the reactor building vent's effluent radioactivity monitor, an alarm will alert the Control Room operators that release limits are being approached. The Control Room operators, according to procedure, will isolate the reactor building ventilation system and initiate the standby gas treatment system to remove airborne particulates and

gaseous halogen radioactivity from the reactor building exhaust. This filtration assembly consists of high-efficiency particulate air filters and charcoal absorber beds. The purified air is then directed to the main stack. The main stack has dilution flow which further reduces concentration levels of gaseous releases to the environment to as far below the release limits as is reasonably achievable.

The approximately 330 foot tall main stack has a special probe inside it which draws a portion of the air out and passes it through a radioactivity monitoring system. This main stack effluent radioactivity monitoring system samples radioactive particulates, iodines, and noble gases and collects a tritium sample. The system also contains radioactivity detectors that monitor the levels of radioactive noble gases in the stack flow and display the result on radiation level meters and strip chart recorders located in the Control Room. To supplement the information continuously provided by the detectors, the particulate, iodine, tritium, and gas samples are analyzed periodically to quantify the total amount of radioactive gaseous effluent being released.

The purpose of the augmented off-gas system is to reduce the radioactivity from the gases that are removed from the condenser. This purification system consists of a 30-minute holdup line to reduce the radioactive gases with short half-lives, a pre-filter to remove radioactive particulates, and several charcoal absorbers to remove radioactive iodines and further retard the short half-life gases.

The radioactive off-gas from the condenser is then directed into a ventilation pipe to which the off-gas radiation monitors are attached. The radiation level meters and strip chart recorders for this detector are also located in the Control Room. If a radiation alarm setpoint is exceeded, an audible alarm will sound to alert the Control Room operators. In addition, the off-gas bypass and charcoal absorber inlet valve will automatically re-direct the off-gas into the charcoal absorbers if they are temporarily being bypassed. If the radioactivity levels are not returned to below the alarm setpoint within 13 minutes, the off-gas releases will be automatically isolated, thereby preventing any gaseous radioactivity from being released that may exceed the release limits.

Therefore, for both liquid and gaseous releases, radioactive effluent 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 effluents are always monitored, sampled and analyzed prior to release to make sure that radioactivity levels are below the release limits. If the release limits are being approached, isolation valves in some of the waste effluent lines will automatically shut to stop the release, or Control Room operators will implement procedures to ensure that federal regulatory limits are always met.

1.5 Radiological Impact on Humans

The final effluent control is the determination of the radiological dose impact to 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 complied with. This is the first stage for assessing releases to the environment.

Next, calculations of the dose impact to the general public from Pilgrim Station's radioactive effluents are performed. 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. This is the second stage for assessing releases to the environment.

The types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during 1991 were reported to the Nuclear Regulatory Commission semiannually. The 1991 Radioactive Effluents are provided in Appendix B and will be discussed in more detail in Section 3 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 operational objectives.

These 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 are 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, drinking water supplies, 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

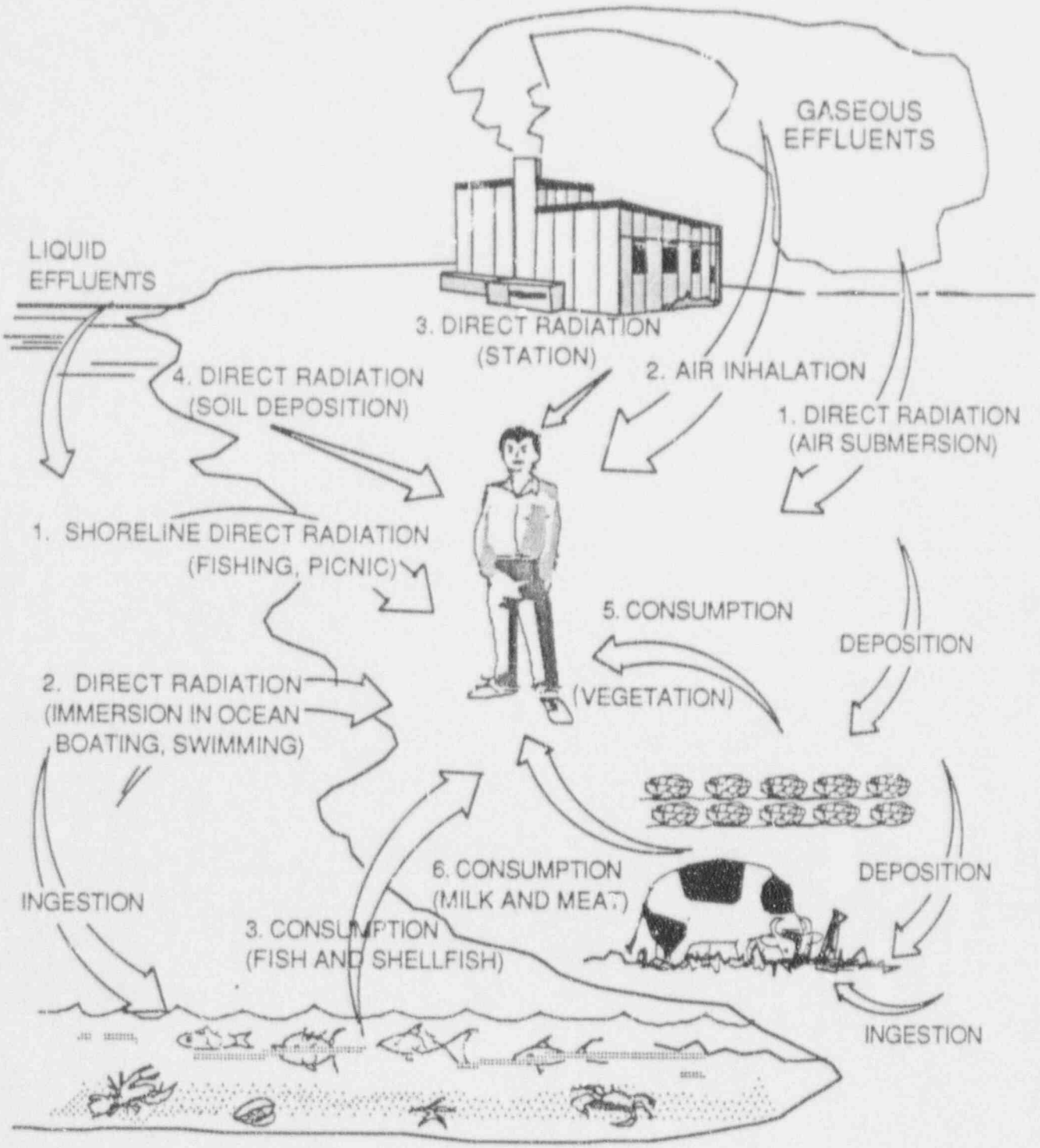


Figure 1.5-1
Radiation Exposure Pathways

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

1) external radiation from an airborne plume of radioactivity;

2) internal radiation from inhalation of airborne radioactivity;

3) direct radiation emitted from 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 cattle and other livestock.

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

1) external radiation from liquid effluents that deposit and accumulate 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). However, the operation of Pilgrim Nuclear Power Station results in releases of only small amounts of radioactivity, and, as a result of dilution in the atmosphere and ocean, even the most sensitive radioactivity measurements and analysis techniques cannot detect these tiny amounts of radioactivity above that which is naturally present in the environment. Therefore, radiation doses are calculated using radioactivity release data and computerized dose calculations that are based on very conservative (over-estimated) NRC-recommended models. These computerized dose calculations are performed by or for Boston Edison Co. personnel. These computer codes use the guidelines and methodology set forth by the NRC in Regulatory Guide 1.109.[6] The dose calculations are documented and described in detail in the Pilgrim Nuclear Power Station's Off-site Dose Calculation Manual[7] which has been reviewed by the NRC.

Monthly dose calculations are performed by Boston Edison Co. personnel. Semiannual dose calculations are performed for Boston Edison Co. by Yankee Atomic Electric Co., using their advanced "YODA" computer program. It should be emphasized that because of the very conservative assumptions made in the computer code calculations, the maximum hypothetical dose to an individual is considerably higher than the dose that would actually be received by a real individual.

After dose calculations are performed, 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,[8] 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,[9] 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,[10] sets forth the environmental standards for the uranium fuel cycle. During normal operation, the annual dose to any member of the public from the entire uranium fuel cycle 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.

The summary of the 1991 radiological impact for 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 Section 3 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 REMP at Pilgrim Nuclear Power Station during 1991 will be discussed in Section 2 of this report.

2.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

2.1 Pre-Operational Monitoring Results

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:[11]

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

2) evaluate procedures, equipment, and techniques.

The pre-operational program continued for approximately three and a half years, from August 1968 to June 1972.[12] Examples of background radiation and radioactivity levels measured during this time period are as follows:

- Airborne Radioactivity Particulate Concentration (gross beta): 0.02 - 1.11 pCi/m^3;
- Direct Radiation (TLDs): 4.2 - 22 micro-R/hr (37 - 190 mR/yr);
- Seawater Radioactivity Concentrations (gross beta): 12 - 31 pCi/liter;
- Fish Radioactivity Concentrations (gross beta): 2,200 - 11,300 pCi/kg;
- Milk Radioactive Cesium-137 Concentrations: 9.3 - 32 pCi/liter;
- Milk Radioactive Strontium-90 Concentrations: 4.7 - 17.6 pCi/liter;
- Cranberries Radioactive Cesium-137 Concentrations: 140 - 450 pCi/kg;
- Forage Radioactive Cesium-137 Concentrations: 150 - 290 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:[13]

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's 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 unforeseen conditions and, where appropriate, to trigger 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 or not 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 from postulated accidents. The NRC has established guidelines which specify an acceptable monitoring program.[14] 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[15] has been used to improve the program. In addition, the program has incorporated the provisions of an agreement made with the Massachusetts Wildlife Federation.[16] 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.

2.2 Environmental Monitoring Locations

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 and natural radioactivity and fallout from prior nuclear weapons tests.

The environmental sampling media collected in the vicinity of Pilgrim Station during 1991 included air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation, and forage. The medium, station number, description, distance, and direction for indicator and control samples are listed in Table 2.2-1. These sampling locations are also displayed on the maps shown in Figures 2.2-1, 2, 3, 4, and 5.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.2-1, 2, and 3. The frequency of collection and types of radioactivity analysis are described in Pilgrim Station's Technical Specifications, Sections 7.0/8.0.

The land-based (terrestrial) 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 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, respectively. The radioactivity analysis of samples and the processing of the environmental TLDs is performed by Yankee's Environmental Laboratory personnel.

The frequency, types, minimum number of samples, and maximum lower limits of detection (LLD) for the analytical measurements, are specified in the PNPS Technical Specifications.

Upon receipt of the analysis results from Yankee Atomic Electric Co., the Boston Edison staff reviews the results. 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's 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 1991 special studies). Most importantly, if radioactivity levels in the environment become elevated as a result of the station's 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 1991 Garden and Milk Animal Census are reported in Appendix C.

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 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 the other four sponsor companies. The 1991 results of this QA program are summarized in Appendix E. These results indicate that the analyses and measurements which were performed during 1991 exhibited acceptable precision and accuracy.

2.3 Interpretation of Radioactivity Analyses Results

The following pages summarize the analytical results of the environmental samples which were collected during 1991. 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.[17] 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.

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 separate 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) the indicator stations, (2) the station having the highest annual mean concentration, and (3) the control stations. For each of these three groups of data, the Yankee Atomic 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 the radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the sampling and analysis process. A sample or measurement is considered to contain <u>detectable</u> radioactivity if the measured value (e.g., concentration) exceeds three times its associated standard deviation. For example, a milk sample with a strontium-90 concentration of 3.5 ± 0.8 pCi/liter would be considered "positive" (detectable Sr-90), whereas another sample with a concentration of 2.1 ± 0.9 pCi/liter would be considered "negative", indicating no <u>detectable</u> strontium-90. The latter sample may actually contain strontium-90, but the levels counted during its analysis were not significantly different than background levels. The strontium-90 may be detectable at lower levels if the sample were counted for a longer period of time or analyzed in a different manner.

As an example of how to interpret data presented in the results tables, refer to the first entry on the table for air particulate filters (page 38). Gross beta (GR-B) analyses were performed on 566 routine samples (11 stations/wk * 52 weeks, minus six samples missed due to power outages at sampling stations). None of the samples exceeded ten times the average concentration at the control location. The lower limit of detection (LLD) required by Technical Specifications is 0.01 pCi/m^3.

For samples collected from the ten indicator stations, 511 out of 514 samples indicated detectable activity at the three-sigma (standard deviation) level. The mean concentration of gross beta activity in these 514 indicator station samples was 0.021 ± 0.000 (2.1 ± 0.0 E-2) pCi/m^3. Individual values ranged from 0.0043 to 0.043 (4.3 - 43.0 E-3) pCi/m^3.

The indicator station which yielded the highest mean concentration was station number 10 (Cleft Rock), which yielded a mean concentration of 0.022 ± 0.001 pCi/m^3, based on 52 observations. Individual values ranged from 0.0065 to 0.0355 pCi/m^3. All 52 out of 52 samples showed detectable activity at the three-sigma level.

At the control location, all 52 out of 52 samples yielded detectable gross beta activity, for an average concentration of 0.021 ± 0.001 pCi/m^3. Individual samples at the control location ranged from 0.0083 to 0.0385 pCi/m^3.

Referring to the third entry in the table, analyses for potassium-40 (K-40) were performed 44 times (quarterly composites for 11 stations * 4 quarters). No samples exceeded ten times the mean control station concentration. There is no LLD value listed for K-40 in the PNPS Technical Specifications.

At the indicator stations, individual concentrations of K-40 ranged from -0.0062 to 0.0101 pCi/m^3, for a mean concentration of 0.002 ± 0.0005 pCi/m^3. However, none of the forty samples analyzed showed detectable amounts of potassium-40 at the three-sigma level. It is important to note that the mean value presented is calculated from forty observations, all of which yielded no detectable activity. Although the mean value appears to indicate some potassium-40 present in the samples, neither the individual observations nor the collective mean were significantly different from background levels.

The station which yielded the highest mean concentration of K-40 was station 08. Again, the mean value of 0.004 ± 0.0013 pCi/m^3 is based on four observations, none of which yielded any detectable activity. Therefore, no potassium-40 was detected in any of the samples collected from the sampling stations.

2.4 Direct Radiation Measurements

The primary technique for measuring direct radiation exposure in the vicinity of Pilgrim Station involves posting environmental thermoluminescent dosimeters (TLDs) at given monitoring locations and retrieving the TLD after a specified time period. The TLDs are then taken to a laboratory and processed to determine the total amount of radiation exposure received over the period. Although TLDs can be used to monitor radiation exposure for short time periods, environmental TLDs are typically posted for periods of one to three months. Such TLD monitoring yields average exposure rate measurement over a relatively long time period. The PNPS environmental TLD monitoring program is based on a quarterly (three month) posting period, and a total of 107 locations are monitored using this technique. Forty of these locations are listed as required monitoring locations in the PNPS Technical Specifications. In addition, 28 of the 107 TLDs are located on-site, within the PNPS protected/restricted area.

Out of the 428 TLDs (107 locations * 4 quarters) posted during 1991, 417 were retrieved and processed. Those TLDs missing from their monitoring locations were lost to storm damage and vandalism, and their absence is discussed in Appendix D. The results for environmental TLDs located off-site, beyond the PNPS protected/restricted area fence, are presented in Table 2.4-1. Results from on-site TLDs posted within the restricted area presented in Table 2.4-2. In addition to TLD results for individual locations, results from off-site TLDs were grouped according to geographic zone to determine average exposure rates as a function of distance. These results are summarized in Table 2.4-3. All of the listed exposure values represent continuous occupancy (2190 hr/qtr or 8760 hr/yr).

Annual exposure rates at off-site locations ranged from 43 to 208 mR/yr. The average exposure rate at control locations greater than 15 km from Pilgrim Station (i.e., Zone 4) was 61.4 ± 8.7 mR/yr. In other words, 99% of all measurements of background exposure would be expected to be between 35 and 88 mR/yr. A number of the on-site TLDs indicated direct radiation exposure above background levels due to their proximity to radiation sources within the PNPS protected/restricted area.

A small number of TLDs (locations OA, PB, TC and PO1) in close proximity to the station indicated direct radiation exposure resulting from PNPS operations. However, these TLDs are on Boston Edison controlled property, and a maximum hypothetically exposed member of the public accessing such areas on Boston Edison property for limited periods of time would receive a maximum dose of 0.7 mrem/yr above their average background doses of 61 mrem/yr. The exposure rates measured at areas beyond Boston Edison control did not indicate any direct radiation exposure from Pilgrim Station operations. For example, the annual exposure rate at the nearest off-site residence (location HB, 0.5 mi SE) was 61.7 ± 4.0 mR/yr, which compares quite well with the average control location exposure of 61.4 mR/yr.

A second technique for measuring direct radiation exposure utilizes a sensitive high-pressure ion chamber to make "real time" exposure rate measurements. This technique allows for instantaneous assessments, with the instrument providing a direct readout of exposure rates. Such monitoring with a high-pressure ion chamber can be used to perform rapid, short-term measurements at locations where it may be impractical to post long-term TLD monitors.

Annual measurements are taken with a high-pressure ion chamber at five locations on beaches in the Plymouth area, and at the control location in Duxbury. Results of these measurements are listed in Table 2.4-4. These values, as well as historical measurements, are depicted graphically in Figure 2.4-1. There are no apparent trends in exposure levels at these locations.

In conclusion, measurements of direct radiation exposure around Pilgrim Station do not indicate any significant increase in exposure levels. Although some increases in direct radiation exposure level were apparent on Boston Edison property very close to Pilgrim Station, there were no measurable increases at areas beyond Boston Edison's control.

2.5 Air Particulate Filter Radioactivity Analyses

Airborne particulate radioactivity is sampled by drawing a stream of air through a glass fiber filter which has a very high efficiency for collecting airborne particles. These samplers are operated continuously, and the resulting filters are collected weekly for analysis. Weekly filter samples are analyzed for gross beta radioactivity, and the filters are then composited on a quarterly basis for each location for gamma spectroscopy analysis. Boston Edison uses this technique to monitor 10 locations in the Plymouth area, along with the control location in East Weymouth.

Out of 572 filters (11 locations * 52 weeks), 566 were collected and analyzed during 1991. Those six samples which were missed resulted from extended power outages and damage to the sampling stations from Hurricane Bob in August and the large storm in late October. There were two instances in which the lower limit of detection was not met on the filters. This was due to low sample volume resulting from power losses at the monitoring station. These discrepancies are noted in Appendix D.

The results of the analyses performed on these 566 filter samples are summarized in Table 2.5-1. Trend plots for the gross beta radioactivity levels at the near station, property line, and off-site airborne monitoring locations are shown in Figures 2.5-1, 2.5-2 and 2.5-3, respectively. Gross beta radioactivity was detected in 563 of the filter samples collected, including all 52 control location samples. This gross beta activity arises from naturally occurring radionuclides such as radon decay daughter products. Beryllium-7 was the only gamma emitting nuclide detected, and it was observed in all 44 of the quarterly composites analyzed. No radionuclides attributable to Pilgrim Station operations were detected in any of the air particulate samples collected.

2.6 Charcoal Cartridge Radioactivity Analyses

Airborne radioactive iodine is sampled by drawing a stream of air through a charcoal cartridge after it has passed through the high efficiency glass fiber filter. As is the case with the air particulate filters, these samplers are operated continuously, and the resulting cartridges are collected weekly for analysis. Weekly cartridge samples are analyzed for radioactive iodine. The same eleven locations monitored for airborne particulate radioactivity are also sampled for airborne radioiodine.

Out of 572 cartridges (11 locations * 52 weeks), 566 were collected and analyzed during 1991. The six samples missed resulted from external power outages and damage to the sampling stations resulting from Hurricane Bob in August and the large storm in late October. These discrepancies are noted in Appendix D.

The results of the analyses performed on these 566 charcoal cartridges are summarized in Table 2.6-1. No airborne radioactive iodine was detected in any of the charcoal cartridges collected.

2.7 Milk Radioactivity Analyses

Samples of unprocessed milk are collected from the Plymouth County Farm and from the control location in Whitman. The Annual Land Use Census conducted within three miles of Pilgrim Station did not identify any additional milk animals requiring sampling. Results of this census are summarized in Appendix C. Milk samples are collected monthly from November through April, and once every two weeks when animals are assumed to be on pasture during the period May through October. These milk samples are analyzed by gamma spectroscopy, low-level analysis for radioiodine and strontium 89 and 90.

All 40 samples scheduled for collection during the year were obtained and analyzed. No problems were encountered in sampling milk during 1991.

The results of the analyses performed on the 40 milk samples are summarized in Table 2.7-1. Naturally-occurring potassium-40 was detected in all 40 samples. No radioactive iodine was detected in any of the samples. Strontium-90 was detected in 16 of the 20 samples from Plymouth County Farm, and in 14 of the 20 samples collected from the control location in Whitman. Cesium-137 was also detected in two of the samples collected from Plymouth County Farm. Concentrations of Sr-90 and Cs-137 as a function of time are shown in Figures 2.7-1 and 2.7-2, respectively.

The highest concentration of Sr-90, 4.0 pCi/liter, was observed in a sample collected from the control location in Whitman. The highest concentration of Sr-90 in samples collected from Plymouth County Farm was 3.6 pCi/liter. The Sr-90 detected in the samples resulted from radioactivity in the environment which was deposited from nuclear weapons testing conducted in the 1950s and 60s. Strontium-90 was routinely detected in the preoperational sampling program conducted prior to Pilgrim Startup in 1972, at concentrations ranging from 5 to 18 pCi/liter. When the average preoperational Sr-90 concentration of 9 pCi/liter is corrected for radioactive decay which occurred between 1972 and 1991, the expected concentration would be 6 pCi/liter. The concentrations of 3 to 4 pCi/liter observed in 1991 samples are well below the expected Sr-90 concentrations resulting from weapons testing. It is clear that the Sr-90 observed did not arise from Pilgrim Station operations.

The highest concentration of Cs-137 detected in samples from Plymouth County Farm was 5.2 pCi/liter. Cesium-137 is also a product of nuclear weapons testing, and was routinely detected in the preoperational monitoring program at levels of 9 to 32 pCi/liter. When the average preoperational Cs-137 concentration of 18 pCi/liter is corrected for radioactive decay, the expected concentration in 1991 samples would be 12 pCi/liter. Clearly, the Cs-137 concentrations observed in the two samples collected from Plymouth County Farm are indicative of radioactivity arising from weapons testing fallout, and not Pilgrim Station operations.

2.8 Forage Radioactivity Analyses

Samples of animal forage (hay) are collected from the Plymouth County Farm and from the control location in Whitman. Samples of corn to be used for silage at Plymouth County Farm were also collected from the Whipple Farm (1.8 mi. SW). Samples are collected annually and analyzed by gamma spectroscopy.

All samples of forage were collected and analyzed as required during 1991. Results of the gamma analyses of forage samples are summarized in Table 2.8-1. The only radionuclides detected in any of the samples were naturally-occurring beryllium-7 and potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.9 Vegetable/Vegetation Radioactivity Analyses

Samples of vegetables are routinely collected from the Plymouth County Farm and from the control location at Bridgewater Farm. In addition, samples of vegetables or leafy vegetation were collected at or near a number of gardens identified during the Annual Land Use Census. Results of this census are discussed in Appendix C. Samples of vegetables are collected annually and analyzed by gamma spectroscopy.

All samples of vegetables/vegetation were collected and analyzed as required during 1991. Results of the gamma analyses of samples of vegetables/vegetation are summarized in Table 2.9-1. The only radionuclides detected in any of the samples were naturally-occurring beryllium-7 and potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.10 Cranberry Radioactivity Analyses

Samples of cranberries are routinely collected from two bogs in the Plymouth area and from the control location in Halifax. Samples of cranberries are collected annually and analyzed by gamma spectroscopy.

All three samples of cranberries were collected and analyzed as required during 1991. Results of the gamma analyses of cranberry samples are summarized in Table 2.10-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.11 Soil Radioactivity Analyses

A survey of radioactivity in soil is conducted once every three years at the 10 air sampling stations in the Plymouth area and the control location in East Weymouth. These locations serve as fixed survey locations at which repeated measurements can be made to determine any buildup of radioactivity from deposition of airborne radionuclides. At each of these locations, samples of topsoil are collected for gamma spectroscopy analysis in the laboratory. Soil cores are also collected if possible for gamma analyses as a function of depth. In addition, in-field measurements are made at each location with a portable gamma spectroscopy unit and a high pressure ion chamber. The portable gamma spectrometer is used to identify radionuclides present across a large area beneath the detector, whereas the high pressure ion chamber is used to detect exposure levels arising from naturally-occurring and deposited radionuclides in the soil.

The soil survey was performed as required during 1991. A total of 35 samples of topsoil and depth-divided soil cores were collected and analyzed. The results of the laboratory analyses of these soil samples are summarized in Table 2.11-1. Naturally-occurring beryllium-7, potassium-40 and thorium 232 were detected in a number of the samples. Cobalt-60 was detected in samples collected from three locations on Boston Edison property. Cesium-137 was detected in 29 of the 35 samples, including those collected from the control location.

Cobalt-60 concentrations observed in soil samples during the 1991 soil survey ranged from non-detectable to 295 pCi/kg. Concentrations of Cs-137 ranged from non-detectable to 2895 pCi/kg. The observed concentrations of both Co-60 and Cs-137 were comparable to those observed during the last soil survey performed in 1988, and do not indicate any significant buildup of these nuclides since the last soil survey. In fact, concentrations in most of the samples from these locations decreased from 1988 to 1991. Results of the in-field measurements with the portable gamma spectroscopy unit indicated that the real concentrations of Cs-137 are typical of those observed throughout New England from weapons testing. In other words, none of the Cs-137 concentrations observed at any of the locations were elevated over typical fallout levels. However, since it would be difficult to separate Cs-137 resulting from PNPS effluent releases from that deposited by weapons testing, the assessment of dose impacts was performed assuming that all of the Cs-137 detected resulted from PNPS operations.

A special study was performed to determine the radiological impact to man from the Co-60 and Cs-137 detected in the soil samples collected on Boston Edison property adjacent to Pilgrim Station. This study is discussed in detail in Appendix A. The external radiation dose resulting from the maximum concentrations of Co-60 and Cs-137 deposited on the ground (sampling location OA, near the I&S Building) would result in a dose rate of 0.001 mrem/hr. By comparison, the dose rate from the naturally-occurring potassium-40, thorium-232 and uranium-238 in the soil at this location was estimated as 0.004 mrem/hr. The maximum exposed hypothetical individual was assumed to be at this location on Boston Edison property for 40 hours. The resulting annual maximum total body dose from the Co-60 and Cs-137 in the soil at this location was estimated to be 0.04 mrem.

2.12 Surface Water Radioactivity Analyses

Samples of surface water are routinely collected from the Discharge Canal, Bartlett Pond in Manomet and from the control location at Powder Point Bridge in Duxbury. The Discharge Canal is sampled continuously by a composite sampler. Grab samples are collected weekly from the Bartlett Pond and Powder Point Bridge locations. Samples of surface water are composited every four weeks and analyzed by gamma spectroscopy and low-level iodine analysis. These monthly composites are further composited on a quarterly basis and tritium analysis is performed on this quarterly sample.

A total of 39 samples (3 locations * 13 sampling periods) of surface water were collected and analyzed as required during 1991. There were a few instances of problems with obtaining composite samples from the Discharge Canal. The sampler was unable to collect samples during extreme low tide conditions that coincided with reduced flow through the Discharge Canal when pumps were shutdown during the refueling outage in July. This problem was corrected by using a submersible pump in the canal to pump water up to the composite sampler. There were also problems with the sample line freezing during extremely cold weather in December. This was corrected by adding heat tracing to the intake line. These discrepancies are discussed in Appendix D.

Results of the analyses of water samples are summarized in Table 2.12-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.13 Fish Radioactivity Analyses

Samples of fish are routinely collected from the area at the outfall of the Discharge Canal and from the control locations in Cape Cod Bay and Buzzard's Bay. Fish species are grouped into four major categories according to their biological requirements and mode of life. These major categories and the representative species are as follows:

Group I - Bottom Oriented: Winter Flounder, Yellowtail Flounder

Group II - Near-Bottom Distribution: Tautog, Cunner, Pollock, Atlantic Cod, Hake

Group III - Anadromous: Alewife, Smelt, Striped Bass

Group IV - Coastal Migratory: Bluefish, Herring, Menhaden, Mackerel

Two subsamples of each category of fish are typically collected during each collection period. Group I and II fishes are sampled on a quarterly basis from the outfall area of the Discharge Canal, and on an annual basis from a control location. Group III and IV fishes are sampled annually from the Discharge Canal outfall and control location. All samples of fish are analyzed by gamma spectroscopy.

Twenty-seven samples of fish were collected during 1991. Both Group I and Group II species of fish were unavailable in the vicinity of the Discharge Canal during the second quarter of the year due to low water temperatures and rough seas, and samples of these species were not obtained during this period. This discrepancy is noted in Appendix D.

Results of the gamma analyses of fish samples which were collected are summarized in Table 2.13-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.14 Shellfish Radioactivity Analyses

Samples of blue mussels, soft-shell clams and quahogs are collected from the Discharge Canal outfall and two other locations in the Plymouth area (Manomet Point, Plymouth Harbor), and from control locations in Duxbury and Marshfield. All samples are collected on a quarterly basis, and processed in the laboratory for gamma spectroscopy analysis. In addition to analyzing the edible portion (meat) from each of the samples, the shells from samples collected from the Discharge Canal outfall and from all control location samples are also analyzed.

All 48 samples of shellfish meat and shells scheduled for collection during 1991 were obtained and analyzed. Results of the gamma analyses of these samples are summarized in Table 2.14-1. Naturally-occurring beryllium-7, potassium-40 and thorium-232 were detected in a number of the samples. Cobalt-60 was detected in four of the mussel samples collected from the Discharge Canal outfall. No other radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

The cobalt-60 detected in the mussels collected from the outfall area of the PNPS Discharge Canal ranged in concentrations from non-detectable to 7.2 pCi/kg. The Co-60 was observed in three of the four samples of meat and in one of the four samples of shells. The average concentration of Co-60 in the edible portion was 6.0 pCi/kg. This level shows a continuous decrease in Co-60 levels in the mussels in the area of the Discharge Canal. For comparison, the average concentrations of Co-60 in mussels from this area were 89 pCi/kg in 1987, 37 pCi/kg in 1988, 22 pCi/kg in 1989 and 12 pCi/kg in 1990. Due to the moderate half-life of Co-60 (5.3 yr), any of the nuclide deposited in the area in past years should still be detectable. The observed decrease in these levels through time indicates that no additional accumulation is taking place.

A special study was performed to determine the radiological impact to man from the Co-60 detected in the mussel samples. This study is discussed in detail in Appendix A. The maximum-exposed hypothetical individual was assumed to eat 9 kg/yr of mussels containing Co-60 at the mean concentration of 6 pCi/kg. This resulted in a maximum total body dose of 0.0003 mrem, with a corresponding maximum organ dose of 0.002 mrem.

In conclusion, the analysis of radioactivity in samples of shellfish collected during 1991 showed no indication of additional accumulation of radionuclides related to Pilgrim Station operations. Further, the radiological impact of the low levels of Co-60 observed in a limited number of the samples poses no significant radiological impact to the environment or general public in the area.

2.15 Irish Moss Radioactivity Analyses

Samples of Irish moss are collected from the Discharge Canal outfall and two other locations in the Plymouth area (Manomet Point, Ellisville), and from a control location in Marshfield (Green Harbor). All samples are collected on a quarterly basis, and processed in the laboratory for gamma spectroscopy analysis.

All 16 samples of Irish moss scheduled for collection during 1991 were obtained and analyzed. Results of the gamma analyses of these samples are summarized in Table 2.15-1. Naturally-occurring beryllium-7, potassium-40 and thorium-232 were detected in a number of the samples. Cobalt-60 was detected in one of the samples collected from the Discharge Canal outfall at a concentration of 47 pCi/kg. No other radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

A special study was performed to determine the radiological impact to man from the Co-60 detected in the sample of Irish moss. This study is discussed in detail in Appendix A. The maximum-exposed hypothetical individual was assumed to eat 9 kg/yr of Irish moss products containing Co-60 at the maximum concentration of 47 pCi/kg. This resulted in a maximum total body dose of 0.002 mrem, with a corresponding maximum organ dose of 0.02 mrem. In reality, the dose would be considerably lower, as some of the Co-60 would likely be lost in the processing of the Irish moss into food products.

In conclusion, the analysis of radioactivity in samples of Irish moss collected during 1991 showed no indication of additional accumulation of radionuclides related to Pilgrim Station operations. Furthermore, the radiological impact of the low levels of Co-60 observed in a limited number of the samples poses no significant radiological impact to the environment or general public in the area.

2.16 Lobster Radioactivity Analyses

Samples of lobsters are routinely collected from the outfall area of the Discharge Canal and from the control location in Duxbury. Samples are collected monthly from the Discharge Canal outfall from June through September and annually from the control location. All lobster samples are analyzed by gamma spectroscopy.

All five samples of lobsters were collected and analyzed as required during 1991. Results of the gamma analyses of lobster samples are summarized in Table 2.16-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.17 Sediment Radioactivity Analyses

Samples of sediment are routinely collected from the outfall area of the Discharge Canal and from three other locations in the Plymouth area (Manomet Point, Plymouth Harbor and Plymouth Beach), and from control locations in Duxbury and Marshfield. Samples are collected twice per year and are analyzed by gamma spectroscopy. Sediment cores are subdivided into depth increments for analysis of radionuclide distribution by depth. During the first half of the year, samples are divided into 2 cm increments, whereas samples for the second half of the year are divided into 5 cm increments. In addition to the gamma analyses, plutonium analyses are performed on the surface layer samples collected during the first half of the year from the Discharge Canal outfall, Plymouth Harbor, Manomet Point and Duxbury. Plutonium analyses are also performed on a mid-depth section from the Discharge Canal sample and Duxbury sample.

All 56 samples of sediment were collected and analyzed as required during 1991. Results of the gamma analyses of sediment samples are summarized in Table 2.17-1. Results of the plutonium analyses are presented in Table 2.17-2. Naturally-occurring beryllium-7, potassium-40 and thorium-232 were detected in a number of the samples. Cesium-137 was detected in 10 of 39 indicator station samples and in 13 of 17 control station samples. Plutonium-239/240 was detected in three out of four indicator station samples and in both of the control station samples.

Cesium-137 levels in indicator samples ranged from non-detectable to a maximum concentration of 75 pCi/kg. Concentrations in samples collected from the control locations beyond the influence of Pilgrim Station also ranged from non-detectable to a maximum concentration of 75 pCi/kg. The comparability of the results from indicator and control stations indicates that the source of this activity is not Pilgrim Station. The levels detected are also comparable to concentrations observed in the past few years and are indicative of Cs-137 resulting from nuclear weapons testing.

Plutonium-239/240 levels in indicator samples ranged from non-detectable to a maximum concentration of 10.2 pCi/kg. Concentrations in samples collected from the control locations beyond the influence of Pilgrim Station ranged from 3.4 pCi/kg to a maximum concentration of 19.1 pCi/kg. The fact that the results from indicator locations are lower than those from the control stations indicates that the source of this activity is not Pilgrim Station. The levels detected are also comparable to concentrations observed in the past few years and are indicative of plutonium deposited in the environment from nuclear weapons testing.

In conclusion, the only radionuclides detected in sediment samples collected in the vicinity of Pilgrim Station during 1991 were naturally-occurring radionuclides and those resulting from nuclear weapons testing. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

Table 2.2-1

Routine Radiological Environmental Sampling Locations
Pilgrim Nuclear Power Station, Plymouth, MA

Media	No	Code	Description	Dist.	Dir.
Air Particulate Filters/ Charcoal Cartridges Soil	00	WS	Warehouse	0.1 Mi	ESE
	01	ER	E. Rocky Hill Road	0.3 Mi	SE
	03	WR	W. Rocky Hill Road	0.2 Mi	WSW
	06	PL	Property Line	0.3 Mi	W
	07	PB	Pedestrian Bridge	0.1 Mi	NNW
	08	OA	Overlook Area	0.1 Mi	SW
	09	EB	East Breakwater	0.3 Mi	SE
	10	CR	Cleft Rock	0.9 Mi	SW
	15	PC	Plymouth Center	4.1 Mi	W
	17	MS	Manomet Substation	2.3 Mi	SSE
	21	EW	East Weymouth Control	24 Mi	NW
Milk	11	CF	Plymouth County Farm	3.4 Mi	W
	21	WF	Whitman Farm Control	20 Mi	WNW
Forage	11	CF	Plymouth County Farm	3.4 Mi	W
	12	WF	Whitman Farm Control	20 Mi	WNW
	43	WH	Whipple Farm	1.8 Mi	SW
Vegetation	11	CF	Plymouth County Farm	3.4 Mi	W
	27	BF	Bridgewater Farm Ctrl	20 Mi	W
	60	AF	Work Residence	0.8 Mi	SE
	77	MG	Moon Residence	2.1 Mi	WSW
Cranberries	13	MR	Manomet Pt. Bog	2.5 Mi	SE
	14	BR	Bartlett Rd. Bog	2.7 Mi	SSE
	23	PS	Pine St. Bog Control	17 Mi	WNW
Surface Water	11	DIS	Discharge Canal	0.1 Mi	NNW
	17	BP	Bartlett Pond	3 Mi	SE
	23	PP	Powder Point Control	8 Mi	NNW
Fishes	11	DIS	Discharge Canal	0.2 Mi	N
	29	PC	Priest Cove Control	30 Mi	SW
	30	JR	Jones River Control	8 Mi	NNW
	92	MV	Vineyard Sound Control	50 Mi	SSW
	98	CC-Bay	Cape Cod Bay Control	15 Mi	ESE
Shellfish	11	DIS	Discharge Canal	0.2 Mi	N
	12	Ply-H	Plymouth Harbor	3 Mi	N
	13	Dux-Bay	Duxbury Bay Control	8 Mi	NNW
	15	MP	Manomet Point	3 Mi	SE
	23	PP	Powder Point Control	8 Mi	NNW
	24	GH	Green Harbor Control	9 Mi	NNW
Irish Moss	11	DIS	Discharge Canal	0.2 Mi	N
	15	MP	Manomet Point	3 Mi	SE
	22	EL	Ellisville	8 Mi	SE
	34	BR	Brant Rock Control	10 Mi	NNW

Table 2.2-1 (continued)

Routine Radiological Environmental Sampling Locations
Pilgrim Nuclear Power Station, Plymouth, MA

Media	No	Code	Description	Dist.		Dir.
Lobster	11	DIS	Discharge Canal	0.2	Mi	N
	12	Ply-H	Plymouth Harbor	3	MI	W
	13	Dux-Bay	Duxbury Bay Control	8	Mi	NNW
Sediment	11	DIS	Discharge Canal	0.2	Mi	N
	12	Ply-H	Plymouth Harbor	3	Mi	W
	13	Dux-Bay	Duxbury Bay	8	Mi	NNW
	14	PLB	Plymouth Beach	2	Mi	W
	15	MP	Manomet Point	3	Mi	SE
	24	GH	Green Harbor Control	9	Mi	NNW

Table 2.4-1

Off-Site Environmental TLD Results

TLD Station		Location*		Exposure Rate - mR/quarter (Value ± STD.DEV)				Annual Mean** Exposure
ID	Description	Distance	Dir.	First	Second	Third	Fourth	mR/yr
OA	OVERLOOK AREA	0.15 km	W	56.7 ± 2.7	26.8 ± 1.8	36.3 ± 1.8	88.3 ± 6.4	208.0 ±110.2
TC	I&S BUILDING	0.16 km	W	26.8 ± 1.4	16.1 ± 1.1	19.8 ± 0.8	38.0 ± 1.0	100.7 ± 38.8
PB	PEDESTRIAN BRIDGE	0.21 km	N	29.5 ± 0.7	27.1 ± 2.0	27.2 ± 1.0	33.7 ± 1.2	117.4 ± 13.8
P01	SHOREFRONT SECURTY	0.22 km	NNW	21.7 ± 1.1	18.6 ± 1.3	Missing	26.7 ± 1.2	89.3 ± 17.3
CT	CNTR PARKING LOT	0.34 km	SSE	19.2 ± 1.5	17.0 ± 1.1	19.9 ± 0.8	21.9 ± 0.8	78.0 ± 9.6
PMT	PNPS MET TOWER	0.44 km	NW	15.9 ± 0.6	15.8 ± 1.0	16.2 ± 0.7	16.9 ± 0.5	64.8 ± 3.9
PA	SHFNT PARKING AREA	0.36 km	NNW	17.1 ± 0.5	18.4 ± 1.2	18.4 ± 1.1	20.0 ± 0.7	73.9 ± 6.4
A	STATION A	0.40 km	W	16.4 ± 0.7	16.9 ± 1.0	16.5 ± 0.7	18.5 ± 0.7	68.2 ± 5.3
B	STATION B	0.40 km	SSW	18.0 ± 0.6	17.6 ± 1.1	18.0 ± 0.8	19.1 ± 0.8	72.7 ± 4.6
F	STATION F	0.43 km	NW	16.7 ± 0.6	17.7 ± 1.1	18.3 ± 1.2	17.9 ± 0.7	70.7 ± 5.1
L	STATION L	0.44 km	ESE	15.7 ± 0.5	16.1 ± 1.1	16.4 ± 0.5	17.8 ± 0.5	65.9 ± 4.9
EB	EAST BREAKWATER	0.47 km	ESE	17.8 ± 0.9	18.3 ± 1.3	19.6 ± 0.9	Missing	74.3 ± 6.4
I	STATION I	0.48 km	WNW	16.2 ± 0.8	17.1 ± 1.3	16.8 ± 0.7	17.6 ± 0.5	67.7 ± 4.7
H	STATION H	0.51 km	SW	19.7 ± 0.7	19.5 ± 1.2	21.5 ± 0.8	20.8 ± 0.7	81.5 ± 5.4
C	STATION C	0.52 km	SE	15.9 ± 0.6	Missing	16.8 ± 0.5	16.1 ± 0.4	65.1 ± 3.1
PL	PROPERTY LINE	0.53 km	NW	16.0 ± 0.8	17.4 ± 1.2	17.1 ± 0.7	17.4 ± 0.6	67.9 ± 4.8
D	STATION D	0.55 km	NNW	21.6 ± 0.9	21.7 ± 1.5	21.5 ± 0.9	21.7 ± 0.6	86.4 ± 4.8
HB	HALL'S BOG	0.60 km	SSE	14.6 ± 0.3	15.2 ± 0.9	15.9 ± 0.7	16.0 ± 0.6	61.7 ± 4.0
G	STATION G	0.62 km	W	16.1 ± 0.6	16.6 ± 1.0	16.4 ± 0.9	16.9 ± 0.5	66.0 ± 3.8
GH	GREENWOOD HOUSE	0.69 km	SE	17.4 ± 0.6	18.6 ± 1.2	18.6 ± 0.9	17.9 ± 0.7	72.4 ± 4.6
WR	W ROCKY HILL ROAD	0.82 km	WNW	19.1 ± 0.4	19.8 ± 1.3	20.6 ± 1.0	20.4 ± 0.6	79.9 ± 4.9
ER	E ROCKY HILL ROAD	0.90 km	[illegible]	14.4 ± 0.6	14.7 ± 0.9	15.1 ± 0.5	15.0 ± 0.4	59.3 ± 3.2
MT	MICROWAVE TOWER	0.92 km	SSW	15.8 ± 0.4	16.9 ± 1.1	17.3 ± 0.9	15.8 ± 0.6	65.8 ± 4.8
CR	CLEFT ROCK	1.23 km	SSW	15.2 ± 0.5	16.1 ± 1.0	15.9 ± 0.4	15.1 ± 0.5	62.4 ± 3.7
BD	BAYSHORE DRIVE	1.32 km	WNW	16.8 ± 0.6	17.3 ± 1.1	17.7 ± 0.8	17.7 ± 0.5	69.5 ± 3.9
MR	MANOMET ROAD	1.38 km	S	14.2 ± 0.5	14.5 ± 1.0	15.1 ± 0.6	14.6 ± 0.5	59.1 ± 3.3
DR	DIRT ROAD	1.45 km	SW	[illegible]	15.1 ± 0.9	14.9 ± 0.4	14.7 ± 0.7	59.6 ± 3.6
EM	EMERSON ROAD	1.54 km	SSE	15.5 ± 0.7	15.4 ± 1.0	16.3 ± 1.0	15.5 ± 0.6	62.8 ± 4.3
AR	EDISON ACCESS ROAD	1.54 km	SSE	14.6 ± 0.7	15.0 ± 1.0	15.5 ± 1.1	14.9 ± 0.4	60.0 ± 4.3
EP	EMERSON & PRISCIL	1.56 km	SE	15.0 ± 0.7	14.9 ± 0.9	16.1 ± 0.9	15.1 ± 0.6	61.2 ± 4.3
BS	BAYSHORE	1.73 km	W	17.2 ± 0.5	17.8 ± 1.0	17.8 ± 1.0	18.0 ± 0.5	70.8 ± 4.1
E	STATION E	1.86 km	S	15.0 ± 0.6	14.7 ± 1.2	15.5 ± 0.6	14.3 ± 0.5	59.4 ± 4.2
JG	JOHN GAULEY	1.96 km	W	15.9 ± 0.8	15.9 ± 1.0	16.4 ± 0.7	15.7 ± 0.4	63.9 ± 3.7
J	STATION J	2.02 km	S	13.9 ± 0.7	14.3 ± 0.9	13.8 ± 0.7	15.6 ± 0.6	57.6 ± 4.7
RC	PLYMOUTH YMCA	2.06 km	WSW	15.8 ± 0.5	16.1 ± 1.1	16.4 ± 0.8	16.7 ± 0.5	65.0 ± 3.9
WH	WHITEHORSE ROAD	2.13 km	SSE	14.7 ± 0.7	15.4 ± 1.0	15.3 ± 0.5	14.7 ± 0.6	60.0 ± 3.7
K	STATION K	2.14 km	SSE	14.8 ± 0.6	14.9 ± 1.3	15.8 ± 0.7	14.6 ± 0.7	60.0 ± 4.6
TT	TAYLOR & THOMAS	2.25 km	SE	15.4 ± 0.6	15.2 ± 0.9	15.2 ± 0.7	15.1 ± 0.5	60.9 ± 3.1
YV	YANKEE VILLAGE	2.27 km	WSW	15.9 ± 0.6	15.9 ± 1.1	18.1 ± 0.6	17.1 ± 0.6	66.9 ± 5.5
GN	GOODWIN PROPERTY	2.43 km	SW	11.0 ± 0.5	11.6 ± 0.8	11.9 ± 0.4	10.9 ± 0.4	45.5 ± 3.2

* Distance and direction are measured from the centerline of the reactor building to the monitoring location.

** Annual average value is based on arithmetic mean of the observed quarterly values multiplied by 4 quarters/yr.

Table 2.4-1 (continued)

Off-Site Environmental TLD Results

TLD Station		Location*		Exposure Rate - mR/quarter (Value ± STD.DEV)				Annual Mean** Exposure
ID	Description	Distance	Dir.	First	Second	Third	Fourth	mR/yr
RW	RIGHT OF WAY	2.83 km	S	13.0 ± 0.8	13.0 ± 0.9	14.2 ± 0.4	12.6 ± 0.8	52.9 ± 4.5
TP	TAYLOR & PEARL	2.99 km	SE	14.4 ± 0.8	13.6 ± 0.9	Missing	14.2 ± 0.6	56.3 ± 4.3
VR	VALLEY ROAD	3.26 km	SSW	13.1 ± 0.7	13.2 ± 0.9	13.8 ± 0.6	13.0 ± 0.5	53.1 ± 3.5
WC	WARREN & CLIFFORD	3.30 km	W	14.4 ± 0.6	14.2 ± 0.9	14.7 ± 0.7	13.7 ± 0.5	57.0 ± 3.6
ME	MANOMET ELEM	3.30 km	SE	12.9 ± 0.8	13.5 ± 1.1	14.1 ± 0.7	13.2 ± 0.6	53.7 ± 4.2
BB	3A & BARTLETT RD	3.37 km	SSE	15.2 ± 0.6	15.1 ± 1.0	15.4 ± 0.7	14.9 ± 0.5	60.5 ± 3.5
MP	MANOMET POINT	3.57 km	SE	14.8 ± 0.5	15.3 ± 1.0	15.2 ± 0.7	14.9 ± 0.5	60.2 ± 3.4
MS	MANOMET SUBST	3.59 km	SSE	17.7 ± 0.6	18.5 ± 1.2	18.6 ± 0.9	17.2 ± 0.6	71.9 ± 4.7
BW	BEACHWOOD ROAD	3.91 km	SE	14.7 ± 0.5	15.7 ± 1.0	15.9 ± 0.5	14.9 ± 0.5	61.2 ± 3.8
PT	PINES ESTATE	4.47 km	SSW	13.4 ± 0.4	14.3 ± 1.0	14.3 ± 0.6	13.1 ± 0.4	55.2 ± 3.8
EA	EARL ROAD	4.60 km	SSE	12.7 ± 0.4	13.3 ± 0.8	13.2 ± 0.5	12.5 ± 0.4	51.7 ± 2.9
SP	S PLYMOUTH SUBST	4.61 km	W	14.9 ± 0.7	16.2 ± 1.0	15.7 ± 0.6	15.0 ± 0.5	61.8 ± 4.1
RP	ROUTE 3 OVERPASS	4.79 km	SW	14.8 ± 0.5	15.5 ± 1.0	15.9 ± 0.5	15.2 ± 0.6	61.4 ± 3.6
RM	RUSSELL MILLS RD	4.82 km	WSW	13.5 ± 0.7	13.9 ± 1.0	Missing	13.2 ± 0.5	54.3 ± 3.9
HD	HILLDALE ROAD	5.15 km	W	15.0 ± 0.5	16.0 ± 1.1	15.5 ± 0.8	14.9 ± 0.5	61.4 ± 4.0
MB	MANOMET BEACH	5.42 km	SSE	14.9 ± 0.6	15.6 ± 1.0	15.9 ± 1.5	14.7 ± 0.6	61.2 ± 5.2
BR	BEAVERDAM ROAD	5.55 km	S	12.6 ± 0.7	12.8 ± 1.0	13.3 ± 0.4	13.5 ± 0.7	52.2 ± 3.7
PC	PLYMOUTH CENTER	6.65 km	W	10.6 ± 0.5	11.0 ± 0.8	11.1 ± 0.7	10.4 ± 0.5	43.1 ± 3.3
LD	LONG POND & DREW	6.96 km	WSW	13.6 ± 0.4	13.9 ± 0.9	14.3 ± 0.4	Missing	55.8 ± 3.3
HR	HYANNIS ROAD	7.34 km	SSE	12.8 ± 0.8	13.1 ± 0.8	13.4 ± 0.5	Missing	52.4 ± 3.8
CP	COLLEGE POND	7.51 km	SW	14.3 ± 0.5	14.8 ± 0.9	15.3 ± 0.5	14.4 ± 0.5	58.8 ± 3.5
MH	MEMORIAL HALL	7.59 km	WNW	23.0 ± 0.9	22.7 ± 1.6	23.7 ± 0.8	23.3 ± 0.6	92.6 ± 5.2
DW	DEEP WATER POND	8.64 km	W	Missing	17.5 ± 1.0	17.7 ± 0.6	15.9 ± 0.4	68.2 ± 5.2
LP	LONG POND ROAD	8.86 km	SSW	12.6 ± 0.6	13.3 ± 0.8	13.6 ± 0.5	12.7 ± 0.4	52.3 ± 3.4
NP	NORTH PLYMOUTH	9.36 km	WNW	16.9 ± 0.6	17.7 ± 1.1	17.7 ± 0.6	17.3 ± 0.5	69.6 ± 3.7
SS	STANDISH SHORES	10.37 km	NW	13.0 ± 0.4	13.6 ± 0.8	13.1 ± 0.5	13.2 ± 0.5	52.8 ± 2.8
EL	ELLISVILLE ROAD	11.53 km	SSE	14.6 ± 0.7	13.9 ± 0.9	14.6 ± 0.6	14.2 ± 0.4	57.3 ± 3.4
UC	UP COLLEGE POND RD	11.79 km	SW	12.7 ± 0.4	12.9 ± 0.9	13.1 ± 0.5	13.2 ± 1.0	51.9 ± 3.5
SH	SACRED HEART	12.90 km	W	14.7 ± 0.5	15.0 ± 0.9	15.4 ± 0.5	14.2 ± 0.4	59.4 ± 3.5
KC	KING CAESAR ROAD	13.07 km	NNW	14.0 ± 0.7	14.2 ± 1.0	14.8 ± 0.4	13.5 ± 0.5	56.5 ± 3.7
SA	SHERMAN AIRPORT	13.36 km	WSW	13.4 ± 0.5	Missing	15.1 ± 1.5	14.0 ± 0.7	56.6 ± 5.9
BE	BOURNE ROAD	13.37 km	S	11.8 ± 0.3	12.6 ± 0.8	13.1 ± 0.5	12.2 ± 0.4	49.7 ± 3.2
CS	CEDARVILLE SUBST	15.93 km	S	15.3 ± 0.7	15.8 ± 0.9	15.5 ± 0.4	15.2 ± 0.7	61.9 ± 3.4
KS	KINGSTON SUBST	16.10 km	WNW	14.1 ± 0.5	21.1 ± 3.9	14.3 ± 0.4	13.5 ± 0.6	62.9 ± 17.0
LR	LANDING ROAD	16.44 km	NNW	13.7 ± 0.4	14.1 ± 0.8	14.7 ± 0.5	13.5 ± 0.6	56.0 ± 3.5
CW	CHURCH & WEST	16.54 km	NW	13.1 ± 0.7	13.3 ± 0.8	13.8 ± 0.5	12.6 ± 0.4	52.8 ± 3.6
MM	MAIN & MEADOW	16.99 km	WSW	14.2 ± 0.6	14.8 ± 1.0	15.7 ± 0.5	14.1 ± 0.6	58.8 ± 4.3
DMF	DIV MARINE FISH	20.97 km	SSE	18.2 ± 0.8	16.6 ± 1.1	17.1 ± 0.5	16.3 ± 0.5	68.1 ± 4.8
EW	E WEYMOUTH SUBST	39.61 km	NW	16.4 ± 0.6	17.7 ± 1.1	17.9 ± 1.3	17.3 ± 0.6	69.2 ± 5.2

* Distance and direction are measured from the centerline of the reactor building to the monitoring location.

** Annual average value is based on arithmetic mean of the observed quarterly values multiplied by 4 quarters/yr.

Table 2.4-2

On-Site Environmental TLD Results

TLD Station		Location*		Exposure Rate - mR/quarter (Value ± STD.DEV)				Annual Mean** Exposure
ID	Description	Distance	Dir.	First	Second	Third	Fourth	mR/yr
P21	WW ADMIN & PROC	50 m	SE	30.0 ± 1.6	37.4 ± 2.0	87.4 ± 6.3	50.9 ± 1.9	205.7 ±103.2
P24	OLD ADMIN	57 m	W	32.4 ± 1.9	27.4 ± 2.2	28.5 ± 0.8	38.5 ± 1.2	126.8 ± 21.4
P04	FENCE/R SCREENH	66 m	N	84.9 ± 4.5	80.4 ± 4.8	103.2 ± 2.6	114.6 ± 3.6	383.3 ± 66.4
P20	RP WINDOW	66 m	SE	40.4 ± 2.6	20.7 ± 1.4	34.4 ± 1.4	57.2 ± 2.2	152.8 ± 61.2
P25	FIRST AID TRAIL	76 m	WNW	55.1 ± 3.7	24.5 ± 1.4	36.6 ± 1.7	82.9 ± [illegible].3	199.0 ±102.4
P05	FENCE/WATER TANK	81 m	NNE	37.5 ± 1.8	32.0 ± 1.8	59.0 ± 2.1	51.8 ± [illegible].7	180.3 ± 50.6
P06	FENCE/CULVERT	84 m	NE	48.2 ± 1.9	56.2 ± 3.5	109.4 ± 2.9	68.0 ± 1.8	281.8 ±109.4
P19	COMPLIANCE AREA	85 m	SSE	39.3 ± 1.7	19.4 ± 1.1	30.2 ± 1.4	55.6 ± [illegible].0	144.5 ± 62.3
P18	I&C NEW ADMIN	90 m	S	34.4 ± 1.4	20.3 ± 1.4	30.2 ± 0.9	54.1 ± 4.0	138.9 ± 57.7
P08	FENCE/NEW ADMIN	92 m	ENE	40.0 ± 2.3	35.7 ± 2.7	54.5 ± 4.4	61.2 ± 3.5	191.4 ± [illegible].4
P03	FENCE/L SCREENH	100 m	NW	42.1 ± 2.3	56.4 ± 3.1	40.9 ± 1.3	70.9 ± 2.0	210.4 ± 57.3
P17	FENCE/SHF M GATE	108 m	W	64.1 ± 4.4	29.0 ± 2.1	45.5 ± 2.1	99.5 ± 3.5	238.1 ±121.8
P23	CMG CORNER	120 m	SSE	25.0 ± 0.9	15.3 ± 1.2	20.3 ± 1.0	33.2 ± 1.1	93.9 ± 30.8
P07	FENCE/INTAKE	121 m	ENE	85.6 ± 2.6	54.5 ± 2.9	60.1 ± 4.4	57.4 ± 2.3	257.6 ± 59.0
P02	SHOREFRONT FENCE	135 m	NW	34.4 ± 2.7	26.5 ± 1.5	31.0 ± 1.9	46.0 ± 2.0	137.9 ± 34.8
P09	FENCE/TCF SIDE	136 m	E	87.7 ± 3.3	56.5 ± 3.1	61.8 ± 2.3	68.9 ± 3.6	274.9 ± 56.4
P22	QA/QC CORNER	137 m	SE	27.5 ± 1.1	19.8 ± 1.1	26.3 ± 0.9	34.0 ± 0.9	107.6 ± 23.7
P26	FENCE/WAREHOUSE	149 m	ESE	40.9 ± 3.1	37.0 ± 2.7	45.8 ± 1.8	53.8 ± 2.7	177.6 ± 31.4
P16	FENCE/SWY M GATE	172 m	SW	51.9 ± 3.0	24.9 ± 1.9	36.9 ± 2.3	77.4 ± 3.5	191.0 ± 91.3
WS	WAREHOUSE	181 m	SSE	23.3 ± 1.2	16.5 ± 1.2	21.0 ± 0.8	32.5 ± 1.6	93.3 ± 27.4
P11	FENCE/TCF GATE	188 m	ESE	35.5 ± 1.3	88.8 ± 5.0	68.3 ± 2.2	78.8 ± 6.2	271.4 ± 94.4
P27	TCF/BOAT RAMP	195 m	ESE	33.2 ± [illegible]	114.1 ± 8.4	91.1 ± 3.2	129.6 ± 10.7	368.1 ±172.2
P12	FENCE/CNTR GATE	202 m	SE	Missing	19.7 ± 1.2	24.4 ± 1.1	31.4 ± 1.5	100.7 ± 24.5
P15	FENCE/UNIT #9	220 m	S	24.4 ± 0.6	17.6 ± 1.1	21.6 ± 0.9	32.7 ± 1.6	96.3 ± 26.1
P13	FENCE/CON & RHR	224 m	SSE	21.0 ± 0.9	18.5 ± 1.1	20.7 ± 1.4	25.4 ± 1.2	85.5 ± 12.9
P10	FENCE/INTAKE TCF	224 m	E	31.6 ± 1.7	33.1 ± 2.1	44.6 ± 2.6	47.2 ± 1.7	156.4 ± 33.1
P14	FENCE/BUTLER BLDG	227 m	S	17.0 ± 0.6	17.2 ± 1.1	20.4 ± 0.9	25.4 ± 1.1	80.0 ± 16.4
P28	TCF/CNTR LOT	244 m	ESE	22.2 ± 0.8	23.4 ± 1.6	42.4 ± 2.1	44.1 ± 3.2	132.0 ± 48.4

* Distance and direction are measured from the centerline of the reactor building to the monitoring location.

** Annual average value is based on arithmetic mean of the observed quarterly values multiplied by 4 quarters/yr.

Table 2.4-3

Average TLD Exposures By Distance Zone During 1991

	Average Exposure ± Standard Deviation (mR/period)			
	Zone 1* 0 km - 3 km	Zone 2 3 km - 8 km	Zone 3 8 km - 15 km	Zone 4 > 15 km
Period	Avg StD	Avg StD	Avg StD	Avg StD
Qtr-1	17.7 ± 7.1	14.4 ± 2.5	13.8 ± 1.6	15.0 ± 1.9
Qtr-2	16.8 ± 3.2	14.9 ± 2.6	14.5 ± 2.1	16.2 ± 3.2
Qtr-3	15.2 ± 4.1	15.2 ± 2.7	14.8 ± 1.9	15.6 ± 1.6
Qtr-4	19.6 ± 12.1	14.5 ± 2.7	14.0 ± 1.6	14.6 ± 1.8
Year	71.8 ± 30.0	59.1 ± 10.4	57.2 ± 7.2	61.4 ± 8.7

* Zone 1 extends from the restricted/protected area boundary outward to 3 kilometers (2 miles).

Table 2.4-4

Beach Survey Exposure Rate Measurements

Direct Radiation Survey Results
July 24, 1991

Location	Exposure Rate Micro-R/hr ± 1 std. dev.	Beach Terrain
White Horse Beach (Near Hilltop Ave)	7.3 ± 0.4	Sandy. Few granite boulders within thirty feet.
White Horse Beach (In Back of Full Sail Bar)	7.5 ± 0.4	Sandy with small amounts of gravel.
Plymouth Beach (Outer Beach)	6.6 ± 0.4	Sandy.
Plymouth Beach (Inner Beach)	5.7 ± 0.4	Sandy.
Plymouth Beach (Behind Bert's Restaurant)	10.9 ± 0.4	Sandy with gravel. Breakwater and seawall nearby.
Duxbury Beach (Control)	6.1 ± 0.3	Sandy with coarse gravel.

Table 2.5-1

Air Particulate Filter Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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 (566)	.01	(2.1 ± 0.0)E -2	10	(2.2 ± 0.1)E -2	(2.1 ± 0.1)E -2
(0)		(4.3 - 43.0)E -3		(6.5 - 35.5)E -3	(8.3 - 38.5)E -3
		(511/514)		*(52/ 52)*	*(52/ 52)*
BE-7 (44)		(7.3 ± 0.2)E -2	03	(7.8 ± 0.9)E -2	(5.9 ± 0.8)E -2
(0)		(4.4 - 9.5)E -2		(5.6 - 9.4)E -2	(4.3 - 7.9)E -2
		(40/ 40)		*(4/ 4)*	*(4/ 4)*
K-40 (44)		(2.0 ± 0.1 -3	08	(4.0 ± 1.3)E -3	(3.2 ± 1.1)E -3
(0)		(-6.2 - 10.1)E -3		(1.9 - 7.3)E -3	(4.2 - 51.5)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CS-134 (44)	.01	(-1.2 ± 0.4)E -4	08	(4.3 ± 4.0)E -5	(-1.7 ± 1.6)E -4
(0)		(-7.4 - 4.5)E -4		(-2.0 - 14.9)E -5	(-6.1 - 1.7)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CS-137 (44)	.01	(4.6 ± 3.3)E -5	08	(1.2 ± 0.9)E -4	(3.0 ± 14.8)E -5
(0)		(-4.9 - 4.5)E -4		(-9.5 - 34.5)E -5	(-2.5 - 4.5)E -4
		(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 2.6-1

Charcoal Cartridge Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
I-131 (566)	.07	(-1.6 ± 4.7)E -4	15	(1.1 ± 1.1)E -3	(-2.0 ± 1.5)E -3
(0)		(-6.4 - 3.7)E -2		(-1.5 - 3.1)E -2	(-2.5 - 1.8)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 *( )*.

Table 2.7-1

Milk Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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 (40)		(2.0 ± 1.1)E -1	11	(2.0 ± 1.1)E -1	(-5.3 ± 2.0)E -1
(0)		(-9.6 - 9.7)E -1		(-9.6 - 9.7)E -1	(-2.5 - 1.3)E 0
		(0/ 20)		*(0/ 20)*	*(0/ 20)*
SR-90 (40)		(2.0 ± 0.1)E 0	21	(2.1 ± 0.2)E 0	(2.1 ± 0.2)E 0
(0)		(9.1 - 36.0)E -1		(2.4 - 40.3)E -1	(2.4 - 40.3)E -1
		(16/ 20)		*(14/ 20)*	*(14/ 20)*
K-40 (40)		(1.3 ± 0.0)E 3	21	(1.4 ± 0.0)E 3	(1.4 ± 0.0)E 3
(0)		(1.1 - 1.4)E 3		(1.2 - 1.6)E 3	(1.2 - 1.6)E 3
		(20/ 20)		*(20/ 20)*	*(20/ 20)*
I-131 (40)	1.	(1.3 ± 3.7)E -2	11	(1.3 ± 3.7)E -2	(-7.3 ± 31.0)E -3
(0)		(-2.4 - 3.7)E -1		(-2.4 - 3.7)E -1	(-2.6 - 3.2)E -1
		(0/ 20)		*(0/ 20)*	*(0/ 20)*
CS-134 (40)	15.	(-1.0 ± 0.4)E 0	11	(-1.0 ± 0.4)E 0	(-1.3 ± 0.3)E 0
(0)		(-4.5 - 1.4)E 0		(-4.5 - 1.4)E 0	(-3.5 - 1.7)E 0
		(0/ 20)		*(0/ 20)*	*(0/ 20)*
CS-137 (40)	15.	(2.5 ± 0.3)E 0	11	(2.5 ± 0.3)E 0	(1.1 ± 0.3)E 0
(0)		(3.6 - 51.6)E -1		(3.6 - 51.6)E -1	(-2.0 - 3.3)E 0
		(2/ 20)		*(2/ 20)*	*(0/ 20)*
BA-140 (40)	15.	(1.3 ± 5.1)E -1	11	(1.3 ± 5.1)E 1	(-1.0 ± 0.3)E 0
(0)		(-3.8 - 5.2)E 0		(-3.8 - 5.2)E 0	(-3.4 - 1.4)E 0
		(0/ 20)		*(0/ 20)*	*(0/ 20)*

* 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 2.8-1

Forage Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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 (4)		(1.5 ± 1.0)E 3	33	(1.6 ± 1.7)E 3	(6.7 ± 2.0)E 2
(0)		(-1.1 - 33.0)E 2		(-1.1 - 33.0)E 2	
		(2/ 3)		*(1/ 2)*	*(1/ 1)*
K-40 (4)		(4.2 ± 1.9)E 3	21	(1.2 ± 0.1)E 4	(1.2 ± 0.1)E 4
(0)		(1.2 - 7.8)E 3			
		(3/ 3)		*(1/ 1)*	*(1/ 1)*
I-131 (4)		(-7.7 ± 3.7)E 1	21	(6.9 ± 9.7)E 1	(6.9 ± 9.7)E 1
(0)		(-1.5 - -0.3)E 2			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CS-134 (4)	130.	(-3.8 ± 8.4)E 0	11	(1.1 ± 1.6)E 1	(-6.9 ± 17.3)E 0
(0)		(-1.7 - 1.2)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CS-137 (4)	130.	(1.0 ± 1.2)E 1	21	(4.4 ± 1.7)E 1	(4.4 ± 1.7)E 1
(0)		(-5.0 - 34.2)E 0			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
TH-232 (4)		(2.1 ± 25.6)E 0	21	(1.9 ± 0.8)E 2	(1.9 ± 0.8)E 2
(0)		(-3.8 - 5.0)E 1			
		(0/ 3)		*(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 2.9-1

Vegetable/Vegetation Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

MEDIUM: VEGETABLE/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 (17)		(5.6 ± 2.2)E 2	32	(1.6 ± 0.1)E 3	(4.9 ± 1.8)E 1
(7)		(-8.2 - 291.0)E 1			(2.0 - 8.3)E 1
		(7/ 14)		*(1/ 1)*	*(0/ 3)*
K-40 (17)		(2.4 ± 0.3)E 3	77	(4.5 ± 0.2)E 3	(2.6 ± 1.0)E 3
(0)		(1.2 - 4.5)E 3			(1.1 - 4.4)E 3
		(14/ 14)		*(1/ 1)*	*(3/ 3)*
I-131 (17)	60.***	(-3.2 ± 22.8)E -1	32	(1.5 ± 1.1)E 1	(-5.9 ± 10.3)E 0
(0)		(-1.7 - 1.5)E 1			(-2.6 - 0.9)E 1
		(0/ 14)		*(0/ 1)*	*(0/ 3)*
CS-134 (17)	60.	(-6.9 ± 1.9)E 0	77	(-3.1 ± 4.9)E 0	(-5.3 ± 4.1)E 0
(0)		(-1.7 - 0.5)E 1			(-1.3 - 0.1)E 1
		(0/ 14)		*(0/ 1)*	*(0/ 3)*
CS-137 (17)	60.	(3.6 ± 1.8)E 0	27	(1.1 ± 0.8)E 1	(1.1 ± 0.8)E 1
(0)		(-6.7 - 19.4)E 0		(-1.5 - 25.2)E 0	(-1.5 - 25.2)E 0
		(0/ 14)		*(0/ 3)*	*(0/ 3)*
TH-232 (17)		(1.2 ± 0.8)E 1	77	(6.2 ± 2.7)E 1	(2.2 ± 2.1)E 1
(0)		(-4.3 - 6.2)E 1			(-6.7 - 63.3)E 0
		(0/ 14)		*(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 *( )*.

*** THE LISTED LLD OF 60 pCi/KG FOR I-131 APPLIES ONLY TO LEAFY VEGETABLES. SUMMARIES PRESENTED IN THIS TABLE INCLUDE RESULTS FOR ALL VEGETABLES, INCLUDING ROOT CROPS AND NON-LEAFY VEGETABLES.

Table 2.10-1

Cranberry Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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)		(5.1 ± 68.9)E 0	13	(7.4 ± 7.0)E 1	(-1.7 ± 0.9)E 2
(0)		(-6.4 - 7.4)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
K-40 (3)		(6.5 ± 0.4)E 2	23	(7.4 ± 2.3)E 2	(7.4 ± 2.3)E 2
(0)		(6.1 - 6.8)E 2			
		(2/ 2)		*(1/ 1)*	*(1/ 1)*
I-131 (3)		(2.8 ± 25.4)E 0	13	(2.8 ± 2.8)E 1	(1.1 ± 28.5)E 0
(0)		(-2.2 - 2.8)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CS-134 (3)	60.	(-1.6 ± 0.2)E 1	23	(-9.3 ± 11.4)E 0	(-9.3 ± 11.4)E 0
(0)		(-1.8 - -1.3)E 1			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
CS-137 (3)	60.	(3.0 ± 1.6)E 0	23	(3.0 ± 1.2)E 1	(3.0 ± 1.2)E 1
(0)		(1.4 - 4.7)E 0			
		(0/ 2)		*(0/ 1)*	*(0/ 1)*
TH-232 (3)		(1.5 ± 1.0)E 1	23	(3.4 ± 5.7)E 1	(3.4 ± 5.7)E 1
(0)		(5.9 - 25.0)E 0			
		(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. >2 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.11-1

Soil Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

MEDIUM: SOIL — UNITS: PCI/KG DRY

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**
BE-7 (35)		(1.4 ± 0.4)E 2	21	(6.3 ± 0.8)E 2	(6.3 ± 0.8)E 2
(0)		(-1.0 - 7.9)E 2			
		(9/ 34)		*(1/ 1)*	*(1/ 1)*
K-40 (35)		(1.0 ± 0.0)E 4	21	(1.8 ± 0.1)E 4	(1.8 ± 0.1)E 4
(0)		(5.2 - 15.5)E 3			
		(34/ 34)		*(1/ 1)*	*(1/ 1)*
CO-58 (35)	50.	(-7.3 ± 1.3)E 0	15	(5.7 ± 7.4)E 0	(-1.2 ± 0.8)E 1
(0)		(-2.1 - 0.6)E 1			
		(0/ 34)		*(0/ 1)*	*(0/ 1)*
CO-60 (35)	50.	(1.8 ± 1.0)E 1	08	(6.9 ± 5.0)E 1	(-2.0 ± 11.0)E 0
(5)		(-2.0 - 29.5)E 1		(-2.0 - 29.5)E 1	
		(5/ 34)		*([illegible] 6)*	*(0/ 1)*
ZN-65 (35)	50.	(1.5 ± 0.[illegible])E 1	09	([illegible].9 ± 2.4)E 1	-3.6 ± 28.4)E 0
(0)		(-2.2 - 8.4)E 1			
		(0/ 34)		*(0/ 1)*	*(0/ 1)*
ZR-95 (35)	50.	(1.1 ± 0.3)E 1	10	([illegible].5 ± [illegible].6)E 1	(8.6 ± 15.6)E 0
(0)		(-2.7 - 4.0)E 1			
		(0/ 34)		*(0/ 1)*	*(0/ 1)*
CS-134 (35)	50.	(8.6 ± 15.7)E -1	21	([illegible].7 ± 9.6)E 0	(6.7 ± 9.6)E 0
(0)		(-1.5 - 2.1)E 1			
		(0/ 34)		*(0/ 1)*	*(0/ 1)*
CS-137 (35)	50.	(4.6 ± 1.3)E 2	03	(1.7 ± 0.0)E 3	(8.6 ± 1.2)E 1
(7)		(-1.1 - 290.0)E 1			
		(28/ 34)		*(1/ 1)*	*(1/ 1)*
CE-144 (35)	150.	(2.3 ± 1.0)E 1	03	(1.5 ± 0.6)E 2	(4.2 ± 6.0)E 1
(0)		(-1.4 - 1.5)E 2			
		(0/ 34)		*(0/ 1)*	*(0/ 1)*
TH-232 (35)		(7.2 ± 0.3)E 2	09	(1.0 ± 0.1)E 3	(6.6 ± 0.6)E 2
(0)		(4.4 - 11.4)E 2			
		(34/ 34)*		*(1/ 1)*	*(1/ 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 2.12-1

Surface Water Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

MEDIUM: SURFACE WATER — 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**
K-40 (39)		(1.5 ± 0.3)E 2	11	(2.8 ± 0.1)E 2	(2.7 ± 0.1)E 2
(0)		(-1.1 - 35.3)E 1		(2.5 - 3.5)E 2	(2.4 - 3.4)E 2
		(14/ 26)		*(13/ 13)*	*(13/ 13)*
MN-54 (39)	15.	(3.0 ± 1.6)E -1	17	(3.2 ± 2.1)E -1	(1.6 ± 2.7)E -1
(0)		(-1.6 - 1.5)E 0		(-8.3 - 14.8)E -1	(-1.4 - 1.9)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
CO-58 (39)	15.	(9.9 ± 18.4)E -2	11	(1.1 ± 2.7)E -1	(-7.9 ± 2.4)E -1
(0)		(-1.3 - 2.0)E 0		(-1.3 - 2.0)E 0	(-2.4 - 0.6)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
FE-59 (39)	30.	(-7.8 ± 3.2)E -1	11	(-7.4 ± 4.5)E -1	(-1.1 ± 0.7)E 0
(0)		(-4.1 - 2.6)E 0		(-4.1 - 1.5)E 0	(-4.2 - 3.6)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
CO-60 (39)	15.	(-3.1 ± 1.9)E -1	17	(-1.4 ± 3.1)E -1	(-8.3 ± 4.1)E -1
(0)		(-2.0 - 2.4)E 0		(-2.0 - 2.4)E 0	(-3.0 - 2.1)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
ZN-65 (39)	30.	(-6.5 ± 3.8)E -1	17	(9.4 ± 63.6)E -2	(-9.0 ± 4.2)E -1
(0)		(-3.8 - 3.7)E 0		(-3.8 - 3.7)E 0	(-4.3 - 1.2)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
ZR-95 (39)	15.	(4.9 ± 3.2)E -1	17	(9.6 ± 3.9)E -1	(2.5 ± 3.9)E -1
(0)		(-3.0 - 2.8)E 0		(-1.2 - 2.8)E 0	(-2.3 - 2.8)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
I-131 (39)	1.	(-3.0 ± 4.0)E -2	11	(-5.8 ± 67.2)E -3	(-3.2 ± 4.2)E -2
(0)		(-3.7 - 5.5)E -1		(-3.5 - 5.5)E -1	(-2.9 - 3.0)E -1
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
CS-134 (39)	15.	(-8.2 ± 1.5)E -1	23	(-3.7 ± 2.5)E -1	(-3.7 ± 2.5)E -1
(0)		(-2.7 - 0.8)E 0		(-1.9 - 1.5)E 0	(-1.9 - 1.5)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
CS-137 (39)	18.	(5.0 ± 16.6)E -2	11	(1.9 ± 2.2)E -1	(-4.3 ± 29.9)E -2
(0)		(-1.7 - 1.3)E 0		(-1.7 - 1.3)E 0	(-2.1 - 2.2)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
BA-140 (39)	15.	(-3.5 ± 4.9)E -1	23	(5.6 ± 6.7)E -1	(5.6 ± 6.7)E -1
(0)		(-6.2 - 4.8)E 0		(-4.7 - 4.8)E 0	(-4.7 - 4.8)E 0
		(0/ 26)		*(0/ 13)*	*(0/ 13)*
H-3 (12)	3000.	(-4.9 ± 7.6)E 1	17	(-2.2 ± 10.3)E 1	(-1.3 ± 0.6)E 2
(0)		(-3.5 - 2.0)E 2		(-2.1 - 1.8)E 2	(-2.4 - 0.2)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 *( )*.

Table 2.13-1

Fish Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (27)		(3.2 ± 21.9)E 0	11	(3.2 ± 21.9)E 0	(-3.2 ± 1.4)E 1
(0)		(-1.5 - 2.0)E 2		(-1.5 - 2.0)E 2	(-1.0 - 0.5)E 2
		(0/ 18)		*(0/ 18)*	*(0/ 9)*
K-40 (27)		(3.2 ± 0.1)E 3	11	(3.2 ± 0.1)E 3	(3.0 ± 0.1)E 3
(0)		(2.1 - 3.9)E 3		(2.1 - 3.9)E 3	(2.0 - 3.3)E 3
		(18/ 18)		*(18/ 18)*	*(9/ 9)*
MN-54 (27)	130.	(2.6 ± 1.8)E 0	11	(2.6 ± 1.8)E 0	(-1.0 ± 2.5)E 0
(0)		(-7.4 - 20.2)E 0		(-7.4 - 20.2)E 0	(-1.7 - 0.9)E 1
		(0/ 18)		*(0/ 18)*	*(0/ 9)*
CO-58 (27)	130.	(-3.9 ± 3.0)E 0	98	(1.5 ± 2.7)E 0	(1.1 ± 2.7)E 0
(0)		(-2.1 - 1.9)E 1		(-8.4 - 11.8)E 0	(-1.1 - 1.2)E 1
		(0/ 18)		*(0/ 7)*	*(0/ 9)*
FE-59 (27)	260.	(7.0 ± 55.8)E -1	11	(7.0 ± 55.8)E -1	(-2.0 ± 6.5)E 0
(0)		(-4.6 - 5.0)E 1		(-4.6 - 5.0)E 1	(-3.3 - 1.9)E 1
		(0/ 18)		*(0/ 18)*	*(0/ 9)*
CO-60 (27)	130.	(-5.7 ± 2.1)E 0	29	(-2.5 ± 0.8)E 0	(-4.4 ± 1.1)E 0
(0)		(-2.1 - 1.1)E 1		(-3.3 - -1.7)E 0	(-1.0 - 0.0)E 1
		(0/ 18)		*(0/ 2)*	*(0/ 9)*
ZN-65 (27)	260.	(-5.9 ± 37.7)E -1	11	(-5.9 ± 37.7)E -1	(-1.5 ± 0.5)E 1
(0)		(-2.2 - 2.6)E 1		(-2.2 - 2.6)E 1	(-4.2 - 1.3)E 1
		(0/ 18)		*(0/ 18)*	*(0/ 9)*
CS-134 (27)	130.	(-1.1 ± 0.2)E 1	11	(-1.1 ± 0.2)E 1	(-1.1 ± 0.3)E 1
(0)		(-2.6 - 0.1)E 1		(-2.6 - 0.1)E 1	(-2.3 - -0.2)E 1
		(0/ 18)		*(0/ 18)*	*(0/ 9)*
CS-137 (27)	130.	(4.4 ± 1.9)E 0	29	(1.4 ± 0.1)E 1	(7.5 ± 3.6)E 0
(0)		-1.3 - 1.8)E 1		(1.3 - 1.6)E 1	(-7.7 - 25.4)E 0
		(0/ 18)		*(0/ 2)*	*(0/ 9)*
TH-232 (27)		(2.0 ± 0.7)E 1	11	(2.0 ± 0.7)E 1	(-5.8 ± 8.3)E 0
(0)		(-2.4 - 7.0)E 1		(-2.4 - 7.0)E 1	(-3.7 - 3.6)E 1
		(0/ 18)		*(0/ 18)*	*(0/ 9)*

* 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 2.14-1

Shellfish Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

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.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (50)		(1.7 ± 1.0)E 1	24	(2.8 ± 0.8)E 1	(6.4 ± 10.2)E 0
(1)		(-9.6 - 12.4)E 1		(-1.2 - 5.7)E 1	(-1.1 - 0.8)E 2
		(5/ 26)		*(4/ 8)*	*(4/ 24)*
K-40 (50)		(7.8 ± 0.8)E 2	15	(1.1 ± 0.0)E 3	(6.7 ± 1.0)E 2
(0)		(1.8 - 15.8)E 2		(9.9 - 11.6)E 2	(4.4 - 147.0)E 1
		(22/ 26)		*(4/ 4)*	*(17/ 24)*
MN-54 (50)	130.	(4.4 ± 9.8)E -1	12	(1.0 ± 2.1)E 0	(-1.8 ± 1.7)E 0
(0)		(-1.6 - 1.0)E 1		(-1.6 - 1.0)E 1	(-1.6 - 1.9)E 1
		(0/ 26)		*(0/ 12)*	*(0/ 24)*
CO-58 (50)	130.	(-2.2 ± 1.4)E 0	24	(-3.3 ± 23.1)E -2	(-1.5 ± 1.4)E 0
(0)		(-1.9 - 1.9)E 1		(-1.2 - 0.7)E 0	(-1.9 - 1.4)E 1
		(0/ 26)		*(0/ 8)*	*(0/ 24)*
FE-59 (50)	260.	(-3.5 ± 2.1)E 0	24	(5.1 ± 5.7)E -1	(-8.6 ± 32.3)E -1
(0)		(-3.6 - 1.4)E 1		(1.5 - 2.9)E 0	(-3.0 - 4.9)E 1
		(0/ 26)		*(0/ 8)*	*(0/ 24)*
CO-60 (50)	5.	(-4.3 ± 17.9)E -1	11	(2.3 ± 0.9)E 0	(-1.6 ± 1.6)E 0
(0)		(-2.7 - 2.7)E 1		(-1.5 - 7.2)E 0	(-1.4 - 2.8)E 1
		(4/ 26)		*(4/ 10)*	*(0/ 24)*
ZN-65 (50)	5.	(2.1 ± 2.0)E 0	13	(5.7 ± 5.0)E 0	(4.2 ± 3.3)E 0
(0)		(-1.4 - 3.4)E 1		(-1.6 - 5.3)E 1	(-1.6 - 5.3)E 1
		(0/ 26)		*(0/ 16)*	*(0/ 24)*
CS-134 (50)	5.	(-2.2 ± 1.3)E 0	11	(-5.1 ± 3.2)E -1	(-4.7 ± 1.2)E 0
(0)		(-2.6 - 0.8)E 1		(-2.1 - 0.9)E 0	(-2.2 - 0.2)E 1
		(0/ 26)		*(0/ 10)*	*(0/ 24)*
CS-137 (50)	5.	(1.3 ± 0.9)E 0	13	(3.0 ± 1.5)E 0	(2.0 ± 1.0)E 0
(0)		(-7.2 - 18.7)E 0		(-6.6 - 17.5)E 0	(-6.6 - 17.5)E 0
		(0/ 26)		*(0/ 16)*	*(0/ 24)*
TH-232 (50)		(2.5 ± 0.9)E 1	13	(6.2 ± 1.3)E 1	(4.8 ± 1.0)E 1
(0)		(-1.8 - 20.3)E 1		(-4.1 - 14.3)E 1	(-4.1 - 14.3)E 1
		(6/ 26)		*(5/ 16)*	*(9/ 24)*

* 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 2.15-1

Irish Moss Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM - Y
PILGRIM NUCLEAR POWER STATION, PLYMO - KA
(JANUARY - DECEMBER 1991)

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	15	(1.7 ± 0.3)E 2	(1.1 ± 0.2)E 2
(0)		(5.8 - 26.3)E 1		(1.2 - 2.6)E 2	(3.9 - 24.1)E 1
		(5/ 8)		*(3/ 4)*	*(5/ 8)*
K-40 (16)		(6.0 ± 0.5)E 3	11	(6.8 ± 0.8)E 3	(5.4 ± 0.5)E 3
(0)		(4.2 - 8.2)E 3		(4.8 - 8.2)E 3	(3.9 - 7.8)E 3
		(8/ 8)		*(4/ 4)*	*(8/ 8)*
MN-54 (16)	130.	(2.0 ± 1.9)E 0	11	(3.8 ± 3.2)E 0	(-5.8 ± 11.6)E -1
(0)		(-4.2 - 10.3)E 0		(-4.2 - 10.3)E 0	(-4.9 - 4.2)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CO-58 (16)	130.	(-1.7 ± 1.6)E 0	22	(7.6 ± 25.2)E -1	(-6.7 ± 13.5)E -1
(0)		(-1.1 - 0.3)E 1		(-2.9 - 7.9)E 0	(-4.4 - 7.9)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
FE-59 (16)	260.	(4.4 ± 5.6)E 0	1[illegible]	(1.3 ± 0.8)E 1	(-2.3 ± 4.9)E 0
(0)		(-1.5 - 3.0)E 1		(-5.0 - 305.0)E -1	(-3.2 - 1.4)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CO-60 (16)	130.	(4.4 ± 6.1)E 0	11	(1.2 ± 1.2)E 1	(-9.0 ± 13.0)E -1
(1)		(-5.3 - 46.6)E 0		(- 46.6)E 0	(-5.7 - 5.9)E 0
		(1/ 8)		1/ 4)*	*(0/ 8)*
ZN-65 (16)	260.	(-2.5 ± 1.2)E 0	34	(4.6 ± 42.7)E -1	(-1.1 ± 3.0)E 0
(0)		(-6.9 - 2.4)E 0		(-1.2 - 0.6)E 1	(-1.4 - 0.6)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CS-134 (16)	130.	(-3.2 ± 1.0)E 0	15	(-2.4 ± 1.2)E 0	(-3.7 ± 1.7)E 0
(0)		(-6.4 - 0.9)E 0		(-4.5 - 0.8)E 0	(-9.2 - 4.8)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CS-137 (16)	130.	(-1.8 ± 1.3)E 0	22	(8.8 ± 3.3)E -1	(3.9 ± 8.4)E -1
(0)		(-9.8 - 1.4)E 0		(-4.4 - 138.0)E -2	(-2.7 - 5.1)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
TH-232 (16)		(2.7 ± 1.1)E 1	15	(4.3 ± 1.8)E 1	(2.9 ± 0.8)E 1
(0)		(1.7 - 74.8)E 0		(7.9 - 74.8)E 0	(-5.3 - 70.0)E 0
		(1/ 8)		*(1/ 4)*	*(1/ 8)*

* 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 2.16-1

Lobster Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

MEDIUM: 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)		(-1.6 ± 6.5)E 1	13	(4.5 ± 7.5)E 1	(4.5 ± 7.5)E 1
(0)		(-1.6 - 1.0)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
K-40 (5)		(2.2 ± 0.2)E 3	11	(2.2 ± 0.2)E 3	(2.1 ± 0.2)E 3
(0)		(1.6 - 2.7)E 3		(1.6 - 2.7)E 3	
		(4/ 4)		*(4/ 4)*	*(1/ 1)*
MN-54 (5)	130.	(1.2 ± 0.2)E 1	11	(1.2 ± 0.2)E 1	(8.8 ± 8.0)E 0
(0)		(7.9 - 19.4)E 0		(7.9 - 19.4)E 0	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
CO-58 (5)	130.	(1.4 ± 5.1)E 0	11	(1.4 ± 5.1)E 0	(1.0 ± 8.2)E 0
(0)		(-1.4 - 0.7)E 1		(-1.4 - 0.7)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
FE-59 (5)	260.	(8.6 ± 17.1)E 0	11	(8.6 ± 17.1)E 0	(-3.3 ± 1.7)E 1
(0)		(-3.6 - 4.5)E 1		(-3.6 - 4.5)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
CO-60 (5)	130.	(3.5 ± 8.5)E 0	11	(3.5 ± 8.5)E 0	(-1.9 ± 1.2)E 1
(0)		(-1.9 - 2.3)E 1		(-1.9 - 2.3)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
ZN-65 (5)	260.	(-1.0 ± 0.5)E 1	13	(2.3 ± 1.9)E 1	(2.3 ± 1.9)E 1
(0)		(-1.8 - 0.4)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CS-134 (5)	130.	(-8.3 ± 4.9)E 0	13	(1.2 ± 0.9)E 1	(1.2 ± 0.9)E 1
(0)		(-2.2 - -0.1)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CS-137 (5)	130.	(9.1 ± 23.7)E -1	13	(7.3 ± 8.5)E 0	(7.3 ± 8.5)E 0
(0)		(-2.3 - 7.8)E 0			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
TH-232 (5)		(1.0 ± 1.0)E 1	13	(3.2 ± 4.1)E 1	(3.2 ± 4.1)E 1
(0)		(-1.8 - 3.0)E 1			
		(0/ 4)		*(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 2.17-1

Sediment Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1991)

UNITS: PCI/KG DRY

MEDIUM: SEDIMENT

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 (56) (0)		(3.1 ± 1.1)E 1 (-9.4 - 30.5)E 1 *(3/ 39)*	13	(7.4 ± 3.5)E 1 (-2.2 - 39.3)E 1 *(1/ 11)*	(7.1 ± 2.4)E 1 (-2.2 - 39.3)E 1 *(2/ 17)*
K-40 (56) (0)		(9.0 ± 0.2)E 3 (6.2 - 11.7)E 3 *(39/ 39)*	13	(1.3 ± 0.1)E 4 (1.0 - 1.6)E 4 *(11/ 11)*	(1.2 ± 0.1)E 4 (9.0 - 16.2)E 3 *(17/ 17)*
CO-58 (56) (0)	50.	(-3.3 ± 0.7)E 0 (-1.3 - 0.7)E 1 *(0/ 39)*	14	(-1.5 ± 2.0)E 0 (-7.3 - 4.3)E 0 *(0/ 6)*	(-4.1 ± 1.3)E 0 (-1.9 - 0.3)E 1 *(0/ 17)*
CO-60 (56) (0)	50.	(4.9 ± 9.0)E -1 (-1.4 - 1.3)E 1 *(0/ 39)*	13	(1.3 ± 2.0)E 0 (-7.4 - 15.5)E 0 *(0/ 11)*	(-1.2 ± 1.8)E 0 (-1.4 - 1.6)E 1 *(0/ 17)*
ZN-65 (56) (0)	50.	(4.4 ± 1.8)E 0 (-1.6 - 3.0)E 1 *(0/ 39)*	13	(1.4 ± 0.3)E 1 (-8.6 - 30.7)E 0 *(0/ 11)*	(1.1 ± 0.3)E 1 (-8.6 - 30.7)E 0 *(0/ 17)*
ZR-95 (56) 0)	50.	(5.2 ± 1.3)E 0 (-1.3 - 1.7)E 1 *(0/ 39)*	11	(8.9 ± 2.9)E 0 (-1.2 - 1.7)E 1 *(0/ 11)*	(6.0 ± 2.2)E 0 (-1.0 - 2.6)E 1 *(0/ 17)*
CS-134 (56) (0)	50.	(5.9 ± 6.8)E -1 (-7.5 - 9.4)E 0 *(0/ 39)*	15	(2.1 ± 1.4)E 0 (-6.0 - 9.4)E 0 *(0/ 11)*	(7.2 ± 8.5)E -1 (-3.7 - 8.5)E 0 *(0/ 17)*
CS-137 (56) (0)	50.	(1.0 ± 0.3)E 1 (-5.4 - 64.0)E 0 *(10/ 39)*	13	(4.2 ± 0.5)E 1 (1.3 - 7.5)E 1 *(10/ 11)*	(3.1 ± 0.5)E 1 (-3.0 - 74.5)E 0 *(13/ 17)*
CE-144 (56) (0)	150.	(1.1 ± 0.5)E 1 (-4.0 - 8.2)E 1 *(0/ 39)*	15	(2.0 ± 1.1)E 1 (-3.5 - 8.2)E 1 *(0/ 11)*	(1.0 ± 0.8)E 1 (-4.2 - 9.0)E 1 *(0/ 17)*
TH-232 (56) (0)		(3.5 ± 0.1)E 2 (2.1 - 4.8)E 2 *(39/ 39)*	13	(5.2 ± 0.4)E 2 (3.5 - 7.5)E 2 *(11/ 11)*	(4.6 ± 0.3)E 2 (3.3 - 7.5)E 2 *(17/ 17)*
PU-238 (6) (0)	25.	(1.8 ± 4.8)E 0 (-5.4 - 15.8)E 0 *(0/ 4)*	11	(7.3 ± 8.5)E 0 (-1.2 - 15.8)E 0 *(0/ 2)*	(2.2 ± 3.1)E 0 (-9.5 - 53.5)E -1 *(0/ 2)*
PU-239/(6) 240 (0)	25.	(4.3 ± 2.0)E 0 (1.4 - 10.2)E 0 *(3/ 4)*	13	(1.1 ± 0.8)E 1 (3.4 - 19.1)E 0 *(2/ 2)*	(1.1 ± 0.8)E 1 (3.4 - 19.1)E 0 *(2/ 2)*

* 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 2.17-2

Sediment Plutonium Analyses

Environmental Radiological Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 1991)

Location	Core Depth (cm)	Results pCi/Kg (dry) +-1 S.D.	
		Plutonium 238	Plutonium 239, Plutonium 240
Rocky Point	0-2	NDA	NDA
Rocky Point	12-14	NDA	1.41 ± 0.33
Plymouth Harbor	0-2	NDA	10.2 ± 2.0
Manomet Point	0-2	NDA	2.34 ± 0.41
Duxbury Bay - Control	0-2	NDA	19.1 ± 1.6
Duxbury Bay - Control	12-14	NDA	3.37 ± 0.97

*NDA indicates no detectable activity.

Figure 5.2-1

Environmental Thermoluminescent
Dosimeter and Air Sampling Locations Within Exclusion Area

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
A	Station A	1300 ft	W
B	Station B	1300 ft	SSW
C	Station C	1700 ft	SE
D	Station D	1700 ft	NNW
EB	East Breakwater	1800 ft	SE
F	Station F	1400 ft	NW
G	Station G	1700 ft	WNW
I	Station I	1600 ft	NW
L	Station L	1400 ft	ESE
OA	Overlook Area	500 ft	W
PO1	Sec H Shore	720 ft	NNW
PO2	Fence Shore	440 ft	NW
PO3	Fen L Screenh	330 ft	NW
PO4	Fen R Screenh	220 ft	N
PO5	Fen Water Tank	[illegible] ft	NE
PO6	Fen Culvert	280 ft	ENE
PO7	Fen Intake	400 ft	E
PO8	Fen New Admin	300 ft	E
PO9	Fen TCF Side	450 ft	E
P10	Fen Intake TCF	740 ft	ESE
P11	Gate Wh to TCF	620 ft	SE
P12	Fen Wh Con Gate	660 ft	SSE
P13	Fen Con & RHR	740 ft	S
P14	Fen Butler B	750 ft	S
P15	Fen Unit #9	740 ft	SSW
P16	Fen Swy M Gate	560 ft	SW
P17	Fen Shf M Gate	350 ft	WNW
P18	I&C N Admin	290 ft	S
P19	Compliance Area	280 ft	S
P20	Dosimetry Window	220 ft	SSE
P21	WW Admin & Turb	170 ft	SE
P22	QA/QC Area	450 ft	SE
P23	CMG Area	400 ft	SSE
P24	Old Admin Bld 2nd	190 ft	W
P25	First Aid Trailer	250 ft	WNW
P26	Fence Warehouse	490 ft	SE
P27	TCF Boat Launch	640 ft	ESE
P28	TCF Cont. Lot	800 ft	ESE
PA	Parking Area	1200 ft	NNW
PB	Pedestrian Bridge	700 ft	N
PL	Property Line	1700 ft	NW
TC	Training Center	520 ft	W
WR	W. Rocky Hill Road	2500 ft	WNW
WS	Warehouse	600 ft	SSE
PMT	Plymouth Met Twr	1400 ft	NW
HB	Halls Bog	2000 ft	SSE
CT	Contractor Lot	1100 ft	SSE

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
EB	East Breakwater	0.33 mi	ESE
OA	Overlook Area	0.09 mi	W
PB	Pedestrian Bridge	0.13 mi	N
PL	Property Line	0.32 mi	NW
WR	W. Rocky Hill Road	0.48 mi	WNW
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 2.2-1 (cont.)

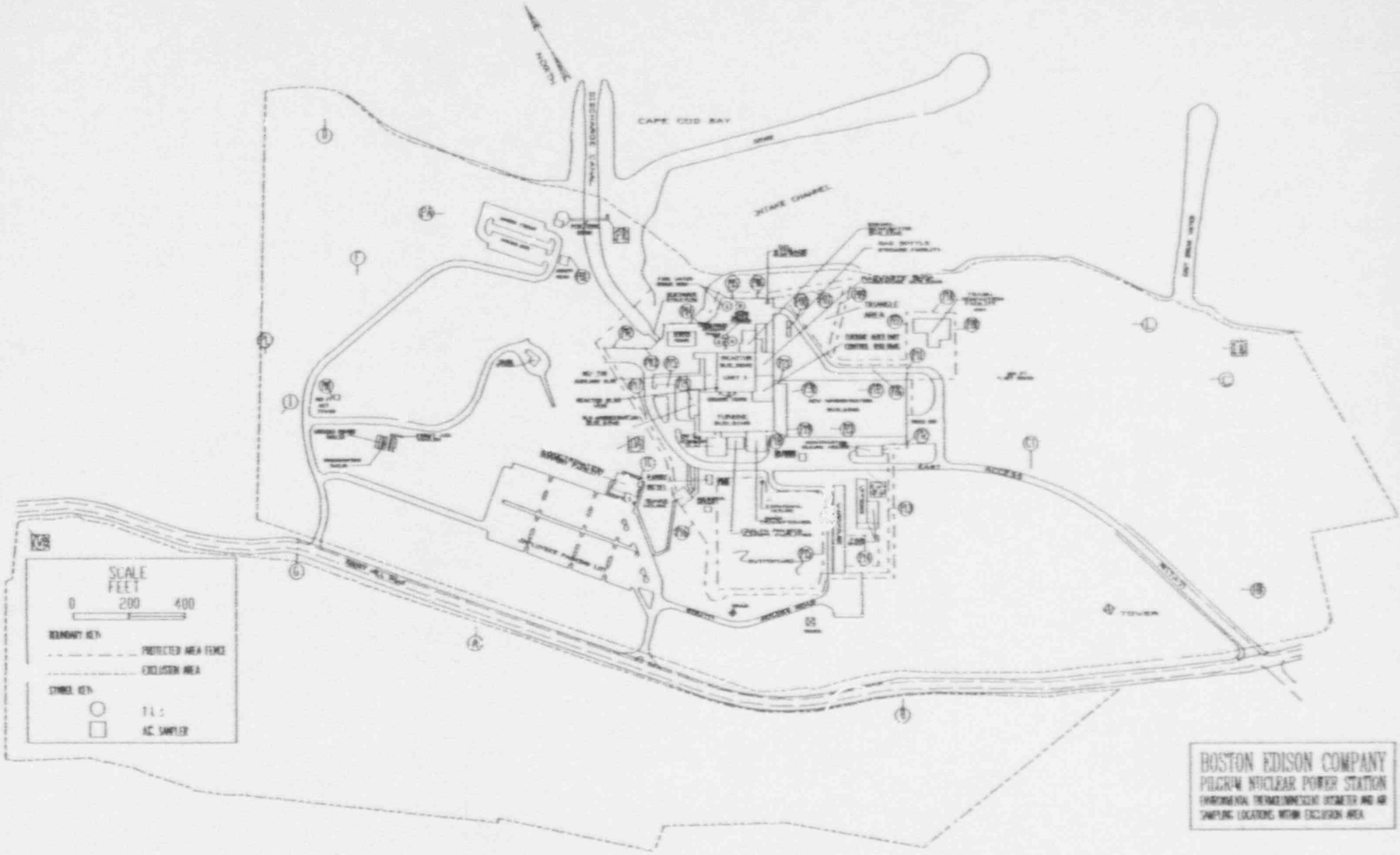


Figure 2.2-2

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

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
AR	Access Road	0.92 mi	S
BB	3A & Bartlett Rd	2.1 mi	SSE
BD	Bayshore Drive	0.81 mi	WNW
BS	Bayshore	1.3 mi	W
BW	Beechwood Road	2.5 mi	SE
CR	Cleft Rock	0.86 mi	S
DR	Dirt Road	0.94 mi	SW
E	Station E	1.2 mi	S
EM	Emerson Road	1.1 mi	SSE
EP	Emer Rd & Pris	1.1 mi	SE
ER	E Rocky Hill Rd	0.65 mi	SE
GH	Greenwood House	0.57 mi	SE
GN	Goodwin Property	1.4 mi	SW
H	Station H	0.57 mi	SW
J	Station J	1.3 mi	S
JG	John Gauley	1.1 mi	W

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
K	Station K	1.4 mi	SSE
ME	Manomet Elm	2.1 mi	SE
MP	Manomet Pt	2.3 mi	SE
MR	Manomet Road	0.98 mi	S
MS	Manomet Subst	2.3 mi	SSE
MT	Micro Tower	0.58 mi	SSW
PT	Pines Estate	2.7 mi	SSW
RC	Rec Pool	1.3 mi	WSW
RW	Right of Way	1.7 mi	S
SP	S Ply. Sub	2.8 mi	W
TP	Taylor & Pearl	1.9 mi	SE
TT	Taylor & Tom Ave	1.5 mi	SE
VR	Valley Road	1.8 mi	SSW
WC	Warren & Clifford	2.1 mi	W
WH	White Horse Rd	1.3 mi	SSE
YV	Yankee Village	1.4 mi	WSW

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
CR	Cleft Rock	0.86 mi	SSW
MS	Manomet Substation	2.3 mi	SSE
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.

SCALE
0 MILES 1

BOUNDARY KEY:
EXCLUSION AREA
PROPERTY

SYMBOL KEY:
T L D
AIR SAMPLER

BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER AND AIR SAMPLING LOCATIONS OUTSIDE EXCLUSION AREA TO ABOUT 2 MILES

Figure 2.2-2 (cont.)

Figure 2.2-3

Environmental Thermoluminescent Dosimeter and
Air Sampling Locations Outside Property Boundary

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
BB	3A & Bartlett	2.1 mi	SSE
BD	Bayshore Drive	0.81 mi	WNW
BE	Bourne Road	8.4 mi	SSW
BR	Beaver Dam Road	3.5 mi	S
BS	Bayshore	1.3 mi	W
BW	Beachwood Road	2.5 mi	SE
CR	Cleft Rock	0.86 mi	S
CS	Cedarville Sub	10 mi	S
CP	College Pond	4.8 mi	SW
CW	Church & West	10 mi	NW
DMF	Div. Mar. Fish.	14 mi	SSE
DW	Deep Water	5.3 mi	W
EA	Earl Road	3.0 mi	SSE
EL	Ellisville Road	7.2 mi	SSE
EP	Emer. Rd & Pris	1.1 mi	SE
EW	E. Weymouth Sub	24 mi	NW
HD	Hilldale Road	3.1 mi	W
HR	Hyannis Road	4.8 mi	SSE
JG	John Gauley	1.1 mi	W
KC	King Caesar Road	8.1 mi	NNW
KS	Kingston Subst.	10 mi	WNW
SH	Snake Hill Road	4.5 mi	WSW
LP	Long Pond Road	5.7 mi	SSW
LR	Landing Road	10 mi	NNW

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
MB	Manomet Beach	3.4 mi	SSE
ME	Manomet Elem	2.1 mi	SE
MH	Memorial Hall	4.7 mi	WNW
MM	Main & Meadow	11 mi	WSW
MP	Manomet Point	2.3 mi	SE
MS	Manomet Subst	2.3 mi	SSE
NP	North Plymouth	5.8 mi	WNW
PC	Plymouth Center	4.1 mi	W
PT	Pine Estates	2.7 mi	SSW
RC	Rec Pool	1.3 mi	WSW
RM	Russell Mill	3.0 mi	WSW
RP	Rt 3 Overpass	3.0 mi	SW
SA	Sherman Airport	8.4 mi	WSW
ES	Elm Street	8.1 mi	W
SS	Standish Shores	6.5 mi	NW
SP	S. Plymouth Sub	2.8 mi	W
TP	Taylor & Pearl	1.9 mi	SE
TT	Taylor & Thomas	1.5 mi	SE
UC	Up Coll. Pnd. Rd	7.4 mi	SW
WC	Warren & Clifford	2.1 mi	W
YV	Yankee Village	1.4 mi	WSW

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
CR	Cleft Rock	0.86 mi	SSW
EW	East Weymouth	24 mi	NW
MS	Manomet Subst	2.3 mi	SSE
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 2.2-3 (cont.)

Figure 2.2-4

Terrestrial and Aquatic Sampling Locations

Code	Description	Dist.*	Dir.*
	SEAWATER		
DIS	Discharge Canal	0.13 mi	N
BP	Bartlett Pond	1.7 mi	SE
PP	Powder Point Control	7.9 mi	NNW
	SHELLFISH		
DIS	Discharge Canal	0.21 mi	N
PLY-H	Plymouth Harbor	2.8 mi	W
MP	Manomet Point	3.0 mi	ESE
DUX-BAY	Duxbury Bay Control	7.8 mi	NNW
PP	Powder Point Control	8.0 mi	NNW
GH	Green Harbor Control	9.9 mi	NNW
	IRISH MOSS		
DIS	Discharge Canal	0.21 mi	N
MP	Manomet Point	2.2 mi	ESE
EL	Ellisville	7.9 mi	SSE
BK	Brant Rock Control	10 mi	NNW
	AMERICAN LOBSTER		
DIS	Discharge Canal	0.21 mi	N
PLY-H	Plymouth Harbor	4.0 mi	WNW
DUX-B	Duxbury Beach Control	5.8 mi	NNW
DUX-BAY	Duxbury Bay Control	7.1 mi	NNW
PLB	Plymouth Beach	2.5 mi	W
	FISHES		
DIS	Discharge Canal	0.21 mi	N
PLB	Plymouth Beach	2.5 mi	W
JR	Jones River Control	7.8 mi	W
CC-BAY	Cape Cod Bay Control	15 mi	E
NR	N River-Hanover Control	15 mi	NNW
CA	Cataumet Control	20 mi	SSW
PT	Provincetown Control	20 mi	NE
BB	Buzzards Bay Control	25 mi	SSW
PC	Priest Cove Control	30 mi	SW
NS	Nantucket Sound Control	30 mi	SSE
AO	Atlantic Ocean Control	30 mi	E
MV	Vineyard Sound Control	40 mi	SSW

Code	Description	Dist.*	Dir.*
	SEDIMENT		
RP	Rocky Point	0.21 mi	N
PLY-H	Plymouth Harbor	3.0 mi	W
PLB	Plymouth Beach	2.5 mi	W
MP	Manomet Point	2.5 mi	ESE
DUX-BAY	Duxbury Bay Control	8.7 mi	NNW
GH	Green Harbor Control	10 mi	NNW
	MILK		
CF	Plymouth County Farm	3.5 mi	W
WF	Whitman Farm Control	20 mi	WNW
	CRANBERRIES		
MR	Manomet Pt. Bog	2.4 mi	SE
BT	Bartlett Rd. Bog	2.7 mi	SSE
PS	Pine St. Bog Control	16 mi	WNW
	VEGETABLES		
CF	Plymouth County Farm	3.4 mi	W
BF	Bridgewater Farm Ctrl	20 mi	W
WH			
AF			
ML			
JG			
MG			
	FORAGE		
CF	Plymouth County Farm	3.5 mi	W
WF	Whitman Farm Control	20 mi	WNW
	Whipple Farm	1.8 mi	SW

* 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.

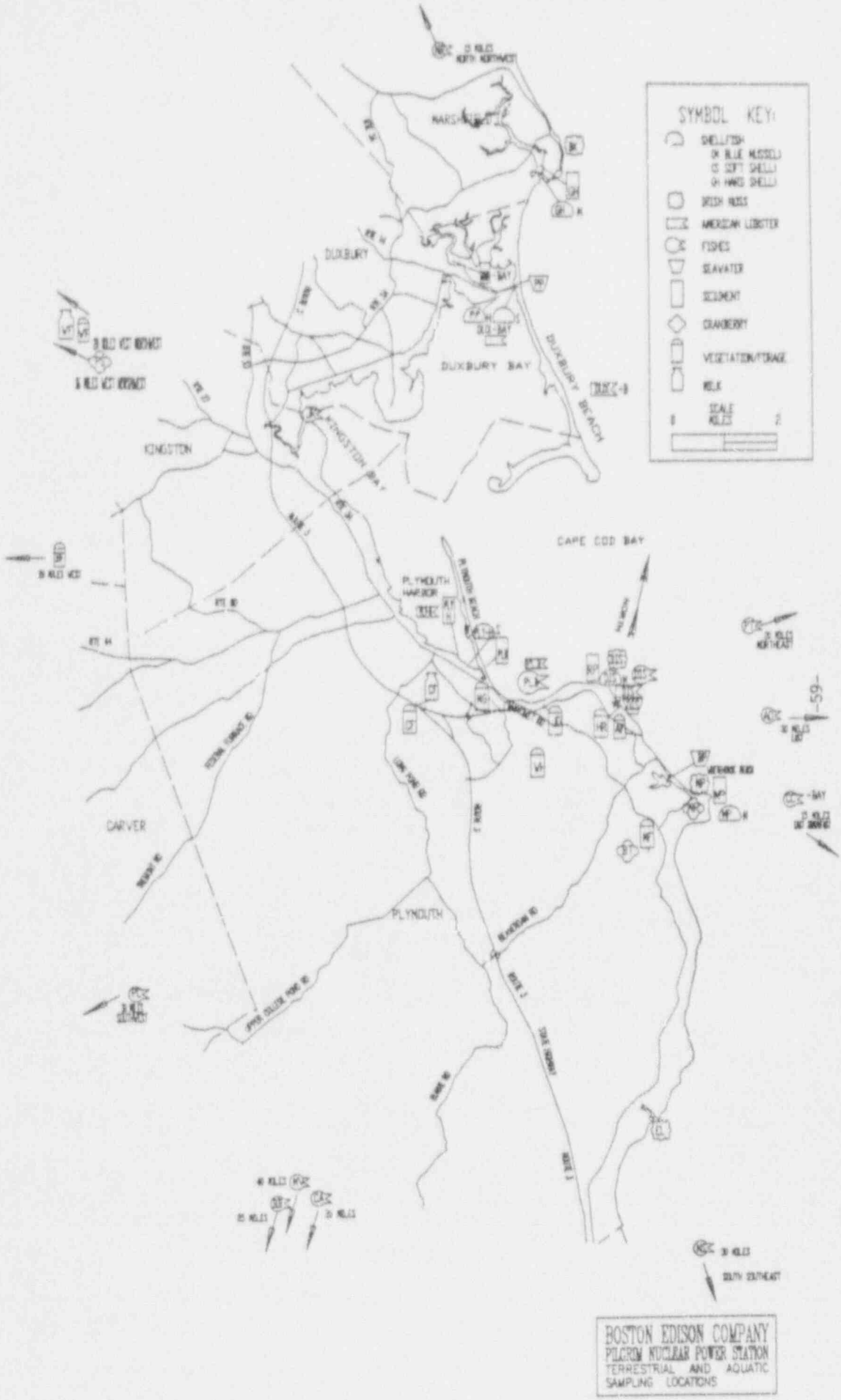


Figure 2.2-4 (cont.)

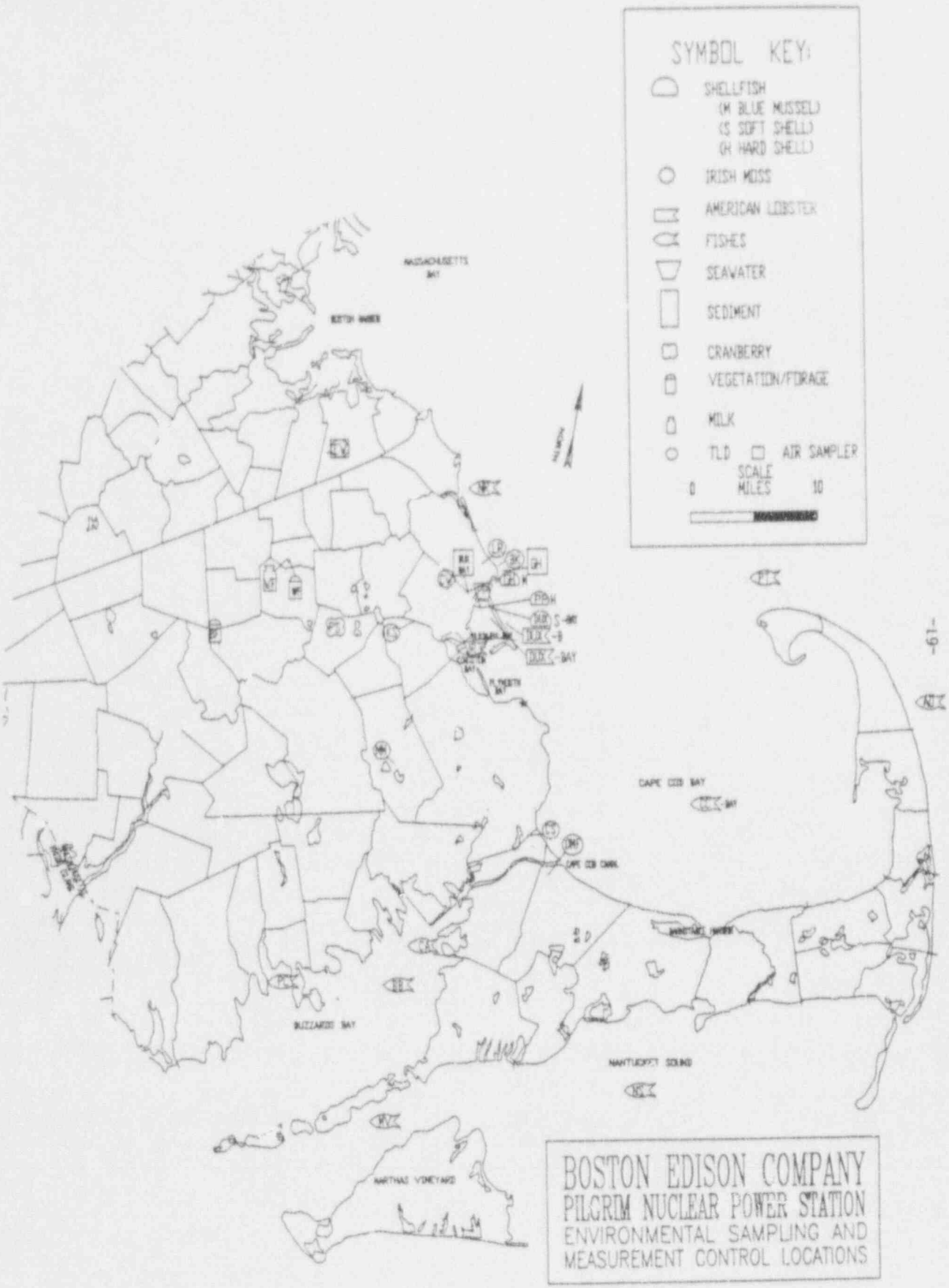
Figure 2.2-5

Environmental Sampling And Measurement Control Locations

Code	Description	Dist.*	Dir.*
	AIR SAMPLE		
EW	East Weymouth	24 mi	NW
	SEDIMENT		
GH	Green Harbor Control	10 mi	NNW
DUX-BAY	Duxbury Bay Control	8.7 mi	NNW
	SEAWATER		
PP	Powder Point Control	7.9 mi	NNW
	SHELLFISH		
DUX-BAY	Duxbury-Bay Control	7.8 mi	NNW
PP	Powder Point Control	8.0 mi	NNW
GH	Green Harbor Control	9.9 mi	NNW
	IRISH MOSS		
BK	Brant Rock Control	10 mi	NNW
	AMERICAN LOBSTER		
DUX-BAY	Duxbury Bay Control	7.1 mi	NNW
	FISHES		
JR	Jones River Control	7.8 mi	WNW
CC-BAY	Cape Cod Bay Control	15 mi	ESE
NR	N. River Hanover Control	15 mi	NNW
CA	Cataumet Control	20 mi	SSW
PT	Provincetown Control	20 mi	NE
BB	Buzzards Bay Control	25 mi	SSW
PC	Priest Cove Control	30 mi	SW
NS	Nantucket Sound Control	30 mi	SSE
AO	Atlantic Ocean Control	30 mi	E
MV	Vineyard Sound Control	40 mi	SSW

Code	Description	Dist.*	Dir.*
	TLD		
KS	Kingston Subst	10 mi	WNW
LR	Landing Road	10 mi	NNW
CS	Cedarville Sub	10 mi	S
CW	Church & West	10 mi	NW
MM	Main & Meadow	11 mi	WSW
DMF	Div. Mar. Fish	14 mi	SSE
EW	East Weymouth Sub	24 mi	NW
	MILK		
WF	Whitman Farm Control	20 mi	WNW
	CRANBERRIES		
PS	Pine St. Bog Control	16 mi	WNW
	VEGETABLES		
BF	Bridgewater Farm Control	20 mi	W
WF			
	FORAGE		
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.



BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
ENVIRONMENTAL SAMPLING AND
MEASUREMENT CONTROL LOCATIONS

Figure 2.2-5 (cont.)

Figure 2.4-1

Historical Beach Survey Exposure Rate Measurements

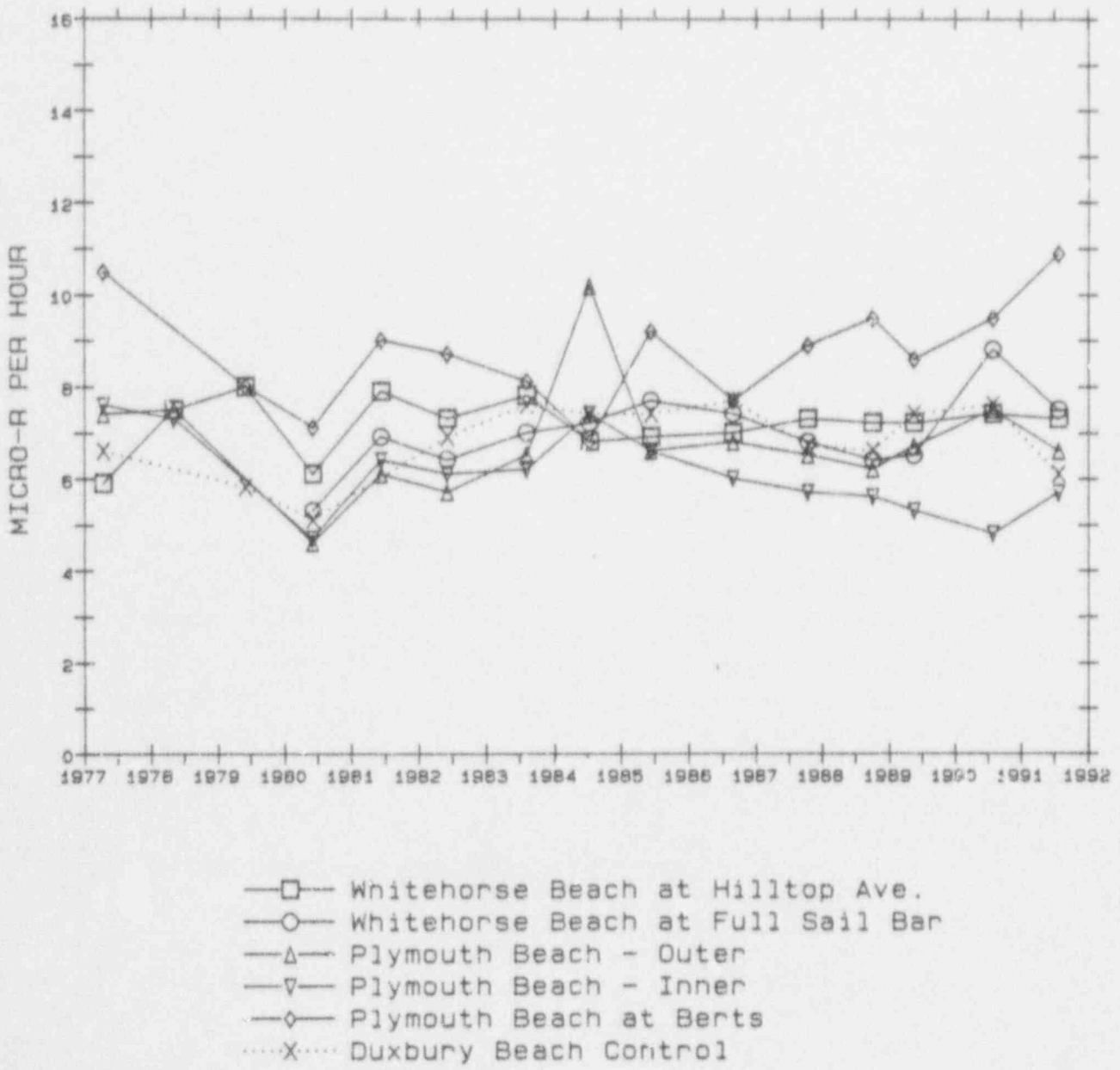


Figure 2.5-1

Airborne Gross Beta Radioactivity Levels: Near Station

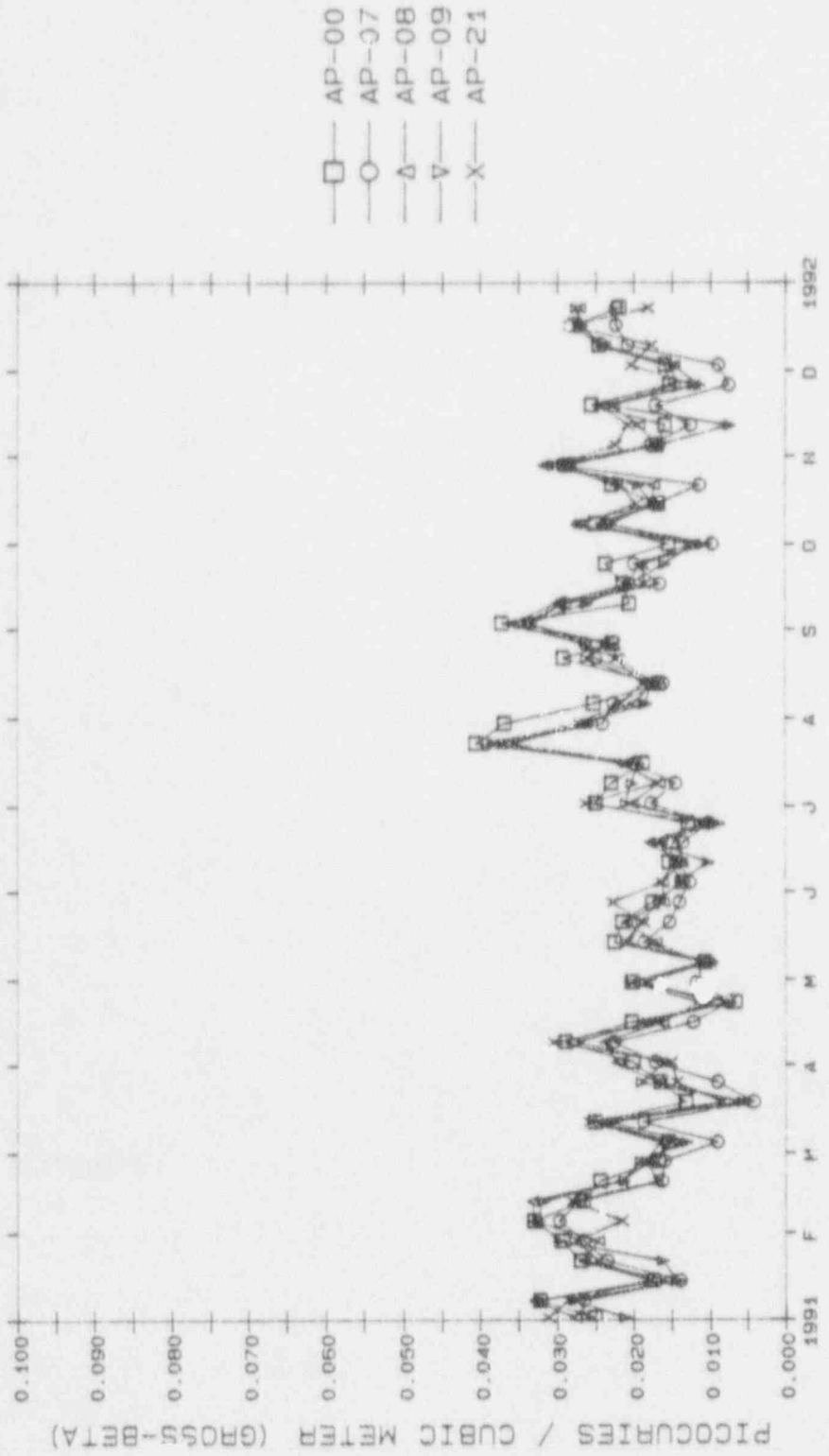


Figure 2.5-2

Airborne Gross Beta Radioactivity Levels: Property Line

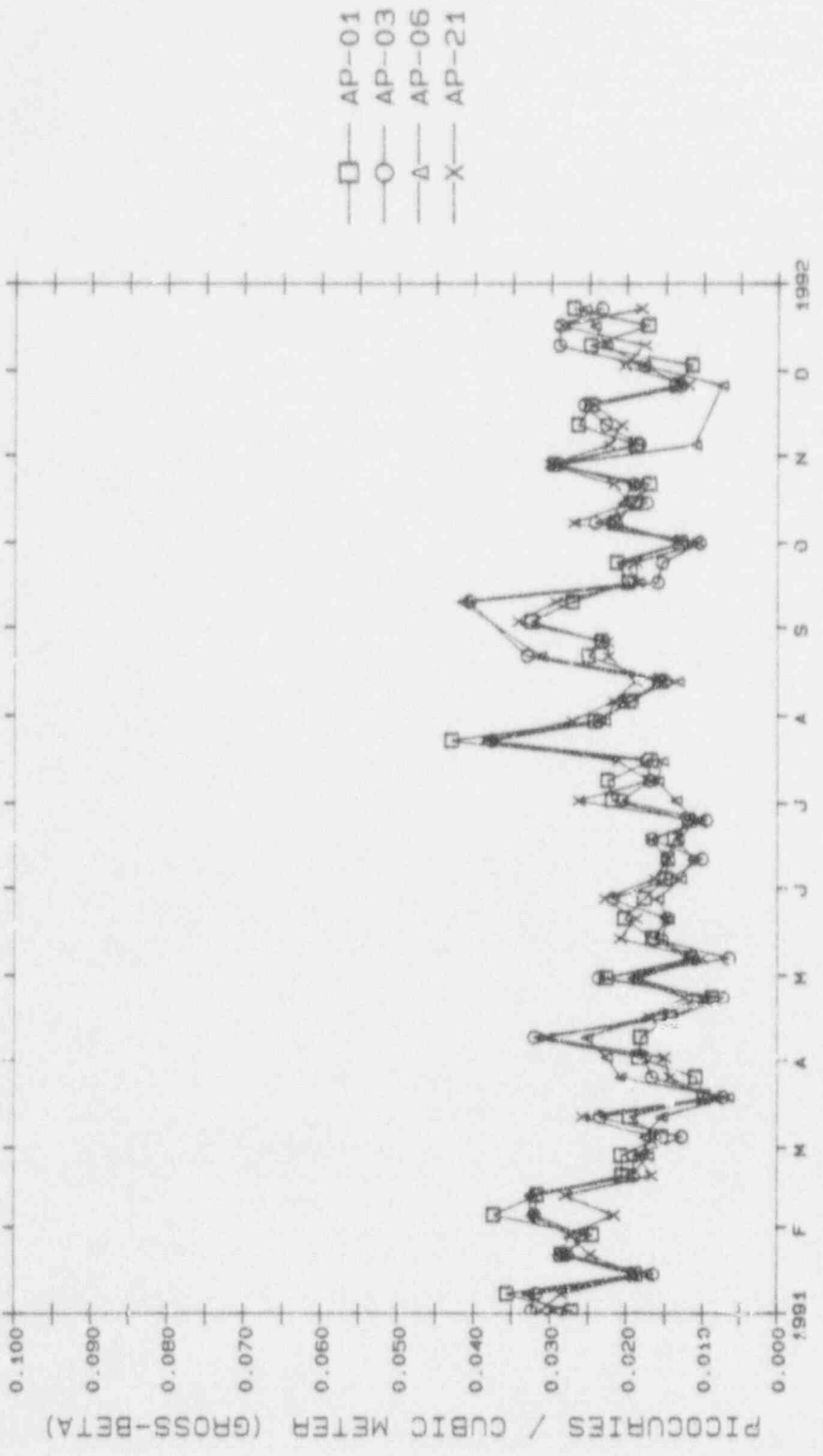


Figure 2.5-3

Airborne Gross Beta Radioactivity Levels: Off-Site

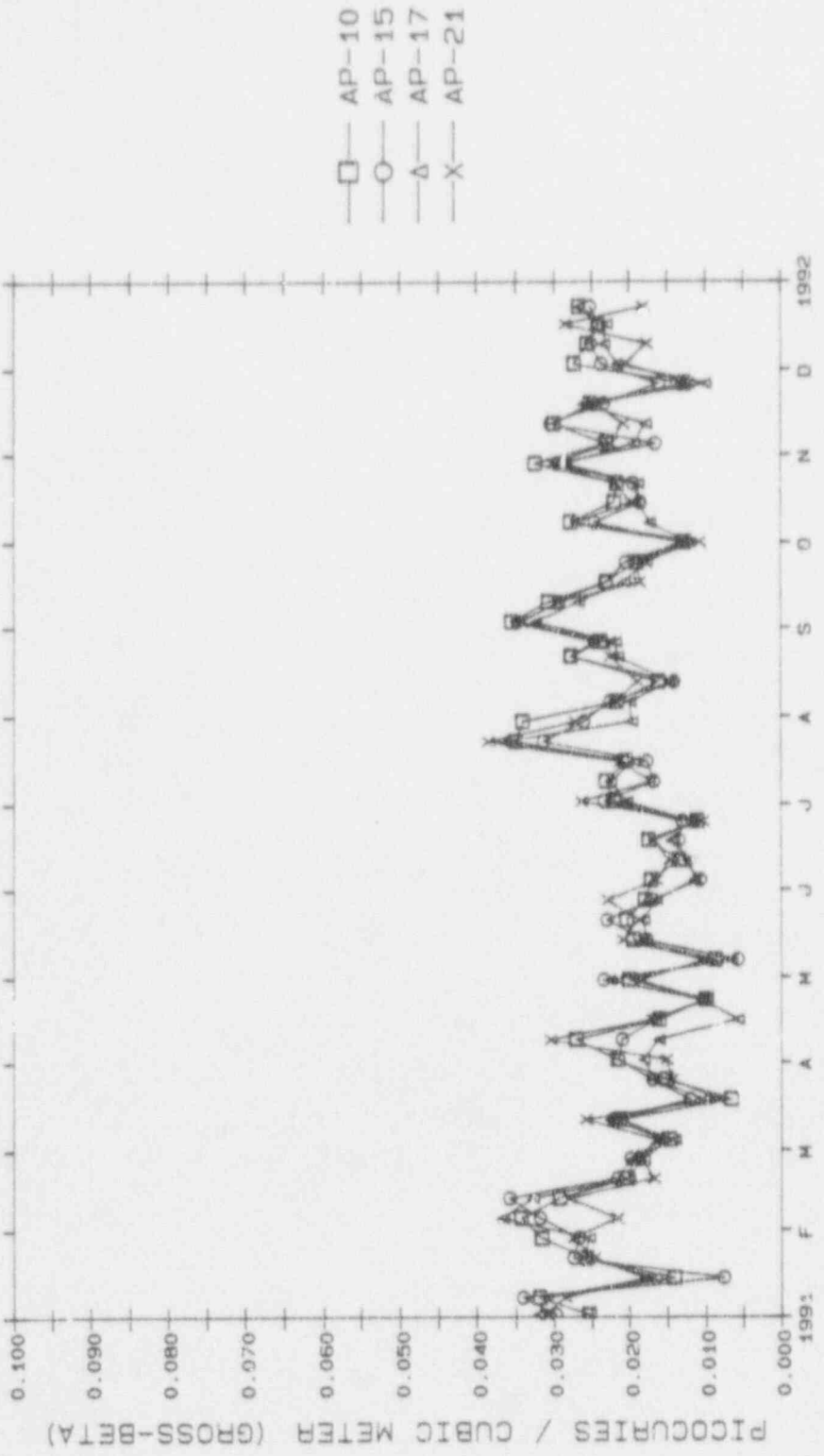


Figure 2.7-1

Levels of Strontium-90 in Milk Samples

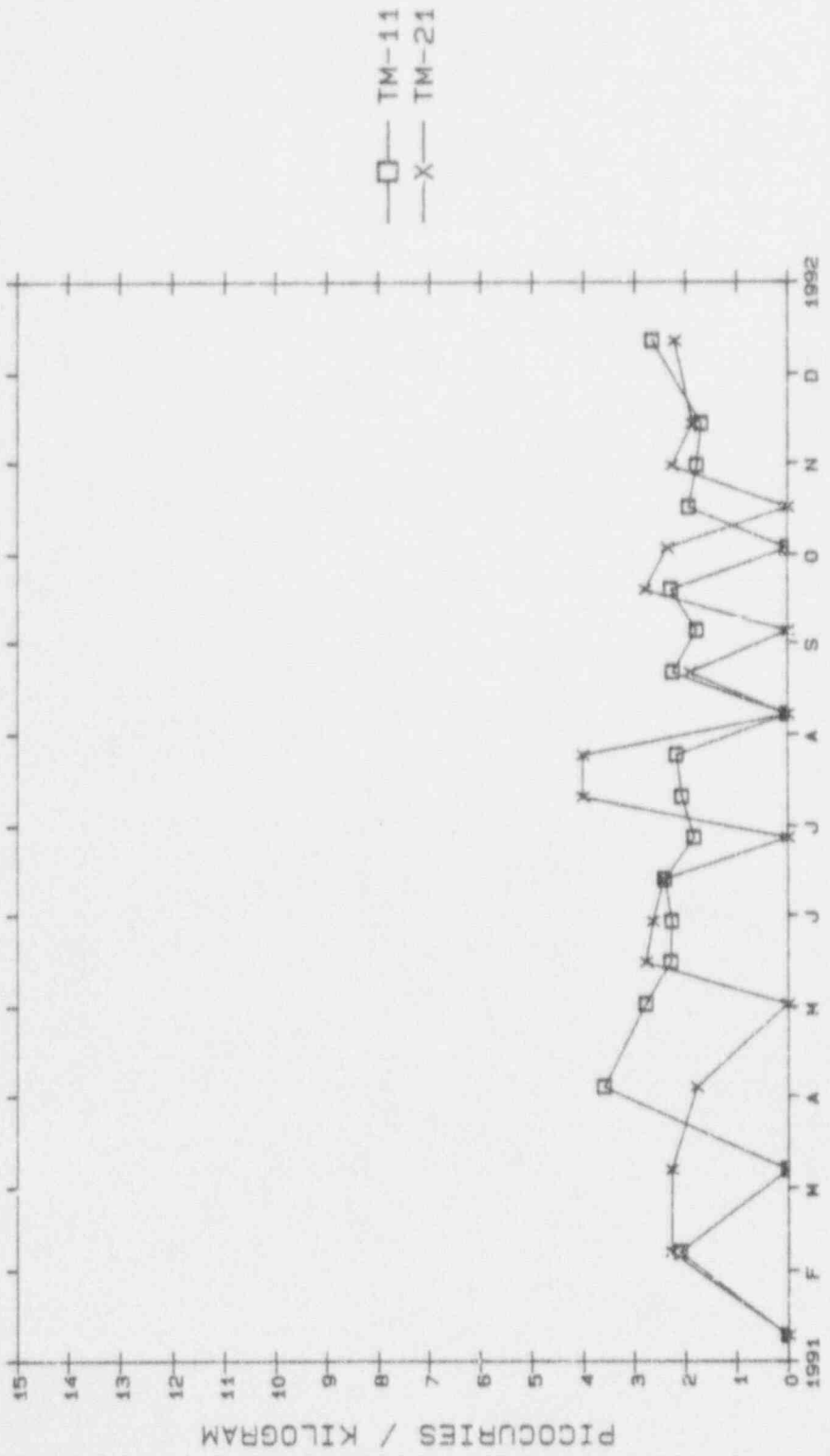
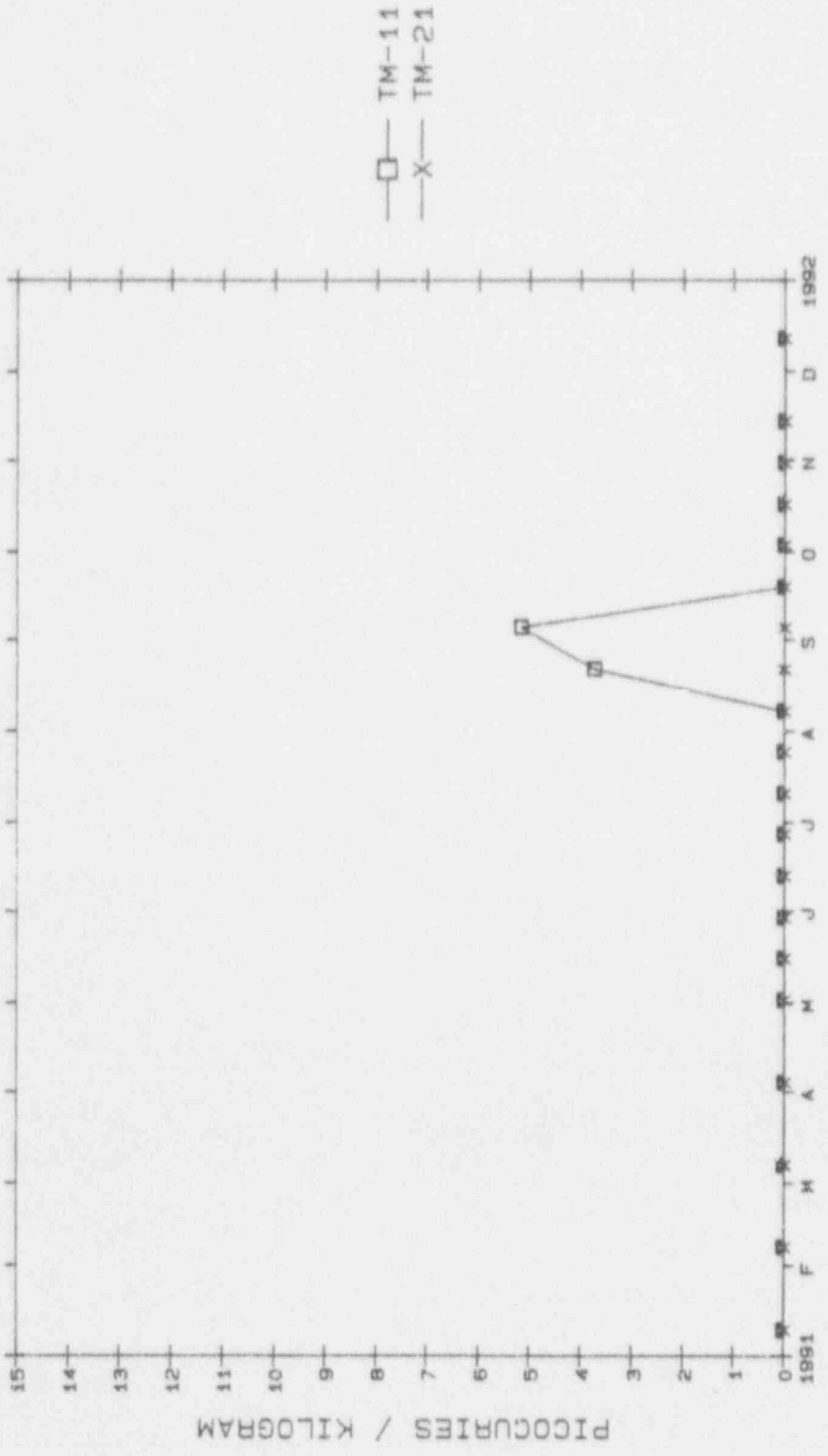


Figure 2.7-2

Levels of Cesium-137 in Milk Samples



3.0 SUMMARY OF RADIOLOGICAL IMPACT ON HUMANS

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

1) calculations based on measurements of plant effluent 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 1991 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 listed in Appendix A.

The maximum individual dose from liquid effluents was calculated using the following radiation exposure pathways:

1) shoreline external radiation during fishing and recreation at the Pilgrim Station Shorefront;

2) external 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) external radiation from cloud shine and submersion in gaseous effluents;

2) inhalation of airborne radioactivity;

3) external radiation from soil deposition;

4) consumption of vegetables; and

5) consumption of milk and meat.

The results from the dose calculations based on PNPS operations are presented in Table 3.0-1. The dose assessment data presented was taken from the "Annual Dose Assessment to the General Public from Radioactive Effluents" report for the period of January 1 through December 31, 1991.

Table 3.0-1

Radiation Doses from 1991 Pilgrim Station Operations

Receptor	Maximum Individual Dose From Exposure Pathway - mrem/yr			
	Liquid Effluents	Gaseous Effluents*	Direct Radiation**	Total
Total Body	0.002	0.55	0.67	1.2
Skin	0.002	1.28	0.67	2.0
Thyroid	0.001	2.87	0.67	3.5
Max. Organ	0.003	2.87	0.67	3.5

* Gaseous effluent exposure pathway includes combined dose from particulates, iodines and tritium in addition to noble gases.

** Direct radiation dose for hypothetical maximum-exposed individual at location on Boston Edison property yielding highest direct radiation exposure value.

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 300 to 400 mrem/yr from such sources.

As can be seen from the doses resulting from Pilgrim Station Operations during 1991, all values are well within the federal limits specified by the NRC and EPA. In addition, the calculated doses from PNPS operation 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 1991, three special studies were performed to determine the dose impact associated with radionuclides detected in environmental media. These calculations are discussed in detail in Appendix A of this report.

Internal radiation doses associated with ingestion of Cobalt-60 detected in blue mussels are discussed in Appendix A, Section I. The estimated maximum total body dose associated with the hypothetical ingestion of blue mussels taken from the area of the Pilgrim Station Discharge Canal outfall was 0.0003 mrem/yr.

Internal radiation doses associated with ingestion of Cobalt-60 detected in Irish moss are discussed in Appendix A, Section II. The estimated maximum total body dose associated with the hypothetical ingestion of Irish moss taken from the area of the Pilgrim Station Discharge Canal outfall was 0.002 mrem/yr.

External radiation dose associated with direct radiation from Cobalt-60 and Cesium-137 deposited on the soil surface on areas of Boston Edison Company property accessible to the general public are discussed in Appendix A, Section III. The total body dose to the maximum exposed individual from this direct radiation exposure was estimated as 0.03 mrem/yr.

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.

4.0 REFERENCES

1. United States of America, Code of Federal Regulations, Title 10, Part 50, Appendix A Criteria 64.

2. Donald T. Oakley, "Natural Radiation Exposure in the United States." U. S. Environmental Protection Agency, ORP/SID 72-1, June 1972.

3. National Council on Radiation Protection and Measurements, Report No. 93, "Ionizing Radiation Exposures of the Population of the United States," September 1987.

4. United States Nuclear Regulatory Commission, Regulatory Guide 8.29, "Instructions Concerning Risks from Occupational Radiation Exposure," Revision 0, July 1981.

5. Boston Edison Company, "Pilgrim Station" Public Information Brochure 100M, WNTHP, September 1989.

6. United States Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

7. Boston Edison Company, Pilgrim Nuclear Power Station Off-site Dose Calculation Manual, Revision 5, October 1991.

8. United States of America, Code of Federal Regulations, Title 10, Part 20.105.

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

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

11. United States Nuclear Regulatory Commission, Regulatory Guide 4.1, "Program for Monitoring Radioactivity in the Environs of Nuclear Power Plants," Revision 1, April 1975.

12. ICN/Tracerlab, "Pilgrim Nuclear Power Station Pre-operational Environmental Radiation Survey Program, Quarterly Reports," August 1968 to June 1972.

13. International Commission of Radiological Protection, Publication No. 43, "Principles of Monitoring for the Radiation Protection of the Population," May 1984.

14. United States Nuclear Regulatory Commission, NUREG-0473, "Standard Radiological Effluent Technical Specifications for Boiling Water Reactors," Revision 3, September 1982.

4.0 REFERENCES (continued)

15. United States Nuclear Regulatory Commission, Branch Technical Position, "An Acceptable Radiological Environmental Monitoring Program," Revision 1, November 1979.

16. Settlement Agreement Between Massachusetts Wildlife Federation and Boston Edison Company Relating to Off-site Radiological Monitoring - June 9, 1977.

17. J. E. Vossahlik, Yankee Atomic Electric Company, Computer Program "ERMAP," Version 3.1 - January 9, 1979.

18. E. R. Cumming, Yankee Atomic Electric Company, "1991 Annual Direct Radiation Survey," REG 189/91, August 7, 1991.

APPENDIX A

SPECIAL STUDIES

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part I: Blue Mussels

A. Introduction

As a part of the routine radiological environmental sampling program at PNPS, blue mussels are sampled and analyzed on a quarterly basis. During 1991, as in previous years, samples from the outfall of the PNPS discharge canal exhibited measurable quantities of cobalt-60. One sample also showed detectable silver-110m. This special study documents the radiological analysis results as well as the dose calculations to evaluate the maximum radiological impact to a hypothetical member of the general public.

B. 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 (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 mollusks has been studied and documented.

The uptake rate can be described by the biological accumulation 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.

The following sections of this document will describe:

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

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.

C. Mussel Radioactivity Measurements and Maximum Internal Dose

Samples of blue mussels were collected during each calendar quarter from the outfall of the PNPS discharge canal by personnel from the Massachusetts Division of Marine Fisheries as part of the routine radiological environmental monitoring program. The mussel meat and surrounding liquid were removed from the shells to yield approximately 500 grams of sample during each collection. Samples were then submitted to Yankee Atomic Electric Company's Environmental Laboratory for analysis. Samples were counted on a lithium-drifted germanium detector using standard procedures.[6]

The only radionuclide attributable to PNPS operations that was detected in any of the 1991 mussel samples was cobalt-60. The activity concentrations of Co-60 observed in the quarterly samples are as follows:

Collection Period	Co-60 Concentration ± S.D. in mussel meat (pCi/kg)
First Quarter	7.2 ± 1.4
Second Quarter	5.4 ± 1.4
Third Quarter	5.3 ± 1.4
Fourth Quarter	No Detectable Activity
Average	6.0 ± 1.8

The average concentration of Co-60 in the edible portion was 6.0 pCi/kg. This level shows a continuous decrease in Co-60 levels in the mussels in the area of the Discharge Canal. For comparison, the average concentrations of Co-60 in mussels from this area were 89 pCi/kg in 1987, 37 pCi/kg in 1988, 22 pCi/kg in 1989 and 12 pCi/kg in 1990. Due to the moderate half-life of Co-60 (5.3 yr), any of the nuclide deposited in the area in past years should still be detectable. The observed decrease in these levels through time indicates that no additional accumulation is taking place.

Based on the average observed concentration of Co-60 in the mussel meat during 1991, an estimate of the maximum internal dose from the ingestion of these mussels was calculated. This was based on the conservative assumption that the maximum exposed individual would ingest mussels that were raked from the discharge canal outfall. The calculations were performed in accordance with the Pilgrim Nuclear Power Station Off-site Dose Calculation Manual.[7] The results shown in the following table indicate that the maximum organ dose from the ingestion of mussel bodies harvested from the Pilgrim Nuclear Power Station discharge canal outfall would be about 0.002 mrem/yr.

Estimated Maximum Internal Dose from Ingestion of
Blue Mussels taken from Pilgrim Station Discharge Canal Outfall

Organ	Adult (mrem/yr)	Teenager (mrem/yr)	Child (mrem/yr)
Total Body	0.0003	0.0002	0.0003
Maximum Organ (GI)	0.002	0.001	0.0005

D. 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)[5]. 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)[8].

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (e.g., diagnostic X-rays) sources of radiation. The typical American receives 300 to 400 mrem/yr from such sources.

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

E. 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 0.01 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 is much less than one percent of the natural/man-made radiation levels received annually by the average American.

F. REFERENCES

1. Lowman, F. G., T. R. Rice, and F. A. Richards. 1971. "Accumulation and Redistribution of Radionuclides by Marine Organisms in Radioactivity in the Marine Environment," National Academy of Sciences, pp. 168-169.

2. Chapman, W. H., H. L. Fisher, and M. W. Pratt. 1968. "Concentration Factors of Chemical Elements in Edible Aquatic Organisms". Lawrence Radiatior Laboratory, Livermore, Report UCRL-50564.

3. Weaver, C. L., "A Proposed Radioactivity Concentration Guide for Shellfish", U.S. Public Health Service, September, 1967.

4. Harrison, F. Personal communication with D. E. McCurdy, 1972 (from Reference 9).

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

6. Yankee Atomic Environmental Laboratory Procedure No. 450, "Identification and Quantitative Determination of Radionuclides by Gamma Ray Spectrometric Techniques", Rev. 4.

7. Boston Edison Company, Pilgrim Nuclear Power Station, Off-site Dose Calculation Manual, Revision 5, October 1991.

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

APPENDIX A

SPECIAL STUDIES

PART II: IRISH MOSS

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part II: Irish Moss

A. Introduction

As part of the routine environmental sampling program at PNPS, Irish moss (algae) is sampled and analyzed on a quarterly basis. During 1991, 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.

B. 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. Approximately 20,000 to 30,000 pounds of Irish moss was harvested in the Plymouth area each year.

Once harvested, the Irish moss is eventually processed into a fine white powder called carrageenin, a starch-like extract used as an additive in foods and other commercial products. Carrageenin serves as a food stabilizer, thickener, and gelling agent. Products containing carrageenin 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]

C. Radioactivity Measurements and Maximum Internal Dose

Measurable quantities of cobalt-60 were observed in only one sample collected from the Discharge Canal Outfall area during 1991, and no other radioactive isotopes were detected that could be attributed to PNPS. The sample of Irish moss collected in August yielded a cobalt-60 concentration of 47 pCi/kg.

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.

NRC Regulatory Guide 1.109[2] 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 8/13/91) 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 much less than 0.01 mrem/year. This amount 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 Ingestion 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	0.002	0.002	0.002
Maximum Organ (GI)	0.02	0.01	0.004

D. 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)[3]. 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)[4].

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 300 to 400 mrem/yr from such sources.

When the maximum estimated total body dose of 0.0002 mrem/yr is compared to the federal dose limits, such an exposure is well within established guidelines. In addition, this maximum dose is a fraction of a percent of the radiation levels typically received each year by members of the general public.

E. 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 much less than 0.01 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.

F. References

[illegible] of Marine Fisheries Newsletter, November - December 1984.

[illegible]lear Regulatory Commission, "Calculation of Annual Doses to [illegible] Routine Release of Reactor Effluents for the Purpose of [illegible]ng Compliance with 10CFR Part 50, Appendix I," Regulatory [illegible].109, October 1977.

3. [illegible]ited States of America, Code of Federal Regulations, Title 10, Part 20.

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

APPENDIX A

SPECIAL STUDIES

PART III: SOIL

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Part III: Soil

A. Introduction

Topsoil and soil core samples and in situ radioactivity measurements are routinely collected at the eleven air sampling locations around Pilgrim Station every three years. During the 1991 surveys, cobalt-60 (Co-60) 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.

B. Background Information

As reported in the 1987 and 1988 annual Radiological Environmental Monitoring Program (REMP) reports,[1,2] 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 trench work, 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 previously stored in the upper contractor parking lot (now stored in a covered location in the 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, ranging from 500 to 1500 pCi/kg. Any elevated levels of Cs-137 or detectable Co-60 concentrations observed in 1987 surveys were attributed to deposition of wind-blown dust.

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

Cesium-137 was detected at ten of the eleven locations surveyed.[3]. Cobalt-60 was also detected at three 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 in 1991 yielded detectable Co-60 or Cs-137 concentrations elevated over expected fallout levels of 500 to 1500 pCi/kg.

None of the air particulate samples yielded detectable activities of Cs-137 or Co-60 during 1991, indicating that suspension and deposition of wind-blown dust was not occurring as in previous years. In addition, 1991 soil survey results were similar to those obtained in the 1987 and 1988 measurements. These two factors indicate that the Co-60 and elevated Cs-137 levels observed in 1991 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 activities would not be expected to change appreciably between the surveys conducted in 1987/88 and 1991.

The highest concentrations of both Co-60 and Cs-137 were measured at the Overlook Area airborne sampling station, immediately overlooking the Turbine and Reactor Buildings. This location yielded a Cs-137 concentration of 2895 pCi/kg and a corresponding Co-60 concentration of 295 pCi/kg in topsoil scraped from the upper inch of the soil profile. 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.

Releases of radionuclides in airborne effluents (see Appendix B) from Pilgrim Station during 1991 were minimal. Although the detectable levels of Co-60 and Cs-137 do not appear to be attributable to effluent releases from Pilgrim Station operations during 1991, 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.

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 a 40 hour period while the person was at this location on Boston Edison controlled property. 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 doses are presented in the table below.

Estimated Maximum Dose From External Irradiation
From Surface Deposited Radioactivity

Organ	Resulting External Dose (mrem/yr)		
	Co-60	Cs-137	Total
Total Body	0.008	0.020	0.028
Skin	0.010	0.023	0.033

D. 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 300-400 mrem/yr from such sources.

When the maximum estimated total body dose of 0.028 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.

E. Conclusions

Detectable levels of cobalt-60 and cesium-137 were measured in soil at a number of the locations surveyed during 1991. 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 between the last survey in 1988 and the survey conducted in 1991 did not appear to contribute additional activity.

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 and cesium-137 which could be attributed to Pilgrim Station was relatively minor. The resulting maximum dose of 0.028 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.

F. References

1. Boston Edison Company, Pilgrim Nuclear Power Station, "Radiological Environmental Monitoring Program Report No. 20", May 1987.

2. Boston Edison Company, Pilgrim Nuclear Power Station, "Radiological Environmental Monitoring Program Report No. 21", May 1988.

3. Yankee Atomic Electric Company, Letter EL 206/92, dated February 20, 1992.

4. Boston Edison Company, Pilgrim Nuclear Power Station, Off-site Dose Calculation Manual, Revision 5, October 1991.

APPENDIX B

RADIOACTIVE EFFLUENT RELEASES

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information (1991)
January - June 1991

Facility Pilgrim Nuclear Power Station Licensee 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,c. Iodines, particulates with half-lives >8 days, tritium: 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**

   a. Fission and activation gases: 10 CFR 20 Appendix B Table II
   b. Iodines: 10 CFR 20 Appendix B Table II
   c. Particulates, half-lives >8 days: 10 CFR 20 Appendix B Table II
   d. Liquid effluents: 2E-4 µCi/ml for entrained noble gases; 10 CFR 20 Appendix B Table II values for all other radionuclides.

3. **Average Energy** Not applicable

4. **Methods used to determine radionuclide composition in effluents**

   a. Fission and activation gases:
   b. Iodines:
   c. Particulates:
   d. Liquid effluents:

   High-purity Ge gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquids only), Sr-89, and Sr-90.

5. **Batch Releases**

   a. Liquid

	Quarter 1st	Quarter 2nd
1. Number of batch releases:	24	28
2. Total time period for batch releases (minutes):	1.34E+3	1.14E+3
3. Maximum time period for a batch release (minutes):	1.35E+2	2.45E+2
4. Average time period for batch releases (minutes):	5.58E+1	4.07E+1
5. Minimum time period for a batch release (minutes):	1.00E+1	2.00E+1
6. Average stream flow during periods of release of effluent into a flowing stream (liter/min):	1.17E+6	6.64E+5

   b. Gaseous: Not applicable

6. **Abnormal Releases**

   a. Liquid: None
   b. Gaseous: None

TABLE 1A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
GASEOUS EFFLUENTS SUMMATION OF ALL RELEASES
January - June 1991

	Unit	Quarter 1st	Quarter 2nd	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	3.38E+02	4.83E+02	22%
2. Average release rate for period	µCi/sec	4.29E+01	6.13E+01	
3. Percent of Tech. Spec. limit	%	*	*	
B. Iodines				
1. Total iodine-131	Ci	1.28E-02	1.32E-02	20%
2. Average release rate for period	µCi/sec	1.62E-03	1.67E-03	
3. Percent of Tech. Spec. limit	%	*	*	
C. Particulates				
1. Particul. with half-lives>8 days	Ci	6.46E-04	9.97E-04	21%
2. Average release rate for period	µCi/sec	8.19E-05	1.26E-04	
3. Percent of Tech. Spec. limit	%	*	*	
4. Gross alpha radioactivity	Ci	3.48E-07	3.75E-07	
D. Tritium				
1. Total release	Ci	1.32E+01	4.29E+00	20%
2. Average release rate for period	µCi/sec	1.67E+00	5.44E-01	
3. Percent of Tech. Spec. limit	%	*	*	

Notes for Table 1A:

* Percent of Technical Specification Limit Values in Section A.3 through D.3 are provided in the annual supplemental dose assessment report issued March 27, 1992.

1. NDA is no detectable activity.

2. LLD for gross alpha listed as NDA is 1E-11 µCi/ml.

TABLE 1B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
GASEOUS EFFLUENTS - ELEVATED RELEASE
January - June 1991

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 1st	Quarter 2nd	Quarter	Quarter
				No Batch Mode Releases During Period	
1. Fission gases					
Kr-85m	Ci	5.53E+01	5.11E+01		
Kr-87	Ci	4.67E+00	9.29E+00		
Kr-88	Ci	2.70E+01	2.79E+01		
Xe-133	Ci	1.77E+02	2.65E+02		
Xe-135	Ci	9.47E+00	9.29E+00		
Xe-135m	Ci	2.53E+01	2.79E+01		
Xe-138	Ci	3.36E+01	7.89E+01		
Total for period	Ci	3.32E+02	4.69E+02		
2. Iodines					
I-131	Ci	7.54E-03	8.01E-03		
I-133	Ci	1.37E-02	1.66E-02		
Total for period	Ci	2.12E-02	2.46E-02		
3. Particulates					
Sr-89	Ci	2.43E-05	4.89E-05		
Sr-90	Ci	6.07E-07	NDA		
Cs-134	Ci	NDA	NDA		
Cs-137	Ci	NDA	NDA		
Ba/La-140	Ci	1.01E-04	1.64E-04		
Total for period	Ci	1.26E-04	2.13E-04		
4. Tritium					
H-3	Ci	2.25E-01	9.19E-02		

Notes for Table 1B:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 1C
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
GASEOUS EFFLUENTS - GROUND LEVEL RELEASE
January - June 1991

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 1st	Quarter 2nd	Quarter	Quarter
				No Batch Mode Releases During Period	
1. Fission gases					
Kr-85m	Ci	NDA	NDA		
Kr-87	Ci	NDA	NDA		
Kr-88	Ci	NDA	NDA		
Xe-133	Ci	NDA	NDA		
Xe-135	Ci	5.93E+00	4.90E+00		
Xe-135m	Ci	NDA	NDA		
Xe-138	Ci	NDA	9.55E+00		
Total for period	Ci	5.93E+00	1.45E+01		
2. Iodines					
I-131	Ci	5.27E-03	5.23E-03		
I-133	Ci	1.36E-02	1.30E-02		
Total for period	Ci	1.89E-02	1.82E-02		
3. Particulates					
Co-60	Ci	NDA	1.07E-04		
Sr-89	Ci	4.83E-04	2.07E-04		
Sr-90	Ci	1.23E-05	NDA		
Cs-134	Ci	NDA	NDA		
Cs-137	Ci	NDA	1.84E-05		
Ba/La-140	Ci	2.45E-05	4.52E-04		
Total for period	Ci	5.20E-04	7.84E-04		
4. Tritium					
H-3	Ci	1.30E+01	4.20E+00		

Notes for Table 1C:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 2A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
LIQUID EFFLUENTS SUMMATION OF ALL RELEASES
January - June 1991

	Unit	Quarter 1st	Quarter 2nd	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	2.67E-03	3.05E-03	12%
2. Average diluted concentration during period	µCi/ml	1.69E-09	4.03E-09	
3. Percent of applicable limit	%	*	*	
B. Tritium				
1. Total release	Ci	7.66E-01	1.67E-02	9.4%
2. Average diluted concentration during period	µCi/ml	4.85E-07	2.21E-08	
3. Percent of applicable limit	%	*	*	
C. Dissolved and entrained gases				
1. Total release	Ci	4.91E-05	NDA	16%
2. Average diluted concentration during period	µCi/ml	3.11E-11	NDA	
3. Percent of applicable limit	%	*	*	
D. Gross alpha radioactivity				
1. Total release	Ci	NDA	NDA	
E. Volume of waste released (prior to dilution)	liters	2.49E+05	7.66E+04	5.7%
F. Volume of dilution water used during period	liters	1.58E+09	7.57E+08	10%

Notes for Table 2A:

* Percent of Technical Specification Limit Values in Section A.3 through C.3 are to be provided in the annual supplemental dose assessment report issued March 27, 1992.

1. NDA is no detectable activity.

2. LLD for gross alpha listed as NDA is 1E-7 µCi/ml.

TABLE 2B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
LIQUID EFFLUENTS
January - June 1991

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter	Quarter	Quarter	Quarter
		No Continuous Mode Releases during period		1st	2nd
1. Fission and Activation Products					
Na-24	Ci			5.56E-05	NDA
Cr-51	Ci			NDA	1.85E-04
Mn-54	Ci			1.09E-04	1.62E-04
Fe-55	Ci			2.12E-04	6.85E-04
Fe-59	Ci			NDA	1.77E-05
Co-58	Ci			1.85E-05	2.13E-05
Co-60	Ci			7.07E-04	1.42E-03
Zn-65	Ci			NDA	1.83E-05
Sr-89	Ci			1.05E-05	1.20E-05
Sr-90	Ci			7.07E-06	1.21E-05
Zr/Nb-95	Ci			NDA	4.00E-05
Ag-110m	Ci			NDA	1.78E-05
Ru-103	Ci			NDA	9.95E-06
I-131	Ci			1.55E-05	2.90E-06
Cs-134	Ci			1.92E-05	2.14E-07
Cs-137	Ci			1.52E-03	3.82E-04
Ba/La-140	Ci			4.39E-07	7.79E-06
Ce-141	Ci			NDA	1.44E-05
Ce/Pr-144	Ci			NDA	3.74E-05
Total for period	Ci			2.67E-3	3.05E-3
2. Dissolved and Entrained Noble Gases					
Xe-133	Ci			6.80E-07	NDA
Xe-135	Ci			4.84E-05	NDA
Total for period	Ci			4.91E-05	NDA

Notes for Table 2B:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Sr-89	5E-8 µCi/ml
I-131	1E-6 µCi/ml
Xe-133, 135	1E-5 µCi/ml
All Others	5E-7 µCi/ml

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information (1991)
July - December 1991

Facility Pilgrim Nuclear Power Station Licensee 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,c.	Iodines, particulates with half-lives >8 days, tritium:	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**

a.	Fission and activation gases:	10 CFR 20 Appendix B Table II
b.	Iodines:	10 CFR 20 Appendix B Table II
c.	Particulates, half-lives >8 days:	10 CFR 20 Appendix B Table II
d.	Liquid effluents:	2E-4 µCi/ml for entrained noble gases; 10 CFR 20 Appendix B Table II values for all other radionuclides.

3. **Average Energy** Not applicable

4. **Methods used to determine radionuclide composition in effluents**

a.	Fission and activation gases:	High-purity Ge gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquids only), Sr-89, and Sr-90.
b.	Iodines:	
c.	Particulates:	
d.	Liquid effluents:	

5. **Batch Releases**

a. Liquid

		Quarter 3rd	Quarter 4th
1.	Number of batch releases:	58	14
2.	Total time period for batch releases (minutes):	3.94E+3	6.65E+2
3.	Maximum time period for a batch release (minutes):	1.65E+2	9.00E+1
4.	Average time period for batch releases (minutes):	6.78E+1	6.18E+1
5.	Minimum time period for a batch release (minutes):	2.50E+1	3.00E+1
6.	Average stream flow during periods of release of effluent into a flowing stream (liter/min):	7.33E+8	1.08E+9

b. Gaseous: Not applicable

6. **Abnormal Releases**

a. Liquid: None
b. Gaseous: None

TABLE 1A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
GASEOUS EFFLUENTS SUMMATION OF ALL RELEASES
July - December 1991

	Unit	Quarter 3rd	Quarter 4th	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	1.17E+03	2.32E+02	22%
2. Average release rate for period	µCi/sec	1.48E+02	2.94E+01	
3. Percent of Tech. Spec. limit	%	*	*	
B. Iodines				
1. Total iodine-131	Ci	3.47E-03	8.97E-03	20%
2. Average release rate for period	µCi/sec	4.40E-04	1.14E-03	
3. Percent of Tech. Spec. limit	%	*	*	
C. Particulates				
1. Particul. with half-lives>8 days	Ci	2.89E-03	4.10E-03	21%
2. Average release rate for period	µCi/sec	3.67E-04	5.20E-04	
3. Percent of Tech. Spec. limit	%	*	*	
4. Gross alpha radioactivity	Ci	NDA	NDA	
D. Tritium				
1. Total release	Ci	2.01E+00	2.27E+00	20%
2. Average release rate for period	µCi/sec	2.55E-01	2.88E-01	
3. Percent of Tech. Spec. limit	%	*	*	

Notes for Table 1A:

* Percent of Technical Specification Limit Values in Section A.3 through D.3 are provided in the annual supplemental dose assessment report issued March 27, 1992.

1. NDA is no detectable activity.

2. LLD for gross alpha listed as NDA is 1E-11 µCi/ml.

TABLE 1B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
GASEOUS EFFLUENTS - ELEVATED RELEASE
July - December 1991

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 3rd	Quarter 4th	Quarter	Quarter
				No Batch Mode Releases During Period	
1. Fission gases					
Kr-85m	Ci	6.71E+01	1.59E+01	N/A	N/A
Kr-87	Ci	1.66E+02	5.83E+00	N/A	N/A
Kr-88	Ci	1.75E+02	9.05E+00	N/A	N/A
Xe-133	Ci	2.79E+01	2.60E+01	N/A	N/A
Xe-135	Ci	2.21E+02	6.99E+00	N/A	N/A
Xe-135m	Ci	9.69E+01	2.78E+01	N/A	N/A
Xe-138	Ci	4.04E+02	1.05E+02	N/A	N/A
Total for period	Ci	1.16E+03	1.97E+02	N/A	N/A
2. Iodines					
I-131	Ci	3.02E-03	7.31E-03	N/A	N/A
I-133	Ci	1.79E-02	4.19E-02	N/A	N/A
Total for period	Ci	2.09E-02	4.92E-02	N/A	N/A
3. Particulates					
Mn-54	Ci	NDA	3.15E-06	N/A	N/A
Co-58	Ci	NDA	1.12E-06	N/A	N/A
Co-60	Ci	NDA	6.21E-06	N/A	N/A
Sr-89	Ci	5.13E-04	4.56E-04	N/A	N/A
Sr-90	Ci	2.76E-06	3.27E-06	N/A	N/A
Cs-134	Ci	NDA	NDA	N/A	N/A
Cs-137	Ci	NDA	NDA	N/A	N/A
Ba/La-140	Ci	9.45E-04	1.05E-03	N/A	N/A
Ce-141		NDA	1.00E-06	N/A	N/A
Total for period	Ci	1.46E-03	1.52E-03	N/A	N/A
4. Tritium					
H-3	Ci	2.00E-01	1.12E-01	N/A	N/A

Notes for Table 1B:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 1C
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
GASEOUS EFFLUENTS - GROUND LEVEL RELEASE
July - December 1991

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 3rd	Quarter 4th	Quarter	Quarter
				No Batch Mode Releases During Period	
1. Fission gases					
Kr-85m	Ci	NDA	NDA	N/A	N/A
Kr-87	Ci	NDA	NDA	N/A	N/A
Kr-88	Ci	NDA	NDA	N/A	N/A
Xe-133	Ci	2.55E-01	1.82E+00	N/A	N/A
Xe-135	Ci	1.05E+01	2.80E+01	N/A	N/A
Xe-135m	Ci	NDA	5.14E+00	N/A	N/A
Xe-138	Ci	NDA	NDA	N/A	N/A
Total for period	Ci	1.08E+01	3.50E+01	N/A	N/A
2. Iodines					
I-131	Ci	4.54E-04	1.66E-03	N/A	N/A
I-133	Ci	3.63E-03	1.52E-02	N/A	N/A
Total for period	Ci	4.08E-03	1.68E-02	N/A	N/A
3. Particulates					
Co-60	Ci	2.14E-05	NDA	N/A	N/A
Sr-89	Ci	1.05E-03	5.73E-04	N/A	N/A
Sr-90	Ci	2.80E-06	2.97E-06	N/A	N/A
Cs-134	Ci	NDA	NDA	N/A	N/A
Cs-137	Ci	NDA	NDA	N/A	N/A
Ba/La-140	Ci	3.56E-04	2.01E-03	N/A	N/A
Total for period	Ci	1.43E-03	2.58E-03	N/A	N/A
4. Tritium					
H-3	Ci	1.81E+00	2.16E+00	N/A	N/A

Notes for Table 1C:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 2A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1991)
LIQUID EFFLUENTS SUMMATION OF ALL RELEASES
Ju'. - December 1991

	Unit	Quarter 3rd	Quarter 4th	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	2.72E-02	1.09E-03	12%
2. Average diluted concentration during period	µCi/ml	9.93E-09	1.16E-09	
3. Percent of applicable limit	%	*	*	
B. Tritium				
1. Total release	Ci	8.71E+00	6.86E-01	9.4%
2. Average diluted concentration during period	µCi/ml	3.18E-06	7.32E-07	
3. Percent of applicable limit	%	*	*	
C. Dissolved and entrained gases				
1. Total release	Ci	1.07E-03	4.94E-03	16%
2. Average diluted concentration during period	µCi/ml	3.89E-10	5.27E-09	
3. Percent of applicable limit	%	*	*	
D. Gross alpha radioactivity				
1. Total release	Ci	NDA	NDA	34%
E. Volume of waste released (prior to dilution)	liters	2.16E+06	2.23E+05	5.7%
F. Volume of dilution water used during period	liters	2.74E+09	9.37E+08	10%

Notes for Table 2A:

* Percent of Technical Specification Limit Values in Section A.3 through C.3 are provided in the annual supplemental dose assessment report issued March 27, 1992.

1. NDA is no detectable activity.

2. LLD for gross alpha listed as NDA is 1E-7 µCi/ml.

TABLE 2B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
LIQUID EFFLUENTS
July - December 1991

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter	Quarter	Quarter	Quarter
		No Continuous Mode Releases During Period		3rd	4th
1. Fission and Activation Products					
Cr-51	Ci	N/A	N/A	6.24E-04	2.42E-04
Mn-54	Ci	N/A	N/A	1.17E-03	2.22E-05
Fe-55	Ci	N/A	N/A	5.74E-04	5.32E-05
Fe-59	Ci	N/A	N/A	4.77E-05	NDA
Co-58	Ci	N/A	N/A	4.51E-04	NDA
Co-60	Ci	N/A	N/A	7.53E-03	1.89E-04
Zn-65	Ci	N/A	N/A	NDA	NDA
Sr-89	Ci	N/A	N/A	NDA	NDA
Sr-90	Ci	N/A	N/A	5.32E-05	4.18E-06
Y-92	Ci	N/A	N/A	NDA	2.49E-04
Zr/Nb-95	Ci	N/A	N/A	1.04E-04	NDA
Mo-99/Tc-99m	Ci	N/A	N/A	1.94E-04	7.66E-05
Ru-103	Ci	N/A	N/A	3.81E-05	NDA
I-131	Ci	N/A	N/A	4.08E-07	NDA
Cs-134	Ci	N/A	N/A	7.53E-04	NDA
Cs-137	Ci	N/A	N/A	1.50E-02	9.94E-05
Ba/La-140	Ci	N/A	N/A	1.07E-04	1.12E-04
Ce-141	Ci	N/A	N/A	5.79E-05	NDA
Ce/Pr-144	Ci	N/A	N/A	2.17E-04	NDA
Np-239	Ci	N/A	N/A	2.47E-04	4.24E-05
Total for period	Ci	N/A	N/A	2.72E-02	1.09E-03
2. Dissolved and Entrained Noble Gases					
Xe-133	Ci	N/A	N/A	2.60E-04	8.46E-04
Xe-135	Ci	N/A	N/A	8.07E-04	4.09E-03
Total for period	Ci	N/A	N/A	1.07E-03	4.94E-03

Notes for Table 2B:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Sr-89	5E-8 µCi/ml
I-131	1E-6 µCi/ml
Xe-133, 135	1E-5 µCi/ml
All Others	5E-7 µCi/ml

APPENDIX C

LAND USE CENSUS RESULTS

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LAND USE CENSUS RESULTS

The annual land use census for gardens and milk and meat animals in the vicinity of Pilgrim Station was performed between September 11 and October 11, 1991. The census was conducted by driving along each improved road/street in the Plymouth area within three miles of Pilgrim Station to survey for visible gardens with an area of greater than 500 square feet. In compass sectors where no gardens were identified within three miles (SSW and NNW sectors), the survey was extended to five miles. In addition, the Town of Plymouth Animal Inspector was contacted for information regarding milk and meat animals.

A total of 45 gardens were identified in the vicinity of Pilgrim Station. A majority of these gardens had been identified during previous land use censuses.

Atmospheric deposition (D/Q values) at the locations of the identified gardens were compared to those for the existing sampling program locations. These comparisons enabled Boston Edison Company personnel to ascertain the best locations for monitoring for releases of airborne radionuclides. Gardens yielding higher D/Q values than those currently in the sampling program were also sampled as part of the radiological environmental monitoring program.

Based on analysis of the gardens identified during the 1991 land use census, garden-grown vegetables or naturally-growing vegetation were collected at or near gardens at the following locations:

Hall residence - Rocky Hill Road	0.5 mi. SE
Gadbois residence - Brook Road	1.7 mi. SSE
Minahan residence - Beaverdam Road	2.1 mi. S
Cotti residence - Bay Colony Drive	1.9 mi. WSW
Hanlon residence - Clay Hill Road	1.0 mi. W

Permission was obtained from owners of most of these gardens to add these locations to the sampling program. In addition to these special locations, samples were also collected at or near the Plymouth County Farm (3.5 mi. W), Whipple Farm (1.8 mi. SW), Moon residence (2.1 mi. WSW) and from the control location at Bridgewater Farm (20 mi. W).

No new milk or meat animals were identified during the land use census. In addition, the Town of Plymouth Animal Inspector stated that their office is not aware of any animals at locations other than the Plimoth Plantation and the Plymouth County Farm. Samples of milk and forage have historically been collected from the Plymouth County Farm and were part of the 1991 sampling program.

APPENDIX D

ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES

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ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES

There were a number of instances during 1991 where problems were encountered in the collection of environmental samples or monitoring devices. Most of these problems were minor in nature and did not have an adverse affect on the results or the integrity of the monitoring program.

During 1991, eleven thermoluminescent dosimeters (TLDs) were found missing during the quarterly retrieval process. During the first quarter, TLDs were missed at the Dirt Road (DR) and Deep Water Pond (DW) locations off-site, and from the on-site location near the contractor gate (P12). During the second quarter, TLDs were not collected from Station C (C) and Sherman Airport (SA). TLD losses during the first and second quarters were attributed to vandalism and to replacement of utility poles on which the TLDs were mounted. Storm damage from Hurricane Bob in late August 1991 caused the loss of TLDs at the PNPS shorefront (P01), Taylor and Pearl (TP) and Russell Mills Road (RM) during the third quarter. Another storm in late October resulted in the loss of TLDs at East Breakwater (EB), Long Pond and Drew Road (LD) and Hyannis Road (HR). At those locations where losses were attributed to presumed vandalism, the TLDs were relocated in the immediate vicinity to be less conspicuous. Despite the loss of TLDs during the year, 417 out of 428 TLDs were retrieved and analyzed during 1991.

There were a few instances where problems occurred with obtaining samples of air particulate filters and charcoal cartridges. In early April, a power loss at the Manomet Substation (MS) location resulted in collection of a small volume of air. Due to this small volume, the required lower limit of detection (LLD) for gross beta on the particulate filter and for iodine-131 on the charcoal filter could not be met. The filters were still analyzed for screening purposes. Problems also occurred with failure of sample pumps at the Warehouse (WS) and Cleft Rock (CR) locations during the last week of July. The samples collected at these locations represented the first half of the weekly sampling period. Despite the lower sampling volume, the required LLDs were met on these samples.

Storm damage from Hurricane Bob in late August resulted in power losses at nearly all of the air sampling locations. However, power was restored to most of the locations within 24 hours. Due to extensive damage at the West Rocky Hill Road (WR) and Property Line (PL) locations, these sampling stations were out of commission and samples were not collected for an additional two weeks after the hurricane. Another storm on October 30, 1991 resulted in power loss and damage at the Warehouse (WS), Property Line (PL) and East Breakwater (EB) sampling stations. Due to low sample volumes at the WS and EB locations, the required LLDs could not be met on these samples collected during the weekly sampling period corresponding to the date of the storm. The samples were still analyzed for screening purposes. This storm also damaged electrical lines to the PL location and this station was not in service for an additional two weeks following the storm.

Despite the problems encountered with the collection of air samples, 1132 out of the required 1144 samples were collected and analyzed during 1991. None of the sample analyses performed indicated any questionable or anomalous results.

A few problems occurred with collection of composite water samples from the Discharge Canal during 1991. Pilgrim Station was shut down for maintenance and refueling from April 29 through August 17,1991. During this period, work was performed on circulating water pumps which provide the majority of flow through the Discharge Canal. Due to lack of circulating water flow during this maintenance, the low water levels in the Discharge Canal that occurred during low tides exceeded the pumping capacity of the composite sampler. Therefore, the composite sampler was performing intermittently during these periods of low flow. A booster pump was installed to provide water flow to a sampling well in the laboratory at the base of the Pedestrian Bridge, from which composite samples were drawn. This sampling setup was used for the remainder of the refueling outage during which low water levels in the Discharge Canal were expected.

Samples of Group I (bottom-oriented) and Group II (near-bottom distribution) fishes were not collected in the vicinity of the Discharge Canal outfall during the second quarter of 1991. Concerted and repeated efforts by personnel from the Massachusetts Division of Marine Fisheries failed to catch any of the required species during this period. Species from these two categories tend to move to deeper waters during cold months and were not available in the area for collection.

In general, the environmental monitoring program discrepancies noted during 1991 resulted from circumstances beyond the control of Boston Edison and contractor personnel responsible for collection of the samples. None of the discrepancies resulted in an adverse affect on the monitoring program.

APPENDIX E

QUALITY ASSURANCE PROGRAM RESULTS

APPENDIX E

QUALITY ASSURANCE PROGRAM RESULTS

A. 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 1991," and the YAEL "Semi-Annual Quality Assurance Status Report: July - December 1991."

B. Laboratory Analyses

The quality control programs that were performed during 1991 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 1991 for YAEL intralaboratory analyses and EPA interlaboratory cross-check analyses. For accuracy, 64 and 86 percent of the results were within 5 and 10 percent of the known values, respectively, with 98 percent of all results falling within the laboratory criterion of 15 percent. For precision, 86 and 96 percent of the results were within 5 and 10 percent of the mean, respectively, with 99.5 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 1991. A total of 177 analyses were performed on air particulate filters, milk, and water. Based upon this sample analysis total, 171 analyses (i.e., 96.6 percent) met the EPA's definition of "control limit" acceptance criteria for accuracy.

TABLE 1

INTRALABORATORY AND EPA INTERLABORATORY RESULTS - 1991

Category	Total Number of Measurements	Fraction of Measurements within deviation range 0-5%	0-10%	0-15%*
	YAEL INTRALABORATORY ANALYSES			
Accuracy	612	69.3%	90.5%	98.9%
Precision	649	91.1%	97.5%	99.5%
	EPA INTERLABORATORY ANALYSES			
Accuracy	177	45.2%	70.1%	93.2%
Precision	177	67.2%	89.8%	99.4%
	TOTAL COMBINED ANALYSES			
Accuracy	789	63.9%	85.9%	97.6%
Precision	826	86.0%	95.9%	99.5%

* This category also contains those [illegible] 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 58 paired samples were submitted by the five sponsor companies for analysis during 1991. 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 has been 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 criteria, then a two standard deviation range (95 percent confidence level) is established for each of the analyses. If the confidence intervals for the two analyses overlap, agreement is obtained.

From the 58 paired samples, 1470 paired duplicate measurements were analyzed during 1991. Out of these measurements, 1466 (99.7%) fell within the established criteria discussed above. No trend was evident with respect to repeated failings of measurements for the listed radionuclides and media.

C. Environmental TLD Measurements

Two separate quality control programs were performed during 1991 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 1991.

1. 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 1991 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 1991, there were 96 quality control tests. All 48 environmental TLDs tested during January - June 1991 were within the control limits for both accuracy and precision. The comparisons yielded a mean accuracy of -0.4 percent, with an associated standard deviation of ± 4.3 percent. The comparisons exhibited a precision value with an overall standard deviation of 1.8 percent. The 48 TLDs tested in July - December 1991 showed a mean accuracy of +4.1 percent with an associated standard deviation of ± 5.6 percent. TLDs measured during the second semiannual period exhibited a precision value with a standard deviation of 1.3 percent, well within the acceptance criteria. In total, all 96 environmental TLDs tested during 1991 were within the control limits for accuracy (± 20.0%) and precision (± 12.8%).

2. Boston Edison's TLD QA Program

Boston Edison Company personnel evaluate the accuracy of the environmental TLDs on a quarterly basis. The following acceptance criteria have been established: 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 1991, the average difference was -0.26%.

There were two instances during 1991 when the second TLD acceptance criterion (all individual results within ± 15%) were not met. During the second quarter, one TLD showed a deviation of -16% from the known exposure value. A followup investigation found that an error had been made in the irradiation of the TLDs, and that actual results were within the acceptance criterion. During the fourth quarter, one TLD showed a deviation of +33% from the know exposure. This deviation appeared to be due to a faulty TLD. All other TLDs checked during this quarter were within 10% of the known exposure. Overall, the results of Boston Edison's TLD QA Program demonstrate acceptable performance.

D. 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 more than 97% of all cases.

The environmental TLD measurements for intralaboratory and independent third party comparisons resulted in both mean accuracy and precision within 5 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 1991 exhibited acceptable accuracy and precision.