Entergy

Entergy Nuclear Generation Company
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

J. F. Alexander
Director
Nuclear Assessment

Technical Specification 5.6.2

May 15, 2001
ENGC Ltr. 2.01.058

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

License No. DPR-35
Docket No. 50-293

In accordance with Pilgrim Nuclear Power Station Technical Specification 5.6.2, Entergy Nuclear Generation Company submits the annual "Radiological Environmental Monitoring Program Report" for 2000 (Report #33).

Sincerely,

J.F. Alexander

PMK/
Attachment

cc: Mr. Hubert Miller
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Mr. Steven Bloom, Project Manager
Project Directorate I-3
Office of Nuclear Reactor Regulation
Mail Stop: 0-7A-3
U. S. Nuclear Regulatory Commission
1 White Flint North
11555 Rockville Pike
Rockville, MD 20852

Senior Resident Inspector

IE25

PILGRIM NUCLEAR POWER STATION

Radiological Environmental Monitoring Program Report

January 1 through December 31, 2000

Entergy

PILGRIM NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM REPORT
JANUARY 01 THROUGH DECEMBER 31, 2000

Prepared by: ____________________
K. J. Sejkora
Coordinator: HP/Chemistry Support

Reviewed by: ____________________
P.J. McNulty
Chemistry Superintendent

Approved by: ____________________
J.C. Wend
Radiation Protection Manager

Pilgrim Nuclear Power Station
Radiological Environmental Monitoring Program Report
January-December 2000

TABLE OF CONTENTS

SECTION	SECTION TITLE	PAGE
--	EXECUTIVE SUMMARY	5
1.0	INTRODUCTION	7
1.1	Radiation and Radioactivity	7
1.2	Sources of Radiation	8
1.3	Nuclear Reactor Operations	9
1.4	Radioactive Effluent Control	14
1.5	Radiological Impact on Humans	17
2.0	RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM	22
2.1	Pre-Operational Monitoring Results	22
2.2	Environmental Monitoring Locations	23
2.3	Interpretation of Radioactivity Analyses Results	24
2.4	Ambient Radiation Measurements	26
2.5	Air Particulate Filter Radioactivity Analyses	28
2.6	Charcoal Cartridge Radioactivity Analyses	28
2.7	Milk Radioactivity Analyses	29
2.8	Forage Radioactivity Analyses	29
2.9	Vegetable/Vegetation Radioactivity Analyses	30
2.10	Cranberry Radioactivity Analyses	30
2.11	Soil Radioactivity Analyses	31
2.12	Surface Water Radioactivity Analyses	31
2.13	Irish Moss Radioactivity Analyses	31
2.14	Shellfish Radioactivity Analyses	32
2.15	Lobster Radioactivity Analyses	32
2.16	Fish Radioactivity Analyses	33
2.17	Sediment Radioactivity Analyses	33
3.0	SUMMARY OF RADIOLOGICAL IMPACT ON HUMANS	72
4.0	REFERENCES	74
APPENDIX A	Special Studies	75
APPENDIX B	Effluent Release Information	76
APPENDIX C	Land Use Census	89
APPENDIX D	Environmental Monitoring Program Discrepancies	90
APPENDIX E	Quality Assurance Program Results	93

LIST OF TABLES

TABLE	TABLE TITLE	PAGE
1.2-1	Radiation Sources and Corresponding Doses	8
1.3-1	PNPS Operating Capacity Factor During 2000	9
2.2-1	Routine Radiological Environmental Sampling Locations	34
2.4-1	Offsite Environmental TLD Results	36
2.4-2	Onsite Environmental TLD Results	38
2.4-3	Average TLD Exposures By Distance Zone During 2000	39
2.4-4	Beach Survey Exposure Rate Measurements	40
2.5-1	Air Particulate Filter Radioactivity Analyses	41
2.6-1	Charcoal Cartridge Radioactivity Analyses	42
2.7-1	Milk Radioactivity Analyses	43
2.8-1	Forage Radioactivity Analyses	44
2.9-1	Vegetable/Vegetation Radioactivity Analyses	45
2.10-1	Cranberry Radioactivity Analyses	46
2.11-1	Soil Radioactivity Analyses	47
2.12-1	Surface Water Radioactivity Analyses	48
2.13-1	Irish Moss Radioactivity Analyses	49
2.14-1	Shellfish Radioactivity Analyses	50
2.15-1	Lobster Radioactivity Analyses	51
2.16-1	Fish Radioactivity Analyses	52
2.17-1	Sediment Radioactivity Analyses	53
2.17-2	Sediment Plutonium Analyses	54
3.0-1	Radiation Doses From 2000 Pilgrim Station Operations	73
B.1	Supplemental Information	77
B.2-A	Gaseous Effluents Summation of All Releases	79
B.2-B	Gaseous Effluents - Elevated Releases	81
B.2-C	Gaseous Effluents - Ground Level Releases	83
B.3-A	Liquid Effluents Summation of All Releases	85
B.3-B	Liquid Effluents: January-June 2000	87
E.1	Intralaboratory And Interlaboratory Results - 2000	94

LIST OF FIGURES

FIGURE	FIGURE TITLE	PAGE
1.3-1	Radioactive Fission Product Formation	11
1.3-2	Radioactive Activation Product Formation	12
1.3-3	Barriers to Confine Radioactive Materials	13
1.5-1	Radiation Exposure Pathways	19
2.2-1	Environmental TLD Locations Within the PNPS Protected Area	55
2.2-2	TLD and Air/Soil Sampling Locations: Within 1 Kilometer	57
2.2-3	TLD and Air/Soil Sampling Locations: 1 to 5 Kilometers	59
2.2-4	TLD and Air/Soil Sampling Locations: 5 to 25 Kilometers	61
2.2-5	Terrestrial and Aquatic Sampling Locations	63
2.2-6	Environmental Sampling and Measurement Control Locations	65
2.4-1	Historical Beach Survey Exposure Rate Measurements	67
2.5-1	Airborne Gross Beta Radioactivity Levels: Near Station	68
2.5-2	Airborne Gross Beta Radioactivity Levels: Property Line	69
2.5-3	Airborne Gross Beta Radioactivity Levels: Offsite	70
2.7-1	Levels of Strontium-90 in Milk Samples	71

EXECUTIVE SUMMARY

ENTERGY NUCLEAR
PILGRIM NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM REPORT
JANUARY 01 THROUGH DECEMBER 31, 2000

INTRODUCTION

This report summarizes the results of the Entergy Nuclear Radiological Environmental Monitoring Program (REMP) conducted in the vicinity of Pilgrim Nuclear Power Station (PNPS) during the period from January 1 to December 31, 2000. This document has been prepared in accordance with the requirements of PNPS Technical Specifications section 5.6.2.

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.

In July 1999, ownership and control of Pilgrim Station was transferred from Boston Edison Company to Entergy Nuclear Generation Company. Although the operating license of the plant was transferred with the ownership, no changes were made in the operation of the plant which would affect the environmental monitoring program or releases of radioactivity to the environment, as summarized in this report.

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 2000, there were 1,434 samples collected from the atmospheric, aquatic and terrestrial environments. In addition, 437 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs) and six exposure rate measurements were performed using a high pressure ion chamber. All of the various samples and TLDs were collected by Boston Edison Company and Massachusetts Division of Marine Fisheries personnel.

A small number of inadvertent issues were encountered during 2000 in the collection of environmental samples in accordance with the PNPS Offsite Dose Calculation Manual (ODCM). Three out of 440 TLDs were unaccounted for during the quarterly retrieval process. However, the 437 TLDs which were collected provided the information necessary to assess ambient radiation levels in the vicinity of Pilgrim Station. Equipment failures and power outages resulted in a small number of instances in which lower than normal volumes were collected at the airborne sampling stations. However, 579 of 583 air particulate and charcoal cartridges were collected and analyzed as required. A full description of any discrepancies encountered with the environmental monitoring program is presented in Appendix D of this report.

There were 1,623 analyses performed on the environmental media samples. Analyses were performed by the Duke Engineering and Services Environmental Laboratory in Westborough, Massachusetts. Samples were analyzed as required by the PNPS ODCM.

LAND USE CENSUS

The annual land use census in the vicinity of Pilgrim Station was conducted as required by the PNPS ODCM between October 19 and 23, 2000. A total of 31 vegetable gardens having an area of more than 500 square feet were identified within five kilometers (three miles) of PNPS. No new milk or meat animals were located during the census. Of the 31 garden locations identified, samples were collected at or near five of the gardens as part of the environmental monitoring program.

RADIOLOGICAL IMPACT TO THE ENVIRONMENT

During 2000, 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. None of the samples collected in 2000 showed any detectable activity potentially attributable to PNPS operations. Offsite ambient radiation measurements using environmental TLDs and a high pressure ion chamber ranged between 44 and 99 milliRoentgens per year. The range of ambient radiation levels observed with the TLDs is consistent with natural background radiation levels for Massachusetts as determined by the Environmental Protection Agency (EPA).

RADIOLOGICAL IMPACT TO THE GENERAL PUBLIC

During 2000, 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 sources of man-made (e.g., X-rays, medical, fallout) and naturally-occurring (e.g., cosmic, radon) radiation.

The calculated total body dose to the maximally-exposed member of the general public from radioactive effluents and ambient radiation resulting from PNPS operations for 2000 was about 3.2 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.

CONCLUSIONS

The 2000 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 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 2000 performed by Entergy Nuclear 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 (Reference 1). This report, which is required to be published annually by Pilgrim Station's Technical Specifications section 5.6.2, 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, 2000.

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 PNPS'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 (References 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	1
		Nuclear Power Plants	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). The majority of a person's annual dose results from exposure to radon and thoron in the air we breathe. 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 total, these various sources of naturally-occurring radiation and radioactivity contribute to a total dose of about 300 mrem per year.

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 mrem) and nuclear power plants (less than 1 mrem/yr). Typically, 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 eight kilometers (five miles) east-southeast of Plymouth Center. Commercial operation began in December, 1972.

Pilgrim Station was operational during 2000, as no refueling outages occurred during the year. The resulting monthly capacity factors are presented in Table 1.3-1.

TABLE 1.3-1

PNPS OPERATING CAPACITY FACTOR DURING 2000
(Based on 670 megawatts electric)

Month	Percent Capacity
January	100.0
February	88.5
March	100.0
April	100.0
May	94.6
June	98.1
July	98.9
August	73.2
September	91.1
October	81.3
November	97.8
December	100.0
Annual Average	93.7

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.

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.

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, as illustrated in Figure 1.3-1 (Reference 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 krypton-85 (Kr-85), strontium-90 (Sr-90), iodine-131 (I-131), xenon-133 (Xe-133), and cesium-137 (Cs-137).

Nuclear Fission

Fission is the splitting of the uranium-235 atom by a neutron to release heat and more neutrons, creating a chain reaction. Radiation and fission products are by-products of the process.

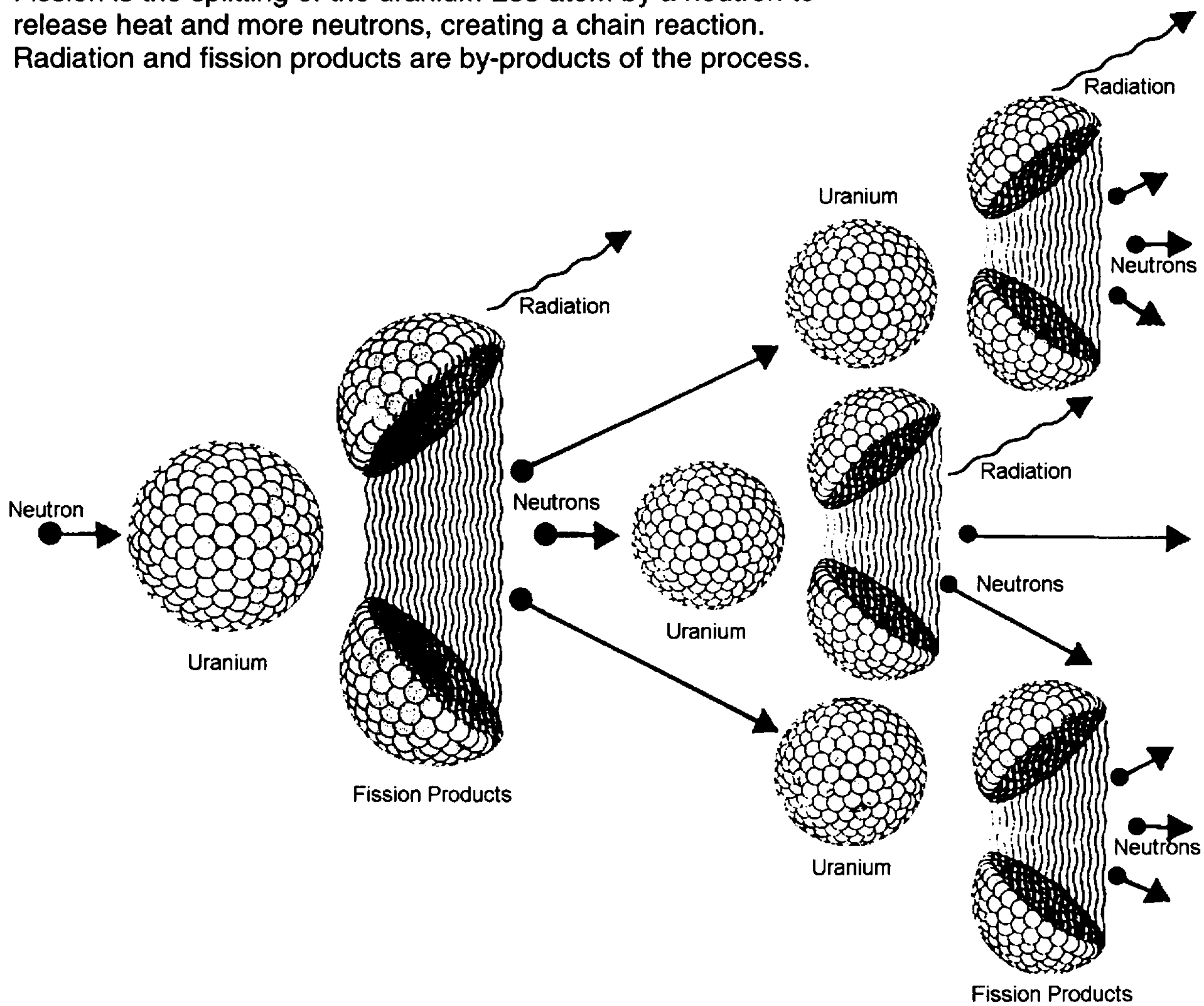


Figure 1.3-1
Radioactive Fission Product Formation

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 manganese-54 (Mn-54), iron-59 (Fe-59), cobalt-60 (Co-60), and zinc-65 (Zn-65).

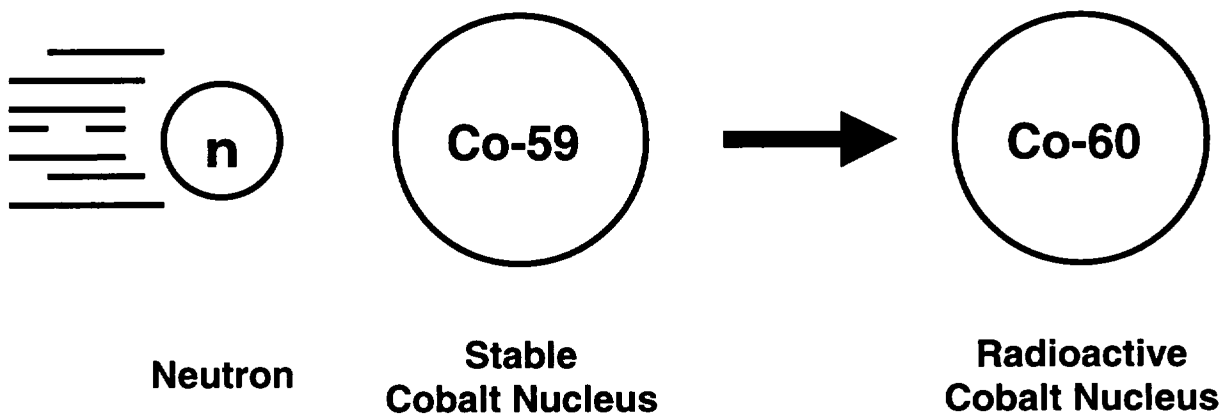


Figure 1.3-2
Radioactive Activation Product Formation

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 (Reference 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).

SIMPLIFIED DIAGRAM OF A BOILING WATER REACTOR

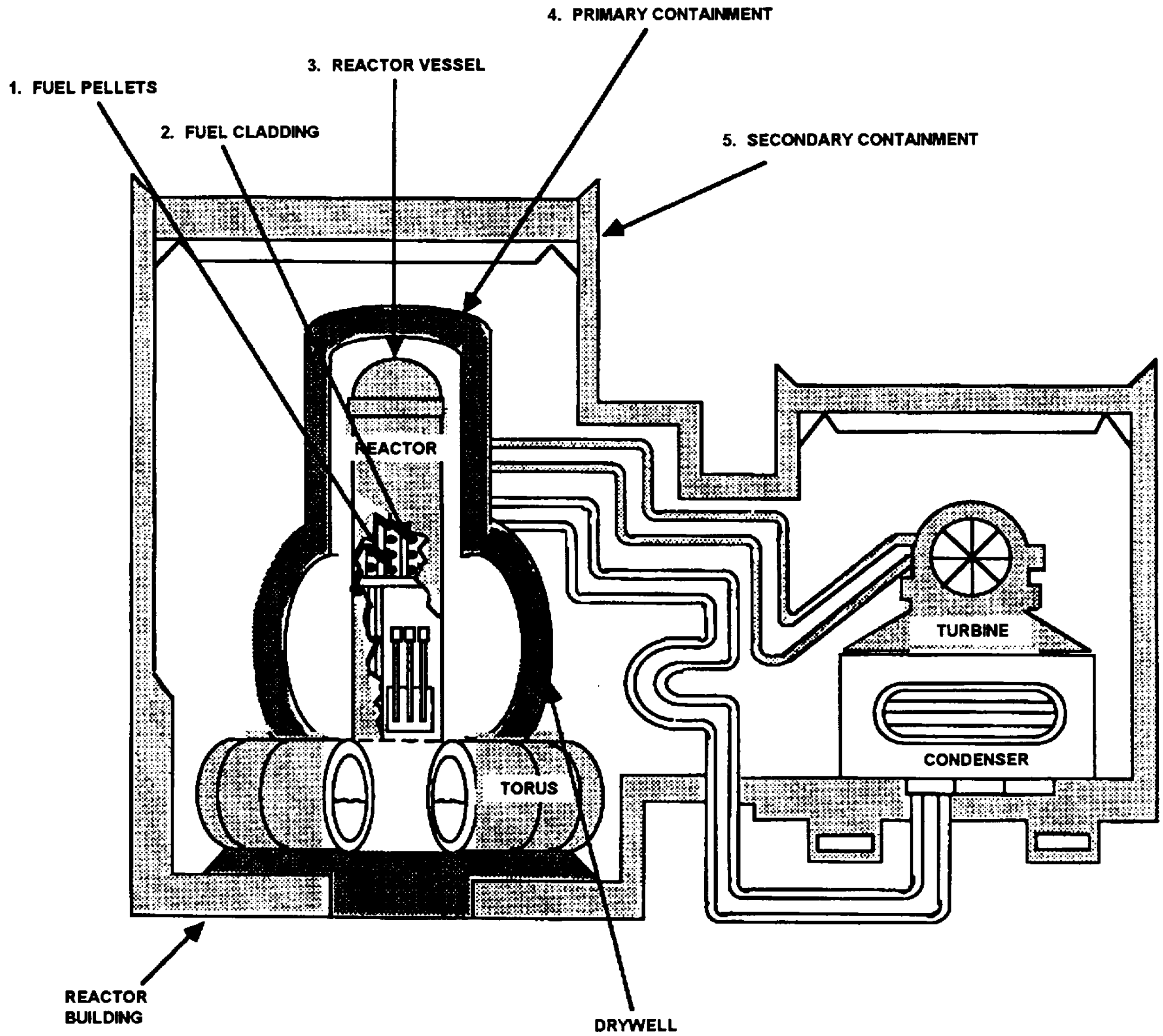


Figure 1.3-3
Barriers To Confine Radioactive Materials

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 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; and,
- 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 directed through ion exchange resins where radioactive elements, dissolved and suspended in the water, are removed through chemical processes. The net effect is a substantial 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 are 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 is 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 is provided with a shielded radioactivity monitor. 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.

Some liquid waste sources which have a low potential for containing radioactivity, and/or may contain very low levels of contamination, may be discharged directly to the discharge canal without passing through the liquid radwaste discharge header. One such source of liquids is the neutralizing sump. However, prior to discharging such liquid wastes, the tank is thoroughly mixed and a representative sample is collected for analysis of radioactivity content prior to being discharged.

Another means for adjusting liquid effluent concentrations to 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;
- steam jet air ejector (SJAE) monitor; and,
- 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, is equipped with a radiation detector. 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 tritium and radioactive gaseous and particulate effluents 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 adsorber 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 withdraws a portion of the air and passes it through a radioactivity monitoring system. This main stack effluent radioactivity monitoring system continuously samples radioactive particulates, iodines, and noble gases. Grab samples for a tritium analysis are also collected at this location. 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 two 30-minute holdup lines to reduce the radioactive gases with short half-lives, several charcoal adsorbers to remove radioactive iodines and further retard the short half-life gases, and offgas filters to remove radioactive particulates. The recombiner collects free hydrogen and oxygen gas and recombines them into water. This helps reduce the gaseous releases of short-lived isotopes of oxygen which have been made radioactive by neutron activation.

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 adsorber inlet valve will automatically re-direct the off-gas into the charcoal adsorbers 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 step in the effluent control process 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 continuous radiation monitoring and periodic sampling and analysis is to measure the quantities of radioactivity being released to determine compliance with the radioactivity release limits. 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 2000 were reported to the Nuclear Regulatory Commission annually. The 2000 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 ODCM effluent control limits.

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 affect on man. The movement of radioactivity through the environment and its transport to humans is portrayed in Figure 1.5-1.

There are three major ways in which liquid effluents affect 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.

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

1) external radiation from an airborne plume of radioactivity;
2) internal radiation from inhalation of airborne radioactivity;
3) external radiation from deposition of radioactive effluents on soil;
4) ambient (direct) radiation from contained sources at the power plant;
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.

In addition, ambient (direct) radiation emitted from contained sources of radioactivity at PNPS contribute to radiation exposure in the vicinity of the plant. Radioactive nitrogen-16 contained in the steam flowing through the turbine accounts for the majority of this "sky shine" radiation exposure immediately adjacent to the plant. Smaller amount of ambient radiation result from low-level radioactive waste stored at the site prior to shipping and disposal.

To the extent possible, the radiological dose impact on humans is based on direct measurements of radiation and radioactivity in the environment. When PNPS-related activity is detected in samples which represent a plausible exposure pathway, the resulting dose from such exposure is assessed (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 measurement and analysis techniques cannot usually detect these tiny amounts of radioactivity above that which is naturally present in the environment. Therefore, radiation doses are calculated using radioactive effluent release data and computerized dose calculations that are based on very conservative NRC-recommended models that tend to result in over-estimates of resulting dose. These computerized dose calculations are performed by or for Entergy Nuclear personnel. These computer codes use the guidelines and methodology set forth by the NRC in Regulatory Guide 1.109 (Reference 6). The dose calculations are documented and described in detail in the Pilgrim Nuclear Power Station's Offsite Dose Calculation Manual (Reference 7) which has been reviewed by the NRC.

EXAMPLES OF PILGRIM STATION'S RADIATION EXPOSURE PATHWAYS

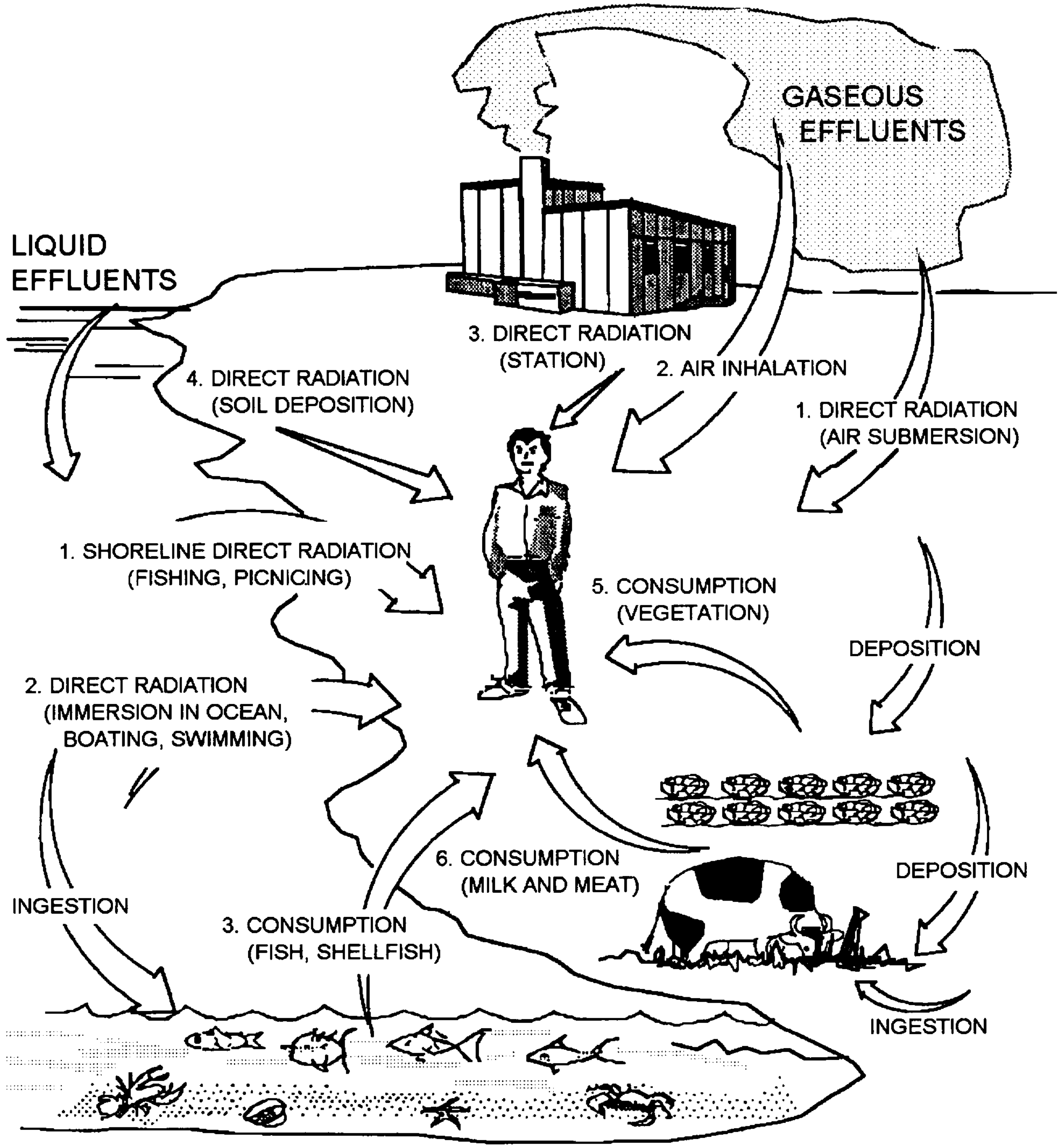


Figure 1.5-1
Radiation Exposure Pathways

Monthly dose calculations are performed by PNPS personnel. Semiannual dose calculations are performed for Entergy Nuclear by Duke Engineering and Services, 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 20.1301 (Reference 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 100 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 (Reference 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 (Reference 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 2000 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 2000 is 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 Pilgrim Nuclear Power Station was first initiated in August 1968, in the form of a pre-operational monitoring program prior to bringing the station on-line. The NRC's intent (Reference 11) with performing a pre-operational environmental monitoring program is to:

1) measure background levels and their variations in the environment in the area surrounding the licensee's station; and,

2) evaluate procedures, equipment, and techniques for monitoring radiation and radioactivity in the environment.

The pre-operational program (Reference 12) continued for approximately three and a half years, from August 1968 to June 1972. 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;
- Ambient 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 Company implemented a comprehensive operational environmental monitoring program at Pilgrim Nuclear Power Station. This program (Reference 13) provides information on radioactivity and radiation levels in the environment for the purpose of:

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 Pilgrim Station 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 (Reference 14) which specify an acceptable monitoring program. The PNPS 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 (Reference 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 (Reference 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 kilometers 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 2000 included air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation, and forage. The sampling medium, station description, station number, 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 through 2.2-6.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.2-1 through 2.2-4. The frequency of collection and types of radioactivity analysis are described in Pilgrim Station's ODCM, Sections 3/4.5.

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 Duke Engineering and Services Radiological Engineering Group and Environmental Laboratory personnel, respectively. The radioactivity analysis of samples and the processing of the environmental TLDs is performed by Duke Engineering and Services 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 ODCM.

Upon receipt of the analysis results from Duke Engineering and Services, the PNPS 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 2000 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 2000 Garden and Milk Animal Census are reported in Appendix C.

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

- Regular surveillances 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 and other cross-check programs;
- Use of blind duplicates for comparing separate analyses of the same sample; and,
- Spiked sample analyses by the analytical laboratory.

QA audits and inspections of the Radiological Environmental Monitoring Program are performed by the NRC, American Nuclear Insurers, and by the PNPS Quality Assurance Department.

The blind duplicates, split samples and spiked samples are analyzed by PNPS, Duke Engineering and Services Environmental Laboratory, and the other four sponsor companies. The 2000 results of this QA program are summarized in Appendix E. These results indicate that the analyses and measurements performed during 2000 exhibited acceptable precision and accuracy.

2.3 Interpretation of Radioactivity Analyses Results

The following pages summarize the analytical results of the environmental samples collected during 2000. 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 Duke Engineering and Services ERMAP computer program (Reference 17). The unit of measurement for each medium is listed at the top of each table. The left hand column contains the radionuclides 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 specified in the PNPS ODCM.

Those sampling stations 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. Ambient 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 Duke Engineering and Services ERMAP computer program calculates:

- The mean value of all concentrations, including negative values and values below LLD;
- The standard deviation of the measurements;
- The lowest and highest concentrations; and,
- The number of positive measurements (activity which is three times greater than the standard deviation), out of 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 detectable 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 detectable 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 Duke Engineering and Services Environmental Laboratory uses background-subtract corrections when analyzing samples for radioactivity content. This method involves analyzing a representative "clean" sample of the given material under similar conditions as a true sample, and storing the results of this analysis. When a true sample is analyzed, the results of the "clean" background sample are subtracted from the results to correct for any naturally-occurring radioactivity that may be present in the sample. If the true sample undergoing analysis has radioactivity count data which is lower than the "clean' background sample, the method can result in a arithmetically-negative value, yielding a concentration value less than zero.

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 41). Gross beta (GR-B) analyses were performed on 579 routine samples (11 stations/wk * 53 weeks, minus 4 missing results). None of the samples exceeded ten times the average concentration at the control location. The lower limit of detection (LLD) required by the ODCM is 0.01 pCi/m^3.

For samples collected from the ten indicator stations, 519 out of 527 samples indicated detectable activity at the three-sigma (standard deviation) level. The mean concentration of gross beta activity in these 527 indicator station samples was 0.016 ± 0.007 (1.6 ± 0.7 E-2) pCi/m^3. Individual values ranged from 0.0011 to 0.042 (1.1 – 42.0 E-3) pCi/m^3.

The monitoring station which yielded the highest mean concentration was station number 21 (East Weymouth Control), which yielded a mean concentration of 0.018 ± 0.007 pCi/m^3, based on 52 observations. Individual values ranged from 0.0041 to 0.0381 pCi/m^3. Fifty-two of the fifty-two samples showed detectable activity at the three-sigma level.

At the control location, 52 out of 52 samples yielded detectable gross beta activity, for an average concentration of 0.018 ± 0.007 pCi/m^3. Individual samples at the control location ranged from 0.0041 to 0.0381 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, plus one special analysis). No samples exceeded ten times the mean control station concentration. There is no LLD value listed for K-40 in the PNPS ODCM.

At the indicator stations, individual concentrations of K-40 ranged from -0.011 to 0.009 pCi/m^3, for a mean concentration of 0.0017 ± 0.0041 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.

The station which yielded the highest mean concentration of K-40 was station 17. Again, the mean value of 0.0047 ± 0.0041 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.

The previous paragraphs illustrates an important point about applying the three-sigma criterion to determine if radioactivity is detected. While such a screening criterion can be applied to a single measurement, it is inappropriate to apply it to a mean value calculated from multiple measurements. In the case of K-40 in air particulate filters, none of the 40 individual samples was "positive" at the 3-sigma, level. If the individual results are similar, even though they are "non-positive", the resulting standard deviation is artificially low, and does not reflect the total uncertainty associated with all of the measurements. This makes the 3-sigma criterion inappropriate for application to a mean and standard error calculation from several measurements.

2.4 Ambient Radiation Measurements

The primary technique for measuring ambient radiation exposure in the vicinity of Pilgrim Station involves posting environmental thermoluminescent dosimeters (TLDs) at given monitoring locations and retrieving the TLDs 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 measurements 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 110 locations are monitored using this technique. In addition, 27 of the 110 TLDs are located onsite, within the PNPS protected/restricted area.

Out of the 440 TLDs (110 locations * 4 quarters) posted during 2000, 437 were retrieved and processed. Those TLDs missing from their monitoring locations were lost to storm damage and/or vandalism, and their absence is discussed in Appendix D. The results for environmental TLDs located offsite, beyond the PNPS protected/restricted area fence, are presented in Table 2.4-1. Results from onsite TLDs posted within the restricted area presented in Table 2.4-2. In addition to TLD results for individual locations, results from offsite 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 measured at offsite locations ranged from 42 to 584 mR/yr. The average exposure rate at control locations greater than 15 km from Pilgrim Station (i.e., Zone 4) was 61.0 ± 7.9 mR/yr. When the 3-sigma confidence interval is calculated based on these control measurements, 99% of all measurements of background ambient exposure would be expected to be between 37 and 85 mR/yr.

Inspection of onsite TLD results listed in Table 2.4-2 indicates that all of those TLDs located within the PNPS protected/restricted area yield exposure measurements higher than the expected background. These increases are due to the close proximity of these locations to radiation sources onsite. The radionuclide nitrogen-16 (N-16) contained in steam flowing through the turbine accounts for most of the exposure onsite. Although this radioactivity is contained within the turbine and is not released to the atmosphere, the "sky shine" which occurs from the turbine increases the ambient radiation levels in areas near the turbine building.

Several of the TLDs located within or immediately adjacent to the PNPS protected area exhibited a significant (>20%) increase in exposure since 1999. Most of this increase is attributed to the fact that PNPS was shut down for several weeks for refueling during 1999, and the "sky shine" from station operation was diminished when compared to a year at normal power operations, such as 2000. If such a comparison is performed for year 2000 exposures compared to the last operational year (1998), one TLD exhibited an appreciable increase in exposure since 1998. The TLD at Station P14, on the fence near the Butler Building, showed an increase of 40% over the 1998 annual exposure. This increase in exposure occurred from the temporary storage of radioactive wastes onsite near that TLD. It must be emphasized that this location is within the protected/restricted area and is not accessible by members of the general public.

A small number of offsite TLD locations in close proximity to the protected/restricted area indicated ambient radiation exposure above expected background levels. All of these locations are on Pilgrim Station controlled property, and experience exposure increases due to turbine sky shine (e.g., locations OA, TC, P01, and WS) and/or transit and storage of radwaste onsite (e.g., location BLW). A hypothetical maximum exposed member of the public accessing these near-site areas on Pilgrim Station controlled property for limited periods of time would receive a maximum dose of about 2.4 mrem/yr above their average ambient background dose of 61 mrem/yr.

One TLD, located in the basement of the Plymouth Memorial Hall, indicated an annual exposure of 99 mR. The exposure at this location is due to the close proximity of stone building material, which contains higher levels of naturally-occurring radioactivity, as well a from buildup of radon in this area of the building.

It should be noted that several of the TLDs used to calculate the Zone 1 averages presented in Table 2.4-3 are located on Pilgrim Station property. If the Zone 1 value is corrected for the near-site TLDs (those less than 0.6 km from the Reactor Building), the Zone 1 mean falls from a value of 94.4 ± 84.6 mR/yr to 62.8 ± 6.5 mR/yr. Additionally, exposure rates measured at areas beyond Entergy's control did not indicate any increase in ambient exposure from Pilgrim Station operation. For example, the annual exposure rate near the nearest offsite resident (location HB, 0.6 km SE) was 63.3 ± 4.5 mR/yr, which compares quite well with the average control location exposure of 61.0 ± 7.9 mR/yr.

A second technique for measuring ambient 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 (Reference 18) 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 ambient radiation exposure around Pilgrim Station do not indicate any significant increase in exposure levels. Although some increases in ambient radiation exposure level were apparent on Entergy property very close to Pilgrim Station, there were no measurable increases at areas beyond Entergy'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 particulates. 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. PNPS uses this technique to monitor 10 locations in the Plymouth area, along with the control location in East Weymouth.

Out of 583 filters (11 locations * 53 weeks), 579 samples were collected and analyzed during 2000. There were a few instances where power was lost or pumps failed during the course of the sampling period at some of the air sampling stations, resulting in lower than normal sample volumes. These discrepancies are noted in Appendix D. One such series of events occurred during 2000, resulting in the required LLDs not being met on 1 of the 572 filters collected during 2000. This occurrence did not adversely affect the monitoring results.

The results of the analyses performed on these 579 filter samples are summarized in Table 2.5-1. Trend plots for the gross beta radioactivity levels at the near station, property line, and offsite airborne monitoring locations are shown in Figures 2.5-1, 2.5-2 and 2.5-3, respectively. Gross beta radioactivity was detected in 571 of the filter samples collected, including 52 of the 52 control location samples. This gross beta activity arises from naturally-occurring radionuclides such as radon decay daughter products. Naturally-occurring beryllium-7 was detected in all 44 of the quarterly composites analyzed, as well as in a single weekly sample which was analyzed with gamma spectroscopy. No airborne radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2000.

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 583 cartridges (11 locations * 53 weeks), 579 samples were collected and analyzed during 2000. There were a few instances where power was lost or pumps failed during the course of the sampling period at some of the air sampling stations, resulting in lower than normal sample volumes. These discrepancies are noted in Appendix D. Despite such events during 2000, required LLDs were met on all 579 filters collected during 2000.

The results of the analyses performed on these 579 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 five kilometers 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 2000.

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 11 of the 20 samples from Plymouth County Farm, and in 3 of the 20 samples collected from the control location in Whitman. Cesium-137 was not detected in any of the samples collected during the year. Concentrations of Sr-90 as a function of time are shown in Figure 2.7-1.

The highest concentration of Sr-90, 4.7 pCi/liter, was observed in a sample collected from the control location at Whitman Farm. The highest concentration of Sr-90 in samples collected from Plymouth County Farm was 2.2 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 2000, the expected concentration would be about 5 pCi/liter. The concentrations of 2 to 4 pCi/liter observed in 2000 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.

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 (2.9 km SW). Samples are collected annually and analyzed by gamma spectroscopy.

All samples of forage were collected and analyzed as required during 2000. Results of the gamma analyses of forage samples are summarized in Table 2.8-1. Naturally-occurring beryllium-7 and potassium-40 were detected in forage samples collected during 2000, and the sample collected at the control location at Whitman Farm indicated detectable cesium-137. Such Cs-137 concentrations (54 pCi/kg) are indicative of fallout from past nuclear weapons testing. 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 in Bridgewater. Due to a loss of state funding at the Bridgewater Correctional Facility, garden samples were not available from this source. An alternate sampling location (Hanson Farm) was identified in the general vicinity in Bridgewater, and was used as a source of control vegetable samples. 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 were also collected from four locations corresponding to the highest atmospheric deposition factors from the two PNPS release points. Samples of vegetables are collected annually and analyzed by gamma spectroscopy.

All samples of vegetables/vegetation were collected and analyzed as required during 2000. Results of the gamma analyses of these samples are summarized in Table 2.9-1. Naturally-occurring beryllium-7, potassium-40, and thorium-232 were identified in most of the samples collected. Cesium-137 was also detected in six of the samples collected.

The highest level of cesium-137 (268 pCi/kg) was detected in a sample of naturally-growing vegetation, a mixture of grass, herbaceous plants, and leaves from bushes and trees, which was collected 1.0 km (0.6 mi) southwest of the PNPS Reactor Building. As was the case for all samples of naturally-growing vegetation, these samples were collected and analyzed "as is", without processing the material to remove soil and dust on the surface of the plants. As documented in the previous REMP reports, Cs-137 was detected in nearly all of the soil surveys conducted in previous years, indicating that Cs-137 is widespread in soil throughout New England. In addition to Cs-137, the vegetation samples in question also contained detectable thorium-232 decay-chain nuclides, indicating appreciable levels of soil and dust were incorporated with the vegetation comprising the sample.

Cesium-137 is a product of nuclear weapons testing, and was routinely detected in the preoperational monitoring program at levels of 150 to 290 pCi/kg. When corrected for radioactive decay, the expected concentration in samples of naturally-growing vegetation collected during 2000 would be between 90 and 170 pCi/kg. The average Cs-137 concentration of 60 pCi/kg observed in the samples collected is indicative of radioactivity arising from weapons fallout, and not Pilgrim Station operations.

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 2000. 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, *in situ* (in-field) measurements were made 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. Samples of soil are also collected at these 11 locations and taken to the laboratory for more detailed gamma spectroscopy analysis.

The soil survey was performed as required in 2000. Results of the gamma analyses of these samples are summarized in Table 2.11-1. Naturally-occurring beryllium-7, potassium-40, and thorium-232 were identified in most of the samples collected. Cesium-137 was also detected in six of the samples collected.

The highest level of cesium-137 (991 pCi/kg) was detected in a sample of soil collected 1.0 km (0.6 mi) southwest of the PNPS Reactor Building. Cesium-137 is a product of nuclear weapons testing, and has been routinely detected in the monitoring program in the past. As documented in the previous REMP reports, Cs-137 was detected in nearly all of the soil surveys conducted in previous years, indicating that Cs-137 is widespread in soil throughout New England. The average Cs-137 concentration of 190 pCi/kg observed in the samples collected is indicative of radioactivity arising from weapons fallout, and not Pilgrim Station operations.

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 36 samples (3 locations * 12 sampling periods) of surface water were collected and analyzed as required during 2000. Results of the analyses of water samples are summarized in Table 2.12-1. Naturally-occurring potassium-40 was detected in samples composed primarily of seawater. No radioactivity attributable to Pilgrim Station operations was detected in any of the samples collected during 2000.

2.13 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 2000 were obtained and analyzed. Results of the gamma analyses of these samples are summarized in Table 2.13-1. Naturally-occurring beryllium-7 and potassium-40 were detected in a number of the samples. No radioactivity attributable to Pilgrim Station operations was detected in any of the samples collected during 2000.

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 2000 were obtained and analyzed, as well as an additional sample of mussel shell. 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. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.15 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 2000. Results of the gamma analyses of lobster samples are summarized in Table 2.15-1. 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.

2.16 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-five samples of fish were collected during 2000. Results of the gamma analyses of fish samples collected 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 as required during 2000. All of the required gamma analyses were performed on these samples. 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. No cobalt-60 was detected in any of the 39 indicator samples. Cesium-137 was detected in 8 of 39 indicator station samples and in 10 of 17 control station samples. Plutonium-238 was detected in 2 of 4 indicator samples, and both control samples. Plutonium-239/240 was also detected in two of four indicator station samples, and both of the control station samples.

Cesium-137 levels in indicator samples ranged from non-detectable to a maximum concentration of 31 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 30 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.

The concentration of plutonium isotopes the samples collected from the control locations beyond the influence of Pilgrim Station ranged from 16 to 707 pCi/kg. Plutonium in indicator samples ranged from non-detectable to 9.9 pCi/kg. The levels detected are comparable to concentrations observed in the past few years and are indicative of plutonium deposited in the environment from nuclear weapons testing.

Table 2.2-1

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

Description	No	Code	Distance	Direction
Air Particulate Filters, Charcoal Cartridges, Soil				
Medical Building	00	WS	0.2 km	SSE
East Rocky Hill Road	01	ER	0.9 km	SE
West Rocky Hill Road	03	WR	0.8 km	WNW
Property Line	06	PL	0.5 km	NNW
Pedestrian Bridge	07	PB	0.2 km	N
Overlook Area	08	OA	0.1 km	W
East Breakwater	09	EB	0.5 km	ESE
Cleft Rock	10	CR	1.3 km	SSW
Plymouth Center	15	PC	6.7 km	W
Manomet Substation	17	MS	3.6 km	SSE
East Weymouth Control	21	EW	40 km	NW
Milk				
Plymouth County Farm	11	CF	5.6 km	W
Whitman Farm Control	21	WF	34 km	WNW
Forage				
Plymouth County Farm	11	CF	5.6 km	W
Whitman Farm Control	12	WF	34 km	WNW
Whipple Farm	43	WH	2.9 km	SW
Vegetation				
Plymouth County Farm	11	CF	5.6 km	W
Bridgewater Farm Control	27	BF	31 km	W
Cranberries				
Manomet Point Bog	13	MR	3.9 km	SE
Bartlett Road Bog	14	BR	4.3 km	SSE
Pine Street Bog Control	23	PS	26 km	WNW

Table 2.2-1 (continued)

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

Description	No	Code	Distance	Direction
Surface Water				
Discharge Canal	11	DIS	0.2 km	N
Bartlett Pond	17	BP	2.7 km	SE
Powder Point Control	23	PP	13 km	NNW
Irish Moss				
Discharge Canal Outfall	11	DIS	0.7 km	NNE
Manomet Point	15	MP	4.0 km	ESE
Ellisville	22	EL	12 km	SSE
Brant Rock Control	34	BR	18 km	NNW
Shellfish				
Discharge Canal Outfall	11	DIS	0.7 km	NNE
Plymouth Harbor	12	Ply-H	4.1 km	W
Duxbury Bay Control	13	Dux-Bay	13 km	NNW
Manomet Point	15	MP	4.0 km	ESE
Green Harbor Control	24	GH	16 km	NNW
Lobster				
Discharge Canal Outfall	11	DIS	0.5 km	N
Plymouth Harbor	15	Ply-H	6.4 km	WNW
Duxbury Bay Control	13	Dux-Bay	11 km	NNW
Fishes				
Discharge Canal Outfall	11	DIS	0.5 km	N
Priest Cove Control	29	PC	48 km	SW
Jones River Control	30	JR	13 km	WNW
Vineyard Sound Control	92	MV	64 km	SSW
Buzzard's Bay Control	90	BB	40 km	SSW
Cape Cod Bay Control	98	CC-Bay	24 km	ESE
Sediment				
Discharge Canal Outfall	11	DIS	0.8 km	NE
Plymouth Harbor	12	Ply-H	4.1 km	W
Duxbury Bay Control	13	Dux-Bay	14 km	NNW
Plymouth Beach	14	PLB	4.0 km	WNW
Manomet Point	15	MP	3.3 km	ESE
Green Harbor Control	24	GH	16 km	NNW

Table 2.4-1

Offsite Environmental TLD Results

TLD Station	TLD Location*	Exposure Rate - mR/quarter (Value ± Std.Dev.)				2000 Annual** Exposure mR/year
ID Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Zone 1 TLDs: 0-3 km	0-3 km	22.6 ± 20.8	23.7 ± 23.0	23.6 ± 19.1	24.5 ± 22.3	94.4 ± 84.6
BLW BOAT LAUNCH WEST	0.11 km E	56.9 ± 6.0	55.1 ± 3.0	54.7 ± 2.9	61.9 ± 4.7	228.6 ± 15.8
OA OVERLOOK AREA	0.15 km W	143.1 ± 5.5	155.0 ± 7.1	132.9 ± 6.2	153.1 ± 5.8	584.1 ± 42.6
TC HEALTH CLUB	0.15 km WSW	44.9 ± 3.7	50.6 ± 2.0	47.1 ± 2.5	49.4 ± 2.0	192.1 ± 11.3
BLE BOAT LAUNCH EAST	0.16 km ESE	50.6 ± 4.0	53.0 ± 3.8	50.2 ± 2.3	53.8 ± 4.0	207.6 ± 10.1
PB PEDESTRIAN BRIDGE	0.21 km N	34.9 ± 1.8	36.0 ± 1.1	34.5 ± 1.0	36.0 ± 1.6	141.4 ± 4.2
P01 SHOREFRONT SECURITY	0.22 km NNW	33.0 ± 2.7	35.7 ± 1.8	33.1 ± 1.7	37.6 ± 1.5	139.5 ± 9.7
WS MEDICAL BUILDING	0.23 km SSE	31.8 ± 2.6	33.2 ± 1.8	34.9 ± 2.7	35.7 ± 3.4	135.5 ± 8.9
CT PARKING LOT	0.31 km SE	24.0 ± 1.7	23.9 ± 0.9	22.4 ± 1.5	23.1 ± 1.4	93.4 ± 4.2
PA SHOREFRONT PARKING	0.35 km NNW	19.5 ± 0.7	20.9 ± 0.8	21.1 ± 0.8	21.7 ± 1.1	83.2 ± 4.0
A STATION A	0.37 km WSW	18.6 ± 1.1	21.0 ± 1.1	20.4 ± 1.2	21.9 ± 1.3	81.9 ± 6.0
F STATION F	0.43 km NW	18.0 ± 0.9	19.2 ± 0.9	19.6 ± 1.1	20.2 ± 1.1	77.1 ± 4.2
B STATION B	0.44 km S	22.4 ± 1.1	23.6 ± 1.2	24.5 ± 1.1	24.0 ± 1.1	94.5 ± 4.3
EB EAST BREAKWATER	0.44 km ESE	19.8 ± 0.8	20.1 ± 0.8	21.6 ± 0.9	20.9 ± 1.2	82.4 ± 3.9
PMT PNPS MET TOWER	0.44 km WNW	16.9 ± 0.8	19.0 ± 0.9	18.3 ± 0.6	18.4 ± 1.4	72.7 ± 4.0
H STATION H	0.47 km SW	20.0 ± 0.9	20.4 ± 0.9	21.5 ± 1.2	22.3 ± 1.2	84.2 ± 4.6
I STATION I	0.48 km WNW	16.9 ± 0.8	18.6 ± 0.5	19.1 ± 0.9	19.4 ± 1.1	74.0 ± 4.9
L STATION L	0.50 km ESE	17.3 ± 1.4	17.3 ± 0.6	19.1 ± 0.8	18.5 ± 1.1	72.2 ± 4.2
G STATION G	0.53 km W	16.1 ± 0.8	16.6 ± 0.5	17.7 ± 0.7	17.8 ± 0.9	68.1 ± 3.7
D STATION D	0.54 km NNW	17.1 ± 0.8	18.3 ± 0.8	19.0 ± 0.8	19.1 ± 1.3	73.6 ± 4.1
PL PROPERTY LINE	0.54 km NW	16.5 ± 0.9	17.1 ± 0.7	18.3 ± 0.7	18.3 ± 0.9	70.2 ± 4.0
C STATION C	0.57 km ESE	15.4 ± 0.7	15.5 ± 0.7	17.8 ± 1.3	17.1 ± 1.2	65.9 ± 5.2
HB HALL'S BOG	0.63 km SE	15.1 ± 0.8	14.8 ± 0.6	16.6 ± 0.8	16.9 ± 0.9	63.3 ± 4.5
GH GREENWOOD HOUSE	0.65 km ESE	16.8 ± 1.4	16.9 ± 1.1	18.7 ± 0.8	18.1 ± 1.0	70.4 ± 4.3
WR W ROCKY HILL ROAD	0.83 km WNW	18.4 ± 0.7	19.5 ± 0.6	20.2 ± 1.0	20.5 ± 0.9	78.6 ± 4.0
ER E ROCKY HILL ROAD	0.89 km SE	13.6 ± 0.8	13.4 ± 0.5	15.1 ± 0.6	14.5 ± 0.8	56.6 ± 3.5
MT MICROWAVE TOWER	1.03 km SSW	16.5 ± 0.9	15.9 ± 0.6	18.0 ± 1.0	17.2 ± 0.8	67.7 ± 3.9
CR CLEFT ROCK	1.27 km SSW	14.7 ± 0.8	14.7 ± 0.8	16.1 ± 0.7	17.1 ± 2.3	62.6 ± 5.4
BD BAYSHORE/GATE RD	1.34 km WNW	15.9 ± 0.9	15.9 ± 0.5	17.0 ± 0.8	16.9 ± 0.9	65.7 ± 3.0
MR MANOMET ROAD	1.38 km S	14.1 ± 1.1	14.4 ± 0.8	15.4 ± 0.8	15.1 ± 0.8	59.0 ± 3.0
DR DIRT ROAD	1.48 km SW	13.4 ± 0.6	14.2 ± 0.5	14.7 ± 0.6	14.4 ± 0.9	56.8 ± 2.6
EM EMERSON ROAD	1.53 km SSE	14.8 ± 0.9	Missing	16.2 ± 0.7	15.8 ± 0.8	62.4 ± 3.5
EP EMERSON/PRISCILLA	1.55 km SE	15.2 ± 1.1	14.5 ± 0.6	17.2 ± 1.1	16.9 ± 1.1	63.9 ± 5.6
AR EDISON ACCESS ROAD	1.59 km SSE	13.8 ± 0.8	Missing	15.3 ± 0.8	14.8 ± 0.7	58.4 ± 3.5
BS BAYSHORE	1.76 km W	16.9 ± 0.9	17.4 ± 0.6	17.8 ± 1.5	17.7 ± 0.9	69.8 ± 2.7
E STATION E	1.86 km S	15.3 ± 0.6	16.1 ± 0.8	16.9 ± 0.6	17.1 ± 1.4	65.4 ± 3.9
JG JOHN GAULEY	1.99 km W	16.5 ± 1.5	15.8 ± 0.7	17.4 ± 1.2	17.9 ± 0.9	67.6 ± 4.5
J STATION J	2.04 km SSE	14.5 ± 0.7	15.0 ± 1.1	16.2 ± 0.4	15.7 ± 0.7	61.4 ± 3.4
RC PLYMOUTH YMCA	2.09 km WSW	14.5 ± 0.7	15.1 ± 0.8	15.8 ± 0.8	16.1 ± 1.0	61.6 ± 3.3
WH WHITEHORSE ROAD	2.09 km SSE	15.1 ± 0.7	14.9 ± 0.7	16.9 ± 1.1	16.2 ± 0.8	63.1 ± 4.2
K STATION K	2.17 km S	14.1 ± 0.6	14.3 ± 0.6	15.6 ± 0.7	15.6 ± 0.8	59.6 ± 3.5
TT TAYLOR/THOMAS	2.26 km SE	15.2 ± 0.9	14.2 ± 0.5	16.3 ± 1.2	16.6 ± 0.9	62.3 ± 4.7
YV YANKEE VILLAGE	2.28 km WSW	15.5 ± 0.7	14.9 ± 0.4	16.5 ± 1.0	17.0 ± 0.9	63.9 ± 4.0
GN GOODWIN PROPERTY	2.38 km SW	12.2 ± 1.1	11.2 ± 0.5	12.4 ± 0.5	12.3 ± 0.7	48.1 ± 2.6
RW RIGHT OF WAY	2.83 km S	14.8 ± 1.3	13.9 ± 0.5	15.9 ± 0.9	15.6 ± 1.3	60.2 ± 4.1
TP TAYLOR/PEARL	2.98 km SE	14.5 ± 0.9	13.3 ± 0.5	15.6 ± 1.0	15.4 ± 1.0	58.9 ± 4.5

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.

Table 2.4-1 (continued)

Offsite Environmental TLD Results

TLD Station	TLD Location*	Exposure Rate - mR/quarter (Value ± Std.Dev.)				2000 Annual** Exposure mR/year
ID Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Zone 2 TLDs: 3-8 km	3-8 km	14.1 ± 2.7	13.9 ± 2.7	15.4 ± 2.8	15.4 ± 2.8	58.8 ± 11.2
VR VALLEY ROAD	3.26 km SSW	13.4 ± 1.1	12.7 ± 0.5	14.1 ± 0.6	14.3 ± 0.7	54.5 ± 3.4
ME MANOMET ELEM	3.29 km SE	14.4 ± 0.6	14.2 ± 0.5	16.6 ± 0.7	16.4 ± 1.1	61.5 ± 5.3
WC WARREN/CLIFFORD	3.31 km W	14.2 ± 0.9	13.7 ± 0.7	14.6 ± 0.6	15.3 ± 0.8	57.8 ± 3.0
BB RT.3A/BARTLETT RD	3.33 km SSE	14.5 ± 1.2	14.0 ± 0.4	15.5 ± 0.6	15.8 ± 1.0	59.9 ± 3.8
MP MANOMET POINT	3.57 km SE	14.1 ± 0.6	13.7 ± 0.8	15.8 ± 0.9	15.8 ± 0.7	59.4 ± 4.6
MS MANOMET SUBSTATION	3.60 km SSE	16.8 ± 0.7	17.1 ± 0.8	18.9 ± 0.5	18.6 ± 0.8	71.3 ± 4.4
BW BEACHWOOD ROAD	3.93 km SE	14.2 ± 0.6	14.7 ± 0.8	16.6 ± 1.1	16.0 ± 0.8	61.4 ± 4.7
PT PINES ESTATE	4.44 km SSW	13.4 ± 0.7	13.7 ± 0.5	14.5 ± 1.0	13.8 ± 0.7	55.3 ± 2.4
EA EARL ROAD	4.60 km SSE	12.7 ± 0.7	13.3 ± 0.4	14.0 ± 0.9	14.5 ± 0.7	54.6 ± 3.6
SP S PLYMOUTH SUBST	4.62 km W	14.6 ± 0.8	14.8 ± 0.6	16.1 ± 0.8	15.7 ± 1.0	61.3 ± 3.2
RP ROUTE 3 OVERPASS	4.81 km SW	13.3 ± 0.7	13.7 ± 0.4	15.2 ± 0.6	15.4 ± 1.0	57.5 ± 4.4
RM RUSSELL MILLS RD	4.85 km WSW	12.3 ± 1.1	11.9 ± 0.6	13.7 ± 0.9	13.9 ± 0.7	51.9 ± 4.4
HD HILLDALE ROAD	5.18 km W	14.3 ± 0.7	14.7 ± 0.5	15.7 ± 0.7	15.6 ± 0.9	60.4 ± 3.2
MB MANOMET BEACH	5.43 km SSE	14.4 ± 1.0	13.3 ± 0.4	15.3 ± 0.7	14.5 ± 0.8	57.5 ± 3.5
BR BEAVERDAM ROAD	5.52 km S	12.8 ± 0.7	12.2 ± 0.6	14.3 ± 0.4	13.5 ± 0.9	52.8 ± 3.9
PC PLYMOUTH CENTER	6.69 km W	10.0 ± 0.5	9.8 ± 0.7	11.1 ± 0.8	11.0 ± 0.8	42.0 ± 3.0
LD LONG POND/DREW RD	6.97 km WSW	13.5 ± 1.0	13.9 ± 0.8	14.5 ± 0.5	14.7 ± 0.7	56.7 ± 2.6
HR HYANNIS ROAD	7.33 km SSE	14.5 ± 1.0	13.1 ± 0.5	15.2 ± 0.9	15.6 ± 0.8	58.4 ± 4.6
MH MEMORIAL HALL	7.58 km WNW	24.1 ± 1.7	23.6 ± 1.0	25.6 ± 1.2	25.6 ± 1.1	98.9 ± 4.8
SN SAQUISH NECK	7.58 km NNW	11.5 ± 1.0	10.5 ± 0.4	11.7 ± 0.7	12.4 ± 0.7	46.0 ± 3.4
CP COLLEGE POND	7.59 km SW	13.5 ± 0.8	13.2 ± 0.6	14.7 ± 0.6	14.3 ± 0.9	55.7 ± 3.1
Zone 3 TLDs: 8-15 km	8-15 km	14.0 ± 1.3	13.4 ± 1.5	15.3 ± 1.5	15.2 ± 1.4	57.9 ± 6.4
DW DEEP WATER POND	8.59 km W	16.0 ± 1.4	15.4 ± 0.8	17.9 ± 1.1	17.8 ± 0.9	67.1 ± 5.4
LP LONG POND ROAD	8.88 km SSW	12.3 ± 0.9	11.7 ± 0.5	13.8 ± 0.6	13.7 ± 1.0	51.6 ± 4.5
NP NORTH PLYMOUTH	9.38 km WNW	16.2 ± 0.8	16.4 ± 0.5	17.8 ± 0.7	17.3 ± 0.8	67.6 ± 3.2
SS STANDISH SHORES	10.39 km NW	13.5 ± 0.7	13.1 ± 0.7	14.2 ± 0.7	14.4 ± 1.0	55.1 ± 2.9
EL ELLISVILLE ROAD	11.52 km SSE	14.1 ± 1.0	13.1 ± 0.5	14.8 ± 0.7	15.2 ± 0.8	57.1 ± 4.1
UC UP COLLEGE POND RD	11.78 km SW	12.8 ± 0.7	11.9 ± 0.3	Missing	14.9 ± 1.2	52.7 ± 6.4
SH SACRED HEART	12.92 km W	13.9 ± 1.3	13.3 ± 0.6	15.2 ± 0.7	15.7 ± 0.8	58.1 ± 4.8
KC KING CAESAR ROAD	13.11 km NNW	14.7 ± 0.7	13.9 ± 0.6	15.0 ± 0.6	15.3 ± 1.0	58.9 ± 3.0
BE BOURNE ROAD	13.37 km S	12.9 ± 0.9	12.4 ± 0.5	14.2 ± 0.7	13.8 ± 0.8	53.3 ± 3.6
SA SHERMAN AIRPORT	13.43 km WSW	13.6 ± 0.7	13.1 ± 0.7	15.0 ± 0.7	14.3 ± 0.8	55.9 ± 3.6
Zone 4 TLDs: >15 km	>15 km	14.4 ± 1.3	14.1 ± 1.7	16.3 ± 2.2	16.2 ± 2.0	61.0 ± 7.9
CS CEDARVILLE SUBST	15.93 km S	14.7 ± 0.6	14.5 ± 0.9	16.3 ± 1.0	15.8 ± 0.8	61.3 ± 3.8
KS KINGSTON SUBST	16.15 km WNW	13.5 ± 1.6	13.1 ± 1.0	14.8 ± 1.0	15.5 ± 0.9	56.8 ± 5.1
LR LANDING ROAD	16.46 km NNW	14.0 ± 0.9	13.4 ± 0.7	15.3 ± 0.5	14.8 ± 1.0	57.5 ± 3.9
CW CHURCH/WEST	16.56 km NW	12.6 ± 0.8	12.0 ± 0.5	13.9 ± 0.5	14.0 ± 0.8	52.5 ± 4.3
MM MAIN/MEADOW	17.02 km WSW	14.5 ± 0.8	13.6 ± 0.7	15.9 ± 0.7	15.6 ± 1.3	59.6 ± 4.5
DMF DIV MARINE FISH	20.97 km SSE	16.0 ± 1.1	15.1 ± 0.8	20.3 ± 0.7	19.9 ± 0.9	71.4 ± 10.7
EW E WEYMOUTH SUBST	39.69 km NW	15.8 ± 0.8	17.0 ± 0.8	17.8 ± 1.1	17.6 ± 0.9	68.1 ± 4.1

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

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

Table 2.4-2

Onsite Environmental TLD Results

TLD Station ID	Description	TLD Location* Distance/Direction	Exposure Rate - mR/quarter (Value ± Std.Dev.) Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	2000 Annual** Exposure mR/year
Onsite TLDs							
P21	O&M/RXB. BREEZEWAY	50 m SE	26.7 ± 1.8	26.6 ± 0.9	27.8 ± 1.5	33.6 ± 1.7	114.7 ± 13.6
P24	EXEC.BUILDING	57 m W	57.3 ± 4.0	58.5 ± 1.6	54.8 ± 4.9	66.3 ± 8.3	236.9 ± 22.5
P04	FENCE-R SCREENHOUSE	66 m N	109.3 ± 7.3	112.9 ± 6.5	104.4 ± 6.0	108.1 ± 4.7	434.7 ± 18.8
P20	O&M - 2ND W WALL	67 m SE	64.8 ± 7.5	70.6 ± 4.3	66.2 ± 4.5	75.5 ± 6.0	277.0 ± 22.5
P25	EXEC.BUILDING LAWN	76 m WNW	123.0 ± 7.9	116.7 ± 4.3	107.6 ± 10.2	135.9 ± 10.9	483.2 ± 50.7
P05	FENCE-WATER TANK	81 m NNE	33.5 ± 2.5	36.0 ± 2.3	36.9 ± 3.0	47.1 ± 3.6	153.6 ± 24.6
P06	FENCE-OIL STORAGE	85 m NE	55.6 ± 3.9	58.6 ± 2.3	69.3 ± 5.8	80.9 ± 5.4	264.4 ± 46.9
P19	O&M - 2ND SW CORNER	86 m S	80.6 ± 5.1	105.9 ± 9.6	92.6 ± 5.4	102.4 ± 5.6	381.6 ± 47.3
P18	O&M - 1ST SW CORNER	90 m S	70.5 ± 11.1	71.0 ± 9.4	62.4 ± 8.4	75.3 ± 7.9	279.1 ± 28.5
P08	COMPRESSED GAS STOR	92 m E	59.6 ± 5.0	60.3 ± 5.1	53.9 ± 3.3	63.2 ± 5.5	236.9 ± 18.3
P03	FENCE-L SCREENHOUSE	100 m NW	88.5 ± 4.5	90.9 ± 6.0	84.7 ± 3.8	95.9 ± 6.4	359.9 ± 21.6
P17	FENCE-EXEC.BUILDING	107 m W	187.7 ± 16.3	186.1 ± 10.7	164.1 ± 11.2	195.3 ± 9.6	733.2 ± 58.9
P07	FENCE-INTAKE BAY	121 m ENE	56.0 ± 5.6	54.4 ± 3.6	56.0 ± 3.7	59.5 ± 2.7	226.0 ± 11.8
P23	O&M - 2ND S WALL	121 m SSE	47.0 ± 3.3	49.2 ± 2.1	46.3 ± 2.0	48.8 ± 2.4	191.3 ± 7.4
P26	FENCE-WAREHOUSE	134 m ESE	54.1 ± 5.2	53.7 ± 3.9	51.0 ± 3.0	58.0 ± 4.7	216.7 ± 14.3
P02	FENCE-SHOREFRONT	135 m NW	58.9 ± 4.0	60.4 ± 3.3	58.3 ± 2.7	67.1 ± 5.0	244.7 ± 17.8
P09	FENCE-W BOAT RAMP	136 m E	46.0 ± 3.0	45.5 ± 2.3	44.5 ± 1.6	50.0 ± 4.3	186.1 ± 11.3
P22	O&M - 2ND N WALL	137 m SE	38.3 ± 2.2	39.6 ± 2.5	37.1 ± 1.8	40.6 ± 2.6	155.6 ± 7.7
P16	FENCE-W SWITCHYARD	172 m SW	134.2 ± 8.6	144.8 ± 9.3	133.9 ± 11.2	146.9 ± 8.3	559.8 ± 33.3
P11	FENCE-TCF GATE	183 m ESE	70.8 ± 4.4	61.0 ± 2.6	48.3 ± 2.6	47.1 ± 4.1	227.1 ± 45.6
P27	FENCE-TCF/BOAT RAMP	185 m ESE	50.9 ± 4.6	54.9 ± 3.2	40.0 ± 2.4	43.7 ± 4.0	189.6 ± 28.0
P12	FENCE-ACCESS GATE	202 m SE	37.4 ± 4.5	35.7 ± 1.4	35.0 ± 3.0	38.2 ± 2.8	146.4 ± 8.6
P15	FENCE-E SWITCHYARD	220 m S	45.8 ± 2.8	50.1 ± 2.4	47.9 ± 2.2	54.6 ± 3.1	198.4 ± 15.9
P10	FENCE-TCF/INTAKE BAY	223 m E	45.0 ± 2.3	42.8 ± 2.4	43.0 ± 2.0	47.5 ± 5.1	178.3 ± 10.9
P13	FENCE-MEDICAL BLDG.	224 m SSE	34.8 ± 2.4	34.6 ± 1.7	34.7 ± 2.7	36.3 ± 3.4	140.3 ± 6.1
P14	FENCE-BUTLER BLDG	228 m S	35.8 ± 3.7	36.3 ± 2.9	46.6 ± 2.3	81.4 ± 4.3	200.1 ± 86.3
P28	FENCE-TCF/PRKNG LOT	259 m ESE	89.5 ± 8.6	63.3 ± 5.5	102.1 ± 14.8	61.2 ± 5.0	316.1 ± 82.4

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

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

Table 2.4-3

Average TLD Exposures By Distance Zone During 2000

Exposure Period	Average Exposure ± Standard Deviation: mR/period			
	Zone 1* 0-3 km	Zone 2 3-8 km	Zone 3 8-15 km	Zone 4 >15 km
Jan-Mar	22.6 ± 20.8	14.1 ± 2.7	14.0 ± 1.3	14.4 ± 1.3
Apr-Jun	23.7 ± 23.0	13.9 ± 2.7	13.4 ± 1.5	14.1 ± 1.7
Jul-Sep	23.6 ± 19.1	15.4 ± 2.8	15.3 ± 1.5	16.3 ± 2.2
Oct-Dec	24.5 ± 22.3	15.4 ± 2.8	15.2 ± 1.4	16.2 ± 2.0
Jan-Dec	94.4 ± 84.6**	58.8 ± 11.2	57.9 ± 6.4	61.0 ± 7.9

* Zone 1 extends from the PNPS restricted/protected area boundary outward to 3 kilometers (2 miles), and includes several TLDs located within the site boundary.

** When corrected for TLDs located within the site boundary, the Zone 1 annual average is calculated to be 62.8 ± 6.5 mR/yr.

Table 2.4-4

Beach Survey Exposure Rate Measurements

<u>Ambient Radiation Survey Results</u>

Location	Exposure Rate ± 1 std. dev.		Beach Terrain
	μR/hr	mR/yr	
White Horse Beach (Near Hilltop Ave) 2.62 km SE	7.4 ± 0.4	64 ± 3.2	Sandy. Few granite boulders within thirty feet.
Priscilla Beach (In Back of Full Sail Bar) 1.89 km SE	10.2 ± 0.5	90 ± 4.4	Sandy with small amounts of gravel.
Plymouth Beach (Outer Beach) 7.21 km WNW	6.5 ± 0.4	57 ± 3.4	Sandy.
Plymouth Beach (Inner Beach) 6.07 km WNW	6.9 ± 0.4	60 ± 3.2	Sandy.
Plymouth Beach (Behind Bert's Restaurant) 3.66 km W	13.3 ± 0.7	117 ± 5.9	Sandy with gravel. Breakwater and seawall nearby.
Duxbury Beach (Control) 10.94 km NNW	8.3 ± 0.4	73 ± 3.7	Sandy with coarse gravel and exposed cobble.

Table 2.5-1
Air Particulate Filter Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Air Particulates (AP) UNITS: pCi/cubic meter

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations Mean Range (No. Detected**)	Station With Highest Mean Sta.	Mean Range (No. Detected**)	Control Stations Mean Range (No. Detected**)
GR-B	(579) (0)	0.01	(1.6 ± 0.7)E -2 (1.1 - 42.0)E -3 (519/ 527)	21	(1.8 ± 0.7)E -2 (4.1 - 38.1)E -3 (52/ 52)	(1.8 ± 0.7)E -2 (4.1 - 38.1)E -3 (52/ 52)
Be-7	(44) (0)		(7.0 ± 1.8)E -2 (3.9 - 11.4)E -2 (40/ 40)	15	(8.4 ± 1.3)E -2 (7.6 - 9.9)E -2 (4/ 4)	(7.8 ± 1.8)E -2 (5.4 - 8.8)E -2 (4/ 4)
K-40	(44) (0)		(1.7 ± 4.1)E -3 (-1.1 - 0.9)E -2 (0/ 40)	17	(4.7 ± 4.1)E -3 (1.8 - 8.7)E -3 (0/ 4)	(3.9 ± 4.9)E -3 (2.0 - 100.1)E -4 (0/ 4)
Mn-54	(44) (0)		(-2.4 ± 29.7)E -5 (-6.6 - 5.9)E -4 (0/ 40)	10	(2.3 ± 2.4)E -4 (0.0 - 4.2)E -4 (0/ 4)	(-3.0 ± 27.0)E -5 (-3.5 - 1.2)E -4 (0/ 4)
Co-60	(44) (0)		(5.5 ± 31.0)E -5 (-4.8 - 6.1)E -4 (0/ 40)	10	(2.4 ± 3.5)E -4 (-1.6 - 6.0)E -4 (0/ 4)	(1.7 ± 2.2)E -4 (-3.5 - 28.9)E -5 (0/ 4)
Cs-134	(44) (0)	0.01	(5.3 ± 31.2)E -5 (-2.9 - 8.3)E -4 (0/ 40)	09	(3.8 ± 5.5)E -4 (-2.5 - 8.2)E -4 (0/ 4)	(-1.8 ± 2.7)E -4 (-3.5 - 1.5)E -4 (0/ 4)
Cs-137	(44) (0)	0.01	(-8.4 ± 23.0)E -5 (-5.2 - 4.1)E -4 (0/ 40)	15	(2.2 ± 2.0)E -4 (3.9 - 41.0)E -5 (0/ 4)	(6.3 ± 24.9)E -5 (-1.3 - 3.3)E -4 (0/ 4)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.6-1
Charcoal Cartridge Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Charcoal Cartridge (CF) UNITS: pCi/cubic meter

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean, Range (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean, Range (No. Detected**)	Control Stations: Mean, Range (No. Detected**)
I-131	(579) (0)	0.07	(-2.9 ± 66.8)E -4 (-2.8 - 3.7)E -2 (0/ 527)	21	(1.4 ± 7.5)E -3 (-2.5 - 1.8)E -2 (0/ 52)	(1.4 ± 7.5)E -3 (-2.5 - 1.8)E -2 (0/ 52)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.7-1
Milk Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Milk (TM) UNITS: pCi/kg

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean / Range / (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / (No. Detected**)	Control Stations: Mean / Range / (No. Detected**)
K-40	(40) (0)		(1.4 ± 0.1)E 3 (1.3 - 1.5)E 3 (20/ 20)	11	(1.4 ± 0.1)E 3 (1.3 - 1.5)E 3 (20/ 20)	(1.4 ± 0.1)E 3 (1.3 - 1.6)E 3 (20/ 20)
Sr-89	(40) (0)		(-1.5 ± 2.1)E 0 (-5.1 - 2.0)E 0 (0/ 20)	11	(-1.5 ± 2.1)E 0 (-5.1 - 2.0)E 0 (0/ 20)	(-1.7 ± 2.0)E 0 (-5.3 - 1.7)E 0 (0/ 20)
Sr-90	(40) (0)		(1.2 ± 0.7)E 0 (-5.4 - 21.8)E -1 (11/ 20)	11	(1.2 ± 0.7)E 0 (-5.4 - 21.8)E -1 (11/ 20)	(9.1 ± 11.1)E -1 (-6.5 - 46.9)E -1 (3/ 20)
I-131	(40) (0)	1	(1.7 ± 6.5)E -1 (-9.2 - 267.7)E -2 (0/ 20)	11	(1.7 ± 6.5)E -1 (-9.2 - 267.7)E -2 (0/ 20)	(8.9 ± 19.9)E -2 (-6.9 - 82.4)E -2 (0/ 20)
Cs-134	(40) (0)	15	(-1.9 ± 17.5)E -1 (-4.3 - 3.4)E 0 (0/ 20)	21	(2.3 ± 144.4)E -2 (-2.7 - 3.8)E 0 (0/ 20)	(2.3 ± 144.4)E -2 (-2.7 - 3.8)E 0 (0/ 20)
Cs-137	(40) (0)	15	(3.5 ± 11.7)E -1 (-1.8 - 2.6)E 0 (0/ 20)	11	(3.5 ± 11.7)E -1 (-1.8 - 2.6)E 0 (0/ 20)	(2.5 ± 17.8)E -1 (-5.4 - 3.0)E 0 (0/ 20)
Ba-140	(40) (0)	15	(3.5 ± 25.1)E -1 (-4.8 - 4.9)E 0 (0/ 20)	11	(3.5 ± 25.1)E -1 (-4.8 - 4.9)E 0 (0/ 20)	(-3.5 ± 19.3)E -1 (-4.2 - 2.4)E 0 (0/ 20)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.8-1
Forage Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Forage (TC) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations Mean Range (No. Detected**)	Station With Highest Mean Sta.	Station With Highest Mean Mean Range (No. Detected**)	Control Stations Mean Range (No. Detected**)
Be-7	(3) (0)		(1.4 ± 1.1)E 3 (5.8 - 21.6)E 2 (2/ 2)	21	(2.0 ± 0.2)E 3 (1/ 1)	(2.0 ± 0.2)E 3 (1/ 1)
K-40	(3) (0)		(5.1 ± 2.7)E 3 (3.3 - 7.0)E 3 (2/ 2)	21	(7.8 ± 0.4)E 3 (1/ 1)	(7.8 ± 0.4)E 3 (1/ 1)
I-131	(3) (0)		(-4.5 ± 15.6)E 1 (-1.5 - 0.6)E 2 (0/ 2)	11	(-4.5 ± 15.6)E 1 (-1.5 - 0.6)E 2 (0/ 2)	(-4.1 ± 1.8)E 2 (0/ 1)
Cs-134	(3) (0)	130	(5.4 ± 207.3)E -1 (-1.2 - 1.4)E 1 (0/ 2)	21	(1.1 ± 1.4)E 1 (0/ 1)	(1.1 ± 1.4)E 1 (0/ 1)
Cs-137	(3) (0)	130	(-1.6 ± 1.3)E 1 (-2.1 - -1.0)E 1 (0/ 2)	21	(5.4 ± 1.6)E 1 (1/ 1)	(5.4 ± 1.6)E 1 (1/ 1)
Th-232	(3) (0)		(8.5 ± 6.0)E 1 (7.9 - 9.1)E 1 (0/ 2)	11	(8.5 ± 6.0)E 1 (7.9 - 9.1)E 1 (0/ 2)	(-4.3 ± 8.1)E 1 (0/ 1)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.9-1
Vegetable/Vegetation Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Vegetation (TF) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean / Range / (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / (No. Detected**)	Control Stations: Mean / Range / (No. Detected**)
Be-7	(15) (0)		(1.2 ± 0.9)E 3 (-5.8 - 251.8)E 1 (8/ 10)	32	(2.5 ± 0.1)E 3 (1/ 1)	(4.8 ± 6.5)E 2 (-1.4 - 14.8)E 2 (2/ 5)
K-40	(15) (0)		(3.0 ± 1.1)E 3 (1.4 - 5.4)E 3 (10/ 10)	31	(5.4 ± 0.1)E 3 (1/ 1)	(2.6 ± 0.7)E 3 (1.9 - 3.6)E 3 (5/ 5)
I-131	(15) (0)	60	(-9.2 ± 165.3)E -1 (-2.7 - 1.9)E 1 (0/ 10)	05	(1.9 ± 1.8)E 1 (0/ 1)	(9.6 ± 44.4)E 0 (-3.1 - 7.6)E 1 (0/ 5)
Cs-134	(15) (0)	60	(4.2 ± 5.3)E 0 (-5.5 - 10.0)E 0 (0/ 10)	32	(1.0 ± 0.5)E 1 (0/ 1)	(6.2 ± 6.5)E 0 (-1.6 - 12.2)E 0 (0/ 5)
Cs-137	(15) (0)	60	(6.0 ± 8.3)E 1 (1.2 - 268.4)E 0 (5/ 10)	06	(2.7 ± 0.1)E 2 (1/ 1)	(9.3 ± 13.6)E 0 (-3.6 - 30.9)E 0 (1/ 5)
Th-232	(15) (0)		(1.2 ± 0.8)E 2 (1.0 - 19.6)E 1 (6/ 10)	30	(2.0 ± 0.1)E 2 (1/ 1)	(7.6 ± 6.2)E 1 (1.0 - 15.2)E 1 (2/ 5)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.10-1
Cranberry Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Cranberries (CB) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations ********** Mean Range (No. Detected**)	Station With Highest Mean ********** Sta.	Mean Range (No. Detected**)	Control Stations ********** Mean Range (No. Detected**)
Be-7	(3) (0)		(-1.6 ± 14.1)E 1 (-9.9 - 6.8)E 1 (0/ 2)	13	(6.8 ± 13.4)E 1 (0/ 1)	(-5.6 ± 7.2)E 1 (0/ 1)
K-40	(3) (0)		(6.1 ± 1.7)E 2 (5.4 - 6.7)E 2 (1/ 2)	23	(8.2 ± 1.7)E 2 (1/ 1)	(8.2 ± 1.7)E 2 (1/ 1)
I-131	(3) (0)		(7.1 ± 34.1)E 0 (3.4 - 10.8)E 0 (0/ 2)	13	(1.1 ± 6.4)E 1 (0/ 1)	(-1.7 ± 5.3)E 1 (0/ 1)
Cs-134	(3) (0)	60	(9.5 ± 8.3)E 0 (6.9 - 12.2)E 0 (0/ 2)	23	(1.4 ± 1.0)E 1 (0/ 1)	(1.4 ± 1.0)E 1 (0/ 1)
Cs-137	(3) (0)	60	(1.0 ± 1.4)E 1 (2.2 - 18.7)E 0 (0/ 2)	13	(1.9 ± 1.5)E 1 (0/ 1)	(-2.7 ± 7.9)E 0 (0/ 1)
Th-232	(3) (0)		(5.1 ± 5.1)E 1 (2.3 - 7.8)E 1 (0/ 2)	14	(7.8 ± 3.5)E 1 (0/ 1)	(5.2 ± 2.9)E 1 (0/ 1)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.11-1
Soil Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Soil (TS) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean, Range, (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean, Range, (No. Detected**)	Control Stations: Mean, Range, (No. Detected**)
Be-7	(28) (0)		(2.3 ± 14.0)E 1 (-3.4 - 3.0)E 2 (1/ 27)	03	(1.3 ± 0.3)E 2 (1/ 1)	(-1.7 ± 2.6)E 1 (0/ 1)
K-40	(28) (0)		(1.1 ± 0.3)E 4 (7.4 - 17.6)E 3 (27/ 27)	09	(1.6 ± 0.1)E 4 (1.6 - 1.8)E 4 (4/ 4)	(1.4 ± 0.0)E 4 (1/ 1)
Mn-54	(28) (0)		(1.5 ± 12.6)E 0 (-3.2 - 2.6)E 1 (0/ 27)	01	(9.3 ± 17.5)E 0 (-1.7 - 2.6)E 1 (0/ 5)	(3.9 ± 2.0)E 0 (0/ 1)
Co-58	(28) (0)		(-5.0 ± 13.0)E 0 (-3.4 - 2.3)E 1 (0/ 27)	07	(4.7 ± 12.9)E 0 (-5.1 - 19.8)E 0 (0/ 4)	(-3.6 ± 2.9)E 0 (0/ 1)
Co-60	(28) (0)		(1.9 ± 8.7)E 0 (-2.0 - 2.2)E 1 (0/ 27)	06	(6.8 ± 9.2)E 0 (1.3 - 16.8)E 0 (0/ 4)	(1.5 ± 3.1)E 0 (0/ 1)
Zn-65	(28) (0)		(2.8 ± 4.9)E 1 (-5.5 - 15.6)E 1 (0/ 27)	01	(4.7 ± 7.4)E 1 (-1.3 - 15.6)E 1 (0/ 5)	(-8.1 ± 142.8)E -1 (0/ 1)
Zr-95	(28) (0)		(1.4 ± 2.5)E 1 (-4.4 - 6.8)E 1 (0/ 27)	09	(2.7 ± 1.7)E 1 (1.5 - 3.9)E 1 (0/ 4)	(1.1 ± 0.5)E 1 (0/ 1)
Cs-134	(28) (0)		(-3.4 ± 335.0)E -1 (-5.9 - 6.3)E 1 (0/ 27)	07	(3.3 ± 3.0)E 1 (5.7 - 52.9)E 0 (0/ 4)	(-8.4 ± 39.3)E -1 (0/ 1)
Cs-137	(28) (0)		(1.9 ± 2.7)E 2 (-3.0 - 991.3)E 0 (19/ 27)	03	(9.9 ± 0.1)E 2 (1/ 1)	(2.9 ± 0.1)E 2 (1/ 1)
Ce-144	(28) (0)		(6.1 ± 70.7)E 0 (-2.1 - 1.4)E 2 (0/ 27)	06	(7.4 ± 6.7)E 1 (2.1 - 13.9)E 1 (0/ 4)	(-4.9 ± 16.7)E 0 (0/ 1)
Th-232	(28) (0)		(7.6 ± 2.1)E 2 (4.0 - 11.7)E 2 (27/ 27)	09	(1.1 ± 0.1)E 3 (9.6 - 11.7)E 2 (4/ 4)	(5.0 ± 0.1)E 2 (1/ 1)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.12-1
Surface Water Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Surface Water (WS) UNITS: pCi/kg

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean / Range / (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / (No. Detected**)	Control Stations: Mean / Range / (No. Detected**)
H-3	(12) (0)	3000	(2.9 ± 25.1)E 1 (-2.8 - 4.2)E 2 (0/ 8)	23	(5.9 ± 49.0)E 1 (-3.6 - 7.0)E 2 (0/ 4)	(5.9 ± 49.0)E 1 (-3.6 - 7.0)E 2 (0/ 4)
K-40	(36) (0)		(1.5 ± 1.5)E 2 (-2.6 - 35.8)E 1 (12/ 24)	11	(3.0 ± 0.4)E 2 (2.4 - 3.6)E 2 (12/ 12)	(3.0 ± 0.3)E 2 (2.6 - 3.5)E 2 (12/ 12)
Mn-54	(36) (0)	15	(-3.2 ± 11.5)E -1 (-3.2 - 1.9)E 0 (0/ 24)	11	(4.9 ± 99.4)E -2 (-1.4 - 1.9)E 0 (0/ 12)	(4.4 ± 2305.7)E -3 (-4.2 - 5.1)E 0 (0/ 12)
Co-58	(36) (0)	15	(-3.7 ± 10.4)E -1 (-2.3 - 1.8)E 0 (0/ 24)	11	(-1.7 ± 10.6)E -1 (-1.6 - 1.8)E 0 (0/ 12)	(-8.9 ± 17.0)E -1 (-4.8 - 1.2)E 0 (0/ 12)
Fe-59	(36) (0)	30	(3.2 ± 32.8)E -1 (-5.8 - 5.9)E 0 (0/ 24)	17	(3.4 ± 30.3)E -1 (-4.8 - 5.9)E 0 (0/ 12)	(2.3 ± 35.0)E -1 (-6.3 - 5.7)E 0 (0/ 12)
Co-60	(36) (0)	15	(6.2 ± 12.4)E -1 (-1.8 - 3.4)E 0 (0/ 24)	11	(9.9 ± 14.5)E -1 (-7.2 - 34.1)E -1 (0/ 12)	(9.1 ± 139.9)E -2 (-2.8 - 2.1)E 0 (0/ 12)
Zn-65	(36) (0)	30	(-2.4 ± 5.4)E 0 (-1.6 - 1.1)E 1 (0/ 24)	23	(-1.3 ± 4.6)E 0 (-6.4 - 6.9)E 0 (0/ 12)	(-1.3 ± 4.6)E 0 (-6.4 - 6.9)E 0 (0/ 12)
Zr-95	(36) (0)	15	(-3.6 ± 248.6)E -2 (-4.2 - 4.5)E 0 (0/ 24)	17	(5.2 ± 23.8)E -1 (-2.7 - 4.5)E 0 (0/ 12)	(-4.8 ± 220.7)E -2 (-3.4 - 4.4)E 0 (0/ 12)
I-131	(36) (0)	1	(2.0 ± 16.7)E -2 (-3.5 - 4.4)E -1 (0/ 24)	23	(1.2 ± 1.6)E -1 (-4.7 - 40.1)E -2 (0/ 12)	(1.2 ± 1.6)E -1 (-4.7 - 40.1)E -2 (0/ 12)
Cs-134	(36) (0)	15	(3.4 ± 16.4)E -1 (-3.0 - 3.3)E 0 (0/ 24)	17	(3.9 ± 20.4)E -1 (-3.0 - 3.3)E 0 (0/ 12)	(2.7 ± 16.8)E -1 (-4.1 - 2.1)E 0 (0/ 12)
Cs-137	(36) (0)	18	(-3.8 ± 18.2)E -1 (-3.3 - 4.0)E 0 (0/ 24)	17	(-1.7 ± 14.5)E -1 (-1.9 - 2.7)E 0 (0/ 12)	(-1.2 ± 2.6)E 0 (-7.1 - 1.2)E 0 (0/ 12)
Ba-140	(36) (0)	15	(5.4 ± 21.0)E -1 (-3.3 - 4.8)E 0 (0/ 24)	17	(1.2 ± 2.0)E 0 (-1.7 - 4.8)E 0 (0/ 12)	(3.1 ± 16.2)E -1 (-1.3 - 3.3)E 0 (0/ 12)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.13-1
Irish Moss Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Irish Moss (AL) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean Range (No. Detected**)	Station With Highest Mean: Sta.	Mean Range (No. Detected**)	Control Stations: Mean Range (No. Detected**)
Be-7	(16) (0)		(1.9 ± 0.9)E 2 (3.9 - 32.6)E 1 (8/ 12)	11	(2.7 ± 0.7)E 2 (1.9 - 3.3)E 2 (3/ 4)	(6.2 ± 5.2)E 1 (3.2 - 12.9)E 1 (0/ 4)
K-40	(16) (0)		(6.1 ± 1.5)E 3 (4.2 - 8.0)E 3 (12/ 12)	11	(6.9 ± 1.8)E 3 (4.2 - 8.0)E 3 (4/ 4)	(6.2 ± 1.0)E 3 (5.2 - 7.5)E 3 (4/ 4)
Cr-51	(16) (0)		(-1.5 ± 5.5)E 1 (-9.2 - 6.8)E 1 (0/ 12)	15	(3.0 ± 4.1)E 1 (5.0 - 67.9)E 0 (0/ 4)	(-1.9 ± 7.1)E 1 (-8.1 - 7.5)E 1 (0/ 4)
Mn-54	(16) (0)		(-3.8 ± 65.3)E -1 (-1.6 - 0.7)E 1 (0/ 12)	15	(2.1 ± 5.6)E 0 (-5.0 - 5.3)E 0 (0/ 4)	(-1.7 ± 3.0)E 0 (-3.9 - -0.1)E 0 (0/ 4)
Co-58	(16) (0)		(-3.6 ± 7.5)E 0 (-1.7 - 0.6)E 1 (0/ 12)	34	(-3.4 ± 74.6)E -1 (-1.1 - 0.4)E 1 (0/ 4)	(-3.4 ± 74.6)E -1 (-1.1 - 0.4)E 1 (0/ 4)
Fe-59	(16) (0)		(-8.1 ± 178.4)E -1 (-1.8 - 3.9)E 1 (0/ 12)	22	(8.2 ± 108.5)E -1 (-1.0 - 0.8)E 1 (0/ 4)	(-6.7 ± 13.4)E 0 (-1.9 - 0.6)E 1 (0/ 4)
Co-60	(16) (0)		(-1.0 ± 6.2)E 0 (-1.6 - 0.8)E 1 (0/ 12)	15	(1.5 ± 6.3)E 0 (-5.4 - 8.0)E 0 (0/ 4)	(3.3 ± 70.5)E -1 (-7.8 - 5.9)E 0 (0/ 4)
Zn-65	(16) (0)		(5.3 ± 189.2)E -1 (-3.5 - 2.9)E 1 (0/ 12)	15	(1.6 ± 1.4)E 1 (4.7 - 29.4)E 0 (0/ 4)	(-9.6 ± 20.2)E 0 (-3.2 - 1.2)E 1 (0/ 4)
Cs-134	(16) (0)		(1.7 ± 5.4)E 0 (-6.9 - 10.0)E 0 (0/ 12)	15	(4.9 ± 4.7)E 0 (1.8 - 10.0)E 0 (0/ 4)	(-1.9 ± 8.7)E 0 (-1.3 - 0.6)E 1 (0/ 4)
Cs-137	(16) (0)		(-2.3 ± 8.8)E 0 (-2.8 - 0.5)E 1 (0/ 12)	34	(1.8 ± 6.8)E 0 (-4.7 - 10.3)E 0 (0/ 4)	(1.8 ± 6.8)E 0 (-4.7 - 10.3)E 0 (0/ 4)
Th-232	(16) (0)		(3.4 ± 2.7)E 1 (-1.8 - 87.6)E 0 (0/ 12)	22	(3.6 ± 2.5)E 1 (1.5 - 6.8)E 1 (0/ 4)	(1.9 ± 2.6)E 1 (-1.6 - 3.8)E 1 (0/ 4)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.14-1
Shellfish Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Shellfish (SF) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations Mean Range (No. Detected**)	Station With Highest Mean Sta.	Station With Highest Mean Mean Range (No. Detected**)	Control Stations Mean Range (No. Detected**)
Be-7	(49) (0)		(3.4 ± 3.2)E 1 (-4.3 - 9.6)E 1 (7/ 25)	11	(4.3 ± 2.0)E 1 (5.6 - 71.1)E 0 (6/ 8)	(3.0 ± 7.9)E 1 (-9.3 - 24.6)E 1 (2/ 24)
K-40	(49) (0)		(1.2 ± 0.6)E 3 (-1.3 - 22.3)E 2 (24/ 25)	15	(1.6 ± 0.3)E 3 (1.3 - 1.9)E 3 (4/ 4)	(9.1 ± 7.0)E 2 (-1.1 - 210.9)E 1 (18/ 24)
Cr-51	(49) (0)		(-2.4 ± 45.8)E 0 (-1.5 - 1.5)E 2 (0/ 25)	24	(8.2 ± 9.4)E 0 (-3.2 - 26.5)E 0 (0/ 8)	(-2.5 ± 8.5)E 1 (-1.9 - 1.5)E 2 (0/ 24)
Mn-54	(49) (0)	130	(-9.4 ± 45.6)E -1 (-1.4 - 0.5)E 1 (0/ 25)	11	(5.1 ± 10.6)E -1 (-1.5 - 1.8)E 0 (0/ 8)	(-1.0 ± 5.6)E 0 (-1.4 - 0.9)E 1 (0/ 24)
Co-58	(49) (0)	130	(3.0 ± 45.1)E -1 (-1.3 - 1.2)E 1 (0/ 25)	12	(1.0 ± 6.4)E 0 (-1.3 - 1.2)E 1 (0/ 13)	(-1.6 ± 9.1)E 0 (-1.7 - 2.8)E 1 (0/ 24)
Fe-59	(49) (0)	260	(-2.9 ± 12.1)E 0 (-5.5 - 1.1)E 1 (0/ 25)	24	(9.5 ± 26.2)E -1 (-3.9 - 4.2)E 0 (0/ 8)	(-4.3 ± 17.1)E 0 (-5.4 - 1.7)E 1 (0/ 24)
Co-60	(49) (0)	5	(4.2 ± 38.1)E -1 (-9.7 - 8.5)E 0 (0/ 25)	11	(1.2 ± 0.7)E 0 (6.1 - 20.5)E -1 (0/ 8)	(-8.0 ± 79.4)E -1 (-2.6 - 1.1)E 1 (0/ 24)
Zn-65	(49) (0)	5	(4.2 ± 1739.2)E -2 (-3.8 - 4.4)E 1 (0/ 25)	15	(2.7 ± 2.6)E 0 (-4.1 - 49.0)E -1 (0/ 4)	(-2.0 ± 29.8)E 0 (-6.2 - 10.1)E 1 (0/ 24)
Zr-95	(49) (0)	5	(2.0 ± 9.6)E 0 (-1.9 - 3.7)E 1 (0/ 25)	12	(2.9 ± 13.3)E 0 (-1.9 - 3.7)E 1 (0/ 13)	(1.7 ± 20.0)E 0 (-2.8 - 7.4)E 1 (0/ 24)
Cs-134	(49) (0)	5	(-8.2 ± 80.7)E -1 (-2.9 - 1.5)E 1 (0/ 25)	13	(3.2 ± 9.9)E 0 (-2.0 - 1.6)E 1 (0/ 16)	(3.0 ± 8.0)E 0 (-2.0 - 1.6)E 1 (0/ 24)
Cs-137	(49) (0)	5	(3.2 ± 783.1)E -2 (-2.7 - 2.2)E 1 (0/ 25)	15	(4.2 ± 10.0)E -1 (-5.0 - 14.9)E -1 (0/ 4)	(-2.6 ± 9.7)E 0 (-2.7 - 1.4)E 1 (0/ 24)
Ce-144	(49) (0)	15	(3.8 ± 295.8)E -1 (-6.6 - 10.1)E 1 (0/ 25)	13	(3.2 ± 50.4)E 0 (-1.0 - 1.2)E 2 (0/ 16)	(1.8 ± 40.4)E 0 (-1.0 - 1.2)E 2 (0/ 24)
Th-232	(49) (0)		(3.2 ± 4.0)E 1 (-7.3 - 139.6)E 0 (6/ 25)	13	(4.6 ± 8.5)E 1 (-1.7 - 1.8)E 2 (6/ 16)	(3.8 ± 7.0)E 1 (-1.7 - 1.8)E 2 (10/ 24)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.
** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.15-1
Lobster Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: American Lobster (HA) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations: Mean Range (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean Range (No. Detected**)	Control Stations: Mean Range (No. Detected**)
Be-7	(5) (0)		(8.9 ± 62.5)E 0 (-4.4 - 6.2)E 1 (0/ 4)	13	(5.1 ± 7.4)E 1 (0/ 1)	(5.1 ± 7.4)E 1 (0/ 1)
K-40	(5) (0)		(1.8 ± 0.3)E 3 (1.5 - 2.1)E 3 (4/ 4)	11	(1.8 ± 0.3)E 3 (1.5 - 2.1)E 3 (4/ 4)	(1.6 ± 0.2)E 3 (1/ 1)
Mn-54	(5) (0)	130	(-6.0 ± 11.4)E 0 (-1.5 - 0.7)E 1 (0/ 4)	11	(-6.0 ± 11.4)E 0 (-1.5 - 0.7)E 1 (0/ 4)	(-8.1 ± 8.7)E 0 (0/ 1)
Co-58	(5) (0)	130	(-6.5 ± 7.6)E 0 (-1.2 - -0.2)E 1 (0/ 4)	13	(5.5 ± 9.9)E 0 (0/ 1)	(5.5 ± 9.9)E 0 (0/ 1)
Fe-59	(5) (0)	260	(-5.8 ± 15.8)E 0 (-2.2 - 0.4)E 1 (0/ 4)	13	(-5.1 ± 20.3)E 0 (0/ 1)	(-5.1 ± 20.3)E 0 (0/ 1)
Co-60	(5) (0)	130	(8.9 ± 11.3)E 0 (2.9 - 235.7)E -1 (0/ 4)	13	(2.1 ± 0.9)E 1 (0/ 1)	(2.1 ± 0.9)E 1 (0/ 1)
Zn-65	(5) (0)	260	(-6.8 ± 16.9)E 0 (-1.9 - 0.7)E 1 (0/ 4)	11	(-6.8 ± 16.9)E 0 (-1.9 - 0.7)E 1 (0/ 4)	(-1.2 ± 1.6)E 1 (0/ 1)
Cs-134	(5) (0)	130	(1.7 ± 14.2)E 0 (-1.5 - 1.4)E 1 (0/ 4)	11	(1.7 ± 14.2)E 0 (-1.5 - 1.4)E 1 (0/ 4)	(-1.5 ± 7.6)E 0 (0/ 1)
Cs-137	(5) (0)	130	(-1.6 ± 17.7)E 0 (-1.6 - 2.0)E 1 (0/ 4)	13	(7.2 ± 9.7)E 0 (0/ 1)	(7.2 ± 9.7)E 0 (0/ 1)
Th-232	(5) (0)		(3.2 ± 5.0)E 1 (-9.3 - 79.4)E 0 (0/ 4)	11	(3.2 ± 5.0)E 1 (-9.3 - 79.4)E 0 (0/ 4)	(-8.8 ± 28.6)E 0 (0/ 1)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.16-1
Fish Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Fish (FH) UNITS: pCi/kg wet

Radionuclides (No. Analyses) (Non-Routine*)	Required LLD	Indicator Stations: Mean Range (No. Detected**)	Station With Highest Mean: Sta.	Station With Highest Mean: Mean Range (No. Detected**)	Control Stations: Mean Range (No. Detected**)
Be-7 (25) (0)		(-1.8 ± 11.2)E 1 (-1.7 - 1.9)E 2 (0/ 17)	98	(-6.9 ± 85.3)E 0 (-8.1 - 9.2)E 1 (0/ 4)	(-2.6 ± 6.2)E 1 (-8.1 - 9.2)E 1 (0/ 8)
K-40 (25) (0)		(3.0 ± 0.6)E 3 (1.5 - 4.3)E 3 (17/ 17)	97	(3.6 ± 0.3)E 3 (3.6 - 3.7)E 3 (2/ 2)	(3.1 ± 0.6)E 3 (2.2 - 3.7)E 3 (8/ 8)
Mn-54 (25) (0)	130	(-2.5 ± 11.2)E 0 (-1.7 - 1.5)E 1 (0/ 17)	98	(-1.4 ± 7.4)E 0 (-5.5 - 6.0)E 0 (0/ 4)	(-4.6 ± 7.3)E 0 (-1.6 - 0.6)E 1 (0/ 8)
Co-58 (25) (0)	130	(-2.0 ± 88.4)E -1 (-1.6 - 1.7)E 1 (0/ 17)	97	(9.0 ± 21.2)E 0 (-5.0 - 22.9)E 0 (0/ 2)	(-9.0 ± 126.4)E -1 (-1.3 - 2.3)E 1 (0/ 8)
Fe-59 (25) (0)	260	(-6.3 ± 35.4)E 0 (-6.3 - 7.9)E 1 (0/ 17)	98	(4.6 ± 20.6)E 0 (-1.4 - 2.5)E 1 (0/ 4)	(-1.6 ± 18.4)E 0 (-2.0 - 2.5)E 1 (0/ 8)
Co-60 (25) (0)	130	(-3.4 ± 14.2)E 0 (-3.3 - 2.0)E 1 (0/ 17)	98	(4.4 ± 9.1)E 0 (-1.8 - 14.1)E 0 (0/ 4)	(4.9 ± 926.0)E -2 (-1.6 - 1.4)E 1 (0/ 8)
Zn-65 (25) (0)	260	(-1.9 ± 2.6)E 1 (-5.8 - 4.1)E 1 (0/ 17)	11	(-1.9 ± 2.6)E 1 (-5.8 - 4.1)E 1 (0/ 17)	(-2.4 ± 1.9)E 1 (-4.8 - 0.7)E 1 (0/ 8)
Cs-134 (25) (0)	130	(-6.1 ± 14.4)E 0 (-2.8 - 2.8)E 1 (0/ 17)	97	(1.1 ± 1.3)E 1 (4.6 - 18.3)E 0 (0/ 2)	(-5.4 ± 119.8)E -1 (-1.4 - 1.8)E 1 (0/ 8)
Cs-137 (25) (0)	130	(-1.4 ± 13.5)E 0 (-2.3 - 1.8)E 1 (0/ 17)	99	(1.1 ± 6.8)E 0 (1.1 - 1.1)E 0 (0/ 2)	(-9.1 ± 94.6)E -1 (-1.6 - 1.2)E 1 (0/ 8)
Th-232 (25) (0)		(9.2 ± 52.8)E 0 (-1.0 - 0.9)E 2 (0/ 17)	97	(2.1 ± 3.8)E 1 (7.9 - 33.7)E 0 (0/ 2)	(-1.8 ± 4.4)E 1 (-9.7 - 3.4)E 1 (0/ 8)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.17-1
Sediment Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

MEDIUM: Sediment (SE) UNITS: pCi/kg dry

Radionuclides (No. Analyses) (Non-Routine*)		Required LLD	Indicator Stations Mean Range (No. Detected**)	Station With Highest Mean Sta.	Mean Range (No. Detected**)	Control Stations Mean Range (No. Detected**)
Be-7	(56) (0)		(3.4 ± 6.0)E 1 (-4.9 - 30.2)E 1 (4/ 39)	13	(1.3 ± 3.8)E 2 (-3.1 - 126.5)E 1 (3/ 11)	(9.5 ± 30.6)E 1 (-5.2 - 126.5)E 1 (3/ 17)
K-40	(56) (0)		(9.1 ± 1.5)E 3 (6.5 - 13.3)E 3 (39/ 39)	13	(1.3 ± 0.2)E 4 (1.1 - 1.7)E 4 (11/ 11)	(1.2 ± 0.2)E 4 (8.8 - 16.5)E 3 (17/ 17)
Co-58	(56) (0)	50	(-2.8 ± 3.2)E 0 (-9.1 - 5.5)E 0 (0/ 39)	13	(-1.7 ± 8.3)E 0 (-8.1 - 21.2)E 0 (0/ 11)	(-2.7 ± 6.9)E 0 (-8.9 - 21.2)E 0 (0/ 17)
Co-60	(56) (0)	50	(-3.2 ± 23.8)E -1 (-5.1 - 4.1)E 0 (0/ 39)	11	(4.7 ± 27.0)E -1 (-3.5 - 4.1)E 0 (0/ 11)	(1.2 ± 34.9)E -1 (-5.3 - 6.5)E 0 (0/ 17)
Zn-65	(56) (0)	50	(1.1 ± 1.2)E 1 (-1.6 - 4.1)E 1 (0/ 39)	11	(1.4 ± 1.3)E 1 (-4.0 - 41.2)E 0 (0/ 11)	(8.9 ± 15.2)E 0 (-1.8 - 3.6)E 1 (0/ 17)
Zr-95	(56) (0)	50	(5.4 ± 4.3)E 0 (-4.0 - 15.8)E 0 (0/ 39)	13	(1.0 ± 0.8)E 1 (2.3 - 25.6)E 0 (0/ 11)	(8.7 ± 6.7)E 0 (-4.3 - 256.2)E -1 (0/ 17)
Cs-134	(56) (0)	50	(-5.3 ± 70.4)E -1 (-1.6 - 1.9)E 1 (0/ 39)	11	(1.6 ± 9.0)E 0 (-1.0 - 1.9)E 1 (0/ 11)	(-5.0 ± 12.0)E 0 (-3.2 - 1.7)E 1 (0/ 17)
Cs-137	(56) (0)	50	(4.7 ± 9.2)E 0 (-5.6 - 30.7)E 0 (8/ 39)	13	(2.0 ± 0.6)E 1 (1.2 - 2.9)E 1 (10/ 11)	(1.5 ± 0.9)E 1 (-1.6 - 29.5)E 0 (10/ 17)
Ce-144	(56) (0)	150	(5.6 ± 168.0)E -1 (-3.9 - 3.1)E 1 (0/ 39)	14	(7.1 ± 16.1)E 0 (-1.5 - 3.1)E 1 (0/ 6)	(-3.2 ± 26.2)E 0 (-6.2 - 2.7)E 1 (0/ 17)
Th-232	(56) (0)		(3.1 ± 0.9)E 2 (1.5 - 5.5)E 2 (39/ 39)	13	(4.8 ± 0.9)E 2 (3.9 - 7.2)E 2 (11/ 11)	(4.4 ± 1.0)E 2 (2.9 - 7.2)E 2 (17/ 17)
Pu-238	(6) (0)	25	(4.0 ± 4.3)E 0 (9.1 - 99.0)E -1 (2/ 4)	13	(6.1 ± 1.4)E 2 (5.1 - 7.1)E 2 (2/ 2)	(6.1 ± 1.4)E 2 (5.1 - 7.1)E 2 (2/ 2)
Pu-239	(6) (0)	25	(4.1 ± 2.4)E 0 (2.5 - 7.6)E 0 (2/ 4)	13	(1.7 ± 0.4)E 1 (1.6 - 1.9)E 1 (2/ 2)	(1.7 ± 0.4)E 1 (1.6 - 1.9)E 1 (2/ 2)

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

** The fraction of sample analyses yielding detectable measurements (i.e. >3 standard deviations) is shown in parentheses.

Table 2.17-2
Sediment Plutonium Analyses

Environmental Radiological Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2000)

Location	Core Depth (cm)	pCi/kg (dry) ± 1 S.D.	
		Plutonium-238	Plutonium-239/240
Discharge Canal Outfall	0 - 5	NDA	NDA
Discharge Canal Outfall	5 - 10	9.9 ± 2.6	NDA
Plymouth Harbor	14 - 16	1.19 ± 0.36	7.56 ± 0.76
Manomet Point	0 - 2	NDA	2.45 ± 0.45
Duxbury Bay - Control	0 - 2	707 ± 28	15.6 ± 4.5
Duxbury Bay - Control	12 - 14	506 ± 20	19.2 ± 4.1

* NDA indicates no detectable activity.

Figure 2.2-1

Environmental TLD Locations Within the PNPS Protected Area

TLD Station		Location*
Description	Code	Distance/Direction
TLDs Within Protected Area		
O&M/RXB. BREEZEWAY	P21	50 m SE
EXEC.BUILDING	P24	57 m W
FENCE-R SCREENHOUSE	P04	66 m N
O&M - 2ND W WALL	P20	67 m SE
EXEC.BUILDING LAWN	P25	76 m WNW
FENCE-WATER TANK	P05	81 m NNE
FENCE-OIL STORAGE	P06	85 m NE
O&M - 2ND SW CORNER	P19	86 m S
O&M - 1ST SW CORNER	P18	90 m S
COMPRESSED GAS STOR	P08	92 m E
FENCE-L SCREENHOUSE	P03	100 m NW
FENCE-EXEC.BUILDING	P17	107 m W
O&M - 2ND S WALL	P23	121 m ENE
FENCE-INTAKE BAY	P07	121 m SSE
FENCE-WAREHOUSE	P26	134 m ESE
FENCE-SHOREFRONT	P02	135 m NW
FENCE-W BOAT RAMP	P09	136 m E
O&M - 2ND N WALL	P22	137 m SE
FENCE-W SWITCHYARD	P16	172 m SW
FENCE-TCF GATE	P11	183 m ESE
FENCE-TCF/BOAT RAMP	P27	185 m ESE
FENCE-ACCESS GATE	P12	202 m SE
FENCE-E SWITCHYARD	P15	220 m S
FENCE-TCF/INTAKE BAY	P10	223 m E
FENCE-MEDICAL BLDG.	P13	224 m SSE
FENCE-BUTLER BLDG	P14	228 m S
FENCE-TCF/PRKNG LOT	P28	259 m ESE

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-1 (continued)

Environmental TLD Locations Within the PNPS Protected Area

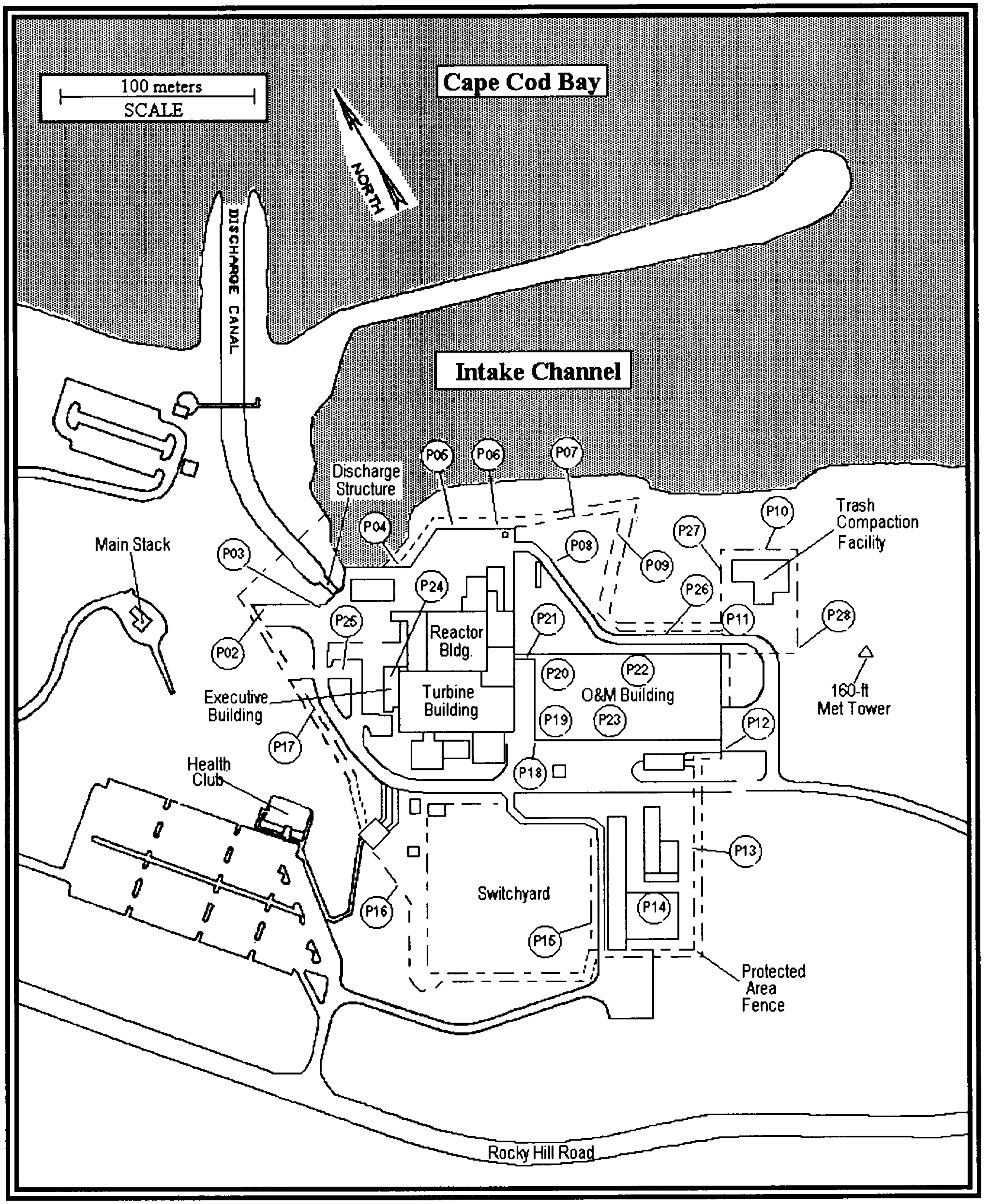


Figure 2.2-2

TLD and Air/Soil Sampling Locations: Within 1 Kilometer

TLD Station		Location*	Air/Soil Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
BOAT LAUNCH WEST	BLW	0.11 km E	OVERLOOK AREA	OA	0.15 km W
OVERLOOK AREA	OA	0.15 km W	PEDESTRIAN BRIDGE	PB	0.21 km N
HEALTH CLUB	TC	0.15 km WSW	MEDICAL BUILDING	WS	0.23 km SSE
BOAT LAUNCH EAST	BLE	0.16 km ESE	EAST BREAKWATER	EB	0.44 km ESE
PEDESTRIAN BRIDGE	PB	0.21 km N	PROPERTY LINE	PL	0.54 km NNW
SHOREFRONT SECURITY	P01	0.22 km NNW	W ROCKY HILL ROAD	WR	0.83 km WNW
MEDICAL BUILDING	WS	0.23 km SSE	E ROCKY HILL ROAD	ER	0.89 km SE
PARKING LOT	CT	0.31 km SE			
SHOREFRONT PARKING	PA	0.35 km NNW			
STATION A	A	0.37 km WSW			
STATION F	F	0.43 km NW			
STATION B	B	0.44 km S			
EAST BREAKWATER	EB	0.44 km ESE			
PNPS MET TOWER	PMT	0.44 km WNW			
STATION H	H	0.47 km SW			
STATION I	I	0.48 km WNW			
STATION L	L	0.50 km ESE			
STATION G	G	0.53 km W			
STATION D	D	0.54 km NW			
PROPERTY LINE	PL	0.54 km NNW			
STATION C	C	0.57 km ESE			
HALL'S BOG	HB	0.63 km SE			
GREENWOOD HOUSE	GH	0.65 km ESE			
W ROCKY HILL ROAD	WR	0.83 km WNW			
E ROCKY HILL ROAD	ER	0.89 km SE			

Figure 2.2-2 (continued)

TLD and Air/Soil Sampling Locations: Within 1 Kilometer

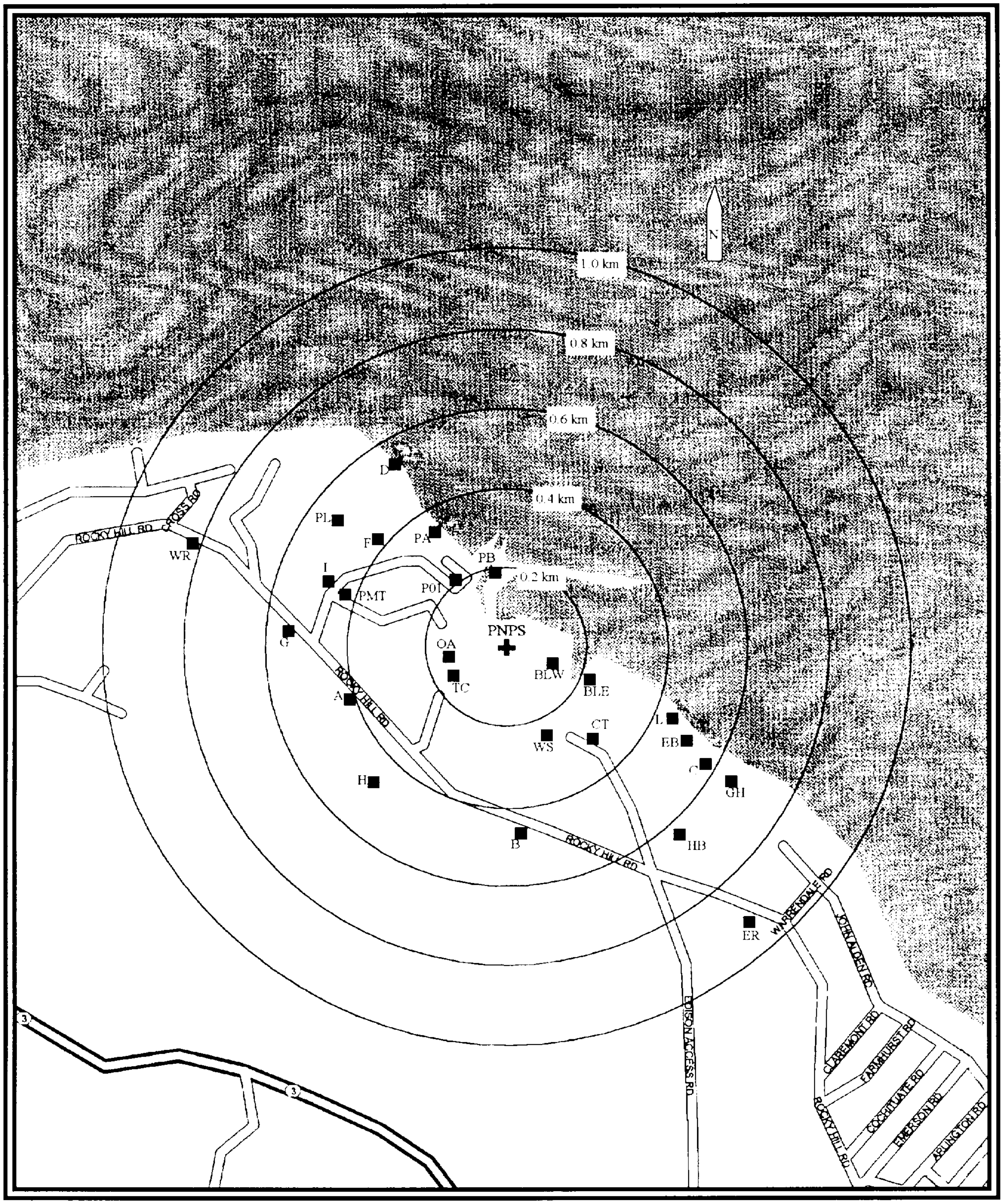


Figure 2.2-3

TLD and Air/Soil Sampling Locations: 1 to 5 Kilometers

TLD Station		Location*	Air/Soil Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
MICROWAVE TOWER	MT	1.03 km SSW	CLEFT ROCK	CR	1.27 km SSW
CLEFT ROCK	CR	1.27 km SSW	MANOMET SUBSTATION	MS	3.60 km SSE
BAYSHORE/GATE RD	BD	1.34 km WNW			
MANOMET ROAD	MR	1.38 km S			
DIRT ROAD	DR	1.48 km SW			
EMERSON ROAD	EM	1.53 km SSE			
EMERSON/PRISCILLA	EP	1.55 km SE			
EDISON ACCESS ROAD	AR	1.59 km SSE			
BAYSHORE	BS	1.76 km W			
STATION E	E	1.86 km S			
JOHN GAULEY	JG	1.99 km W			
STATION J	J	2.04 km SSE			
WHITEHORSE ROAD	WH	2.09 km SSE			
PLYMOUTH YMCA	RC	2.09 km WSW			
STATION K	K	2.17 km S			
TAYLOR/THOMAS	TT	2.26 km SE			
YANKEE VILLAGE	YV	2.28 km WSW			
GOODWIN PROPERTY	GN	2.38 km SW			
RIGHT OF WAY	RW	2.83 km S			
TAYLOR/PEARL	TP	2.98 km SE			
Zone 2 TLDs: 3-8 km					
VALLEY ROAD	VR	3.26 km SSW			
MANOMET ELEM	ME	3.29 km SE			
WARREN/CLIFFORD	WC	3.31 km W			
RT.3A/BARTLETT RD	BB	3.33 km SSE			
MANOMET POINT	MP	3.57 km SE			
MANOMET SUBSTATION	MS	3.60 km SSE			
BEACHWOOD ROAD	BW	3.93 km SE			
PINES ESTATE	PT	4.44 km SSW			
EARL ROAD	EA	4.60 km SSE			
S PLYMOUTH SUBST	SP	4.62 km W			
ROUTE 3 OVERPASS	RP	4.81 km SW			
RUSSELL MILLS RD	RM	4.85 km WSW			

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-3 (continued)

TLD and Air/Soil Sampling Locations: 1 to 5 Kilometers

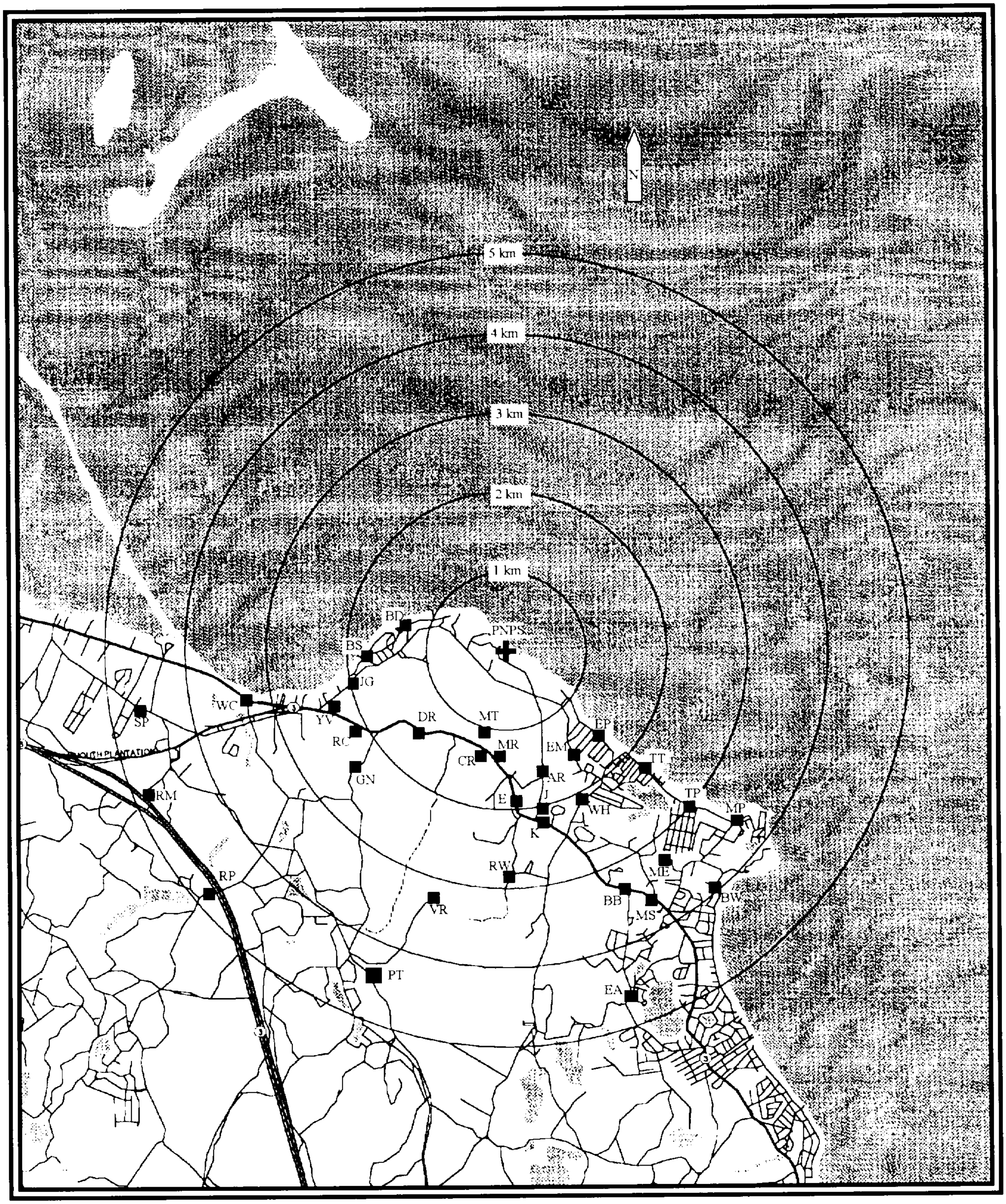


Figure 2.2-4

TLD and Air/Soil Sampling Locations: 5 to 25 Kilometers

TLD Station		Location*	Air/Soil Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 2 TLDs: 3-8 km					
HILLDALE ROAD	HD	5.18 km W	PLYMOUTH CENTER	PC	6.69 km W
MANOMET BEACH	MB	5.43 km SSE			
BEAVERDAM ROAD	BR	5.52 km S			
PLYMOUTH CENTER	PC	6.69 km W			
LONG POND/DREW RD	LD	6.97 km WSW			
HYANNIS ROAD	HR	7.33 km SSE			
MEMORIAL HALL	MH	7.58 km WNW			
SAQUISH NECK	SN	7.58 km NNW			
COLLEGE POND	CP	7.59 km SW			
Zone 3 TLDs: 8-15 km					
DEEP WATER POND	DW	8.59 km W			
LONG POND ROAD	LP	8.88 km SSW			
NORTH PLYMOUTH	NP	9.38 km WNW			
STANDISH SHORES	SS	10.39 km NW			
ELLISVILLE ROAD	EL	11.52 km SSE			
UP COLLEGE POND RD	UC	11.78 km SW			
SACRED HEART	SH	12.92 km W			
KING CAESAR ROAD	KC	13.11 km NNW			
BOURNE ROAD	BE	13.37 km S			
SHERMAN AIRPORT	SA	13.43 km WSW			
Zone 4 TLDs: >15 km					
CEDARVILLE SUBST	CS	15.93 km S			
KINGSTON SUBST	KS	16.15 km WNW			
LANDING ROAD	LR	16.46 km NNW			
CHURCH/WEST	CW	16.56 km NW			
MAIN/MEADOW	MM	17.02 km WSW			
DIV MARINE FISH	DMF	20.97 km SSE			

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-4 (continued)

TLD and Air/Soil Sampling Locations: 5 to 25 Kilometers

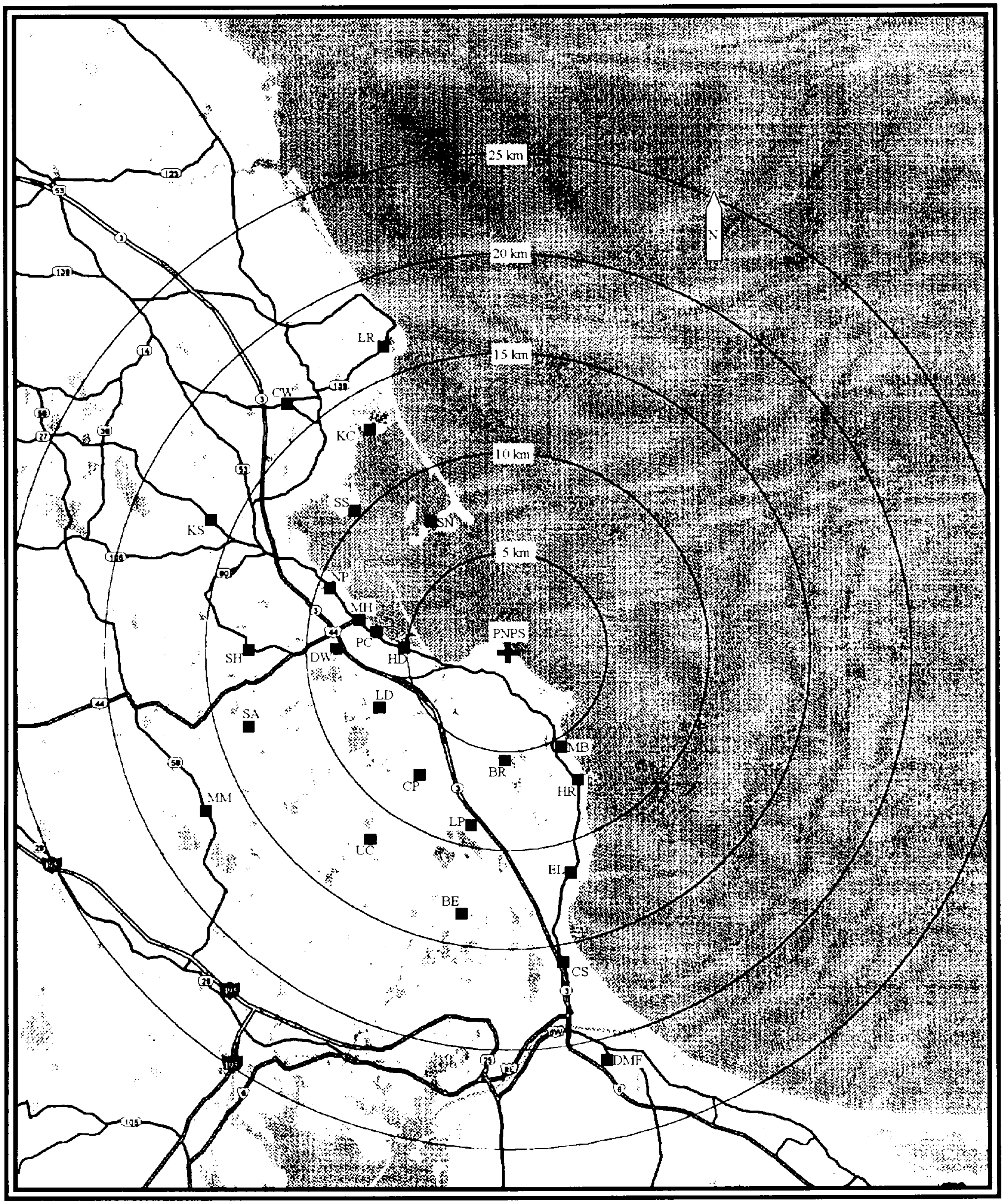


Figure 2.2-5

Terrestrial and Aquatic Sampling Locations

Description	Code	Distance/Direction*
MILK		
Plymouth County Farm	CF	5.6 km W
Whitman Farm Control	WF	34 km WNW
FORAGE		
Whipple Farm	WH	2.9 km SW
Plymouth County Farm	CF	5.6 km W
Whitman Farm Control	WF	34 km WNW
VEGETABLES/VEGETATION		
Site Boundary C	BC	0.5 km SW
Site Boundary B	BB	0.5 km ESE
Rocky Hill Road	RH	0.9 km SE
Site Boundary D	Bd	1.1 km SSW
Site Boundary A	BA	1.5 km SSW
Clay Hill Road	CH	1.6 km W
Brook Road	BK	2.9 km SSE
Beaverdam Road	BD	3.4 km S
Plymouth County Farm	CF	5.6 km W
Div. Marine Fisheries	DMF	21 km SSE
Bridgewater Farm Control	BF	31 km W
Norton Control	NC	50 km W
CRANBERRIES		
Manomet Point Bog	MR	3.9 km SE
Bartlett Road Bog	BT	4.3 km SSE
Pine Street Bog Control	PS	26 km WNW

Description	Code	Distance/Direction*
SURFACE WATER		
Discharge Canal	DIS	0.2 km N
Bartlett Pond	BP	2.7 km SE
Powder Point Control	PP	13 km NNW
IRISH MOSS		
Discharge Canal Outfall	DIS	0.7 km NNE
Manomet Point	MP	4.0 km ESE
Ellisville	EL	12 km SSE
Brant Rock Control	BK	18 km NNW
SHELLFISH		
Discharge Canal Outfall	DIS	0.7 km NNE
Plymouth Harbor	PLY-H	4.1 km W
Manomet Point	MP	4.0 km ESE
Duxbury Bay Control	DUX-BAY	13 km NNW
Powder Point Control	PP	13 km NNW
Green Harbor Control	GH	16 km NNW
LOBSTER		
Discharge Canal Outfall	DIS	0.5 km N
Plymouth Beach	PLB	4.0 km W
Plymouth Harbor	PLY-H	6.4 km WNW
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Discharge Canal Outfall	DIS	0.5 km N
Plymouth Beach	PLB	4.0 km W
Jones River Control	JR	13 km WNW
Cape Cod Bay Control	CC-BAY	24 km ESE
N River-Hanover Control	NR	24 km NNW
Cataumet Control	CA	32 km SSW
Provincetown Control	PT	32 km NE
Buzzards Bay Control	BB	40 km SSW
Priest Cove Control	PC	48 km SW
Nantucket Sound Control	NS	48 km SSE
Atlantic Ocean Control	AO	48 km E
Vineyard Sound Control	MV	64 km SSW
SEDIMENT		
Discharge Canal Outfall	DIS	0.8 km NE
Plymouth Beach	PLB	4.0 km W
Manomet Point	MP	3.3 km ESE
Plymouth Harbor	PLY-H	4.1 km W
Duxbury Bay Control	DUX-BAY	14 km NNW
Green Harbor Control	GH	16 km NNW

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

Figure 2.2-5 (continued)

Terrestrial and Aquatic Sampling Locations

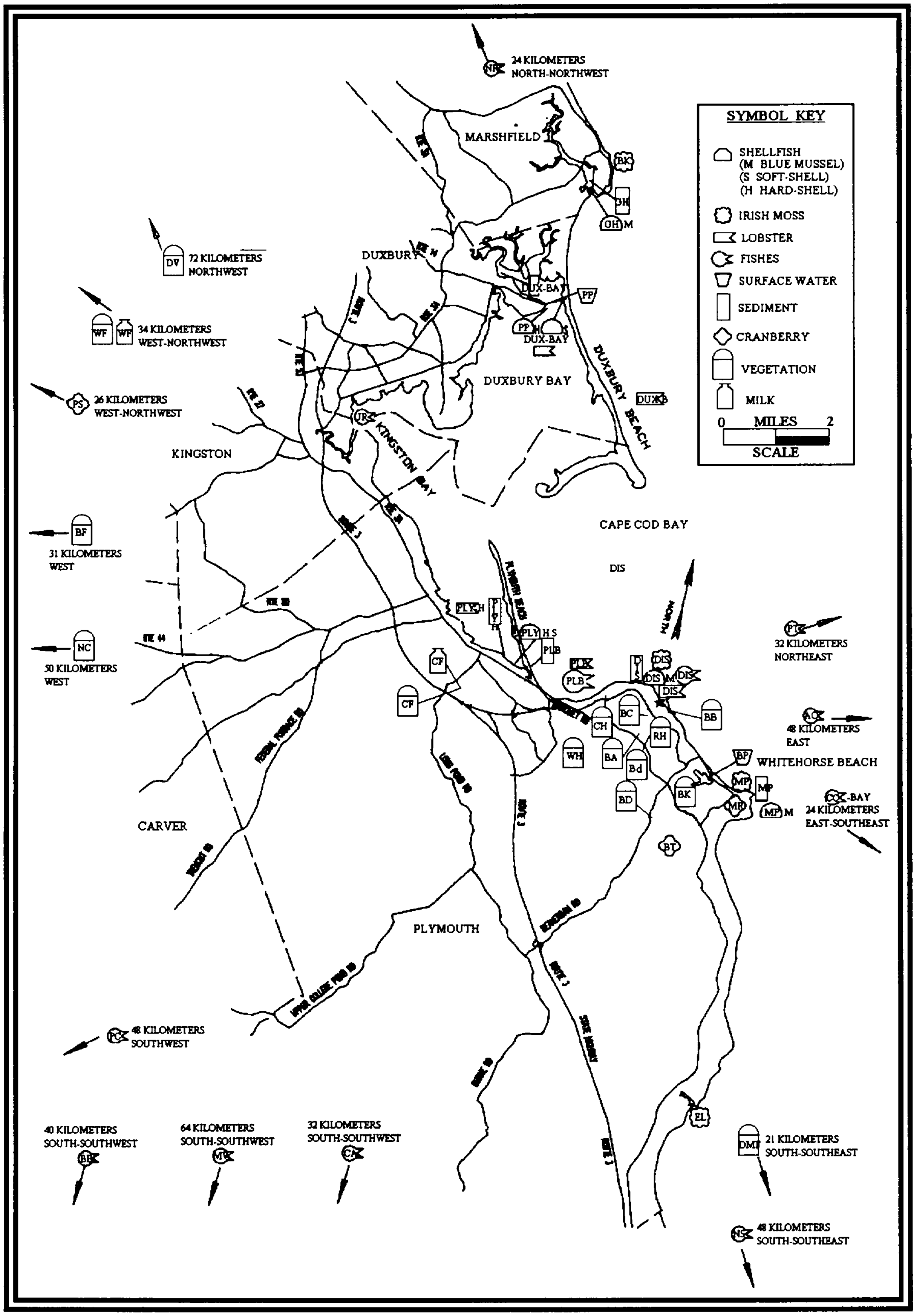


Figure 2.2-6

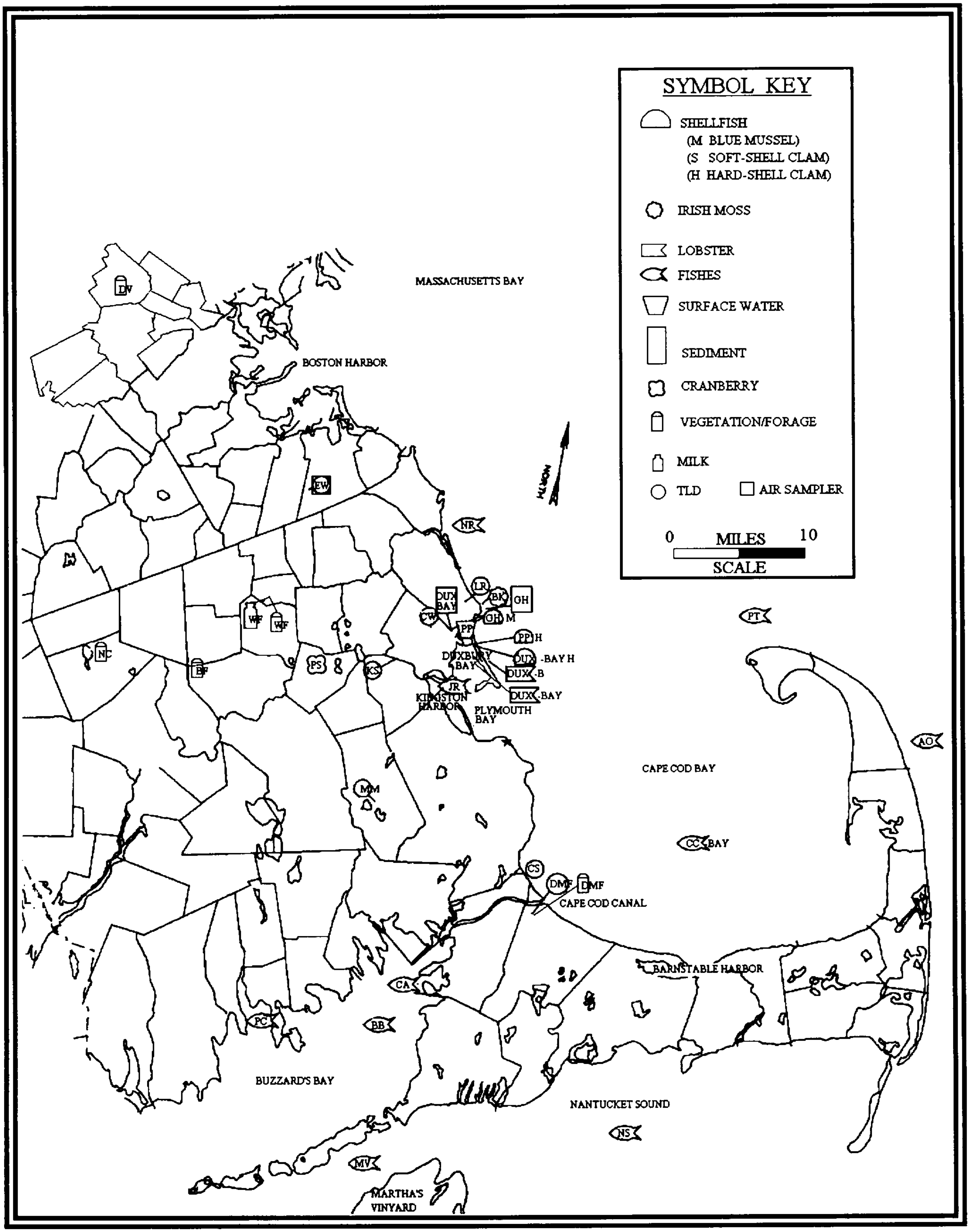
Environmental Sampling And Measurement Control Locations

Description	Code	Distance/Direction*	Description	Code	Distance/Direction*
<u>TLD</u>			<u>SURFACE WATER</u>		
Cedarville Substation	CS	16 km S	Powder Point Control	PP	13 km NNW
Kingston Substation	KS	16 km WNW			
Landing Road	LR	16 km NNW	<u>IRISH MOSS</u>		
Church & West Street	CW	17 km NW	Brant Rock Control	BK	18 km NNW
Main & Meadow Street	MM	17 km WSW			
Div. Marine Fisheries	DMF	21 km SSE	<u>SHELLFISH</u>		
East Weymouth	EW	40 km NW	Duxbury Bay Control	DUX-BAY	13 km NNW
Substation					
			Powder Point Control	PP	13 km NNW
<u>AIR SAMPLER</u>			Green Harbor Control	GH	16 km NNW
East Weymouth	EW	40 km NW			
Substation					
			<u>LOBSTER</u>		
<u>MILK</u>			Duxbury Bay Control	DUX-BAY	11 km NNW
Whitman Farm Control	WF	34 km WNW			
			<u>FISHES</u>		
<u>FORAGE</u>			Jones River Control	JR	13 km WNW
Whitman Farm Control	WF	34 km WNW	Cape Cod Bay Control	CC-BAY	24 km ESE
			N River-Hanover Control	NR	24 km NNW
<u>VEGETABLES/VEGETATION</u>			Cataumet Control	CA	32 km SSW
Div. Marine Fish. Control	DMF	21 km SSE	Provincetown Control	PT	32 km NE
Bridgewater Farm Control	BF	31 km W	Buzzards Bay Control	BB	40 km SSW
Norton Control	NC	50 km W	Priest Cove Control	PC	48 km SW
			Nantucket Sound Control	NS	48 km SSE
			Atlantic Ocean Control	AO	48 km E
<u>CRANBERRIES</u>			Vineyard Sound Control	MV	64 km SSW
Pine Street Bog Control	PS	26 km WNW			
			<u>SEDIMENT</u>		
<u>SOIL</u>			Duxbury Bay Control	DUX-BAY	14 km NNW
East Weymouth	EW	40 km NW	Green Harbor Control	GH	16 km NNW
Substation					

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

Figure 2.2-6 (continued)

Environmental Sampling And Measurement Control Locations



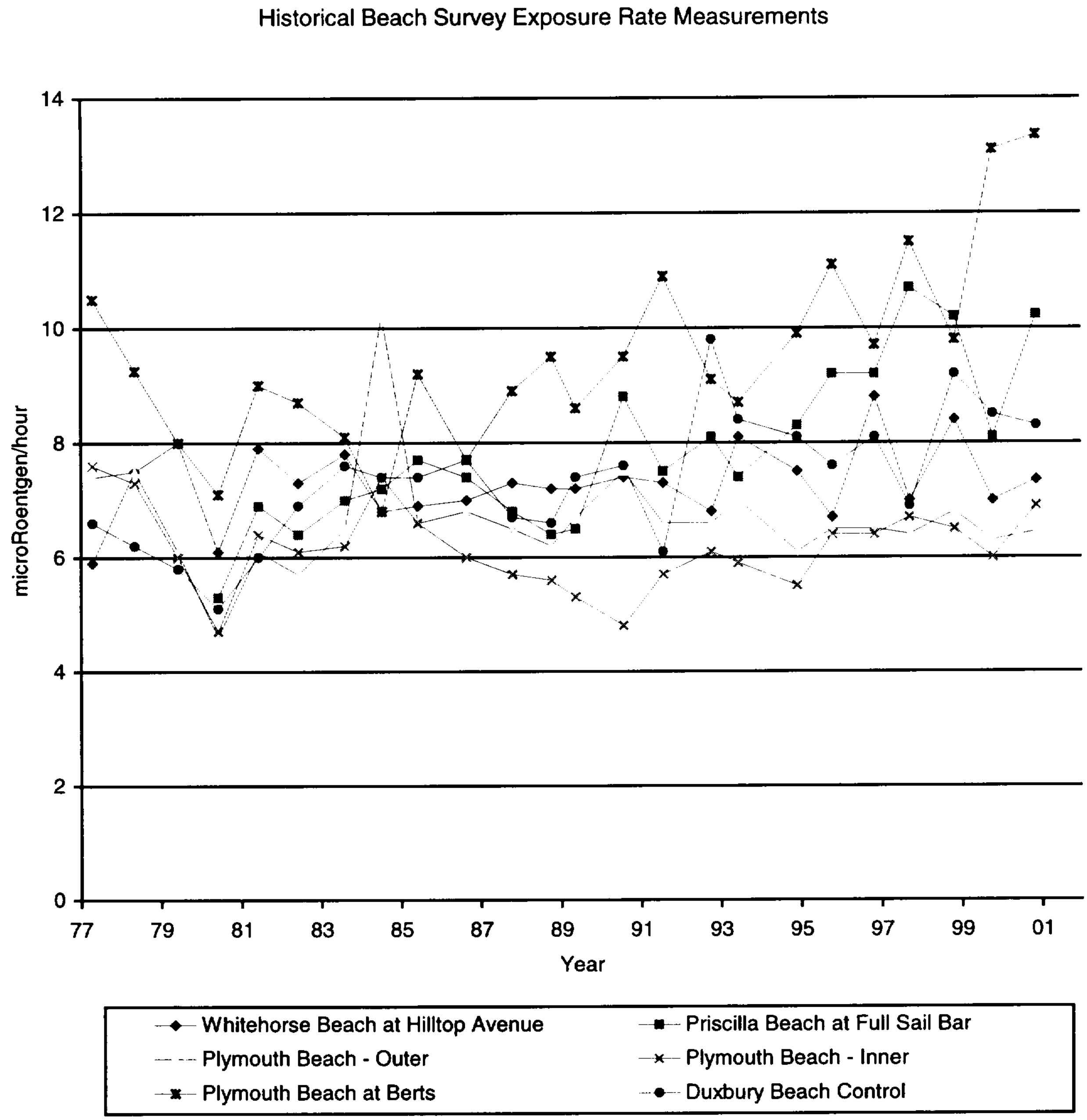


Figure 2.4-1
Historical Beach Survey Exposure Rate Measurements

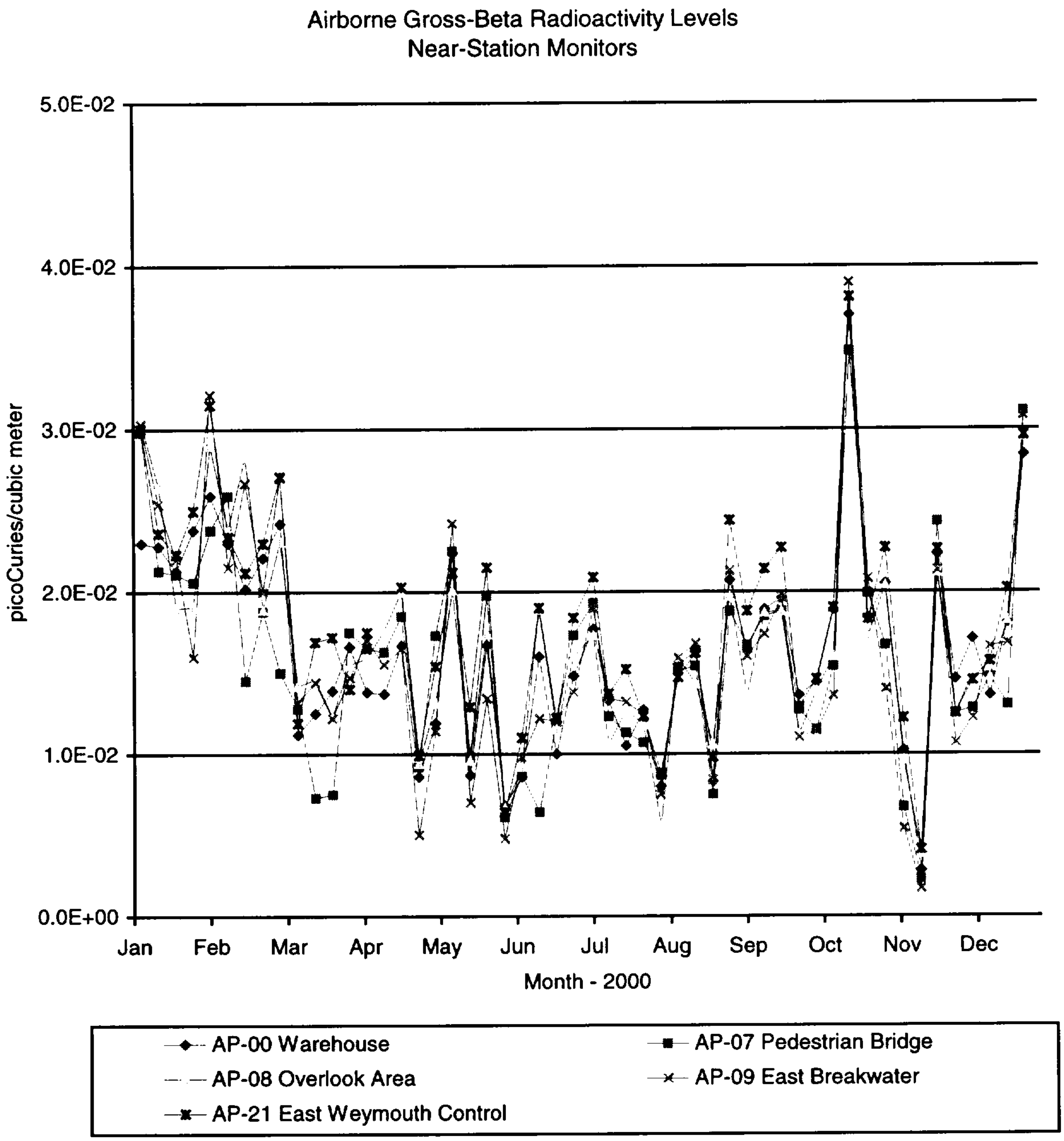


Figure 2.5-1
Airborne Gross-Beta Radioactivity Levels: Near Station Monitors

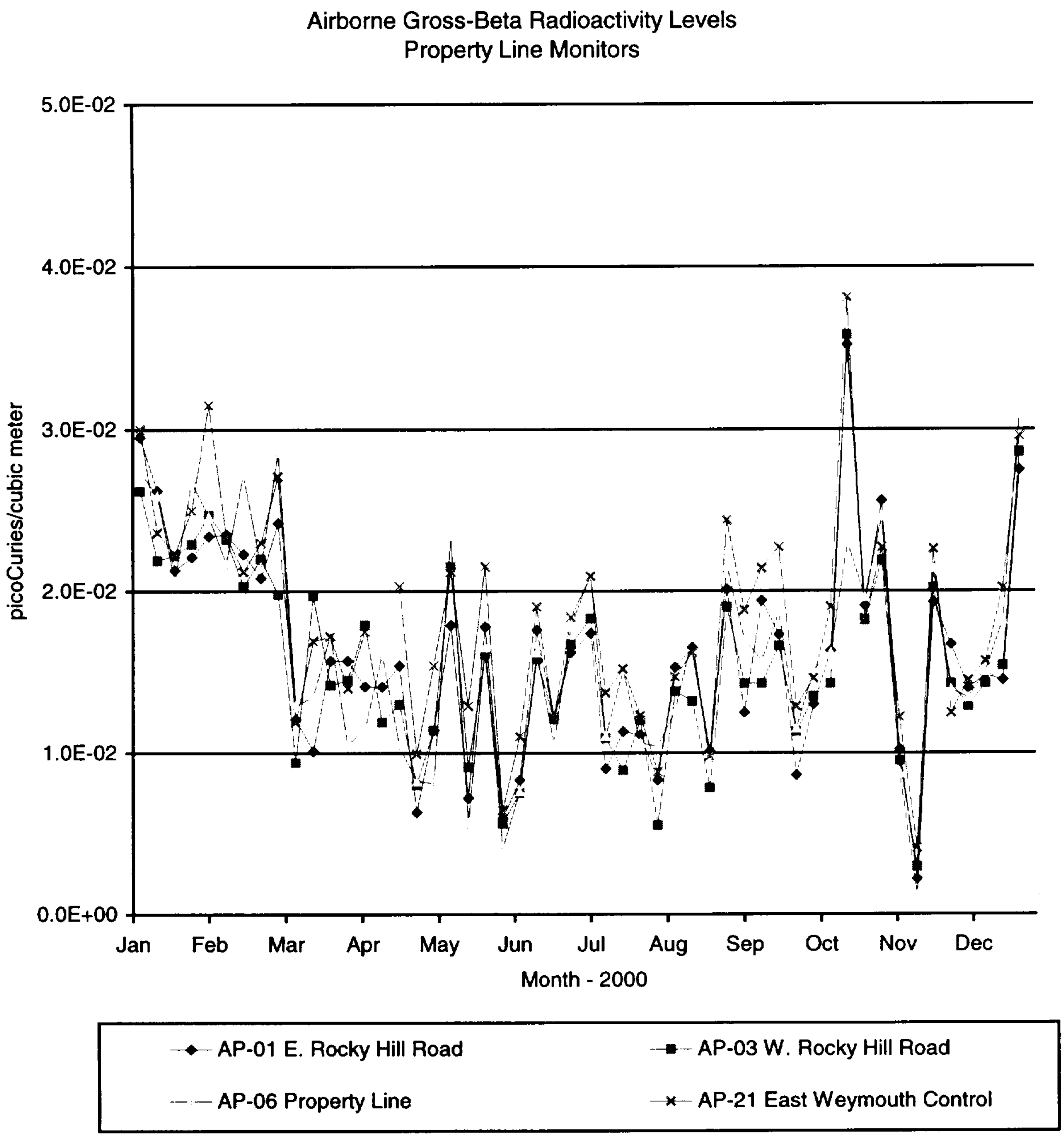


Figure 2.5-2
Airborne Gross-Beta Radioactivity Levels: Property Line Monitors

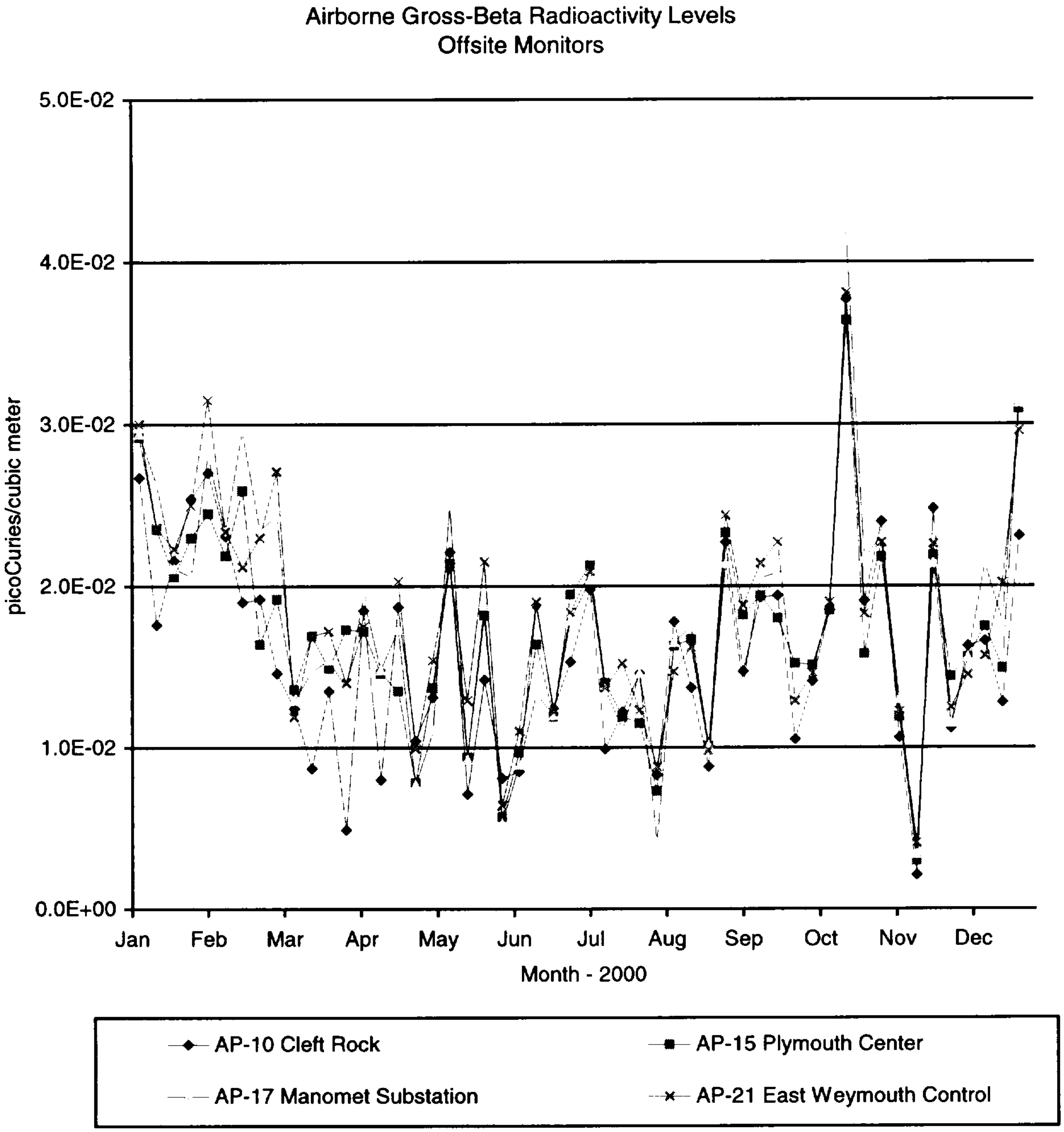


Figure 2.5-3
Airborne Gross-Beta Radioactivity Levels: Offsite Monitors

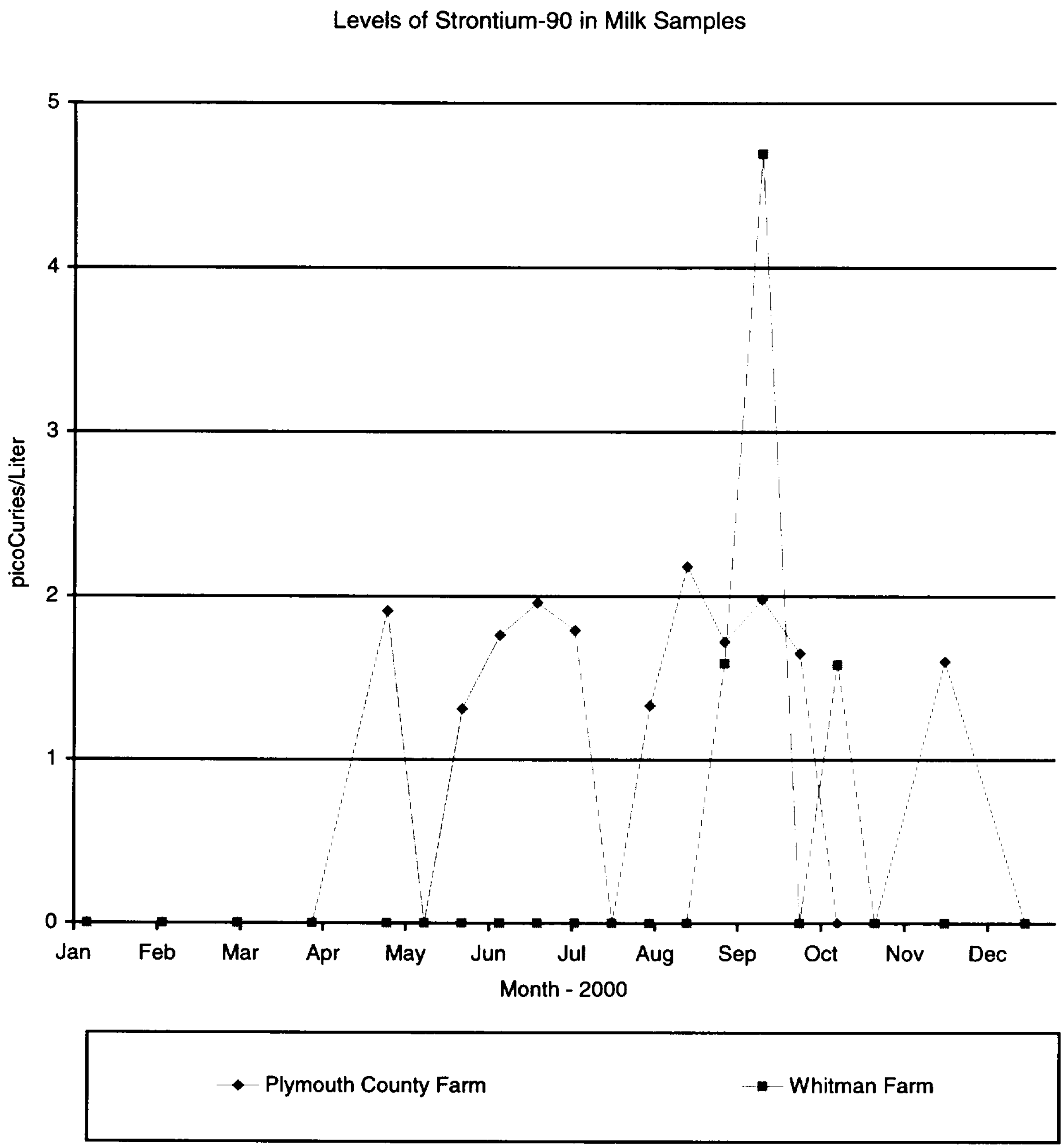


Figure 2.7-1
Levels of Strontium-90 in Milk Samples

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 effluents; and

2) calculations based on measurements of environmental samples.

The first method utilizes data from the radioactive effluents (measured at the point of release) together with conservative models that calculate the dispersion and transport of radioactivity through the environment to humans (Reference 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 2000 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 "Radioactive Effluent and Waste Disposal Report" for the period of January 1 through December 31, 2000.

Table 3.0-1

Radiation Doses from 2000 Pilgrim Station Operations

Receptor	Maximum Individual Dose From Exposure Pathway - mrem/yr			
	Gaseous Effluents*	Liquid Effluents	Ambient Radiation**	Total
Total Body	0.76	0.010	2.4	3.2
Thyroid	0.92	0.00040	2.4	3.3
Max. Organ	0.18	0.058	2.4	2.6

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

** Ambient radiation dose for the hypothetical maximum-exposed individual at a location on PNPS property yielding highest ambient radiation exposure value as measured with TLDs.

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 100 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 1301, 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 (e.g.,. 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 2000, 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 2000, no plant-related radioactivity was detected in any of the environmental samples collected in the vicinity of Pilgrim Station.

In conclusion, the radiological impact of Pilgrim Station operations, whether based on actual environmental measurements or calculations made from effluent releases, would yield doses well within any federal dose limits set by the NRC or EPA. Such doses represent only a small percentage of the typical annual dose received from natural and man-made sources of radiation.

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) Pilgrim Nuclear Power Station Offsite Dose Calculation Manual, Revision 8, August 1998.

8) United States of America, Code of Federal Regulations, Title 10, Part 20.1301.

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.

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 Offsite Radiological Monitoring - June 9, 1977.

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

18) J. Pelczar, Duke Engineering and Services, "Summary of the Results of the 2000 PNPS Beach Survey," REG 00-088, December 27, 2000.

APPENDIX A

SPECIAL STUDIES

No radioactivity attributable to Pilgrim Station operations was detected in environmental samples collected during 2000. Therefore, no special dose calculation studies were performed for year 2000.

APPENDIX B

Effluent Release Information

TABLE	TITLE	PAGE
B.1	Supplemental Information	77
B.2-A	Gaseous Effluents Summation of All Releases	79
B.2-B	Gaseous Effluents - Elevated Releases	81
B.2-C	Gaseous Effluents - Ground Level Releases	83
B.3-A	Liquid Effluents Summation of All Releases	85
B.3-B	Liquid Effluents	87

Table B.1
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Supplemental Information
January-June 2000

FACILITY: PILGRIM NUCLEAR POWER STATION **LICENSE: DPR-35**

1. REGULATORY LIMITS

a. Fission and activation gases:	500 mrem/yr total body and 3000 mrem/yr for skin at site boundary
b,c. Iodines, particulates with half-life: >8 days, tritium	1500 mrem/yr to any organ at site boundary
d. Liquid effluents:	0.06 mrem/month for whole body and 0.2 mrem/month for any organ (without radwaste treatment)

2. EFFLUENT CONCENTRATION LIMITS

a. Fission and activation gases:	10CFR20 Appendix B Table II
b. Iodines:	10CFR20 Appendix B Table II
c. Particulates with half-life > 8 days:	10CFR20 Appendix B Table II
d. Liquid effluents:	2E-04 μCi/mL for entrained noble gases; 10CFR20 Appendix B Table II values for all other radionuclides

3. AVERAGE ENERGY

Not Applicable

4. MEASUREMENTS AND APPROXIMATIONS OF TOTAL RADIOACTIVITY

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

High purity germanium gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquid effluents), Sr-89, and Sr-90

	Jan-Mar 2000	Apr-Jun 2000
5. BATCH RELEASES		
a. Liquid Effluents		
1. Total number of releases:	1.40E+01	1.70E+01
2. Total time period (minutes):	8.05E+02	1.09E+03
3. Maximum time period (minutes):	1.25E+02	2.00E+02
4. Average time period (minutes):	5.75E+01	6.41E+01
5. Minimum time period (minutes):	2.50E+01	2.50E+01
6. Average stream flow (Liters/min): during periods of release of effluents into a flowing stream	1.17E+06	1.17E+06
b. Gaseous Effluents	None	None
6. ABNORMAL RELEASES		
a. Liquid Effluents	None	None
b. Gaseous Effluents	None	None

Table B.1 (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Supplemental Information
July-December 2000

FACILITY: PILGRIM NUCLEAR POWER STATION **LICENSE: DPR-35**

1. REGULATORY LIMITS

a. Fission and activation gases: 500 mrem/yr total body and 3000 mrem/yr for skin at site boundary

b,c. Iodines, particulates with half-life: >8 days, tritium: 1500 mrem/yr to any organ at site boundary

d. Liquid effluents: 0.06 mrem/month for whole body and 0.2 mrem/month for any organ (without radwaste treatment)

2. EFFLUENT CONCENTRATION LIMITS

a. Fission and activation gases: 10CFR20 Appendix B Table II
b. Iodines: 10CFR20 Appendix B Table II
c. Particulates with half-life > 8 days: 10CFR20 Appendix B Table II
d. Liquid effluents: 2E-04 µCi/mL for entrained noble gases; 10CFR20 Appendix B Table II values for all other radionuclides

3. AVERAGE ENERGY

Not Applicable

4. MEASUREMENTS AND APPROXIMATIONS OF TOTAL RADIOACTIVITY

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

High purity germanium gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquid effluents), Sr-89, and Sr-90

	Jul-Sep 2000	Oct-Dec 2000
5. BATCH RELEASES		
a. Liquid Effluents		
1. Total number of releases:	2.60E+01	1.00E+01
2. Total time period (minutes):	2.02E+03	4.27E+02
3. Maximum time period (minutes):	1.95E+02	1.50E+02
4. Average time period (minutes):	7.77E+01	4.27E+01
5. Minimum time period (minutes):	2.50E+01	2.20E+01
6. Average stream flow (Liters/min): during periods of release of effluents into a flowing stream	1.17E+06	1.17E+06
b. Gaseous Effluents	None	None
6. ABNORMAL RELEASES		
a. Liquid Effluents	None	None
b. Gaseous Effluents	None	1: Oct 6-8, 2000

Table B.2-A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Summation of All Releases
January-June 2000

	Period: Jan-Mar 2000	Period: Apr-Jun 2000	Estimated Total Error
A. FISSION AND ACTIVATION GASES			
Total Release: Ci	1.24E+02	1.72E+02	±22%
Average Release Rate During Period: µCi/sec	1.57E+01	2.18E+01	
Percent of Effluent Control Limit	*	*	
B. IODINES			
Total Iodine-131 Release: Ci	3.44E-04	4.09E-04	±20%
Average Release Rate During Period: µCi/sec	4.36E-05	5.18E-05	
Percent of Effluent Control Limit	*	*	
C. PARTICULATES			
Total Release: Ci	5.72E-04	7.34E-04	±21%
Average Release Rate During Period: µCi/sec	7.25E-05	9.30E-05	
Percent of Effluent Control Limit	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	
D. TRITIUM			
Total Release: Ci	1.16E+01	1.95E+01	±20%
Average Release Rate During Period: µCi/sec	1.47E+00	2.47E+00	
Percent of Effluent Control Limit	*	*	

Notes for Table 2.2-A:

* Percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for airborne gross alpha activity listed as NDA is 1E-11 µCi/cc.

Table B.2-A (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Summation of All Releases
July-December 2000

	Period: Jul-Sep 2000	Period: Oct-Dec 2000	Estimated Total Error
A. FISSION AND ACTIVATION GASES			
Total Release: Ci	1.74E+02	1.93E+02	±22%
Average Release Rate During Period: µCi/sec	2.21E+01	2.44E+01	
Percent of Effluent Control Limit	*	*	
B. IODINES			
Total Iodine-131 Release: Ci	4.64E-04	4.02E-04	±20%
Average Release Rate During Period: µCi/sec	5.88E-05	5.10E-05	
Percent of Effluent Control Limit	*	*	
C. PARTICULATES			
Total Release: Ci	5.75E-04	8.13E-04	±21%
Average Release Rate During Period: µCi/sec	7.29E-05	1.03E-04	
Percent of Effluent Control Limit	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	
D. TRITIUM			
Total Release: Ci	2.26E+01	3.44E+01	±20%
Average Release Rate During Period: µCi/sec	2.87E+00	4.36E+00	
Percent of Effluent Control Limit	*	*	

Notes for Table 2.2-A:

* Percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for airborne gross alpha activity listed as NDA is 1E-11 µCi/cc.

Table B.2-B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Elevated Release
January-June 2000

Nuclide Released	Continuous Mode		Batch Mode	
	Jan-Mar 2000	Apr-Jun 2000	Jan-Mar 2000	Apr-Jun 2000
1. FISSION AND ACTIVATION GASES - Ci				
Ar-41	1.53E+00	2.54E+00	N/A	N/A
Kr-85m	2.52E+01	3.02E+01	N/A	N/A
Kr-87	1.48E+01	2.10E+01	N/A	N/A
Kr-88	4.07E+01	7.00E+01	N/A	N/A
Xe-133	2.05E+01	2.10E+01	N/A	N/A
Xe-135	1.55E+01	1.91E+01	N/A	N/A
Xe-135m	NDA	2.14E+00	N/A	N/A
Total for period	1.18E+02	1.66E+02	N/A	N/A
2. IODINES – Ci				
I-131	1.75E-04	1.90E-04	N/A	N/A
I-133	9.04E-04	1.19E-03	N/A	N/A
Total for period	1.08E-03	1.38E-03	N/A	N/A
3. PARTICULATES – Ci				
Mn-54	7.65E-07	NDA	N/A	N/A
Co-60	3.01E-06	2.20E-06	N/A	N/A
Sr-89	3.14E-05	3.70E-05	N/A	N/A
Sr-90	5.71E-07	NDA	N/A	N/A
Cs-137	3.29E-07	9.57E-07	N/A	N/A
Ba/La-140	3.39E-04	3.57E-04	N/A	N/A
Total for period	3.75E-04	3.97E-04	N/A	N/A
4. TRITIUM – Ci				
H-3	9.15E-01	1.78E+00	N/A	N/A

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for airborne radionuclides listed as NDA are as follows:
   - Fission Gases: 1E-04 µCi/cc
   - Iodines: 1E-12 µCi/cc
   - Particulates: 1E-11 µCi/cc

Table B.2-B (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Elevated Release
July-December 2000

Nuclide Released	Continuous Mode		Batch Mode	
	Jul-Sep 2000	Oct-Dec 2000	Jul-Sep 2000	Oct-Dec 2000
1. FISSION AND ACTIVATION GASES - Ci				
Ar-41	2.98E+00	7.27E+00	N/A	N/A
Kr-85m	2.97E+01	3.84E+01	N/A	N/A
Kr-87	2.63E+01	2.26E+01	N/A	N/A
Kr-88	7.05E+01	5.61E+01	N/A	N/A
Xe-133	1.98E+01	2.65E+01	N/A	N/A
Xe-135	2.11E+01	5.07E+00	N/A	N/A
Xe-135m	2.60E-01	NDA	N/A	N/A
Total for period	1.71E+02	1.56E+02	N/A	N/A
2. IODINES – Ci				
I-131	2.75E-04	2.85E-04	N/A	N/A
I-133	1.56E-03	1.20E-03	N/A	N/A
Total for period	1.84E-03	1.49E-03	N/A	N/A
3. PARTICULATES – Ci				
Mn-54	2.28E-07	9.30E-07	N/A	N/A
Co-60	2.67E-06	6.51E-05	N/A	N/A
Sr-89	2.72E-05	6.12E-05	N/A	N/A
Ru-103	NDA	3.29E-07	N/A	N/A
Cs-137	2.31E-06	4.01E-06	N/A	N/A
Ba/La-140	2.69E-04	2.56E-04	N/A	N/A
Total for period	3.01E-04	3.87E-04	N/A	N/A
4. TRITIUM – Ci				
H-3	2.13E+00	3.01E+00	N/A	N/A

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 µCi/cc
   Iodines: 1E-12 µCi/cc
   Particulates: 1E-11 µCi/cc

Table B.2-C
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Ground Level Release
January-June 2000

Nuclide Released	Continuous Mode		Batch Mode	
	Jan-Mar 2000	Apr-Jun 2000	Jan-Mar 2000	Apr-Jun 2000
1. FISSION AND ACTIVATION GASES - Ci				
Xe-135	4.44E+00	5.60E+00	N/A	N/A
Xe-135m	1.60E+00	1.88E-01	N/A	N/A
Total for period	6.04E+00	5.79E+00	N/A	N/A
2. IODINES – Ci				
I-131	1.69E-04	2.18E-04	N/A	N/A
I-133	1.51E-03	2.04E-03	N/A	N/A
Total for period	1.68E-03	2.26E-03	N/A	N/A
3. PARTICULATES – Ci				
Cr-51	NDA	3.32E-05	N/A	N/A
Mn-54	6.23E-06	3.24E-08	N/A	N/A
Co-58	2.54E-07	NDA	N/A	N/A
Co-60	2.63E-05	1.01E-05	N/A	N/A
Sr-89	9.82E-05	9.65E-05	N/A	N/A
Ru-103	NDA	1.43E-06	N/A	N/A
Cs-137	2.00E-05	1.38E-05	N/A	N/A
Ba/La-140	4.62E-05	1.82E-04	N/A	N/A
Total for period	1.97E-04	3.37E-04	N/A	N/A
4. TRITIUM – Ci				
H-3	1.07E+01	1.77E+01	N/A	N/A

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for airborne radionuclides listed as NDA are as follows:
   - Fission Gases: 1E-04 μCi/cc
   - Iodines: 1E-12 μCi/cc
   - Particulates: 1E-11 μCi/cc

Table B.2-C (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Ground Level Release
July-December 2000

Nuclide Released	Continuous Mode		Batch Mode	
	Jul-Sep 2000	Oct-Dec 2000	Jul-Sep 2000	Oct-Dec 2000
1. FISSION AND ACTIVATION GASES - Ci				
Kr-85m	NDA	NDA	N/A	3.75E-01
Kr-87	NDA	1.29E+00	N/A	1.65E+00
Xe-135	1.83E+00	1.40E+01	N/A	2.17E+00
Xe-135m	NDA	6.95E+00	N/A	1.93E+00
Xe-137	1.56E+00	1.23E+00	N/A	NDA
Xe-138	NDA	NDA	N/A	7.18E+00
Total for period	3.39E+00	2.34E+01	N/A	1.33E+01
2. IODINES – Ci				
I-131	1.89E-04	1.17E-04	N/A	N/A
I-133	1.67E-03	8.43E-04	N/A	N/A
Total for period	1.86E-03	9.60E-04	N/A	N/A
3. PARTICULATES – Ci				
Cr-51	2.01E-05	NDA	N/A	N/A
Mn-54	1.36E-06	NDA	N/A	N/A
Co-60	1.35E-05	1.31E-05	N/A	N/A
Sr-89	7.47E-05	2.23E-04	N/A	N/A
Ru-103	1.52E-06	2.82E-06	N/A	N/A
Cs-137	1.76E-05	3.75E-05	N/A	N/A
Ba/La-140	1.45E-04	1.49E-04	N/A	N/A
Total for period	2.74E-04	4.25E-04	N/A	N/A
4. TRITIUM – Ci				
H-3	2.05E+01	3.14E+01	N/A	N/A

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 μCi/cc
   Iodines: 1E-12 μCi/cc
   Particulates: 1E-11 μCi/cc

Table B.3-A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents - Summation of All Releases
January-June 2000

	Period: Jan-Mar 2000	Period: Apr-Jun 2000	Estimated Total Error
A. FISSION AND ACTIVATION PRODUCTS			
Total Release (not including H-3, noble gas, or alpha): Ci	1.90E-03	7.97E-04	±12%
Average Diluted Concentration During Period: µCi/mL	2.02E-09	6.23E-10	
Percent of Effluent Concentration Limit*	3.31E-02%	2.65E-02%	
B. TRITIUM			
Total Release: Ci	2.79E+00	4.52E-02	±9.4%
Average Diluted Concentration During Period: µCi/mL	2.96E-06	3.53E-08	
Percent of Effluent Concentration Limit*	2.96E-01%	3.53E-03%	
C. DISSOLVED AND ENTRAINED GASES			
Total Release: Ci	NDA	NDA	±16%
Average Diluted Concentration During Period: µCi/mL	NDA	NDA	
Percent of Effluent Concentration Limit*	NDA	NDA	
D. GROSS ALPHA RADIOACTIVITY			
Total Release: Ci	NDA	NDA	±34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION			
Waste Volume: Liters	1.85E+05	7.76E+04	±5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD			
Dilution Volume: Liters	9.45E+08	1.28E+09	±10%

Notes for Table 2.3-A:

* Additional percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for dissolved and entrained gases listed as NDA is 1E-05 µCi/mL.
3. LLD for liquid gross alpha activity listed as NDA is 1E-07 µCi/mL.

Table B.3-A (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents - Summation of All Releases
July-December 2000

	Period: Jul-Sep 2000	Period: Oct-Dec 2000	Estimated Total Error
A. FISSION AND ACTIVATION PRODUCTS			
Total Release (not including H-3, noble gas, or alpha): Ci	2.10E-01	1.87E-03	±12%
Average Diluted Concentration During Period: µCi/mL	8.89E-08	3.74E-09	
Percent of Effluent Concentration Limit*	2.39E-01%	3.04E-01%	
B. TRITIUM			
Total Release: Ci	7.77E+00	5.11E-02	±9.4%
Average Diluted Concentration During Period: µCi/mL	3.29E-06	1.02E-07	
Percent of Effluent Concentration Limit*	3.29E-01%	1.02E-02%	
C. DISSOLVED AND ENTRAINED GASES			
Total Release: Ci	NDA	NDA	±16%
Average Diluted Concentration During Period: µCi/mL	NDA	NDA	
Percent of Effluent Concentration Limit*	NDA	NDA	
D. GROSS ALPHA RADIOACTIVITY			
Total Release: Ci	NDA	NDA	±34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION			
Waste Volume: Liters	5.94E+05	1.80E+04	±5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD			
Dilution Volume: Liters	2.36E+09	5.01E+08	±10%

Notes for Table 2.3-A:

* Additional percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for dissolved and entrained gases listed as NDA is 1E-05 µCi/mL.
3. LLD for liquid gross alpha activity listed as NDA is 1E-07 µCi/mL.

Table B.3-B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents
January-June 2000

Nuclide Released	Continuous Mode		Batch Mode	
	Jan-Mar 2000	Apr-Jun 2000	Jan-Mar 2000	Apr-Jun 2000
1. FISSION AND ACTIVATION PRODUCTS - Ci				
Mn-54	N/A	N/A	1.47E-04	6.81E-05
Fe-55	N/A	N/A	1.38E-03	1.21E-04
Co-58	N/A	N/A	4.13E-06	NDA
Co-60	N/A	N/A	1.09E-04	4.07E-04
Zn-65	N/A	N/A	9.33E-06	7.21E-06
Sr-90	N/A	N/A	1.40E-06	4.84E-06
I-133	N/A	N/A	NDA	3.02E-07
Cs-137	N/A	N/A	2.53E-04	1.89E-04
Total for period	N/A	N/A	1.90E-03	7.97E-04
2. DISSOLVED AND ENTRAINED GASES - Ci				
Xe-133	N/A	N/A	NDA	NDA
Xe-135	N/A	N/A	NDA	NDA
Total for period	N/A	N/A	NDA	NDA

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 µCi/mL
   - Iodines: 1E-06 µCi/mL
   - Noble Gases: 1E-05 µCi/mL
   - All Others: 5E-07 µCi/mL

Table B.3-B (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents
July-December 2000

Nuclide Released	Continuous Mode Jul-Sep 2000	Continuous Mode Oct-Dec 2000	Batch Mode Jul-Sep 2000	Batch Mode Oct-Dec 2000
1. FISSION AND ACTIVATION PRODUCTS - Ci				
Na-24	N/A	N/A	1.28E-07	NDA
Mn-54	N/A	N/A	1.32E-02	4.38E-05
Fe-55	N/A	N/A	1.88E-01	4.74E-05
Co-58	N/A	N/A	1.49E-05	NDA
Co-60	N/A	N/A	7.42E-03	4.17E-04
Zn-65	N/A	N/A	4.75E-04	NDA
Sr-89	N/A	N/A	NDA	1.19E-05
Sr-90	N/A	N/A	6.99E-05	2.89E-05
Cs-137	N/A	N/A	6.05E-04	1.32E-03
Ce-141	N/A	N/A	2.46E-05	NDA
Total for period	N/A	N/A	2.10E-01	1.87E-03
2. DISSOLVED AND ENTRAINED GASES - Ci				
Xe-133	N/A	N/A	NDA	NDA
Xe-135	N/A	N/A	NDA	NDA
Total for period	N/A	N/A	NDA	NDA

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 µCi/mL
   - Iodines: 1E-06 µCi/mL
   - Noble Gases: 1E-05 µCi/mL
   - All Others: 5E-07 µCi/mL

APPENDIX C

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 October 21 and 30, 2000. The census was conducted by driving along each improved road/street in the Plymouth area within 5 kilometers (3 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 5 km (SSW, WNW, NW, and NNW sectors), the survey was extended to 8 km (5 mi). A total of 29 gardens were identified in the vicinity of Pilgrim Station. In addition, the Town of Plymouth Animal Inspector was contacted for information regarding milk and meat animals.

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 PNPS 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 assessment of the gardens identified during the 2000 land use census, samples of garden-grown vegetables or naturally-growing vegetation (e.g. grass, leaves from bushes or trees, etc.) were collected at or near the closest gardens in each of the following landward compass sectors. These locations, and their distance and direction relative to the PNPS Reactor Building, are as follows:

Rocky Hill Road	0.9 km SE
Brook Road	2.9 km SSE
Beaverdam Road	3.4 km S
Clay Hill Road	1.6 km W

In addition to these special sampling locations identified and sampled in conjunction with the 2000 land use census, samples were also collected at or near the Plymouth County Farm (5.6 km W), Whipple Farm (2.9 km SW), and from a control location in Bridgewater (31 km W).

Samples of naturally-growing vegetation were also collected from the site boundary locations yielding the highest deposition (D/Q) factors for each of the two release points. These locations, and their distance and direction relative to the PNPS Reactor Building were:

Highest Main Stack D/Q:	1.5 km SSW
Highest Reactor Building Vent D/Q:	0.5 km ESE

Control sample of naturally-growing vegetation were collected at the DMF shop in Sandwich (21 km SSE) and in Norton, MA (50 km 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 2000 sampling program.

APPENDIX D

ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES

There were a number of instances during 2000 in which inadvertent issues were encountered in the collection of environmental samples. All of these issues were minor in nature and did not have an adverse affect on the results or integrity of the monitoring program. Details of these various problems are given below.

In 2000, three thermoluminescent dosimeters (TLDs) were not recovered from their assigned locations during the quarterly retrieval process. During the second quarter retrieval, the TLDs were not recovered at Edison Access Road (AR) and Emerson Road (EM). In this case, the TLD missing from its posted location at AR was presumably lost to storm damage or premature weathering of the TLD holder, while the TLD at EM was presumed lost to vandalism. During the third quarter retrieval, the TLD was missing at Upper College Pond (UC). In this case, the plastic straps, plastic cages, and TLD was missing and presumably lost due to vandalism. Steps were taken whenever possible to post the TLD cages in a less conspicuous manner. The 437 TLDs which were collected (99.3%) allowed for adequate assessment of the ambient radiation levels in the vicinity of Pilgrim Station.

Within the air sampling program, there were a few instances in which continuous sampling was interrupted at the eleven airborne sampling locations during 2000. Most of these interruptions were due to short-term power losses and were sporadic and of limited duration (less than 24 hours out of the weekly sampling period). Such events did not have any significant impact on the scope and purpose of the sampling program, and all lower limits of detection (LLDs) were met for both particulates and iodine-131 on the filters.

Power surges resulting in blown fuses contributed to partial sampling at the West Rocky Hill Road (WR) air sampler during the weeks of 07-14 Mar (37.3 hour run time) and 04-11 Apr (146.3 hour run time), and also at he East Weymouth (EW) sampler during the period 22-29 Aug (0.3 hour run time). In all cases, the fuse was found blown, but the sampler operated correctly when the fuse was replaced. The required LLDs were met on the particulate and charcoal samples collected in the WR samples. Due to the extremely low sample collection time for the East Weymouth situation, these samples were not analyzed for this period.

A failure of the pump diaphragm occurred at the Medical Building (WS) air sampler during the week of 23-30 May. In this case, the pump ran for about 5 days before the failure occurred. Due to the nature of the failure, the sampler continued to pump air following the diaphragm failure, but pump capacity was diminished for the last two days of sampling. Again, the required LLDs were met on the particulate and charcoal samples collected, and the results were comparable to other monitoring locations from the same period.

During the week of 22-29 Aug, the ground fault interrupt circuit tripped at the Pedestrian Bridge (PB) air sampler. This resulted in a pump run time of only 26 hours. The GFI was reset and power restored. Despite the low sample flow, the required LLDs for particulate radioactivity and iodine-131 were met on this sample.

During the period 19-Sep through 10-Oct, Commonwealth Electric was performing upgrades to their substation located in Manomet. These activities resulted in isolation of power to the Manomet Station (MS) air sampler during this period. Due to the complete absence of power for the periods 19-26 Sep, 26 Sep-03 Oct, and 03-10 Oct, no samples were collected during these three weeks. Unfortunately, alternate power was not available at this site, and a partial restoration of power to the sampler was considered to pose safety concerns to personnel working on the substation upgrade. Power was restored on 10-Oct, and sampling was resumed as of that date.

Despite the lower-than-normal sampling volumes in the various instances involving power interruptions and equipment failures, required LLDs were met on 579 of the 579 particulate filters and 579 of the 579 iodine cartridges collected during 2000. None of the sample analyses associated with limited pump run times indicated any questionable or anomalous results. When viewed collectively during the entire year of 2000, the following sampling recoveries were achieved in the airborne sampling program:

Location	Recovery	Location	Recovery	Location	Recovery
WS	100.0%	PB	98.4%	PC	100.0%
ER	100.0%	OA	100.0%	MS	94.3%
WR	98.3%	EB	100.0%	EW	98.1%
PL	100.0%	CR	100.0%		

Problems were encountered with the milk sample collected from the Plymouth County Farm on 22-Jun-2000. Chemicals (formaldehyde and methimazole) are normally added to milk samples as preservatives in lieu of refrigeration. Although it is believed that chemical preservatives had been added to that sample, the milk in the container curdled, causing complications in the radiochemical analyses for iodine-131 and strontium-89/90. Although required LLDs were achieved for gamma-emitters in the sample, the LLDs were not achieved for iodine-131. Analyses for strontium-89/90 yielded expected results. This is the first occurrence of this type in over 25 years of sampling. Technicians were cautioned to ensure chemical preservatives are added to the sample containers.

An alternate location had to be found for sampling control vegetable samples in the Bridgewater area. In past years, samples had been collected at the Bridgewater County Farm, associated with the Bridgewater Correctional Facility. Due to loss of state funding for garden projects during 2000, no garden was grown. An alternate location was found at the Hanson Farm in Bridgewater, located in the same compass sector, and at approximately the same distance as the Bridgewater County Farm. As expected for control samples, vegetables collected at this location only contained naturally-occurring radioactivity (K-40).

Samples of naturally-growing vegetation (grass, leaves from trees and bushes, etc.) were collected near some gardens identified during the annual land use census. Due to the unavailability of crops grown in these gardens, these substitute samples were collected as near as practicable to the gardens of interest. In addition to these substitute samples, samples of naturally-growing vegetation were also collected in the three locations yielding the highest calculated deposition coefficients (D/Q) for airborne releases from PNPS. Such samples represent "worst case" samples for comparison, as the deposition and resulting ground-level concentrations of radionuclides at these locations would be 2 to 10 times higher than at the gardens identified during the land use census. No radionuclides attributed to PNPS operations were detected in any of the samples. Additional details regarding the land use census can be found in Appendix E of this report.

In the sampling of water from the discharge canal, two problems were encountered during 2000. During the week of 07-14 Mar, the sampler failed to collect a composite water sample due to the sampling hose being out of the water. The hose had become detached from its anchor in the canal and washed up onto the edge of the canal, preventing the collection of a complete sample. The partial sample was composited into the remainder of the samples for the monthly composite analyses. During the period 18-25 Apr, the pump motor in the water sampler failed. The entire composite sampler was replaced with a spare unit. No problems have occurred since that event.

Samples of Group I (bottom-distribution) and Group II (near-bottom distribution) fishes were not collected in the vicinity of the discharge outfall during the first calendar quarter of 2000. Such fish species move to deeper water during colder months, and were not available. Repeated and concerted efforts were made, but failed to produce fish samples during the first quarter.

Sediment samples for the first half of the year were not collected in the vicinity of the discharge outfall by the 09-Jun-2000 due date. Diving activities necessary to collect the samples had to be delayed due to adverse weather and tide conditions. Sample collection was completed on 16-Jun once favorable weather and tide conditions occurred.

In summary, the various problems encountered in collecting and analyzing environmental samples during 2000 were relatively minor when viewed in the context of the entire monitoring program. None of the discrepancies resulted in an adverse impact on the overall monitoring program.

APPENDIX E

QUALITY ASSURANCE PROGRAM RESULTS

Introduction

The accuracy of the data obtained through the PNPS 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 PNPS from the Duke Engineering and Services Environmental Laboratory (DESEL). Much of the information contained herein has been summarized from the DESEL "Semi-Annual Quality Assurance Status Report: January - June 2000," and the DESEL "Semi-Annual Quality Assurance Status Report: July - December 2000."

Laboratory Analyses

The quality control programs that were performed during 2000 to demonstrate the validity of laboratory analyses by DESEL in the media types of air filter, charcoal (iodine) cartridges, milk, soil/sediment, vegetation, and water. These quality control assessments are performed within the following intercomparison programs:

- DESEL intralaboratory 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.
- DESEL participation in a cross-check program with Analytics, Inc. for environmental air filter, water, and milk samples.
- DESEL participation in a cross-check program with the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards. This comparison program evaluates the E-Lab's performance relative to standard measurement techniques certified by the NIST.

In addition to the intercomparison programs mentioned previously, a blind duplicate program is maintained in which paired samples from the five sponsor companies, including Pilgrim Station, 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 in environmental media typically collected and analyzed for the sponsor companies.

The results of these studies are discussed below.

DESEL Intralaboratory and Independent Interlaboratory Results

Results of the Quality Assurance Program are reported in two separate categories based upon DESEL 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.

The Quality Assurance Program implemented at the analytical laboratory indicated good precision and accuracy in reported values. Table E.1 shows the cumulative results of accuracy and precision for laboratory analyses in 2000 for DESEL intralaboratory analyses, as well as Analytics and NIST interlaboratory cross-check analyses. A total of 589 analyses were performed for accuracy cross-comparisons, while 453 cross-check analyses were performed to assess precision. For accuracy, 61.5% and 85.9% of the results were within 5 and 10 percent of the known values, respectively, with 96.8% of all results falling within the laboratory criterion of 15 percent. For precision, 76.4% and 91.4% of the results were within 5 and 10 percent of the mean, respectively, with 99.8% of all results meeting the laboratory criterion of 15 percent.

TABLE E.1

INTRALABORATORY AND INTERLABORATORY RESULTS – 2000

Category	Total Number of Measurements	Fraction of Measurements within deviation range		
		± 5%	± 10%	± 15%*
	DESEL INTRALABORATORY ANALYSES			
Accuracy	271	76.4%	92.3%	98.5%
Precision	135	78.5%	91.1%	100.0%
	ANALYTICS INTERLABORATORY ANALYSES			
Accuracy	306	47.4%	79.7%	95.1%
Precision	306	74.5%	91.2%	99.7%
	NIST INTERLABORATORY ANALYSES			
Accuracy	12	83.3%	100.0%	100.0%
Precision	12	100.0%	100.0%	100.0%
	TOTAL COMBINED ANALYSES			
Accuracy	589	61.5%	85.9%	96.8%
Precision	453	76.4%	91.4%	99.8%

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

The results of the numerous intercomparisons performed during 2000 validate the quality of the analyses performed by DESEL. Even though some of the analyses may not be directly applicable to samples and analyses encountered in a REMP program, they high degree of compliance reflects the overall quality of laboratory controls in place at DESEL.

Blind Duplicate Program

A total of 36 paired samples were submitted for analysis during 2000. The database used for the duplicate analysis consisted of paired measurements of 25 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% of their average value, then agreement between the measurements has been met. If the value falls outside of the ± 15% 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 36 paired samples, 934 paired duplicate measurements were analyzed during 2000. Out of these measurements, 933 (99.9%) fell within the established criteria discussed above. No trend was evident with respect to repeated failings of measurements for the listed radionuclides and media. The single 'failure' involved gamma spectroscopy pairings for nuclides in which there was no detectable radioactivity in either of the paired measurements.

Environmental TLD Measurements

Quality control testing was performed during 2000 to demonstrate the performance of the routine environmental TLD processing by DESEL. 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 DESEL. In all of these tests, dosimeters were irradiated to known doses and submitted to DESEL 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.

DESEL began performance testing of the Panasonic environmental TLDs in July 1987. The testing included internal performance testing and testing by an independent third party.

A ± 30% 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 2000 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% (for bias) were set by the LQCAC. The actual magnitude of the 3 sigma plus 5% 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 is used as a measure of precision.

The quality control program implemented for dosimetry processing indicated good precision and accuracy in the reported values. In 2000, there were 96 quality control tests. All 48 environmental TLDs tested during January - June 2000 were within the control limits for both accuracy and precision. The comparisons yielded a mean accuracy of –3.15%. The comparisons exhibited a precision value with an overall standard deviation of 3.4%. The 48 TLDs tested in July - December 2000 showed a mean accuracy of 0.4%. TLDs measured during the second semiannual period exhibited a precision value with a standard deviation of 0.97%, well within the acceptance criteria. In total, all 96 environmental TLDs tested during 2000 were within the control limits for both accuracy (± 20.1%) and precision (± 12.8%).

Conclusions

Laboratory analysis results for the independent Interlaboratory Comparison programs (i.e., EPA, Analytics, DOE, and NIST), the DESEL 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 PNPS Radiological Environmental Monitoring Program indicated that the analyses and measurements performed by Duke Engineering and Services Environmental Laboratory during 2000 exhibited acceptable accuracy and precision.