

YANKEE NUCLEAR POWER STATION
ANNUAL RADIOLOGICAL ENVIRONMENTAL
OPERATING REPORT

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1.0 INTRODUCTION

This report summarizes the findings of the Radiological Environmental Monitoring Program (REMP) conducted by Yankee Atomic Electric Company in the vicinity of the Yankee Nuclear Power Station (YNPS) in Rowe, Massachusetts during the calendar year 1993. It is submitted annually in compliance with plant Technical Specification 6.8.2.a.

The remainder of this report is organized as follows:

Section 2: Provides an introductory explanation to the background radioactivity and radiation that is routinely detected in the YNPS environs.

Section 3: Provides a brief description of the YNPS site and its environs.

Section 4: Provides a description of the overall REMF program design. Included is a summary of the Offsite Dose Calculation Manual (ODCM) Requirements for REMF sampling, tables listing all routine sampling and thermoluminescent dosimeter (TLD) monitoring locations with compass sectors and distances from the plant, and maps showing the location of each of the sampling and TLD monitoring locations. Tables listing Lower Limit of Detection requirements and Reporting Levels are also included.

Section 5: Consists of the summarized data as required by the ODCM. The tables are in the format specified by the NRC Radiological Assessment Branch Technical Position on Environmental Monitoring (Reference 1). Also included is a summary of the environmental TLD measurements for 1993.

Section 6: Provides the results of the 1993 monitoring program. The performance of the program in meeting regulatory requirements as given in the Radiological Effluent Technical Specifications and ODCM is discussed, and the data acquired during the year are analyzed.

Section 7: Provides an overview of the Quality Assurance programs used at the Yankee Atomic Environmental Laboratory (YAEL). As required by the ODCM, the results of the EPA Intercomparison Program are given.

Section 8: Summarizes the requirements and the results of the 1993 Land Use Census.

Section 9: Gives an overall summary of the results of the 1993
Radiological Environmental Monitoring Program.

2.0 Naturally Occurring and Man-Made Background Radioactivity

Radiation or radioactivity potentially detected in the YNPS environment can be grouped into three categories. The first is "naturally-occurring" radiation and radioactivity. The second is "man-made" radioactivity from sources other than YNPS. The third potential source of radioactivity is due to emissions from YNPS. For the purposes of the YNPS REMP, the first two categories are classified as "background" radiation, and are the subject of discussion in this section of the report. The third category, radioactivity from plant emissions, is the one that the REMP is primarily designed to detect and evaluate.

2.1 Naturally Occurring Background Radioactivity

Natural radiation and radioactivity in the environment, which provide the major source of human radiation exposure, may be subdivided into three separate sub-categories: "primordial radioactivity", "cosmogenic radioactivity" and "cosmic radiation". "Primordial radioactivity" is made up of those radionuclides that were created with the universe and that have a sufficiently long half-life to be still present on the earth. Included in this category are the radionuclides that these elements have decayed into. A few of the more important radionuclides in this category are Uranium-238 (U-238), Thorium-228 (Th-228), Potassium-40 (K-40), Radium-226 (Ra-226), and Radon-222 (Rn-222). Uranium-238 and Thorium-228 are readily detected in soil and rock, whether through direct field measurements or through laboratory analysis of samples. Radium-226 in the earth can find its way from the soil into ground water, and is often detectable there. Radon-222 is one of the components of natural background in the air we breath, and its daughter products are detectable on air sampling filters. Potassium-40 comprises about 0.01 percent of all natural potassium in the earth, and is consequently detectable in most biological substances, including the human body. There are many more primordial radionuclides found in the environment in addition to the major ones discussed above (Reference 2).

The second sub-category of naturally-occurring radiation and radioactivity is "cosmogenic radioactivity". This is produced through the nuclear interaction of high energy cosmic radiation with elements in the earth's atmosphere, and to a much lesser degree in the earth's crust. These radioactive elements are then incorporated into the entire geosphere and atmosphere, including the earth's soil, surface rock, biosphere, sediments, ocean floors, polar ice and atmosphere. The major radionuclides in this

category are Carbon-14 (C-14), Hydrogen-3 (H-3 or Tritium), Sodium-22 (Na-22), and Beryllium-7 (Be-7). Beryllium-7 is the one most readily detected, and is found on air sampling filters and occasionally in biological media (Reference 2).

The third sub-category of naturally-occurring radiation and radioactivity is "cosmic radiation". This consists of high energy atomic and sub-atomic particles of extra-terrestrial origin and the secondary particles and radiation that are produced through their interaction in the earth's atmosphere. The primary radiation comes mostly from outside of our solar system, and to a lesser degree from the sun. We are protected from most of this radiation by the earth's atmosphere, which absorbs the radiation. Consequently, one can see that with increasing elevation one would be exposed to more cosmic radiation as a direct result of a thinner layer of air for protection. This "direct radiation" is best detected in the field with high pressure ion chambers.

2.2 Man-Made Background Radioactivity

The second source of "background" radioactivity in the YNPS environment is from "man-made" sources not related to the power plant. The most recent contributor to this category was the fallout from the Chernobyl accident in April of 1986, which was detected in the YNPS environment and other parts of the world. A much greater contributor to this category, however, has been fallout from atmospheric nuclear weapons tests. Tests were conducted from 1945 through 1980 by the United States, the Soviet Union, the United Kingdom, China and France, with the large majority of testing occurring during the periods 1954-1958 and 1961-1962. (A test ban treaty was signed in 1963 by the United States, Soviet Union and United Kingdom, but not by France and China.) The most recent test, conducted by the People's Republic of China, occurred in October of 1980. Much of the fallout detected today is due to this explosion and the last large scale one, done in November of 1976 (Reference 3).

The radioactivity produced by these detonations was deposited worldwide. The amount of fallout deposited in any given area is dependent on many factors, such as the explosive yield of the device, the latitude and altitude of the detonation, the season in which it occurred, and the timing of subsequent rainfall which washes fallout from the troposphere (Reference 4). Most of this fallout has decayed into stable elements, but the residual radioactivity is still readily detectable in environmental samples worldwide. The two predominant radionuclides are Cesium-137

(Cs-137) and Strontium-90 (Sr-90). They are found in soil and in vegetation, and since cows and goats graze large areas of vegetation, these radionuclides are also readily detected in milk.

Other potential "man-made" sources of environmental "background" radioactivity include other nuclear power plants, coal-fired power plants, national defense installations, hospitals, research laboratories and industry. These collectively are insignificant on a global scale when compared to the sources discussed above (natural and fallout).

3.0 GENERAL PLANT AND SITE INFORMATION

The Yankee Nuclear Power Station (YNPS) is located on a 2200 acre site in a predominantly rural area of northwestern Massachusetts, three-quarters of a mile south of the Vermont border. The plant resides in the town of Rowe, Massachusetts, approximately 9 miles east-northeast of North Adams, Massachusetts. The surrounding area is heavily forested and lightly populated. Hills bounding the river valley rise 500 to 1000 feet above the site, reaching elevations of 2100 feet. The plant itself consists of several structures including a reactor containment building, turbine, auxiliary and office buildings, warehouse and storage facilities.

The Deerfield River is used extensively for hydroelectric power generation both upstream and downstream of YNPS. Sherman Dam, immediately adjacent to YNPS, operates as a hydroelectric generating station. Sherman Pond, the impoundment behind this dam, has been used as a source of cooling water for YNPS.

YNPS was voluntarily shut down on October 1, 1991 and ceased power operation on February 26, 1992 after 32 years of reliable operation. The plant has begun a process of decommissioning which will eventually entail the disassembly and removal of the plant components and structures. This process will take place in strict conformance with USNRC regulations. Oversight will also continue from the U.S. Environmental Protection Agency, the Massachusetts Department of Environmental Protection, Massachusetts Department of Public Health, and Massachusetts Emergency Management Administration.

The radiological environmental monitoring program for YNPS continued to operate through 1993, and will continue throughout the decommissioning period.

4.0 PROGRAM DESIGN

The Radiological Environmental Monitoring Program for the YNPS was designed with specific objectives in mind. These were:

- To provide an early indication of the appearance or accumulation of any radioactive material in the environment caused by YNPS activities.
- To provide assurance to regulatory agencies and the public that the environmental impact from YNPS is known and within anticipated limits.
- To verify the adequacy and proper functioning of station effluent controls and monitoring systems.
- To provide standby monitoring capability for rapid assessment of risk to the general public in the event of unanticipated or accidental releases of radioactive material.

These objectives will continue to be in force, to varying degrees, throughout decommissioning activities at the YNPS site. Due to the shutdown status of the plant, and due to the relatively low quantities of radioactive material now on the site, some of the objectives have a different degree of importance than in the past.

The radiological environmental monitoring program was initiated in 1958, approximately two years before the plant began commercial operation in 1960. It has been in operation continuously since that time, with improvements made periodically over those years.

The current program was designed to meet the intent of NRC Regulatory Guide 4.1, Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants; NRC Regulatory Guide 4.8, Environmental Technical Specifications for Nuclear Power Plants; the NRC Branch Technical Position of November 1979 entitled, An Acceptable Radiological Environmental Monitoring Program; and NRC NUREG-0472, Radiological Effluent Technical Specifications for PWR's. The environmental TLD program was designed and tested around NRC Regulatory Guide 4.13, Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications. The quality assurance program was designed around the guidance given in NRC Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment.

Prior to August 1992, the requirements for the Radiological Environmental Monitoring Program (REMP) were given in the YNPS Technical Specifications. In August 1992, the REMP requirements were removed from the Technical Specifications and placed in the Offsite Dose Calculation Manual (ODCM) (Reference 5) pursuant to NRC Generic Letter 89-01 (Reference 6). Since the specific requirements of the REMP did not change at that time (they only changed documents), the current ODCM "Controls" will be cited in this report whenever discussing REMP requirements.

The minimal sampling requirements of the REMP are given in Table 4.1 of the ODCM, which is summarized in Table 4.1 of this report. The identification of the required sampling locations is given in Table 4.4 of the ODCM, as well as in Tables 4.2 and 4.3 of this report. The sampling and monitoring locations are shown graphically on the maps in Figures 4.1 through 4.7.

4.1 Monitoring Zones

The REMP is designed to allow comparison of levels of radioactivity in samples from the area possibly influenced by the plant to levels found in areas not influenced by the plant. The first area is called Zone 1, and its monitoring locations are called "indicators." The second area is called Zone 2, and its monitoring locations are called "controls." The distinction between the two zones, depending on the type of sample or sample pathway, is based on one or more of several factors, such as site meteorological history, meteorological dispersion calculations, relative direction from the plant, river flow, and distance. Analysis of survey data from the two zones aids in determining if there is a significant difference between the two areas. It can also help in differentiating between radioactivity or radiation due to plant activities and that due to other fluctuations in the environment, such as atmospheric nuclear weapons test fallout or seasonal variations in the natural background.

4.2 Pathways Monitored

Four pathway categories are monitored by the REMP. They are the Direct Radiation, Airborne, Waterborne, and Ingestion Pathways. Each of these four categories is monitored by the collection of one or more sample media, which are listed below, and are described in more detail in this section:

Airborne Pathway

- Air Particulate Sampling
- Charcoal Cartridge (Radioiodine) Sampling

Waterborne Pathways

- River Water Sampling
- Ground Water Sampling
- Storm Drain Water Sampling
- Shoreline Sediment Sampling

Ingestion Pathways

- Milk Sampling
- Fish Sampling
- Food Product and Broad Leaf Vegetation Sampling

Direct Radiation Pathway

- TLD Monitoring

4.3 Descriptions of Monitoring Programs

4.3.1 Air Sampling

Continuous air samplers are installed at seven locations, five of which are required by the YNPS ODCM. On September 22, 1992, one of the sampling stations was taken out of service, leaving six in operation for the remainder of 1992 through 1993. This is discussed in more detail in section 6.1 of this report.

The sampling pumps at these locations operate continuously at a flow rate of approximately one cubic foot per minute. Airborne particulates are collected by passing air through a 47 mm glass-fiber filter. A dry gas meter is incorporated into the sampling stream to measure the total volume of air sampled in a given interval. The entire system is housed in a weatherproof structure. The filters are collected weekly, and to allow for the decay of radon daughter products, they are held for at least 100 hours at the YAEL before being analyzed for gross-beta radioactivity (indicated as GR-B in the data tables). The weekly filters are composited (by location) at the YAEL for a quarterly gamma spectroscopy analysis.

4.3.2 Charcoal Cartridge (Radioiodine) Sampling

Continuous air samplers are installed at seven locations, five of which are required by the YNPS ODCM. On September 22, 1992, one of the sampling stations was taken out of service, leaving six in operation for the remainder of 1992 through 1993. This is discussed in more detail in section 6.1 of this report.

The sampling pumps at these locations operate continuously at a flow rate of approximately one cubic foot per minute. A 60cc TEDA impregnated charcoal cartridge is located downstream of the air particulate filter described above. A dry gas meter is incorporated into the sampling stream to measure the total volume of air sampled in a given interval. The entire system is housed in a weatherproof structure. These cartridges are collected and analyzed weekly for I-131.

4.3.3 River Water Sampling

Automatic compositing samplers are located at one upstream and one downstream sampling location. The samplers are controlled by timers that collect an aliquot of river water at least every two hours. An additional grab sample is collected monthly at Sherman Pond. All river water samples are preserved with HCl and NaHSO₃, or HNO₃, to prevent the plate out of potentially-present radionuclides on the container walls. Each sample is analyzed for gross-beta and gamma-emitting radionuclides. These monthly composites or grabs are composited again (by location) at the YAEL for a H-3 analysis.

4.3.4 Ground Water Sampling

Grab samples are collected monthly from two on-site locations. The ODCM requires a minimum of a quarterly collection. All ground water samples are preserved with HCl and NaHSO₃ to prevent the plate out of potentially-present radionuclides on the container walls. Each sample is analyzed for gross-beta and gamma-emitting radionuclides, as well as H-3.

4.3.5 Storm Drain Water Sampling

Grab samples are collected monthly from the West Storm Drain. This is not an ODCM requirement. This water is comprised of non-radioactive secondary

side plant effluents, as well as groundwater and precipitation (including snow melt) draining from the west side of the plant facility. All storm drain water samples are preserved with HCl and NaHSO₃, or HNO₃, to prevent the plate out of potentially-present radionuclides on the container walls. Each sample is analyzed for gross-beta and gamma-emitting radionuclides, as well as H-3.

4.3.6 Sediment Sampling

Shoreline sediment cores are collected semiannually from two locations, one upstream and one downstream of the plant. Only a single shoreline sediment sample is required by the ODCM. At each location, six two-inch I.D. plastic coring tubes are driven into the sediment at least six inches deep. The cores are carefully extracted and kept in an upright position and frozen prior to delivery to the YAEL. At the Laboratory, the frozen cores are cut into two-inch segments. For each location, the 0-5 cm segments are blended into a single sample, as are the 5-10 cm and 10-15 cm segments. These composite samples are then analyzed for gamma-emitting radionuclides.

An additional bottom sediment core is collected semiannually in Sherman Pond near the plant discharge. A Wildco K. B. Core Sampler, fitted with a plastic coring tube, is dropped from a boat. Six cores are collected here, and are processed and analyzed as described above.

4.3.7 Milk Sampling

Between November 1 and June 1, milk samples are collected on a monthly schedule from three locations. During the "grazing season", which runs from June 1 to November 1, samples are collected once per two weeks. Two indicator locations are chosen as part of the annual Land Use Census, based on meteorological dispersion calculations. The third location is a control, which is located sufficiently far away from the plant to be outside any potential influence from it. Immediately after collection, each milk sample is preserved with an appropriate amount of formaldehyde. Methimazole is also added to prevent protein binding of any radioiodine. Each sample is analyzed for gamma-emitting radionuclides. Following a chemical separation, a separate low-level I-131 analysis is performed to meet the Lower Limit of Detection requirements in the ODCM. Although not required by the ODCM, Sr-89 and Sr-90 analyses are also performed on quarterly composited samples.

4.3.8 Fish Sampling

Fish samples are collected semiannually at two locations (upstream of the plant and in Sherman Pond). A gill net is set overnight from a boat, and mixed species of fish are removed the following day. The species typically collected are yellow perch, smelt, pickerel, trout, bullheads and suckers. The fish samples are frozen and delivered to the YAEL where the edible portions are analyzed for gamma-emitting radionuclides.

4.3.9 Food Products and Broadleaf Vegetation Sampling

Food products are collected annually (at harvest) at three locations. The samples are either tuberous vegetables, above-ground vegetables or fruit. Two indicator locations are chosen as a result of the annual Land Use Census, based on meteorological dispersion calculations. The third location is a control, which is located sufficiently far away from the plant to be outside any potential influence from it. Immediately after collection, each unwashed food product sample is preserved with an appropriate amount of NaOH. The edible portions of the samples are then analyzed at the YAEL for gamma-emitting radionuclides.

An additional sample of edible broadleaf vegetation is collected at a single location (as determined from the Land Use Census) and is preserved as above. A separate low-level I-131 analysis is performed on this sample to meet the Lower Limit of Detection requirements in the ODCM.

In addition to the above food products, optional maple syrup samples are collected annually, as described below.

4.3.10 Maple Syrup Sampling

Maple syrup is an important commercial product in northern New England, including the YNPS plant environs. Because of this, samples are collected annually from three locations. These samples are collected from the syrup manufacturer as a finished product - that is, following the boiling down of the maple sap. Since the samples have already been boiled down as part of the syrup production process, no preservatives are needed in the samples. Following collection, the samples are analyzed at the YAEL for gamma-emitting radionuclides. It should be noted that because of the boiling down and filtering of the sap, the resulting radionuclide measurements do not represent actual environmental concentrations. It is estimated that

the resulting syrup has been concentrated by a factor of from 15 to 120 times the original sap, depending mostly on the time of the season that the sap was collected.

4.3.11 TLD Monitoring

Direct gamma radiation exposure was continuously monitored with the use of thermoluminescent dosimeters (TLDs). Specifically, Panasonic UD-801AS1 and UD-814AS1 calcium sulfate dosimeters were used, with a total of five elements in place at each monitoring location. Each pair of dosimeters is sealed in a plastic bag, which is in turn housed in a plastic-screened container. This container is attached to an object such as a tree, fence or utility pole. A total of 38 stations are required by the ODCM. Of these, 22 must be read out quarterly, while those from the remaining 16 incident response (outer ring) stations need only be de-dosed (annealed) quarterly, unless a gaseous release Control was exceeded during the period. Although not required by the ODCM, the TLDs from the 16 outer ring stations are read out quarterly along with the other stations's TLDs. The plant staff posts and retrieves all TLDs, while the YAEL processes them.

TABLE 4.1

Radiological Environmental Monitoring Program
(as required by ODCM Table 4.1)

Exposure Pathway and/or Sample Media	Collection			Analysis	
	Number of Sample Locations	Routine Sampling Mode	Collection Frequency	Analysis Type	Analysis Frequency
1. Direct Radiation (TLDs)	38 Includes 16 Outer Ring Incident Response TLDs	Continuous	Quarterly	Gamma; Outer Ring - de-dose only, unless gaseous release Control was exceeded	Each TLD
2. Airborne (Particulates and Radioiodine)	5	Continuous	Weekly	Particulate Sample: Gross Beta Gamma Isotopic Radioiodine Canister: I-131	Each Sample Quarterly Composite (by location) Each Sample
3. Waterborne					
a. Surface Water	2	Composite (aliquot every 2 hours)	Monthly	Gross Beta Gamma Isotopic Tritium (H-3)	Each Sample Each Sample Quarterly Composite
b. Ground Water	2	Grab	Quarterly	Gamma Isotopic Tritium (H-3)	Each Sample Each Sample
c. Shoreline Sediment	1	Grab	Semiannually	Gamma Isotopic	Each Sample

TABLE 4.1
(continued)

Radiological Environmental Monitoring Program
(as required by ODCM Table 4.1)

Exposure Pathway and/or Sample Media	Collection			Analysis	
	Nominal Number of Sample Locations	Routine Sampling Mode	Nominal Collection Frequency	Analysis Type	Analysis Frequency
4. Ingestion					
a. Milk	3	Grab	Monthly (Once per 2 weeks when on pasture)	Gamma Isotopic I-131	Each sample Each sample
b. Fish	2	Grab	Semiannually (or seasonal if appropriate)	Gamma Isotopic on edible portions	Each sample
c. Food Products					
- Tuberos or above- ground vegetables, or fruit	3	Grab	At harvest	Gamma Isotopic on edible portion	Each sample
- Broad leaf vegetation	1	Grab	At harvest	I-131	Each sample

TABLE 4.2

Radiological Environmental Monitoring Locations (non-TLD) in 1993
Yankee Nuclear Power Station

<u>Exposure Pathway</u>	<u>Station Code</u>	<u>Station Description</u>	<u>Zone*</u>	<u>Distance From Plant (km)</u>	<u>Direction From Plant</u>
1. Airborne					
	AP/CF-11	Observation Stand	1	0.5	NW
	AP/CF-12	Monroe Bridge	1	1.1	SW
	AP/CF-13	Rowe School	1	4.2	SE
	AP/CF-14	Harriman Station	1	3.2	N
	AP/CF-21	Williamstown, MA	2	22.2	W
	AP/CF-31	YAEC Visitor's Center	1	0.8	SW
	AP/CF-32	Heartwellville, VT	2	12.6	NNW
2. Waterborne					
a. Surface	WR-11	Bear Swamp Lower Reservoir	1	6.3	Down-river
	WR-21	Harriman Reservoir	2	10.1	Up-river
	WR-31	Sherman Pond	1	0.1	N
b. Ground	WG-11	Plant Potable	1	On-site	--
	WG-12	Sherman Spring	1	0.2	NW
c. Storm Drain	WW-52	West Storm Drain	1	On-site	--
d. Sediment	SE-11	No. 4 Station	1	36.2	Down-river
	SE-21	Harriman Reservoir	2	10.1	Up-river
	SE-91	Sherman Pond	1	0.1	N
3. Ingestion					
a. Milk	TM-12	Readsboro, VT	1	6.1	N
	TM-13	Whitingham, VT	1	8.4	ENE
	TM-14	Rowe, MA	1	3.2	SE
	TM-21	Williamstown, MA	2	21	WSW
b. Fish	FH-11	Sherman Pond	1	1.5	Near Dischg.
	FH-21	Harriman Reservoir	2	10.1	Up-river

TABLE 4.2
(continued)

Radiological Environmental Monitoring Locations (non-TLD) in 1993
Yankee Nuclear Power Station

<u>Exposure Pathway</u>	<u>Station Code</u>	<u>Station Description</u>	<u>Zone*</u>	<u>Distance From Plant (km)</u>	<u>Direction From Plant</u>
3. Ingestion, (continued)					
c. Food Products	TF-11	Monroe Bridge, MA	1	1.3	SW
	TF-13	Monroe, MA	1	1.9	WNW
	TF-21	Williamstown, MA	2	21.0	WSW
	TF-32	Whitingham, Vt (Maple syrup)	1	8.4	ENE
	TF-33	Rowe, MA (Maple syrup)	1	1.0	S
	TF-42	Williamstown, MA (Maple syrup)	2	28.3	WSW

* 1 - Indicator Stations; 2 - Control Stations

TABLE 4.3

Radiological Environmental Monitoring Locations (TLD) in 1993
Yankee Nuclear Power Station

<u>Station Code</u>	<u>Station Description</u>	<u>Zone*</u>	<u>Distance From Plant (km)</u>	<u>Direction From Plant</u>
GM-1	YAEC Visitors' Center	1	0.8	SW
GM-2	Observation Stand	1	0.5	NW
GM-3	Rowe School	1	4.2	SE
GM-4	Harriman Station	1	3.2	N
GM-5	Monroe Bridge	1	1.1	SW
GM-6	Readsboro Road Barrier	1	1.3	N
GM-7	Whitingham Line	1	3.5	NE
GM-8	Monroe Hill Barrier	1	1.8	S
GM-9	Dunbar Brook	1	3.2	SW
GM-10	Cross Road	1	3.5	E
GM-11	Adams High Line	1	2.1	WNW
GM-12	Readsboro, VT	1	5.5	NNW
GM-13	Restricted Area Fence	F	0.08	WSW
GM-14	Restricted Area Fence	F	0.11	WNW
GM-15	Restricted Area Fence	F	0.08	NNW
GM-16	Restricted Area Fence	F	0.13	NNE
GM-17	Restricted Area Fence	F	0.14	ENE
GM-18	Restricted Area Fence	F	0.14	ESE
GM-19	Restrictor' Area Fence	F	0.16	SE
GM-20	Restricted Area Fence	F	0.16	SSE
GM-21	Restricted Area Fence	F	0.11	SSW
GM-22	Heartwellville, VT	2	12.6	NNW
GM-23	Williamstown Substation	2	22.2	W
GM-24	Harriman Dam	0	7.3	N
GM-25	Whitingham, VT	0	7.7	NNE
GM-26	Sadoga Road	0	7.6	NE
GM-27	Number 9 Road	0	7.6	ENE
GM-28	Number 9 Road	0	6.0	E
GM-29	Route 8A	0	8.2	ESE
GM-30	Route 8A	0	9.4	SE

TABLE 4.3
(continued)

Radiological Environmental Monitoring Locations (TLD) in 1993
Yankee Nuclear Power Station

<u>Station Code</u>	<u>Station Description</u>	<u>Zone*</u>	<u>Distance From Plant (km)</u>	<u>Direction From Plant</u>
GM-31	Legate Hill Road	0	7.6	SSE
GM-32	Rowe Road	0	7.9	S
GM-33	Zoar Road	0	6.9	SSW
GM-34	Fife Brook Road	0	6.4	SW
GM-35	Whitcomb Summit	0	8.6	WSW
GM-36	Tilda Road	0	6.6	W
GM-37	Turner Hill Road	0	6.7	WNW
GM-38	West Hill Road	0	6.6	NW
GM-39	Route 100	0	6.8	NNW
GM-40	Readsboro Road	1	0.5	W

* 1 - Indicator TLD; 2 - Control TLD; 0 - Outer Ring Incident Response TLD;
F - Fenceline TLD.

TABLE 4.4

Environmental Lower Limit of Detection (LLD) Sensitivity Requirements

Analysis	Water (pCi/l)	Airborne Particulates or Gases (pCi/m ³)	Fish (pCi/kg)	Milk (pCi/l)	Food Product (pCi/kg)	Sediment (pCi/kg -dry)
Gross-Beta	4	0.01				
H-3	2000					
Mn-54	15		130			
Fe-59	30		260			
Co-58,60	15		130			
Zn-65	30		260			
Zr-Nb-95	15					
I-131	1*	0.07		1	60**	
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-La-140	15			15		

* LLD for drinking water.

** LLD for leafy vegetation.

(Several other explanatory footnotes are given in ODCM Table 4.3.)

TABLE 4.5

Reporting Levels for Radioactivity Concentrations
In Environmental Samples

Analysis	Water (pCi/l)	Airborne Particulates or Gases (pCi/m ³)	Fish (pCi/kg)	Milk (pCi/l)	Food Product (pCi/kg)
H-3	3 x 10 ⁴ *				
Mn-54	1 x 10 ³		3 x 10 ⁴		
Fe-59	4 x 10 ²		1 x 10 ⁴		
Co-58	1 x 10 ³		3 x 10 ⁴		
Co-60	3 x 10 ²		1 x 10 ⁴		
Zn-65	3 x 10 ²		2 x 10 ⁴		
Zr-Nb-95	4 x 10 ²				
I-131	2	0.9		3	1 x 10 ²
Cs-134	3 ⁰	10	1 x 10 ³	60	1 x 10 ³
Cs-137	.	20	2 x 10 ³	70	2 x 10 ³
Ba-La-140	2 x 10 ²			3 x 10 ²	

* Reporting Level for non-drinking water pathways.

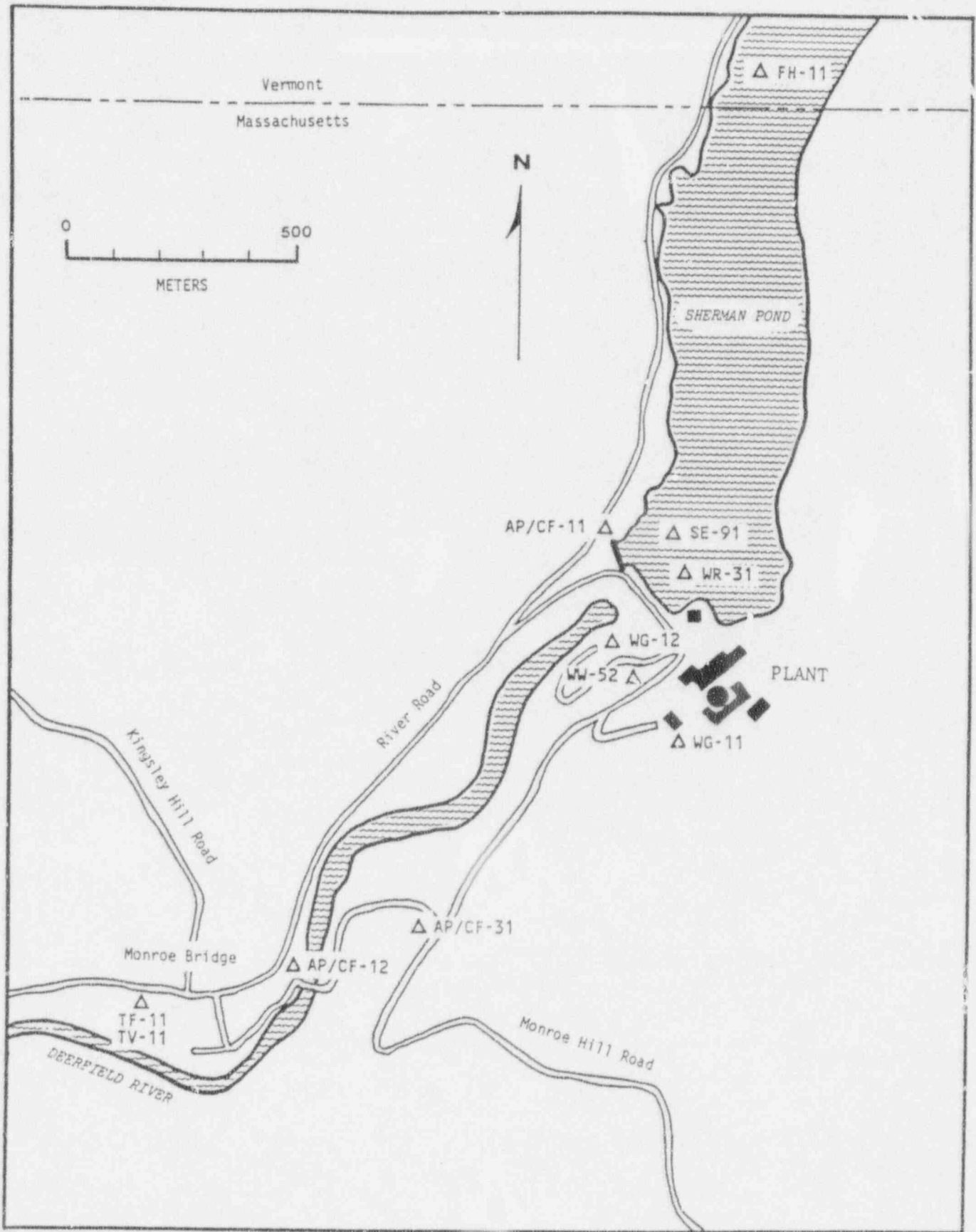


Figure 4.1 Radiological Environmental Sampling Locations Within 1 Mile of YNPS

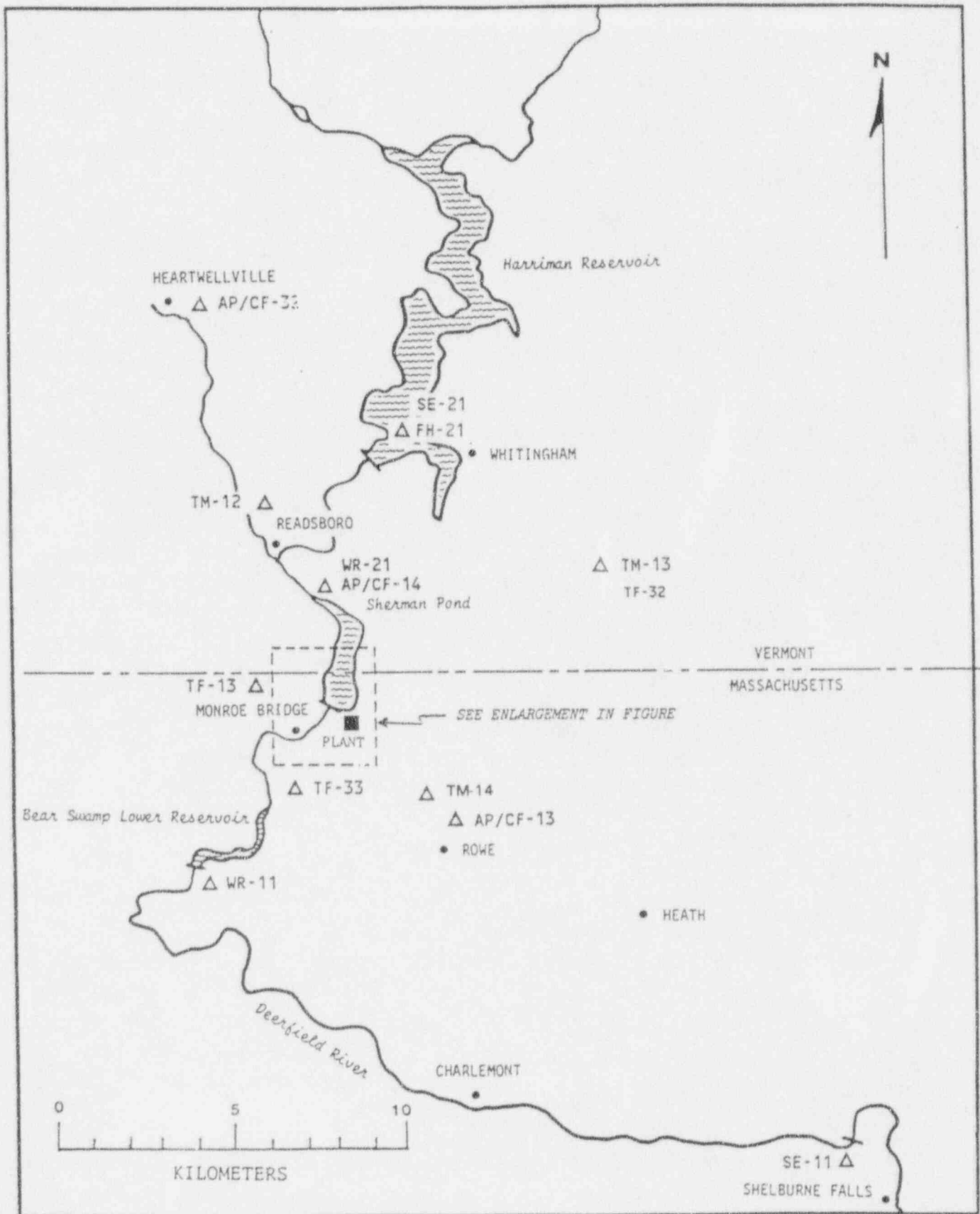


Figure 4.2 Radiological Environmental Sampling Locations Within 12 Miles of YNPS

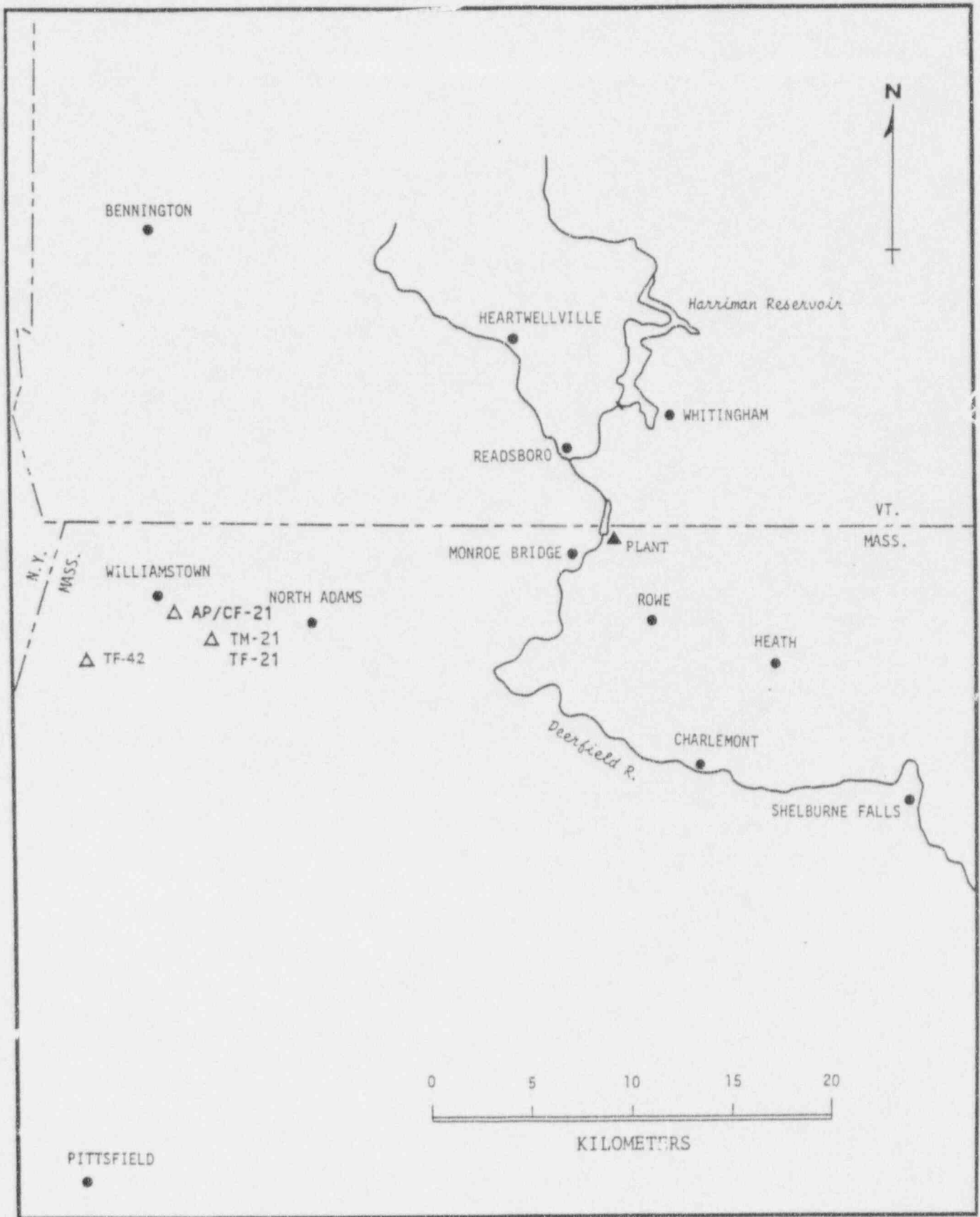


Figure 4.3 Radiological Environmental Sampling Locations Outside 12 Miles of YNPS

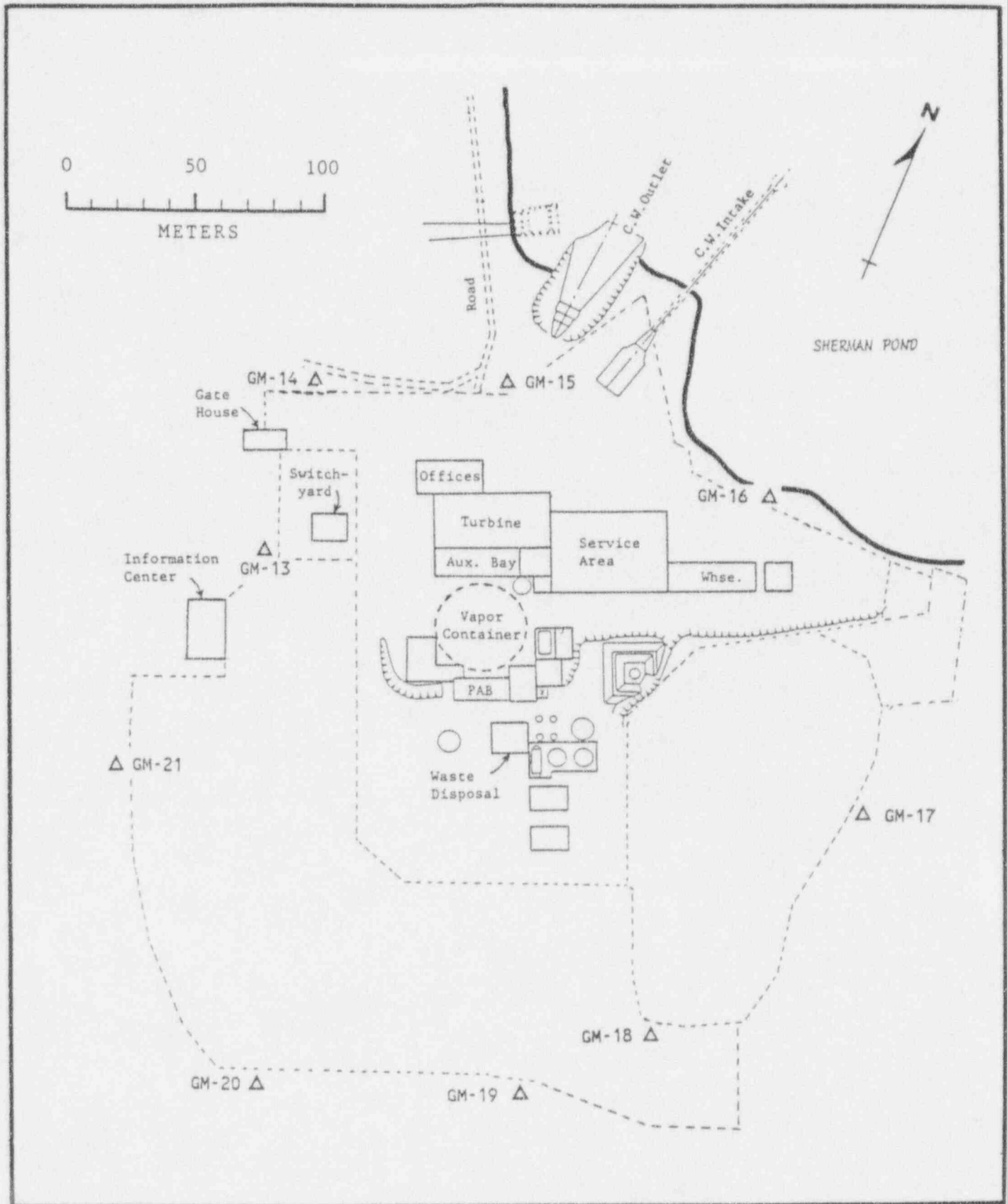


Figure 4.4 Environmental TLD Monitoring Locations at the YNPS Restricted Area Fence

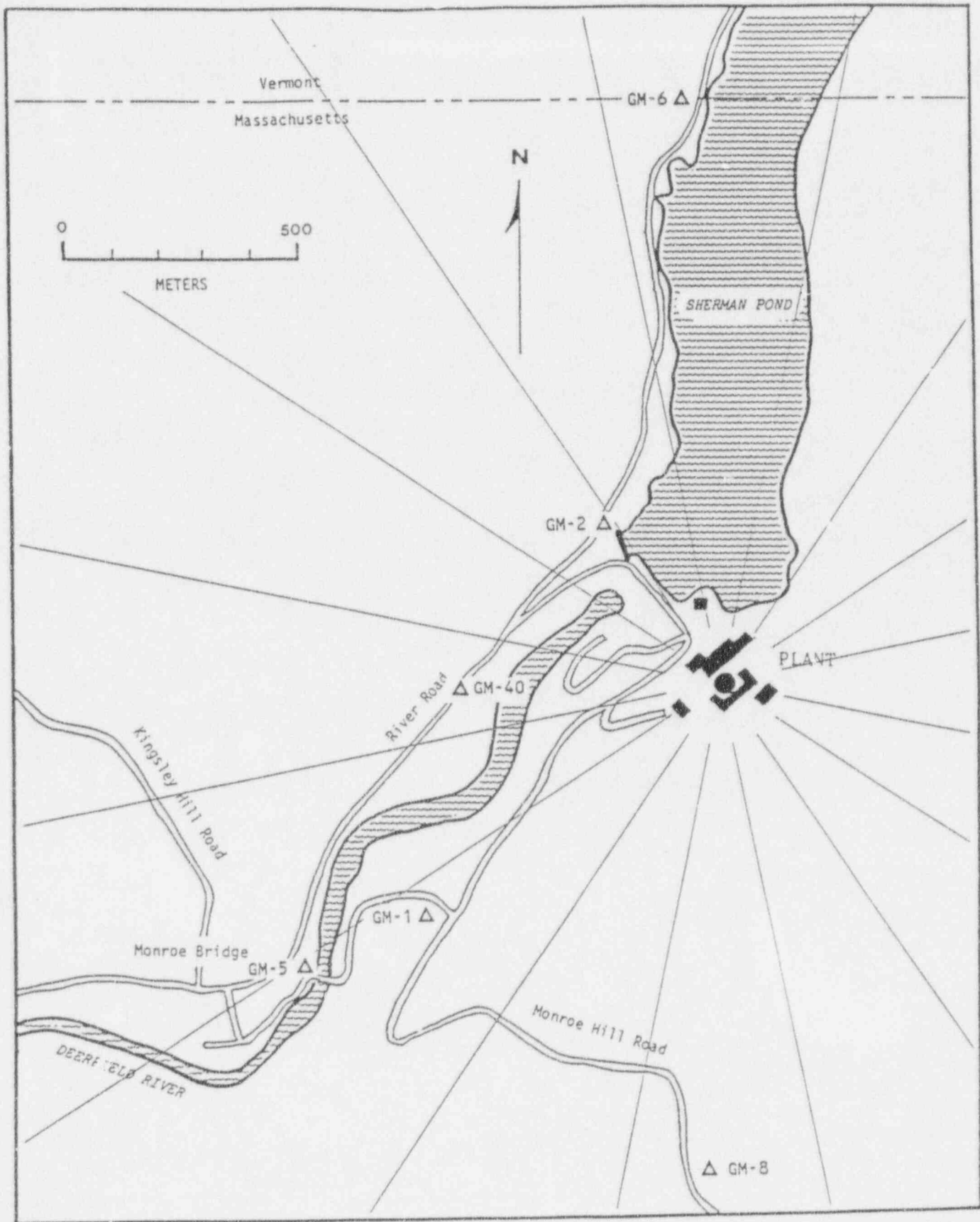


Figure 4.5 Environmental TLD Monitoring Locations Within 1 Mile of YNPS

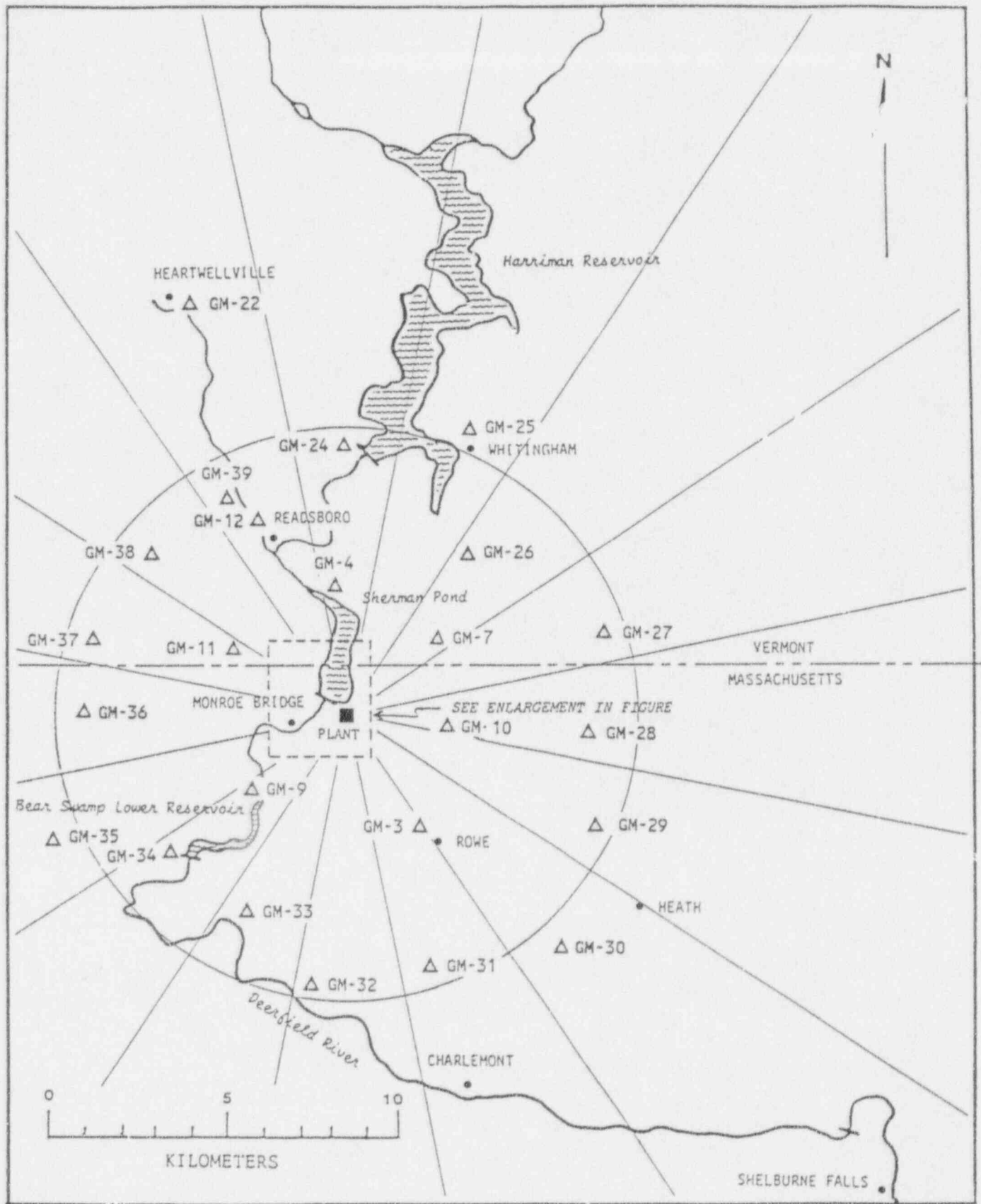


Figure 4.6 Environmental TLD Monitoring Locations Within 12 Miles of YNPS

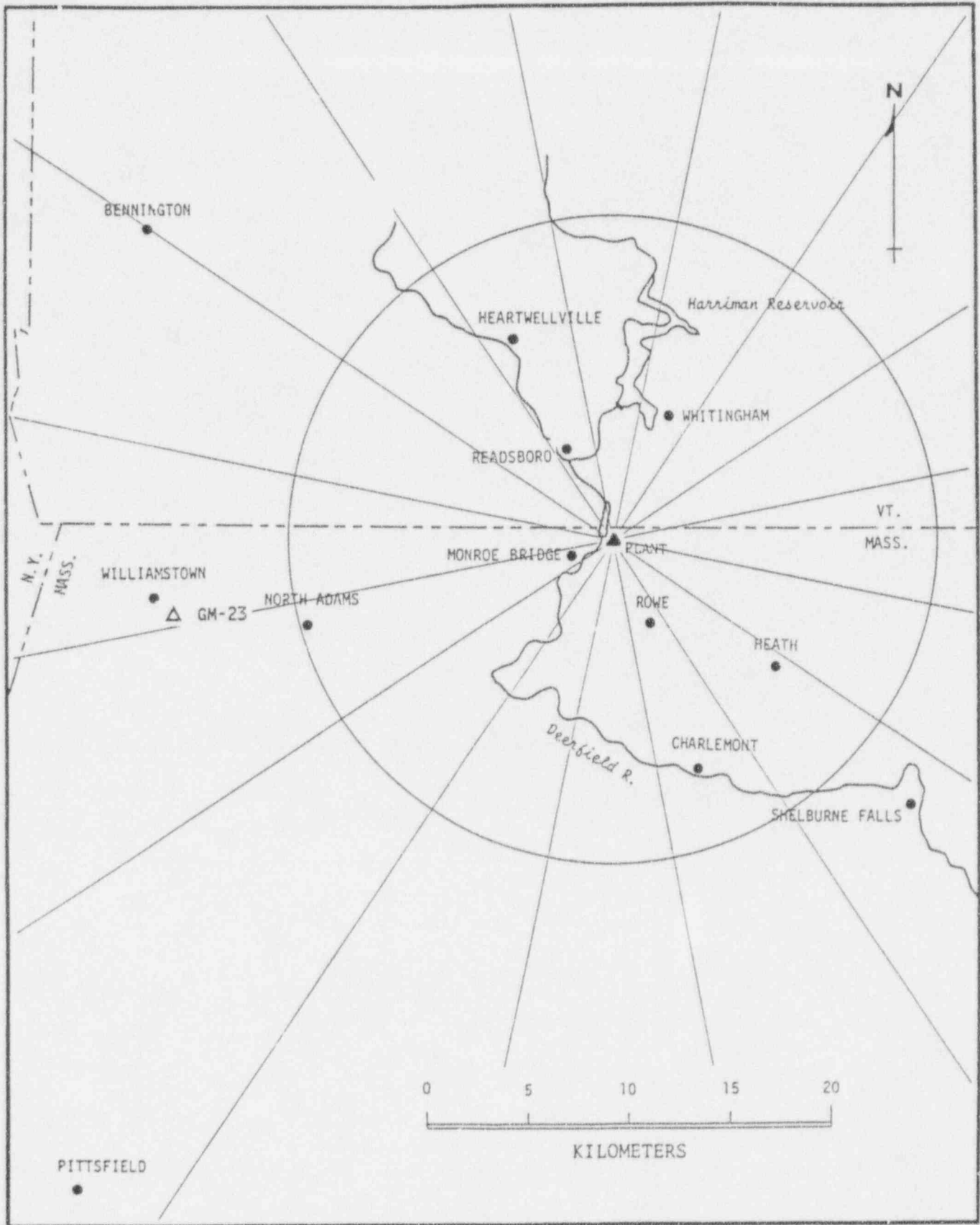


Figure 4.7 Environmental TLD Monitoring Locations Outside of 12 Miles from YNPS

5.0 RADIOLOGICAL DATA SUMMARY TABLES

This section summarizes the analytical results of the environmental samples that were collected during 1993. These results, shown in Table 5.1, are presented in a format similar to that prescribed in the NRC's Radiological Assessment Branch Technical Position on Environmental Monitoring (Reference 1). The results are ordered by sample media type and then by radionuclide. The units for each media type are also given. Table 5.2 provides the same information for TLD direct radiation measurements.

The left-most column contains the radionuclide of interest, the total number of analyses for that radionuclide in 1993, and the number of measurements which exceeded the Reporting Levels found in Table 4.2 of the YNPS ODCM. The latter are classified as "Non-routine" measurements. The second column lists the required Lower Limit of Detection (LLD) for those radionuclides which have detection capability requirements as specified in the plant's ODCM (Table 4.3). The absence of a value in this column indicates that no LLD is specified in the ODCM for that radionuclide in that media. The target LLD for any analysis is typically 30-40 percent of the most restrictive required LLD. On rare occasions the required LLD is not met. This is usually due to malfunctions in sampling equipment, which result in low sample volume. Such cases are addressed in Section 6.2.

For each radionuclide and media type, the remaining three columns summarize the data for the following categories of monitoring locations: (1) the Indicator or Zone 1 stations, which are within the range of influence of the plant and which could conceivably be affected by plant activities; (2) the station which had the highest mean concentration during 1993 for that radionuclide; and (3) the Control or Zone 2 stations, which are beyond the influence of the plant. Direct radiation monitoring stations (using TLDs) are grouped into Indicator, Outer Ring, Fenceline and Control stations.

In each of these columns, for each radionuclide, the following are given:

- The mean value of all concentrations including negative values and values below the LLD.
- The standard error of the mean.
- The lowest and highest concentration.
- The number of detectable measurements divided by the total number of measurements.

A sample is considered to yield a "detectable measurement" when the concentration exceeds three times its associated standard deviation. The standard deviation on each measurement represents only the random uncertainty associated with the radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the analytical procedure.

The radionuclides reported in this section represent those that: 1) had an LLD requirement in Table 4.3 of the ODCM, or a Reporting Level listed in Table 4.2 of the ODCM, or 2) had a positive measurement of radioactivity, whether it was naturally-occurring or man-made; or 3) were of specific interest for any other reason. The radionuclides that were routinely analyzed and reported by the YAEL (in a gamma spectroscopy analysis) were: AcTh-228, Ag-110m, Ba-140, Be-7, Ce-141, Ce-144, Co-57, Co-58, Co-60, Cr-51, Cs-134, Cs-137, Fe-59, I-131, I-133, K-40, Mn-54, Mo-99, Np-239, Ru-103, Ru-106, Sb-124, Se-75, TeI-132, Zn-65 and Zr-95. In no case did a radionuclide not shown in Table 5.1 appear as a "detectable measurement" during 1993.

Data from direct radiation measurements made by TLDs are provided in Table 5.2 in a format essentially the same as above. The complete listing of quarterly TLD data is provided in Table 5.3.

TABLE 5.1

RADIOLOGICAL ENVIRONMENTAL PROGRAM SUMMARY
 YANKEE NUCLEAR POWER STATION, ROME, MA
 (JANUARY - DECEMBER 1993)

RADIOISOTOPES* (NO. ANALYSES) (NON-ROUTINE)**	REQUIRED LLD	INDICATOR STATIONS *****	STATION WITH HIGHEST MEAN *****	CONTROL STATIONS *****
		MEAN RANGE NO. DETECTED***	MEAN STA. RANGE NO. NO. DETECTED***	MEAN RANGE NO. DETECTED***
MEDIUM: STORM DRAIN WATER (W), cont. UNITS: pCi/kg				
CO-60 (12) (0)		(-6.0 ± 32.1)E -2 (-1.6 - 1.5)E 0 (0/ 12)	52 (-6.0 ± 32.1)E -2 (-1.6 - 1.5)E 0 (0/ 12)	NO DATA
ZN-65 (12) (0)		(1.1 ± 5.1)E -1 (-2.3 - 3.1)E 0 (0/ 12)	52 (1.1 ± 5.1)E -1 (-2.3 - 3.1)E 0 (0/ 12)	NO DATA
ZR-95 (12) (0)		(-2.4 ± 49.6)E -2 (-2.3 - 3.8)E 0 (0/ 12)	52 (-2.4 ± 49.6)E -2 (-2.3 - 3.8)E 0 (0/ 12)	NO DATA
I-131 (12) (0)		(-2.9 ± 445.5)E -3 (-2.4 - 1.9)E 0 (0/ 12)	52 (-2.9 ± 445.5)E -3 (-2.4 - 1.9)E 0 (0/ 12)	NO DATA
CS-134 (12) (0)		(-4.5 ± 2.8)E -1 (-1.7 - 1.7)E 0 (0/ 12)	52 (-4.5 ± 2.8)E -1 (-1.7 - 1.7)E 0 (0/ 12)	NO DATA
CS-137 (12) (0)		(-6.4 ± 1.3)E -1 (-1.2 - 0.3)E 0 (0/ 12)	52 (-6.4 ± 1.3)E -1 (-1.2 - 0.3)E 0 (0/ 12)	NO DATA
BA-140 (12) (0)		(-1.6 ± 5.8)E -1 (-5.5 - 2.3)E 0 (0/ 12)	52 (-1.6 ± 5.8)E -1 (-5.5 - 2.3)E 0 (0/ 12)	NO DATA
H-3 (12) (0)		(8.3 ± 5.8)E 1 (-2.3 - 3.7)E 2 (0/ 12)	52 (8.3 ± 5.8)E 1 (-2.3 - 3.7)E 2 (0/ 12)	NO DATA

NOTE: Footnotes may be found at the end of Table 5.1.

TABLE 5.1

RADIOLOGICAL ENVIRONMENTAL PROGRAM SUMMARY
 YANKEE NUCLEAR POWER STATION, ROME, MA
 (JANUARY - DECEMBER 1993)

RADIOISOTOPES* (NO. ANALYSES) (NON-ROUTINE)**	REQUIRED LLD	INDICATOR STATIONS *****	STATION WITH HIGHEST MEAN *****	CONTROL STATIONS *****
		MEAN RANGE NO. DETECTED***	MEAN STA. RANGE NO. NO. DETECTED***	MEAN RANGE NO. DETECTED***
MEDIUM: SEDIMENT (SE) UNITS: pCi/kg (dry)				
K-40 (24) (0)		(1.8 ± 0.1)E 4 (1.0 - 2.4)E 4 (18/ 18)	91 (2.0 ± 0.1)E 4 (1.0 - 2.4)E 4 (12/ 12)	(1.7 ± 0.0)E 4 (1.0 - 1.9)E 4 (6/ 6)
CO-58 (24) (0)		(-1.0 ± 0.3)E 1 (-3.5 - 0.8)E 1 (0/ 18)	21 (-2.3 ± 9.1)E 0 (-2.9 - 2.4)E 1 (0/ 6)	(-2.3 ± 9.1)E 0 (-2.9 - 2.4)E 1 (0/ 6)
CO-60 (24) (0)		(7.6 ± 4.1)E 1 (-3.7 - 75.6)E 1 (2/ 18)	91 (1.1 ± 0.6)E 2 (-3.7 - 75.6)E 1 (2/ 12)	(-7.3 ± 10.8)E 0 (-3.8 - 3.7)E 1 (0/ 6)
CS-134 (24) (0)	150.	(-6.3 ± 7.3)E 0 (-6.9 - 5.3)E 1 (0/ 18)	21 (8.2 ± 7.3)E 0 (-1.5 - 3.1)E 1 (0/ 6)	(8.2 ± 7.3)E 0 (-1.5 - 3.1)E 1 (0/ 6)
CS-137 (24) (0)	180.	(9.0 ± 1.6)E 2 (1.2 - 27.3)E 2 (18/ 18)	91 (1.3 ± 0.1)E 3 (8.3 - 27.3)E 2 (12/ 12)	(8.3 ± 5.5)E 1 (-6.3 - 342.0)E 0 (2/ 6)
TH-232 (24) (0)		(1.3 ± 0.1)E 3 (6.0 - 20.9)E 2 (18/ 18)	91 (1.6 ± 0.1)E 3 (1.3 - 2.1)E 3 (12/ 12)	(5.7 ± 0.7)E 2 (4.2 - 9.1)E 2 (6/ 6)
MEDIUM: MILK (TM) UNITS: pCi/kg				
SR-89 (12) (0)		(3.9 ± 4.7)E -1 (-9.8 - 32.0)E -1 (0/ 8)	14 (1.2 ± 1.1)E 0 (-4.4 - 32.0)E -1 (0/ 3)	(1.7 ± 4.8)E -1 (-4.5 - 16.0)E -1 (0/ 4)
SR-90 (12) (0)		(2.4 ± 0.4)E 0 (5.8 - 39.9)E -1 (6/ 8)	14 (3.5 ± 0.4)E 0 (2.8 - 4.0)E 0 (3/ 3)	(1.1 ± 0.3)E 0 (4.5 - 19.2)E -1 (1/ 4)
K-40 (56) (0)		(1.4 ± 0.0)E 3 (1.2 - 1.9)E 3 (37/ 37)	14 (1.5 ± 0.0)E 3 (1.3 - 1.9)E 3 (16/ 16)	(1.4 ± 0.0)E 3 (1.2 - 1.5)E 3 (19/ 19)

NOTE: Footnotes may be found at the end of Table 5.1.

TABLE 5.1

RADIOLOGICAL ENVIRONMENTAL PROGRAM SUMMARY
 YANKEE NUCLEAR POWER STATION, ROKE, MA
 (JANUARY - DECEMBER 1993)

RADIONUCLIDES* (NO. ANALYSES) (NON-ROUTINE)**	REQUIRED LLD	INDICATOR STATIONS *****	STATION WITH HIGHEST MEAN *****	CONTROL STATIONS *****
		MEAN RANGE NO. DETECTED***	MEAN STA. RANGE NO. DETECTED***	MEAN RANGE NO. DETECTED***
MEDIUM: FISH (FH), cont. UNITS: pCi/kg				
ZM-65 (4) (0)	260.	(-3.7 ± 16.4)E 0 (-2.0 - 1.3)E 1 (0/ 2)	21 (-1.2 ± 19.6)E 0 (-2.1 - 1.8)E 1 (0/ 2)	(-1.2 ± 19.6)E 0 (-2.1 - 1.8)E 1 (0/ 2)
CS-134 (4) (0)	130.	(-4.4 ± 1.1)E 0 (-5.6 - -3.2)E 0 (0/ 2)	21 (3.8 ± 10.7)E 0 (-6.9 - 14.5)E 0 (0/ 2)	(3.8 ± 10.7)E 0 (-6.9 - 14.5)E 0 (0/ 2)
CS-137 (4) (0)	150.	(2.7 ± 1.0)E 1 (1.6 - 3.7)E 1 (1/ 2)	11 (2.7 ± 1.0)E 1 (1.6 - 3.7)E 1 (1/ 2)	(2.1 ± 0.3)E 1 (1.8 - 2.3)E 1 (0/ 2)
MEDIUM: FOOD CROP (TF) UNITS: pCi/kg				
K-40 (3) (0)		(4.7 ± 0.2)E 3 (4.6 - 4.9)E 3 (2/ 2)	11 (4.9 ± 0.4)E 3 (1/ 1)	(2.6 ± 0.3)E 3 (1/ 1)
CO-58 (3) (0)		(6.8 ± 10.6)E 0 (-3.8 - 17.4)E 0 (0/ 2)	11 (1.7 ± 1.0)E 1 (0/ 1)	(-2.2 ± 10.7)E 0 (0/ 1)
CO-60 (3) (0)		(-4.9 ± 3.2)E 0 (-8.1 - -1.7)E 0 (0/ 2)	21 (1.2 ± 1.1)E 1 (0/ 1)	(1.2 ± 1.1)E 1 (0/ 1)
I-131 (4) (0)		(-1.2 ± 1.2)E 1 (-3.7 - 0.0)E 1 (0/ 3)	21 (1.3 ± 11.8)E 0 (0/ 1)	(1.3 ± 11.8)E 0 (0/ 1)
CS-134 (3) (0)	60.	(-1.2 ± 0.8)E 1 (-2.0 - -0.4)E 1 (0/ 2)	21 (-2.9 ± 107.0)E -1 (0/ 1)	(-2.9 ± 107.0)E -1 (0/ 1)
CS-137 (3) (0)	80.	(-3.8 ± 5.7)E 0 (-9.5 - 1.8)E 0 (0/ 2)	11 (1.3 ± 12.6)E 0 (0/ 1)	(-8.9 ± 9.2)E 0 (0/ 1)

NOTE: Footnotes may be found at the end of Table 5.1.

TABLE 5.1

RADIOLOGICAL ENVIRONMENTAL PROGRAM SUMMARY
 YANKEE NUCLEAR POWER STATION, BOME, MA
 (JANUARY - DECEMBER 1993)

RADIONUCLIDES* (NO. ANALYSES) (NON-ROUTINE)**	REQUIRED LLD	INDICATOR STATIONS *****	STATION WITH HIGHEST MEAN *****	CONTROL STATIONS *****
		MEAN RANGE NO. DETECTED***	MEAN STA. RANGE NO. NO. DETECTED***	MEAN RANGE NO. DETECTED***
MEDIUM: MAPLE SYRUP (TF) UNITS: pCi/kg				
K-40 (3) (0)		(2.1 ± 0.1)E 3 (2.0 - 2.2)E 3 (2/ 2)	33 (2.2 ± 0.1)E 3 (1/ 1)	(2.1 ± 0.1)E 3 (1/ 1)
CO-58 (3) (0)		(7.7 ± 0.7)E -2 (7.0 - 8.4)E -2 (0/ 2)	42 (5.2 ± 1.9)E 0 (0/ 1)	(5.2 ± 1.9)E 0 (0/ 1)
CO-60 (3) (0)		(-9.7 ± 4.8)E -1 (-1.5 - -0.5)E 0 (0/ 2)	42 (-1.8 ± 28.6)E -1 (0/ 1)	(-1.8 ± 28.6)E -1 (0/ 1)
I-131 (3) (0)		(-4.2 ± 0.4)E -1 (-4.6 - -3.8)E -1 (0/ 2)	42 (1.3 ± 1.9)E 0 (0/ 1)	(1.3 ± 1.9)E 0 (0/ 1)
CS-134 (3) (0)		(9.4 ± 4.4)E -1 (4.9 - 13.8)E -1 (0/ 2)	32 (1.4 ± 1.5)E 0 (0/ 1)	(-2.4 ± 2.0)E 0 (0/ 1)
CS-137 (3) (0)		(1.5 ± 0.5)E 1 (9.5 - 19.8)E 0 (2/ 2)	33 (2.0 ± 0.2)E 1 (1/ 1)	(-3.2 ± 1.8)E 0 (0/ 1)

NOTE: Footnotes may be found at the end of Table 5.1.

Footnotes to Table 5.1:

- * The only radionuclides reported in this table are those with LLD requirements, those for which positive radioactivity was detected, and those which may be of interest for some other specific reason. See Section 5 of this report for a discussion of other radionuclides that were analyzed.
- ** Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 4.2.
- *** The fraction of sample analyses yielding detectable measurements (i.e. > 3 standard deviations) is shown in parentheses.

TABLE 5.2

ENVIRONMENTAL TLD DATA SUMMARY
 YANKEE NUCLEAR POWER STATION, ROME, MA
 (JANUARY - DECEMBER 1993)

INDICATOR TLDs *****	OUTER RING TLDs *****	FENCELINE TLDs *****	CONTROL TLDs *****
MEAN RANGE (NO. MEASUREMENTS)*	MEAN RANGE (NO. MEASUREMENTS)*	MEAN RANGE (NO. MEASUREMENTS)*	MEAN RANGE (NO. MEASUREMENTS)*
-----	-----	-----	-----
6.8 ± 0.9 4.8 - 9.2 (51)	7.0 ± 1.2 4.7 - 9.6 (64)	12.9 ± 3.4 8.0 - 19.5 (36)	7.5 ± 0.9 5.8 - 8.4 (8)

OFFSITE STATION WITH HIGHEST MEAN

STA. NO.	MEAN RANGE (NO. MEASUREMENTS)*
-----	-----
GM-34	8.9 ± 0.7 8.1 - 9.6 (4)

* Each "measurement" is based typically on quarterly readings from five TLD elements.

TABLE 5.3

ENVIRONMENTAL TLD MEASUREMENTS
1993
(Micro-R per Hour)

Sta. No.	Description	1ST QUARTER		2ND QUARTER		3RD QUARTER		4TH QUARTER		ANNUAL
		EXP.	S.D.	EXP.	S.D.	EXP.	S.D.	EXP.	S.D.	AVE. EXP.
GM-01	YNPS Visitor's Center	6.5 ± 0.3		7.0 ± 0.2		7.6 ± 0.3		7.1 ± 0.1		7.1
GM-02	Observation Stand	5.9 ± 0.3		6.3 ± 0.3		7.0 ± 0.3		7.1 ± 0.3		6.6
GM-03	Rowe School	4.8 ± 0.2		5.5 ± 0.4		6.1 ± 0.3		5.7 ± 0.3		5.5
GM-04	Harriman Station	6.1 ± 0.3		5.8 ± 0.2		6.3 ± 0.2		6.1 ± 0.3		6.1
GM-05	Monroe Bridge	7.9 ± 0.3		8.4 ± 0.3		9.2 ± 0.2		7.8 ± 0.3		8.3
GM-06	Readsboro Rd. Barrier	5.9 ± 0.2		6.9 ± 0.3		8.0 ± 0.3		7.6 ± 0.2		7.1
GM-07	Whitingham Line	5.7 ± 0.2		5.9 ± 0.2		7.0 ± 0.3		6.5 ± 0.2		6.3
GM-08	Monroe Hill Barrier	5.7 ± 0.3		5.9 ± 0.2		7.2 ± 0.3		6.8 ± 0.3		6.4
GM-09	Dunbar Brook	*		6.6 ± 0.3		7.6 ± 0.2		7.3 ± 0.2		7.2
GM-10	Cross Rd.	5.4 ± 0.2		6.2 ± 0.2		7.5 ± 0.3		6.7 ± 0.2		6.5
GM-11	Adams High Line	6.3 ± 0.2		7.1 ± 0.3		8.5 ± 0.3		7.6 ± 0.4		7.4
GM-12	Readsboro, VT	6.4 ± 0.2		6.9 ± 0.3		8.0 ± 0.2		7.5 ± 0.4		7.2
GM-13	Restr. Area Fence	9.7 ± 0.4		11.2 ± 0.7		12.3 ± 0.7		13.7 ± 0.5		11.7
GM-14	Restr. Area Fence	8.0 ± 0.3		9.3 ± 0.5		10.5 ± 0.3		11.3 ± 0.5		9.8
GM-15	Restr. Area Fence	8.2 ± 0.3		9.5 ± 0.5		9.7 ± 0.3		12.1 ± 0.4		9.9
GM-16	Restr. Area Fence	8.6 ± 0.3		10.1 ± 0.4		9.9 ± 0.4		10.9 ± 0.4		9.9
GM-17	Restr. Area Fence	10.9 ± 0.7		12.1 ± 0.7		11.9 ± 0.6		12.4 ± 0.6		11.9
GM-18	Restr. Area Fence	17.0 ± 1.0		18.8 ± 0.9		18.0 ± 0.8		19.3 ± 1.4		18.3
GM-19	Restr. Area Fence	16.1 ± 0.6		19.5 ± 0.8		17.1 ± 1.0		19.0 ± 0.9		17.9
GM-20	Restr. Area Fence	12.7 ± 0.3		15.9 ± 0.7		14.7 ± 0.5		16.0 ± 1.3		14.8
GM-21	Restr. Area Fence	10.6 ± 0.3		12.7 ± 0.6		12.4 ± 0.4		13.7 ± 0.6		12.3
GM-22	Heartwellville, VT	5.8 ± 0.2		6.7 ± 0.2		7.8 ± 0.3		7.2 ± 0.4		6.9
GM-23	Williamstown Subst.	8.0 ± 0.3		8.0 ± 0.3		8.4 ± 0.3		8.3 ± 0.3		8.2
GM-24	Harriman Dam	6.7 ± 0.3		7.8 ± 0.3		8.8 ± 0.3		8.5 ± 0.2		8.0
GM-25	Whitingham, VT	5.8 ± 0.3		6.4 ± 0.3		7.2 ± 0.3		6.7 ± 0.2		6.5
GM-26	Sadoga Rd.	5.6 ± 0.3		6.5 ± 0.3		7.6 ± 0.3		7.1 ± 0.4		6.7
GM-27	Number 9 Rd.	5.5 ± 0.5		5.7 ± 0.3		6.7 ± 0.2		6.9 ± 0.3		6.2
GM-28	Number 9 Rd.	6.0 ± 0.3		6.6 ± 0.2		7.5 ± 0.2		7.5 ± 0.2		6.9
GM-29	Route 8A	4.7 ± 0.3		4.7 ± 0.2		5.6 ± 0.2		5.4 ± 0.2		5.1
GM-30	Route 8A	5.4 ± 0.2		5.6 ± 0.2		6.7 ± 0.2		6.4 ± 0.2		6.0
GM-31	Legate Hill Rd.	5.8 ± 0.3		6.1 ± 0.2		6.9 ± 0.2		6.8 ± 0.2		6.4
GM-32	Rowe Rd.	5.4 ± 0.2		6.3 ± 0.2		6.9 ± 0.3		6.7 ± 0.3		6.3
GM-33	Zoar Rd.	5.9 ± 0.2		6.2 ± 0.4		6.9 ± 0.2		7.3 ± 0.2		6.6
GM-34	Fife Brook Rd.	8.1 ± 0.4		8.5 ± 0.3		9.6 ± 0.5		9.4 ± 0.3		8.9
GM-35	Whitcomb Summit	6.5 ± 0.5		7.1 ± 0.2		8.7 ± 0.2		7.8 ± 0.2		7.5
GM-36	Tilda Rd.	6.1 ± 0.3		6.8 ± 0.3		8.1 ± 0.2		7.7 ± 0.2		7.2
GM-37	Turner Hill Rd.	6.1 ± 0.2		7.1 ± 0.3		8.7 ± 0.2		8.0 ± 0.2		7.5
GM-38	West Hill Rd.	6.8 ± 0.3		7.8 ± 0.3		9.4 ± 0.3		8.7 ± 0.3		8.2
GM-39	Route 100	7.1 ± 0.4		8.3 ± 0.4		9.3 ± 0.4		9.1 ± 0.3		8.5
GM-40	Readsboro Rd.	6.0 ± 0.3		6.9 ± 0.3		7.9 ± 0.3		7.5 ± 0.3		7.1

* TLD missing, apparently due to vandalism.

6.0 ANALYSIS OF ENVIRONMENTAL RESULTS

6.1 Sampling Program Deviations

ODCM Control 4.1 allows for deviations "if specimens are unobtainable due to hazardous conditions, seasonal unavailability or to malfunction of automatic sampling equipment." In 1993, four deviations were noted in the REMP. These deviations did not compromise the program's effectiveness and in fact are considered insignificant with respect to what is normally anticipated for any radiological environmental monitoring program. The specific deviations for 1993 were:

1. The power was turned off at air sampling station AP/CF-14 from approximately 0900 on Nov. 3 to 0900 on Nov.24 due to construction work at the Harriman Station service building.
2. The air sampling station AP/CF-12 continued to be out of service due to dam construction and related activities. This sampler was effectively replaced by the nearby sampler at the Yankee Visitor's Center (AP/CF-31).
3. The dairy farm at TM-12 (Readsboro, VT) went out of business in March 1993. The last sample collected there was on February 2, 1993. The replacement location was TM-14 (Rowe, MA). The first sample at TM-14 was collected on April 6, 1993. This constituted Revision 9 to the YNPS Offsite Dose Calculation Manual (ODCM).
4. The TLDs posted for the first quarter of 1993 at station GM-09 were lost, apparently due to vandalism.

6.2 Comparison of Achieved LLDs with Requirements

Table 4.3 of the ODCM (reproduced as Table 4.4 in this report) gives the required Lower Limits of Detection (LLDs) for environmental sample analyses. On occasion, an LLD is not achievable due to a situation such as a low sample volume caused by sampling equipment malfunction. In such a case, Control 7.1 of the ODCM requires a discussion of the situation in the Annual Radiological Environmental Operating Report. At the YAEL, the target LLD for any analysis is typically 30-40 percent of the most restrictive required LLD. Expressed differently, the typical sensitivities achieved for each analysis are at least 2.5 to 3 times better than that

required by the YNPS ODCM.

For each analysis having an LLD requirement in ODCM Table 4.3, the a posteriori (after the fact) LLD calculated for that analysis was compared with the required LLD. Of the approximate 6000 analyses performed during 1993, of which approximately 1800 had an LLD requirement in ODCM Table 4.3, all met the requirement.

6.3 1993 Results Compared Against Reporting Levels

ODCM Control 4.1.a requires the written notification of the NRC (within 30 days) whenever a Reporting Level in ODCM Table 4.2 is exceeded. Reporting Levels are the environmental concentrations that relate to the ALARA design dose objectives of 10 CFR 50, Appendix I. It should be noted that environmental concentrations are averaged over calendar quarters for the purposes of this comparison, and that Reporting Levels apply only to measured levels of radioactivity due to plant effluents. During 1993, no Reporting Levels were exceeded.

6.4 Data Analysis by Media Type

The 1993 REMP data for each media type are discussed below. These are arranged in the same order as in Table 5.1, and are further categorized by pathway. Graphical plots of monitoring data are shown at the end of the chapter in Figures 6.1 to 6.20. With respect to data plots, all values are plotted, whether they are "detectable" or "non-detectable."

6.4.1 Airborne Pathways

6.4.1.1 Air Particulates

The weekly air particulate filters from each of the six operating sampling sites were analyzed for gross-beta radioactivity. At the end of each quarter, the thirteen weekly filters from each sampling site were composited for a gamma analysis. The results of the weekly air particulate sampling program are shown in Table 5.1 and Figures 6.1, 6.2 and 6.3.

As shown in Figure 6.1, there has been no significant difference between the quarterly average concentration at the indicator (near-plant) stations and the control (distant from plant) stations. Also notable is a distinct

annual cycle, with the minimum concentration in the second quarter, and the maximum concentration in the first quarter. The peak seen in the second quarter of 1986 is airborne contamination resulting from the Chernobyl accident, as detected by the YNPS monitoring program.

Figures 6.2 through 6.6 show the weekly gross beta concentration at each air particulate sampling location alongside the same for the control air particulate sampling location at AP-21 (Williamstown, MA). It can be readily seen that the gross-beta measurements on air particulate filters fluctuate significantly over the course of a year. The measurements from control station AP-21 vary similarly, indicating that these fluctuations are due to regional changes in naturally-occurring airborne radioactive materials, and not due to YNPS operations. Table 5.1 shows that the mean concentrations from indicator stations are approximately equal to those from control locations, further supporting this conclusion. The only other radionuclide detected on air particulate filters was Be-7, a naturally-occurring cosmogenic radionuclide.

The gross-beta measurement for station AP-31 for the week October 12-19, shown on Figure 6.5, was unusually low. A visual inspection of the filter showed less dust buildup than expected. Although no reason for this situation was identified, it does indicate either a low sample flow or a partial bypass of the filter by the sampled air.

6.4.1.2 Charcoal Cartridges

The weekly charcoal cartridges from each of the six operating air sampling sites were analyzed for I-131. The results of these analyses are summarized in Table 5.1. As in previous years, no I-131 was detected in any charcoal cartridge during 1993.

6.4.2 Waterborne Pathways

6.4.2.1 Ground Water

Monthly ground water samples were collected from two on-site locations during 1993. (Only quarterly samples are required by ODCM Table 4.1.) Table 5.1 and Figure 6.6 show that gross-beta measurements were positive in all samples. This is due to naturally-occurring radionuclides in the water. The levels were consistent with that detected in previous years.

The semiannual average gross-beta concentration for the first half of 1992 at WG-11 (plant potable) stands out in Figure 6.6. An investigation conducted in 1992 revealed that the high gross-beta measurement was related to a temporary water supply problem at the plant. The water storage tank had been emptied, and water had been trucked in from an outside source and pumped into the plant storage tank. The high gross-beta measurements were possibly caused by naturally-occurring radionuclides in the sediment stirred up from the bottom of the storage tank as new water was pumped in. In any case, the water sampled was not from the plant well but from the outside source after it had been pumped into the storage tank. No plant-related radionuclides were detected in the water sample, and the subsequent monthly samples in 1992 had typical gross-beta concentrations.

H-3 was detected in all of the WG-12 (Sherman Spring) samples, as shown in Table 5.1 and Figure 6.7. The water from Sherman Spring leaves the ground on YNPS property and flows into the Deerfield River. Neither the Deerfield River nor Sherman Spring are used for drinking water. The maximum monthly concentration was 940 pCi/kg, and the mean value for 1993 was 610 pCi/kg. This is due to early plant operations and has been detected in all previous samples from this location. The concentration of H-3 at this location has decreased steadily for many years. The above maximum concentration of 940 pCi/kg may be compared against the NRC Reporting Level of 30,000 pCi/kg (for non-drinking water) in ODCM Table 4.2. At this Reporting Level, which is based on 10CFR50 Appendix I Design Dose Objectives, the YNPS ODCM would require notification to the NRC in writing within 30 days. This maximum concentration at station WG-12 is only 3.1 percent of the above Reporting Level.

No gamma-emitting radionuclides were detected in any of the ground water samples.

6.4.2.2 River Water

Aliquots of river water were automatically collected every two hours from the Deerfield River downstream from the plant, as well as at the Harriman Reservoir control location. These composited samples were collected monthly and sent to the YAEL for analysis. Monthly grab samples were also collected at Sherman Pond near the discharge area.

Table 5.1 shows that gross-beta measurements were positive in most samples, as would be expected, due to naturally-occurring radionuclides in the water. The historical concentrations at the indicator and control

locations have not been significantly different, as shown in Figure 6.8. Figure 6.8 does show, however, that during the last half of 1992 the levels at WR-11 were slightly elevated relative to the control. Since there were no discharges from YNPS during this period, it is believed that this was due indirectly to the dam construction upstream from the sampler at Monroe Bridge, as discussed in the 1992 Annual Radiological Environmental Operating Report.

No gamma-emitting radionuclides attributable to YNPS operations were detected in any of the samples. For each sampling site, the monthly samples were composited into quarterly samples for Tritium (H-3) analyses. No Tritium was detected in river water samples during 1993.

6.4.2.3 Storm Drain Water

Monthly grab samples were collected from the West Storm Drain (WW-52) during 1993. Each sample was analyzed for gross-beta and gamma-emitting radionuclides and H-3. Gross-beta measurements were positive in all of the twelve samples, as would be expected. The levels are consistent with those from previous years. No gamma-emitting radionuclides or H-3 were detected in any of the samples.

6.4.2.4 Sediment

Semiannual sediment core samples were collected from two locations during 1993. Each set of samples was segmented by depth (0-5, 5-10, 10-15 cm) and analyzed for gamma-emitting radionuclides. As would be expected, naturally-occurring K-40 and Ac-Th-228 were detected in all samples.

In addition to the above radionuclides, Cs-137 was detected in most segments. The levels measured at downstream location SE-11 were consistent with what has been measured in the previous several years (see Figure 6.9) and are attributed to nuclear weapons testing fallout that has persisted in the environment. At the control location, the character of the sediment is highly dependent on the specific location of the sample, which in turn is dependent on the water level in Harriman Reservoir at the time of sampling. Since Cs-137 tends to bind to sandy and rocky sediment to a much lesser degree than to that containing more organic matter, this diverse character of the sediment at SE-21 leads to a wide range of Cs-137 concentrations, as shown in Figure 6.10.

Table 5.1 and Figure 6.11 show higher levels of Cs-137 at station SE-91. These samples were collected from a deep water location near the plant discharge in Sherman Pond. Although some of the Cs-137 in these samples is likely due to plant effluents, much of it is believed to be due to global nuclear weapons testing fallout, which accumulates in the rich organic mud at the bottom of Sherman Pond.

The 0-5 cm segment from the core taken on May 18, 1993 at SE-91 showed a Co-60 concentration of 756 ± 89 pCi/kg. This sample, as all others at SE-91, were collected in deep water, well away from the shoreline. None of this radioactivity is involved in any significant pathway of exposure to man. To further quantify the levels of Co-60 at this location, two additional sets of cores were taken in the southern end of Sherman Pond near the plant discharge area, along with the routine set of cores collected on October 7, 1993. Of the nine core segments analyzed (three depth increments at each of three locations), only one contained a detectable concentration of Co-60 (155 ± 35 pCi/kg in the 0-5 cm segment).

6.4.3 Ingestion Pathways

6.4.3.1 Milk

Milk samples from cows at three local farms were collected twice-per-month during the 1993 pasture season, and monthly during the remainder of the year. Each sample was analyzed for I-131 and other gamma-emitting radionuclides. Quarterly composites (by location) were analyzed for Sr-89 and Sr-90. As mentioned previously in this report, the farm at TM-12 went out of business in February 1993, only providing samples in January and February. It was replaced by a new location, which began providing samples in April 1993.

As was expected, naturally-occurring K-40 was detected in all samples. Also expected was Cs-137 and Sr-90. Cs-137 was detected in 15 out of 37 indicator samples. Although no Cs-137 was detected in the 1993 control samples, it has been detected in previous years, as shown in Figure 6.12. Sr-90 was detected in all six of the eight indicator samples, and one of the four control samples.

Although both Cs-137 and Sr-90 are a by-product of plant operations, the levels detected in milk are due to worldwide fallout from nuclear weapons tests, and to a much lesser degree from fallout from the Chernobyl incident. These two radionuclides are present throughout the natural

environment as a result of atmospheric nuclear weapons testing that started primarily in the late 1950's and continued through 1980. They may be found in soil and vegetation, as well as anything that feeds upon vegetation, directly or indirectly. The Cs-137 and Sr-90 levels shown in Table 5.1 and Figures 6.12 and 6.13 are consistent with those detected at other New England farms that are monitored as part of other Yankee-affiliated environmental monitoring programs. As shown in these figures, the levels are also consistent with those detected in previous years near YNPS.

It may be noted that the location with the highest annual average Cs-137 concentration for 1993 was TM-14 (see Table 5.1 and Figure 6.12). It should also be noted that the milk animals providing samples at that location were primarily goats. It is generally known that goats have a much higher transfer coefficient from vegetation to milk for strontium and cesium. This means that for a given amount of Cs-137 or Sr-90 in the diet, the concentration in the milk will typically be higher for a goat than for a cow (Reference 7).

6.4.3.2 Fish

Semiannual samples of fish were collected from two locations during 1993. The edible portions of each of these were analyzed for gamma-emitting radionuclides. As expected in biological matter, naturally-occurring K-40 was detected in all samples. As shown in Table 5.1, Cs-137 was detected in one of the two indicator samples, but not in the two control samples. (In previous years, Cs-137 has been detected in control samples as well.) This radioactivity is attributed to global nuclear weapons testing fallout. No other radionuclides were detected.

6.4.3.3 Food Products/Broad Leaf Vegetation

The food crops collected in 1993 consisted of samples of kale, spinach and tomatoes. Each was analyzed for gamma-emitting radionuclides. K-40 was detected in all samples. No other radionuclides were detected.

A sample of kale was collected in 1993 at Station TV-11 to satisfy the broad leaf vegetation sampling requirement. A low-level I-131 analysis was done on this sample. No I-131 was detected.

6.4.3.4 Maple Syrup

Processed maple syrup samples were collected from three locations in April of 1993. These samples had been concentrated, relative to the original tree sap, by boiling. Naturally occurring K-40 was detected in all three samples. Cs-137 was detected in the two indicator samples. The concentrations of Cs-137 in 1993 samples are consistent with that detected in both indicator and control samples in previous years, and is attributed to global nuclear weapons testing fallout. This radioactivity has been detected in most samples since collection was started in 1972.

6.4.4 Direct Radiation Pathway

Direct radiation is continuously measured at 40 locations surrounding YNPS with the use of thermoluminescent dosimeters (TLDs). These are collected every calendar quarter for readout at the YAEL.

As can be seen in Figures 6.15 to 6.25, there is a distinct annual cycle at both indicator and control locations. The lowest point of the cycle occurs during the winter months. This is due primarily to the attenuating effect of the snow cover on radon emissions and on direct irradiation by naturally-occurring radionuclides in the soil. Differing amounts of these naturally-occurring radionuclides in the underlying soil, rock or nearby building materials result in different radiation levels between one field site and another. This explains why the control TLD station at the Fife Brook Road station (GM-34, 6.4 km from the plant) had the highest mean exposure for 1993, as can be seen in Tables 5.2 and 5.3, as well as Figure 6.21.

From Table 5.2 and 5.3, it can be seen that the mean exposure rates for the Indicator, Outer Ring and Control categories were not statistically different in 1993. This indicates that there was no significant overall increase in direct radiation exposure rates in the plant vicinity. As shown in Figures 6.15 to 6.25, the levels in 1993 are consistent with those in previous years.

It should be noted that the "Fenceline" TLDs shown in Figure 6.24 and summarized in Tables 5.2 and 5.3 are located on the fence surrounding the Radiation Control Area on the YNPS site, and are influenced by licensed plant activities. The fenceline is well within the YNPS property bounds.

Figure 6.1
Gross-Beta Measurements on Air Particulate Filters
Quarterly Averages

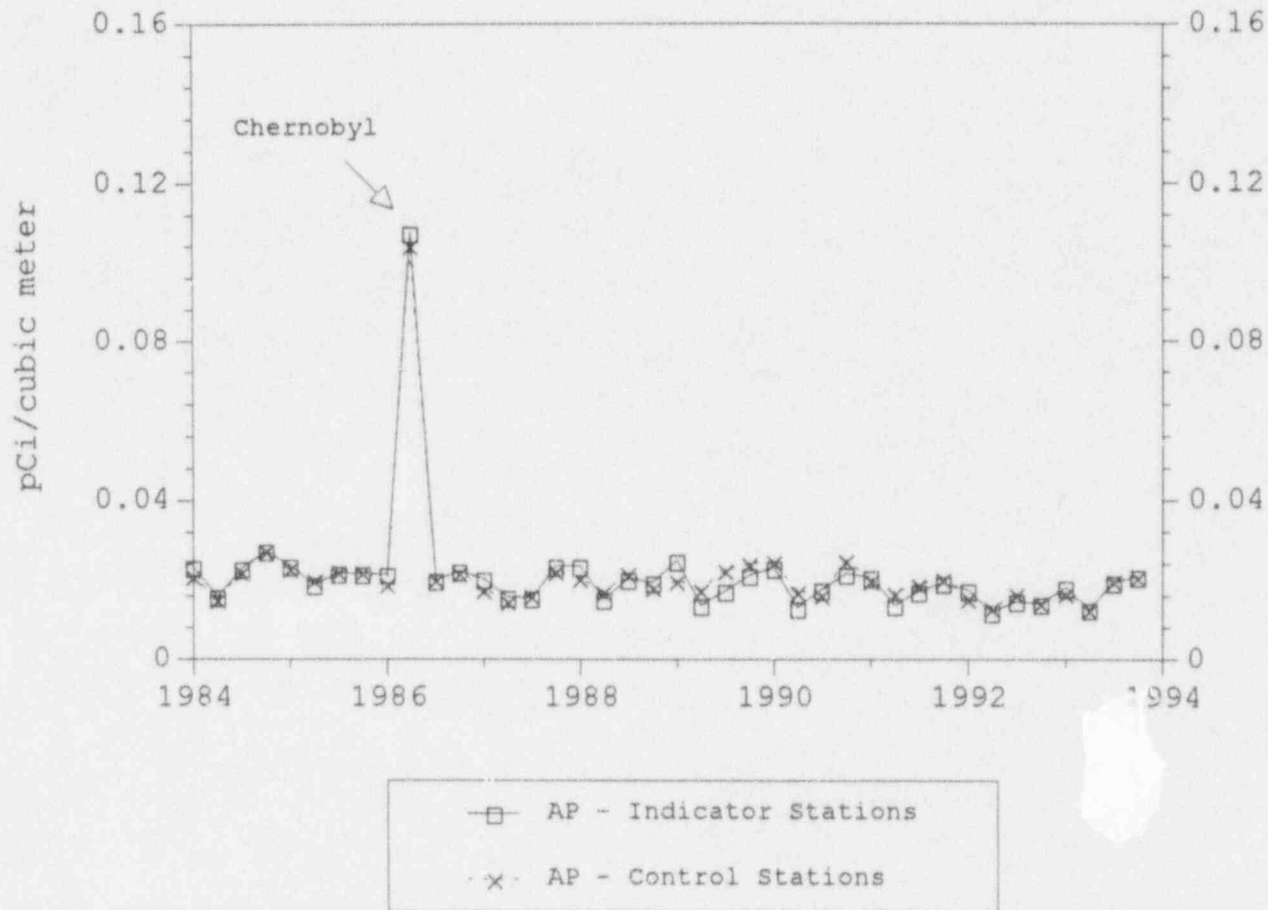


Figure 6.2
Gross-Beta Measurements on Air Particulate Filters

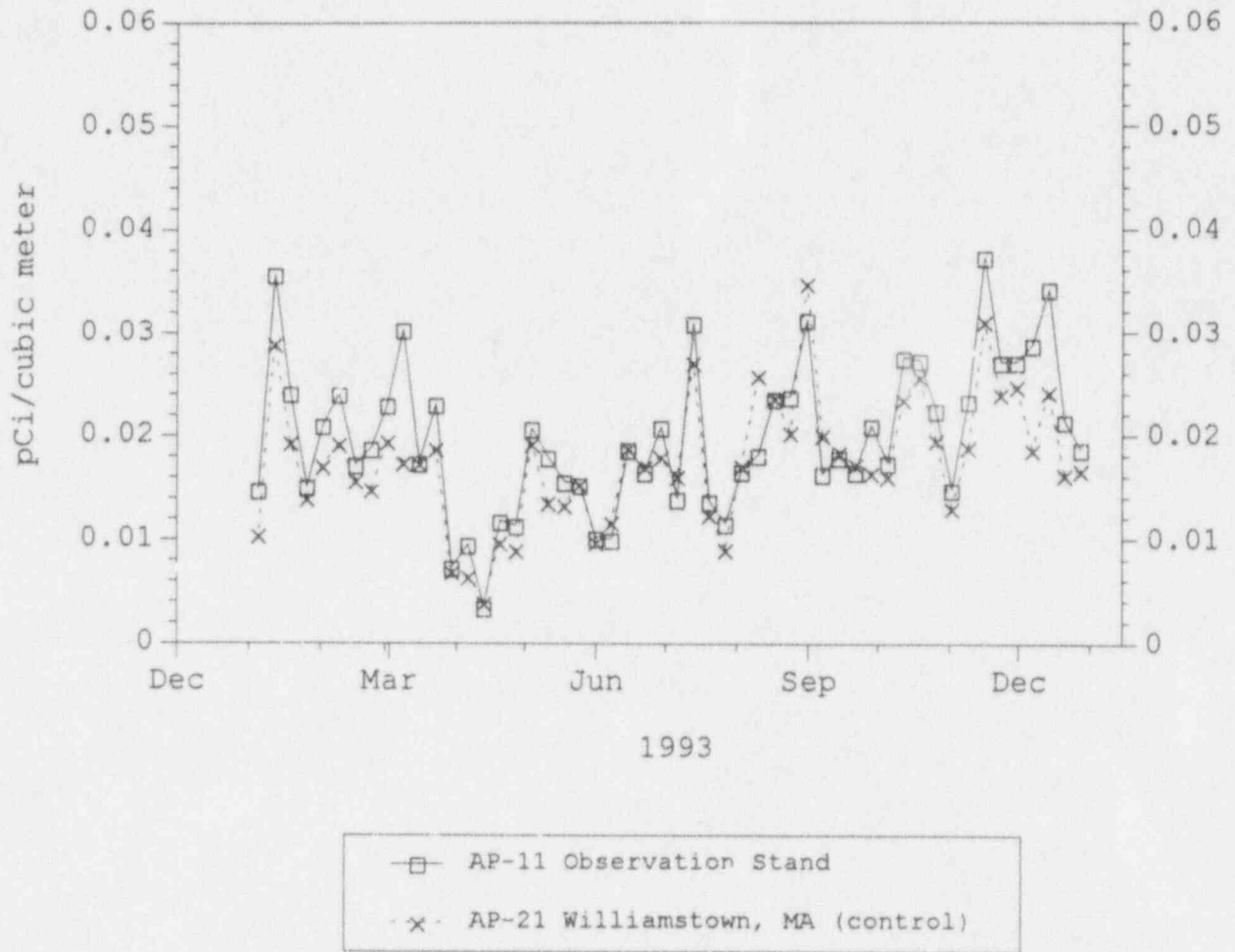
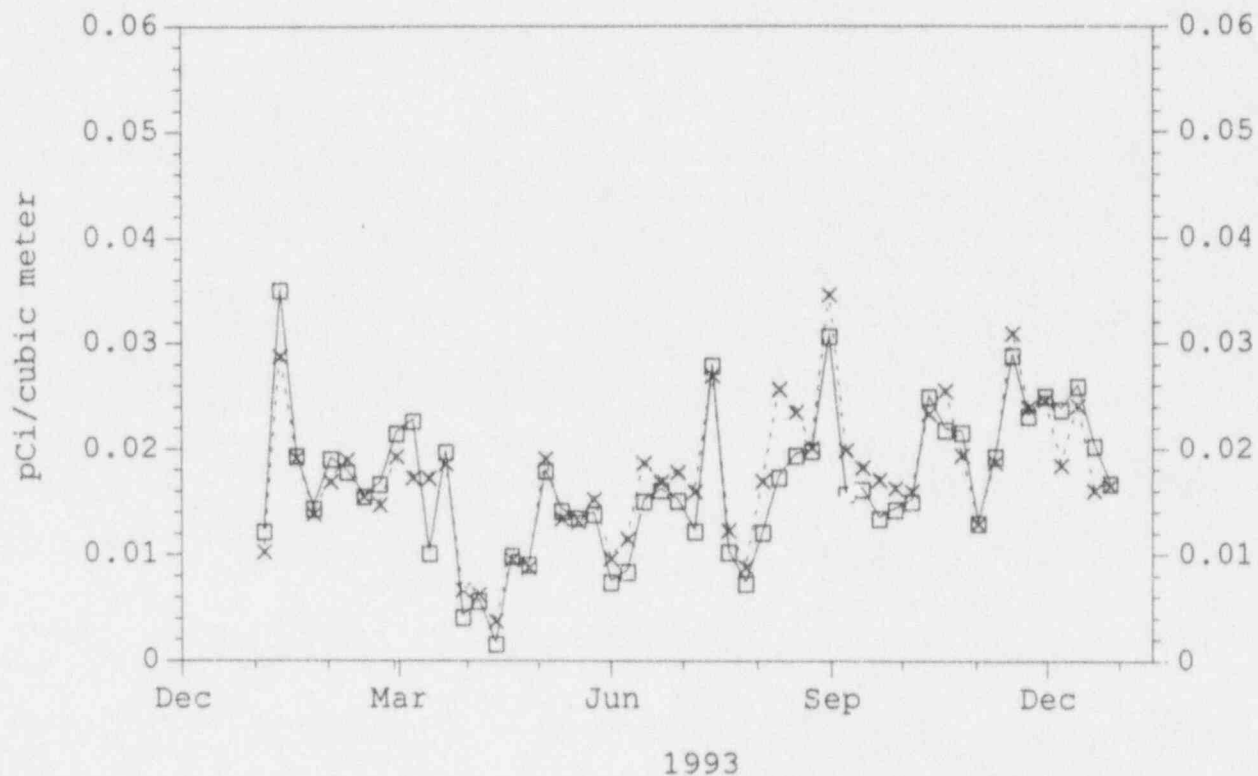
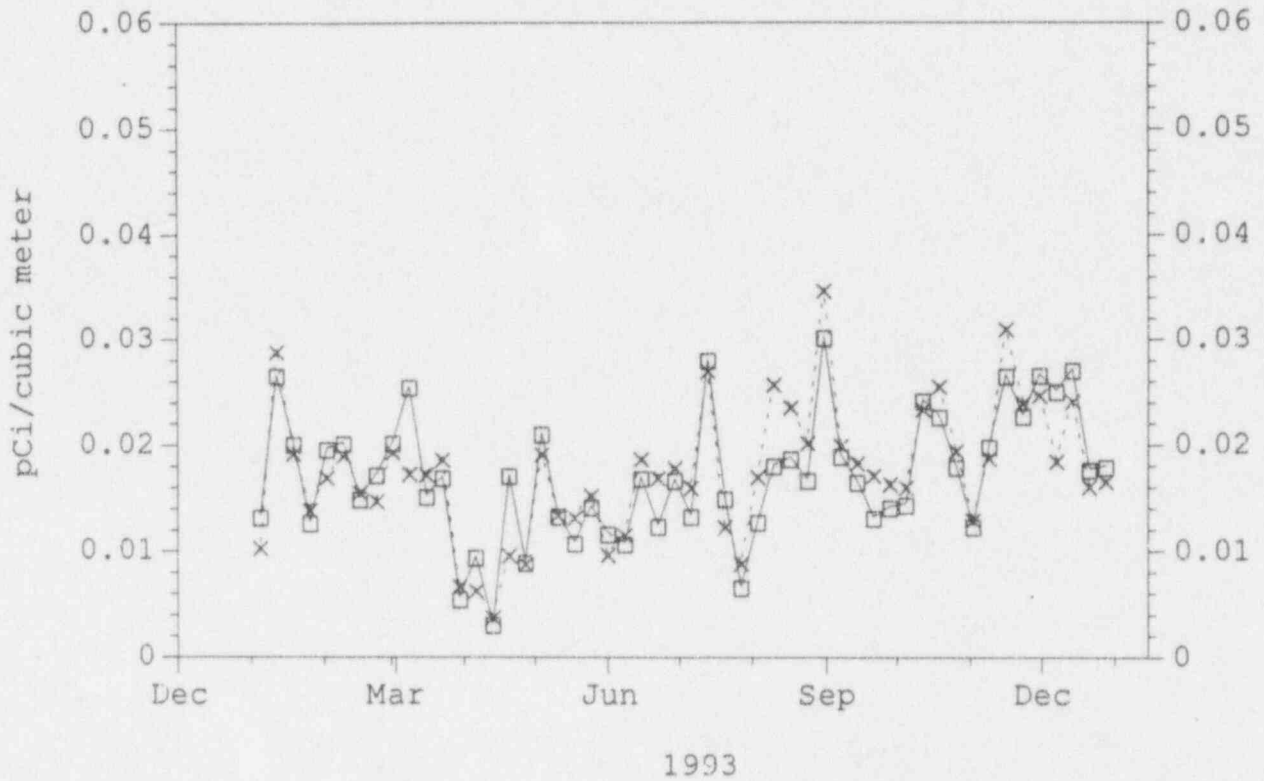


Figure 6.3
 Gross-Beta Measurements on Air Particulate Filters



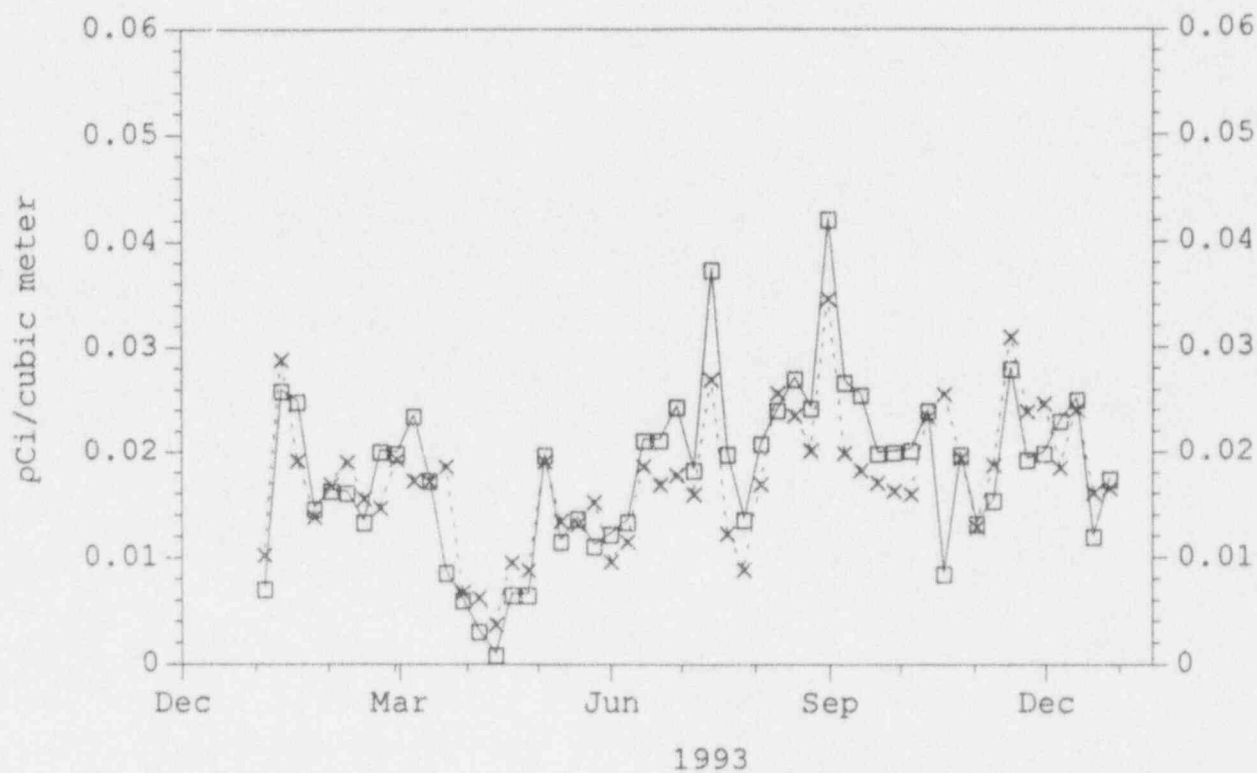
—□— AP-13 Rowe School
-x- AP-21 Williamstown, MA (control)

Figure 6.4
Gross-Beta Measurements on Air Particulate Filters



—□— AP-14 Harriman Station
-x- AP-21 Williamstown, MA (control)

Figure 6.5
 Gross-Beta Measurements on Air Particulate Filters



—□— AP-31 YAEC Visitor's Center
 -x- AP-21 Williamstown, MA (control)

Figure 6.6
Gross Beta Measurements of Ground Water
Semi-Annual Averages

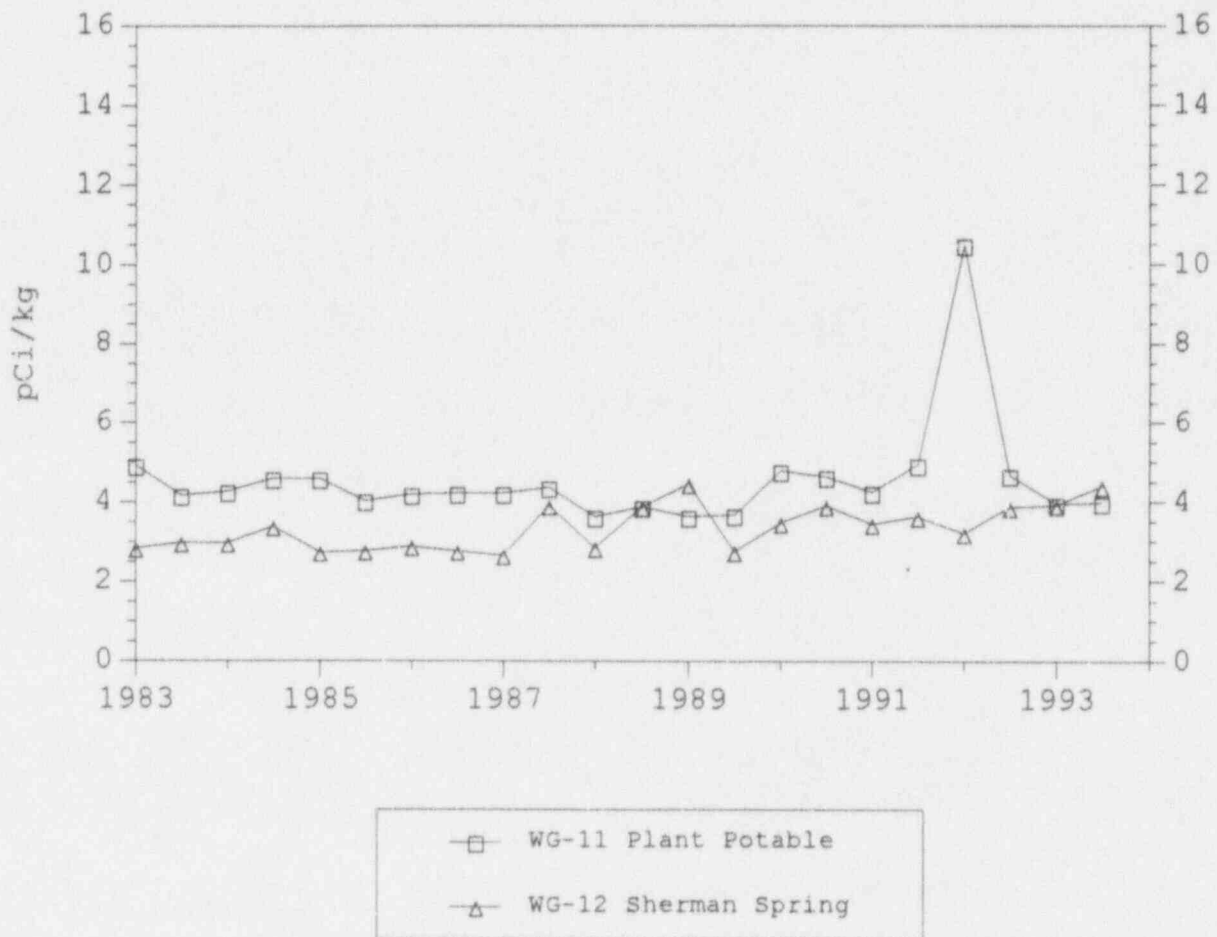


Figure 6.7
H-3 in Ground Water
Station WG-12, Sherman Spring

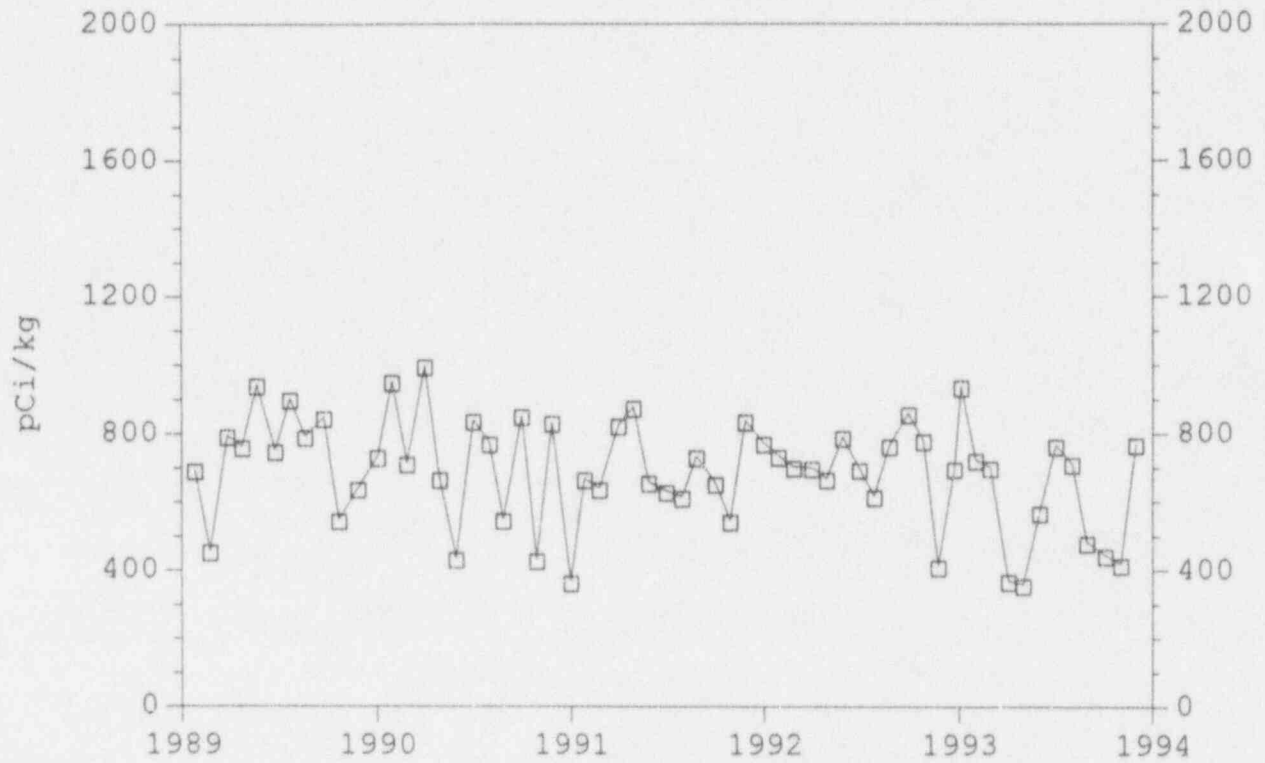


Figure 6.8
Gross-Beta Measurements of River Water
Semi-Annual Averages

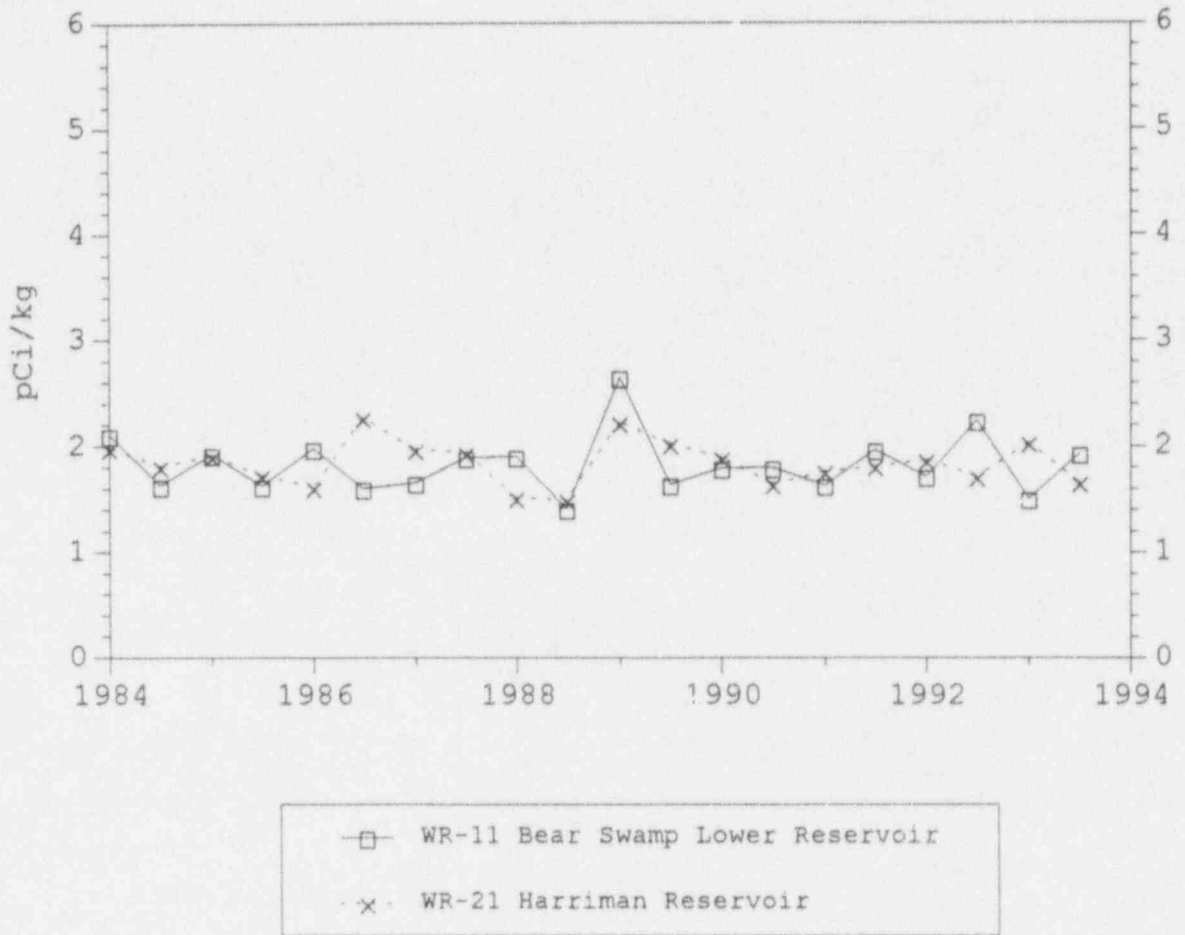


Figure 6.9
Cesium-137 in Shoreline Sediment
Station SE-11, NO.4 Station

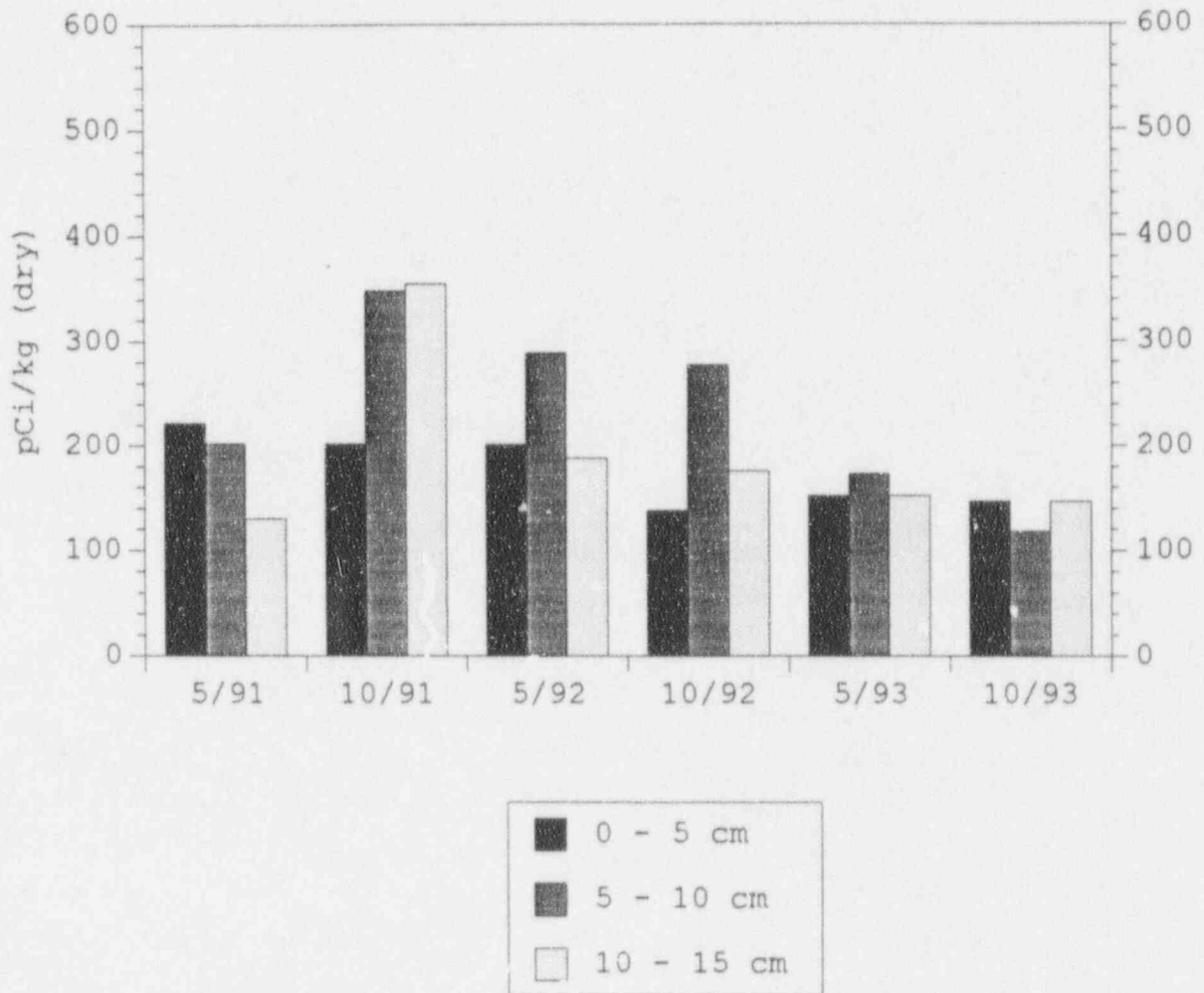


Figure 6.10
 Cesium-137 in Shoreline Sediment
 Station SE-21, Harriman Reservoir

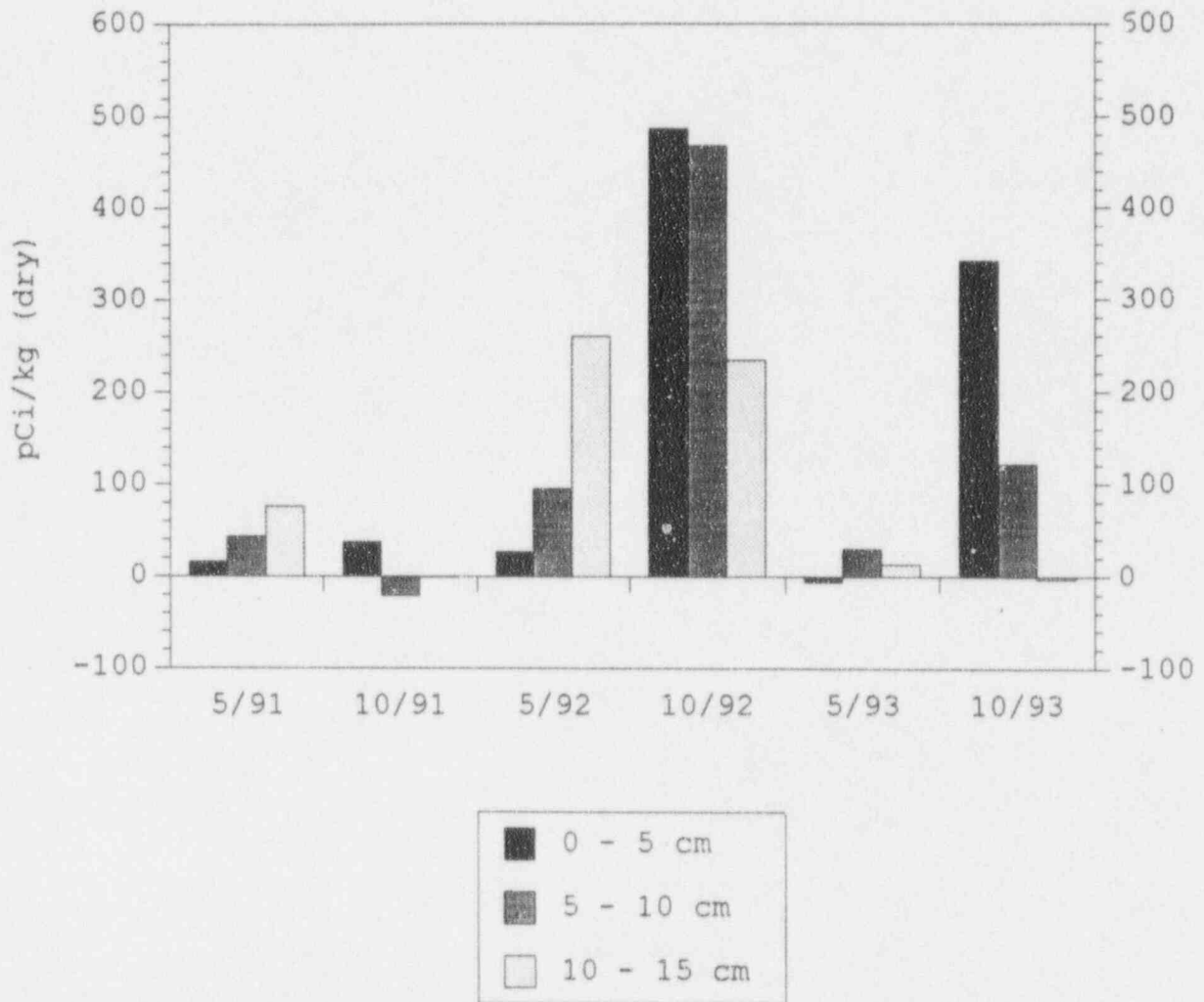


Figure 6.11
Cesium-137 in Bottom Sediment
Station SE-91, Sherman Pond

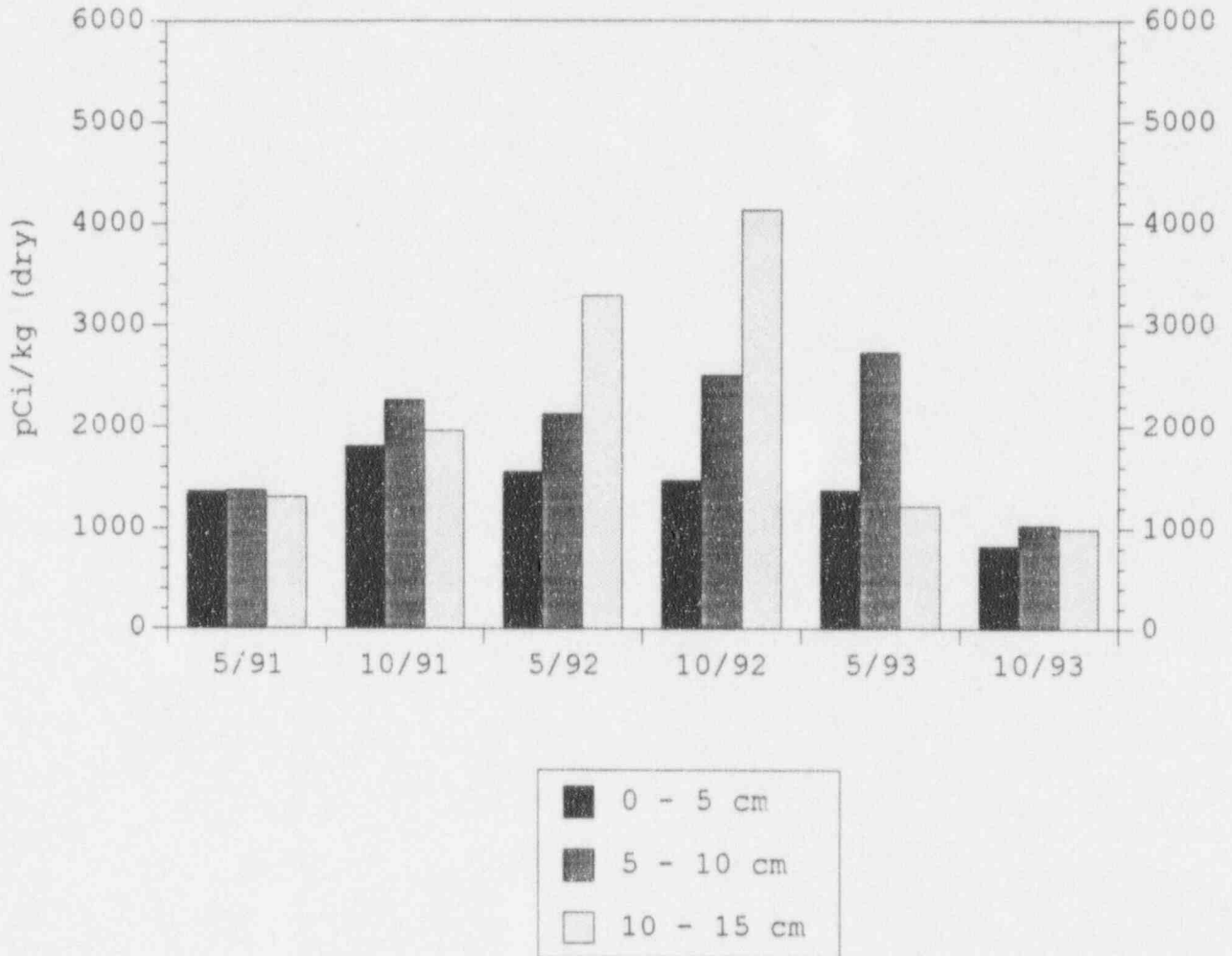


Figure 6.12
Cesium-137 in Milk
Annual Averages

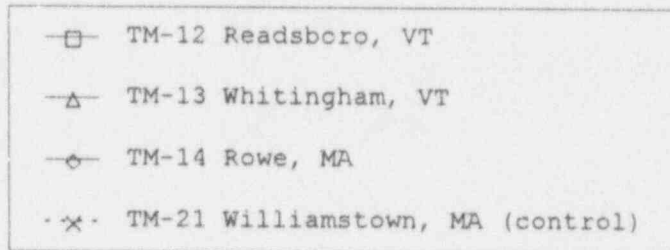
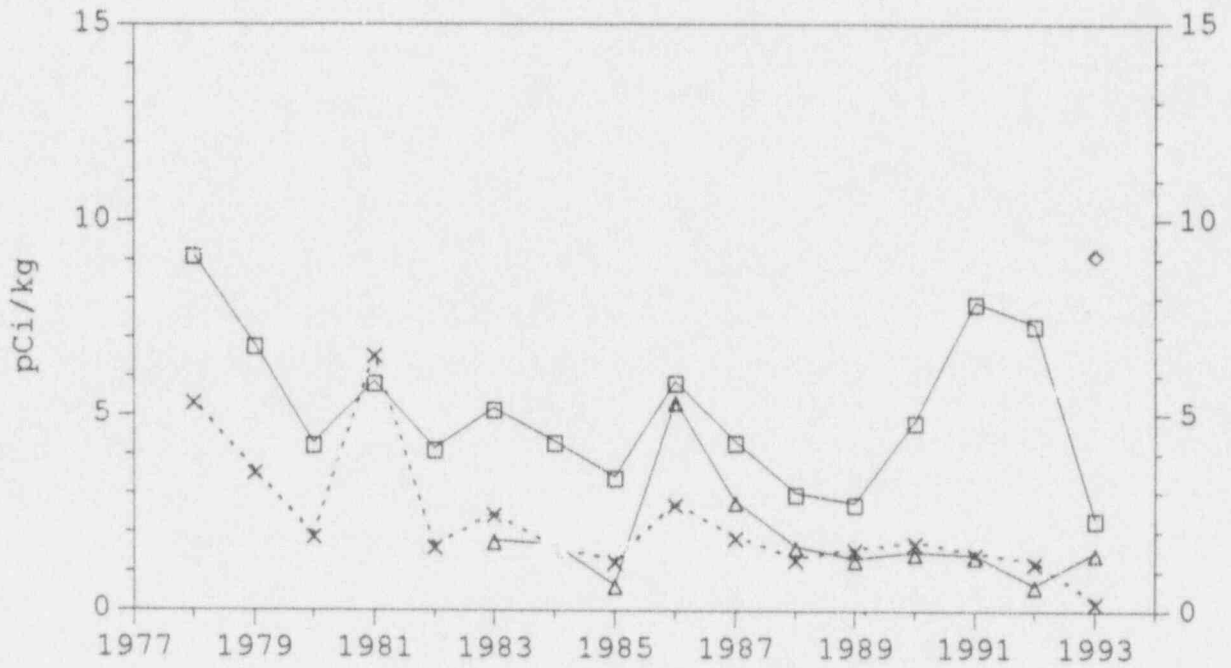
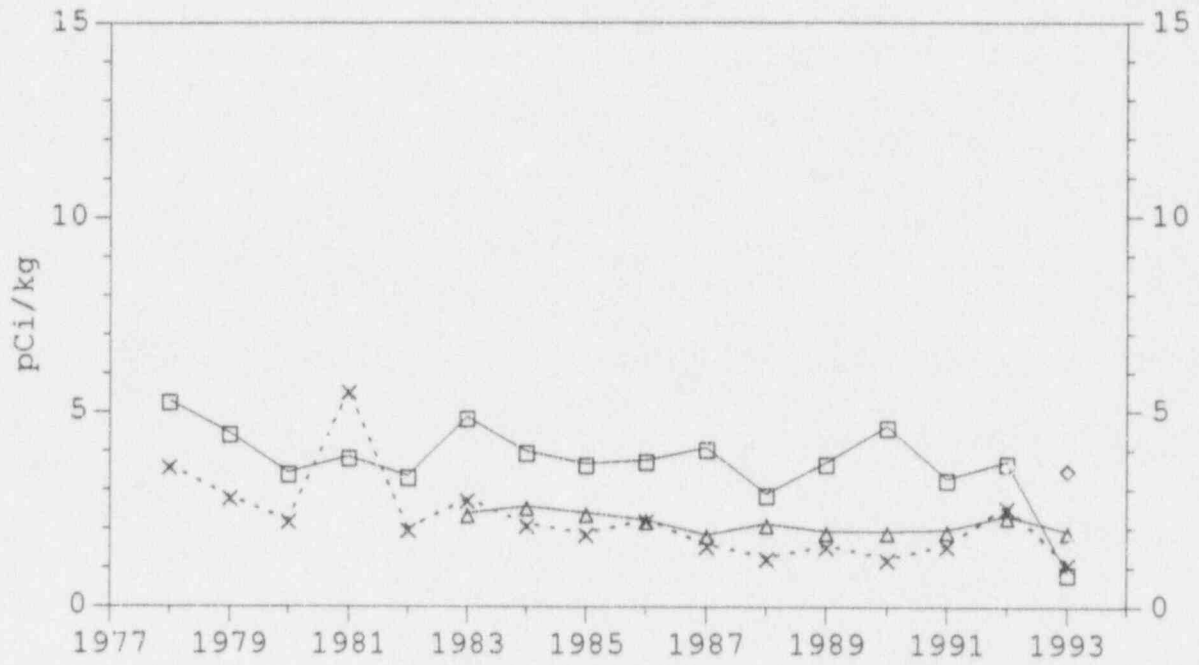


Figure 6.13
Strontium-90 in Milk
Annual Averages



- TM-12 Readsboro, VT
- △— TM-13 Whitingham, VT
- ◇— TM-14 Rowe, MA
- x·- TM-21 Williamstown, MA (control)

Figure 6.14
Cesium-137 in Fish
Annual Average Concentrations

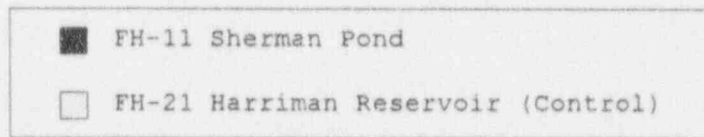
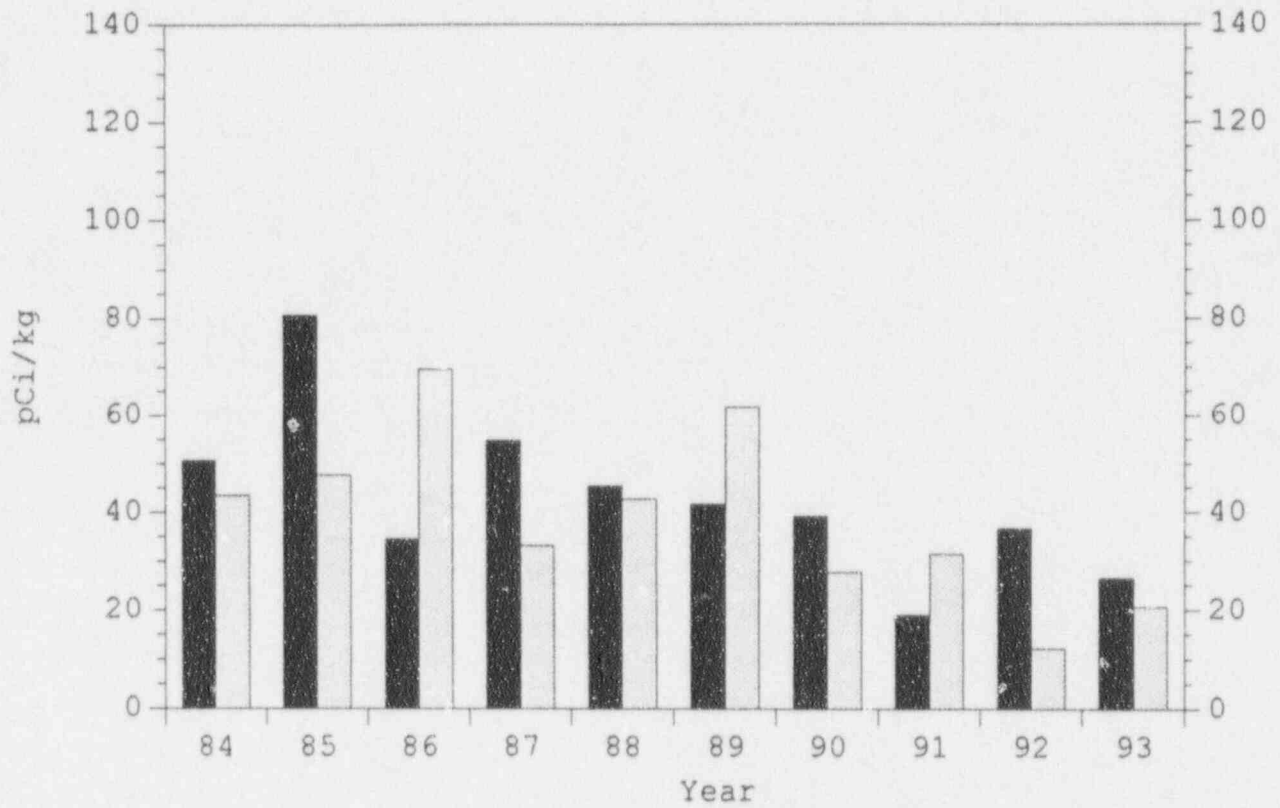


Figure 6.15
Exposure Rate at Indicator, Outer Ring and Control TLD'S

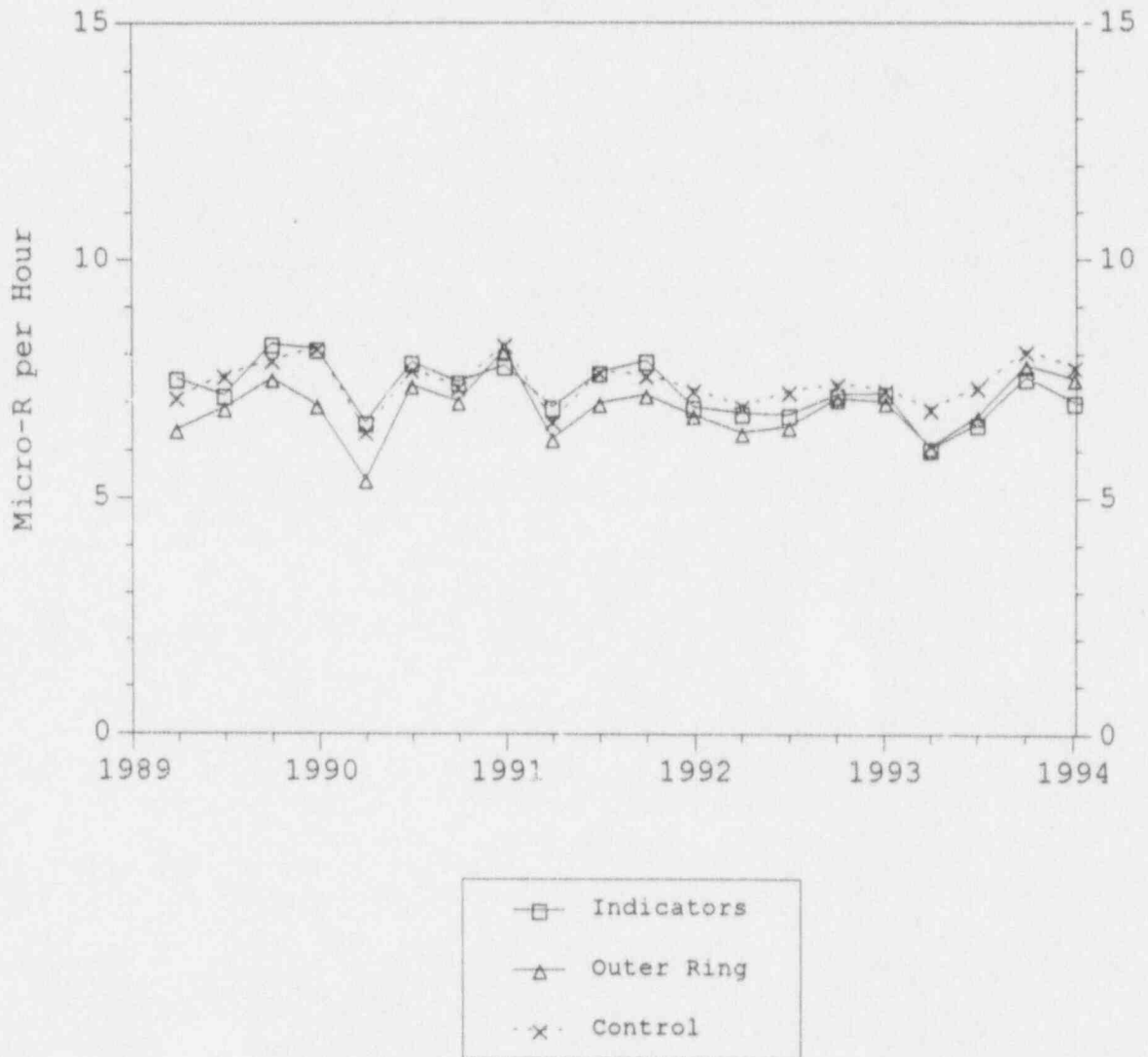
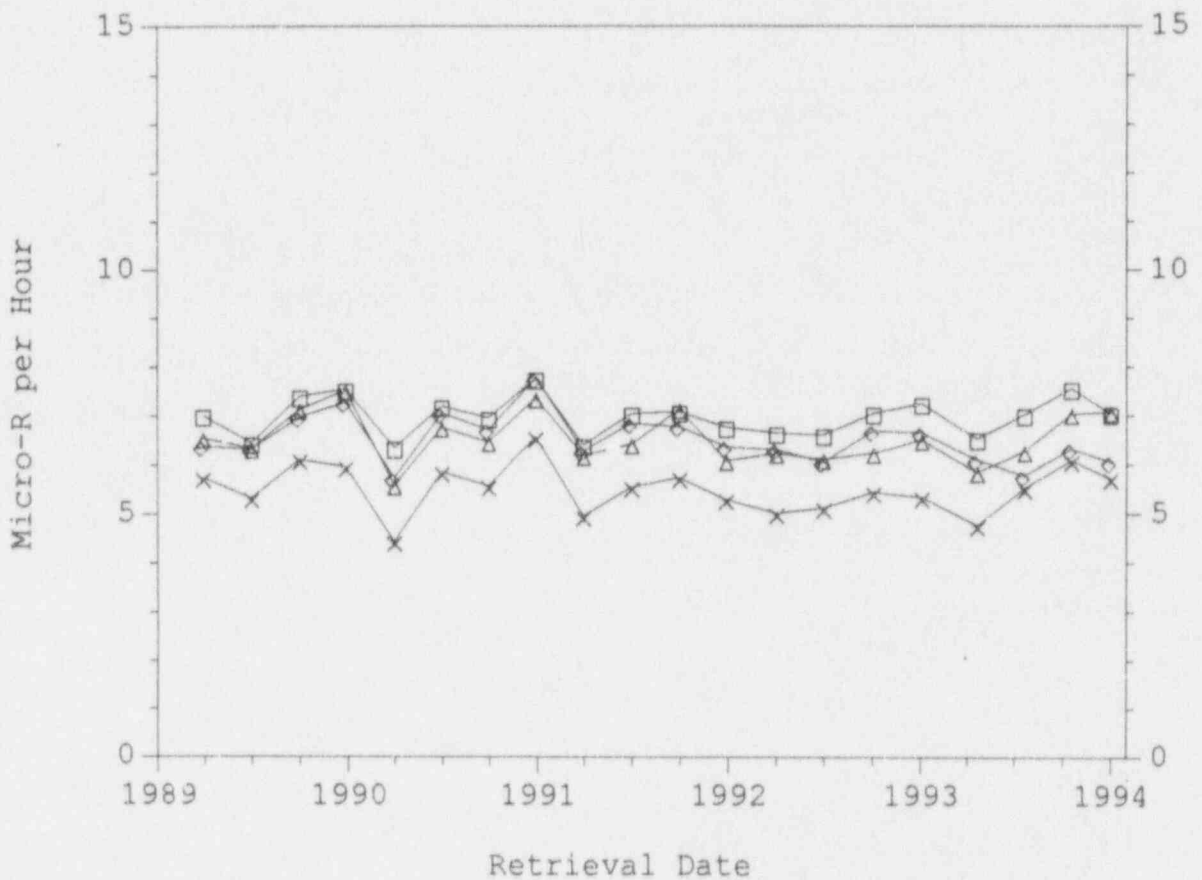


Figure 6.16
Exposure Rate at Indicator TLDS, GM 01-04



- GM-01 YAEC Visitor's Center
- △- GM-02 Observation Stand
- x- GM-03 Rowe School
- ◇- GM-04 Harriman Station

Figure 6.17
 Exposure Rate at Indicator TLDS, GM 05-08

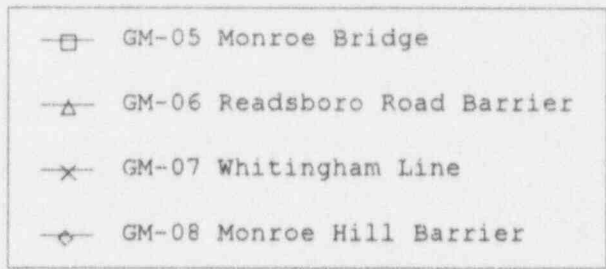
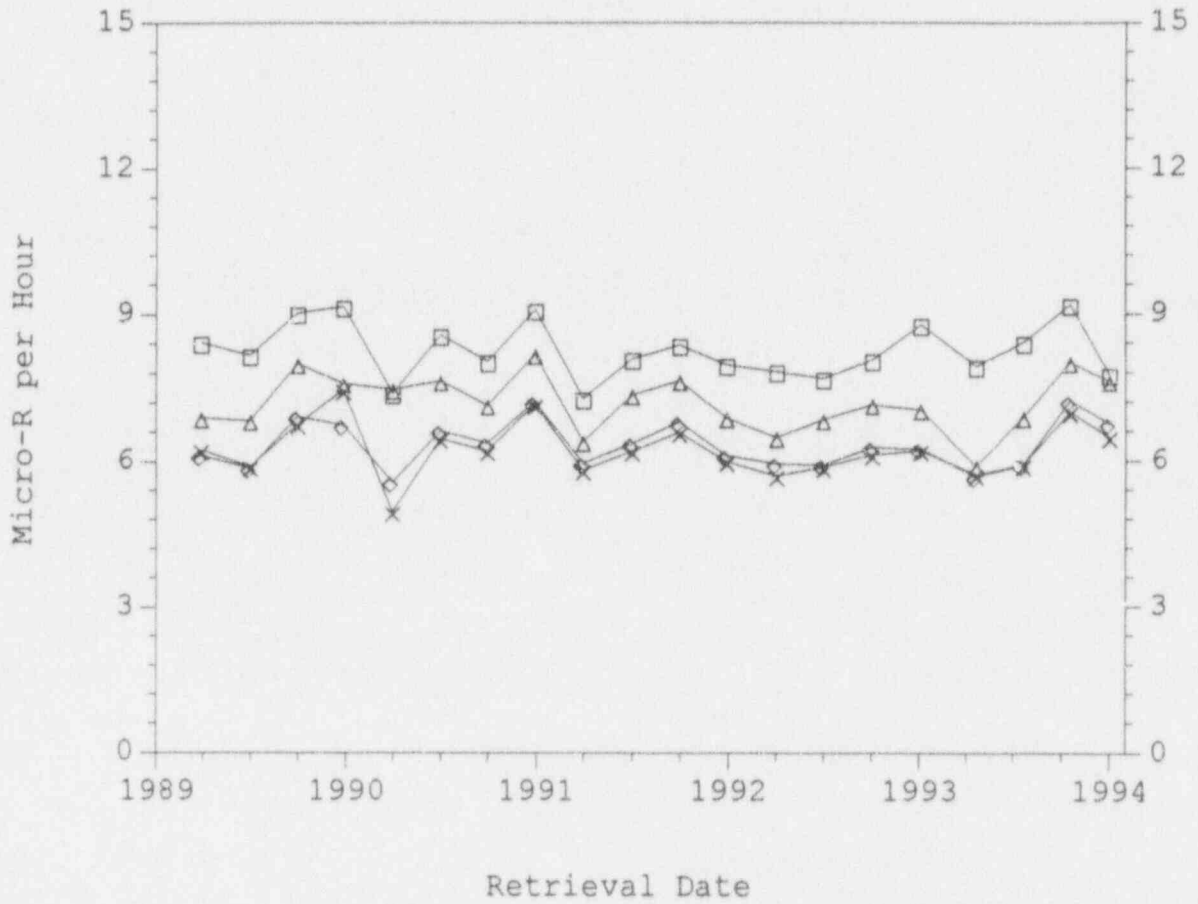
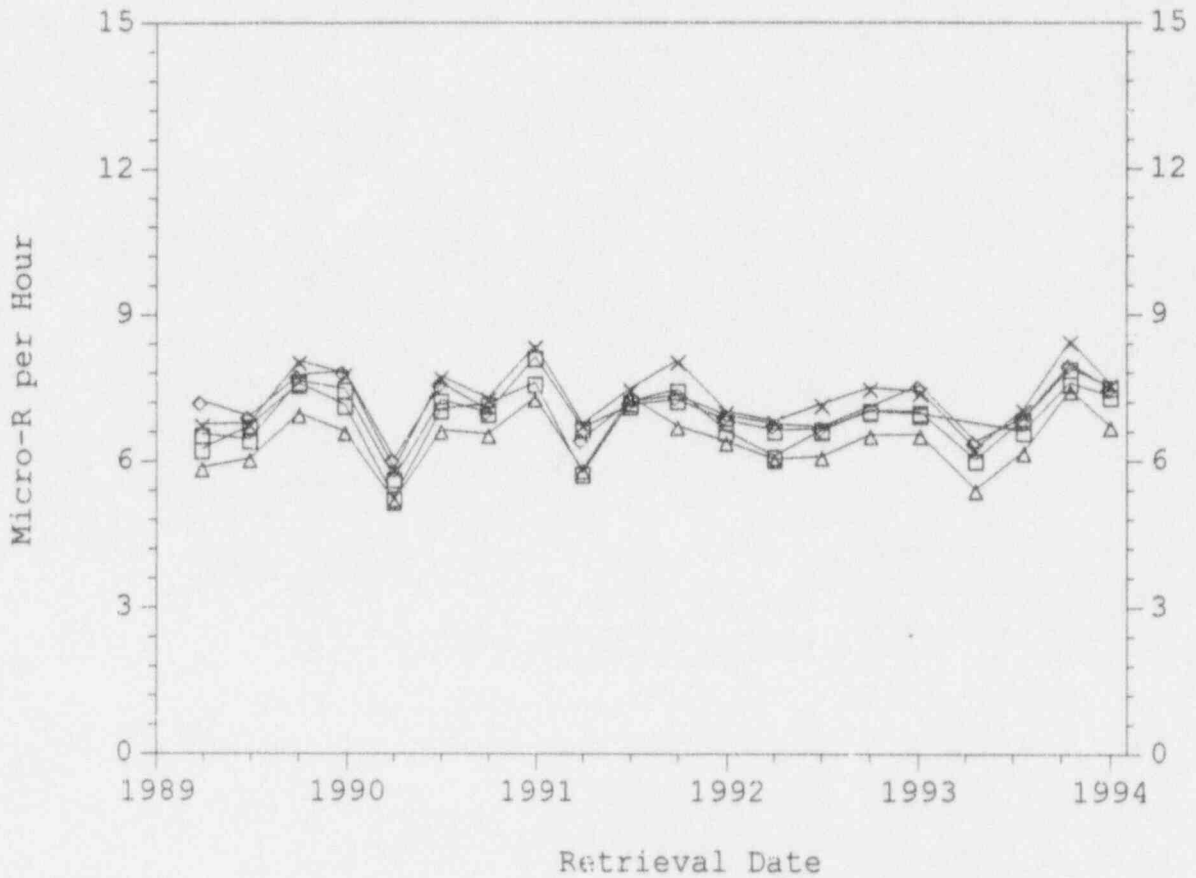


Figure 6.18
 Exposure Rate at Indicator TLDS, GM 09-12,40



- GM-9 Dunbar Brook
- △— GM-10 Cross Road
- ×— GM-11 Adams High Line
- ◇— GM-12 Readsboro, VT
- ◻— GM-40 Readsboro Road

Figure 6.19
 Exposure Rate at Indicator TLDS, GM 24-27

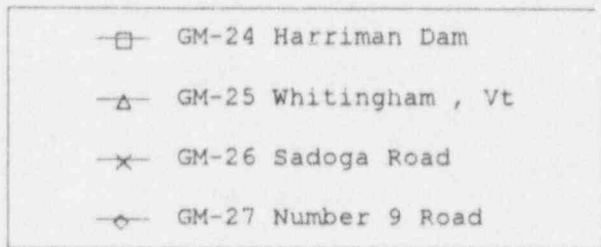
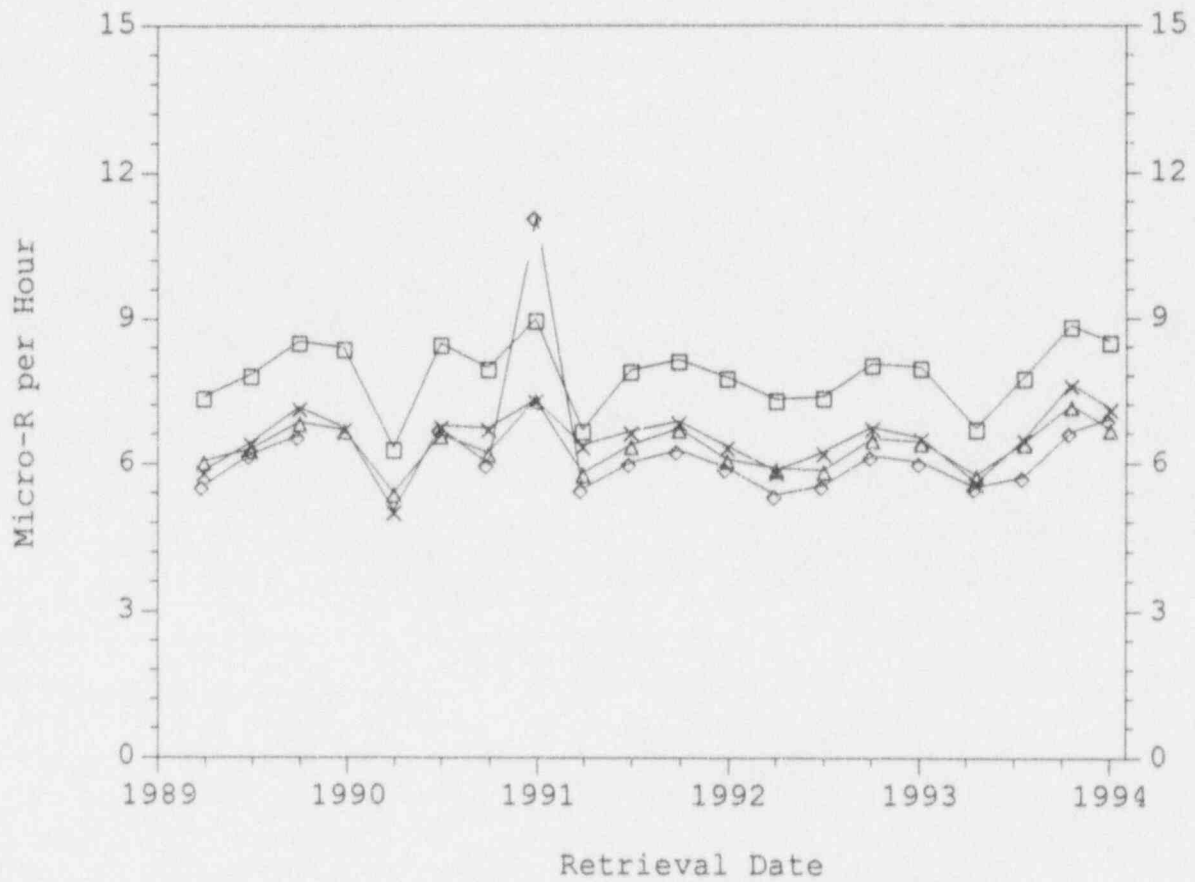


Figure 6.20
 Exposure Rate at Indicator TLDS, GM 28-31

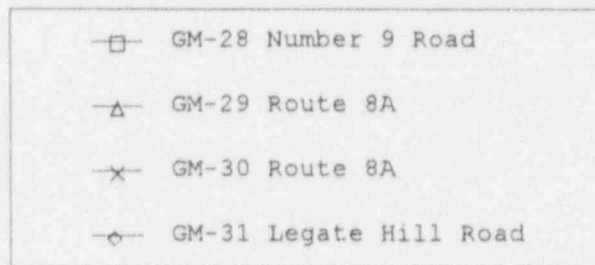
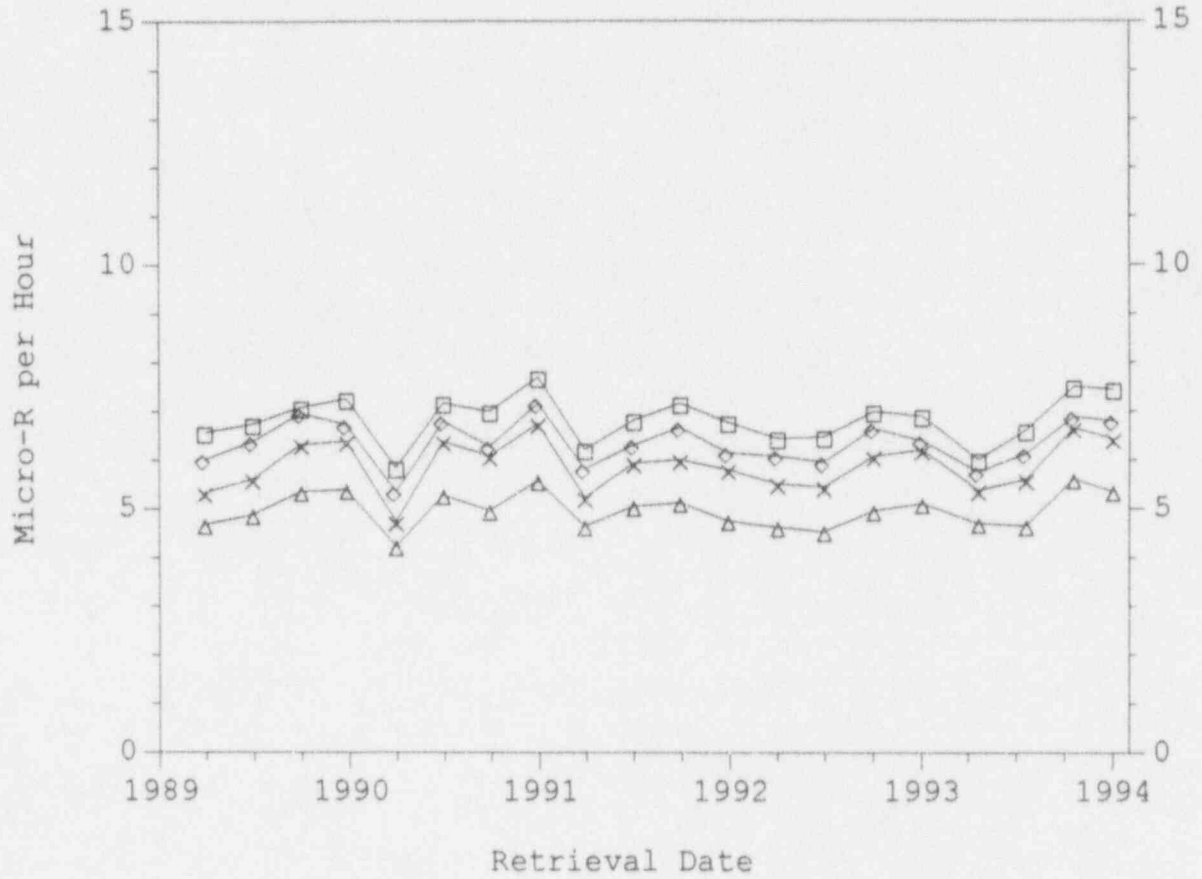
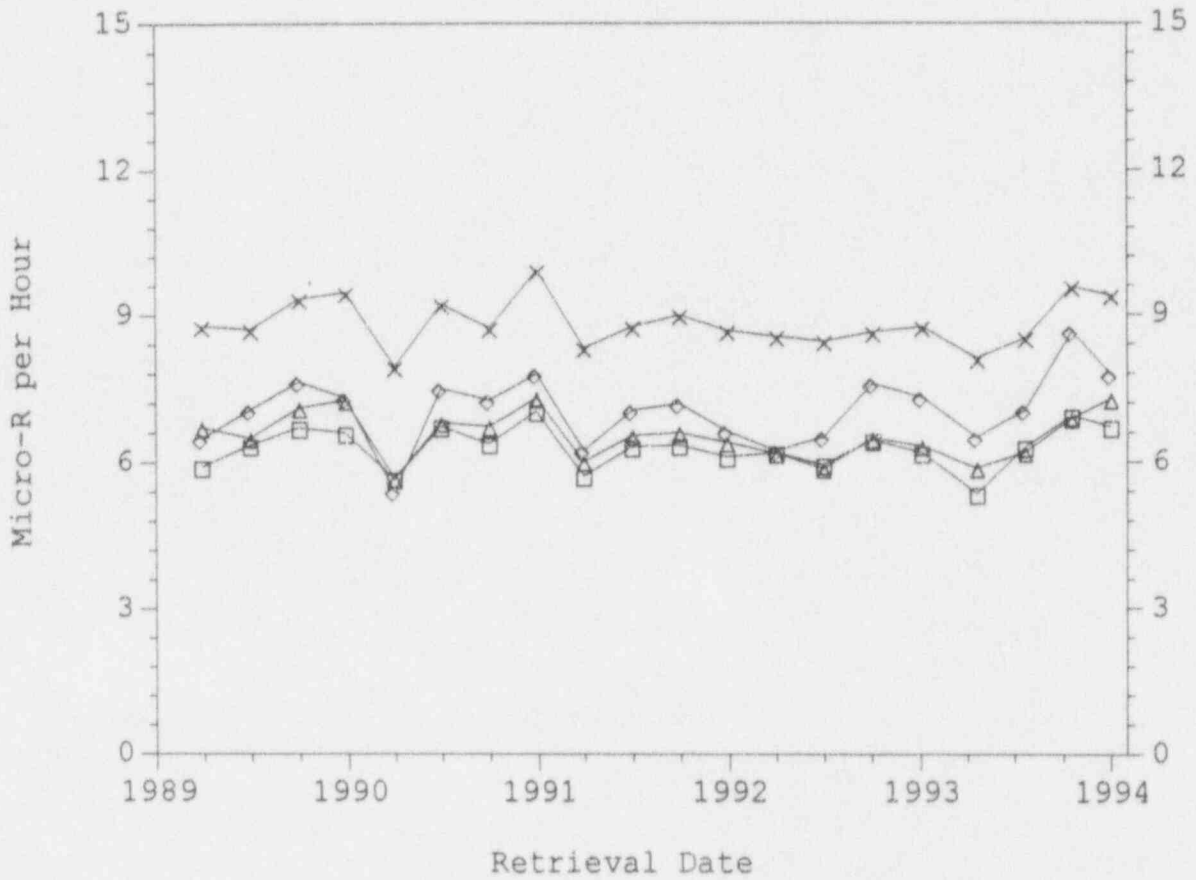


Figure 6.21
 Exposure Rate at Indicator TLDS, GM 32-35



- GM-32 Rowe Road
- △ GM-33 Zoar Road
- × GM-34 Fife Brook Road
- ◇ GM-35 Whitcomb Summit

Figure 6.22
Exposure Rate at Indicator TLDS, GM 36-39

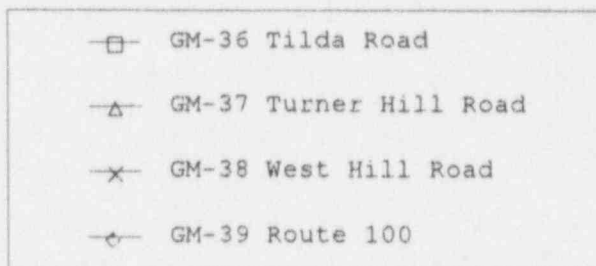
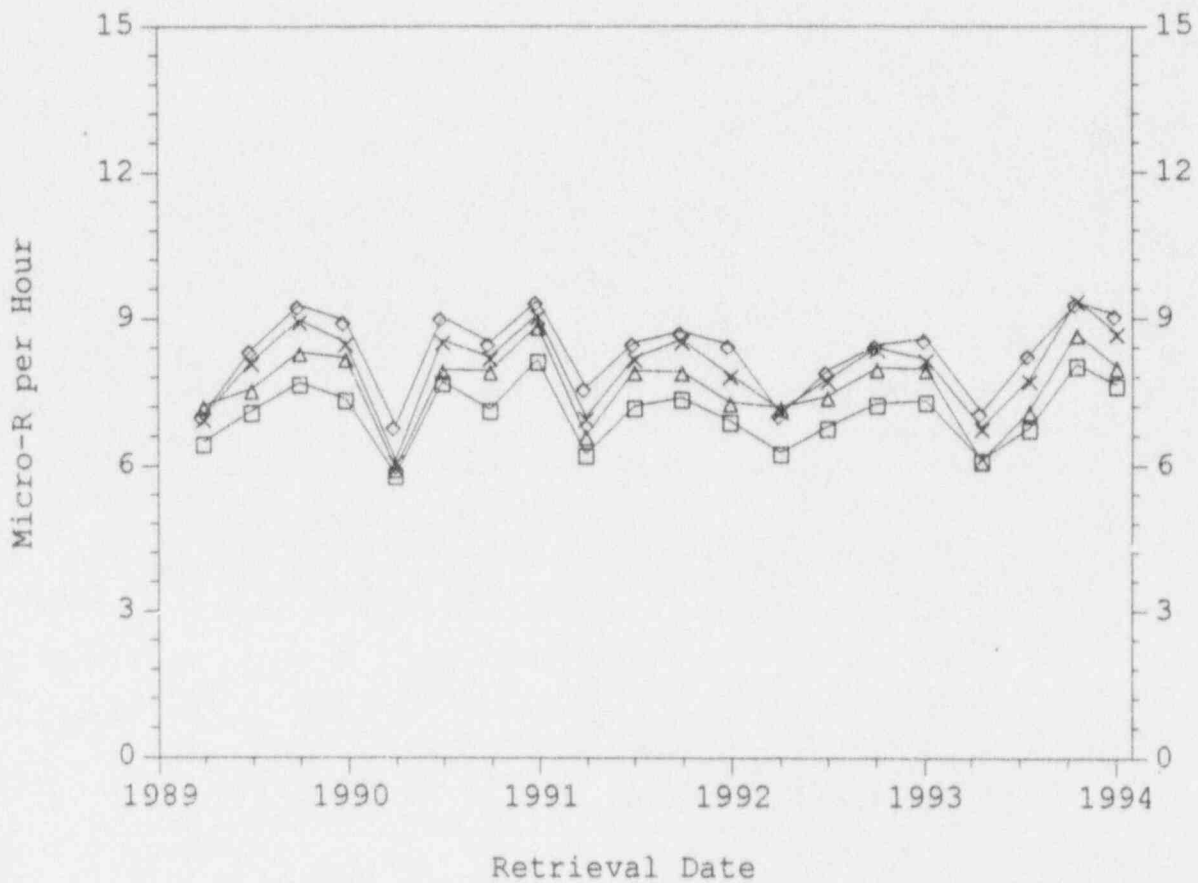


Figure 6.23
 Exposure Rate at Indicator TLDS, GM 13-16

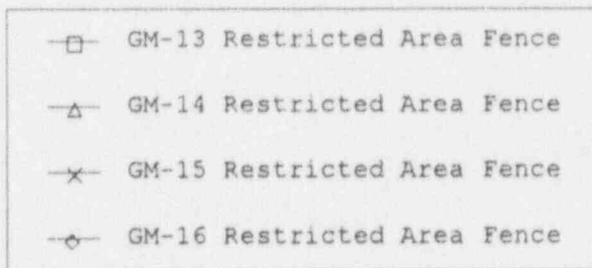
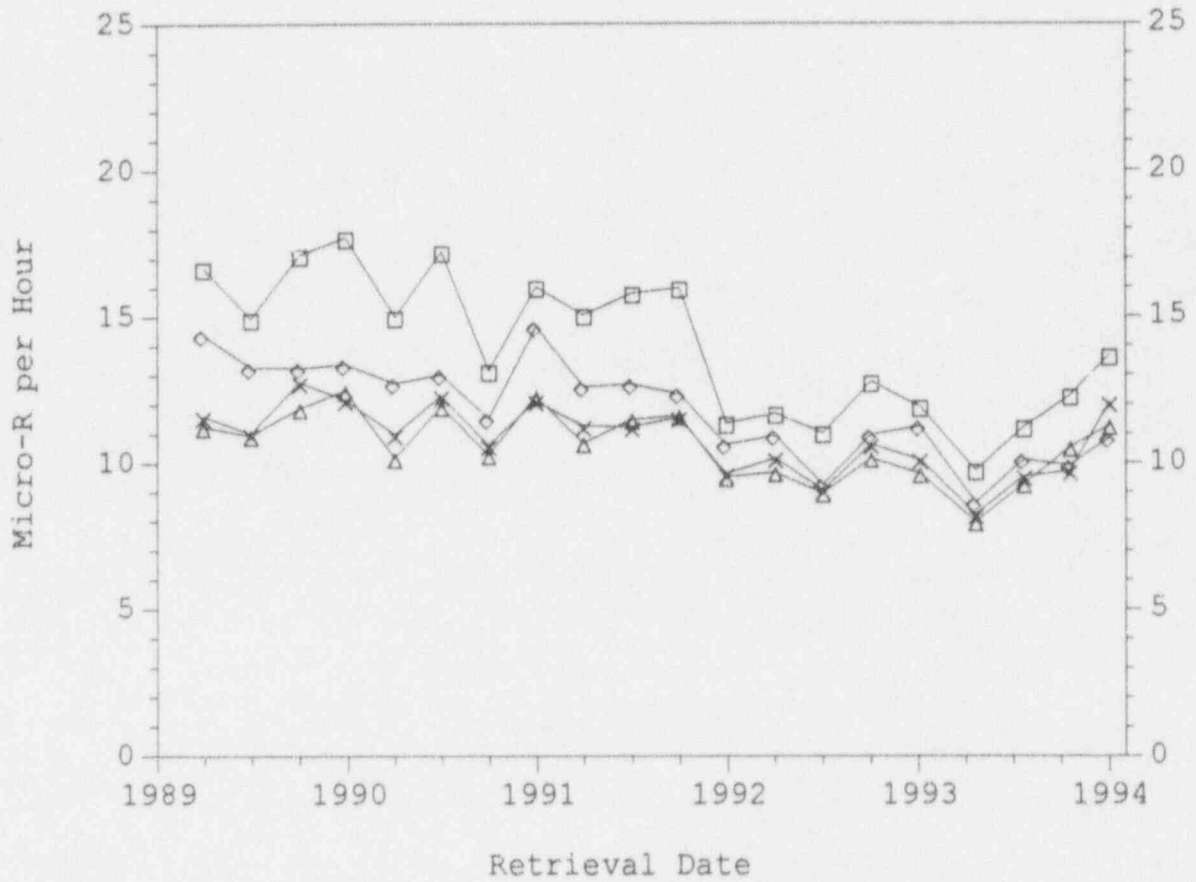
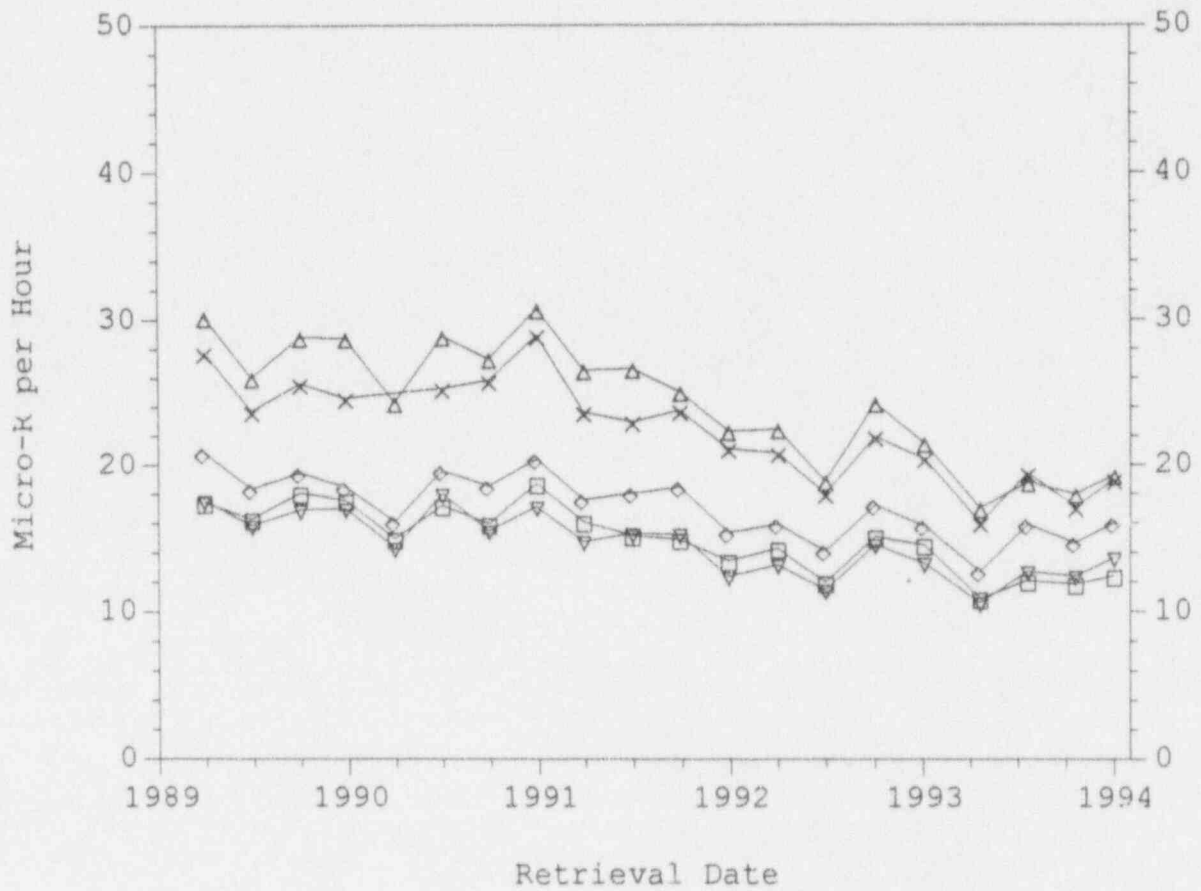
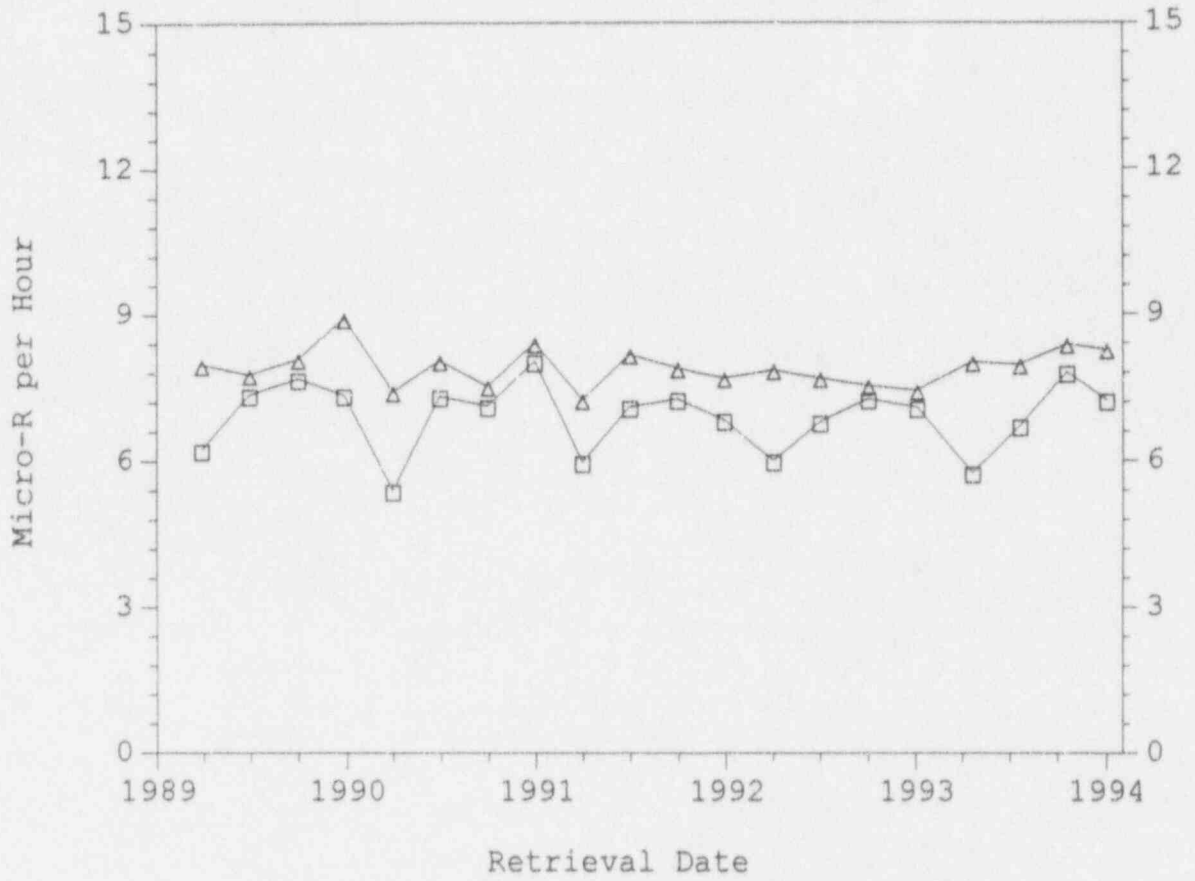


Figure 6.24
 Exposure Rate at Indicator TLDS, GM 17-21



- GM-17 Restricted Area Fence
- △-- GM-18 Restricted Area Fence
- x-- GM-19 Restricted Area Fence
- ◇-- GM-20 Restricted Area Fence
- ▽-- GM-21 Restricted Area Fence

Figure 6.25
Exposure Rate at Indicator TLDS, GM 22-23



—□— GM-22 Heartwellville, VT
—△— GM-23 Williamstown Substation

7.0 QUALITY ASSURANCE PROGRAM

The quality assurance program at the Yankee Atomic Environmental Laboratory (YAEL) is designed to serve two overall purposes: 1) Establish a measure of confidence in the measurement process to assure the licensee, regulatory agencies and the public that the analytical results are accurate and precise; and 2) identify deficiencies in the sampling and/or measurement process to those responsible for these operations so that corrective action can be taken. Quality assurance is applied to all steps of the measurement process, including the collection, reduction, evaluation and reporting of data, as well as the record keeping of the final results. Quality control is a part of the quality assurance program. It provides a means to control and measure the characteristics of measurement equipment and processes, relative to established requirements.

The YAEL employs a thorough quality assurance program to ensure reliable environmental monitoring data. The program includes the use of written, approved and controlled procedures for all work activities, a non-conformance and corrective action tracking system, systematic internal audits, audits from external groups, a laboratory quality control program, and a complete training and retraining system. The Intralaboratory Quality Control program at the YAEL and the EPA third party interlaboratory program are discussed in more detail below. Also discussed is the environmental TLD quality assurance program and the blind duplicate quality assurance program conducted by the Laboratory Quality Control Audit Committee.

7.1 Intralaboratory Quality Control Program

The YAEL conducts an extensive intralaboratory quality control program to assure the validity and reliability of non-TLD analytical data. Included are the internal process control program and the National Institute of Standards and Technology (NIST) Measurement Assurance Program. These together comprise about five percent of the laboratory sample throughput. The records of the quality control program are reviewed by the responsible cognizant individual, and corrective measures are taken whenever applicable.

For the internal process control program and the NIST Measurement Assurance Program, there were 334 analyses for accuracy and 179 for precision in 1993. Of the 334 analyses for accuracy reviewed during this period, 95.2% met the YAEL acceptance criteria for accuracy, while 4.8% (16 out of 334 analyses) were identified as outside the YAEL acceptance criteria. Of the

179 analyses for precision during 1993, 99.4% met the YAEL acceptance criteria for precision, while 0.6% (1 out of 179 analyses) were identified as outside of the YAEL acceptance criteria. Table 7.1 shows a summary of the results of this program.

7.2 EPA Intercomparison Program

To further verify the accuracy and precision of the YAEL analyses via an independent outside third party, the YAEL participates in the U.S. Environmental Protection Agency's Environmental Radioactivity Laboratory Intercomparison Studies Program for those available species and matrices routinely analyzed by the YAEL. Participation in this program is required by YNPS Technical Specification 6.7.5.b. Each sample supplied by the EPA is analyzed in triplicate, and the results are returned to the EPA within a specified time frame. When the known values are returned to the YAEL, the YAEL and EPA results are then evaluated against specific YAEL and EPA acceptance criteria. When the results of the cross-check analysis fall outside of the control limit, an investigation is made to determine the cause of the problem and corrective measures are taken, as appropriate. Results of this program are provided in this report in compliance with ODCM Control 7.1.

For the EPA Intercomparison Program, there were 129 analyses for accuracy on 23 sample sets. The samples consisted of water, milk and air particulate filters. The analyses were for gamma-emitting radionuclides, gross-beta, strontium, iodine, plutonium and tritium. Tables 7.2 and 7.3 show summaries of the results for 1993. Of the 129 analyses for accuracy, all but two met the EPA mean value control limits.

The results of the two measurements that did not meet the EPA mean value criteria are given below:

- For the set of Ba-133 measurements for the water sample with EPA Reference Date of 6/11/93, the YAEL mean value of 59.36 pCi/L fell below of the EPA control limit of 81.7-116.3 pCi/L. This radionuclide is not in the gamma software library. Consequently, the Ba-133 results for the EPA sample set were calculated manually using the 356 keV photopeak. A review of the sample paperwork indicated that the hand-calculated radioactivity concentrations did not incorporate the 60 percent gamma-ray abundance factor required for the 356 keV photopeak. A recalculation of the Ba-133 activity concentration using this factor yielded a mean value within the EPA control limits.

- For the set of Ru-106 measurements for the water sample with EPA Reference Date of 11/12/93, the YAEL mean value of 165.53 pCi/L fell below the EPA control limit of 166.3-235.7 pCi/L. The YAEL considers the EPA known value to be suspect since the grand mean of 175.18 pCi/L is 12.8 percent below the EPA stated known value of 201 pCi/L. Assuming the grand mean is the actual activity concentration, the YAEL mean result of 165.53 pCi/L would have a bias difference of only -5.5 percent. A subsequent internal process check analysis of an EPA Ru-106 standard supplied by the EPA to validate the process indicated a mean value within 2 percent of the known. The process is considered in compliance at this time.

7.3 Environmental TLD Quality Assurance Program

The Panasonic environmental TLD (thermoluminescent dosimeter) program at the YAEL has its own quality assurance program. In addition to instrumentation checks performed by the Dosimetry Services Group (DSG), which represent approximately 10% of the TLDs processed, two independent test programs are performed for accuracy and precision. The first of these programs is performed by the in-house Dosimetry QA Officer, and the second involves the University of Michigan third-party testing program. Under these programs, dosimeters are irradiated to known dose (known to the DSG) and given to the DSG for read-out.

In 1993, out of 1525 TLDs processed at the YAEL, 8.3% (126 TLDs) were processed as part of the performance testing program. Of these 126 TLDs, 72 were from the in-house Dosimetry QA Officer, and 18 were from the Battelle Pacific Northwest Laboratories testing program and 36 were from Boston Edison Co. All of these (100%) met the acceptance criteria for accuracy and precision.

7.4 Blind Duplicate Quality Assurance Program

The Laboratory Quality Control Audit Committee (LQCAC) is comprised of one member from each of the five power plants that are serviced by the YAEL. Two of the primary functions of the LQCAC are to conduct an annual audit of YAEL operations and to coordinate the Blind Duplicate Quality Assurance Program. Under the Blind Duplicate Quality Assurance Program, paired samples are submitted from the five plants, including YNPS. They are prepared from homogeneous environmental media at each respective plant, and are sent to the YAEL for analysis. They are "blind" in that the

identification of the matching sample is not identified to the YAEL. The LQCAC analyzes the results of the paired analyses to evaluate precision in YAEL measurements.

A total of 50 paired samples were submitted under this program by the five participating plants during 1993. Paired measurements were evaluated for 26 gamma emitting radionuclides, H-3, Sr-89, Sr-90, I-131 and gross-beta. All measurements were evaluated, whether the results were considered statistically positive or not, and whether the net concentration was positive or negative. Of the 1308 paired duplicate measurements evaluated in 1993, 1305 (99.8%) fell within the established acceptance criteria. With the three paired measurements that did not meet the acceptance criteria, none had radioactivity that was considered statistically positive. The samples submitted through this program are listed in Table 7.4.

TABLE 7.1

SUMMARY OF PROCESS CONTROL ANALYSIS RESULTS
January - December 1993

SAMPLE MEDIA	ACCURACY		PRECISION	
	NUMBER OF ANALYSES	NUMBER ANALYSES OUTSIDE ACCEPTANCE CRITERIA	NUMBER OF ANALYSES	NUMBER ANALYSES OUTSIDE ACCEPTANCE CRITERIA
AIR CHARCOAL				
Gamma	104	1	0	0
AIR FILTER				
Beta	103	0	16	0
Gamma	0	0	0	0
Strontium	0	0	0	0
MILK				
Gamma	30	0	33	0
Iodine	20	3	20	0
Strontium	16	4	16	0
WATER				
Gross-Beta	9	1	9	0
Gamma	3	0	3	0
Iodine	11	1	11	0
Strontium	16	1	16	0
Tritium	13	0	12	0
SOIL/SEDIMENT				
Gamma	0	0	30	0
TOTAL	325	11	166	0

TABLE 7.2

EPA INTERCOMPARISON ANALYSIS RESULTS
January - December 1993

EPA Ref. Date	Sample Type	Nuclide	YAEL Mean (pCi/l)	EPA Control Limits (pCi/l)
10-20-92	Water	Co-60	13.54	6.30-23.70
		Cs-134	5.06	0.00-13.70
		Cs-137	7.56	0.00-16.70
10-20-92	Water	Sr-90	13.27	1.30-18.70
1-15-93	Water	Sr-89	12.11	6.30-23.70
		Sr-90	9.03	1.30-18.70
1-22-93	Water	Pu-239	18.77	16.50-23.50
2-5-93	Water	I-131	109.43	82.70-117.30
4-20-93	Water	Co-60	38.70	30.30-47.70
		Cs-134	25.83	18.30-35.70
		Cs-137	31.60	23.30-40.70
6-4-93	Water	H-3	10603.1	8136.80-11551.2
6-11-93	Water	Cs-134	5.05	0.00-13.70
		Ru-106	99.54	98.20-139.80
		Cs-137	4.62	0.00-13.70
		Zn-65	107.15	85.70-120.30
		Co-60	13.82	6.30-23.70
		Ba-133	59.36*	81.70-116.30
7-23-93	Water	Beta	42.32	31.00-55.00
8-27-93	Part. Filter	Beta	46.24	38.30-55.70

* This mean value did not meet the EPA Control Limits. See text for explanation.

TABLE 7.2, continued

EPA INTERCOMPARISON ANALYSIS RESULTS
January - December 1993

EPA Ref. Date	Sample Type	Nuclide	Yael Mean (pCi/l)	EPA Control Limits (pCi/l)
8-27-93	Part. Filter	Sr-90	18.84	10.30-27.70
8-27-93	Part. Filter	Cs-137	9.07	0.30-17.70
9-24-93	Milk	I-131	119.73	99.20-140.80
		Cs-137	49.02	40.30-57.70
9-24-93	Milk	I-131	125.96	99.20-140.80
9-24-93	Milk	Sr-89	27.91	21.30-38.70
		Sr-90	22.75	16.30-33.70
9-24-93	Milk	K-40	1411.37	1273.77-1521.80
10-8-93	Water	I-131	118.49	96.20-137.80
10-8-93	Water	I-131	121.81	96.20-137.80
10-19-93	Water	Sr-89	12.59	6.30-23.70
		Sr-90	8.85	1.30-18.70
10-19-93	Water	Co-60	9.86	1.30-18.70
		Cs-134	10.09	3.30-20.70
		Cs-137	10.72	1.30-18.70
10-29-93	Water	Beta	17.10	6.30-23.70
11-5-93	Water	H-3	7164.08	6114.10-8681.90
11-12-93	Water	Co-60	29.94	21.30-38.70
		Zn-65	152.32	124.00-176.00
		Ru-106	165.53*	166.30-235.70
		Cs-134	57.10	50.30-67.70
		Cs-137	41.85	31.30-48.70
		Ba-133	79.97	65.10-92.90

* This mean value did not meet the EPA Control Limits. See text for explanation.

TABLE 7.3

SUMMARY OF EPA INTERCOMPARISON PROGRAM RESULTS
January - December 1993

SAMPLE MEDIA	NO. OF SAMPLES ANALYZED*	NO. OF ANALYSES	NO. OUTSIDE EPA CONTROL LIMITS**
AIR FILTER			
Beta	1	3	0
Gamma	1	3	0
Strontium	1	3	0
MILK			
Gamma	1	9	0
Iodine	1	3	0
Strontium	1	6	0
WATER			
Gross-Beta	2	6	0
Gamma	5	66	2
Iodine	2	6	0
Plutonium	1	3	0
Strontium	4	15	0
Tritium	2	6	0

* The number of EPA samples that were analyzed for the specified radionuclide. Each of these samples was analyzed in triplicate.

** The number of mean values (from triplicate samples) outside EPA Control Limits.

TABLE 7.4

SUMMARY OF BLIND DUPLICATE SAMPLES SUBMITTED
January - December 1993

TYPE OF SAMPLE	NUMBER OF PAIRED SAMPLES SUBMITTED
Cow Milk	20
Ground Water	7
River Water	4
Estuary Water	4
Sea Water	8
Irish Moss	2
Mussels	4
Food Product - Cranberries	1
TOTAL	50

8.0 LAND USE CENSUS

A Land Use Census is conducted annually between the dates of June 1 and October 1 to identify the locations of the nearest milk animal, the nearest residence and the nearest garden of greater than 500 square feet producing fresh leafy vegetables in each of the 16 meteorological sectors within a distance of five miles of the plant. Immediately following the collection of field data, in compliance with ODCM Control 4.2, a dosimetric analysis is performed to compare the census locations to the "Critical Receptor" identified in the ODCM. This Critical Receptor is the location that is used in the conservative Method 1 dose calculations found in the ODCM (i.e. the dose calculations done in compliance with ODCM Surveillance Requirement 3.4). If a Census location has a 20% greater potential dose than that of the Critical Receptor, this fact must be announced in the Semiannual Effluent Release Report for that period. A re-evaluation of which location to use as a Critical Receptor would also be done at that time. For the 1993 Census, no such locations were identified.

Pursuant to ODCM Control 4.2, a dosimetric analysis is then performed, using site specific meteorological data, to determine which milk and food product census locations would provide the optimal sampling locations. If any location has a 20% greater potential dose commitment than at a currently-sampled location, the new location is added to the routine environmental sampling program in replacement of the location with the lowest calculated dose (which is later eliminated from the program). For the 1993 Census, no such garden or milk animal locations were identified, and consequently no changes were mandated for the food product, broadleaf vegetation or milk sampling programs.

The Land Use Census was carried out and completed between the dates of June 1 and October 1, as required. The results of the 1993 Land Use Census are included in this report in compliance with ODCM Surveillance Requirement 4.2. The locations identified during the Census may be found in Table 8.1.

TABLE 8.1

1993 LAND USE CENSUS LOCATIONS

SECTOR	NEAREST RESIDENCE Km (Mi)	NEAREST GARDEN Km (Mi)	NEAREST MILK ANIMAL Km (Mi)
N	4.8 (3.0)	3.5 (2.2)	6.1 (3.8) (Cow)
NNE	4.4 (2.75)	4.7 (2.9)	*
NE	3.1 (1.9)	3.1 (1.9)	*
ENE	3.1 (1.9)	5.8 (3.6)	8.4 (5.2) (Cow)
E	3.0 (1.9)	3.1 (1.9)	*
ESE	3.2 (2.0)	3.5 (2.2)	7.9 (4.9) (Cow)
SE	2.3 (1.4)	2.3 (1.4)	3.2 (2.0) (Goat, Cow)
SSE	2.1 (1.3)	4.7 (2.9)	*
S	2.3 (1.4)	2.9 (1.8)	*
SSW	*	*	*
SW	1.3 (0.8)	7.7 (4.8)	*
WSW	1.3 (0.8)	1.3 (0.8)	*
W	1.9 (1.2)	2.7 (1.7)	6.9 (4.3) (Goat)
WNW	1.9 (1.2)	1.9 (1.2)	6.8 (4.2) (Goat, Cow)
NW	0.45 (0.3)	4.6 (2.8)	*
NNW	2.9 (1.8)	3.9 (2.4)	*

* No location was identified within 5 miles of the plant.

9.0 SUMMARY

During 1993, as in all previous years since 1958, a program was conducted to assess the levels of radiation or radioactivity in the Yankee Nuclear Power Station environment. Over 1,000 samples were collected (including TLDs) over the course of the year, with a total of over 5,000 radionuclide or exposure rate analyses being performed on them. The samples included ground water, river water, storm drain water, sediment, fish, locally grown food products, maple syrup and milk. In addition to these samples, the air surrounding the plant was sampled continuously and the radiation levels were measured continuously with environmental TLDs.

Low levels of radioactivity from three sources were detected. Most samples had measurable levels of K-40, Be-7, AcTh-228 or radon daughter products. These are the most common of the naturally-occurring radionuclides. Many samples (milk, sediment, fish and maple syrup in particular) had fallout radioactivity from atmospheric nuclear weapons tests conducted primarily from the late 1950's through 1980. Several samples had low levels of radioactivity resulting from emissions from YNPS. These were all collected in the immediate vicinity of the plant or from on-site locations. In all cases, the possible radiological impact was negligible with respect to exposure from natural background radiation. In no case did the detected levels approach or exceed the most restrictive federal regulatory or plant license limits for radionuclides in the environment.

10.0 REFERENCES

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5. Letter, "Issuance of Amendment No. 146 to Facility Possession Only License No. 1PR-3-Yankee Nuclear Power Station," M. Fairtile, NRC to J. Grant, Yankee Atomic Electric Company, dated November 5, 1992.
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