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

SUBJECT: Three Mile Island Nuclear Station
Units 1 and 2 (TMI-1 & TMI-2)
Operating License Nos. DPR-50 and DPR-73
Docket Nos. 50-289 and 50-320
1996 Radiological Environmental Monitoring Report

Dear Sir:

In accordance with TMI-1 Technical Specification 6.9.3.1 and TMI-2 Technical Specification 6.8.1.1, enclosed is the 1996 Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station.

Please contact J. Schork, TMI Regulatory Affairs at (717) 948-8832 if you have any questions regarding this submittal.

Sincerely,

James W. Langenbach

J. W. Langenbach
Vice President and Director, TMI-1

JSS
Enclosure

cc: USNRC TMI Senior Resident Inspector
USNRC Region 1 Regional Administrator
USNRC TMI-2 Program Manager
File 96011

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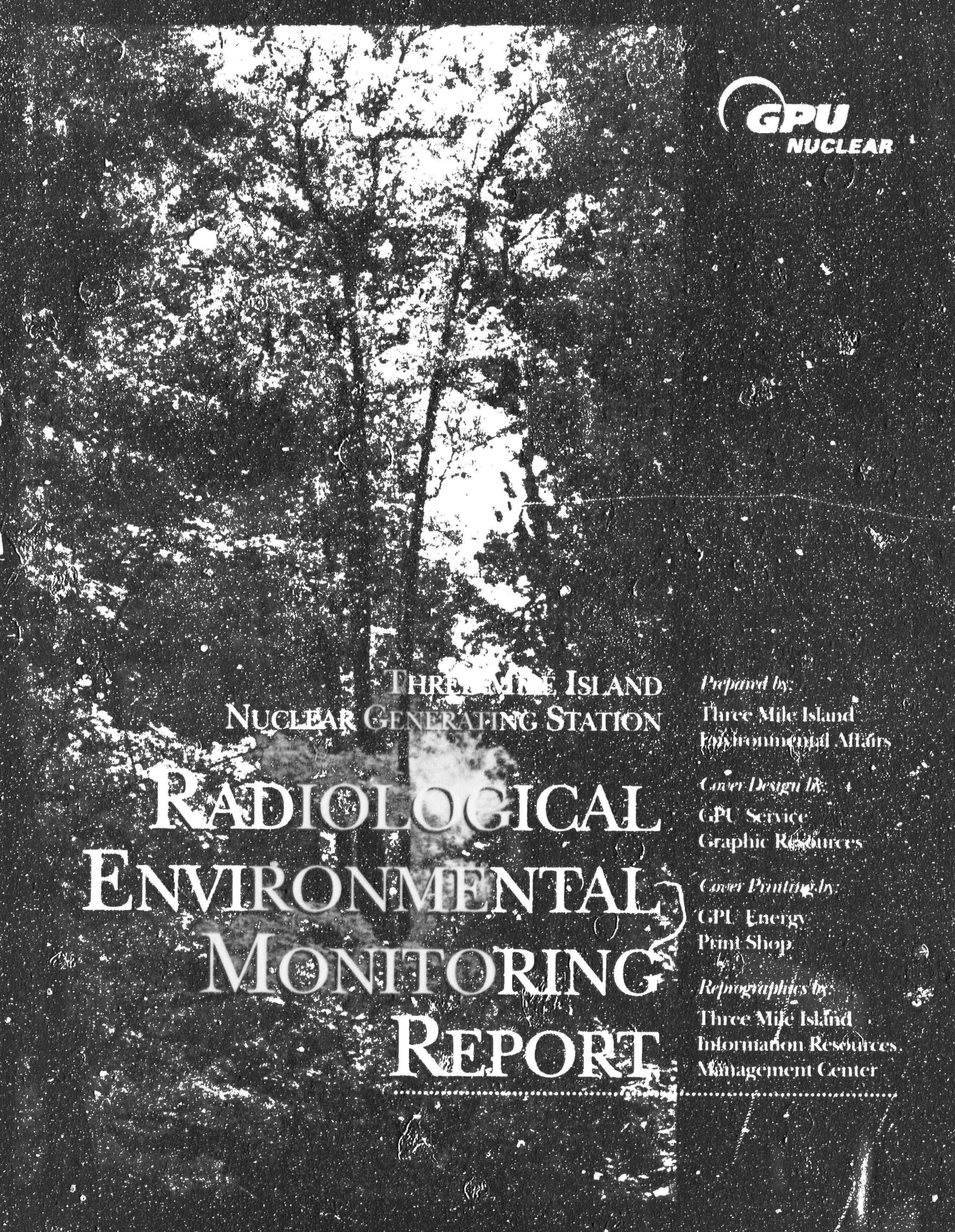


GPU NUCLEAR

THREE MILE ISLAND
NUCLEAR GENERATING STATION

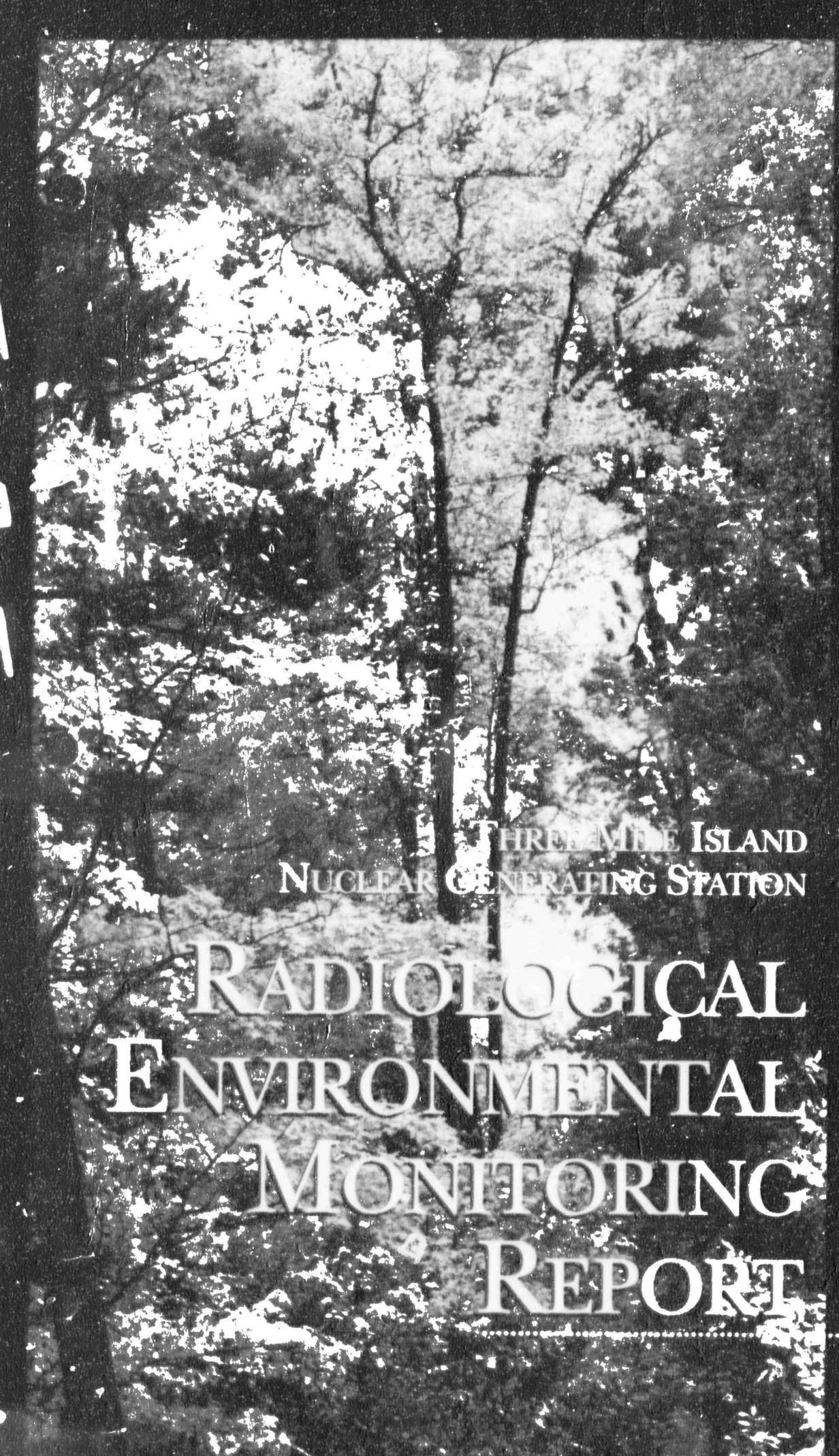
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

Prepared by:
Three Mile Island
Environmental Affairs

Cover Design by:
GPU Service
Graphic Resources

Cover Printing by:
GPU Energy
Print Shop

Reprographics by:
Three Mile Island
Information Resources
Management Center



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LIST OF ABBREVIATIONS, SYMBOLS AND ACRONYMS

ABBREVIATIONS

cubic feet per second	cfs
cubic meter(s)	m^3
curie(s)	Ci
curie(s) per year	Ci/yr
east	E
east-northeast	ENE
east-southeast	ESE
gram(s)	g
hour(s)	h
liter(s)	L
meter(s)	m
microroentgen(s) per hour	□R/h
mile per hour	mph
millirem(s)	mrem
millirem(s) per hour	mrem/h
millirem(s) per standard month	mrem/std month
millirem(s) per year	mrem/yr
milliroentgen(s)	mR
milliroentgen(s) per hour	mR/h
milliroentgen(s) per standard month	mR/std month
north	N
northeast	NE
northwest	NW
north-northeast	NNE
north-northwest	NNW
percent	%
picocurie(s)	pCi
picocurie(s) per cubic meter	pCi/m^3
picocurie(s) per gram	pCi/g
picocurie(s) per liter	pCi/L
reference(s)	Ref. (Refs.)
rem(s) per year	rem/yr
Roentgen(s)	R
Roentgen(s) equivalent man	rem
south	S
southeast	SE
southwest	SW
south-southeast	SSE
south-southwest	SSW
standard deviation	std dev
standard month	std month
west	W
west-northwest	WNW
west-southwest	WSW
year(s)	yr

ELEMENT SYMBOLS

actinium	Ac
antimony	Sb
argon	Ar
barium	Ba
beryllium	Be
carbon	C
cesium	Cs
chromium	Cr
cobalt	Co
curium	Cm
hydrogen (tritium)	H-3
iodine	I
iron	Fe
krypton	Kr
lanthanum	La
manganese	Mn
niobium	Nb
nitrogen	N
oxygen	O
plutonium	Pu
potassium	K
radium	Ra
radon	Rn
ruthenium	Ru
silver	Ag
strontium	Sr
thorium	Th
tritiated water vapor	HTO
uranium	U
xenon	Xe
zinc	Zn
zirconium	Zr

ACRONYMS

American National Standards Institute ..... ANSI

Accident Generated Water ..... AGW

as low as reasonably achievable ..... ALARA

biological effects of atomic radiation ..... BEAR

biological effects of ionizing radiation ..... BEIR

borated water storage tank ..... BWST

Building 48 ..... 48s

Department of Energy ..... DOE

East Dike Catch Basin ..... EDCB

Federal Radiation Council ..... FRC

Final Safety Analysis Report ..... FSAR

General Public Utilities Nuclear Corporation ..... GPU Nuclear

Groundwater Monitoring Program ..... GMP

high efficiency particulate air ..... HEPA

International Committee on Radiation Protection ..... ICRP

lower limit of detection ..... LLD

maximum permissible concentration ..... MPC

mean sea level ..... msl

National Academy of Sciences ..... NAS

National Council on Radiation Protection and Measurements ..... NCRP

National Institute of Standards and Technology ..... NIST

National Voluntary Laboratory Accreditation Program ..... NVLAP

Offsite Dose Calculation Manual ..... ODCM

Operations Support Facility ..... OSF

Pennsylvania State Bureau of Radiation Protection ..... PaBRP

Post Defueling Monitored Storage ..... PDMS

pressurized water reactor ..... PWR

quality assurance ..... QA

quality control ..... QC

radiological environmental monitoring program ..... REMP

Safe Harbor Dam ..... SHD

simplified environmental effluent dosimetry system ..... SEEDS

thermoluminescent dosimeter ..... TLD

Three Mile Island ..... TMI

Three Mile Island Nuclear Station ..... TMINS

Three Mile Island - Unit 1 ..... TMI-1

Three Mile Island - Unit 2 ..... TMI-2

Title 10 of the Code of Federal Regulations, Part 20 ..... 10 CFR 20

ACRONYMS

Title 10 of the Code of Federal Regulations, Part 50, Appendix I ..... 10 CFR 50 App. I

Title 40 of the Code of Federal Regulations, Part 190 ..... 40 CFR 190

United Nations Scientific Committee on the Effects of Atomic Radiation ..... UNSCEAR

United States Environmental Protection Agency ..... USEPA

United States Nuclear Regulatory Commission ..... USNRC

York Haven Dam ..... YHD

York Haven Pond ..... YHP

SUMMARY AND CONCLUSIONS

The radiological environmental monitoring performed in 1996 by GPU Nuclear for Three Mile Island Nuclear Station (TMINS) is discussed in this report. The environmental sample results and the doses calculated from measured effluents indicated that TMINS operations in 1996 had no adverse effect on the health of the public or the environment.

The operation of a nuclear power station results in the release of small amounts of radioactive materials to the environment. A radiological environmental monitoring program (REMP) has been established to monitor radiation and radioactive materials in the environment around TMINS. The results of environmental measurements are used to assess the impact of TMINS operations, to demonstrate compliance with the TMI-1 and TMI-2 Technical Specifications (Refs. 1 and 2) and applicable Federal and State regulations, and to verify the adequacy of containment and radioactive effluent control systems. The program also evaluates the relationship between amounts of radioactive material released in effluents to the environment and resultant radiation doses to individuals.

Summaries and interpretations of the data are published annually in the Radiological Environmental Monitoring Report. Previous reports in this series are referenced at the end of the report (Refs. 3 through 26). Additional information concerning releases of radioactive materials to the environment is contained in the Radiological Effluent Release Reports. These reports are submitted annually to the United States Nuclear Regulatory Commission (USNRC).

Many of the radioactive materials discussed in this report are normally present in the environment, either from natural processes or as a result of non-TMINS activities such as prior atmospheric nuclear weapon tests and medical industry activities. To determine the impact of TMINS operations, if any, on the environment and the public, results from samples collected close to TMINS (indicator stations) are compared to results from samples obtained at distant sites (control or background stations). Comparisons with historical data also are performed, as appropriate.

During 1996, samples of air, surface, effluent and drinking water, sediment, fruits, vegetables, fish, groundwater, milk and rodent carcasses were collected. Direct radiation exposures also were measured in the vicinity of TMINS. Samples were analyzed for gross beta and gross alpha radioactivity, tritium (H-3), strontium-89 (Sr-89) and strontium-90 (Sr-90), iodine-131 (I-131) and/or gamma-emitting radionuclides. The results are discussed in the various sections of this report. Additionally, radiological impacts in terms of radiation dose as a result of TMINS radioactive releases were calculated and are discussed in this report **(Radiological Impact of TMINS Operations and Appendix I)**.

The results provided in this report are summarized in the following highlights:

- More than 1700 samples were collected in 1996 from the aquatic, atmospheric and terrestrial environments around TMINS. There were nearly 2700 analyses performed on these samples. Also, approximately 2100 radiation exposure measurements were taken using thermoluminescent dosimeters (TLDs). Finally, more than 270 groundwater samples were collected and nearly 450 analyses were performed on these samples. The monitoring performed in 1996 met or exceeded the sample collection and analysis requirements of the TMI-1 and TMI-2 Technical Specifications.

- In addition to natural radioactivity, low concentrations of radionuclides such as H-3, cobalt-60 (Co-60), Sr-90, cesium-137 (Cs-137), cesium-134 (Cs-134) and I-131 were detected in various media and were attributed to either fallout from prior nuclear weapon tests, the medical industry or TMINS operations.

- The raw surface water collected downstream of the TMINS liquid discharge outfall typically had H-3 concentrations greater than those detected in control samples as a result of routine TMINS operations. This was expected because the samples were collected from a site where mixing of liquid effluents with Susquehanna River water was incomplete. Although raw water is not consumed by

humans, all of the measured concentrations were well below the United State Environmental Protection Agency's (USEPA) Primary Drinking Water Standard of 20,000 picocuries per liter (pCi/L).

- As a result of routine TMINS operations, H-3 at low concentrations was detected in indicator fish samples. Its presence was not unexpected because H-3 was released in liquid effluents and the indicator fish samples were collected in a zone where mixing of effluents and river water is incomplete. The H-3 concentrations in the extracted water were a small fraction of the USEPA Primary Drinking Water Standard.

- Low concentrations of TMINS-related Co-60, Cs-134 and Cs-137 were detected in aquatic sediments collected proximal to or just downstream of the TMINS liquid discharge outfall. During 1996 as well as in previous years, these materials were routinely released in TMINS liquid effluents. Additionally, Co-60, Cs-134 and Cs-137 are readily adsorbed by suspended particles in the water column and bottom sediments. A portion of the Cs-137 measured in the samples was attributed to fallout from prior nuclear weapon tests.

- Groundwater samples collected from the onsite monitoring and supply wells contained H-3 above ambient concentrations as a result of routine operations at TMI-1 and past operations at TMI-2. All H-3 concentrations detected in onsite groundwater were below the effluent concentration specified in USNRC 10 CFR 20 (Appendix B, Table 2).

- Strontium-90 was detected in one groundwater sample collected from an onsite well. Its presence was attributed to past leaks from a TMI-2 tank which has since been drained. Water from the subject well is not used for drinking. The measured concentration was well below the USNRC 10 CFR 20 effluent concentration limit for Sr-90.

- Tritium was detected in onsite groundwater used for drinking. The presence of H-3 in these samples was attributed to routine TMI-1 operations and possibly past TMI-2 operations. All of the H-3 concentrations measured in onsite drinking water were well below the USEPA Primary Drinking Water Standard.

- Low concentrations of H-3 were detected in offsite groundwater. A portion of the H-3 detected in these samples may be related to atmospheric releases of H-3 from TMI-1. The concentrations were a small fraction of the USEPA Primary Drinking Water Standard.

- Gamma radiation exposure rates recorded at the offsite indicator TLD and real-time monitoring stations averaged 55 and 66 milliroentgens per year (mR/yr), respectively. The exposure rates were consistent with those presented by the National Council on Radiation Protection and Measurements (Ref. 27). No increase in ambient gamma radiation levels was detected.

- During 1996, small amounts of radioactive materials were released in TMI-1 and TMI-2 effluents. The amount released from TMI-1 was the lowest in its operating history. This achievement was attributed to good fuel integrity, minimal leakage in the steam generators and improved efficiency of the waste processing systems.

- The calculated doses to the public from TMINS operations in 1996 were well below all applicable regulatory limits and significantly less than doses received from other common sources of radiation. The hypothetical maximum whole body dose potentially received by an individual from 1996 TMI-1 and TMI-2 liquid and airborne effluents combined was conservatively calculated to be 0.11 mrem. This dose is equivalent to 0.04% of the dose that an individual living in the TMI area receives each year from natural background radiation.

- The hypothetical maximum whole body dose to the surrounding population from all 1996 liquid and airborne effluents was calculated to be 1.06 person-rem. This dose is equivalent to 0.00016% of the dose that the total population in the TMI area receives each year from natural background radiation.

In conclusion, radioactive materials related to TMINS operations were detected in environmental samples, but the measured concentrations were low and consistent with measured effluents. The environmental sample results verified that the doses received by the public from TMINS effluents in 1996 were well below applicable dose limits and only a small fraction of the doses received from natural background radiation. Additionally, the results indicated that there was no permanent buildup of radioactive materials in the environment and no increase in background radiation levels.

Therefore, based on the results of the radiological environmental monitoring program (REMP) and the doses calculated from measured effluents, TMINS operations in 1996 did not have any adverse effects on the health of the public or on the environment.

INTRODUCTION

Characteristics of Radiation

Instability within the nucleus of radioactive atoms results in the release of energy in the form of radiation. Radiation is classified according to its nature -- particulate and electromagnetic. Particulate radiation consists of energetic subatomic particles such as electrons (beta particles), protons, neutrons, and alpha particles. Because of its limited ability to penetrate the human body, particulate radiation in the environment contributes primarily to internal radiation exposure resulting from inhalation and ingestion of radioactivity.

Electromagnetic radiation in the form of x-rays and gamma rays has characteristics similar to visible light but is more energetic and, hence, more penetrating. Although x-rays and gamma rays are penetrating and can pass through varying thicknesses of materials, once they are absorbed they produce energetic electrons which release their energy in a manner that is identical to beta particles. The principal concern for gamma radiation from radionuclides in the environment is their contribution to external radiation exposure.

The rate with which atoms undergo disintegration (radioactive decay) varies among radioactive elements, but is uniquely constant for each specific radionuclide. The term "half-life" defines the time it takes for half of any amount of an element to decay and can vary from a fraction of a second for some radionuclides to millions of years for others. In fact, the natural background radiation to which all mankind has been exposed is largely due to the radionuclides of uranium (U), thorium (Th), and potassium (K). These radioactive elements were formed with the creation of the universe and, owing to their long half-lives, will continue to be present for millions of years to come. For example, potassium-40 (K-40) has a half-life of 1.3 billion years and exists naturally within our bodies. As a result, approximately 4000 atoms of potassium emit radiation internally within each of us every second of our lives.

In assessing the impact of radioactivity on the environment, it is important to know the quantity of radioactivity released and the resultant radiation doses. The common unit of radioactivity is the curie (Ci). It represents the radioactivity in one gram (g) of natural radium (Ra), which is also equal to a decay rate of 37 billion radiation emissions every second. Because of the extremely small amounts of radioactive material in the environment, it is more convenient to use fractions of a curie. Subunits like picocurie, pCi, (one trillionth of a curie) are frequently used to express the radioactivity present in environmental and biological samples.

The biological effects of a whole body equivalent dose of radiation are the same whether the radiation source is external or internal to the body. The important factor is how much radiation energy or dose was deposited. The unit of radiation dose is the Roentgen equivalent man (rem), which also incorporates the variable effectiveness of different forms of radiation to produce biological change. For environmental radiation exposures, it is convenient to use the smaller unit of millirem (mrem) to express dose (1000 mrem equals 1 rem). When radiation exposure occurs over periods of time, it is appropriate to refer to the dose rate. Dose rates, therefore, define the total dose for a fixed interval of time, and for environmental exposures are usually expressed with reference to one year (mrem/yr).

Sources of Radiation

Life on earth has evolved amid the constant exposure to natural radiation. In fact, the single major source of radiation to which the general population is exposed comes from natural sources. Although everyone on the planet is exposed to natural radiation, some people receive more than others. Radiation exposure from natural background has three components (i.e., cosmic, terrestrial, and internal) and varies with altitude and geographic location, as well as with living habits.

For example, cosmic radiation originating from deep interstellar space and the sun increases with altitude, since there is less air which acts as a shield. Similarly, terrestrial radiation resulting from the presence of naturally-occurring radionuclides in the soil and rocks varies and may be

significantly higher in some areas of the country than in others. Even the use of particular building materials for houses, cooking with natural gas, and home insulation affect exposure to natural radiation.

The presence of radioactivity in the human body results from the inhalation and ingestion of air, food, and water containing naturally-occurring radionuclides. For example, drinking water contains trace amounts of uranium and radium and milk contains radioactive potassium. Table 1 summarizes the common sources of radiation and their average annual doses.

The average person in the United States receives about 300 mrem/yr (0.3 rem/yr) from natural background radiation sources (Ref 27). This estimate was revised from about 100 to 300 mrem because of the inclusion of radon gas which was always present but was not previously included in the calculations. In some regions of the country, the amount of natural radiation is significantly higher. Residents of Colorado, for example, receive an additional 60 mrem/yr due to the increase in cosmic and terrestrial radiation levels. In fact, for every 100 feet above sea level, a person will receive an additional 1 mrem/yr from cosmic radiation. In several regions of the world, naturally high concentrations of uranium and radium deposits result in doses of several thousand mrem/yr to their residents (Ref. 28).

TABLE 1

Sources and Doses of Radiation*

Natural (82%)		Manmade (18%)	
Source	Radiation Dose (mrem/yr)	Source	Radiation Dose (mrem/yr)
Radon	200 (55%)	Medical X-rays	39 (11%)
Cosmic rays	27 (8%)	Nuclear Medicine	14 (4%)
Terrestrial	28 (8%)	Consumer products	10 (3%)
Internal	40 (11%)	Other	<1 (<1%)
		(Releases from nat. gas, phosphate mining, burning of coal, weapons fallout, & nuclear fuel cycle)	
APPROXIMATE TOTAL	300	APPROXIMATE TOTAL	60

* Percentage contribution of the total dose is shown in parentheses.

Source: Ref. 27

Recently, public attention has focused on radon (Rn), a naturally-occurring radioactive gas produced from uranium and radium decay. These elements are widely distributed in trace amounts in the earth's crust. Unusually high concentrations have been found in certain parts of eastern Pennsylvania and northern New Jersey. Radon levels in some homes in these areas are hundreds of times greater than levels found elsewhere in the United States. However, additional surveys are needed to determine the full extent of the problem nationwide.

Radon is the largest component of natural background radiation and may be responsible for a substantial number of lung cancer deaths annually. The National Council on Radiation Protection and Measurements (NCRP) estimates that the average individual in the United States receives an annual dose of about 2,400 mrem to the lung from natural radon gas (Ref. 27). This lung dose is considered to be equivalent to a whole body dose of 200 mrem. The NCRP has recommended actions to control indoor radon sources and reduce exposures.

When radioactive substances are inhaled or swallowed, they are not uniformly distributed within the body. For example, radioactive iodine selectively concentrates in the thyroid gland, radioactive cesium is distributed throughout the body water and muscles, and radioactive strontium concentrates in the bones. The total dose to organs by a given radionuclide also is influenced by the quantity and the duration of time that the radionuclide remains in the body, including its physical, biological and chemical characteristics. Depending on their rate of radioactive decay and biological elimination from the body, some radionuclides stay in the body for very short times while others remain for years.

In addition to natural radiation, we are exposed to radiation from a number of manmade sources. The single largest of these sources comes from diagnostic medical x-rays, and nuclear medicine procedures. Some 180 million Americans receive medical x-rays each year. The annual dose to an individual from such radiation averages about 53 mrem. Much smaller doses come from nuclear weapon fallout and consumer products such as televisions, smoke detectors, and fertilizers. Production of commercial nuclear power and its associated fuel cycle contributes less than 1 mrem to the annual dose of about 360 mrem for the average individual living in the United States.

Fallout commonly refers to the radioactive debris that settles to the surface of the earth following the detonation of a nuclear weapon. It is dispersed throughout the environment either by dry deposition or washed down to the earth's surface by precipitation. There are approximately 200 radionuclides produced in the nuclear weapon detonation process, a number of these are detected in fallout. The radionuclides found in fallout which produce most of the fallout radiation exposures to humans are I-131, Sr-89, Cs-137, and Sr-90. There has been no atmospheric nuclear weapon testing since 1980 and many of the radionuclides, still present in our environment, have decayed significantly. Consequently, doses to the public from fallout have been decreasing.

As a result of the nuclear accident at Chernobyl, Ukraine, on April 26, 1986, radioactive materials were dispersed throughout the environment and detected in various media such as air, milk, and soil. Cesium-134, Cs-137, I-131 and other radionuclides were detected in the weeks following the Chernobyl accident.

Nuclear Reactor Operations

Common to the commercial production of electricity is the consumption of fuel to produce heat and steam. The steam turns the turbine which generates electricity. Unlike the burning of coal, oil, or gas in fossil-fuel powered plants to generate heat, the fuel of most nuclear reactors is comprised of the element uranium in the form of uranium oxide. The fuel produces heat by the process called fission.

In fission, the uranium atom absorbs a neutron (an atomic particle found in nature and also produced by the fissioning of uranium in the reactor) and splits to produce smaller atoms termed fission products, along with heat, radiation and free neutrons. The free neutrons travel through the reactor and are similarly absorbed by the uranium, permitting the fission process to continue.

As this process continues, more fission products, radiation, heat and neutrons are produced and a sustained reaction occurs. The heat produced is transferred -- via reactor coolant water -- from the fuel to produce steam which drives a turbine generator to produce electricity. The fission products are mostly radioactive; that is, they are unstable atoms which emit radiation as they decay to stable atoms. Neutrons which are not absorbed by the uranium fuel may be absorbed by stable atoms in the materials which make up the components and structures of the reactor. In such cases, stable atoms often become radioactive. This process is called activation and the radioactive atoms which result are called activation products.

The TMINS reactors (TMI-1 and TMI-2) are pressurized water reactors (PWR). Only TMI-1 is an operating reactor. At the end of 1993, TMI-2 was placed in a condition called Post-Defueling Monitored Storage (PDMS). As the name implies, TMI-2 will continue to be monitored until operations at TMI-1 cease. At that time, both TMI-1 and TMI-2 will be decommissioned.

The nuclear fuel used in an operating reactor such as TMI-1 is contained within sealed fuel rods arranged in arrays called bundles. The bundles are located within a massive steel reactor vessel. Pressurized water reactors utilize steam generators to transfer the heat of the coolant water to the secondary steam loop; thus, the steam generators serve as a boundary between the radioactive primary loop and the secondary steam loop.

As depicted in Figure 1, heat is added to the water as it is pumped around and through the fuel bundles in the reactor vessel. The hot primary coolant then passes inside thousands of sealed tubes within the steam generator. Heat is transferred through the tube walls into the secondary water which flows around the tubes, thereby creating steam for use in

the turbine. After the energy is extracted from the steam in the turbine, it is cooled and condensed back into water by a third loop which circulates water between the condenser and the cooling towers.

Several hundred radionuclides of some 40 different elements are created during the process of generating electricity. And, because of reactor engineering designs, the short half-lives of many radionuclides, and their chemical and physical properties, nearly all radioactivity is contained.

Pressurized water reactors have five independent barriers that confine radioactive materials given off by the reactor fuel as it heats the water. Under normal operating conditions, essentially all radioactivity is contained within the first two barriers.

The ceramic uranium fuel pellets provide the first barrier. Most of the fission products are either trapped or chemically bound in the fuel where they remain. However, a few fission products which are volatile or gaseous at normal operating temperatures may not be contained in the fuel.

The second barrier consists of zirconium (Zr) alloy tubes (cladding) that resist corrosion and high temperatures. The fuel pellets are contained within these tubes. There is a small gap between the fuel and the cladding, in which the noble gases and other volatile radionuclides collect and are contained.

The primary coolant water is the third barrier. Many of the fission products, including radioactive iodine, strontium and cesium are soluble and are retained in water in an ionic (electrically charged) form. These materials can be removed in the primary coolant purification system. However, krypton (Kr) and xenon (Xe) do not readily dissolve in the coolant, particularly at high temperatures. Krypton and xenon collect as a gas above the coolant when the water is depressurized.

The fourth barrier consists of the reactor pressure vessel and the steel piping of the primary coolant system. The reactor pressure vessel is a 36-foot high tank with steel walls a' 9 inches thick. It encases the reactor co[illegible]. The remainder of the primary coolant system includes the pressurizer, steam generators and associated piping. This system provides containment for radioactivity in the primary coolant.

The reactor building (or containment building) provides the fifth barrier. It has steel-lined concrete walls about 4 feet thick that enclose the reactor pressure vessel and the primary coolant system.

Sources of Liquid and Airborne Effluents

Although the previously described barriers contain radioactivity with high efficiency, small amounts of radioactive fission products diffuse or migrate through minor flaws in the fuel cladding and into the primary coolant. Trace quantities of reactor system component and structure surfaces which have been activated also get into the primary coolant water. Many of the soluble fission and activation products such as iodines, strontiums, cobalts, and cesiums are removed by demineralizers in the purification system of

the primary coolant. The physical and chemical properties of noble gas fission products in the primary coolant prevent their removal by the demineralizers.

Because the reactor system has many valves and fittings, an absolute seal cannot be achieved. Small amounts of noble gases and trace quantities of residual fission and activation products have the potential for escape into the reactor building and associated buildings. A portion of the airborne effluents comes from the atmosphere around the primary coolant system, which receives steam and liquid leakage from valves and pumps on systems carrying primary coolant. Environmental release of airborne radioactivity is reduced by simply holding the radioactivity inside the reactor building for a period of time which allows for the natural radioactive decay of some radionuclides. Radioactive gases from purification systems also contribute to airborne effluents and are collected and stored in tanks for radioactive decay before being released.

Airborne effluents pass through a two-stage filtration system prior to environmental release. High efficiency particulate air (HEPA) filters effectively remove radionuclides such as strontium and cesium with a 99 percent (%) efficiency. Activated charcoal filters remove radioiodines with a 90 to 95 % efficiency. Noble gases and tritium, however, cannot be removed by either of these filtration processes because of their chemical and physical properties.

Ventilation systems throughout the plant are designed to maintain a negative pressure (suction) with respect to the outside atmosphere. This pressure differential assures that all building air and air exhausted from potentially radioactive areas of the buildings is filtered by HEPA and charcoal filters prior to release to the environment.

Liquid wastes are generated from the primary coolant purification system and from small amounts of liquids which escape from valves, piping, and equipment associated with the primary coolant system during normal operations. Liquids are treated using filters, demineralizers, and evaporators to remove radioactivity from the water prior to release. Purified water is reused or released to the river and the processed wastes are concentrated for offsite burial at approved, licensed facilities. Tritium, because of its chemical behavior, is not removed from liquid wastes.

As a result of minor leakage in the steam generators, small amounts of radioactive materials are present in the secondary (steam loop) water. Although not all of the water is treated, all of the water is monitored and diluted with nonradioactive water prior to being released.

GPU Nuclear conducts operations such that releases of liquid and gaseous wastes are a small percentage of the Federal limits. Consequently, the doses associated with these releases are a small fraction of the dose limits established by the Federal Government.

GPU NUCLEAR

Three Mile Island Nuclear Station

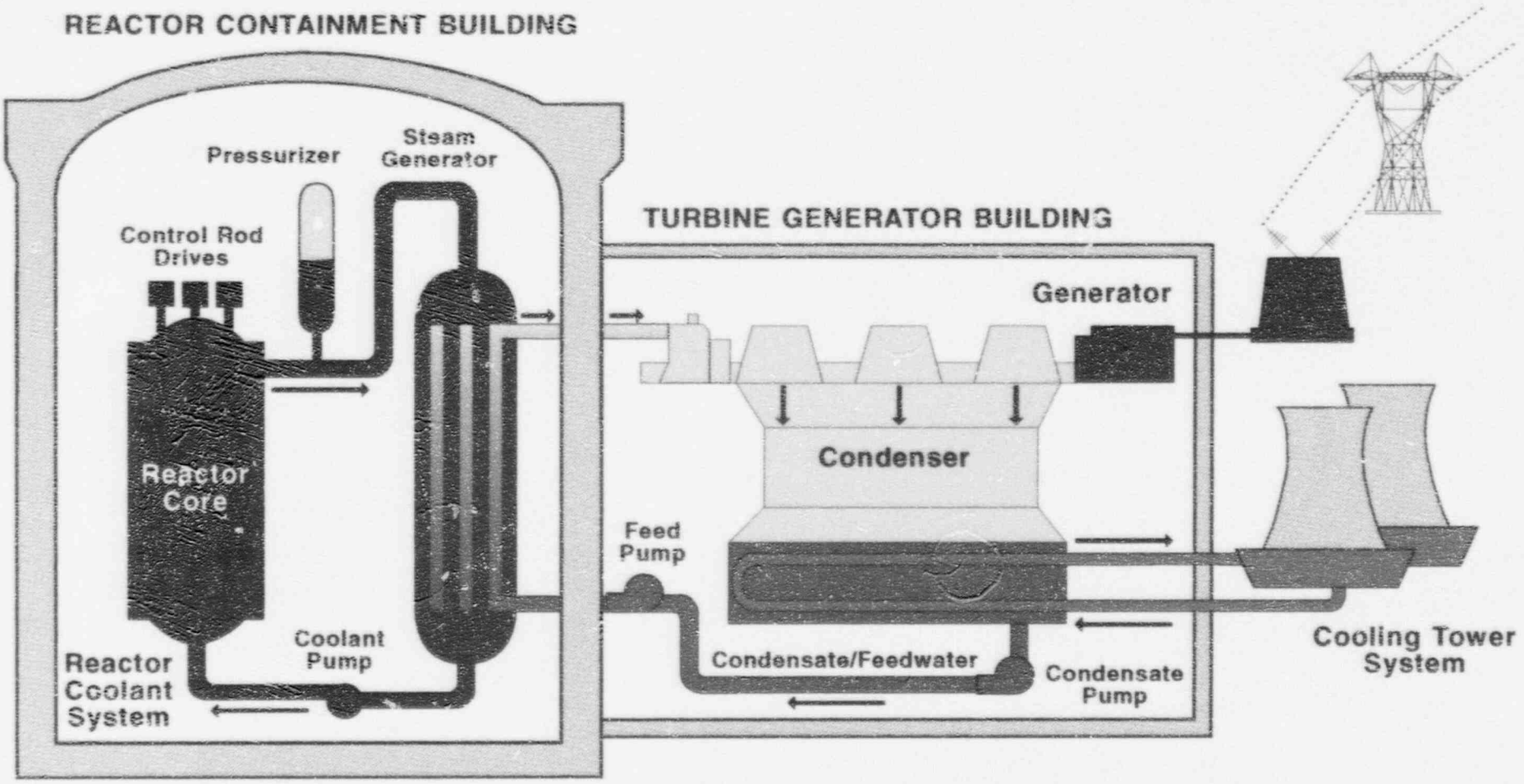

Figure 1

DESCRIPTION OF THE TMINS SITE

General Information

Three Mile Island (TMI) is located in Londonderry Township of Dauphin County, Pennsylvania. It lies approximately 2.5 miles north of the southern tip of the county, where the county borders of Dauphin, Lancaster, and York converge. The Island is part of an 814 acre tract of Company-owned land which encompasses TMI and several adjacent islands in the Susquehanna River (Refs. 29 and 30). Aligned north to south, TMI is approximately 11,000 feet long and 1700 feet wide. The eastern and western riverbanks are 900 and 6500 feet, respectively, from TMI. Covering about 200 acres of land, Three Mile Island Nuclear Station (TMINS) is situated on the northern one-half of TMI.

The Island is relatively flat with elevations ranging from about 280 feet above mean sea level (msl) at the water's edge to slightly more than 300 feet above msl in the north-central portion. The topography of the area immediately surrounding TMI is characterized by rolling terrain which slopes to the river valley floor. The hills within a two mile radius have a maximum relief of about 200 feet with the highest elevation seldom exceeding 500 feet above msl. The Susquehanna River at the site drains a watershed area of approximately 25,000 square miles.

With the exception of the southern border of TMI, the Island is bounded by the part of the Susquehanna River known as York Haven Pond or Lake Frederick. The pond, which is 1.5 miles wide at the site, is formed by the York Haven and Red Hill Dams. Three Mile Island and Shelley Island divide the river into three main channels. Several lesser channels also are formed by smaller islands.

The historical average annual flow of the Susquehanna River in the TMI region is 34,000 cubic feet per second (cfs). During 1996, however, the annual average flow was higher than the historical average. The flow in 1996 averaged about 57,094 for the TMI region with monthly averages ranging from 11,474 cfs in August to 125,974 cfs in January. The historical average annual maximum flow is about 300,000 cfs while the minimum daily flow recorded for the region is 1,700 cfs (Ref. 29). A flood protection dike completely surrounds TMINS and was designed based upon a flow of 1,100,000 cfs. For comparison, the maximum flow/flood of record occurred in June 1972 as a result of tropical storm "Agnes". This event produced a flow of 1,020,000 cfs.

Present uses of the Susquehanna River include public and industrial water supply, power generation, and recreation such as boating, swimming and fishing. While there are no commercial fisheries on the Susquehanna River in the TMI region, recreational fisherman catch several different sporting species that inhabit the River. Three of the more prevalent sporting fishes in the vicinity of TMI include Smallmouth bass, Channel catfish and Walleye.

Based on 1990 census data (Ref. 31), approximately 175,000 people reside within a ten-mile radius of TMINS. The nearest population center is Goldsboro with a population of 458 people. It lies approximately one mile to the west of the site. About 2.5 miles to the north, 9,254 people reside in the town of Middletown. Harrisburg, situated 12 miles to the northwest, is the nearest major city with a population of 52,376. Land within a 10 mile radius of the site is used primarily for farming. Farm products include poultry, meat, fruit, dairy products, vegetables, corn, wheat, alfalfa, tobacco, and other crops of lesser importance.

Climatological Summary - 1996*

The Appalachian Mountains, located about 20 miles to the north of TMI, protect the area somewhat from the cold winter outbreaks of Arctic air that invade central and western Pennsylvania. However, the site is too far inland to derive the full benefits of a coastal climate like that of the southeastern region of Pennsylvania. Summers tend to be warm and humid and winters are cool, with frequent periods of precipitation. Summer rainfall typically comes from thunderstorm activity, while most of the precipitation in the winter is a result of coastal winter storms. Normal yearly rainfall for the TMI region is 40.5 inches. Winds primarily are from the northwesterly direction. The 1996 annual average wind speed in the TMI region was about 8.5 miles per hour (mph). Monthly averages ranged from 4.8 mph in August to 12.7 mph in April. (Ref. 32).

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*Sources:
1) Onsite Meteorological Data.
2) Local Climatological Data, Harrisburg, PA.
3) National Climatic Data Center, Asheville, NC.

During 1996, the average monthly temperatures ranged from 26.2 °F in January to 74.1 °F in July. The maximum monthly deviation occurred in November when the temperatures averaged 4.8 °F below the normal monthly average. The lowest temperature of the year occurred on February 6 when it dropped to -1 °F. On August 23, the temperature rose to 92 °F, marking the year's highest temperature. The overall annual average temperature was 52.4 °F which is within 1 ° of the normal annual average for the area.

A total of 55.9 (water equivalent) inches of precipitation was recorded during 1996. This amount was about 15.4 inches above the normal annual average. Monthly precipitation totals ranged from a low of 1.4 inches in February to a high of 8.2 inches in July. The amount of precipitation which fell in July exceeded the normal total for the month by approximately 4.6 inches.

The most significant rain events occurred on July 12 and 13 and again on October 18 and 19 when about 2.7 inches fell within 24-hour periods. The year's greatest snowfall recorded over a 24-hour period (21.7 inches) occurred on January 7 and 8. January's total snowfall was recorded at 38.9 inches which was the greatest monthly total for the year. The year's greatest depth of snow measured on the ground was at 32 inches which occurred on January 12 and 13.

Compared to 1995 which was a more typical year, 1996 was highlighted by an early blizzard which resulted in major flooding over numerous areas of the Susquehanna Valley. Most of the remainder of the year continued with above normal precipitation which, economically speaking, caused much lower yields of hay in the region because of high moisture content. Corn yields, however, were considered good as they approached the record high which was set in 1994.

A wind rose and joint frequency tables for the TMINS site, which summarize wind and dispersion information used for offsite dose calculations, are provided in Appendix K. The data normally are generated from meteorological parameters recorded by onsite instrumentation. When real-time data are missing or invalid, default values are entered into the data base. The default values are consistent with actual meteorology for the TMINS vicinity. During 1996, a total of 65 hours of real-time data (0.7%) were missing or invalid.

EFFLUENTS

Historical Background

Almost from the outset of the discovery of x-rays in 1895 by Wilhelm Roentgen, the potential hazard of ionizing radiation was recognized and efforts were made to establish radiation protection standards. The International Commission on Radiological Protection (ICRP) and the NCRP were established in 1928 and 1929, respectively. These organizations have the longest continuous experience in the review of radiation health effects and with making recommendations on guidelines for radiological protection and radiation exposure limits.

In 1955, the United Nations created a Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) to summarize reports received on radiation levels and the effects on man and his environment. The National Academy of Sciences (NAS) formed a committee in 1956 to review the biological effects of atomic radiation (BEAR). A series of reports have been issued by this and succeeding NAS committees on the biological effects of ionizing radiation (BEIR), the most recent being 1990 (known as BEIR V).

These committees and commissions of nationally and internationally recognized scientific experts have been dedicated to the understanding of the health effects of radiation by investigating all sources of relevant knowledge and scientific data and by providing guidance for radiological protection. Their members are selected from universities, scientific research centers and other national and international research organizations. The committee reports contain scientific data obtained from physical, biological, and epidemiological studies on radiation health effects and serve as scientific references for information presented in this report.

Since its inception, the USNRC has depended upon the recommendations of the ICRP, the NCRP, and the Federal Radiation Council (FRC), incorporated in the USEPA in 1970, for basic radiation protection standards and guidance in establishing regulations for the nuclear industry (Refs. 33 through 36).

Effluent Release Limits

As part of routine operations at a nuclear power station, limited quantities of radioactive materials are released to the environment in liquid and airborne effluents. At TMINS, an effluent control program is implemented by GPU Nuclear to ensure that the amounts of radioactive materials released to the environment are minimal and do not exceed release limits.

The Federal government establishes limits on radioactive materials released to the environment. Regulated by the USNRC, these limits are set at levels to protect the health and safety of the public. They are specified in the Technical Specifications for TMI-1 and TMI-2 and the Offsite Dose Calculation Manual, ODCM, (Ref. 39). GPU Nuclear conducts operations such that releases of radioactive effluents are a small percentage of the Federal limits.

A recommendation of the ICRP, NCRP, and FRC is that radiation exposures should be maintained at levels which are "as low as reasonably achievable" (ALARA) and commensurate with the societal benefit derived from the activities resulting in such exposures. For this reason, dose limit guidelines were established by the USNRC for releases of radioactive effluents from nuclear power plants. These guidelines are presented in Title 10 of the Code of Federal Regulations, Part 50, Appendix I (10 CFR 50, App. I). Maintaining doses within these operational guidelines demonstrates that releases of radioactive effluents are being maintained "as low as reasonably achievable". These USNRC ALARA guidelines are a fraction of the dose limits established by the USEPA.

The USNRC 10 CFR 50, App. I guidelines are as follows:

- The dose to a member of the public from radioactive materials released in liquid effluents is limited to $\leq$ 3 mrem/yr to the total body or $\leq$ 10 mrem/yr to any organ.
- The air dose due to noble gases at a location which would be occupied by a member of the public is limited to $\leq$ 10 mrad/yr for gamma radiation or $\leq$ 20 mrad/yr for beta radiation.

- The dose to a member of the public from noble gases released in gaseous effluents is limited to ≤ 5 mrem/yr to the total body or ≤ 15 mrem/yr to the skin.

- The dose to a member of the public from airborne iodines, tritium and particulates is limited to ≤ 15 mrem/yr to any organ.

The USEPA dose limits as defined in Title 40 of the Code of Federal Regulations, Part 190 (40 CFR 190), are as follows:

- The dose to a member of the public shall not exceed in a year 25 mrem/yr to the total body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any other organ as a result of uranium fuel cycle operations.

Effluent Control Program

Effluent control includes plant components such as the ventilation system and filters, waste gas holdup tanks, demineralizers and evaporator systems. In addition to minimizing the release of radioactivity, the effluent control program includes all aspects of effluent monitoring. This includes the operation and data analysis associated with a complex radiation monitoring system, collection and analysis of effluent samples, and a comprehensive quality assurance (QA) program. Over the years, the program has evolved in response to changing regulatory requirements and plant conditions. For example, additional instruments and samplers have been installed to ensure that measurements of effluents remain onscale in the event of any accidental release of radioactivity.

Effluent Instrumentation: Liquid and airborne effluent measuring instrumentation is designed to monitor the presence and the amount of radioactivity in effluents. The instruments provide continuous surveillance of radioactivity releases. Calibrations of effluent instruments are performed using reference standards certified by the National Institute of Standards and Technology (NIST). The instruments are calibrated to respond to specific radionuclides and are sensitive enough to measure 100 to 1,000 times below the applicable release limits.

Each instrument is equipped with alarms which are connected to the Control Room. The alarm setpoints are set to ensure that effluent release limits will not be exceeded. If radiation monitor alarm setpoints are reached, liquid and airborne releases are automatically terminated.

Effluent Sampling and Analysis: In addition to continuous radiation monitoring instruments, samples of effluents are taken and subjected to laboratory analysis to identify the specific radionuclide quantities being released. A sample must be representative of the effluent from which it is taken. Sampling and analysis provide a sensitive and precise method of determining effluent composition. Samples are analyzed using state-of-the-art laboratory counting equipment. Radiation instrument readings and sample results are compared to ensure correct correlation.

Effluent Data

The amount of radioactivity released from TMINS varies and is dependent upon operating conditions, power levels, fuel conditions, efficiency of liquid and gas

processing systems, and proper functioning of plant equipment. The largest variations occur in the airborne effluents of fission and activation gases which are particularly sensitive to the holdup time capability in the gas processing system and to the integrity of the fuel cladding.

During 1996, small amounts of radioactive materials were released in TMI-1 and TMI-2 liquid and airborne effluents. The total amount of radioactivity released from TMI-1 in 1996 was the lowest in its operating history. This notable achievement was due primarily to good fuel integrity, minimal leakage in the steam generators and improved efficiency of the waste processing systems. As expected, the doses potentially received by individuals from 1996 TMI-1 and TMI-2 liquid and airborne effluents were very low and a small fraction of the Federal limits. Doses to the public are discussed in more detail in **Radiological Impact of TMINS Operations** and **Appendix I**.

The amounts of radioactive materials released from TMINS as well as the associated doses to the public are summarized and reported annually to the USNRC. The following sections discuss the radioactive constituents of the 1996 TMI-1 and TMI-2 liquid and airborne effluents. They also are summarized in Table 2. All amounts are reported in curies (Ci) to three significant figures.

Noble Gases: Noble gases such as argon, xenon and krypton are produced and released from operating nuclear power stations. These gases are readily dispersed in the atmosphere when released and do not react chemically or biologically with other materials. Typically, xenon and krypton are the predominant radioactive materials released in TMI-1 airborne effluents. This was not true for 1996. The predominant radionuclide released in TMI-1 airborne effluents was tritium. Lesser amounts of xenon and krypton were released due to good fuel integrity.

Specifically, 0.571 Ci of xenon (primarily Xe-133), 0.847 Ci of krypton (primarily Kr-85) and 0.0909 Ci of Ar-41 were released from TMI-1 to the atmosphere in 1996. For comparison, approximately 580 Ci of xenon and about 33 Ci of krypton were released in 1995 TMI-1 airborne effluents. A very small amount of xenon (0.00000882 Ci) also was released in TMI-1 liquid effluents. Noble gases were not detected in 1996 TMI-2 liquid or airborne effluents.

Iodines and Particulates: The discharge of radioiodines and radioactive particulates to the environment is minimized by factors such as their high chemical reactivity, solubility in water, and the high efficiency of removal in airborne and liquid processing systems.

During 1996, iodines were not detected in TMI-2 liquid or gaseous effluents. For TMI-1, I-131 and I-133 were the only radioiodines released in liquid and gaseous effluents. Iodine-131 was released in both liquid and airborne effluents while I-133 was released only in airborne effluents. The other isotopes of iodine were not released at detectable amounts either because of a very short half-life or a low production rate. For example, I-129 has a 17 million year half-life

but its production in the nuclear fission process is so low that it cannot be detected routinely in effluents.

The principal radioactive particulates released as a result of 1996 TMI-1 operations were the radiocesiums (Cs-134 and Cs-137), radiostrontiums (Sr-89 and Sr-90) and activation products Fe-55, Co-58, Co-60, Ag-110m and Sb-125. All of these radionuclides were released in TMI-1 liquid effluents. Only Cs-137 was measured in TMI-1 airborne effluents. For TMI-2, small amounts of Sr-90, Cs-134 and Cs-137 were released in liquid effluents. Like TMI-1, only Cs-137 was measured in TMI-2 airborne effluents.

The total amounts of radioiodines and radioactive particulates released from TMI-1 and TMI-2 in 1996 liquid effluents were 0.00430 Ci and 0.0000657 Ci, respectively. For airborne effluents, 0.00000725 Ci and 0.000000184 Ci of radioiodine and radioactive particulates were released from TMI-1 and TMI-2, respectively.

The combined amounts of radioiodines and radioactive particulates released in liquid effluents from TMI-1 for the period of 1986 through 1996 are depicted in Figure 5. As shown in Figure 5, the amount released in 1996 was much lower compared to previous years. The reduction was due primarily to good fuel integrity, minimal component leakage and improved efficiency of the liquid waste processing systems.

Tritium: Tritium was the predominant radionuclide released in 1996 TMI-1 liquid effluents. This radionuclide also was released in TMI-1 gaseous effluents and TMI-2 liquid and gaseous effluents, but at much lower amounts. Tritium is a radioactive isotope of hydrogen. It is produced in the reactor coolant as a result of neutron interaction with the naturally-occurring deuterium (also a hydrogen isotope) present in water and with the boron used for reactivity control of the reactor.

During 1996, the amounts of H-3 released in TMI-1 liquid and gaseous effluents were 167 Ci and 7.94 Ci, respectively. Figure 6 shows the amounts of H-3 released in TMI-1 liquid effluents for the period 1986-1996. For TMI-2, H-3 releases were 0.00117 Ci and 2.54 Ci for liquids and gases, respectively.

To put these amounts of H-3 into perspective, the world inventory of natural cosmic ray produced H-3 is 70 million Ci, which corresponds to a production rate of 4 million Ci/yr (Ref. 37). Tritium contributions to the environment from nuclear power production are too small to have any significant effect on the existing global environmental concentrations.

Transuranics: Transuranics are produced by neutron capture in the fuel, and typically emit alpha and beta particles as they decay. Important transuranic isotopes produced in reactors are U-239, plutonium-238 (Pu-238), Pu-239, Pu-240, Pu-241, americium-241 (Am-241), Pu-243, plus other isotopes of americium and curium (Cm). They have half-lives ranging from hundreds of days to millions of years. Transuranics are mostly retained within the nuclear fuel. Because they are so insoluble and non-volatile, they are not readily transported from inplant pathways to the environment. Gas and liquid processing

systems remove greater than 90% of any transuranics outside the reactor coolant. Since greater than 99% of all transuranics are retained within the fuel and transuranic removal processes are extremely efficient, releases in airborne and liquid effluents are not routinely detected.

During 1996, transuranics were not detected in TMI-1 or TMI-2 effluents.

TABLE 2

Radionuclide Composition of TMINS Effluents for 1996 (1)

Radionuclide (2)	Half-Life (3)	Liquid Effluents (Ci)		Airborne Effluents (Ci)	
		TMI-1	TMI-2	TMI-1	TMI-2
H-3	1.23E+1 yr	1.67E+2	1.17E-3	7.94E+0	2.54E+0
Ar-41	1.83E+0 h			9.09E-2	
Fe-55	2.70E+0 yr	8.50E-6			
Co-58	7.08E+1 day	2.04E-5			
Co-60	5.27E+0 yr	8.44E-6			
Kr-85	1.07E+1 yr			8.46E-1	
Kr-88	2.84E+0 day			1.04E-3	
Sr-89	5.05E+1 day	2.75E-5			
Sr-90	2.86E+1 yr	6.16E-5	4.59E-6		
Ag-110m	2.50E+2 day	5.55E-7			
Sb-125	2.77E+0 yr	3.16E-4			
I-131	8.04E+0 day	4.37E-7		2.85E-6	
Xe-131m	1.18E+1 day			3.00E-3	
I-133	2.08E+1 h			4.32E-6	
Xe-133	5.25E+0 day			5.44E-1	
Cs-134	2.06E+0 yr	6.74E-4	7.25E-8		
Xe-135	9.11E+0 h	8.82E-6		1.63E-2	
Xe-135m	1.54E+1 min			8.28E-3	
Cs-137	3.02E+1 yr	3.18E-3	6.10E-5	8.16E-8	1.84E-7

(1) The results are expressed in exponential form (i.e., 1.2E-2 = 0.012).

(2) Refer to List of Abbreviations, Symbols and Acronyms (p. v) for nomenclature of the radionuclides/elements.

(3) yr = year, h = hour, min = minute

Historical Releases of Radioiodines and Radioactive Particulates in TMI-1 Liquid Effluents

mCi of Radioiodines and Radioactive Particulates by Year

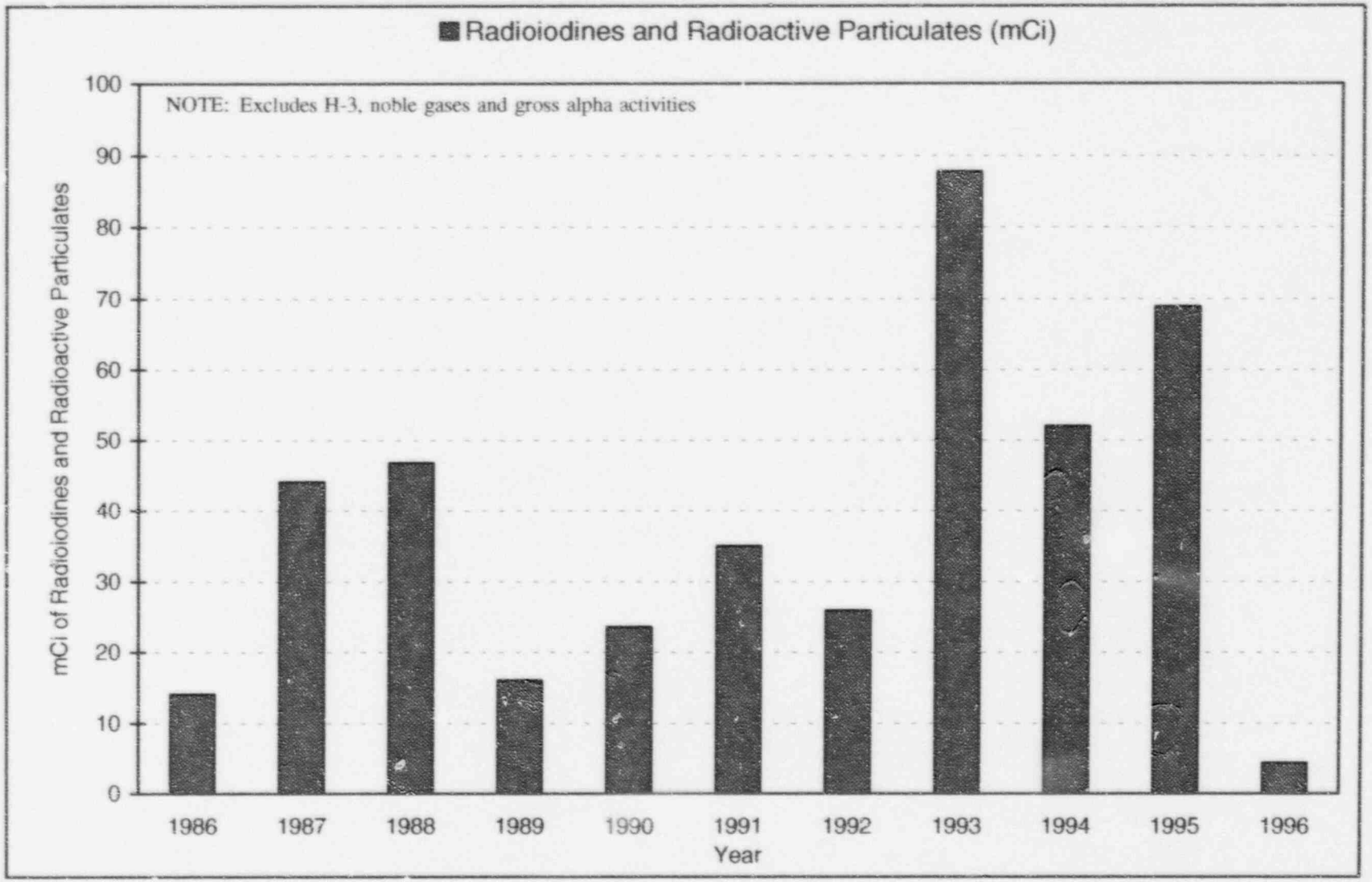


Figure 2

Historical Releases of Tritium in TMI-1 Liquid Effluents

Curies of Tritium by Year

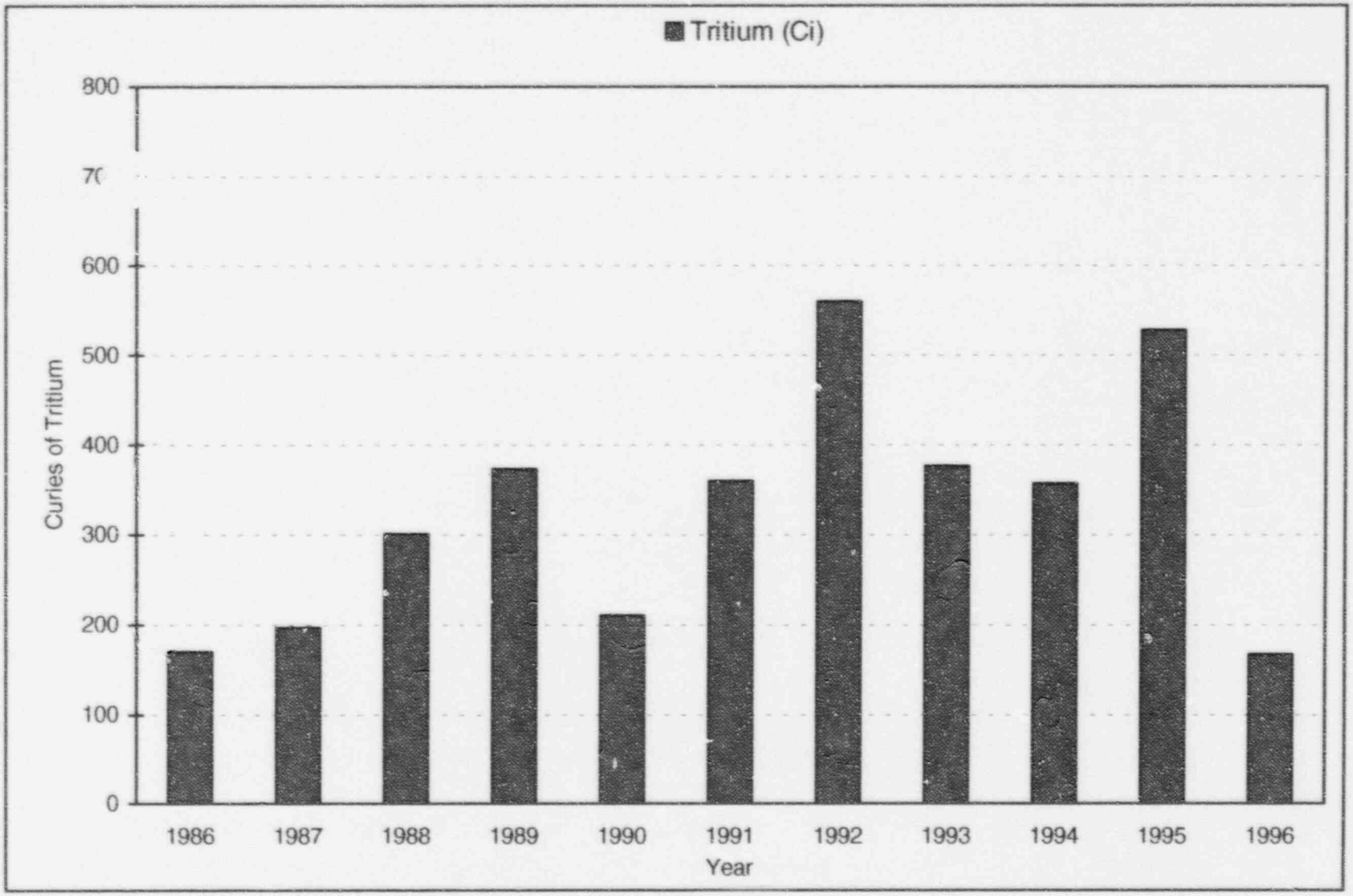


Figure 3

RADIOLOGICAL ENVIRONMENTAL MONITORING

GPU Nuclear conducts a comprehensive radiological environmental monitoring program (REMP) at TMINS to measure levels of radiation and radioactive materials in the environment. The information obtained from the REMP is then used to determine the effect of TMINS operations, if any, on the environment and the public.

The USNRC has established regulatory guides which contain acceptable monitoring practices. The TMINS REMP was designed on the basis of these regulatory guides along with the guidance provided by the USNRC Radiological Assessment Branch Technical Position for an acceptable radiological environmental monitoring program (Ref. 38). The TMINS REMP meets or exceeds the monitoring requirements set forth by the USNRC.

The important objectives of the REMP are:

- To assess dose impacts to the public from TMINS operations.
- To verify inplant controls for the containment of radioactive materials.
- To determine buildup of long-lived radionuclides in the environment and changes in background radiation levels.
- To provide reassurance to the public that the program is capable of adequately assessing impacts and identifying noteworthy changes in the radiological status of the environment.
- To fulfill the requirements of the TMI-1 and TMI-2 Technical Specifications.

Environmental Exposure Pathways to Humans from Airborne and Liquid Effluents

As previously discussed (**Effluents**), small amounts of radioactive materials are released to the environment as a result of operating a commercial nuclear power station. Once released, these materials move through the environment in a variety of ways and may eventually reach humans via breathing, drinking, eating and direct exposure. These routes of exposure are referred to as environmental exposure pathways. Figure 18 illustrates the important exposure routes.

As can be seen from this figure, these exposure pathways are both numerous and varied. While some pathways are relatively simple, such as inhalation of airborne radioactive materials, others may be complex. For example, radioactive airborne particulates may deposit onto forage which when eaten by cows may be transferred into milk, which is subsequently consumed by man. This route of exposure is referred to as the air-grass-cow-milk-human pathway.

Although radionuclides can reach humans by a number of pathways, some are more important than others. The critical pathway for a given radionuclide is the one that produces the greatest dose to a population, or to a specific segment of the population. This segment of the population is termed the critical group, and may be defined by age, diet, or other cultural factors. The dose may be delivered to the whole body or confined to a specific organ; the organ receiving the greatest fraction of the dose is termed as the critical organ. This information was used to develop the TMINS REMP.

Sampling

The TMINS REMP consists of two phases -- the preoperational and the operational. Data gathered in the preoperational phase is used as a basis for evaluating radiation levels and radioactivity in the vicinity of the plant after the plant becomes operational. The operational phase began in 1974 at the time TMI-1 became operational.

The program consists of taking radiation measurements and collecting samples from the environment, analyzing them for radioactivity content, and then interpreting the results. With emphasis on the critical exposure pathways to humans, samples from the aquatic, atmospheric, and terrestrial environments are collected. These samples include, but are not limited to, air, water, sediment, finfish, milk, fruits, vegetables and groundwater. Thermoluminescent dosimeters (TLDs) are placed in the environment to measure gamma radiation levels.

The Offsite Dose Calculation Manual, ODCM, (Ref. 39) implements the TMI-1 and TMI-2 Technical Specifications and defines the sample types to be collected and the analyses to be performed. As appropriate, changes to the REMP are initiated by the recommendations from the scientific staff of GPU Nuclear Environmental Affairs of TMINS. However, the minimum sampling and analysis requirements specified in the ODCM are maintained.

Sampling locations were established by considering topography, meteorology, population distribution, hydrology, areas of public interest and land use characteristics of the local area. The sampling locations are divided into two classes, indicator and control. Indicator locations are those which are expected to show effects from TMINS operations, if any exist. These locations were selected primarily on the basis of where the highest predicted environmental concentrations would occur. The indicator locations are typically within a few miles of TMINS.

Control stations are located generally at distances greater than 10 miles from TMINS. The samples collected at these sites are expected to be unaffected by TMINS operations. Data from control locations provide a basis for evaluating indicator data relative to natural background radioactivity and fallout from prior nuclear weapon tests. Figures 2, 3 and 4 show the current sampling locations around TMI. Table A-1 in Appendix A describes the sampling locations by distance and azimuth along with the type(s) of samples collected at each sampling location.

Analysis

In addition to specifying the media to be collected and the number of sampling locations, the ODCM also specifies the frequency of sample collection and the types and frequency of analyses to be performed. Also specified are analytical sensitivities (detection limits) and reporting levels. Table A-2 in Appendix A provides a synopsis of the sample types, number of sampling locations, collection frequencies, number of samples collected, types and frequencies of analyses, and number of samples analyzed. Table A-3 in Appendix A lists samples which were not collected or analyzed per the requirements of the ODCM. Sample analyses which did not meet the required analytical sensitivities are presented in Appendix B. Changes in sample collection and analysis are described in Appendix C.

Measurement of low radionuclide concentrations in environmental media requires special analysis techniques. Analytical laboratories use state-of-the-art laboratory equipment designed to detect all three types of radiation emitted (alpha, beta, and gamma). This equipment must meet the analytical sensitivities required by the ODCM. Examples of the specialized laboratory equipment used are germanium detectors with multichannel analyzers for determining specific gamma-emitting radionuclides, liquid scintillation counters for detecting H-3 and low level proportional counters for detecting gross alpha and beta radioactivity.

Calibrations of the counting equipment are performed by using standards traceable to the National Institute of Standards and Technology (NIST). Computer hardware and software used in conjunction with the

counting equipment perform calculations and provide data management. Analysis methods are described in Appendix L.

Data Review

The analytical results are routinely reviewed by GPU Nuclear scientists to assure that sensitivities have been achieved and that the proper analyses have been performed. Investigations are conducted when action levels or USNRC reporting levels are reached or when anomalous values are discovered. The action levels were established by GPU Nuclear and are typically 10 percent of the USNRC reporting levels specified in the ODCM. These levels are purposely set low so that corrective action can be initiated before a reporting level is reached. This review process is discussed in more detail in Appendix D.

Table 3 provides a summary of radionuclide concentrations detected in the primary environmental samples for 1996. Statistical methods used to derive this table along with other statistical conclusions are detailed in Appendix H. Quality control (QC) sample results were used mainly to verify the primary sample result or the first result in the case of a duplicate analysis. Therefore, the QC results were excluded from Table 3 and the main text of this report to avoid biasing the results.

Quality Assurance Program

A quality assurance (QA) program is conducted in accordance with guidelines provided in Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs" (Ref. 40) and as required by the Technical Specifications. It is documented by GPU Nuclear written policies, procedures, and records. These documents encompass all aspects of the REMP including sample collection, equipment calibration, laboratory analysis and data review.

The QA program is designed to identify possible deficiencies so that immediate corrective action can be taken. It also provides a measure of confidence in the results of the monitoring program in order to assure the regulatory agencies and the public that the results are valid. The QA program for the measurement of radioactivity in environmental samples is implemented by:

- Auditing all REMP-related activities including analytical laboratories.
- Requiring analytical laboratories to participate in a cross-check program(s).
- Requiring analytical laboratories to split samples for separate analysis (recounts are performed when samples cannot be split).
- Splitting samples, having the samples analyzed by independent laboratories, and then comparing the results for agreement.
- Reviewing QC results of the analytical laboratories including spike and blank sample results and duplicate analysis results.

The QA program and the results of the cross-check programs are outlined in Appendix E and F, respectively.

The TLD readers are calibrated monthly against standard TLDs to within five percent of the standard TLD values. Also, each group of TLDs processed by a reader contains control TLDs that are used to correct for

minor variations in the reader. The accuracy and variability of the results for the control TLDs are examined for each group of TLDs to assure the reader is functioning properly. In addition, each element (TLD) has an individual correction factor based on its response to a known exposure.

Other cross-checks, calibrations, and certifications are in-place to assure the accuracy of the TLD program:

- Semiannually, randomly selected TLDs are sent to an independent laboratory where they are irradiated to set doses not known to GPU Nuclear. TLDs which meet the criteria specified by the National Voluntary Laboratory Accreditation Program (NVLAP) are used for this test. The GPU Nuclear dosimetry laboratory processes the TLDs and the results are compared against established limits.

- Every two years, each TLD is checked to ensure an appropriate correction factor is assigned to each element of the TLD.

- Every two years, GPU Nuclear's dosimetry program is examined and NVLAP recertified by the NIST.

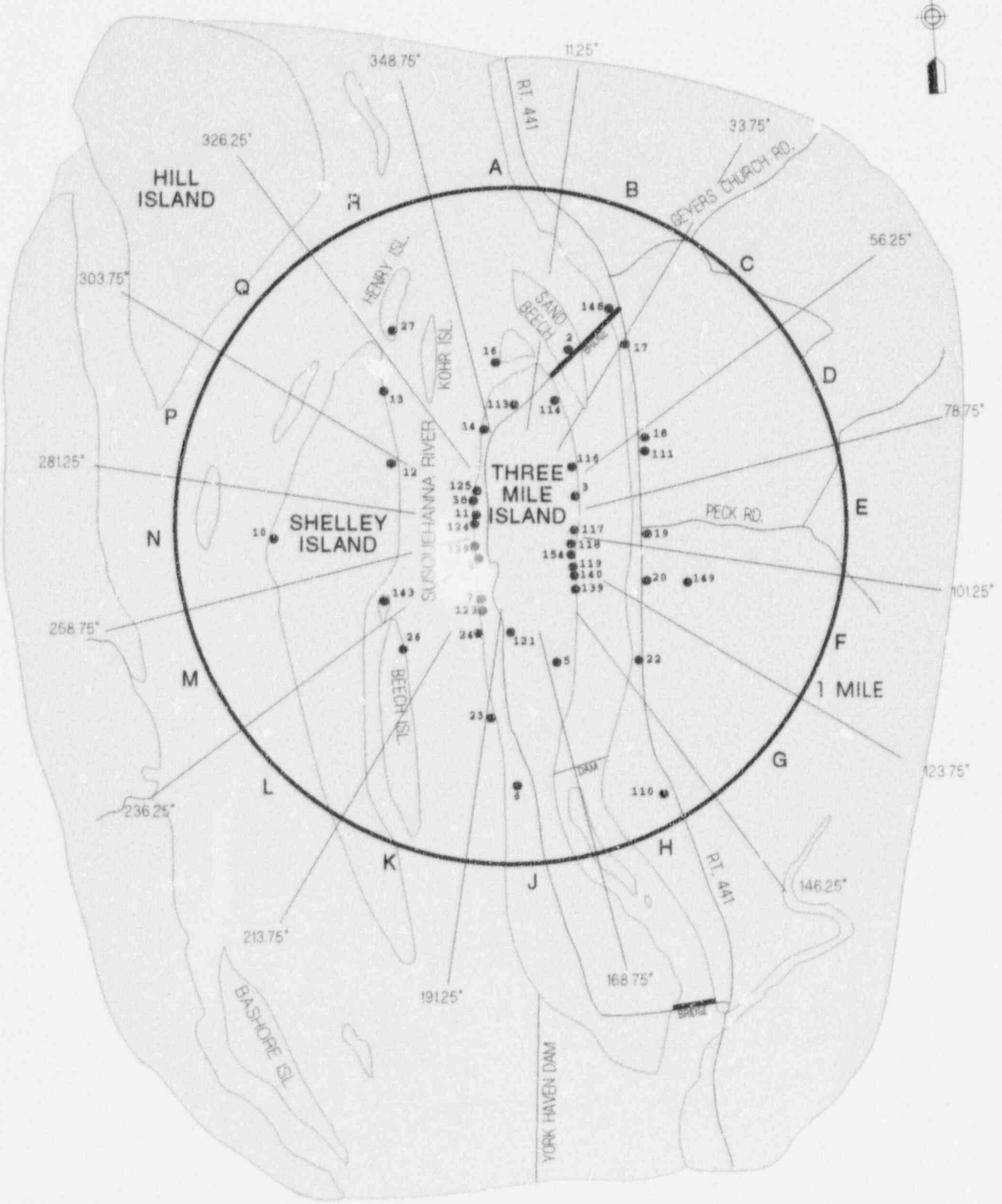
- Ten environmental TLD stations have vendor-supplied quality control badges which are processed by the vendor. The results are compared against GPU Nuclear TLD results.

The environmental dosimeters were tested and qualified to the American National Standard Institutes (ANSI) publication N545-1975 and the USNRC Regulatory Guide 4.13 (Refs. 41 and 42). The results for some of these tests were published in the Health Physics Journal (Ref. 43).

In addition to the GPU Nuclear REMP, the USNRC and the Pennsylvania State Bureau of Radiation Protection (PaBRP) also maintain surveillance programs in the TMI area. These programs provide independent assessments of radioactive releases and the radiological impact on the surrounding environment. The results from these programs have compared favorably with those from the GPU Nuclear program.

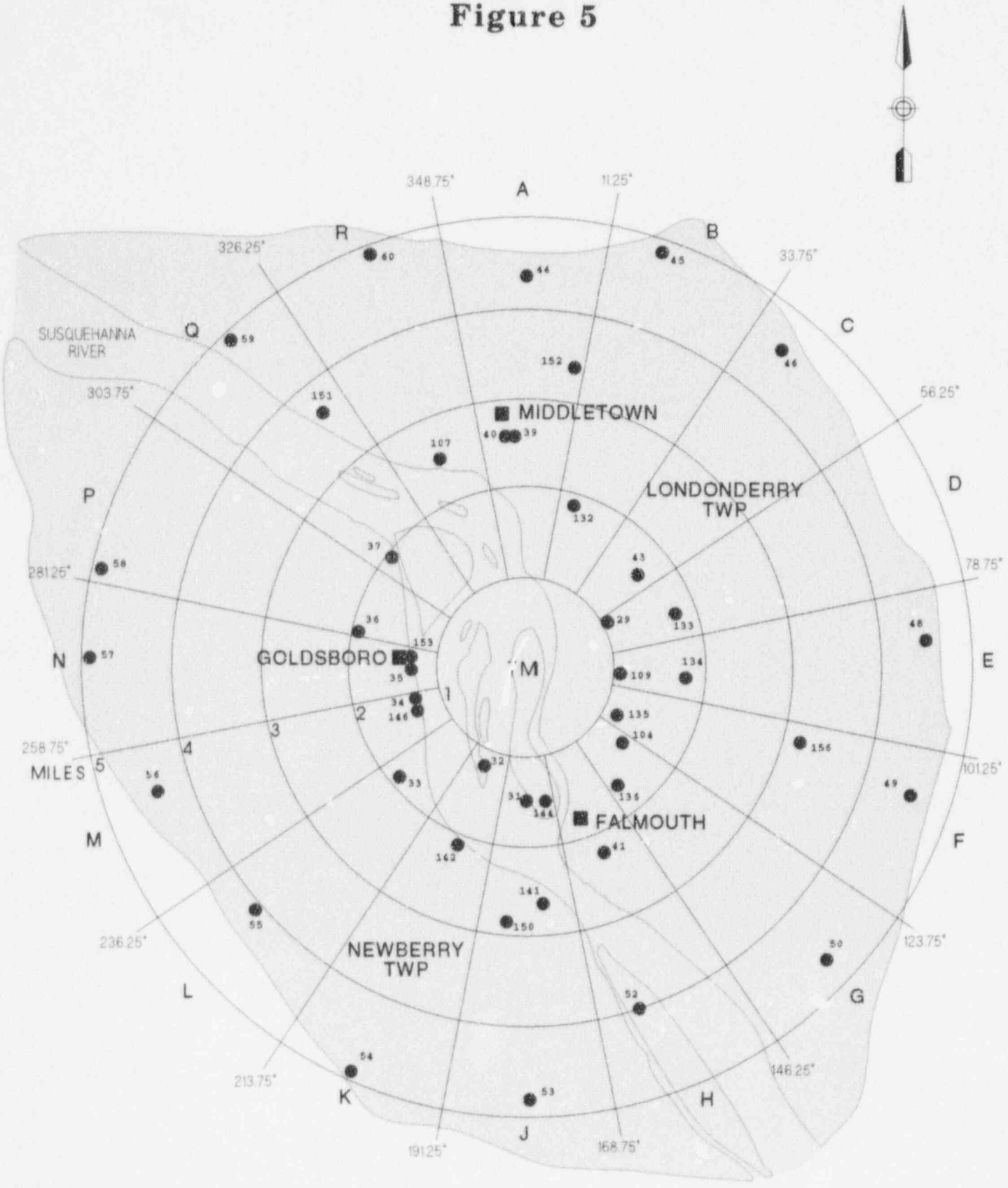
GPU Nuclear Three Mile Island Environmental Affairs Department collects and analyzes samples of the TMINS liquid discharge as a QC check for the inplant effluent sampling program. Results from the REMP samples were consistent with the radioactivity measured inplant prior to release.

Figure 4



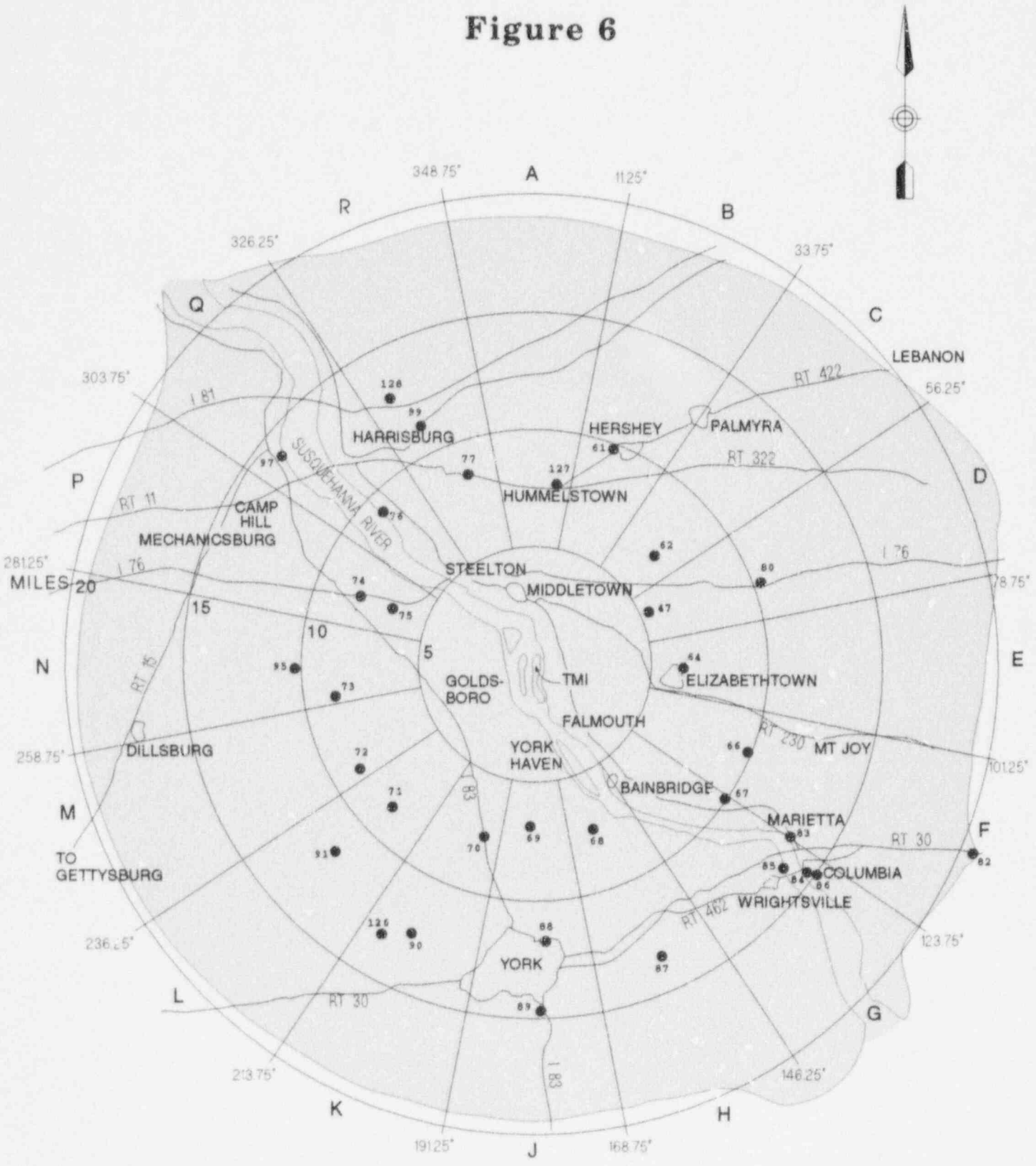
Locations of REMP Stations Within 1 Mile of TMINS

Figure 5



Locations of REMP Stations
1 to 5 Miles from TMINS

Figure 6



Locations of REMP Stations
Greater Than 5 Miles From TMINS

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Air Iodine (pCi/m3)	I-131	620	0.07	ND(8)	---	---	ND	0
Air Particulates (pCi/m3)	Gr-Alpha	306(5)	0.0015	1.3E-03 (153/208) (6.8E-04 - 2.3E-03)	Q15-1, 13.5 mi NW West Fairview	1.4E-03 (38/51) (7.2E-04 - 2.5E-03)	1.4E-03 (76/98) (7.2E-04 - 2.5E-03)	0
	Gr-Beta	616(5)	0.01	1.6E-02 (466/466) (6.2E-03 - 3.4E-02)	J15-1, 12.6 mi S York Substation	1.7E-02 (47/47) (8.7E-03 - 2.9E-02)	1.7E-02 (150/150) (7.8E-03 - 3.1E-02)	0
	Sr-89	24	0.0005	ND	---	---	ND	0
	Sr-90	24	0.01	ND	---	---	ND	0
	Gamma Spec.	48						
	Be-7		0.05	7.0E-02 (36/36) (4.4E-02 - 9.5E-02)	A3-1, 2.6 mi N Middletown Substation	7.5E-2 (4/4) (4.4E-02 - 9.5E-02)	7.0E-02 (12/12) (4.6E-02 - 9.7E-02)	0
	Cs-134		0.05	ND	---	---	ND	0
	Cs-137		0.06	ND	---	---	ND	0
Fish (pCi/g, wet)	H-3	8	0.2	1.4E-01 (4/4) (8.0E-02 - 2.2E-01)	Indbf, Indicator Bottom Feeder Below Discharge	1.5E-01 (2/2) (8.0E-02 - 2.2E-01)	ND	0
	Sr-89	8	0.025	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Fish (pCi/g, wet)	Sr-90	8	0.01	ND	Bkgp, Control Predator Above Discharge	3.9E-03 (1/2)	3.9E-03 (1/4)	0
	Gamma Spec.	8						
	Co-58		0.13	ND	---	---	ND	0
	Co-60		0.13	ND	---	---	ND	0
	Cs-134		0.13	ND	---	---	ND	0
	Cs-137		0.15	6.9E-03 (1/4)	Indp, Indicator Predator Below Discharge	6.9E-03 (1/2)	ND	0
	Fe-59		0.26	ND	---	---	ND	0
	K-40		0.2	3.0E+00 (4/4) (2.7E+00 - 3.2E+00)	Indp, Indicator Predator Below Discharge	3.0E+00 (2/2) (2.9E+00 - 3.2E+00)	2.9E+00 (4/4) (2.8E+00 - 3.0E+00)	0
	Mn-54		0.13	ND	---	---	ND	0
	Zn-65		0.26	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Aquatic Sediment (pCi/g, dry)	Sr-89	4	0.1	ND	---	---	ND	0
	Sr-90	4	0.05	ND	---	---	ND	0
	Gamma Spec.	8						
	Be-7		0.2	1.8E+00 (6/6) (3.5E-01 - 3.1E+00)	J2-1, 1.5 mi S Above York Haven Dam	2.6E+00 (2/2) (2.1E+00 - 3.1E+00)	2.0E+00 (2/2) (1.5E+00 - 2.6E+00)	0
	Co-60		0.1	2.3E-02 (1/6)	K1-3, 0.3 mi SSW West Shore of TMI	2.3E-02 (1/2)	ND	0
	Cs-134		0.15	1.9E-02 (2/6) (1.8E-02 - 2.1E-02)	K1-3, 0.3 mi SSW West Shore of TMI	1.9E-02 (2/2) (1.8E-02 - 2.1E-02)	ND	0
	Cs-137		0.18	1.9E-01 (6/6) (1.3E-01 - 2.9E-01)	K1-3, 0.3 mi SSW West Shore of TMI	2.3E-01 (2/2) (1.7E-01 - 2.9E-01)	7.3E-02 (2/2) (6.3E-02 - 8.4E-02)	0
	I-131		0.1	ND	A1-3, 0.5 mi N North Tip of Three Mile Island	2.8E-02 (1/2)	2.8E-02 (1/2)	0
	K-40		0.2	1.4E+01 (6/6) (9.8E+00 - 2.1E+01)	J2-1, 1.5 mi S Above York Haven Dam	1.9E+01 (2/2) (1.7E+01 - 2.1E+01)	1.2E+01 (2/2) (1.1E+01 - 1.3E+01)	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Aquatic Sediment (pCi/g, dry)	Ra-226		0.3	2.4E+00 (6/6) (1.8E+00 - 3.3E+00)	J2-1, 1.5 mi S Above York Haven Dam	3.1E+00 (2/2) (2.9E+00 - 3.3E+00)	2.1E+00 (2/2) (2.0E+00 - 2.2E+00)	0
	Th-232		0.2	1.3E+00 (6/6) (9.7E-01 - 1.7E+00)	J2-1, 1.5 mi S Above York Haven Dam	1.5E+00 (2/2) (1.4E+00 - 1.7E+00)	1.2E+00 (2/2) (1.1E+00 - 1.3E+00)	0
Drinking Water (pCi/L)	Gr-Beta	60	4	2.6E+00 (31/36) (1.6E+00 - 4.5E+00)	Q9-1, 8.5 mi NW Steelton Water Company	3.1E+00 (6/12) (2.0E+00 - 4.5E+00)	2.7E+00 (16/24) (2.0E+00 - 4.5E+00)	0
	H-3	60	2000	1.1E+02 (1/36)	Q9-1, 8.5 mi NW Steelton Water Company	1.2E+02 (3/12) (9.5E+01 - 1.4E+02)	1.2E+02 (3/24) (9.5E+01 - 1.4E+02)	0
	I-131	87	1	ND	---	---	ND	0
	Sr-89	10	1	ND	---	---	ND	0
	Sr-90	10	2	ND	---	---	ND	0
	Gamma Spec.	60						
	Ba-140		60	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Drinking Water (pCi/L)	Co-58		15	ND	---	---	ND	0
	Co-60		15	ND	---	---	ND	0
	Cs-134		15	ND	---	---	ND	0
	Cs-137		18	ND	---	---	ND	0
	Fe-59		30	ND	---	---	ND	0
	K-40		50	ND	J15-2, 14.7 mi S York Water Company	1.5E+01 (1/12)	1.5E+01 (1/24)	0
	La-140		15	ND	---	---	ND	0
	Mn-54		15	ND	---	---	ND	0
	Nb-95		15	ND	---	---	ND	0
	Zn-65		30	ND	---	---	ND	0
	Zr-95		30	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Fruits (pCi/g, wet)	Gamma Spec.	16						
	Cs-134		0.06	ND	---	---	ND	0
	Cs-137		0.08	ND	---	---	ND	0
	I-131		0.06	ND	---	---	ND	0
	K-40		0.2	2.3E+00 (13/13) (1.8E+00 - 2.7E+00)	D1-3, 0.5 mi ENE Residence on Route 441	2.5E+00 (1/1)	2.5E+0 (3/3) (2.2E+0 - 2.7E+0)	0
Broad Leaf Vegetation (pCi/g, wet)	Sr-89	6	0.025	ND	---	---	ND	0
	Sr-90	6	0.01	6.0E-03 (3/5) (4.3E-03 - 7.1E-03)	J2-2, 1.5 m S South End Of TMI	7.1E-03 (1/1)	4.3E-3 (1/1)	0
	Gamma Spec.	6						
	Cs-134		0.06	ND	---	---	ND	0
	Cs-137		0.08	ND	---	---	ND	0
	I-131		0.06	ND	---	---	Ni	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(5) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Broad Leaf Vegetation (pCi/g, wet)	K-40		0.2	2.0E+00 (5/5) (1.7E+00 - 2.4E+00)	F1-1, 0.5 mi ESE 500 kV Substation	2.4E+00 (1/1)	2.1E+00 (1/1)	0
Vegetables (pCi/g, wet)	Gamma Spec.	10						
	Be-7		0.1	6.7E-01 (1/8)	J2-2, 1.5 mi S South End of TMI	6.7E-01 (1/2)	ND	0
	Cs-134		0.06	ND	---	---	ND	0
	Cs-137		0.08	ND	---	---	ND	0
	I-131		0.06	ND	---	---	ND	0
	K-40		0.2	3.9E+00 (8/8) (3.4E+00 - 4.5E+00)	F1-1, 0.5 mi ESE 500 kV Substation	4.3E+00 (2/2) (4.3E+00 - 4.4E+00)	4.1E+00 (2/2) (4.1E+00 - 4.2E+00)	0
Milk (cow) (pCi/L)	I-131	162	1	ND	---	---	ND	0
	Sr-89	25	5	ND	---	---	ND	0
	Sr-90	25	2	1.2E+00 (6/21) (6.5E-01 - 1.9E+00)	P7-1, 6.7 mi WNW Dairy Farm	1.9E+00 (1/4)	8.5E-01 (1/4)	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Milk (cow) (pCi/L)	Gamma Spec.	162						
	Ba-140		60	ND	---	---	ND	0
	Cs-134		15	ND	---	---	ND	0
	Cs-137		18	ND	---	---	ND	0
	K-40		50	1.4E+03 (136/136) (1.2E+03 - 1.6E+03)	P7-1, 6.7 mi WNW Dairy Farm	1.5E+03 (26/26) (1.3E+03 - 1.6E+03)	1.4E+03 (26/26) (1.2E+03 - 1.6E+03)	0
	La-140		15	ND	---	---	ND	0
	Ra-226		80	1.4E+02 (1/136)	F4-1, 3.2 mi ESE Dairy Farm	1.4E+02 (1/26)	ND	0
Surface Water (pCi/L)	Gr-Beta	12	4	(10)	P1-3, 0.1 mi WNW Station Intake (Unit 1), TMI	2.9E+00 (10/12) (1.5E+00 - 4.3E+00)	2.9E+00 (10/12) (1.5E+00 - 4.3E+00)	0
	H-3	48	2000	1.2E+03 (6/12) (1.0E+02 - 4.1E+03)	J1-2, 0.5 mi S West Shore of TMI	1.2E+03 (6/12) (1.0E+02 - 4.1E+03)	ND	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Surface Water (pCi/L)	I-131	87	1	ND	P1-3, 0.1 mi WNW Station Intake (Unit 1), TMI	8.9E-01 (5/29) (4.8E-01 - 2.0E+00)	7.6E-01 (14/87) (3.3E-01 - 2.0E+00)	0
	Sr-89	8	1	ND	---	---	ND	0
	Sr-90	8	2	ND	---	---	ND	0
	Gamma Spec.	48						
	Ba-140		60	ND	---	---	ND	0
	Co-58		15	ND	---	---	ND	0
	Co-60		15	ND	---	---	ND	0
	Cs-134		15	ND	---	---	ND	0
	Cs-137		18	ND	---	---	ND	0
	Fe-59		30	ND	---	---	ND	0
	La-140		15	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 3

Summary of Radionuclide Concentrations in 1996 Environmental Samples from Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed(2)	Lower Limit of Detection LLD(3)	Indicator Locations Mean (F)(4) (Range)	Location with Highest Mean(9) Station Name Distance, Direction, and Description(6)	Mean (F)(4) (Range)	Control Locations Mean (F)(4) (Range)	Number of Reportable Results(7)
Surface Water (pCi/L)	Mn-54		15	ND	---	---	ND	0
	Nb-95		15	ND	---	---	ND	0
	Zn-65		30	ND	---	---	ND	0
	Zr-95		30	ND	---	---	ND	0
Direct Radiation TLD (mR/std month)	Gamma	2113(5)		4.1E+00 (1850/1850) (3.0E+00 - 6.9E+00)	H8-1, 7.4 mi SSE Saginaw Road Starview	6.7E+00 (24/24) (6.4E+00 - 6.9E+00)	4.6E+00 (263/263) (3.2E+00 - 6.6E+00)	0

Notes:

(1) This table represents results from the primary (base) program. It does not include Quality Control (QC) results. The results listed are expressed in exponential form (i.e., 1.2E-2 = .012). Results from recounts supersede original results; reanalysis results supersede both original and/or recount results.

(2) The total number of analyses does not include duplicate analyses, recounts, or reanalyses.

(3) The ODCM LLD is given when applicable. It should be noted that, in some cases, the TMINS REMP achieves LLDs which are lower than those required by the ODCM.

(4) (F) is the ratio of positive results to the number of samples analyzed. Means and ranges are based on detectable activities only.

(5) The total number of samples or elements (TLDs) used for data analysis.

(6) All distances are measured from a point that is midway between the TMI-1 and TMI-2 reactor buildings.

(7) USNRC reporting levels as specified in the ODCM.

(8) ND= Not Detected. All net sample concentrations were equal to or less than the minimum detectable concentrations (MDC).

(9) The location with the highest mean was determined using more than two significant figures.

(10) Analysis not performed.

(11) Sample results from TMINS liquid discharge point (Station K1-1) were used as a check for the inplant effluent sampling program and therefore were not included in this table.

Note: See footnotes at end of table.

DIRECT RADIATION MONITORING

Radiation is a normal component of the environment resulting primarily from natural sources, such as cosmic radiation and naturally-occurring radionuclides, and to a lesser extent from manmade sources, such as fallout from prior nuclear weapon tests. The cessation of atmospheric nuclear weapon tests and the decay of fallout products have resulted in a gradual decrease in environmental radiation levels. Direct radiation monitoring measures ionizing radiation primarily from cosmic and terrestrial sources.

Gamma radiation exposure rates near TMINS were measured using thermoluminescent dosimeters (TLDs) and a real-time gamma radiation monitoring system. TLD stations were arranged in roughly concentric rings around TMINS, generally with one station in each of the 16 compass sectors, at the site boundary; 1 mile; 2 miles; 5 miles; 8 miles; and 10 miles from the site. Those TLD stations more than 10 miles from the site were control stations, while those less than 10 miles from the site were indicator stations. Indicator stations were located to detect any potential effect of TMINS operations on environmental radiation levels. The TLD network was supplemented by 16 real-time gamma radiation monitors located on and

around the site. The TLDs were processed each calendar quarter, while the real-time gamma radiation monitors provided continuous 15 minute averages throughout the year.

All gamma radiation exposure rates recorded during 1996 were within normal ranges and were consistent with previous results.

For 1996, several changes were made to the environmental TLD program. Twelve stations were eliminated, and 8 stations were moved to improve access or reduce security concerns. Details of the station changes appear in Appendix C and the quarterly environmental TLD report for the first quarter of 1996. Also, Panasonic model 814 TLD badges replaced model 801 badges at all stations. Model 814 badges provide 3 calcium sulfate elements per badge versus 2 calcium sulfate elements for 801 badges. Calcium sulfate elements are more appropriate for routine environmental TLD monitoring. With more calcium sulfate elements per badge, the total number of badges per TLD station was reduced from 4 model 801 badges to 2 model 814 badges. None of these changes are expected to affect significantly the quality of the program or the exposure results.

No relationship between TMINS operations and offsite exposure rates was detected at any station. The 1996 quarterly exposure rates for the individual TLD stations and a map showing onsite TLD station locations are contained in Appendix M.

Sample Collection and Analysis

A thermoluminescent dosimeter (TLD) is composed of a crystal (phosphor) which absorbs and stores energy in traps when exposed to ionizing radiation. These traps are so stable that they do not decay appreciably over time. When heated, the crystal emits light proportional to the amount of radiation received, and the light is measured to determine the integrated exposure. This process is referred to as thermoluminescence. The reading process 'rezeros' (anneals) the TLD and prepares it for reuse. The TLDs in use for environmental monitoring at TMINS are capable of accurately measuring exposures between 1 mR (well below normal environmental exposures for the quarterly monitoring periods) and 200 R.

Each TLD station consists of 2 TLD badges, each of which has 4 phosphors or elements. Since each TLD responds to radiation independently, this provides 8 independent detectors at each station. In addition, 10 stations have a vendor-supplied quality control TLD badge which has 4 independent detectors, for a total of 12 detectors at each station. The quality control badges are used as an independent check on the accuracy of the GPU Nuclear TLD results.

Of the 4 elements in GPU Nuclear's TLDs, 3 are composed of calcium sulfate and 1 is composed of lithium borate. The calcium sulfate elements are shielded with a thin layer of lead making the response to different energies of gamma radiation more linear. The lead also shields the elements from beta radiation, making them sensitive to gamma radiation only. The lithium borate element is shielded differently to permit the detection of beta radiation as well as gamma. The combination of different phosphor materials, shielding, and multiple phosphors per badge permit quantification of both gamma and beta radiation. Only the calcium sulfate phosphors are used for environmental monitoring; however, the lithium borate elements can be

used to evaluate beta exposures or as a backup to the calcium sulfate elements should more data be required.

Data from the TLDs were evaluated by obtaining the average of the usable element results at each station, and comparing the result to historical averages and ranges for the period of TMINS shutdown between the first quarter of 1980 and the third quarter of 1985. The averages and overall trends of the indicator and control stations were also compared with each other and with averages and trends obtained for the five year shutdown period.

All TLD exposure rate data presented in this report were normalized to a standard month (std month) to adjust for variable field exposure periods. A std month is 30.4 days. Several badges were used to quantify transit exposure during storage and handling of TLDs. Transit exposures were subtracted from gross field exposures to produce net field exposures.

The real-time gamma radiation monitors (Reuter-Stokes) are positioned around TMINS, one in each of the 16 compass sectors. They are located 0.1 to 3.5 miles from TMINS. The detectors are sensitive to gamma radiation only, and can detect exposure rates from 1 microroentgen per hour (μR/h) to 100 mR/h. At each station, exposure rate information is displayed continuously and recorded in a data logger. A microprocessor at each monitoring location collects and stores 15 minute averages from the detector. These 15 minute averages are then automatically collected every 4 hours (or more frequently if required) by a computer located in Harrisburg.

Since this is a real-time system, short-term variations in exposure rates can be measured. The system involves the use of sensitive and complex electronics, and data are occasionally lost or inaccurate due to electronic, electrical, or mechanical failures in system components. The real-time gamma monitoring system is used to supplement and backup the TLD monitoring program.

Results

In 1996, the average annual exposure rate for offsite indicator stations, which excludes stations located on the TMINS site boundary fence, was 4.3 ± 1.3 mR/std month. Quarterly exposure rates at offsite indicator stations ranged from 3.0 to 6.9 mR/std month. The average annual exposure rate for all control stations, those stations farther than 10 miles from TMINS, was 4.6 ± 1.5 mR/std month. Quarterly exposure rates at control stations ranged from 3.2 to 6.6 mR/std month.

The 1996 exposure data are consistent with previous results, as average exposures at control stations typically have been slightly higher than average exposures at offsite indicator stations. This is a result of variation in the natural radioactive characteristics of rock and soil near the stations. The historical average exposure rate (for the period from 1980 to 1985, when TMINS did not operate) was 5.2 mR/std month for indicator stations and 5.7 mR/std month for control stations. Exposure rates at both indicator and control stations have been decreasing gradually due to the cessation of atmospheric nuclear weapon testing and the decay of fallout products. Some indicator stations located on the site boundary fence can show elevated exposure rates, especially in Sectors E, F, and G. Stations in these sectors are located close enough to radioactive material transit and storage areas to be affected to some degree. In 1996, the average annual exposure rate for all

indicator stations, including those stations located on the TMINS site boundary fence, was 4.1 ± 1.3 mR/std month. Quarterly average exposure rates ranged from 3.0 to 6.9 mR/std month.

Some onsite stations in Sections E, F, and G did show slightly elevated exposure rates for some of 1996, but average onsite exposure rates still were lower than is typical for offsite stations. This is consistent with previous results and is a function of the differing characteristics of the land surface and geology in the immediate vicinity of the TLD stations. Many onsite stations are located on or above manmade surfaces or structures, which may shield the TLDs from terrestrial sources of radiation.

Exposure rates at stations on the site boundary fence vary with the movement of onsite radioactive materials, and with the number and placement of stations on the fence. Occasionally, stations on the fence may be moved or added to ensure comprehensive coverage of some areas. For these reasons, year-to-year comparisons between stations on the site boundary fence and other indicator or control stations usually are not appropriate.

In 1996, the highest annual average exposure rate of 6.7 mR/std month was measured at indicator Station H8-1. This annual average exposure rate of 6.7 mR/std month is typical for Station H8-1, and is lower than the historical (1980-1985) exposure rate of 7.9 ± 1.4 mR/std month for Station H8-1.

Comparisons of exposure rates by distance ring and radial sector also were performed to test for potential effects of TMINS operations. Any effect of TMINS operations on offsite exposure rates should be evidenced by an increase in the ring averages closer to TMINS, or in the sector averages in predominant wind directions. For the 1996 data, ring or sector differences were not evident when compared to historical data.

A trend of declining average exposure rates observed at both indicator and control stations that began in the fourth quarter of 1995 continued through the third quarter of 1996. The average exposure rate observed at offsite indicator stations for the first, second, and third quarters of 1996 was 4.35, 4.17, and 4.11 mR/std month, respectively. The average exposure rate observed at control stations showed a similar trend for those three quarters. For the fourth quarter of 1996, the average exposure rate at offsite indicator stations was 4.43 mR/std month.

Quarterly comparisons of the results from the 10 TLD stations which are populated by both GPU Nuclear and quality control badges showed comparable results between the two methods. Average GPU Nuclear exposure rates at the 10 substations were 4.39, 4.11, 4.08, and 4.41 mR/std month for the first through fourth quarters of 1996, respectively. Average quality control exposure rates were 3.96, 4.33, 4.84 and 4.74 mR/std month, respectively, for the same periods. Hence, although the results are comparable, the results did not follow the same trend. Differences of these magnitudes are reasonable considering the low exposure rates involved.

Figure 7 is a plot of gamma exposure rates (as measured by TLDs) in the vicinity of TMINS from 1974 through 1996. Based on Figure 7, the trends in exposure rates at indicator stations were similar to those of control stations with the exception of 1979. As a result of the TMI-2 accident, a transitory

TABLE 4

1996 Monthly Average Exposure Rates for Offsite Real-Time Gamma Radiation Monitoring Stations

Month	mR/std Month
January	4.8
February	5.3
March	5.6
April	5.5
May	5.5
June	5.5
July	5.5
August	5.5
September	5.6
October	5.6
November	5.6
December	5.6

increase in exposure rates from the release of noble gases was observed. Increases also were observed in both indicator and control stations in 1976, 1977, and 1978 as a result of nuclear weapon tests.

In 1996, the real-time gamma radiation monitoring system recorded an average exposure rate at offsite locations of 5.5 mR/std month, which is consistent with the 1995 offsite average of 5.5 mR/std month, but higher than the corresponding offsite TLD averages for 1996. Some difference between these two sets of results is expected primarily because TLDs and the real-time monitors measure gamma radiation at different locations. Table 4 shows the monthly average exposure rates recorded by offsite real-time gamma radiation monitors.

For both TLDs and the real-time monitoring system, no elevated exposure rates as a result of TMINS operations were observed at any offsite station. Both TLDs and the real-time monitoring system are sensitive and accurate mechanisms for measuring the low exposure rates characteristic of environmental levels. Effects of normal TMINS operations, however, are too small to be discernible outside the normal range of background radiation levels.

The annual average gamma radiation exposure rates recorded at all offsite indicator TLD and real-time monitoring stations ranged from 4.6 mR/std month to 5.5 mR/std month, respectively. These equate to annual exposure rates of between 55 mR/yr and 66 mR/yr. Exposures of these magnitudes are consistent with the annual average radiation dose a person receives from cosmic and terrestrial sources (**Table 1, "Sources and Doses of Radiation"**).

Historical Gamma Exposure Rates

mR per Standard Month by Quarter

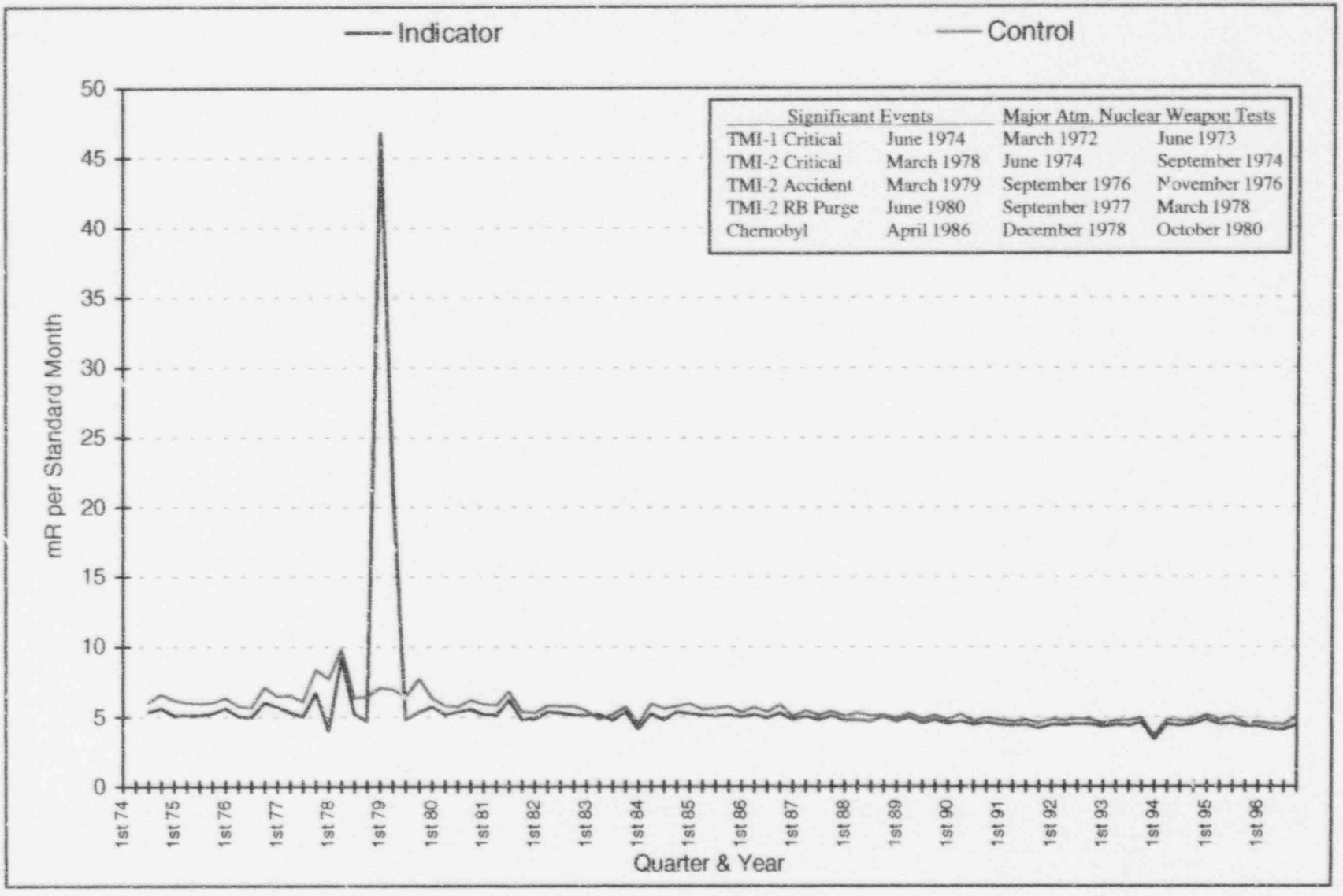


Figure 7

ATMOSPHERIC MONITORING

A potential exposure pathway to humans is inhalation of airborne radioactive materials. To monitor this exposure pathway, ambient air was sampled by a network of continuously operating samplers and then analyzed for radioactivity content. Based on the analytical results, no contribution to the general levels of airborne radioactivity was attributed to TMINS operations during 1996.

The indicator air sampling stations were located primarily in the prevailing downwind directions to the east (TMINS Visitors Center, Station E1-2), the east-southeast (500 kV Substation, Station F1-3), the southeast (dairy farm near Falmouth, Station G2-1), and the south- southeast (Falmouth, Station H3-1) of TMINS and in the nearby communities of Goldsboro (Station M2-1) and Middletown (Station A3-1). There also were indicator air sampling sites to the north-northeast (TMINS North Gate, Station B1-4), the south (Cly, Station J3-2) and the northwest (Harrisburg International Airport, Station Q4-1). The control air sampling stations, which were located greater than 9.5 miles from the site, provided background airborne radioactivity data for comparison. These stations were located in the distant communities

of Marietta (Station G10-1), York(Station J15-1) and West Fairview (Station Q15-1).

Sample Collection and Analysis

Mechanical air samplers were used to continuously draw air through glass fiber filters and charcoal cartridges. To maintain a constant flow rate throughout the collection period, each sampler was equipped with an electronic mass flow controller. This device automatically adjusted the flow rate to compensate for dust loading and changes in atmospheric pressure and temperature. Total air volumes were measured and recorded with dry gas meters. Air volumes were then adjusted based on vacuum readings over the collection period. All air samplers were calibrated semiannually and maintained by instrumentation technicians.

The glass fiber filters were used to collect airborne particulate matter. The filters were collected weekly and analyzed for gross beta radioactivity. Six of these filters also were analyzed weekly for gross alpha radioactivity. The filters were then combined quarterly by individual station locations and analyzed for gamma-emitting radionuclides. Semiannually, the quarterly composites for each station were combined and analyzed for Sr-89 and Sr-90.

Cartridges containing activated charcoal were used for monitoring gaseous radioiodines. These cartridges were placed downstream of the particulate filter at each of the air sampling stations. Charcoal cartridges were collected weekly and analyzed separately from the particulate filters for I-131.

Air Results

During 1996, more than 600 air particulate samples (filters) were collected and analyzed for gross beta radioactivity. The particulate matter (dust particles) collected weekly on all indicator and control filters contained gross beta radioactivity above the minimum detectable concentration (MDC). Due to sampler problems, four samples collected from Station J15-1 had collection periods of 2 days or less, and consequently, low air volumes. This resulted in gross beta concentrations with higher than normal counting uncertainties and gross beta concentrations which were inconsistent with those reported for the other samples collected during the same week. To eliminate biases in the data, the subject sample results were not used in the calculations and graphs.

The gross beta concentrations measured on the filters collected from indicator sites ranged from 0.0062 ± 0.0028 pCi/m^3 to 0.034 ± 0.004 pCi/m^3 and averaged 0.016 ± 0.009 pCi/m^3. The air particulate samples collected from the control locations had gross beta concentrations which ranged from 0.0078 ± 0.0024 pCi/m^3 to 0.031 ± 0.004 pCi/m^3 and averaged 0.017 ± 0.009 pCi/m^3. The 1996 annual average gross beta concentrations were consistent with the 1995 averages of 0.016 ± 0.009 pCi/m^3 for both indicators and controls.

The air sampling location with the highest annual average gross beta concentration (based on more than two significant figures) was control Station J15-1 (York). The average gross beta concentration for airborne particulates collected at this station was 0.017 ± 0.009 pCi/m^3. This average concentration was well below the preoperational average concentration of 0.15 ± 0.16 pCi/m^3 and, as

shown on Table 5, was similar to the annual average gross beta concentrations calculated for particulate samples collected at the other air sampling sites.

As depicted in Figure 8, average weekly gross beta concentrations at indicator and control air monitoring locations were analogous and trended similarly throughout the monitoring period. The weekly gross beta concentrations and trends at individual air sampling sites also were similar. The 1996 data indicated that gross beta radioactivity levels did not change as a result of TMINS operations. Additionally, the gross beta radioactivity associated with airborne particulates was due to naturally-occurring radionuclides.

Historical trends of average quarterly gross beta concentrations associated with airborne particulates from 1972 to 1996 are depicted in Figure 9. Generally, the gross beta concentrations have decreased with time. The 1996 average gross beta concentration of 0.016 pCi/m^3 is approximately 10% of the 1974 preoperational average concentration (0.15 pCi/m^3). The overall diminution in gross beta concentrations is a direct result of the ban on atmospheric nuclear weapon tests and the radioactive decay of fallout products from previous detonations. Elevated concentrations at both indicator and control air monitoring stations were noted after each major nuclear weapon test, the TMI-2 accident, and the Chernobyl accident. The trends for indicator and control stations were similar for the entire TMINS operational period.

The particulate filters collected weekly from six air sampling sites (Stations B1-4, H3-1, M2-1, Q4-1, J15-1 and Q15-1) also were analyzed for gross alpha radioactivity. During 1996, the particulate matter on approximately 75% of the filters (231 of 310) contained gross alpha radioactivity above the MDC. The four 1-2 day samples discussed in the gross beta results section also yielded alpha concentrations which had large counting uncertainties and concentrations that were inconsistent with other results reported for the weekly collection period. Like the gross beta results, the subject gross alpha results were not used to eliminate biases in the data.

Air particulate gross alpha concentrations (detected above the MDC) at indicator stations ranged from 0.00068 ± 0.00045 pCi/m^3 to 0.0023 ± 0.0009 pCi/m^3 and averaged 0.0013 ± 0.0007 pCi/m^3. Control samples averaged 0.0014 ± 0.0010 pCi/m^3 and ranged from 0.00072 ± 0.00057 pCi/m^3 to 0.0025 ± 0.0011 pCi/m^3. For comparison, indicators and controls both averaged 0.0014 ± 0.0008 pCi/m^3 in 1995.

The air sampling location with the highest annual average gross alpha concentration (based on more than two significant figures) was control Station Q15-1 (West Fairview). The 1996 average gross alpha concentration for particulate samples collected at this site was 0.0014 ± 0.0009 pCi/m^3. As shown on Table 6, similar annual average gross alpha concentrations were calculated for the other five air particulate sampling sites.

Average weekly gross alpha concentrations are depicted in Figure 10. Actual concentrations (whether positive, negative or zero) were used to calculate weekly averages because approximately 25% of the weekly results were below the MDC. Using actual concentrations eliminates biases in the data and missing data points on graphs. As depicted in Figure 10, average weekly gross

alpha concentrations at indicator and control stations remained relatively constant throughout the monitoring period. Generally, the trends of average weekly gross alpha concentrations at indicator and control sites were similar.

The data obtained in 1996 indicated that gross alpha radioactivity levels did not change as a result of TMINS operations. Also, the gross alpha radioactivity measured on the particulate filters was due to naturally-occurring radionuclides.

Historical trends of average quarterly gross alpha concentrations from 1972 through 1996 are displayed in Figure 11. Gross alpha concentrations during the preoperational period (1972-1974) averaged 0.001 pCi/m^3 with maximum concentrations up to 0.006 pCi/m^3. Although some of the operational concentrations were slightly higher than the preoperational average concentration, control sample concentrations were comparable to indicator sample concentrations. The overall trends for gross alpha concentrations in air particulates at indicator and control stations were similar throughout the TMINS operational period.

Gamma-emitting radionuclides related to TMINS operations were not detected on any of the quarterly composites (of weekly samples) that were analyzed in 1996. As expected, all of the quarterly composite samples contained naturally-occurring beryllium-7 (Be-7). Concentrations detected on indicator samples were similar to those detected on control filters. Also, naturally-occurring K-40 was detected on two quality control samples.

Semiannual strontium analyses were performed on a total of 26 air particulate composite samples (including QC filters) during 1996. Neither Sr-89 nor Sr-90 was detected above the MDC.

During 1996, more than 600 charcoal cartridges were collected weekly and analyzed for I-131. None of the weekly samples contained I-131 (or any other isotope of iodine) above the MDC.

TABLE 5

1996 Average Gross Beta Concentrations in Airborne Particulates (pCi/m^3)

Station	Description	Average +/- 2 std dev*
A3-1(I)	Middletown	0.017 ± 0.009
B1-4(I)	TMINS North Gate	0.016 ± 0.009
E1-2(I)	TMINS Visitors Center	0.016 ± 0.009
F1-3 (I)	500 kV Substation	0.016 ± 0.009
G2-1(I)	Dairy Farm (Near Falmouth)	0.015 ± 0.009
H3-1(I)	Falmouth	0.017 ± 0.008
J3-2(I)	Cly	0.016 ± 0.008
M2-1(I)	Goldsboro	0.016 ± 0.008
Q4-1(I)	Hbg. International Airport	0.017 ± 0.008
G10-1(C)	Dairy Farm (Marietta)	0.016 ± 0.008
J15-1(C)	York	0.017 ± 0.009
Q15-1(C)	West Fairview	0.017 ± 0.009

* Averages and standard deviations are based on concentrations > MDC.

(I) = Indicator Station (C) = Control Station

TABLE 6

1996 Average Gross Alpha Concentrations in Airborne Particulates (pCi/m^3)

Station	Description	Average +/- 2 std dev*
B1-4(I)	TMINS North Gate	0.0012 ± 0.0006
H3-1(I)	Falmouth	0.0012 ± 0.0007
M2-1(I)	Goldsboro	0.0013 ± 0.0008
Q4-1(I)	Hbg. International Airport	0.0014 ± 0.0008
J15-1(C)	York	0.0013 ± 0.0008
Q15-1(C)	West Fairview	0.0014 ± 0.0009

* Averages and standard deviations are based on concentrations > MDC.

(I) = Indicator Station (C) = Control Station

1996 Gross Beta Concentrations in Air Particulates

Picocuries per Cubic Meter by Week

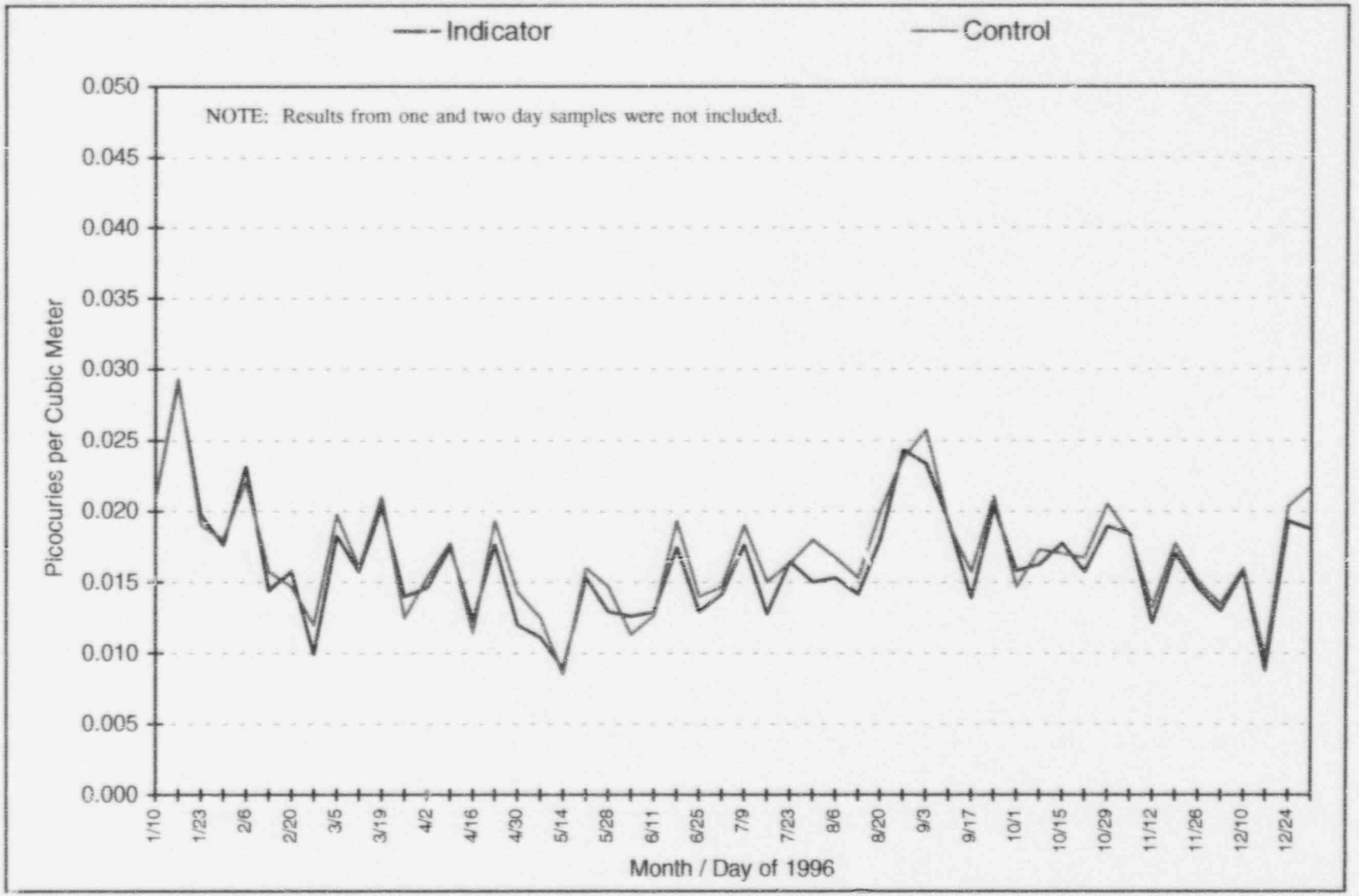


Figure 8

Historical Gross Beta Concentrations in Air Particulates

Picocuries per Cubic Meter by Quarter

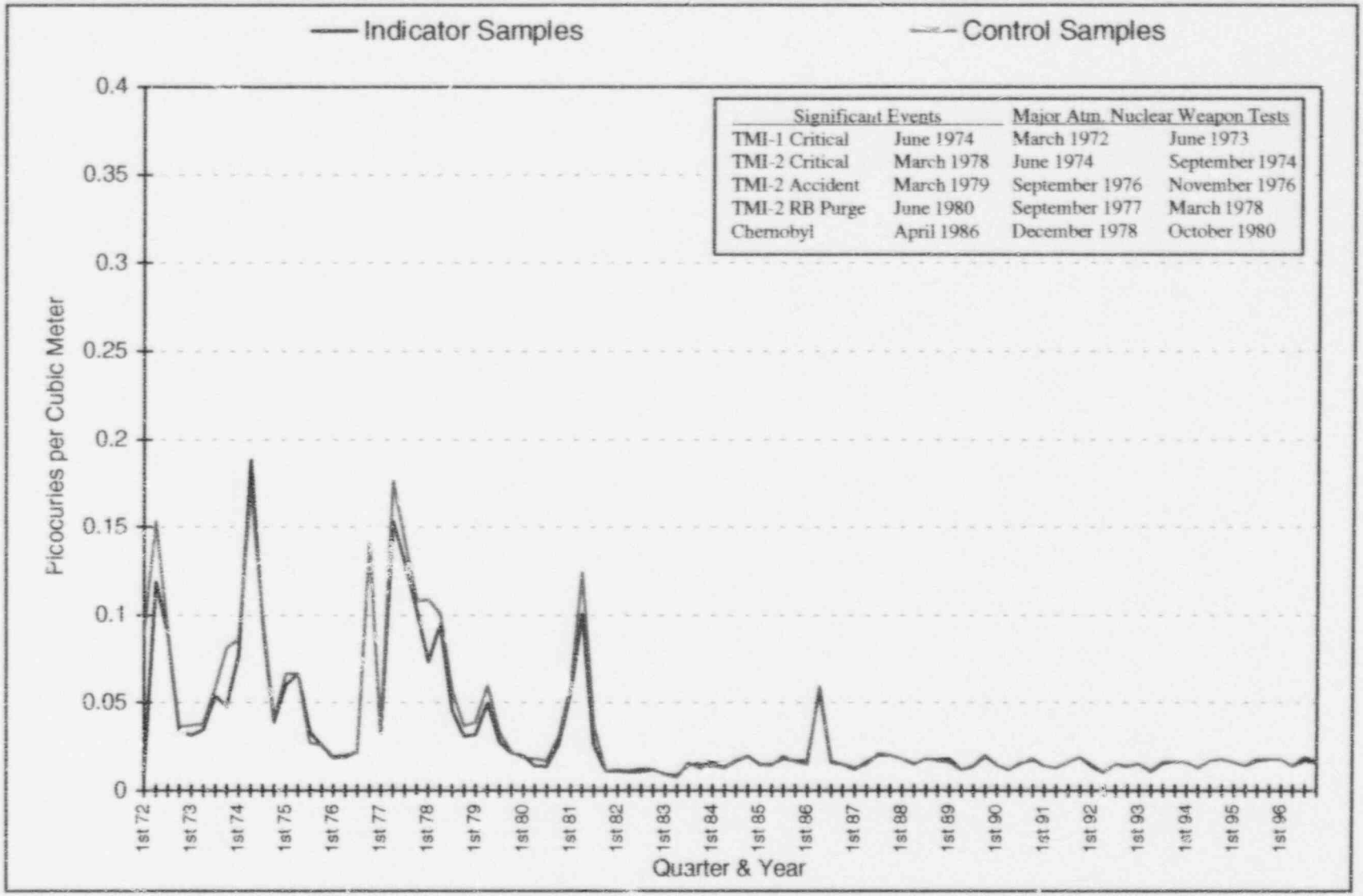


Figure 9

1996 Gross Alpha Concentrations in Air Particulates

Picocuries per Cubic Meter by Week

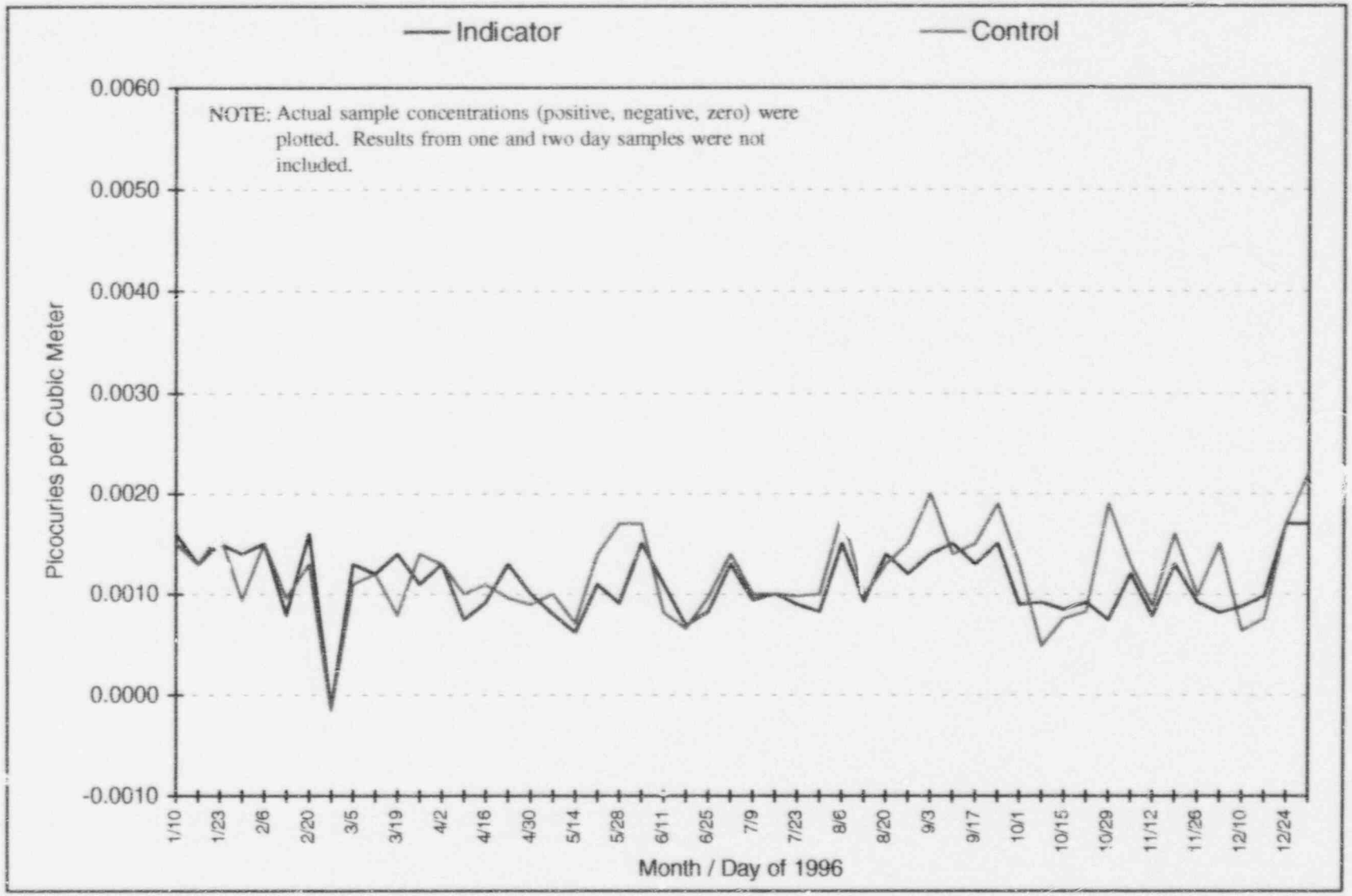


Figure 10

Historical Gross Alpha Concentrations in Air Particulates

Picocuries per Cubic Meter by Quarter

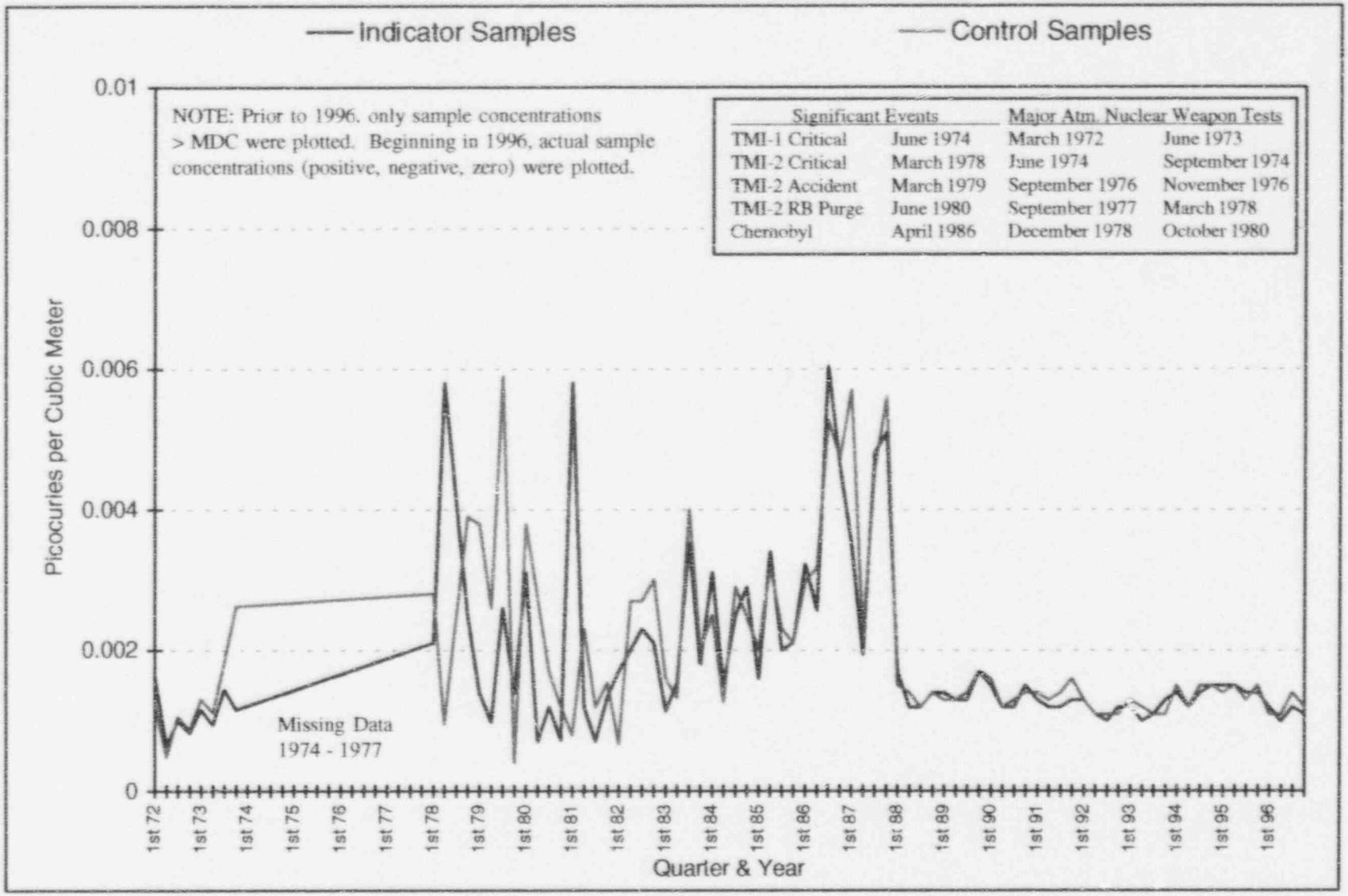


Figure 11

AQUATIC MONITORING

Since radioactive materials are released to the Susquehanna River from routine operations at TMINS and this watershed is used as a source for drinking water and recreational activities, the aquatic environment is monitored extensively for radionuclides of potential TMINS origin. Recreational activities in the TMI reach of the Susquehanna River include fishing, boating, swimming and other water sports.

Monitoring of the aquatic environment in the vicinity of TMINS was accomplished by collecting and analyzing samples of surface water, drinking water, finfish and river sediments. The indicator (downstream) sampling sites were chosen based on studies of travel time and mixing characteristics for the Susquehanna River. Control samples were collected from locations which were not expected to be affected by TMINS operations. The impact of TMINS operations was assessed by comparing control sample concentrations to those measured in indicator samples. As applicable, comparisons with results from previous years also were performed.

During 1996, samples from the aquatic environment were found to contain low concentrations of radioactive materials attributable to routine TMINS operations. They included H-3 in fish, surface water and possibly drinking water and Co-60, Cs-134 and Cs-137 in sediments. The concentrations found in these samples, however, were too low to adversely impact humans or the environment. Radionuclides attributable to medical facilities and their patients, natural production in the atmosphere and fallout from prior nuclear weapon tests also were identified in various aquatic media.

Sample Collection and Analysis

Surface (raw/unfinished) and drinking (finished) water samples were collected at nine stations (four indicators and five controls) and analyzed during 1996. Indicator samples were collected from locations along the Susquehanna River which were downstream of the TMINS liquid discharge outfall. Indicator surface water samples were collected at one location, Station J1-2 (west shore of TMI). Indicator drinking water samples were collected at three water treatment facilities: Station G15-1 (Columbia Water Company, Columbia, PA), Station G15-2 (Wrightsville Water Supply, Wrightsville, PA) and Station G15-3 (Lancaster Water Authority, Columbia, PA).

Control samples were collected from the Susquehanna River upstream of the TMINS liquid discharge outfall or from its tributaries. Control surface water samples were collected from three locations: Station A3-2 (Swatara Creek, Middletown, PA), Station F15-1 (Chickies Creek, Marietta, PA) and Station P1-3 (TMI-1 Pretreatment Building). Control drinking water samples were obtained at two water treatment facilities: Station J15-2 (York Water Company, York, PA) and Station Q9-1 (Steelton Water Authority, Steelton, PA).

Samples of the TMINS liquid discharge (Station K1-1) also were collected and analyzed. The liquid discharge samples were collected from a location where the water was not yet mixed with the Susquehanna River. As appropriate, data from the liquid discharge samples were compared with data obtained from samples collected as part of the TMINS Effluent Monitoring Program.

All water samples except those collected at Station F15-1 (Chickies Creek), were normally obtained by an automatic water compositor. Samples from Chickies Creek (Station F15-1) were collected as grabs twice per week. Grab samples also were collected when the compositors were not operating (e.g. AC power loss or sampler malfunction). The water compositors collected a measured volume of water at a preset interval of time (30 or 60 minutes). These samplers were maintained and calibrated by instrumentation technicians.

The composite samples normally were retrieved biweekly (every two weeks). To verify that the samplers were operating properly, a surveillance was performed weekly. Occasionally, composite samples were retrieved weekly to close out a calendar

month or quarter. The grab samples collected from Chickies Creek (Station F15-1) were composited into weekly or biweekly samples.

The weekly and biweekly composite samples from indicator Stations G15-3 and G15-2 along with those collected from control Stations Q9-1, F15-1, A3-2 and P1-3 were analyzed for low-level I-131 using a chemical separation/concentration technique. Samples of the TMINS liquid discharge also were analyzed for low-level I-131 employing the same technique.

All water samples retrieved weekly and biweekly were combined by station into monthly composites and analyzed for H-3 and gamma-emitting radionuclides, including I-131. Monthly gross beta analyses also were performed on all drinking water samples and the samples collected from Stations P1-3 and K1-1. Semiannual composite samples were prepared for each station from the monthly samples and then analyzed for Sr-89 and Sr-90.

In 1996, electroshocking equipment and hook and line were used to collect finfish samples in the Spring (May and June) and Fall (October). To monitor the progression of radionuclides through the food chain, bottom feeding finfish as well as predator species were collected. Indicator samples were collected from zones or areas immediately downstream of the TMINS liquid discharge outfall, while control specimens were gathered from locations greater than ten miles upstream of TMI. The edible portions were analyzed for Sr-89, Sr-90, H-3 and gamma-emitting radionuclides.

River sediments from four locations (three indicators and one control) were collected in the Spring (May) and Fall (November) of 1996. All sediment samples were collected using a dredge designed for this purpose. Indicator sediment samples were collected at a site just downstream of the TMINS liquid discharge outfall (Station K1-3), at the York Haven Dam, YHD, (Station J2-1) and at a site on the west shore of TMI, between the TMINS liquid outfall and the YHD (Station J1-2). The control samples were obtained from the Susquehanna River just upstream of TMI (Station A1-3). All sediment samples were dried and analyzed for gamma-emitting radionuclides. The samples collected in November also were analyzed for Sr-89 and Sr-90.

Water Results

Iodine-131 may be a constituent of TMI-1 liquid effluents. This radionuclide also is discharged to the Susquehanna River and its tributaries by medical facilities and their patients via the municipal sewage system. Institutions such as hospitals utilize this material for diagnostic studies of the thyroid and thyroid therapy. Iodine-131 from medical facilities and their patients is commonly detected in REMP samples because the methods used to treat sewage do not remove this material.

During 1996, I-131 above the mimimum detectable concentration (MDC) was detected in 14 control surface water samples. Iodine-131 above the MDC also was

identified in 5 samples collected from Station K1-1, the TMINS liquid discharge. None of the indicator surface or drinking water samples collected in 1996 contained I-131 above the MDC.

The I-131 concentrations measured in control surface water samples ranged from 0.33 ± 0.25 pCi/L to 2.0 ± 0.4 pCi/L and averaged 0.8 ± 1.1 pCi/L. For comparison, the average I-131 concentration for 1995 control surface water samples was 0.64 ± 0.91 pCi/L. The medical industry was responsible for the presence of I-131 in all 1996 control surface water samples.

During 1996, 5 of 29 TMINS liquid discharge samples (weekly or biweekly composites) contained I-131 above the MDC. The I-131 concentrations ranged from 0.53 ± 0.27 pCi/L to 1.7 ± 0.3 pCi/L and averaged 0.92 ± 0.91 pCi/L.

The presence of I-131 in the liquid discharge samples, like control surface water samples, was attributed to medical facilities and their patients. When detected in a liquid discharge sample, I-131 at a similar concentration also was detected in an upstream (control) sample(s) collected during the same or previous sampling period. The data obtained from the samples collected as part of the TMINS Effluent Monitoring Program also supported this conclusion.

Only one batch release in 1996 contained low level I-131 above the MDC. This batch, like all others, was diluted prior to release. For the collection period which included the batch release, I-131 was detected in the liquid discharge sample (1.7 ± 0.3 pCi/L) and two control samples. The control samples collected at Stations P1-3 and A3-2 contained I-131 at a concentration of 2.0 ± 0.3 pCi/L and 2.0 ± 0.4 pCi/L, respectively. The similarity of the control and discharge results indicated that medical facilities and their patients, and not TMINS, was the source of the I-131 detected in these samples.

Even though I-131 was detected in the liquid discharge samples, this material was not detected above the MDC in any of the indicator surface or drinking water samples collected during 1996. This was expected because indicator samples were obtained at locations where substantial mixing of liquid effluents with river water has occurred. Additionally, I-131 is effectively removed when water is processed for drinking.

In 1996, H-3 above the MDC was measured in 50% of the monthly indicator surface water samples. Tritium above the MDC was not identified in any of the monthly control surface water samples. Table 7 lists the annual average H-3 concentrations and for the samples collected at each surface water station. Also included in the table are the annual average concentrations based on actual sample concentrations, whether positive, negative or zero.

As expected, H-3, a component of TMINS liquid effluents, was detected in 6 of 12 monthly surface water samples collected at indicator Station J1-2. This station is located just downstream of the TMINS liquid discharge outfall where mixing of liquid effluents with river water is

incomplete. More complete mixing is not achieved until liquid effluents pass over the York Haven Dam.

The annual average H-3 concentration for the samples collected at Station J1-2 was 1200 ± 3200 pCi/L. The results ranged from 100 ± 60 pCi/L to 4100 ± 400 pCi/L. For comparison, H-3 was detected in all monthly samples collected at Station J1-2 in 1995. The concentrations ranged from 400 ± 80 pCi/L to 30000 ± 300 pCi/L and averaged 5000 ± 17000 pCi/L. The 1995 average and maximum concentrations were biased high by a grab sample taken during a release of high activity H-3.

Lower H-3 concentrations and fewer samples with concentrations greater than the MDC were realized in 1996. This was a direct result of releasing lower amounts of H-3 to the Susquehanna River. Approximately 170 Ci of H-3 were released in liquid effluents in 1996, whereas, more than 500 Ci were released in 1995.

Figure 12 depicts the 1996 monthly trends of H-3 concentrations in surface water samples collected at Station J1-2. Actual concentrations (whether positive, negative or zero) were plotted. For comparison, the actual monthly H-3 concentrations measured in the TMINS liquid discharge samples also are depicted in Figure 12. As shown by Figure 12, the H-3 concentrations found in the samples obtained from Station J1-2 were directly related to those detected in the TMINS liquid discharge samples (Station K1-1). Historical trends of H-3 concentrations in surface water are shown in Figure 13.

A dose estimate was not performed for H-3 in surface water because this medium normally is not consumed by humans. All of the H-3 concentrations measured in surface water during 1996 were, however, below the USEPA Primary Drinking Water Standard of 20,000 pCi/L.

In 1996, H-3 above the MDC was measured in only one indicator and three control drinking water samples. Table 7 lists the annual average H-3 concentrations for the samples collected at each drinking water station. Also included are the annual average concentrations based on actual sample concentrations, whether positive, negative or zero.

Tritium at concentrations greater than the MDC was measured in three samples collected from Control Station Q9-1 (Steelton Water Authority). The results ranged from 95 ± 58 pCi/L to 140 ± 60 pCi/L and averaged 120 ± 50 pCi/L. The concentrations measured in the 1996 control samples were consistent with those measured in previous years. The presence of H-3 in these samples was attributed to fallout from prior weapon tests and natural production of this material in the atmosphere.

Only one indicator drinking water sample collected in 1996 contained H-3 above the MDC. The indicator sample collected in March from Station G15-3 (Lancaster Water Authority) contained H-3 at a concentration of 110 ± 70 pCi/L. For comparison, H-3 above the MDC was measured in eight indicator drinking water samples collected in 1995. The 1995 concentrations ranged from 110 ± 70 pCi/L to 320 ± 90 pCi/L and

averaged 200 ± 160 pCi/L. The H-3 concentrations measured in indicator drinking water samples, like indicator surface water samples, were lower in 1996 and fewer samples contained H-3 above the MDC. This primarily was due to releasing lower amounts of H-3 in 1996.

Tritium was discharged in 1996 TMINS liquid effluents and it is possible that a small portion of the H-3 measured in the indicator drinking water sample may be related to TMINS operations. However, because 1) the indicator and control sample concentrations were similar and 2) very low amounts of H-3 were released in March liquid effluents, most, if not all, of the H-3 present in the indicator sample was due to fallout from prior nuclear weapon tests and natural production of this material in the atmosphere.

Figure 14 (upper) displays the average monthly H-3 concentrations measured in the 1996 indicator and control drinking water samples. Instead of only using concentrations above the MDC, actual concentrations (whether positive, negative or zero) were used for the graph. This method eliminated biases in the data and missing data points. For comparison, the actual H-3 concentrations obtained from samples collected monthly at Station K1-1 also were included in Figure 14 (lower).

Except for September results, the average monthly H-3 concentrations calculated for indicators were either consistent with or lower than those calculated for controls (Figure 14, upper). This indicated that the H-3 measured in both indicator and control drinking water samples was most likely due to fallout or natural production.

The average H-3 concentration for September indicator samples (68 pCi/L) was somewhat higher than the average concentration for September controls (-9.5 pCi/L). Tritium was routinely released in 1996 TMINS liquid effluents and it is possible that a portion of the H-3 detected in the September indicator drinking water samples was due to TMINS operations. This conclusion was supported by the liquid discharge sample data. As shown in Figure 14 (lower), the highest H-3 concentration was measured in the September liquid discharge sample. Additionally, the September concentration was at least 5 times higher than the next highest result.

To put this into perspective, the net average H-3 concentration (i.e. the difference between the September indicator average and the September control average) of approximately 78 pCi/L represented less than 0.4% of the Primary Drinking Water Standard. Furthermore, if an individual drank water at this concentration for an entire year, the whole body dose would be 0.0081 mrem. This calculated hypothetical whole body dose is equivalent to 0.0027% of the whole body dose that an individual living in the TMI area receives each year from natural background radiation (300 mrem).

The monthly composites of all drinking water, surface water from Station P1-3 (TMI-1 Pretreatment Building) and the TMINS liquid discharge samples from Station K1-1 were analyzed for gross beta

activity. Table 8 lists the annual average gross beta concentrations for drinking and surface water stations. Actual concentrations are included for comparison.

The indicator drinking water samples collected in 1996 had an annual average gross beta concentration of 2.6 ± 1.3 pCi/L while the average concentration for 1996 control drinking water samples was 2.7 ± 1.5 pCi/L. The 1996 averages were consistent with the 1995 averages of 2.8 ± 1.6 pCi/L and 2.6 ± 1.6 pCi/L for indicators and controls, respectively.

The monthly gross beta averages for indicator and control drinking water are plotted in Figure 15. Actual concentrations were used for this graph. Generally, indicator and control sample concentrations trended similarly throughout the year. Minor differences were evident, but expected.

The variability in the gross beta concentrations was directly related to the type of treatment and the overall contaminant removal efficiency of each water treatment facility. For example, suspended solids with adsorbed man-made or naturally-occurring radioactive materials are removed from raw river water by common treatment processes such as filtration and sedimentation. The amount removed by these processes will vary as a function of the individual system design and operation.

All of the drinking water results for 1996 were well below the Federal and State Primary Drinking Water Standard of 50 pCi/L for gross beta radioactivity. The results indicated that gross beta radioactivity detected in all drinking water samples was attributed to naturally-occurring radionuclides.

The 1996 average gross beta concentration for samples collected from Station P1-3 (TMI-1 Pretreatment Building) was similar to the average concentration calculated for samples collected from Station K1-1 (TMINS Liquid Discharge). The average gross beta concentrations were 2.9 ± 1.8 pCi/L and 4.5 ± 2.8 pCi/L, respectively. Similar average concentrations were calculated in 1995 for samples collected from Station P1-3 (3.8 ± 3.0 pCi/L) and Station K1-1 (5.3 ± 5.1 pCi/L). Like drinking water, all samples collected from Stations P1-3 and K1-1 had gross beta concentrations well below the Federal and State Primary Drinking Water Standard of 50 pCi/L.

Monthly composite samples of surface, drinking and effluent water were analyzed for the presence of gamma-emitting radionuclides. None of the samples collected in 1996 contained detectable levels of reactor-produced, gamma-emitting radionuclides. Naturally-occurring K-40 was measured in one control drinking water sample.

Semiannual composite samples were prepared from monthly composites and then analyzed for the presence of Sr-89 and Sr-90. During 1996, none of the surface or drinking water samples contained detectable levels of Sr-89 or Sr-90. Additionally, Sr-89 and Sr-90 were not detected in semiannual composite samples which were prepared

from the monthly TMINS liquid discharge samples.

Fish Results

In the Spring (May and June) and Fall (October) of 1996, fish samples were collected at indicator and control locations. They included recreationally important predators (Smallmouth bass and Largemouth bass) and bottom feeders (Yellow bullhead, White catfish and Channel catfish). All samples were analyzed for gamma-emitting radionuclides, Sr-89, Sr-90, and H-3.

As expected, naturally-occurring K-40 was detected in all fish samples. Cesium-137 was measured above the MDC in the Spring indicator predator sample at a concentration of 0.0069 ± 0.0052 pCi/g (wet). The result was consistent with the Cs-137 concentration detected in the 1994 control predator sample (0.0076 ± 0.0039 pCi/g, wet). The presence of Cs-137 in the 1996 indicator sample was most likely due to fallout from prior nuclear weapon tests. This conclusion was supported by two other facts. Very low amounts of Cs-137 were released in 1996 liquid effluents. Additionally, other radioactive materials released in 1996 TMI liquid effluents were not detected in the indicator samples.

Strontium-89 was not detected above the MDC in any of the 1996 fish samples. Strontium-90 was measured in one control sample at a concentration of 0.0039 ± 0.0024 pCi/g (wet). Its presence in the 1996 control sample was attributed to fallout from past nuclear weapon tests.

Tritium was detected in all indicator fish samples collected in the Spring and Fall. The H-3 concentrations ranged from 0.080 ± 0.046 pCi/g (wet) to 0.22 ± 0.05 pCi/g (wet) and averaged 0.14 ± 0.12 pCi/g (wet). Tritium above the MDC was not detected in the 1996 control samples.

Since H-3 was identified in indicator samples and not in the controls, a portion of the H-3 measured in the indicator samples was attributed to routine TMINS operations. A portion of the H-3 detected in these samples also was due to fallout and natural production in the atmosphere.

A conservative dose estimate was performed assuming that an individual consumed fish flesh with the highest H-3 concentration for one year. The maximum hypothetical whole body dose was 0.00049 mrem. This dose is equivalent to 0.00016% of the dose that an individual living in the TMI area receives each year from natural background radiation.

Sediment Results

In May and November of 1996, aquatic sediment samples were taken from the Susquehanna River upstream and downstream of the TMINS liquid discharge outfall. All samples were analyzed for gamma-emitting radionuclides. The samples collected in November also were analyzed for Sr-89 and Sr-90.

Strontium-89 and Sr-90 were not detected above the MDC in any of the 1996 sediment samples. The control sample was initially reported by the laboratory to contain Sr-90 above the MDC. A reanalysis was

performed and yielded a result below the MDC. The laboratory determined that the sample holder used in the original analysis was slightly contaminated.

Naturally-occurring Be-7, K-40, Ra-226, thorium-232 (Th-232) as well as fallout Cs-137 were identified in both indicator and control samples. Iodine-131 also was measured in the control sample collected in the Spring. Its presence was attributed to medical facilities and their patients. The samples collected from Indicator Station K1-3 also contained radionuclides associated with TMINS operations. They included Co-60, Cs-134 and Cs-137. All of these radionuclides are readily adsorbed by suspended and bottom sediments.

Annual average Cs-137 concentrations for indicator and control samples were 0.19 $\pm$ 0.13 pCi/g (dry) and 0.073 $\pm$ 0.030 pCi/g (dry), respectively. Indicator sample concentrations ranged from 0.13 $\pm$ 0.02 pCi/g (dry) to 0.29 $\pm$ 0.03 pCi/g (dry). Control sample concentrations were somewhat lower, ranging from 0.063 $\pm$ 0.025 pCi/g (dry) to 0.084 $\pm$ 0.024 pCi/g (dry). For comparison, 1995 average Cs-137 concentrations were 0.67 $\pm$ 0.83 pCi/g (dry) and 0.12 $\pm$ 0.10 pCi/g (dry), for indicators and controls, respectively.

Cesium-137 is a fallout product of weapons testing as well as a constituent of TMINS liquid effluents. Since the 1996 indicator sample concentrations were higher than those measured in the control samples and other reactor-related materials (e.g. Co-60 and Cs-134) also were present, an increment of the Cs-137 detected in the indicator samples was due to TMINS operations.

Figure 16 depicts Cs-137 concentrations in river sediments from 1984 through 1996. As shown in this figure, no discernible buildup of Cs-137 occurred at indicator locations prior to 1995. This was primarily due to periodic scouring or removal of bottom sediments during high river flows (Ref. 44). High river flows typically are caused by snow melts in the Spring and large amounts of rainfall.

Even though the amounts of Cs-137 and Cs-134 released in TMINS liquid effluents were similar to or below those released in 1993 and 1994, a buildup of Cs-137 and Cs-134 occurred in 1995 (Figure 16). Temporary, the buildup was caused by lower than normal river flows during the year and especially in the spring months when most scouring occurs.

As shown in Figure 16, the average Cs-137 concentrations in 1996 indicator samples trended downward. The reduction was due to releasing lower amounts of Cs-137 and having higher than average river flows which increase dilution of liquid effluents.

Additionally, a very high river flow occurred in January of 1996. This event significantly scoured bottom sediments in the York Haven Pond (YHP) and significantly reduced the amount of TMINS-related materials detected in indicator sediments. Sediments which are scoured from the YHP and then transported downstream, will be diluted or mixed with sediments not impacted by TMINS operations.

Cesium-134 was detected above the MDC in both samples collected at Indicator Station K1-3 during 1996. This radionuclide was not measured above the MDC in the other indicator or control samples. The presence of Cs-134 in the samples collected from Station K1-3 was attributed to TMINS operations.

The Cs-134 concentrations averaged 0.019 $\pm$ 0.004 pCi/g (dry) and ranged from 0.018 $\pm$ 0.011 pCi/g (dry) to 0.021 $\pm$ 0.010 pCi/g (dry). For comparison, the 1995 sample results averaged 0.14 $\pm$ 0.18 pCi/g (dry) and ranged from 0.059 $\pm$ 0.017 pCi/g (dry) to 0.33 $\pm$ 0.03 pCi/g (dry). Lower concentrations of Cs-134 in 1996 sediments resulted from smaller release amounts, high river flows and significant scouring of the river bottom.

The sample collected in May from Station K1-3 also contained Co-60, a radionuclide released in 1996 TMI-1 liquid effluents. The concentration measured in the 1996 sample (0.023 $\pm$ 0.010 pCi/g, dry) was similar to those detected in previous years. Like Cs-134 and a portion of Cs-137, its presence was attributed to TMINS operations.

Based on annual average concentrations of Co-60, Cs-134 and Cs-137 in samples collected from Station K1-3, an estimate of the shoreline total body dose to the maximally exposed individual was calculated. For this calculation, the annual average control concentration was subtracted from the annual average Station K1-3 concentration to account for fallout Cs-137. The calculated whole body dose of 0.0069 mrem/yr was a small percentage (0.00023%) of the dose received by an individual from natural background radiation (300 mrem/yr).

TABLE 7

1996 Average Tritium Concentrations in Surface and Drinking Water (pCi/L)

Station	Description	Sample Concentrations > MDC [1] Average +/- 2 std dev	Range	Actual Sample Concentrations [2] Average +/- 2 std dev	Range
		Surface Water			
A3-2 (C)	Swatara Creek (Middletown, PA)	[3]	[3]	17 ± 69	(-43) - 61
P1-3 (C)	TMI-1 Pretreatment Building	[3]	[3]	37 ± 55	(-8.7) - 87
F15-1 (C)	Chickies Creek (Marietta, PA)	[3]	[3]	31 ± 69	(-22) - 79
J1-2 (I)	West shore of TMI	1200 ± 3200	100 - 4100	600 ± 2400	39 - 4100
		Drinking Water			
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	120 ± 50	95 - 140	69 ± 82	14 - 140
J15-2 (C)	York Water Company (York, PA)	[3]	[3]	24 ± 71	(-33) - 89
G15-1 (I)	Columbia Water Company (Columbia, PA)	[3]	[3]	43 ± 70	1.3 - 110
G15-2 (I)	Wrightsville Water Supply (Wrightsville, PA)	[3]	[3]	29 ± 56	(-9.5) - 76
G15-3 (I)	Lancaster Water Authority (Columbia, PA)	110	--	54 ± 69	(-0.77) - 110

[1] Averages and ranges are based on sample results above the minimum detectable concentration (MDC). Duplicate analysis results and quality control sample results are not included.

[2] Averages and ranges are based on actual sample concentrations (whether positive, negative or zero). Negative sample concentrations are enclosed in parentheses. Using actual sample concentrations (sample count rate minus background or blank count rate) eliminates biases such as those caused by averaging only sample concentrations above the MDC. Negative sample concentrations are important to the overall average, but have no physical significance. Duplicate analysis results and quality control sample results are not included.

[3] All monthly sample results were less than the MDC.

(C) = Control (I) = Indicator

TABLE 8

1996 Average Gross Beta Concentrations in Surface and Drinking Water (pCi/L)

Station	Description	Sample Concentrations > MDC [1] Average +/- 2 std dev	Range	Actual Sample Concentrations [2] Average +/- 2 std dev	Range
		Surface Water			
P1-3 (C)	TMI-1 Pretreatment Building	2.9 ± 1.8	1.5 - 4.3	2.5 ± 2.2	0.66 - 4.3
		Drinking Water			
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	3.1 ± 2.1	2.0 - 4.5	2.0 ± 2.6	0.51 - 4.5
J15-2 (C)	York Water Company (York, PA)	2.4 ± 0.6	2.0 - 2.9	2.2 ± 1.2	1.0 - 2.9
G15-1 (I)	Columbia Water Company (Columbia, PA)	2.3 ± 1.0	1.6 - 3.4	2.3 ± 1.0	1.5 - 3.4
G15-2 (I)	Wrightsville Water Supply (Wrightsville, PA)	3.0 ± 1.5	1.8 - 4.5	3.0 ± 1.5	1.8 - 4.5
G15-3 (I)	Lancaster Water Authority (Columbia, PA)	2.5 ± 1.2	1.7 - 3.3	2.1 ± 1.5	1.0 - 3.3

(1) Averages and ranges are based on sample results above the minimum detectable concentration (MDC). Duplicate analysis results and quality control sample results are not included.

(2) Averages and ranges are based on actual sample concentrations (whether positive, negative or zero). Using actual sample concentrations (sample count rate minus background or blank count rate) to calculate annual averages eliminates biases such as those caused averaging only sample concentrations above the MDC. Negative sample concentrations are important to the overall average, but have no physical significance. Duplicate analysis results and quality control sample results are not included.

(C) = Control (I) = Indicator

1996 Tritium Concentrations in Surface Water

Picocuries per Liter by Month

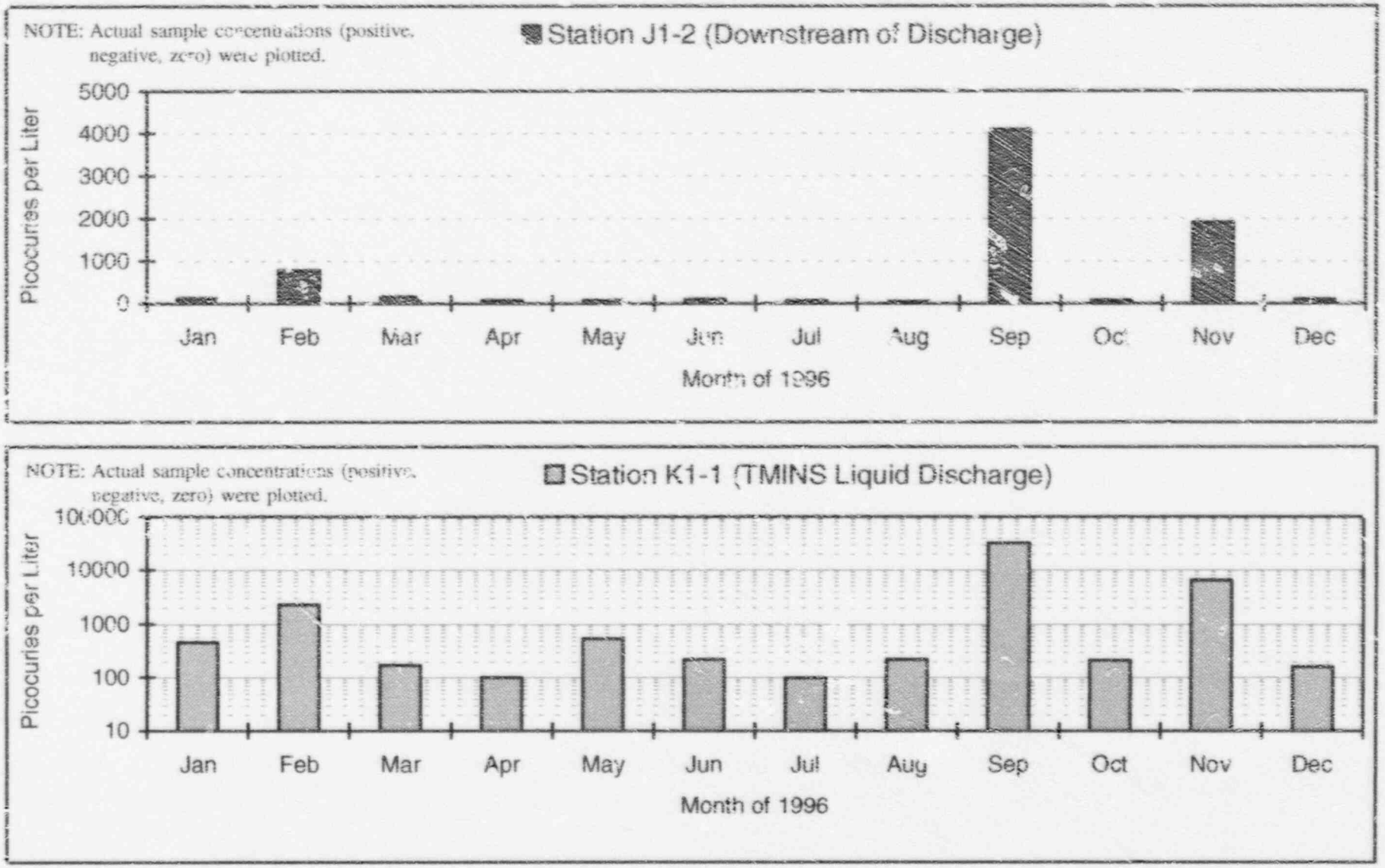


Figure 12

Historical Tritium Concentrations in Surface Water

Picocuries per Liter by Quarter

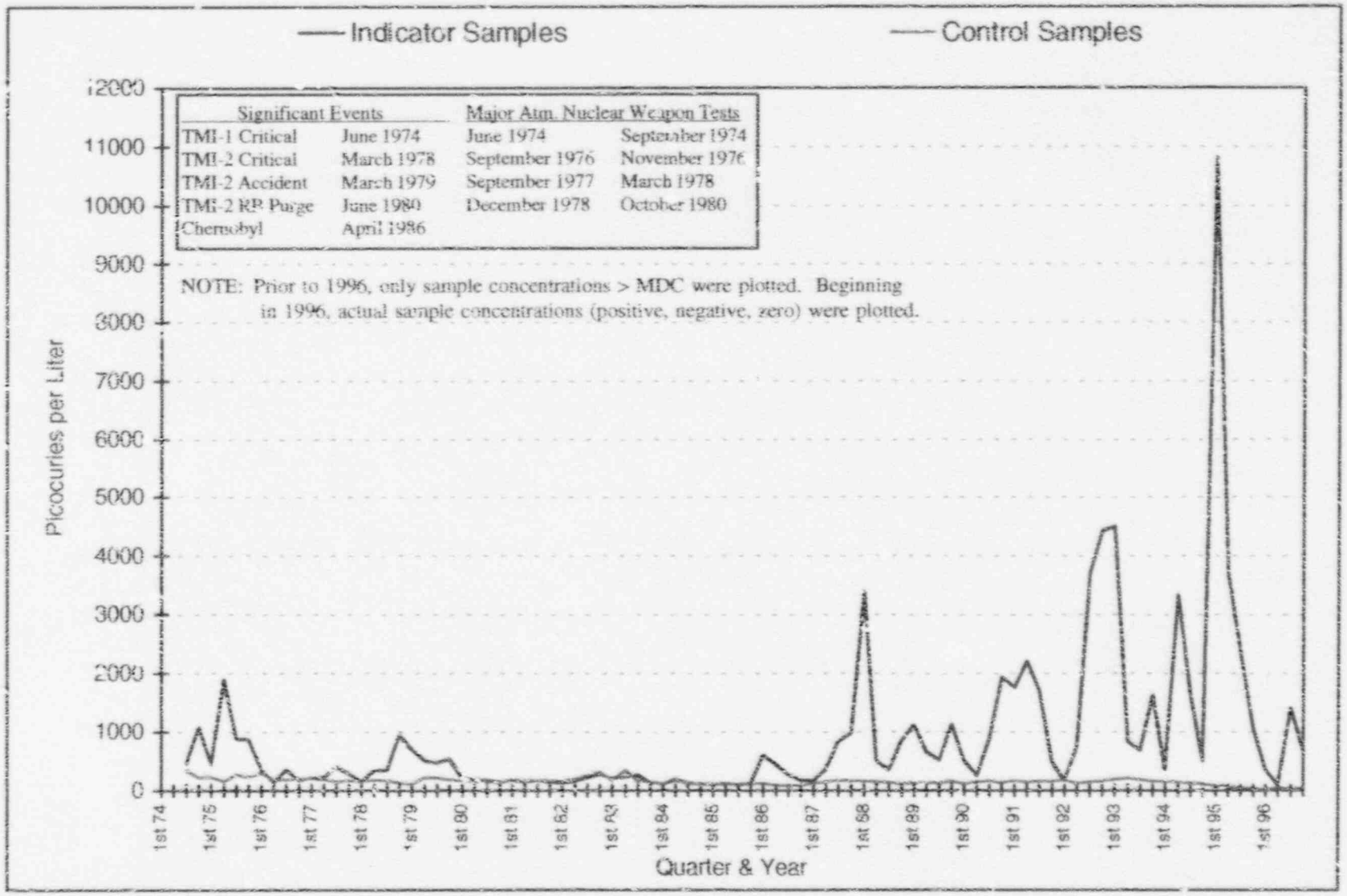
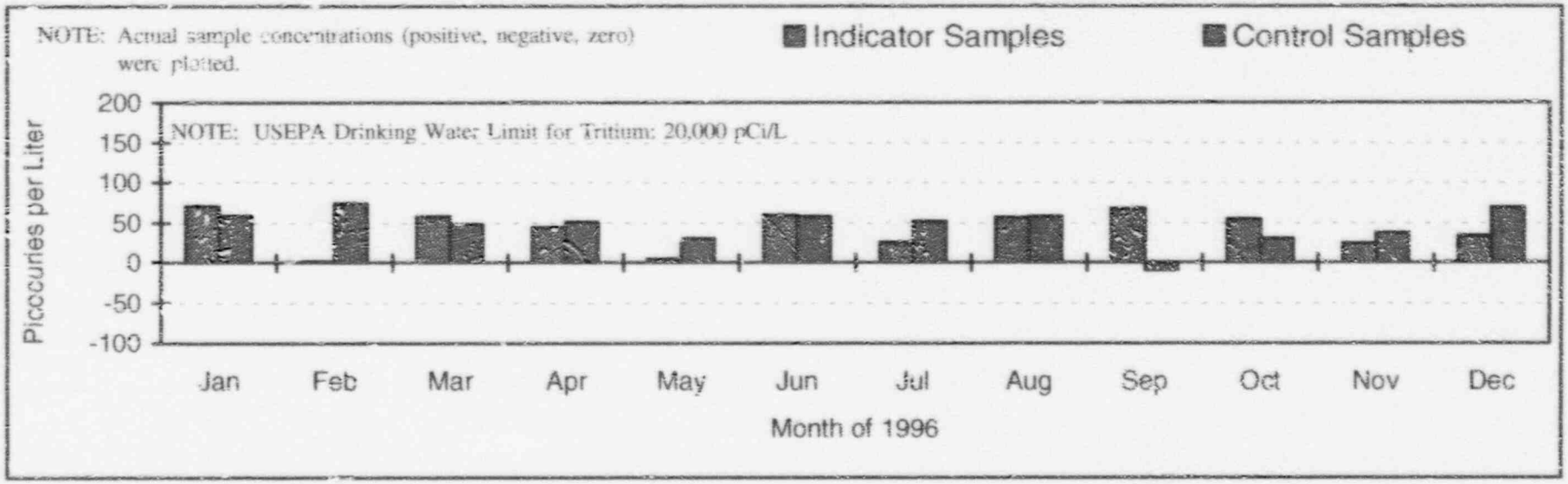


Figure 13

1996 Tritium Concentrations in Drinking Water

Picocuries per Liter by Month



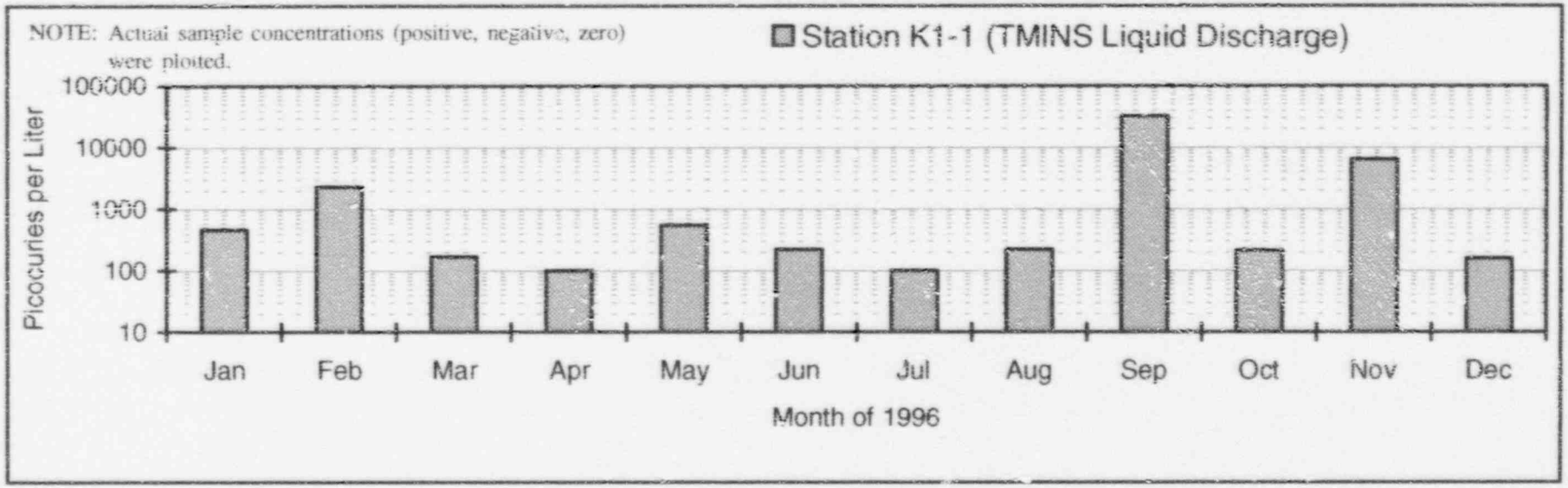


Figure 14

1996 Gross Beta Concentrations in Drinking Water

Picocuries per Liter by Month

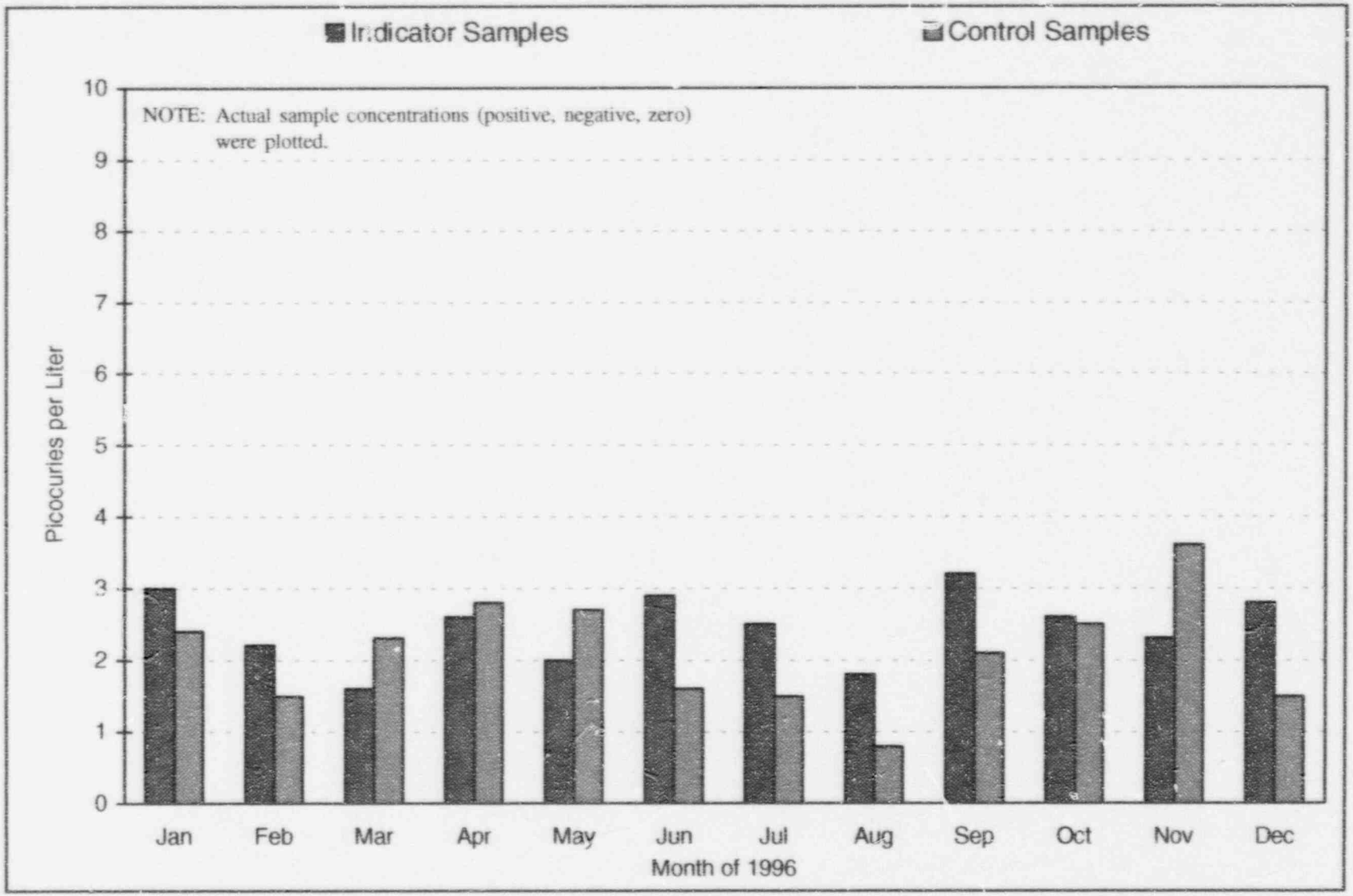


Figure 15

Historical Cesium-137 Concentrations in Aquatic Sediments

Picocuries per Gram (dry)

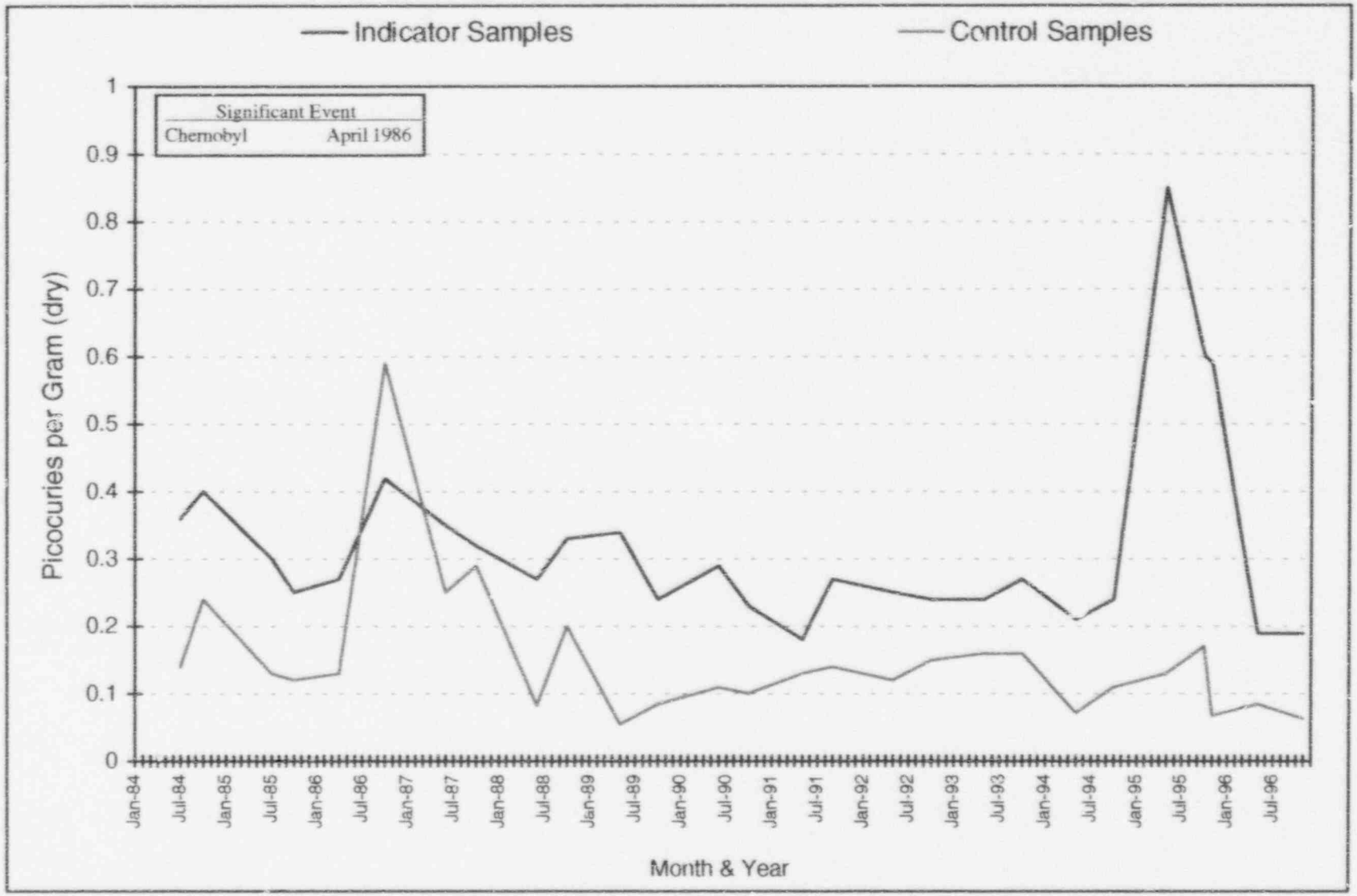


Figure 16

TERRESTRIAL MONITORING

Radionuclides released to the atmosphere may deposit on soil and vegetation. They may eventually be incorporated into milk, meat, fruits, vegetables, or other food products. To assess the impact of TMINS operations to humans from the ingestion pathway, primary food product samples such as green leafy vegetables, root vegetables, fruits, and milk were collected and analyzed during 1996. The ingestion pathway also is normally assessed by collecting and analyzing indicator and control deer meat samples. No deer meat samples were analyzed in 1996 because indicator samples were not available.

In addition to edible products, rodent carcasses were analyzed/frisked as part of the TMI-2 Post-Defueling Monitored Storage (PDMS) Rodent Collection and Analysis Program. The purpose of this program is to determine if radioactive materials have been transported by the movement of animals from radiologically-controlled areas to unrestricted areas.

The radiological contribution of TMINS operations was determined by comparing the results of samples collected in prevalent downwind locations, primarily to the south and east of the site, with control samples collected from distant or generally upwind directions. Comparisons with results from previous years also were performed, as applicable.

The analytical results of samples collected during 1996 indicated that there was no discernible TMINS contribution to radioactivity levels in locally-produced food products. As expected, Sr-90 was found in milk and broad leaf vegetable samples. The concentrations observed in samples collected near TMINS (indicators) were similar to levels observed in samples collected distant from the site (controls) and consistent with data from prior years. The presence of Sr-90 was attributable to fallout from prior atmospheric nuclear weapon tests.

As part of the REMP, a surveillance was performed to identify relevant changes in the use of land (unrestricted areas) around TMI. This land use surveillance consisted of a dairy census, a garden census and a residence census.

The dairy census was performed to determine the locations of the nearest milk animals within five miles of TMINS in each of the sixteen meteorological sectors. Also, information on other livestock (beef cattle, chickens, etc.) within five miles of TMINS was gathered. The results are listed in Table G-1 of Appendix G.

The purpose of the garden and residence censuses was to locate the nearest garden and residence in each of the meteorological sectors, respectively. Only gardens of greater than 500 square feet producing broad leaf vegetation were included in the garden census. The results of the residence and garden censuses are listed in Tables G-2 and G-3 of Appendix G, respectively.

The results of these censuses provide a basis for modifying the environmental monitoring program and the models used for calculating offsite doses. Based on the 1996 land use surveillance, changes to the REMP and the dose model were not required.

Sample Collection and Analysis

During 1996, samples of raw cow milk were collected biweekly from local farmers at one control and six indicator locations. For most of the year, five indicator samples were collected. The farmer at Station A4-1 ceased dairy operations in mid-March. Indicator samples were collected at locations having a high dose potential. These locations generally were proximate to TMINS and in dominant wind directions. Conversely, the control station was located greater than 10 miles from TMINS in a non-prevalent wind direction.

A gamma isotopic analysis and a low-level I-131 analysis were performed on each biweekly milk sample. The biweekly milk samples were then composited quarterly by station and analyzed for Sr-89 and Sr-90.

Ripened fruits and vegetables were collected from local farms and residences and from

gardens maintained by GPU Nuclear Environmental Affairs. A total of seven locations (six indicators and one control) were sampled in 1996. Like milk samples, indicator produce samples were collected at locations having a high dose potential, while controls were obtained from distant sites. Tomatoes, green peppers, red beets, potatoes, cabbages and sweet corn were collected. All samples were analyzed for gamma-emitting radionuclides, including I-131. Cabbage samples also were analyzed for Sr-89 and Sr-90.

When available, GPU Nuclear analyzes a limited number of rodent carcasses as part of the non-routine REMP. During 1996, two mice carcasses were frisked and/or analyzed for gamma-emitting radionuclides. No other rodent carcasses were found in 1996.

Milk Results

Iodine-131 was not detected above the minimum detectable concentration (MDC) in any of the milk samples collected in 1996. Gamma isotopic analyses yielded only naturally-occurring potassium-40 (K-40) and radium-226 (Ra-226). Potassium-40 was detected in all 1996 biweekly milk samples. The concentrations measured in the indicator samples were similar to those measured in the controls. Radium-226, a radionuclide commonly measured in soil, was detected in one sample.

Strontium analyses were performed on quarterly composite samples. None of the samples contained Sr-89 above the MDC. As expected, Sr-90 was measured in a number of milk samples. Six of twenty-one indicator samples (29%) and one of four controls (25%) contained Sr-90 above the MDC. Strontium-90 concentrations in indicator samples ranged from 0.65 ± 0.37 pCi/L to 1.9 ± 0.6 pCi/L and averaged 1.2 ± 0.9 pCi/L. The concentration measured in the control sample was 0.85 ± 0.44 pCi/L. The Sr-90 concentrations measured in the 1996 milk samples were consistent with 1995 concentrations which ranged from 0.88 ± 0.17 pCi/L to 2.8 ± 0.3 pCi/L and 0.82 ± 0.20 pCi/L to 1.7 ± 0.3 pCi/L for indicators and controls, respectively.

The station with the highest annual average Sr-90 concentration was the dairy farm located 6.7 miles west-northwest of TMINS (Indicator Station P7-1). Strontium-90 above the MDC was detected in only one of the four composite samples. The biweekly samples collected and composited during the second quarter of 1996 at Station P7-1 were found to contain Sr-90 at a concentration of 1.9 ± 0.6 pCi/L. This concentration was consistent with the average concentration calculated for Station P7-1 in 1995 (1.2 ± 0.5 pCi/L). Samples collected in previous years from other dairy farms also had similar Sr-90 concentrations.

The presence of Sr-90 in milk primarily resulted from the transfer of this long-lived fallout product from soil to animal feed (fresh or stored) to cow to milk. Figure 17 depicts the trends of Sr-90 concentrations in indicator and control cow milk samples since 1979. The data plotted for 1996 was based on actual sample concentrations because most of the results were below the MDC. Using actual concentrations eliminates biases

in the data and missing data points on graphs.

Generally, the Sr-90 concentrations have trended downward. This decrease is related to the cessation of atmospheric nuclear weapon testing and the radioactive decay and depletion of both atmospheric and terrestrial Sr-90 associated with prior weapon testing.

Terrestrial Vegetation Results

Samples of broad leaf vegetables (cabbages), fruits (tomatoes, sweet corn and green peppers) and root vegetables (red beets and potatoes) were collected in 1996. Naturally-occurring K-40 was measured in all samples. One red beet sample also contained naturally-occurring Be-7. No gamma-emitting radionuclides (including I-131) attributable to TMINS operations were detected above the MDC.

Strontium may become incorporated into plants by either uptake from soil or direct deposition on foliar surfaces. In 1996, none of the leafy vegetables (cabbages) contained Sr-89 above the MDC. Low-level Sr-90 was detected in the control and three of five indicator samples. The annual average Sr-90 concentration for indicator samples was 0.0060 ± 0.0030 pCi/g (wet). The concentrations ranged from 0.0043 ± 0.0019 pCi/g (wet) to 0.0071 ± 0.0025 pCi/g (wet). The control sample had a similar Sr-90 concentration, 0.0043 ± 0.0021 pCi/g (wet).

The 1996 Sr-90 concentrations were consistent with those reported in previous years. In 1995, for example, indicators averaged 0.0061 ± 0.0095 pCi/g (wet) and ranged from 0.0028 ± 0.0005 pCi/g (wet) to 0.013 ± 0.001 pCi/g (wet). The 1995 control sample contained Sr-90 at a concentration of 0.029 ± 0.002 pCi/g (wet).

As in previous years, the Sr-90 detected in 1996 cabbage samples was attributed to fallout from prior nuclear weapon tests. The detection of this long-lived fallout product was expected because measurable amounts of Sr-90 are still present in the terrestrial environment. Additionally, cabbages have a tendency to absorb Sr-90 residing in the soil.

Rodent Results

During 1996, two rodent carcasses were frisked and then analyzed for gamma-emitting radionuclides. Both rodents were mice and both were found in restricted, but radiologically 'clean' areas. One carcass was found in the TMI-1 Machine Shop. The other was discovered near the condenser vacuum pumps in the TMI-1 Turbine Building. Gamma-emitting reactor-related materials were not identified in either carcass.

No definitive conclusion can be made on whether radioactive materials are being transported by rodents. However, since the rodent collection and analysis program began, none of the carcasses collected from either restricted, radiologically 'clean' areas or unrestricted areas have contained radioactive materials attributable to TMINS operations. The data suggest that rodents are not transporting radioactive materials to unrestricted areas.

A pest control program is in place at TMINS. This program minimizes the potential for rodents to transport radioactive materials to unrestricted areas.

Historical Strontium-90 Concentrations in Cow Milk

Picocuries per Liter by Quarter

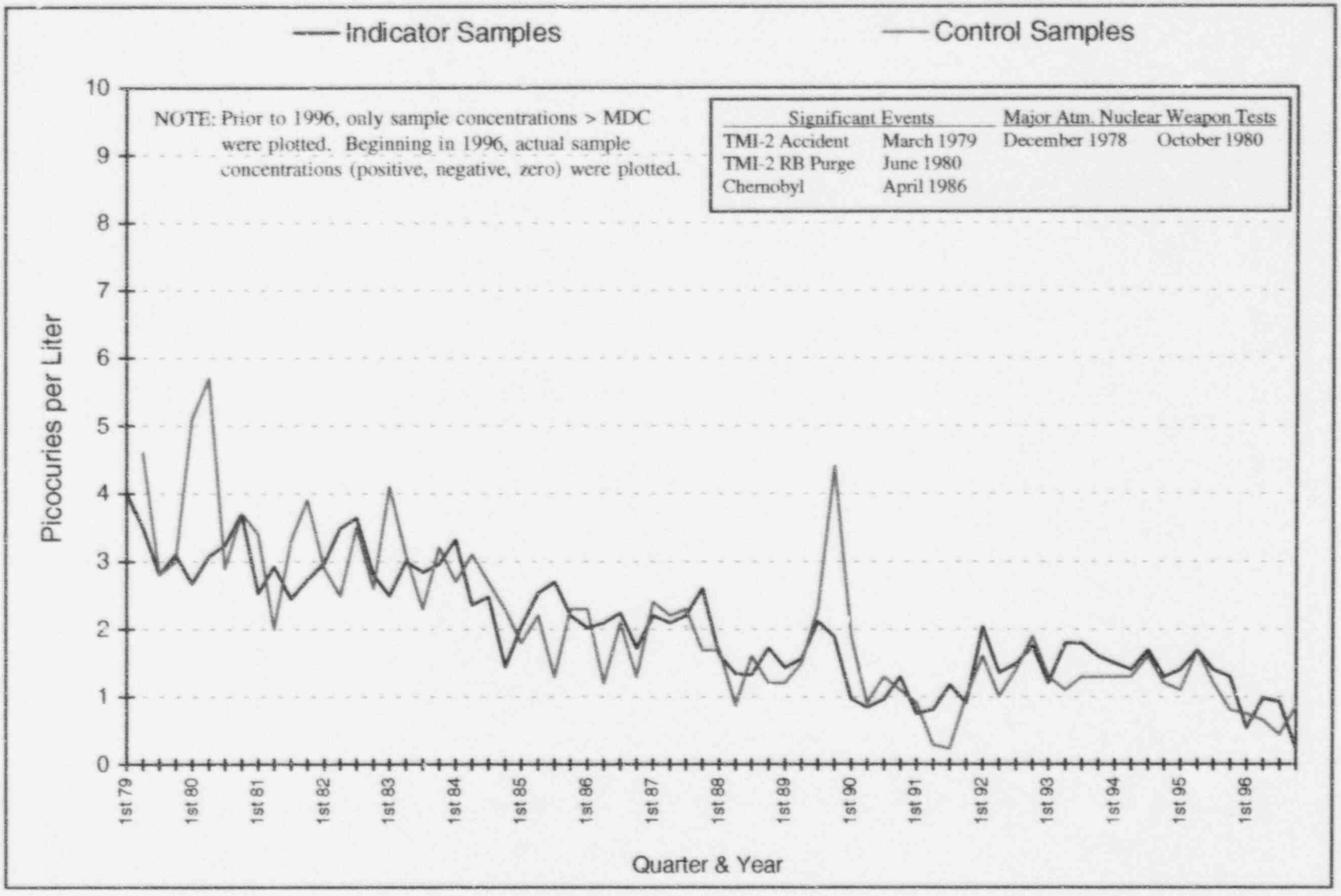


Figure 17

GROUNDWATER MONITORING

Three Mile Island (TMI) is located in the Triassic lowland of Pennsylvania, a region often referred to as the Gettysburg Basin. The Island was formed as a result of fluvial deposition by the Susquehanna River. It is composed of sub-rounded to rounded sand and gravel, containing varying amounts of silt and clay. Soil depths on TMI vary from approximately six feet at the south end to about 30 feet at the center. The site is underlain by Gettysburg shale which lies at an elevation of approximately 277 feet (Refs. 29 and 30).

The Island has two different water-bearing zones. One is composed of the soils overlying the Gettysburg shale (bedrock). The other is the bedrock. Relative to the natural soils, the movement of groundwater is much quicker in the bedrock. Groundwater from TMI migrates to the Susquehanna River, but does not impact onshore groundwater supplies. The migration of TMI groundwater to onshore supplies is prevented by the higher levels and the opposing flows of groundwater which exist beneath the surrounding terrain on the opposite sides of the Susquehanna River. The estimated travel time for groundwater to reach the river from the central portion of TMI is approximately 12 years (Ref. 45).

A groundwater monitoring program (GMP) was initiated around TMI-2 in 1980 to detect leakage of water, if any, from the TMI-2 Reactor and Auxiliary Buildings and outside storage tanks. Since 1980, the TMI GMP has been expanded and now monitors activities associated with both TMI-1 and TMI-2.

A surface water impoundment and 18 onsite monitoring wells, including 4 new wells, were sampled routinely in 1996. Three of the new wells (MS-19, MS-20 and MS-21) were drilled in the latter part of 1995, but were not sampled until 1996. The other new well (MS-22) was drilled in November of 1996. The new wells were installed primarily to monitor TMI-1 activities and components. The water collected from the onsite monitoring wells and the surface water impoundment was not used for drinking. Two onsite and three offsite drinking water wells also were routinely sampled as part of the TMINS GMP.

On a non-routine basis, groundwater samples were collected from four monitoring wells located around an onsite landfill (MW-1, MW-2, MW-3 and MW-4) and three new supply wells (NW-A, NW-B and NW-C). Drilled in September of 1996, the supply wells are expected to provide water to various TMI-1 systems in 1997. The water currently used in these systems is obtained from the Susquehanna River.

During 1996, onsite surface water samples and onsite and offsite groundwater samples were found to contain H-3 above the minimum detectable concentration (MDC). The presence of H-3 in these samples was attributed to routine TMI-1 operations and previous TMI-2 operations.

All H-3 concentrations measured in the water collected from the onsite impoundment and the onsite monitoring and supply wells were below the USNRC 10 CFR 20 effluent concentration limit. For onsite and offsite groundwater used for drinking, all H-3 concentrations were well below the USEPA Primary Drinking Water Standard of 20,000 pCi/L.

Strontium-90 (Sr-90) also was detected in one onsite groundwater sample. The Sr-90 measured in the sample collected from an onsite well was attributed to past leaks from a TMI-2 tank which has since been contained. The water collected from the onsite well is not used for drinking. The measured concentration was well below the USNRC 10 CFR 20 effluent concentration limit of 500 pCi/L for Sr-90. It also was below the USEPA Primary Drinking Water Standard of 8 pCi/L.

Based on the concentrations of H-3 and Sr-90 detected in the 1996 groundwater samples, no adverse impact to humans or the environment resulted.

Sample Collection and Analysis

All groundwater samples were collected using standard plumbing, a dedicated, in-well pumping system or a bailing device. Surface water samples were collected as grabs. Most groundwater stations were sampled quarterly and analyzed for H-3 and gamma-emitting radionuclides. The quarterly samples were then combined into

semiannual composites and analyzed for Sr-90.

The samples collected from the onsite surface water impoundment (East Dike Catch Basin, EDCB), the two onsite drinking water wells (Operations Support Facility, OSF and Building 48, 48s) and RW-1, a pumped well previously used to recover oil, were collected monthly and analyzed for H-3. Except for those collected from RW-1, the monthly samples were combined by station into quarterly composites and analyzed for gamma-emitting radionuclides. The quarterly composites were then combined into semiannual composites and analyzed for Sr-90. Samples collected from RW-1 were analyzed only for H-3.

Nonroutine samples were collected at varying frequencies from several monitoring wells (RW-1, RW-2, MS-19, MS-20, MS-21 and MS-22), the supply wells and the OSF well. These samples were analyzed for H-3 only and the data were used to support special investigations. Precipitation samples also were collected on TMI to support the investigations.

Groundwater Results

Locations of the onsite groundwater stations sampled in 1996 are shown in Figures J-1 and J-2 (Appendix J). Offsite groundwater stations are depicted in Figures 2 and 3 (**Radiological Environmental Monitoring**). The 1996 sample results are summarized in Table J-1 of Appendix J. For comparison, Table J-1 also includes 1995 station averages.

During 1996, H-3 was the only radionuclide consistently detected in samples collected from the onsite surface water impoundment and the onsite monitoring and supply wells. The presence of H-3 in the samples was attributed to routine operations at TMI-1 and past operations at TMI-2.

Generally, the H-3 concentrations measured in most samples collected from the onsite monitoring wells trended downward in 1996. Additionally, the annual average concentrations generally were similar to or below those calculated for the period just prior to the operations of the TMI-2 Evaporator (January 1991 through August 1993).

The highest H-3 concentrations were measured in the onsite groundwater samples collected from two recovery wells, RW-1 and RW-2. The wells were originally drilled to recover oil from a past pipe leak, but only RW-1 was actually used for oil recovery. After the oil recovery process was completed, the wells were included in the TMI GMP to provide additional monitoring coverage for TMI-1 activities and systems (e.g. tanks, components and pipes).

The average H-3 concentrations for samples collected in 1996 from RW-1 and RW-2 were 99,000 ± 230,000 pCi/L and 5,700 ± 21,000 pCi/L, respectively (Table J-1). Maximum concentrations for RW-1 (450,000 ± 50,000 pCi/L) and RW-2 (58,000 ± 6,000 pCi/L) were measured in January. Generally, the H-3 concentrations in the water collected from both wells decreased over the last 11 months of 1996.

The groundwater collected from RW-1 and RW-2 was impacted from leakage of system components which then migrated to the ground near these wells. Higher H-3 concentrations were expected in RW-1 samples because the well is equipped with a pump which draws the groundwater to the well. When pumped, the water from RW-1 is routed directly to the Turbine Building Sump (TBS) and further diluted prior to release. The H-3 activity in the water is accounted for in TMINS liquid effluents.

Tritium above the minimum detectable concentration (MDC) was measured in the groundwater collected from the four new monitoring wells (MS-19, MS-20, MS-21 and MS-22) and the three new supply wells (NW-A, NW-B and NW-C). The measured concentrations were within the expected range based on their locations. The presence of H-3 in these samples was attributed to routine TMI-1 operations and previous TMI-2 operations.

All of the H-3 concentrations found in water collected from the onsite surface water impoundment and the onsite monitoring and supply wells were below the USNRC 10 CFR 20 (Appendix B, Table 2) effluent concentration of 1,000,000 pCi/L.

Tritium also was measured in the water collected from the two onsite drinking water wells. The annual average H-3 concentration for samples collected from the OSF well was 1500 ± 580 pCi/L, with a maximum concentration of 2000 ± 200 pCi/L. The 1996 average H-3 concentration for samples collected from 48s was lower (260 ± 100 pCi/L). The concentrations measured in 1996 were consistent with 1995 results (Table J-1). The 1995 average H-3 concentration for samples collected from from the OSF and 48s were 1500 ± 640 pCi/L and 450 ± 1000, respectively.

The H-3 detected in these samples primarily was attributed to routine operations at TMI-1 (e.g. routine airborne releases) and possibly past operations at TMI-2 (e.g. prior airborne releases from the TMI-2 Evaporator).

All of the H-3 concentrations detected in the onsite drinking water were a small fraction of the USEPA Primary Drinking Water Standard of 20,000 pCi/L.

Tritium above the minimum detectable concentration (MDC) was detected in one of the quarterly samples collected from Station E1-2 (TMI Visitors Center). The concentration was 180 ± 90 pCi/L. All quarterly samples collected from the well at Station N2-1 (Goldsboro Marina) contained H-3 above the MDC. The concentrations averaged 140 ± 60 pCi/L and ranged from 110 ± 60 pCi/L to 170 ± 90 pCi/L.

The H-3 concentrations measured in the samples collected from the offsite wells were low and were consistent with historical results. A portion of the H-3 detected in the offsite well water was attributed to natural production in the atmosphere and fallout from prior nuclear weapon tests. It is possible that a portion of the H-3 found in these samples also may be due to routine airborne releases from TMI-1.

During 1996, reactor-produced, gamma-emitting radionuclides were not detected in

any of the onsite or offsite groundwater samples.

Strontium-90 was detected in two groundwater samples in 1996. The sample collected from onsite Station OS-16, which is proximal to the Borated Water Storage Tank (BWST), contained Sr-90 at a concentration of 1.3 ± 0.4 pCi/L.

The Sr-90 concentration measured in the OS-16 sample was consistent with those measured in previous years. The 1996 result was well below the USNRC 10 CFR 20 effluent concentration limit of 500 pCi/L for Sr-90. And although the water collected from Station OS-16 is not used for drinking, the measured concentration also was below the USEPA Primary Drinking Water Standard of 8 pCi/L.

The presence of this radionuclide in the onsite groundwater sample was attributed to previous spills/leaks from the TMI-2 BWST. To prepare TMI-2 for PDMS, the BWST was drained in 1993 and the contents were processed through the TMI-2 Evaporator.

Another Sr-90 concentration above the minimum detectable concentration (MDC) was reported by the laboratory for the sample collected from the offsite control well (Station R15-3). The reported Sr-90 activity was 1.1 ± 0.6 pCi/L. A reanalysis was performed and the result (0.86 ± 0.5 pCi/L) confirmed the original concentration. Because the sample was collected from a deep offsite control well, the sample result was suspect. The detection of Sr-90 in the sample was believed to be the result of residual contamination on the sample holder.

Precipitation Results

To supplement special groundwater monitoring projects, onsite precipitation samples were collected and analyzed in 1996. Samples of rain and/or snow were collected after each precipitation event and analyzed for H-3. The results are listed in Table J-2, Appendix J.

All of the H-3 concentrations measured in onsite precipitation were below the USNRC 10 CFR 20 effluent concentration limit and were consistent with the trends observed in previous years. The presence of H-3 in these samples primarily was due to routine TMI-1 airborne effluents.

RADIOLOGICAL IMPACT OF TMINS OPERATIONS

An assessment of potential radiological impact indicated that radiation doses to the public from 1996 operations at TMINS were well below all applicable regulatory limits and were significantly less than doses received from natural sources of radiation. The 1996 whole body dose potentially received by an assumed maximum exposed individual from TMI-1 and TMI-2 liquid and airborne effluents was conservatively calculated to be about 0.11 mrem. This dose is equivalent to 0.04% of the dose that an individual living in the TMI area receives each year from natural background radiation.

The 1996 whole body dose to the surrounding population from TMI-1 and TMI-2 liquid and airborne effluents was calculated to be 1.06 person-rem. This is equivalent to 0.00016% of the dose that the total population living within 50 miles of TMI receives each year from natural background radiation.

Determination of Radiation Doses to the Public

Dose assessments can be performed by using either effluent data and an environmental transport model or environmental sample data. To the extent possible, doses to the public are based on the direct measurement of dose rates from external sources and the measurement of radionuclide concentrations in environmental media which may contribute to an internal dose of radiation. Thermoluminescent dosimeters (TLDs) positioned in the environment around TMINS provide measurements to determine external radiation doses to humans. Samples of air, water and food products are used to determine internal doses.

The quantity of radioactive materials released during normal operations are typically too small to be measured once distributed in the offsite environment. Therefore, the potential offsite doses are more effectively calculated for TMINS operations using a computerized model that predicts concentrations of radioactive materials in the environment and subsequent radiation doses based on measured effluents. Another reason for using effluent data and a transport model is that environmental sampling data cannot provide enough information to calculate population doses.

GPU Nuclear calculates doses using an advanced "class A" dispersion model. This model incorporates the guidelines and methodology set forth by the USNRC in Regulatory Guide 1.109. Due to the conservative assumptions that are used in the model, the calculated doses are generally higher than the doses based on actual environmental sample concentrations. Therefore, the model predicts doses which are higher than actual doses received by people.

The type and amount of radioactivity released from TMINS is calculated using measurements from effluent radiation instruments and effluent sample analyses. Once released, the dispersion of radionuclides in the environment is readily determined by computer modelling. Airborne releases are diluted and carried away from the site by atmospheric diffusion which continuously acts to disperse radioactivity. Variables which affect atmospheric dispersion include wind speed, temperature at different elevations, terrain, and shift in wind direction. A weather station on the north end of TMI is linked to a computer terminal which permanently records the meteorological data. Computer models also are used to predict the downstream dilution and travel times for liquid releases into the Susquehanna River.

The pathways to human exposure also are included in the model and are depicted in Figure 18. The exposure pathways considered for the discharge of TMINS liquid effluents are consumption of drinking water and finfish, and shoreline exposure. The exposure pathways considered for the discharge of TMINS airborne effluents are plume exposure, inhalation, cow milk consumption, goat milk consumption, fruit and vegetable consumption, meat consumption and land deposition. Numerous data files are used in the calculations which describe the area around TMI in terms of population distribution and foodstuffs production. Data files include such information as the distance from the plant stack to the site boundary in each sector, the population groupings, milk cows, milk goats, gardens of more than 500 square feet, meat animals, downstream drinking water users, and crop yields.

When determining the dose to humans, it is necessary to consider all applicable pathways and all exposed tissues, summing the dose from each to provide the total dose for each organ as well as the whole body from a given radionuclide in the environment. Dose calculations involve determining the energy absorbed per unit mass in the various tissues. Thus, for radionuclides taken into the body, the metabolism of the radionuclide in the body must be known along with the physical characteristics of the nuclide such as energies, types of radiations emitted and half-life. The dose assessment model also contains dose conversion factors for the radionuclides for each of four age groups (adults, teenagers, children and infants) and eight organs (total body, thyroid, liver, skin, kidney, lung, bone and GI tract).

Doses are calculated for what is termed the "maximum hypothetical individual". This individual is assumed to be affected by the combined maximum environmental concentrations wherever they occur. For liquid releases, the maximum hypothetical individual would consume 193 gallons of water per year from the Susquehanna River, eat 46 pounds of fish each year that reside in the plant discharge area and stand on the shoreline (influenced by the plant discharge) 67 hours per year. For airborne releases, the maximum hypothetical individual would live at the location of highest radionuclide concentration for inhalation and direct plume exposure. Additionally, this individual each year would consume 106 gallons of cow milk, 141 pounds of leafy vegetables, 1389 pounds of non-leafy vegetables and fruits and 243 pounds of meat produced at the locations with the highest predicted radionuclide concentrations. Consumption of goat milk is not included since this exposure pathway does not currently exist. Doses to the population within 50 miles of TMI for airborne effluents and the entire population using Susquehanna River water downstream of the plant also are calculated.

Results of Dose Calculations

Doses from natural background radiation provide a baseline for assessing the potential public health significance of radioactive effluents. The average person in the United States receives about 300 mrem/yr from natural background radiation sources. Natural background radiation from cosmic, terrestrial and natural radionuclides in the human body (not including radon), averages about 100 mrem/yr. The natural background radiation from cosmic and terrestrial sources varies with geographical location, ranging from a low of about 65 mrem/yr on the Atlantic and Gulf coastal plains to as much as 350 mrem/yr on the Colorado Plateau (Ref. 28). The NCRP now estimates that the average individual in the United States receives an annual dose of about 2,400 mrem to the lung from natural radon gas. This lung dose is considered to be equivalent to a whole body dose of 200 mrem (Ref. 27). Effluent releases from TMINS and other nuclear power plants contribute but a very small percentage to the natural radioactivity which has always been present in the air, water, soil and even in our bodies. In general, the annual population doses from natural background radiation (excluding radon) are 1,000 to 1,000,000 times larger than the doses to the same population resulting from nuclear power plant operations (Ref. 46).

Dose calculations based on airborne and liquid radioactive effluents from normal operations for 1996, showed that the maximum doses were well below Federal regulatory dose limits and the guidelines of 10 CFR 50 App. I. This

conclusion was supported by radionuclide concentrations detected in actual environmental samples. These low doses are the result of efforts by GPU Nuclear to maintain releases "as low as reasonably achievable" (ALARA).

Results of the dose calculations are summarized in Tables 9 and 10. Table 9 compares the calculated maximum dose to an individual of the public to the 10 CFR 50, App. I dose guidelines. Table 10 presents the maximum calculated total body radiation doses to the total population within 50 miles of the plant from airborne releases and the entire population using Susquehanna River water downstream of TMINS for liquid releases. These doses are compared to population doses from natural background radiation.

As shown by the data, conservative calculations of the doses to members of the public from TMINS operations are less than the limits specified in 10 CFR 50, App. I, 40 CFR 190 (25 mrem/site/year) and 10 CFR 20 (100 mrem/yr) and the dose from natural background radiation. **Appendix I** of this report contains a more detailed discussion of these dose calculations.

TABLE 9

Calculated Maximum Hypothetical Doses to an Individual for Liquid and Airborne Effluent Releases from TMI-1 and TMI-2 for 1996

	Maximum Hypothetical Dose To An Individual		
	USNRC 10 CFR 50 APP. I Guidelines (mrem/yr)	Calculated Dose (mrem/yr) TMI-1	TMI-2
From Radionuclides In Liquid Releases	3 total body, or	1.07E-1	1.48E-3
	10 any organ	1.57E-1	2.29E-3
From Radionuclides In Airborne Releases (Noble Gases)	5 total body, or	1.20E-4	0
	15 skin	2.12E-4	0
From Radionuclides In Airborne Releases (Iodines, Tritium and Particulates)	15 any organ	5.16E-4	7.14E-5

	40 CFR 190 Limits (mrem/yr)	Calculated Dose (mrem/yr) TMI-1 and TMI-2 Combined*
Total from Site	75 thyroid	3.26E-1
	25 total body or other organs	4.82E-1

* This sums together doses from TMI-1 and TMI-2 and includes the maximum regardless of age group for different pathways. It is further estimated that based on the maximum net fenceline dose rate of 3.5 mrem/std month, a person residing at the fenceline for the duration specified in Regulatory Guide 1.109 for shoreline exposure, would receive no more than 0.32 mrem direct dose, for a maximum potential dose of 0.48 mrem (to any organ or the total body) for both TMI-1 and TMI-2.

TABLE 10

Calculated Maximum Whole Body Doses to the Population for Liquid and Airborne Effluent Releases from TMI-1 and TMI-2 for 1996

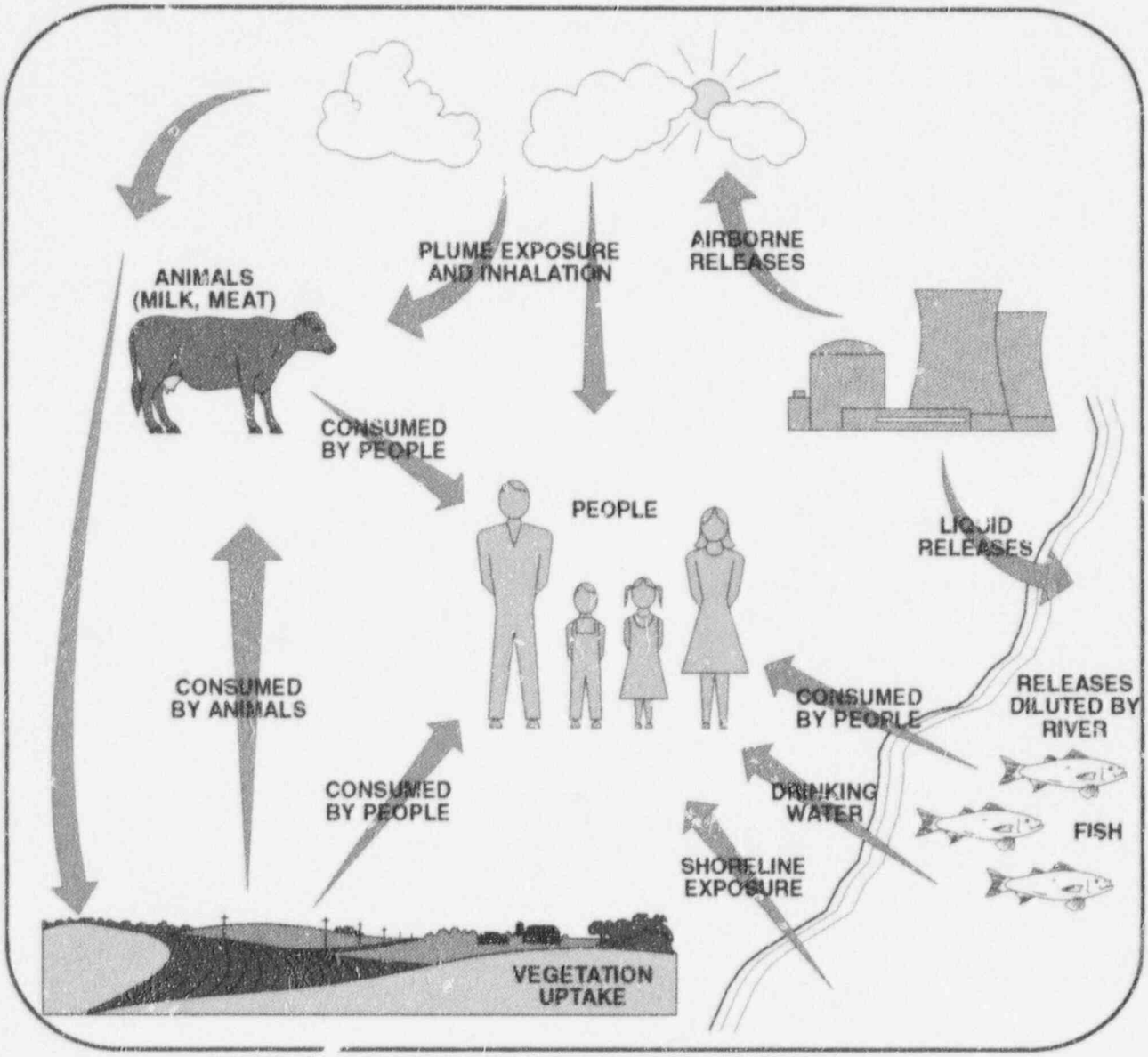
	Calculated Population Total Body Dose Person-rem/yr	
	TMI-1	TMI-2
From Radionuclides In Liquid Releases (Downstream Susquehanna River Water Users)	1.04E0	1.18E-3
From Radionuclides In Airborne Releases (Within 50 Mile Radius of TMINS)	9.76E-3	4.31E-3

Population Dose Due to Natural Background Radiation

Approximately 660,000 person-rem/yr

Figure 18

Exposure Pathways For Radionuclides Routinely Released From TMINS



PREDOMINANT RADIONUCLIDES

NOBLE GASES (Xe,Kr)
Plume exposure

RADIOIODINES (I-131, I-133)
Inhalation and consumption of milk, water, fruits, and vegetables

RADIOSTRONTIUMS (Sr-89, Sr-90)
Consumption of milk, meat, fruits, and vegetables

ACTIVATION PRODUCTS (Co-60, Mn-54)
Shoreline exposure

RADIOCESIUMS (Cs-134, Cs-137)
Shoreline exposure and consumption of milk, meat, fish, water, fruits, and vegetables

TRITIUM (H-3)
Inhalation and consumption of water, milk, fruits, and vegetables

REFERENCES

(1) Three Mile Island Nuclear Station, Unit 1, Technical Specifications, DPR 50.

(2) Three Mile Island Nuclear Station, Unit 2, PDMS Technical Specifications, DPR 73.

(3) Radiation Management Corporation. "Three Mile Island Nuclear Station, Preoperational Radiological Environmental Monitoring Program, January 1, 1974 - June 5, 1974." RMC-TR-75-17, January 1975.

(4) Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, First Operational Period, June 5 through December 31, 1974." RMC-TR-75-02, February 1975.

(5) Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station." RMC-TR-75-13, August 1975.

(6) Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, 1975 Semi-annual Report II, July 1 through December 31." RMC-TR-76-01, February 1976.

(7) Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, 1976 Annual Report, January 1 through December 31." RMC-TR-77-01, March 1977.

(8) Teledyne Isotopes. "Metropolitan Edison Company, Radiological Environmental Monitoring Report, 1977 Annual Report, January 1 through December 31." IWL-5990-427, 1978.

(9) Teledyne Isotopes. "Metropolitan Edison Company, Radiological Environmental Monitoring Report, 1978 Annual Report." IWL-5590-443, 1979.

(10) Metropolitan Edison Company. "Three Mile Island Nuclear Station Radiological Environmental Monitoring Program, Annual Report for 1979." April 1980.

(11) Metropolitan Edison Company. "Three Mile Island Nuclear Station Radiological Environmental Monitoring Report, 1980 Annual Report." March 1981.

(12) GPU Nuclear Corporation. "1981 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Generating Station." May 1982.

(13) GPU Nuclear Corporation. "1982 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Generating Station." May 1983.

(14) GPU Nuclear Corporation. "1983 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1984.

(15) GPU Nuclear Corporation. "1984 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1985.

(16) GPU Nuclear Corporation. "1985 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1986.

(17) GPU Nuclear Corporation. "1986 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1987.

(18) GPU Nuclear Corporation. "1987 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1988.

(19) GPU Nuclear Corporation. "1988 Radiological Environmental Monitoring Report, Three Mile Island Nuclear Station." May 1989.

(20) GPU Nuclear Corporation. "1989 Annual Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station." May 1990.

(21) GPU Nuclear Corporation. "1990 Radiological Environmental Monitoring Report, Three Mile Island Nuclear Station." May 1991.

(22) GPU Nuclear Corporation. "1991 Radiological Environmental Monitoring Report, Three Mile Island Nuclear Generating Station." May 1992.

(23) GPU Nuclear Corporation. "1992 Three Mile Island Nuclear Station, Radiological Environmental Monitoring Report." May 1993.

(24) GPU Nuclear Corporation. "1993 Three Mile Island Nuclear Station, Radiological Environmental Monitoring Report." May 1994.

(25) GPU Nuclear Corporation. "1994 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1995.

(26) GPU Nuclear Corporation. "1995 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1995.

(27) National Council on Radiation Protection and Measurements. Report No. 93. "Ionizing Radiation Exposure of the Population of the United States." 1987.

(28) CRC Handbook. "Radioecology: Nuclear Energy and the Environment." F. Ward Whicker and Vincent Schultz, Volume I, 1982.

(29) GPU Nuclear Corporation. "Final Safety Analysis Report, Three Mile Island Nuclear Station, Unit 1." 1994.

(30) GPU Nuclear Corporation. "Post-Defueling Monitored Storage Safety Analysis Report, Three Mile Island Nuclear Station, Unit 2." 1993.

(31) 1990 Census Information provided by The Pennsylvania State Data Center.

(32) National Climatic Data Center. "Preliminary Local Climatological Data, 1996, Middletown, Pennsylvania".

(33) National Council on Radiation Protection and Measurements. Report No. 22. "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure." (Published as National Bureau of Standards Handbook 69, Issued June 1959, superseding Handbook 52).

(34) International Commission on Radiological Protection. Publication 2. "Report of Committee II on Permissible Dose for Internal Radiation (1959)," with 1962 Supplement Issued in ICRP Publication 6; Publication 9, "Recommendations on Radiation Exposure," (1965); ICRP Publication 7 (1965), amplifying specific recommendations of Publication 9 concerning environmental monitoring; and ICRP Publication 26 (1977).

(35) Federal Radiation Council. Report No. 1. "Background Material for the Development of Radiation Protection Standards." May 13, 1960.

(36) National Council on Radiation Protection and Measurements. Report No. 116. "Limitation of Exposure to Ionizing Radiation." March 1993.

(37) National Council on Radiation Protection and Measurements. Report No. 62. "Tritium in the Environment." March 1979.

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

(39) GPU Nuclear Corporation. "Three Mile Island Nuclear Generating Station Offsite Dose Calculation Manual (ODCM)." 6610-PLN-4200.01, Rev. 11.

(40) United States Nuclear Regulatory Commission. Regulatory Guide 4.15. "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment." Revision 1, February 1979.

(41) American National Standards Institute, Inc. "Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry." ANSI N545-1975.

(42) United States Nuclear Regulatory Commission. Regulatory Guide 4.13. "Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications." Revision 1, July 1977.

(43) L. F. Toke, B. H. Carson, G. G. Baker, M. H. McBride. "Performance Testing of the Environmental TLD System for the Three Mile Island Nuclear Station." Health Physics Vol. 46, No. 5 (May), pp. 1013 - 1020, 1984.

(44) United States Nuclear Regulatory Commission. NUREG-0683. "Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979 Accident Three Mile Island Nuclear Station, Unit 2." Docket No. 50-320, March 1981.

(45) Ground/Water Technology, Inc. "Hydrogeological Investigation, Three Mile Island Nuclear Station, Londonderry Township, Pennsylvania." December 1981.

(46) NUREG/CR-4068. "Summary of Historical Experience with Releases of Radioactive Materials from Commercial Nuclear Power Plants in the United States." 1985.

APPENDIX A

1996 REMP Sampling Locations and Descriptions, Synopsis of REMP, and Sampling and Analysis Exceptions

TABLE A-1

TMINS Radiological Environmental Monitoring Program Sample Locations - 1996

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
AQS	A1-3	16	0.5 mi	0°	N of site off north tip of TMI in Susquehanna River
ID	A1-4	113	0.3	5	N of Reactor Building on W fence adjacent to North Weather Station, TMI
AP,AI,ID	A3-1	39	2.6	358	N of site at Middletown Substation
SW	A3-2	40	2.5	355	N of site at Swatara Creek, Middletown
M	A4-1	152	3.3	10	N of site at farm along Rt. 230
ID	A5-1	44	4.3	3	N of site on Vine Street Exit off Route 283
ID	A9-3	127	8.1	2	N of site at Duke Street Pumping Station, Hummelstown
ID	B1-1	2	0.6	25	NNE of site on light pole in middle of North Bridge, TMI
ID	B1-2	114	0.4	26	NNE of Reactor Building on top of dike, TMI
AP,AI	B1-4	148	0.8	28	NNE of site at North Gate, TMI
ID	B2-1	132	1.9	16	NNE of site on Sunset Dr. (off Hillsdale Rd.)
ID	B5-1	45	4.8	18	NNE of site at intersection of School House and Miller Roads
ID	B10-1	61	9.4	21	NNE of site at intersection of West Areba Avenue and Mill Street, Hershey
FP	B10-2	1	10.1	28	NNE of site at Milton Hershey School, Hershey
D	C1-1	17	0.7	35	NE of site along Route 441 N
ID	C1-2	116	0.3	54	NE of Reactor Building on top of dike, TMI
ID	C2-1	43	1.6	48	NE of site at Middletown Junction
ID	C5-1	46	4.5	42	NE of site on Kennedy Lane
ID	C8-1	62	7.2	48	NE of site at Schenk's Church on School House Road
AQF	Control	-	-	-	All locations where finfish are collected upstream of the TMINS liquid discharge outfall (above Dock St. Dam, Harrisburg) are grouped together and referred to as "control"
GAD	Control	-	-	-	All locations greater than 10 miles from TMINS
ID	D1-1	3	0.2	74	ENE of Reactor Building on top of dike, TMI
ID	D1-2	18	0.6	60	ENE of site on Laurel Road
FP	D1-3	111	0.5	65	ENE of site at residence next to commercial greenhouse on Route 441 N
M	D2-1	29	1.1	65	ENE of site at farm on Gingrich Road
ID	D2-2	133	1.7	73	ENE of site along Hillsdale Rd. (S of Zion Rd.)
ID	D5-1	47	5.2	65	ENE of site off Beagle Road
ID	D15-1	80	10.9	63	ENE of site along Route 241, Lawn, PA
AP,AI,ID,GW,FP	E1-2	19	0.4	95	E of site at TMI Visitor's Center
ID	E1-4	117	0.2	98	E of Reactor Building on top of dike, TMI
M	E2-2	109	1.1	93	E of site at farm on Pecks Road
ID	E2-3	134	1.9	96	E of site along Hillsdale Rd. (N of Creek Rd.)
ID	E5-1	48	4.6	91	E of site at intersection of North Market Street (Route 230) and Zeyger Road
ID	E7-1	64	6.8	86	E of site along Hummelstown Street, Elizabethtown
ID,FP	F1-1	20	0.5	117	ESE of site near entrance to 500 kV Substation

TABLE A-1 (Continued)

TMINS Radiological Environmental Monitoring Program Sample Locations - 1996

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
ID	F1-2	118	0.2 mi	109°	ESE of Reactor Building on top of dike midway within Interim Solid Waste Staging Facility, TMI
AP,AI	F1-3	149	0.6	105	ESE of site in 500 kV Substation
ID	F1-4	154	0.3	115	ESE of Reactor Building on top of dike, TMI
ID	F2-1	135	1.2	120	ESE of site along Engle Road
M	F4-1	156	3.2	104	ESE of site at farm on Turnpike Road
ID	F5-1	49	4.7	107	ESE of site along Amosite Road
ID	F10-1	66	9.4	112	ESE of site along Donegal Springs Road, Donegal Springs
SW	F15-1	83	12.6	122	ESE of site at Chickies Creek, Marietta
ID	F25-1	82	21.1	113	ESE of site at intersection of Steel Way and Loop Roads, Lancaster
ID	G1-2	22	0.6	143	SE of site along Route 441 S
ID	G1-3	119	0.3	129	SE of Reactor Building on top of dike, TMI
ID	G1-5	139	0.3	144	SE of Reactor Building on top of dike, TMI
ID	G1-6	140	0.3	141	SE of Reactor Building on top of dike, TMI
AI,AP,M	G2-1	104	1.4	125	SE of site at farm on Becker Road
ID	G2-4	136	1.7	135	SE of site on Becker Road
ID	G5-1	50	4.8	131	SE of site at intersection of Plainbridge and Risser Roads
AP,AI,ID	G10-1	67	9.8	127	SE of site at farm along Engles Tollgate Road, Marietta
SW,ID	G15-1	84	14.4	124	SE of site at Columbia Water Treatment Plant
SW	G15-2	85	13.6	128	SE of site at Wrightsville Water Treatment Plant
SW	G15-3	86	14.9	124	SE of site at Lancaster Water Treatment Plant
ID	H1-1	5	0.5	167	SSE of site, TMI
FP	H1-2	110	0.3	150	SSE of site at produce stand off of Route 441 S.
AP,AI,ID	H3-1	41	2.3	159	SSE of site in Falmouth-Collins Substation
ID	H5-1	52	4.1	157	SSE of site by Guard Shack at Brunner Island Steam Electric Station
ID	H8-1	68	7.4	163	SSE of site along Saginaw Road, Starview
ID	H15-1	87	13.2	157	SSE of site at intersection of Orchard and Stonewood Roads, Wilshire Hills
AQF	Indicator	-	-	-	All locations where finfish are collected downstream of the TMINS liquid discharge outfall are grouped together and referred to as "indicator"
GAD	Indicator	-	-	-	All locations within ten miles of TMINS
ID	J1-1	6	0.8	184	S of site, TMI
SW, AQS	J1-2	23	0.5	188	S of site downstream of the TMINS liquid discharge outfall in Susquehanna River
ID	J1-3	121	0.3	189	S of Reactor Building on wooden post of Building 221, just S of Unit 2 Admin. Building, TMI
AQS	J2-1	31	1.5	182	S of site in Susquehanna River just upstream of the York Haven Dam
FP	J2-2	144	1.5	178	S of site near York Haven Dam, TMI
ID	J3-1	141	2.7	178	S of site at York Haven/Cly

TABLE A-1 (Continued)

TMINS Radiological Environmental Monitoring Program Sample Locations - 1996

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
AP,AI	J3-2	150	2.9 mi	181°	S of site in Met-Ed Cly Substation
ID	J5-1	53	4.9	182	S of site along Canal Road, Conewago Heights
ID	J7-1	69	6.5	177	S of site off of Maple Street, Manchester
AP,AI,ID	J15-1	88	12.6	180	S of site in Met-Ed York Load Dispatch Station
SW	J15-2	89	14.7	178	S of site at York Water Company
EW	K1-1	7	0.2	209	On site at RML-7 Main Station Discharge Building
AQS	K1-3	24	0.3	202	SSW of site in Susquehanna River
ID	K1-4	123	0.2	208	SSW of Reactor Building on top of dike behind Warehouse 2, TMI
ID	K2-1	32	1.1	200	SSW of site on S Shelley Island
ID	K3-1	142	2.1	202	SSW of site along Rt. 262, N of Cly
ID	K5-1	54	5.0	200	SSW of site along Conewago Creek Road, Strinestown
ID	K8-1	70	7.4	196	SSW of site at intersection of Coppenhaffer Road and Route 295, Zions View
ID	K15-1	90	12.7	204	SSW of site on the Bird's Nest Child Care Center Building, Weigelstown
M	K15-2	126	12.8	208	SSW of site at farm along Route 74 N
ID	L1-1	9	0.1	235	SW of site on top of dike W of Mech. Draft Cooling Tower, TMI
ID	L1-2	26	0.5	221	SW of site on Beech Island
ID	L2-1	33	1.9	227	SW of site along Route 262
ID	L5-1	55	4.1	228	SW of site at intersection of Stevens and Wilson Roads
ID	L8-1	71	8.0	225	SW of site along Rohlers Church Rd., Andersontown
ID	L15-1	91	11.7	225	SW of site on W side of Route 74, rear of church, Mt. Royal
ID	M1-1	129	0.1	249	WSW of Reactor Building on SE corner of U-2 Screenhouse fence, TMI
ID	M1-2	143	0.5	241	WSW of site on W side of unnamed island between N tip of Beech Island and Shelley island
AP,AI,ID	M2-1	34	1.3	253	WSW of site adjacent to Fishing Creek, Goldsboro
FP	M2-2	146	1.3	252	WSW of site along Route 262, Goldsboro
ID	M5-1	56	4.3	249	WSW of site at intersection of Lewisberry and Roxberry Roads, Newberrytown
ID	M9-1	72	8.6	242	WSW of site along Alpine Road, Maytown
ID	N1-1	10	0.7	270	W of site on Shelley Island
ID	N1-3	124	0.1	270	W of Reactor Building on fence adjacent to Screenhouse entrance gate, TMI
ID,GW	N2-1	35	1.2	262	W of site at Goldsboro Marina
FP	N2-2	153	1.3	265	W of site at private residence in Goldsboro
ID	N5-1	57	4.9	268	W of site off of Old York Road along Robin Hood Drive
ID	N8-1	73	7.8	260	W of site along Route 382, 1/2 mile north of Lewisberry
ID	N15-2	95	10.4	274	W of site at intersection of Lisburn Road and Main Street, Lisburn
ID	P1-1	12	0.4	293	WNW of site on Shelley Island
ID	P1-2	38	0.2	299	WNW of Reactor Building on fence N of Unit 1 Screenhouse, TMI
SW	P1-3	11	0.1	284	WNW of Reactor Building in the Pretreatment Building, Influent Water, TMI

TABLE A-1 (Continued)

TMINS Radiological Environmental Monitoring Program Sample Locations - 1996

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
ID	P2-1	36	1.9 mi	283°	WNW of site along Route 262
ID	P5-1	58	4.9	285	WNW of site at intersection of Valley Road (Route 262) and Beinhower Road
M	P7-1	75	6.7	293	WNW of site at farm along Old York Road, New Cumberland
ID	P8-1	74	8.0	292	WNW of site along Evergreen Road, Reesers Summit
ID	Q1-1	13	0.5	317	NW of site on Shelley Island
ID	Q1-2	125	0.2	318	NW of Reactor Building on fence W of Warehouse 1, TMI
ID	Q2-1	37	1.8	310	NW of site along access road along river
AP,AI	Q4-1	151	3.7	325	NW of site at airport near control tower
ID	Q5-1	59	5.0	318	NW of site along Lumber Street, Highspire
SW,ID	Q9-1	76	8.5	308	NW of site at the Steelton Water Company
AP,AI,ID	Q15-1	97	13.5	305	NW of site behind West Fairview Fire Dept. Social Hall
ID	R1-1	14	0.2	335	NNW of Reactor Building along W fence, TMI
ID	R1-2	27	0.7	332	NNW of site on Henry Island
ID	R3-1	107	2.6	338	NNW of site at Crawford Station, Middletown
ID	R5-1	60	4.9	339	NNW of site at interstection of Spring Garden Drive and Route 441
ID	R9-1	77	8.1	340	NNW of site at intersection of Derry and 66th Streets, Rutherford Heights
ID	R15-1	99	11.2	330	NNW of site at intersection of Route 22 and Colonial Road, Colonial Park

IDENTIFICATION KEY

ID = Immersion Dose (TLD)
SW = Surface Water
M = Milk (Cow)
AP = Air Particulate
GW = Ground Water (offsite)
AQS = Aquatic Sediment
EW = Effluent Water
GAD = Meat (Game)
AQF = Finfish
AI = Air Iodine
FP = Food Products (Green Leafy Vegetation, Fruits, Vegetables)

* All distances are measured from a point that is midway between the reactor buildings of TMI-1 and TMI-2.

TABLE A-2

Synopsis of the Operational Radiological Environmental Monitoring Program and Other Radiological Monitoring Programs Conducted by GPUN Environmental Affairs for Three Mile Island Nuclear Station 1996 [1]

Sample Type	Number of Sampling Locations	Collection Frequency[2]	Number of Samples Collected	Type of Analysis	Analysis Frequency	Number of Samples Analyzed [2]
Air Iodine	12	Weekly	620	I-131	Weekly	620
Air Particulate	12	Weekly	620	Gr-Beta	Weekly	616 [4]
				Gr-Alpha	Weekly	306 [4]
				Gamma	Quarterly	48
				Sr-89	Semiannually	24
				Sr-90	Semiannually	24
Finfish	2	Semiannually	8	Gamma	Semiannually	8
				H-3	Semiannually	8
				Sr-89	Semiannually	8
				Sr-90	Semiannually	8
Aquatic Sediment	4	Semiannually	8	Gamma	Semiannually	8
				Sr-89	Annually	4
				Sr-90	Annually	4
Discharge Water	1	Weekly	4	I-131	Weekly	4
		Biweekly	25	I-131	Biweekly	25
				Gamma	Monthly	12
				Gr-Beta	Monthly	12
				H-3	Monthly	12
				Sr-89	Semiannually	2
				Sr-90	Semiannually	2
Fruits	6	Annually	16	Gamma	Annually	16
Broad Leaf Vegetation	6	Annually	6	Gamma	Annually	6
				Sr-89	Annually	6
				Sr-90	Annually	6
Vegetables	6	Annually	10	Gamma	Annually	10
Groundwater	4	Monthly	48	H-3	Monthly	48
	11 [3]	As Needed	135	H-3	As Needed	135
	22	Quarterly	88	H-3	Quarterly	88
				Gamma	Quarterly	84
				Gamma	As Needed	43
				Sr-90	Semiannually	42
Dosimeters (TLD) [3]	90	Quarterly	2115	Immersion Dose	Quarterly	2113 [4]

NOTE: See Notes at end of table.

TABLE A-2

Synopsis of the Operational Radiological Environmental Monitoring Programs and Other Radiological Monitoring Programs Conducted by GPUN Environmental Affairs for Three Mile Island Nuclear Station 1996 (1)

Sample Type	Number of Sampling Locations	Collection Frequency(6)	Number of Samples Collected	Type of Analysis	Analysis Frequency	Number of Samples Analyzed (2)
Milk	7	Biweekly	162	Gamma	Biweekly	162
				I-131	Biweekly	162
				Sr-89	Quarterly	25
				Sr-90	Quarterly	25
Surface/Drinking Water	9	Weekly	45 (5)	I-131	Weekly	30
		Biweekly	216 (5)	I-131	Biweekly	144
				Gamma	Monthly	108
				Gr-Beta	Monthly	72
				H-3	Monthly	108
				Sr-89	Semiannually	18
				Sr-90	Semiannually	18
Rodent	2 (TMI)	When Available	2	Radiological Frisk or Gamma	When Available	2

NOTES:

(1) This table represents results from the primary (base) program. It does not include quality control (QC) results.
(2) The total number of analyses does not include duplicate analyses, recounts, or reanalyses.
(3) For the purposes of this table a dosimeter is considered to be a phosphor (element).
(4) The total number of samples or elements (TLDs) used for data analysis.
(5) Water from Stations J1-2, J15-2, and G15-1 was not analyzed for low level I-131.
(6) Biweekly means once every two weeks.
(7) Nonroutine samples were collected from RW-1, RW-2, OSF, OS-15, MS-19, MS-20, MS-21, MS-22, NW-A, NW-B, and NW-C.

TABLE A-3

Sampling and Analysis Exceptions 1996*

Period of Deviation	Description of Deviation and Corrective Action
January 9, 1996 to January 22, 1996	The supply line which provides the upstream control surface water (P1-3) became blocked with sediment at the end of this period. The actual stop time was unknown. Maintenance personnel immediately were notified and the blockage was cleared on January 22, 1996. During the same time period, the water compositor was removed from the near field indicator surface water station (J1-2) because of major flooding in the area creating a concern for electrical safety. In this case, a grab sample was collected and added to the available composited sample to account for the collection period.
January 22, 1996 to February 26, 1996	As stated above, a flood caused the water compositor at indicator surface water station J1-2 to be inoperable. Two grab samples were collected per week and composited for each sampling period.
February 26, 1996 to March 11, 1996	There was a power interruption at the closest downstream drinking water station (G15-2) early in this sampling period. When power returned, the unit entered into the "PROGRAM HALTED" mode and compositing did not continue for the remainder of the first week of the period. The unit was reset after the first week and then proper collection was continued for the remainder of the collection period. During this same period, indicator surface water station J1-2 remained inoperable because of initial flood conditions as stated above. Again, two grab samples per week were composited in lieu of automatic compositing
March 11, 1996 to April 15, 1996	Raw river water grab samples were composited in lieu of automatic compositing at indicator surface water station J1-2 as mentioned above. The delay in reinstallation of electric power was the cause of this deviation. The Electrical Maintenance Department again was notified to correct the problem. The main electrical line was cut during the flood and splicing of the line needed to be performed.

TABLE A-3 (Continued)

Sampling and Analysis Exceptions 1996*

Period of Deviation	Description of Deviation and Corrective Action
April 15, 1996 to April 29, 1996	The electrical line problem mentioned above was repaired on April 19, 1996 at indicator surface water station J1-2. Hence, four days of sampling were missed during this period. Also, control surface water station P1-3 lost supply line flow on or about April 22, 1996. The blockage was cleared on April 23, 1996 and about one day of sampling was lost.
July 1, 1996 to August 12, 1996	It was noticed during a mid-collection surveillance that indicator surface water station J1-2 compositor was malfunctioning. The collection tub was filling because the unit continuously sampled. Technicians worked on the unit but could not immediately remedy the problem. The unit was left off while new parts were acquired. Interruptions in sampling occurred over two consecutive sampling periods because of this problem.
August 26, 1996 to September 9, 1996	During the mid-collection surveillance, the suction hose to the closest downstream drinking water sampler (G15-2) was noted to be cracked. After the technicians replaced the hose, they inadvertently left the unit in the "STANDBY" mode resulting in one week loss of sampling. Instrument technicians and their supervisors particpated in a training session to reduce the likelihood of this happening again. At the end of the biweekly period, a grab sample was collected and added to the first week of composited sample.
September 23, 1996 September 30, 1996	After running for over one week, the compositor at indicator surface water station J1-2 exhibited a mechanical breakdown. The pump was replaced on September 30, 1996. Based on the volume of composited water in the collection tub, it is estimated that about one day's loss of sampling occurred.

TABLE A-3 (Continued)

Sampling and Analysis Exceptions 1996*

Period of Deviation	Description of Deviation and Corrective Action
September 30, 1996 to October 14, 1996	During the middle of this sampling period, the supply line for upstream control surface water station P1-3 became blocked with sediment. The line was subsequently cleared and the unit was returned to service. Hence, sampling was interrupted for several days during the middle of this period.
October 28, 1996 to December 30, 1996	Over five consecutive sampling periods, the supply line for upstream control surface water station P1-3 intermittently became blocked. The technicians determined that the inner surface of the piping contained corrosion deposits and blockage from sediment/corrosion readily occurred. Blowing pressurized gas into the line was repeated over the period in an attempt to reopen the blockage. During a one-week sampling period (11/25/96 - 12/02/96), no water was composited and a grab sample was collected to account for that period. During the remaining sampling periods, intermittent compositing occurred.

* The exceptions described in this table are those which are considered deviations from radiological environmental monitoring as required by the Technical Specifications and the ODCM. Other sampling and analysis deviations occurred during the year. They were not included in this table because the minimum number of samples were collected and analyzed. Reports describing all sampling and analysis exceptions are on file at Three Mile Island Environmental Affairs.

APPENDIX B

1996 Lower Limit of Detection (LLD) Exceptions

TABLE B

Analytical Results Which Failed to Meet the USNRC Required LLD During 1996

Sample Media	Analysis	Required LLD	No. of Samples Which Failed to Meet the LLD	Comments
Air Iodine (AI)	I-131	0.07 pCi/m^3	1	The charcoal cartridge collected at Station J15-1 (York Substation) for the period 09/03/96 - 09/10/96 had a low sample volume due to an interruption in electrical power. The power interruption was caused by a blown fuse in the air sampler.
Surface Water (SW)	Ba-140 La-140	60 pCi/L 15 pCi/L	1 1	The quality control (QC) laboratory inadvertently failed to analyze the November drinking water sample from Station Q9-1F in a timely fashion. The primary sample was analyzed to the required LLDs.
Air Iodine (AI)	I-131	0.07 pCi/m^3	1	The charcoal cartridge collected at Station J15-1 (York Substation) for the period 12/03/96 - 12/10/96 had a low sample volume due to an interruption in electrical power. The power interruption was caused by a blown fuse in the air sampler.

APPENDIX C

1996 REMP Changes

TABLE C

1996 REMP Changes

January, 1996	Several changes were made to the environmental TLD program. Twelve TLD stations (C20-1, D9-1, B1-3, E1-1, A1-1, K1-5, J1-4, H1-9, G1-4, G1-7, M15-1 and P15-1) were deleted and eight stations (E5-1, F2-1, G1-2, C1-1, J1-1, P5-1, Q2-1 and N2-1) were moved to new locations within 90 meters of their previous locations. Additionally, 4 Panasonic model 801 badges were replaced with 2 model 814 badges at each TLD station. Model 814 badges contain three calcium sulfate elements, whereas model 801 badges contain two calcium sulfate elements. Changes to the TLD program were made to 1) increase efficiencies in manpower, 2) decrease operating costs, 3) improve access to the sites and reduce security concerns. None of the changes significantly affected the quality of the program or the exposure rates.
January, 1996	Three new groundwater wells (MS-19, MS-20 and MS-21) were added to the monitoring program. The wells were constructed to incorporate a network of monitoring wells which would more completely encompass TMI-1. During the year, several wells were sampled at varying frequencies (weekly to quarterly). The collection frequencies were dependent upon the criticality of their location relative to areas of potential radiological concern.
March, 1996	Milk sampling station A4-1 was deleted from the monitoring program because the farmer retired from the dairy business. A replacement site was not added to the REMP because the number of milk samples collected for the remainder of the year was more than required by the ODCM.
August, 1996	Soil sampling was deleted from the REMP. This was justified because 1) the ODCM does not require soil sampling and 2) other environmental sampling media provide better data to assess impacts from TMINS.
November, 1996	Sampling of a new groundwater monitoring well (MS-22) was initiated. This well was installed to monitor the integrity of the TMI-1 Borated Water Storage Tank. Weekly monitoring of this well continued for the remainder of the year.

APPENDIX D

1996 Action Levels

Analytical results of environmental samples were routinely reviewed and evaluated by the GPU Nuclear Three Mile Island Environmental Affairs staff. The results were checked for LLD violations, anomalous values, USNRC reporting levels, main sample and quality control (QC) sample agreement (Appendix E), and action levels.

Established by GPU Nuclear, the action level is defined as that level of reactor-related radioactivity which when detected in environmental samples initiates an investigation and subsequent actions, as necessary. An action level is reached if either of the following two criteria is met:

- The radioactivity concentration at an indicator station reaches or exceeds those concentrations listed in Table D-1. (With the exception of I-131 in food products and water and Sr-90 in milk, water, fish, food products and airborne particulates, all concentrations listed correspond to 10% of the USNRC reporting levels.)

- The radioactivity concentration at the indicator station reaches or exceeds 10 times the mean concentration for the control locations. (This criteria applies only to those media and analyses which are not listed in Table D-1.)

Action levels for gamma exposure rates measured by TLDs have also been established. For TLDs, an action level is reached if any of the following three criteria is met:

- The exposure rate at an indicator station not on the owner controlled area fence exceeds three times the mean of the control stations.

- The exposure rate at an indicator station on the owner controlled area fence exceeds 135 mR/std month (50% of the 40 CFR 190 limit of 25 mR/yr adjusted by a 67 hour recreational factor).

- The exposure rate at an indicator station not on the owner controlled area fence exceeds either two times the previous quarterly result or two times the historical average for the station.

If an action level is reached, an investigation is initiated which consists of some or all of the following actions:

- Examine the collection sheets for an indication of any equipment malfunctions, collection or delivery errors.
- Examine the running tables (prior data) for trends.
- Review control station data.
- Review QC or duplicate sample data (if available).
- Review TMI-1 and TMI-2 effluent data.

- Recount and/or reanalyze the sample.
- Collect and analyze an additional sample.

The results of the investigation are then documented on the form provided in the TMI Environmental Affairs procedure 6510-SUR-4523.05. As appropriate, site personnel are apprised of plant-related radioactivity which exceeds the GPU Nuclear action level. If it is concluded that the detected activity is related to TMINS operations and also exceeds the USNRC reporting limits as defined in the ODCM, a detailed report will be issued to the USNRC.

During 1996, only 1 indicator sample concentration equalled or exceeded an action level. The results of the investigation are summarized in Table D-2. The composite surface water sample collected in September at Station J1-2 contained H-3 at a concentration greater than 2000 pCi/L, the GPUN action level concentration for H-3 in surface water. The presence of H-3 in the sample was attributed to TMINS operations. Tritium at concentrations greater than background levels is not unexpected in surface water collected at Station J1-2. The samples are collected just downstream of the TMINS liquid discharge outfall where mixing of liquid effluents and river water is incomplete. Complete mixing is not usually achieved until the water passes over the York Haven Dam which is downstream of the sampling site. A dose estimate for ingesting water was not performed because the sample was non-potable water. The action level concentration was not reportable to the USNRC.

TABLE D-1

TMINS REMP Action Levels for Positive Radioactivity Concentrations in Environmental Samples

Analysis	Water[a] (pCi/L)	Airborne Particulates or Gases (pCi/m^3)	Fish (pCi/g, wet)	Milk (pCi/L)	Food Products (pCi/g, wet)
H-3	2000				
Mn-54	100		3		
Fe-59	40		1		
Co-58	100		3		
Co-60	30		1		
Zn-65	30		2		
Sr-90	4[b]	.05[b]	.05[b]	4[b]	.05[b]
Zr-Nb-95	40				
I-131	1[b]	.09		.3	.05[b]
Cs-134	3	1	.1	6	.1
Cs-137	5	2	.2	7	.2
Ba-La-40	20			30	

(a) Includes surface and drinking water.
(b) 50% of USNRC reporting level.

TABLE D-2

Investigations Conducted During 1996

Collection Date	Reason for Investigation	# of Indicator Samples Exceeding the Action Level	Conclusion of Investigation
1. August 26, 1996 to September 30, 1996	The composite surface water sample collected at indicator Station J1-2, located just downstream of the TMINS liquid discharge outfall, contained an H-3 concentration (4,100 ± 400 pCi/L) which equalled or exceeded the GPUN action level of 2000 pCi/L.	1	The H-3 identified in the water sample resulted from the discharge of this material from TMINS into the Susquehanna River. Concentrations of H-3 above background levels are expected in this sample because the collection site is located proximate to the TMINS liquid discharge outfall where mixing of effluents and river water is incomplete. Since the sample is raw (nonpotable) river water, a dose due to ingestion was not calculated. The result was not reportable to the USNRC.

APPENDIX E

1996 Quality Control Results

A quality assurance (QA) program is an essential part of any radiological environmental monitoring program (REMP). It provides reasonable assurance that the results of radiation measurements are valid. To be effective, elements of quality assurance must be evident in all phases of the monitoring program. These include, but are not limited to, sample collection, preservation and shipment, receipt of samples by the analysis laboratory, preparation and analysis of samples and data review and reporting. An effective QA program will allow for the identification of deficiencies in all monitoring processes so that appropriate investigative and corrective actions can be implemented.

The USNRC published Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment", which defines an acceptable QA program (Ref. 40). The guidance contained in Regulatory Guide 4.15 has been adopted by GPU Nuclear. To meet the objectives of this position document, procedures and plans have been written and implemented.

In the laboratory, samples are typically analyzed one time. Therefore, laboratory personnel must be reasonably confident with the analytical results which are generated. One means of achieving confidence in the results is through the analysis of quality control (QC) samples.

Three types of QC samples are routinely analyzed by the laboratories as part of the GPU Nuclear Three Mile Island Environmental Affairs REMP QA Program. They include intralaboratory split samples, cross-check program samples, and interlaboratory split samples. A discussion of each QC sample type is provided below.

Intralaboratory Split Samples

Each laboratory is required to split at a minimum every twentieth sample and perform an analysis (or analyses) on each portion. The samples which can not be split (e.g., air particulate filters) are counted twice. The results of the two analyses are then checked by staff scientists for agreement using the criteria defined in procedure 6510-SUR-4523.03. Agreement is considered acceptable if the coefficient of variation for the two values is eighty-five percent or less. Nonagreement of the sample concentrations may result in recounting or reanalyzing the sample(s) in question.

During 1996, all of the paired intralaboratory split sample results were found to agree.

Cross-check Program Samples

Each laboratory analyzing environmental samples for GPU Nuclear participates in two separate cross-check programs. Water samples are supplied by the USEPA; non-water samples (e.g., milk, filters and soil) are supplied by Analytics. All samples are sent to the laboratories as unknowns. Participation in these programs provides an independent check on the ability of each laboratory to

perform analyses on various kinds of samples containing detectable concentrations of radioactivity. The results submitted by the laboratories are compared to 1) limits established by the USEPA or 2) agreement criteria used by the NRC in their Configuratory Measurement Inspection Program. If the results are outside the established limits or agreement criteria, the laboratories are requested to perform an investigation and take corrective action as necessary.

The 1996 cross-check program results from each laboratory are listed in Appendix F. Explanations are provided for those results which were not submitted and/or which were not within the established limits.

Interlaboratory Split Samples

The third type of QC sample is the interlaboratory split sample. These samples are the ones which are collected routinely for the REMP. After or during the collection process, the sample is thoroughly mixed (as necessary) to ensure that, as much as possible, the distribution of radioactivity in the sample is homogeneous. The sample is then split into two portions. One portion is sent to the primary (main) lab and the other portion is sent to the QC laboratory.

Since it is impractical to split airborne materials (filters, charcoal cartridges, etc.) separate samples from independent, but colocated, samplers are collected and then sent to the analysis laboratories. Unfortunately, this practice of using distinctly different samples may result in higher than normal concentration differences for the two samples.

Analysis results from the QC laboratory are then compared to those from the primary laboratory. The agreement criteria is the same as that used for the intralaboratory split samples. Corrective action for disagreements may include recounting or reanalyzing the sample(s).

Table E-1 outlines the interlaboratory split sample program for 1996. There were two interlaboratory nonagreements during the entire year. An explanation is provided in Table E-2 for each nonagreement.

TABLE E-1

1996 Interlaboratory Split Sample Program

Sample Medium	No. of Primary Stations	No. of QC Stations	Percentage of Primary Samples Submitted for QC Analysis
Air Particulate (AP)	12	1	8 percent
Air Iodine (AI)	12	1	8 percent
Surface/Drinking Water (SW)	9	1	11 percent
Milk (M)	6	1	17 percent
TLDs (ID)	90	10	11 percent
Groundwater (GW)	19(1)	1	5 percent
Aquatic Sediment (AQS)	8(2)	1(2)	13 percent
Fish (AQF)	8(2)	1(2)	13 percent
Food Products (FPV,FPF,FPL)	32(2)	3(2)	9 percent
Meat (GAD)	0(3)	0(3)	Not applicable
Rodent (ROD)	2(2)	0(2)	0 percent

(1) Refers to the total number of stations routinely sampled and analyzed in 1996.

(2) Refers to the total number of samples collected and analyzed in 1996.

(3) Deer meat samples were not available in 1996.

TABLE E-2

1996 Interlaboratory Split Sample Nonagreements

Sample Medium	Collection Date	Station	Analysis	Action and/or Resolution
1. AP	07/02/96 - 10/01/96	E1-2	Gamma (K-40)	The primary and QC sample results were <0.03 pCi/m^3 and 0.00656 ± 0.00300 pCi/m^3, respectively. The nonagreement was due to counting the QC sample five times longer than the primary sample. No further action was taken because the QC sample concentration was below the estimated minimum detectable concentration (MDC) reported for the primary sample. Potassium-40 is a naturally-occurring radionuclide. Its presence in the QC sample was unrelated to TMINS operations.
2. GW	09/05/96 - 12/05/96	MS-2	Sr 90	The primary and QC sample results were 1.5 ± 0.5 pCi/L and <0.2 pCi/L, respectively. Since the primary sample result was inconsistent with historical concentrations, a reanalysis was requested and performed. The reanalysis yielded a concentration of <0.9 pCi/L. It did not confirm the original result. The laboratory reported that the sample holder used for counting the original sample was slightly contaminated.

APPENDIX F

1996 Cross-Check Program Results

TABLE F-1

1996 USEPA Cross-Check Program Results

Collection Date	Media	Nuclide	EPA Results (A)	GPUN-ERL Results (B)	Teledyne Brown Eng. Results (B)
01/23/96	Water	Sr-89	73.0 ± 8.7	75.33 ± 1.53	73.67 ± 3.21
		Sr-90	5.0 ± 8.7	8.33 ± 0.58	5.00 ± 0.00
01/26/96	Water	Alpha	12.1 ± 8.7	14.00 ± 1.00	19.00 ± 1.00
		Beta	7.0 ± 8.7	8.47 ± 1.15	7.13 ± 0.21
02/02/96	Water	I-131	67.0 ± 12.1	70.00 ± 1.00	71.67 ± 3.06
03/08/96	Water	H-3	22002.0 ± 3816.9	22000.00 ± 0.00	22000.00 ± 0.00
04/16/96	Water	Alpha	74.8 ± 32.4	69.33 ± 2.52	63.67 ± 2.89
		Beta	166.9 ± 43.4	156.67 ± 5.77	160.00 ± 0.00
		Co-60	31.0 ± 8.7	31.33 ± 2.08	31.67 ± 1.15
		Sr-89	43.0 ± 8.7	45.00 ± 1.00	41.33 ± 2.31
		Sr-90	16.0 ± 8.7	16.67 ± 1.15	15.33 ± 0.58
		Cs-134	46.0 ± 8.7	42.00 ± 1.73	42.33 ± 1.53
		Cs-137	50.0 ± 8.7	51.67 ± 1.53	52.33 ± 1.53
06/07/96	Water	Co-60	99.0 ± 8.7	98.67 ± 1.53	99.00 ± 1.73
		Zn-65	300.0 ± 52.0	326.67 ± 5.77	309.33 ± 2.08
		Ba-133	745.0 ± 130.1	770.00 ± 0.00	711.00 ± 71.42
		Cs-134	79.0 ± 8.7	75.33 ± 0.58	69.67 ± 1.53 (C)
		Cs-137	197.0 ± 17.3	206.67 ± 5.77	202.00 ± 2.65
07/12/96	Water	Sr-89	25.0 ± 8.7	30.33 ± 1.53	22.67 ± 1.53
		Sr-90	12.0 ± 8.7	10.33 ± 0.58	12.33 ± 1.15
07/19/96	Water	Alpha	24.4 ± 10.6	23.67 ± 0.58	22.67 ± 0.58
		Beta	44.8 ± 8.7	48.00 ± 3.00	45.33 ± 2.08
08/09/96	Water	H-3	10879.0 ± 1887.6	11000.00 ± 0.00	9800.00 ± 346.41
10/04/96	Water	I-131	27.0 ± 10.4	32.00 ± 3.00	26.33 ± 2.31
10/15/96	Water	Alpha	59.1 ± 25.7	59.33 ± 4.16	55.67 ± 5.03
		Beta	111.8 ± 29.1	106.67 ± 5.77	110.00 ± 0.00
		Co-60	15.0 ± 8.7	15.33 ± 0.58	14.67 ± 1.53
		Sr-89	10.0 ± 8.7	18.00 ± 3.61	9.00 ± 0.00
		Sr-90	25.0 ± 8.7	16.00 ± 1.00 (D)	26.00 ± 1.00
		Cs-134	20.0 ± 8.7	19.33 ± 0.58	19.67 ± 1.15
		Cs-137	30.0 ± 8.7	31.33 ± 0.58	29.33 ± 1.15

TABLE F-1

1996 USEPA Cross-Check Program Results

10/25/96	Water	Alpha	10.3	±	8.7	8.43	±	2.23	9.03	±	0.72
		Beta	34.6	±	8.7	35.33	±	1.53	39.67	±	0.58
11/8/96	Water	Co-60	44.0	±	8.7	45.67	±	0.58	4[illegible]	±	0.58
		Zn-65	35.0	±	8.7	37.67	±	2.08	38.67	±	0.58
		Ba-133	64.0	±	10.4	66.00	±	0.00	56.67	±	3.21
		Cs-134	11.0	±	8.7	11.67	±	0.58	12.00	±	0.00
		Cs-137	19.0	±	8.7	21.00	±	1.00	20.67	±	1.15

A. EPA Results - Expected Laboratory precision (control limit, ± 3 sigma, n = 3). Units are pCi/L.

B. Results - Average ± one standard deviation. Units are pCi/L.

C. The TBE Cs-134 result is below the control limit. To verify the cause for the deviation, a Cs-134 standard has been purchased. If the Cs-134 efficiency is lower than the efficiency at 604 Kev and 795 Kev, then rather than change those efficiencies (which may be needed for other isotopes of comparable energies), the Cs-134 branching intensity shall be adjusted.

D. The ERL Sr-90 result is below the control limit. Upon investigation it was found that the background count rate was 2.47 cpm. This was outside of the instrument background control limit and should not have been used. The sample holders are now being kept clean to prevent reoccurrence.

Criteria are listed in EPA 600/4-81-004

TABLE F-2

1996 ANALYTICS Cross-Check Program Results

Collection Date	Media	Nuclide	ANALYTICS Value (A)	Uncertainty (3 Sigma)	Uncertainty (1 Sigma)	Resolution	GPU Value (B)	Ratio	Min Ratio	Max Ratio	Agreement	
3/12/96	Filter	Alpha	12	1	0.3	36.0	10	0.83	0.75	1.33	Yes	
		Beta	85	4	1.3	63.8	74	0.87	0.8	1.25	Yes	
3/12/96	Filter	Ce-141	194	10	3.3	58.2	210	1.08	0.8	1.25	Yes	
		Cr-51	719	36	12.0	59.9	760	1.06	0.8	1.25	Yes	
		Cs-134	128	6	2.0	64.0	120	0.94	0.8	1.25	Yes	
		Cs-137	141	7	2.3	60.4	150	1.06	0.8	1.25	Yes	
		Co-58	106	5	1.7	63.6	110	1.04	0.8	1.25	Yes	
		Mn-54	70	3	1.0	70.0	75	1.07	0.8	1.25	Yes	
		Fe-59	186	9	3.0	62.0	210	1.13	0.8	1.25	Yes	
		Zn-65	215	11	3.7	58.6	230	1.07	0.8	1.25	Yes	
		Co-60	169	8	2.7	63.4	180	1.07	0.8	1.25	Yes	
3/12/96	Cartridge	I-131	92	5	1.7	55.2	91	0.99	0.8	1.25	Yes	
3/12/96	Filter	Sr-90	36	2	0.7	54.0	26	0.72	0.8	1.25	No	Yes "B" Agreement (1 result see Note D)
3/12/96	Milk	Ce-141	234	12	4.0	58.5	170	0.73	0.8	1.25	No	Out of Range
		Ce-141*	234	12	4.0	58.5	240	1.03	0.8	1.25	Yes	* Corrected Results (see Note C)
		Cr-51	858	43	14.3	59.9	790	0.92	0.8	1.25	Yes	
		Cs-134	154	8	2.7	57.8	140	0.91	0.8	1.25	Yes	
		Cs-137	170	9	3.0	56.7	170	1.00	0.8	1.25	Yes	
		Co-58	128	6	2.0	64.0	130	1.02	0.8	1.25	Yes	
		Mn-54	84	4	1.3	63.0	84	1.00	0.8	1.25	Yes	
		Fe-59	223	11	3.7	60.8	240	1.08	0.8	1.25	Yes	
		Zn-65	260	13	4.3	60.0	290	1.12	0.8	1.25	Yes	
		Co-60	204	10	3.3	61.2	200	0.98	0.8	1.25	Yes	
3/12/96	Milk	I-131	13	1	0.3	39.0	15	1.15	0.75	1.33	Yes	(1 result see Note D)
3/12/96	Milk	Sr 89	31	2	0.7	46.5	20	0.65	0.75	1.33	No	Yes "B" Agreement
		Sr-90	16	1	0.3	48.0	22	1.38	0.75	1.33	No	Yes "B" Agreement
3/12/96	Soil	Ce-141	0.323	0.02	0.007	48.5	0.3	0.93	0.75	1.33	Yes	
		Cr-51	1.182	0.06	0.020	59.1	1.175	0.99	0.8	1.25	Yes	
		Cs-134	0.212	0.01	0.003	63.6	0.175	0.83	0.8	1.25	Yes	
		Cs-137	0.332	0.02	0.007	49.8	0.325	0.98	0.75	1.33	Yes	
		Co-58	0.176	0.01	0.003	52.8	0.163	0.93	0.8	1.25	Yes	
		Mn-54	0.116	0.01	0.003	34.8	0.119	1.03	0.75	1.33	Yes	
		Fe-59	0.307	0.02	0.007	46.1	0.313	1.02	0.75	1.33	Yes	
		Zn-65	0.358	0.02	0.007	53.7	0.363	1.01	0.8	1.25	Yes	
		Co-60	0.281	0.01	0.003	84.3	0.288	1.02	0.8	1.25	Yes	

TABLE F-2

1996 Analytics Cross-Check Program Results

Notes:

A. Units are pCi/L for Milk, pCi/g (dry) for Soil and total pCi for Filter and Cartridge.

B. GPU Value is an average of three or more determinations. Units are pCi/L for Milk, pCi/g (dry) for Soil and total pCi for Filter and Cartridge.

C. The value reported to Analytics was in error (Mean of 233.4+242.0+**24.5** instead of 233.4+242.0+**245**)

D. Due to insufficient sample only 1 analysis was performed.

To determine agreement or possible agreement:

1. Divide each Analytics value by its associated one sigma uncertainty to obtain the resolution.
2. Divide each GPU value by the corresponding Analytics value to obtain the ratio.
3. The GPU measurement is in agreement if the value of the ratio falls within the limits shown in the following table for the corresponding resolution.

Resolution	Agreement	Agreement "A" Criteria	Agreement "B" Criteria
< 3	no comp	no comp	no comp
≥ 3 - < 4	0.4 - 2.5	0.3 - 3.0	no comp
≥ 4 - < 8	0.5 - 2.0	0.4 - 2.5	0.3 - 3.0
≥ 8 - < 16	0.6 - 1.67	0.5 - 2.0	0.4 - 2.5
≥ 16 - < 51	0.75 - 1.33	0.6 - 1.67	0.5 - 2.0
≥ 51 - < 200	0.80 - 1.25	0.75 - 1.33	0.6 - 1.67
≥ 200	0.85 - 1.18	0.80 - 1.25	0.75 - 1.33

"A" criteria are applied to the following analyses:

Gamma Spectrometry where the principal gamma energy used for identification is greater than 250 kev,

Tritium analyses of liquid samples and

Low-level I-131.

"B" criteria are applied to the following analyses:

Gamma Spectrometry where the principal gamma energy used for identification is less than 250 kev,

Sr-89 and Sr-90 determinations and

Gross Alpha and Beta.

Criteria are similar to those listed in USNRC Inspection Procedure 84750 with minor adjustments to account for activity concentrations with large uncertainties.

TABLE F-3

1996 ANALYTICS Cross-Check Program Results

Collection Date	Media	Nuclide	ANALYTICS Value	Teledyne Brown Engineering Value (A)	Ratio (B)
3/12/96	Water	I-131	36 ± 2	39 ± 5	1.08
		Ce-141	88 ± 4	89 ± 9	1.01
		Cr-51	322 ± 16	330 ± 30	1.02
		Cs-134	58 ± 3	53 ± 5	0.91
		Cs-137	64 ± 3	65 ± 7	1.02
		Co-58	48 ± 2	49 ± 5	1.02
		Mn-54	31 ± 2	37 ± 4	1.19
		Fe-59	83 ± 4	93 ± 9	1.12
		Zn-65	97 ± 5	100 ± 10	1.03
		Co-60	76 ± 4	81 ± 8	1.07
3/12/96	Milk	I-131	13 ± 1	16 ± 6	1.23
		Ce-141	234 ± 12	240 ± 20	1.03
		Cr-51	858 ± 43	880 ± 90	1.03
		Cs-134	154 ± 8	150 ± 20	0.97
		Cs-137	170 ± 9	180 ± 20	1.06
		Co-58	128 ± 6	140 ± 10	1.09
		Mn-54	84 ± 4	93 ± 9	1.11
		Fe-59	223 ± 11	250 ± 30	1.12
		Zn-65	260 ± 13	260 ± 30	1.00
		Co-60	204 ± 10	220 ± 20	1.08
3/12/96	Water	Sr-89	24 ± 1	30 ± 4	1.25
		Sr-90	21 ± 1	23 ± 2	1.10
3/12/96	Milk	Sr-89	31 ± 2	30 ± 4	0.97
		Sr-90	16 ± 1	17 ± 1	1.06
3/12/96	Water	H-3	2982 ± 149	2800 ± 200	0.94
6/19/96	Filter	Alpha	35 ± 2	37 ± 3	1.06
		Beta	144 ± 7	150 ± 10	1.04
6/19/96	Filter	Ce-141	400 ± 20	500 ± 50	1.25
		Cr-51	1048 ± 52	1200 ± 100	1.15
		Cs-134	310 ± 16	310 ± 30	1.00
		Cs-137	764 ± 38	910 ± 90	1.19
		Co-58	173 ± 9	210 ± 20	1.21
		Mn-54	559 ± 28	690 ± 70	1.23
		Fe-59	144 ± 7	190 ± 20	1.32
		Zn-65	108 ± 5	140 ± 10	1.30
		Co-60	156 ± 8	180 ± 20	1.15
6/19/96	Filter	Sr-90	74 ± 4	71 ± 3	0.96
6/19/96	Filter	Sr-90	49 ± 2	64 ± 3	1.31
6/19/96	Filter	Sr-90	63 ± 3	66 ± 4	1.05

TABLE F-3

1996 ANALYTICS Cross-Check Program Results

Notes:

A. Teledyne Results -Results are one determination, counting error is two standard deviations. Units are pCi/liter for water and milk. For gamma results, if two standard deviations are less than 10%, than a 10% error is reported. Units are total pCi for air particulate filters.

B. Ratio of Teledyne Brown Engineering to Analytics results.

To determine agreement or possible agreement:

1. Divide each Analytics value by its associated one sigma uncertainty to obtain the resolution.
2. Divide each value by the corresponding Analytics value to obtain the ratio.
3. The measurement is in agreement if the value of the ratio falls within the limits shown in the following table for the corresponding resolution.

Resolution	Agreement	Agreement "A" Criteria	Agreement "B" Criteria
< 3	no comp	no comp	no comp
≥ 3 - < 4	0.4 - 2.5	0.3 - 3.0	no comp
≥ 4 - < 8	0.5 - 2.0	0.4 - 2.5	0.3 - 3.0
≥ 8 - < 16	0.6 - 1.67	0.5 - 2.0	0.4 - 2.5
≥ 16 - < 51	0.75 - 1.33	0.6 - 1.67	0.5 - 2.0
≥ 51 - < 200	0.80 - 1.25	0.75 - 1.33	0.6 - 1.67
≥ 200	0.85 - 1.18	0.80 - 1.25	0.75 - 1.33

"A" criteria are applied to the following analyses:
Gamma Spectrometry where the principal gamma energy used for identification is greater than 250 kev,
Tritium analyses of liquid samples and
Low-level I-131.

"B" criteria are applied to the following analyses:
Gamma Spectrometry where the principal gamma energy used for identification is less than 250 kev,
Sr-89 and Sr-90 determinations and
Gross Alpha and Beta.

Criteria are similar to those listed in USNRC Inspection Procedure 84750 with minor adjustments to account for activity concentrations with large uncertainties.

APPENDIX G

1996 Land Use Census

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
1.9km (1.2mi) N 1	5° A		--	--	--	2 Goats	0	--	--	All year but mainly store bought feed
3.3km (2.1mi) N 2	3° A		Cows, goats, sheep and horses are periodically kept here for quarantine from a few days to a few weeks. Animals are then shipped interstate or to foreign countries. If milked, milk is used as animal feed.							Animals graze for short periods prior to exportation. Occasionally they receive feed
5.3km (3.3mi) N [3]	10° A		Holstein	44 Cows 65 Heifers	0	--	--	3 Hens 1 Rooster 3 Rabbits	--	Cows are confined to silage and grains which are partially grown on farm. Calves on feed
8.5km (5.3mi) N 4	3° A		Holstein	135 Cows 160 Heifers	135	--	--	--	Atlantic Dairy Co-Op & Own Use	April 15 to October. Silage & grains are home grown
8.6km (5.3mi) N 5	358° A		--	--	--	--	--	32 Beef Cattle	Sold at Lebanon Valley Auction	April to October. Feed is home grown
6.4km (4.0mi) NNE 6	24° B		--	--	--	--	--	8 Chickens	Eggs are for Own Use	Store bought feed plus out all year
6.3km (3.9mi) NE 7	35° C		--	--	--	--	--	70 Beef Cattle (Simmentals & Angus)	Some sold at Lebanon Valley Auction & Own Use. Some Show Animals Sold at 4-H. Breeding stock sold in western PA, VA, NY, etc..	May to October. Feed is home grown

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
6.6km (4.1mi) NE 8	35° C		Holstein	120 Cows 100 Heifers	120	--	--	75 Steers	Atlantic Dairy Co-Op & Own Use	Milk cows are on home grown feed. Heifers graze June to October
7.0km (4.4mi) NE 9	48° C		Holstein	140 Cows 125 Heifers	125	--	--	--	Atlantic Dairy Co-Op & Own Use	Confined to their own silage (Heifers graze May 15 - Oct.1)
1.7km (1.1mi) ENE [10]	65° D		Holstein	100 Cows 75 Heifers	80-85	--	--	1 Steer 20 Sheep	Mt. Joy Co-op & Own Use. Steer is for Own Use	May 1 to November 1 plus hay & corn
2.0km (1.3mi) ENE 11	75° D		--	--	--	--	--	4 Steers	Half sold Privately & Half Sold for Own Use	All Summer/Hay in Winter
4.5km (2.8mi) ENE 12	72° D		--	--	--	1	0	8 Sheep	Own Use	Store bought feed & graze most of year
6.7km (4.2mi) ENE 13	59° D		Holstein	58 Cows 60 Heifers & Calves	52	--	--	--	Harrisburg Dairy & Own Use	May 1 to November 1. Feed is home grown
7.2km (4.2mi) ENE 14	57° D		Holstein	82 Cows 70 Heifers & Calves	72	--	--	--	Mt. Joy Co-Op & Own Use	April to November
7.5km (4.7mi) ENE 15	71° D		Holstein	75 Cows 50 Heifers	65	--	--	--	Mt. Joy Co-op & Own Use	May to October
1.8km (1.1mi) E [16]	93° E		Holstein	110 Cows 80 Heifers & Calves	110	--	--	--	Mt.Joy Co-op	April to November plus home-grown feed

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
5.6km (3.5mi) E 17	96° E		Holstein	65Cows 23 Heifers	56	--	--	--	Mt. Joy Co-op & Own Use	April to October/ Winter on Silage & Hay
4.0km (2.5mi) ESE 18	112° F		--	--	--	--	--	100 Pigs	Pigs are raised & then transported to Hatfield or Groff's Meat Market	Store Bought feed
4.7km (2.9mi) ESE 19	107° F		--	--	--	2	0	10 Chickens 16 Sheep	Own Use + eggs to neighbors & friends. Lambs will go to Lancaster Stock Yard, neighbors & friends. Sheep meat sold to neighbors	All year
5.2km (3.2mi) ESE [20]	104° F		Holstein	75 Cows 50 Heifers	64	--	--	70,000 Chickens	Mt Joy Co-op & Chickens to Wengert Feeds	May to November/ Winter on stored silage & hay
5.7km (3.6mi) ESE 21	117° F		Holstein	32 Cows 12 Heifers & Calves	30	--	--	--	Atlantic Dairy & Co Op. & Neighbors	May to November
6.1km (3.8mi) ESE 22	113° F		Holstein	102 Cows 70 Heifers	95	--	--	1200 Hogs 10 Steers	Atlantic Dairy Co-Op. Beef Cows & Hogs Sold at Hatfield and at the Stock Yards	May to October. Dairy Cows are on silage
6.6m (4.1mi) ESE 23	113° F		--	--	--	--	--	38 Beef Cattle 35 Sheep 3 Pigs	Lancaster Stock Yards	May to November Winter on Silage & Hay

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
6.9km (4.3mi) ESE 24	114° F		--	--	--	--	--	45 Beef Cattle (Angus, Hereford & Holstein)	Sold Locally, Own Use & Steers Sold at Lanc. Stock Yards, New Holland Auction & Minnich Sales	All Year
7.6km (4.7mi) ESE 25	121° F		--	--	--	--	--	12 Steers (Angus & Holstein) 36,000 Chickens	Steers sold at New Holland Auction & Vintage Sales Stable. Chickens sold to Empire in Mifflentown, PA	Confined to home-grown hay & corn
8.1km (5.0mi) ESE 26	115° F		Holstein	52 Cows 40 Heifers	49	--	--	28,000 Chickens (Broilers) & 2 Steers	Atlantic Dairy Co-Op. Chickens sold commercially to Pennfield, Roherstown. Steer Own Use	April to October/ Winter on silage
8.1km (5.0mi) ESE 27	119° F		--	--	--	--	--	35 Steers (Angus & Holstein)	Sold Locally & at Lancaster Stock Yard	May to November. Winter on silage & hay
8.2km (5.1mi) ESE 28	113° F		--	--	--	--	--	85,000 Chickens (Broilers)	Sold to Tyson	--
8.2km (5.1mi) ESE 29	122° F		--	--	--	--	--	30 Sheep 1600 Hogs 1 Steer	Sold at Groffs & Lancaster Stock Yard.	Sheep graze April to October/Store-bought feed & 4 acres of pasture in winter
8.3km (5.1mi) ESE 30	123° F		Holstein	150 Cows 90 Heifers	125	--	--	105,000 Chickens (Broilers)	Atlantic Dairy Co-Op & Chickens Sold Commercially to Tyson	Dairy Cows con- fined to own feed/Heifers graze May to October

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
8.5km (5.3mi) ESE 31	103° F		Ayrshire & Holstein	137 Cows 95 Heifers	115	--	--	164 Beef Cattle 1300 Hogs 4 Bulls	Harrisburg Dairy & Livestock sold at local markets. Hogs go to Groff's Meat Market.	May to November Winter on silage & hay
1.8km (1.1mi) SE 32	124° G		--	--	--	1	0	100 Beef Cattle (Holstein) 350,000 Chickens 10 Sheep 110,000 Pullets	Eggs sold to Quaker State. Beef sold at Moyers (Mo Pac). Sheep for Own Use. Also sold locally.	Cattle confined to home-grown hay & silage. Chickens on store-bought feed
2.3km (1.4mi) SE [33]	130° G		Holstein Ayrshire	60 Cows 20 Heifers	55	--	--	10 Steers	National Farmers Organization & Steers Sold at Lancaster Stock Yard	April to November/Winter on silage & hay
4.4km (2.8mi) SE 34	134° G		--	--	--	--	--	43 Beef Cattle (Angus, Hereford & Charlais)	Lancaster Stock Yard	All year.
6.0km (3.8mi) SE 35	141° G		--	--	--	--	--	50 Beef Cattle (Charlais & Limousine) 250 Pigs	Sold at New Holland Vintage, Lancaster & pigs sold at various markets including Groff's Meat Market	Cattle on pasture all year plus feed/Calves on feed (hay & silage) in winter
6.5km (4.0mi) SE 36	141° G		Holstein	60 Cows 50 Heifers & Calves	65	3	0	3 Bulls (calves)	Mt.Joy Co-op & Own Use plus shared with friends	April to November plus silage all year/ Milking cows only on silage & hay

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
6.6km (4.0mi) SE 37	129° G		Holstein	160 Cows 150 Heifers	150	--	--	116 Steers	Mt.Joy Co-op & Steers Sold at Auction (New Holland & Vintage)	April to October but mostly silage. Milk Cows only on silage & hay
7.2km (4.5mi) SE 38	137° G		--	--	--	--	--	6 Steers (Angus) 1 Calf	Own Use	All year
7.4km (4.6 mi) SE 39	136° G		--	--	--	--	--	25 Chickens	Own Use	Store bought feed & scraps
7.9km (4.9mi) SE 40	131° G		--	--	--	--	--	90,000 Chickens 60 Steers	Eggs are Sold Commercially to Quaker State Farms & Own Use. Beef to Lancaster Stock Yard or New Holland	Silage all year
5.3km (3.3mi) S 41	180° J		--	--	--	--	--	70 Beef Cattle (Hereford & Black Angus	Sold at Auction in Lancaster & Own Use	May to December. Corn & silage rest of the year
4.0km (2.5mi) SSW 42	192° K		--	--	--	--	--	1 Steer	Own Use	Graze year round plus store bought feed
7.8km (4.9 mi) SSW 43	200° K		Holstein	70 Cows 50 Heifers	62	--	--	1 Sheep (Pet)	Atlantic Dairy Co-Op	April 15 to October 15

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
20.6km (12.8mi) SSW [44]	208° K		Jersey Holstein Ayrshire Brown Swiss Guernsey Milking Shorthorn	188 Cows 70 Heifers & Calves	155	--	--	13 Hens 1 Rooster 18 Turkeys 4 Rabbits	Atlantic Dairy Co-Op	Cows on store bought feed. Other animals graze April to November plus haylage, silage and grain year round.
4.3km (2.8mi) SW 45	226° L		--	--	--	--	--	12 Beef Cattle (Angus, Hereford & Charlais)	Lancaster Stock Yard	May to November
6.0km (3.7mi) SW 46	233° L		--	--	--	2 Nannies	0	2 Sheep 4 Chickens 1 Rabbit	Own Use	Goats graze all year. Other animals use feed.
6.5km (4.0mi) WSW 47	242° M		--	--	--	--	--	300 Chickens 30 Guineas	Distributed Locally & Own Use	Most confined to chicken house for feeding. Some run loose.
7.1km (4.4mi) WSW 48	238° M		--	--	--	1 Nanny	0	20 Chickens 15 Geese 12 Ducks	Own Use. Eggs from Chickens & Ducks	Goat grazes May to October
5.0km (3.1mi) WNW 49	286° P		--	--	--	--	--	16 Cows (Black Angus) 1 Bull 8 Calves (Bulls)	Own Use & Occasionally Distributed Locally	April to December
5.8km (3.6mi) WNW 50	284° P	***	--	--	--	--	--	30 Beef Cattle (Holstein) 15 Chickens	Beef Own Use & Some to Auction. Eggs Own Use	Most of the year

TABLE G-1
1996 ANNUAL DAIRY AND LIVESTOCK CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Livestock	Dairy Used	Grazing Period
6.0km (3.7mi) WNW 51	295° P		Holstein Jersey Brown Swiss	80 Cows	45	12 Nannies	0	20 Geese	Atlantic Dairy Co-Op	May to October
10.8km (6.7mi) WNW [52]	293° P		Holstein	47 Cows 52 Calves & Heifers	40	--	--	--	Rutters Dairy & Own Use	May to October plus stored feed
TOTALS			Holstein, Jersey, Ayrshire, Brown Swiss, Guernsey, Milking Shorthorn	2,152 Cows 1,557 Heifers & Calves	1,870	24	0	999 Beef Cattle (Includes Steers, Cows & Calves) 16 Bulls 4,453 Pigs & Hogs 874,400 Chickens 35 Geese 12 Ducks 8 Rabbits 122 Sheep 30 Guineas 18 Turkeys	Atlantic Dairy Co-Op, Mt.Joy Co-op, Harrisburg Dairy, Rutters Dairy, National Farmers Organization	Various

* Includes livestock which are used only for human consumption and all dairy farms within approximately five miles of TMINS plus regularly sampled milk farms.
** Names and addresses are on file at Three Mile Island Environmental Affairs.
*** Indicates new farm/livestock owner this census.
# In lower right-hand corner of the first column indicates running total of farms surveyed.
[#] Bracketed #'s indicate regularly sampled milk farms.

TABLE G-2

1996 Annual Residence Census*

Distance and Direction	Azimuth and Sector Code	Name, Address** & Telephone No.	Distance and Direction	Azimuth and Sector Code	Name, Address** & Telephone No.
6,000 ft. (1,839 m) N	5° A		12,000 ft. (3,658 m) S	186° J	
3,800 ft. (1,158 m) NNE	28° B		3,400 ft. (1,036 m) SSW	213.7° K	
2,800 ft. (853 m) NE	48° C		2,850 ft. (869 m) SW	226° L	
2,450 ft. (747 m) ENE	67.5° D		2,500 ft. (777 m) WSW	250° M	
2,300 ft. (700 m) E	80° E		1,850 ft. (564 m) W	272° N	
5,800 ft. (1,770 m) ESE	123° F		1,900 ft. (579 m) WNW	293° P	
3,750 ft. (1,143 m) SE	145° G		2,150 ft. (655 m) NW	306° Q	
3,750 ft. (1,143 m) SSE	152° H		3,500 ft. (1,067 m) NNW	337.5° R	

* Census identifies nearest residence in each of the sixteen meteorological sectors.

** Names and addresses are on file at Three Mile Island Environmental Affairs.

TABLE G-3

Annual Garden Census 1996*

Meteorological Sector Designation	Distance and Direction	Azimuth	**Name, Address & Phone Number	Type of Vegetation	How Used and Distribution of Consumers
A (1)	2.4km (1.5mi) N	4°		Pumpkins, Tomatoes, Squash, Lettuce, Garlic, Zucchini, Corn, Potatoes	Own Use 3 Adults Also given away to other family members, friends & neighbors
B (2)	1.4km (0.9mi) NNE	24°		Winter Turnips, Radishes, Cauliflower, Corn, Peppers, Cabbage, Tomatoes, Asparagus, Horse Radish, Onions, Blueberries, Rhubarb, Strawberries, Broccoli, Beans, Peas, Potatoes	Own Use 3 Adults Also given away to family, friends & neighbors.
C (3)	1.4km (0.85mi) NE	34°		Tomatoes, Peppers, Corn, Lettuce, Carrots, Radishes, Cucumbers	Own Use 2Adults 3 Children
D (4)	2.3km (1.4mi) ENE	73°		Cabbage, Lettuce, Tomatoes, Peppers, Potatoes, Corn, Watermelon, Green Beans, Cantaloupes, Yellow Wax Beans	One Use 2 Adults Also given away to family
E (5)	0.7km (0.5mi) E	94°		Cabbage, Tomatoes, Peppers, Red Beets, Potatoes, Corn	Grown primarily for GPUN REMP. Excess consumed by GPUN personnel and their families.
F (6)	0.8km (0.5mi) ESE	120°		See "E"	See "E"
G (7)	1.0km (0.6mi) SE	135°		Wide assortment of food products including broad-leaf vegetables (cabbage)	Own Use 2 Adults. Also given away to relatives & sold along Rt. 441 at the Red Hill Farm Produce Stand, at the Farm Show Building Farmers Market and at the Hometown Market in Hazelton. Excess goes to Leola Produce Auction.
H (8)	1.1km (0.7mi) SSE	152°		Green Beans, Tomatoes, Onions, Peppers, Strawberries, Rhubarb, Asparagus, Radishes, Turnips	Own Use 3 Adults Also given away to neighbors & friends
J (9)	3.7km (2.3mi) S	186°		Tomatoes, Corn, Melons, Cabbage, Cucumbers, Peppers, Strawberries, Watermelon, Pumpkins	Own Use 2 Adults 1 Child 1 Teen Also given away to family & friends
K (10)	3.5km (2.2mi) SSW	197°		Lettuce, Carrots, Tomatoes, Potatoes, Cantaloupes, Peppers, String Beans, Watermelon, Parsley, Egg Plant, Radishes, Red Beets, Zuchinni	Own Use 2 Adults 3 Children Also shared with family

TABLE G-3

Annual Garden Census 1996*

Meteorological Sector Designation	Distance and Direction	Azimuth	**Name, Address & Phone Number	Type of Vegetation	How Used and Distribution of Consumers
L (11)	2.9km (1.8mi) SW	225°		Lettuce, Corn, Tomatoes, Peppers, Egg Plant, Watermelon, Cantaloupes, Onions, Cucumbers	Own Use 2 Adults 2 Children Also shared with neighbors
M (12)	2.1km (1.3mi) WSW	253°		Endive, Potatoes, Beans, Cabbage, Turnips, Peas, Zucchini, Onions, Lettuce, Tomatoes, Peppers, Egg Plant, Strawberries, Corn, Neck Pumpkins	Own Use 2 Adults Also infrequently sold locally and some given away to friends & neighbors
N (13)	2.1km (1.3mi) W	265°		Tomatoes, Potatoes, Red Beets, Peppers, Onions, String Beans, Cabbage, Cucumbers, Rhubarb	Own Use 2 Adults Also some given away to friends, neighbors & family
P (14)	2.4km (1.5mi) WNW	287°		Brussel Sprouts, Blueberries, Peppers, Zucchini, Tomatoes, Lettuce, Potatoes, Watermelon, Cantaloupes, Raspberries, Pumpkins Cucumbers, Broccolli, Onions	Own Use 2 Adults 1 Teen 2 Children Also given away to family
Q (15)	2.4km (1.5mi) NW	310°		Peppers, Tomatoes, Rhubarb, Grapes, Strawberries (Identifiable vegetation only; there may be additional vegetation produced)	Own Use 6 Adults (Assuming 2 adults per each of 3 plots identified during census)
R (16)	3.9km (2.4mi) NNW	346°		Tomatoes, Cucumbers, Peas, Beans, Peppers, Cabbage, Carrots	Own Use 2 Adults 1 Child Also shared with family & friendss

* Census identifies nearest garden (greater than 500 ft^2 and having a portion of broad-leaf vegetation) in each of the sixteen meteorological sectors.

** Names and addresses are on file at Three Mile Island Environmental Affairs.

APPENDIX H

Data Reporting and Analysis

Environmental samples frequently contain very little, if any, radioactivity. Even when very sensitive, state-of-the-art counting equipment is used, many of the sample count rates can not be differentiated from the background count rate or the count rate of the blank sample. When this occurs, the sample is said to have a radioactivity level or concentration at or below the sensitivity of the analyses method. In this case, the analysis result is reported as less than a numerical value which corresponds to the sensitivity of the analysis method. Sensitivities are influenced by parameters such as sample volume, background or blank sample count rate and efficiency of the counting device.

The terms used to describe the sensitivity are the lower limit of detection (LLD) and minimum detectable concentration (MDC). For this report, these two terms are considered to be synonymous. They are defined as:

$$\text{LLD (MDC)} = \frac{4.66\ Sb}{E * V * 2.22 * Y * \exp(-\lambda\ \Delta t)}$$

where:

Sb	=	the standard deviation of the background counting rate or the counting rate of a blank sample, as counts per minute,
E	=	the counting efficiency of the equipment, as counts per disintegration,
V	=	the volume or mass of the sample, such as L, g or m^3,
2.22	=	the number of disintegrations per minute per picocurie,
Y	=	the chemical yield, if applicable,
λ	=	the radioactive decay constant for the particular radionuclide and
Δt	=	the elapsed time between sample collection (or end of sample collection period) and counting.

The applicable LLD or MDC for each radionuclide and analysis is listed in Table 3. A large percentage of the 1996 sample results were reported as less than the LLD or MDC. Results which were reported as less than the LLD or MDC were not included in the calculations of averages, standard deviations and ranges (by station or group) in the text and tables of this report.

The data from samples which contained concentrations above the LLD or MDC were used in the calculations (averages, standard deviations and ranges) contained in this report. The individual results were generally reported to two significant figures. Each result also included a two-sigma counting uncertainty (95% confidence interval) to the same decimal place. At a minimum, a counting uncertainty equal to 10 percent of the measured concentration was reported. The counting uncertainties were not used in any statistical calculations in this report.

The data used in a few tables and all annual graphs were actual sample concentrations. For historical graphs, actual sample concentrations were used for 1996 data points only. The actual concentration is calculated by subtracting the background count rate or the count rate of a blank sample from the count rate of the sample. The net count rate is the converted to a net sample concentration which is either positive, negative or zero.

There are several advantages of using actual sample concentrations. Biases in the data (averages, ranges, etc.), such as those caused by averaging only sample concentrations above the MDC, are eliminated. Missing data points on graphs also are eliminated. It should be noted that negative sample concentrations are important to the overall averages and trends in the data, but they have no physical significance. A negative sample concentration simply means that the background or blank sample count rate is greater than the sample.

All sample data were analyzed using SAS, a statistical analysis package developed by SAS Institute, Inc. The data were grouped by station, time period and by control and indicator status. Minimum, maximum and average values were calculated for each of these groups as well as standard deviations (2σ, 95% confidence interval).

Quality control results (interlaboratory and intralaboratory) were not statistically analyzed with other data. Including quality control data would introduce a bias at selected stations while providing little additional interpretive information.

APPENDIX I

1996 Dose Calculation Methodology and Results

To the extent possible, radiological impacts were evaluated based on the measurement of exposure rates or radionuclide concentrations in environmental samples. However, the radioactive materials released from TMINS during 1996 were often too small to be measured once dispersed in the offsite environment. As a result, the potential offsite doses were estimated by using computerized models that predict concentrations of radioactive materials in the environment and subsequent radiation doses on the basis of radionuclides released to the environment. GPU Nuclear calculates doses using an advanced class "A" dispersion model called SEEDS (simplified environmental effluent dosimetry system).

This model incorporates the guidelines and methodology set forth in USNRC Regulatory Guide 1.109, and uses actual monthly Susquehanna River flow data and hourly meteorological information matched to the time of releases to assess the dispersion of effluents in the river and the atmosphere. Combining this assessment of dispersion and dilution with TMINS effluent data for each unit, postulated maximum hypothetical doses to the public are calculated. The maximum individual dose is calculated as well as the population dose to the total population within 50 miles of TMINS for gaseous effluents and the entire population using Susquehanna River water downstream of the station for liquid effluents. Values of environmental parameters and radionuclide concentration factors were chosen to provide conservative results. As a result, the doses calculated using this model are conservative estimates (i.e., overestimated).

The dose summary tables, Table I-1 and I-2, present the maximum hypothetical doses to an individual resulting from TMI-1 and TMI-2 effluents, respectively, during the 1996 reporting period. Population doses for both units also are presented in Table I-1 and Table I-2.

Liquid (Individual)

The first two lines of Table I-1 and Table I-2 present the maximum hypothetical dose to an individual from liquids. Presented are the total body and critical organ doses due to the radionuclides in the liquid effluents. As recommended in USNRC Regulatory Guide 1.109, calculations are performed on the four age groups and eight organs. The pathways considered were water ingestion, shoreline exposure, and fresh water sportfish ingestion. The latter two pathways are considered to be the primary recreational activities associated with the Susquehanna River in the vicinity of TMINS. The "receptor" would be that individual who drinks water from the Susquehanna River, eats fish that reside in the plant discharge, and stands on the shoreline influenced by the plant discharge. The tables present the maximum total body dose and critical organ dose for the age group most effected.

For the 1996 reporting period, the calculated maximum hypothetical total body dose received by anyone from TMINS liquid effluents would have been 0.107 mrem (TMI-1) and 0.00148 mrem (TMI-2) to an adult. These represent 3.57 percent and 0.0493 percent, respectively, of the USNRC 10 CFR 50 App. I annual guidelines. The maximum hypothetical organ dose from TMI-and TMI-2 liquid effluents would have been 0.157 mrem to the liver of a teenager and

0.00229 mrem, to the bone of a child, respectively. These represent 1.57 percent and 0.0229 percent, respectively of the USNRC 10 CFR 50 App. I annual guidelines.

Gaseous (Individual)

There were six major pathways considered in the dose calculation for gaseous effluents. These are: (1) plume exposure, (2) inhalation, consumption of (3) cow milk, (4) fruits and vegetables, (5) meat, and (6) standing on contaminated ground. Ingestion of goat milk was not considered because this pathway did not exist in 1996. Real-time meteorology (the actual conditions that existed at the time of releases) was used in dose calculations for gaseous effluents. Default values were used if data were missing or invalid.

Lines 3 and 4 of Table I-1 and Table I-2 present the maximum plume exposures from noble gases at the site boundary. The notation of "air dose" is interpreted to mean that these doses are not to an individual but are considered to be the maximum dose at a location. The location is not necessarily a receptor. The tables present the distance in meters and the affected sector (compass point). With respect to the noble gas releases for the 1996 reporting period, the maximum plume exposure (air dose) would have been 0.000253 and 0.000210 millirads (mrad) for TMI-1, gamma and beta, respectively. The TMI-1 exposures represent 0.00253 and 0.00105 percent of the USNRC 10 CFR 50 App. I annual guidelines, respectively. Since TMI-2 released no noble gases, the gamma and beta air doses are zero.

Lines 5 and 6 present the calculated dose from noble gases to the closest receptor (individual) in the maximally affected sector(s). The location of the receptor is described by both distance (meters) and direction from the site. Plume doses to an individual, regardless of age, from gaseous effluents (noble gases only) during the 1996 reporting period were 0.000120 mrem and 0.000212 mrem for TMI-1 total body and skin dose, respectively. These represent equal to or less than 0.00240 percent of the USNRC 10 CFR 50 App. I annual guidelines. Since TMI-2 released no noble gases, the total body and skin doses were zero.

Line 7 represents the dose to the maximally exposed organ due to airborne releases of iodines, tritium and particulates. This does not include the whole body plume dose which was separated out on line 5. The doses presented in this section again reflect the maximum exposed organ for the appropriate age group.

During 1996, iodines, tritium and particulates released into the atmosphere from TMI-1 would have resulted in a maximum dose of 0.000516 mrem to the thyroid of a child. The corresponding dose from TMI-2 was 0.0000714 mrem to the liver of a child. No other organ of any age group would have received a dose greater than this from either TMI-1 or TMI-2. Both of these doses represent equal to or less than 0.00344 percent of the USNRC 10 CFR 50 App. I annual guidelines.

Liquid and Gaseous (Population)

Lines 8-11 of Tables I-1 and Table I-2 present the person-rem dose resulting from the liquid and gaseous effluents. These doses are summed over all pathways and the affected population. Liquid person-rem is based upon the population encompassed within the region from the TMINS outfall extending down to the Chesapeake Bay (approximately 5,000,000 people). The population dose due to gaseous effluents includes the population out to a distance of 50 miles around TMINS (approximately 2,200,000) as well as the much larger total population which can be fed by foodstuffs grown in the 50 mile radius (up to approximately 13,000,000). Population doses are summed over all distances and sectors to give an aggregate dose.

Based upon the calculations performed for the 1996 reporting period, total TMI-1 and TMI-2 liquid and gaseous effluents resulted in a population dose of 1.06 person-rem to the total body. This is more than 600,000 times lower than the dose that the population living within 50 miles of TMINS receives each year from natural background radiation.

TABLE I-1

Summary of Maximum Individual and Population Doses from TMI-1 Effluents for 1996

Individual Doses

Effluent	Organ	Estimated Dose/year (mrem)	Age Group	Location Dist (m)	Dir (Toward)	Percent of 10 CFR 50 App. I Annual Guideline	10 CFR 50 App I Annual Guideline (mrem/yr)
1 Liquid	Total Body	1.07E-1	Adult	Receptor 1		3.57E0	3
2 Liquid	Liver	1.57E-1	Teenager	Receptor 1		1.57E0	10
3 Noble Gas	Air Dose (Gamma-mrad)	2.53E-4	—	2000	NNW	2.53E-3	10
4 Noble Gas	Air Dose (Beta-mrad)	2.10E-4	—	2000	NNW	1.05E-3	20
5 Noble Gas	Total Body	1.20E-4	All	2300	NNW	2.40E-3	5
6 Noble Gas	Skin	2.12E-4	All	2300	NNW	1.41E-3	15
7 Iodines, Tritium & Particulates	Thyroid	5.16E-4	Child	2000	N	3.44E-3	15

Population Doses

Effluent	Applicable Organ	Estimated Population Dose (Person-rem)
8 Liquid	Total Body	1.04E+0
9 Liquid	Liver	1.05E+0
10 Gaseous	Total Body	9.76E-3
11 Gaseous	Thyroid	1.08E-2

TABLE I-2

Summary of Maximum Individual and Population Doses from TMI-2 Effluents for 1996

Individual Doses

Effluent	Organ	Estimated Dose/year (mrem)	Age Group	Location Dist (m)	Location Dir (Toward)	Percent of 10 CFR 50 App. I Annual Guideline	10 CFR 50 App. I Annual Guideline (mrem/yr)
1 Liquid	Total Body	1.48E-3	Adult	Receptor 1		4.93E-2	3
2 Liquid	Bone	2. 29E-3	Child	Receptor 1		2.29E-2	10
3 Noble Gas	Air Dose (Gamma-mrad)	0	---	---	---	0	10
4 Noble Gas	Air Dose (Beta-mrad)	0	---	---	---	0	20
5 Noble Gas	Total Body	0	---	---	---	0	5
6 Noble Gas	Skin	0	---	---	---	0	15
7 Iodines, Tritium & Particulates	Liver	7.14E-3	Child	2000	SE	4.76E-4	15

Population Doses

Effluent	Applicable Organ	Estimated Population Dose (Person-rem)
8 Liquid	Total Body	1.18E-3
9 Liquid	Bone	4.19E-3
10 Gaseous	Total Body	4.31E-3
11 Gaseous	Liver	4.42E-3

APPENDIX J

1996 Groundwater and Onsite Precipitation Monitoring Results

TABLE J-1
TMI Groundwater Monitoring Tritium Concentrations
(pCi/L)

Station	1995 Average * ± 2 std dev	1996 Average * ± 2 std dev	1996 Range
OSF	1500 ± 640	1500 ± 580	640 - 2000
MS-1	380 ± 310	250 ± 140	170 - 310
MS-2	800 ± 240	560 ± 200	440 - 670
MS-3	1400 ± 850	710 ± 150	640 - 810
MS-4	1100 ± 930	760 ± 580	490 - 1100
MS-5	370 ± 190	230 ± 20	220 - 240
MS-7	230 ± 83	330 ± 220	190 - 450
MS-8	660 ± 370	440 ± 410	160 - 650
OS-13B	340 ± 42	410 ± 230	280 - 510
OS-14	280 ± 68	260 ± 38	250 - 290
OS-15	NS	ND	---
OS-16	2300 ± 1700	1100 ± 600	770 - 1500
OS-17	1900 ± 930	2000 ± 2700	990 - 3900
E1-2	ND	180	**
N2-1	ND	140 ± 64	110 - 170
EDCB	260 ± 150	200 ± 250	100 - 480
48s	450 ± 1000	260 ± 100	170 - 320
RW-1	390,000 ± 380,000	99,000 ± 230,000	590 - 450,000
RW-2	50,000 ± 86,000	5700 ± 21,000	820 - 58,000
MW-1	1400 ± 1200	500 ± 380	350 - 770
MW-2	250	ND	---
MW-3	440 ± 319	330 ± 340	190 - 570
MW-4	210 ± 140	160 ± 92	120 - 210
MS-19	NS	1000 ± 1600	170 - 2400
MS-20	NS	3500 ± 2000	1900 - 4800

TABLE J-1
TMI Groundwater Monitoring Tritium Concentrations
(pCi/L)

Station	1995 Average * ± 2 std dev	1996 Average * ± 2 std dev	1996 Range
MS-21	NS	230 ± 100	160 - 300
MS-22	NS	6500 ± 12,000	2000 - 16,000
NW-A	NS	4600 ± 2500	3100 - 7100
NW-B	NS	5900 ± 2100	3800 - 8200
NW-C	NS	7800 ± 7900	3700 - 17,000
R15-3	NS	150	**

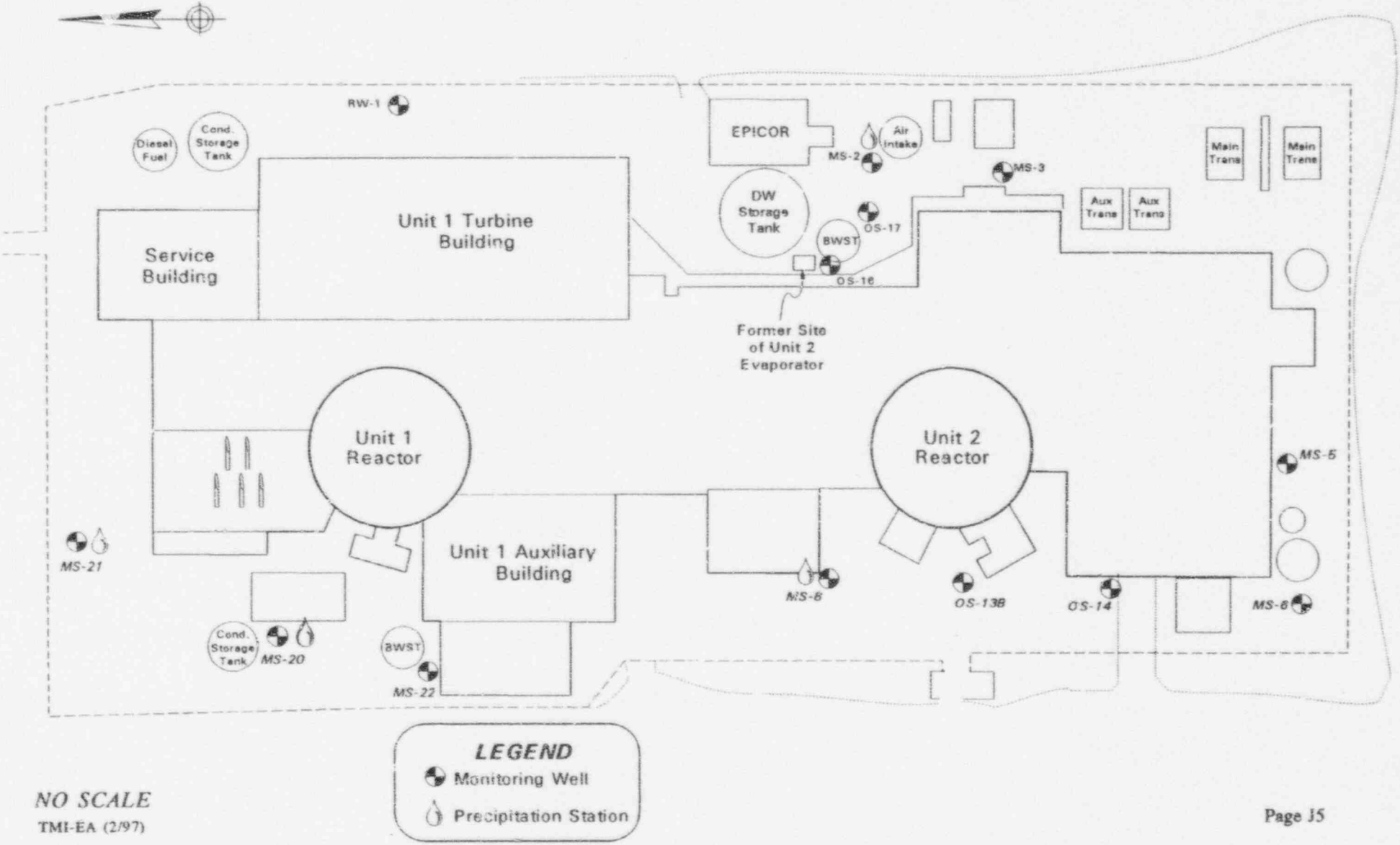
* Average of detectable results
** Only one positive result for this station
ND = No detectable activity
NS = Not sampled, no data available
(Refer to Figures J-1 and J-2 for locations of groundwater stations.)

TABLE J-2
TMI Onsite Precipitation Tritium Concentrations
(pCi/L)

Station	Average * ± 2 std dev	Range
MS-1	370 ± 430	190 -720
MS-2	550 ± 870	160 - 1500
MS-4	360 ± 330	210 - 650
MS-8	540 ± 800	180 - 1400
MS-20	650 ± 1200	100 - 2800
MS-21	540 ± 660	210 - 1100
OS-15	ND	---
OSF	340 ± 270	160 - 490
RW-2	550 ± 970	180 - 1400
Substation	180 ± 43	140 - 210
48S	230 ± 320	150 - 620

* Average of detectable results
ND = No detectable activity
(Refer to Figures J-1 and J-2 for locations of groundwater stations.)

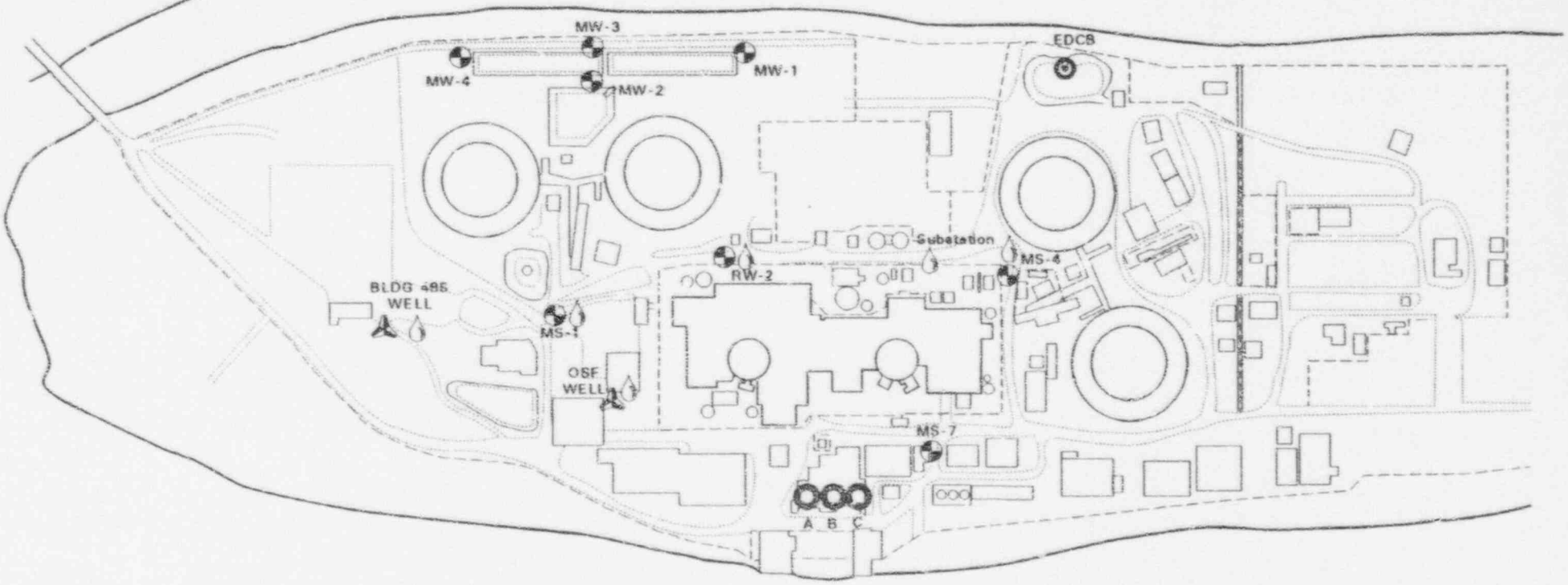
Figure J-1
1996 TMINS REMP Groundwater and Precipitation Stations Inside the Protected Area



NO SCALE

TMI-EA (2/97)

Figure J-2
1996 TMINS REMP Groundwater and Precipitation Stations Outside the Protected Area



LEGEND

- Monitoring Well
- Drinking Water Well
- Surface Water Station
- Precipitation Station
- New Service Water Well

Offsite Groundwater Wells: E1-2 at the TMI Visitor's Center and N2-1 at the Goldsboro Marina.
Onsite Control Well: OS-15 at the south end of the island.

NO SCALE

TMI-EA (2/97)

APPENDIX K

1996 Meteorological Summary

TABLE K-1

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: A
Sensor Height: 100 ft.

Winds From	Wind Speed (mph) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	5	28	8	2	0	0	43
NNE	1	6	0	0	0	0	7
NE	0	2	0	0	0	0	2
ENE	0	3	0	0	0	0	3
E	0	2	0	0	0	0	2
ESE	0	4	4	2	0	0	10
SE	1	3	6	0	0	0	10
SSE	1	6	3	0	0	0	10
S	1	4	2	0	0	0	7
SSW	2	15	13	5	1	0	36
SW	8	30	19	0	0	0	57
WSW	12	14	3	0	0	0	29
W	11	14	11	1	1	0	38
WNW	16	29	19	7	0	1	72
NW	28	77	50	9	1	0	165
NNW	30	82	24	13	3	0	152
TOTAL	116	319	162	39	6	1	643

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: **B**
Sensor Height: 100 ft.

Winds From	Wind Speed (mph) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	2	6	2	1	0	0	11
NNE	0	2	0	0	0	0	2
NE	0	0	0	0	0	0	0
ENE	3	3	0	0	0	0	6
E	1	5	1	0	0	0	7
ESE	1	5	6	4	0	0	16
SE	3	9	10	2	0	0	24
SSE	0	7	1	0	0	0	8
S	1	6	4	0	0	0	11
SSW	3	14	19	4	6	0	46
SW	6	8	4	0	0	0	18
WSW	5	7	1	1	0	0	14
W	5	8	9	3	0	0	25
WNW	5	14	14	15	2	1	51
NW	10	11	17	15	3	0	56
NNW	10	9	13	10	3	1	46
TOTAL	55	114	101	55	14	2	341

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: C
Sensor Height: 100 ft.

	Wind Speed (mph)						
Winds From	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	0	2	1	1	0	0	4
NNE	1	1	0	0	0	0	2
NE	1	1	0	0	0	0	2
ENE	2	1	0	0	0	0	3
E	0	3	0	0	0	0	3
ESE	0	2	6	3	0	0	11
SE	1	4	2	1	0	0	8
SSE	2	3	1	0	0	0	6
S	1	2	1	1	0	0	5
SSW	4	4	12	1	0	1	22
SW	6	6	1	0	0	0	13
WSW	2	6	3	0	0	0	11
W	1	3	4	4	0	2	14
WNW	2	7	5	12	1	0	27
NW	5	8	19	14	6	1	53
NNW	5	4	5	8	2	0	24
TOTAL	33	57	60	45	9	4	208

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: D
Sensor Height: 100 ft.

	Wind Speed (mph)						
Winds From	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	31	48	24	9	0	0	112
NNE	21	39	5	0	0	0	65
NE	30	59	6	0	0	0	95
ENE	30	54	14	0	0	0	98
E	31	74	38	6	6	2	157
ESE	20	88	93	13	0	0	214
SE	29	65	46	5	0	0	145
SSE	20	65	26	0	0	0	111
S	17	45	42	14	0	0	118
SSW	19	56	73	30	7	2	187
SW	25	51	24	3	0	0	103
WSW	26	60	9	1	0	0	96
W	24	87	83	22	4	2	222
WNW	39	72	115	122	30	3	381
NW	45	72	134	138	52	4	445
NNW	42	79	82	59	10	1	273
TOTAL	449	1014	814	422	109	14	2822

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: **E**
Sensor Height: 100 ft.

	Wind Speed (mph)						
Winds From	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	66	108	25	5	0	1	205
NNE	51	58	7	2	0	0	118
NE	62	65	9	3	0	0	139
ENE	58	74	6	0	0	0	138
E	71	105	30	2	1	3	212
ESE	66	101	50	8	0	0	225
SE	59	42	23	5	2	0	131
SSE	37	60	23	3	1	0	124
S	25	74	44	17	3	0	163
SSW	23	102	56	22	10	1	214
SW	67	103	30	7	1	0	208
WSW	72	91	16	1	0	0	180
W	78	126	52	31	7	1	295
WNW	73	101	88	41	9	2	314
NW	70	78	101	49	7	2	307
NNW	65	79	23	17	7	1	192
TOTAL	943	1367	583	213	48	11	3165

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: **F**
Sensor Height: 100 ft.

Winds From	Wind Speed (mph) 1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	45	33	1	0	0	0	79
NNE	17	5	0	0	0	0	22
NE	23	6	0	0	0	0	29
ENE	25	13	0	0	0	0	38
E	58	27	1	0	0	0	86
ESE	50	17	0	1	0	0	68
SE	54	9	1	3	0	0	67
SSE	37	9	2	4	0	0	52
S	39	14	0	1	0	0	54
SSW	41	38	2	1	0	0	82
SW	43	23	3	3	0	0	72
WSW	58	16	1	0	0	0	75
W	76	33	3	0	0	0	112
WNW	82	18	3	0	0	0	103
NW	75	21	7	2	2	0	107
NNW	64	39	3	0	0	0	106
TOTAL	787	321	27	15	2	0	1152

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

Hours at Each Wind Speed and Direction
Period of Record: 96010100 - 96123123
Stability Class: G
Sensor Height: 100 ft.

	Wind Speed (mph)						
Winds From	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	14	8	0	0	0	0	22
NNE	6	5	0	0	0	0	11
NE	6	1	0	0	0	0	7
ENE	9	4	0	0	0	0	13
E	13	13	0	0	0	0	26
ESE	23	6	0	0	0	0	29
SE	21	2	0	0	0	0	23
SSE	18	0	0	0	0	0	18
S	18	2	0	0	0	0	20
SSW	14	14	0	0	0	0	28
SW	23	11	1	0	0	0	35
WSW	21	4	1	0	0	0	26
W	19	16	0	0	0	0	35
WNW	20	8	0	0	0	0	28
NW	19	11	2	0	0	0	32
NNW	26	9	0	0	0	0	35
TOTAL	270	114	4	0	0	0	388

TABLE K-1
(Continued)

Meteorological Data
1996 Joint Frequency Tables

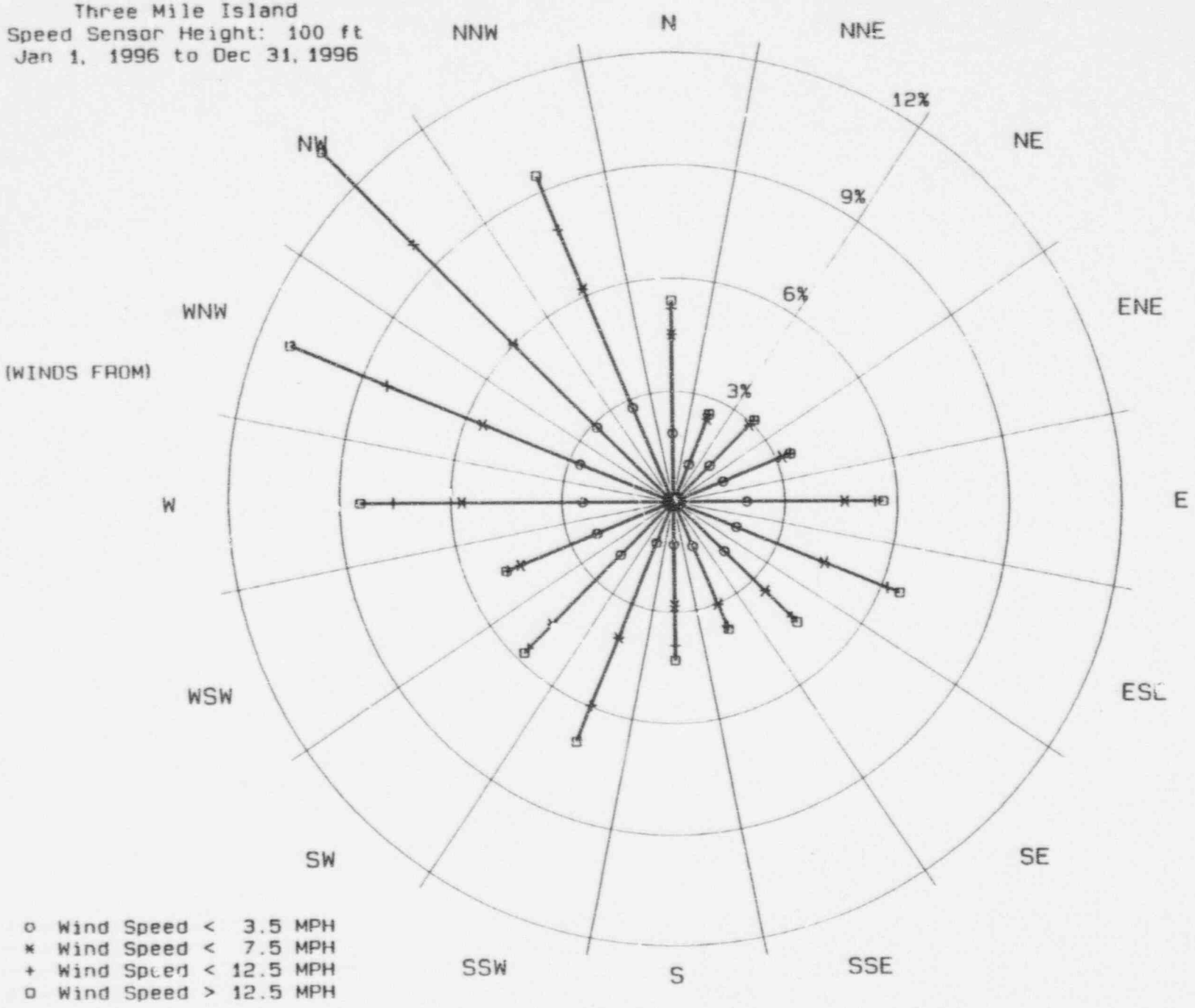
Hours at Each Wind Speed and Direction
Period of Record: 9601010[illegible] - 96123123
Stability Class: **ALL**
Sensor Height: 100 ft.

	Wind Speed (mph)						
Winds From	1-3	4-7	8-12	13-18	19-24	>24	TOTAL
N	163	233	61	18	0	1	476
NNE	97	116	12	2	0	0	227
NE	122	134	15	3	0	0	274
ENE	127	152	20	0	0	0	299
E	174	229	70	8	7	5	493
ESE	160	223	159	31	0	0	573
SE	168	134	88	16	2	0	408
SSE	115	150	56	7	1	0	329
S	102	147	93	33	3	0	378
SSW	106	243	175	63	24	4	615
SW	178	232	82	13	1	0	506
WSW	196	198	34	3	0	0	431
W	214	287	162	61	12	5	741
WNW	237	249	244	197	42	7	976
NW	252	278	330	227	71	7	1165
NNW	242	301	150	107	25	3	828
TOTAL	2653	3306	1751	789	188	32	8719

HOURS OF MISSING/INVALID DATA : 65

Three Mile Island
Speed Sensor Height: 100 ft
Jan 1, 1996 to Dec 31, 1996

Figure K-1
1996 Wind Rose



APPENDIX L

1996 REMP Sample Collection and Analysis Methods

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Gr-Alpha	AP	Continuous weekly air sampling through filter paper	1 filter (570 Cubic Meters)	TMI-EA 6510-IMP-4592.05	Low background gas flow proportional counting
			1 filter (570 Cubic Meters)	TBE-Westwood PRO-032-10	Same as above
Gr-Beta	AP	Continuous weekly air sampling through filter paper	1 filter (570 Cubic Meters)	TMI-EA 6510-IMP-4592.05	Low background gas flow proportional counting
			1 filter (570 Cubic Meters)	TBE-Westwood PRO-032-10	Same as above
	SW, EW	Monthly composite of grabs or biweekly or weekly samples which are automatically composited on a timed frequency	500 mL	TMI-EA 6510-IMP-4592.01	Sample evaporated on stainless steel planchet for low background gas flow proportional counting
			1 liter	TBE-Westwood PRO-032-1	Same as above
Gamma Spectroscopy	AP	Quarterly composite of filter paper collected weekly	12 to 15 filters (6,900 - 9,300 Cubic Meters)	TMI-EA 6510-IMP-4592.05 6510-OPS-4591.04	Sample placed in counting container for gamma isotopic analysis
			12 to 15 filters (6,900 - 9,300 Cubic Meters)	TBE- Westwood PRO-042-5	Same as above
	AI	Continuous weekly air sampling through charcoal cartridges	1 cartridge (570 Cubic Meters)	TMI-EA 6510-OPS-4591.04	Sample counted for gamma isotopic analysis
			1 cartridge (570 Cubic Meters)	TBE- Westwood PRO-042-5	Same as above

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Gamma Spectroscopy (Cont'd)	M	Biweekly grab sample of one or more milkings	3.5 liters	TMI-EA 6510-IMP-4592.06 6510-OPS-4591.04	Sample placed in counting container for gamma isotopic analysis
			1 liter	TBE-Westwood PRO-042-5	Same as above
	SW, EW	Monthly composite of grabs or biweekly or weekly samples which are automatically composited on a timed frequency	3.5 liters	TMI-EA 6510-IMP-4592.06 6510-OPS-4591.04	Sample placed in counting container for gamma isotopic analysis
			1 liter	TBE-Westwood PRO-042-5	Same as above
	AQF	Composite sample semiannually by feeding types (bottom feeder and predator) collected by either electrofishing or hook and line	1 kg (if possible)	TMI-EA 6510-IMP 4592.03 6510-OPS-4591.04	Edible portion placed in counting container for gamma isotopic analysis
			1 kg (if possible)	TBE-Westwood PRO-042-5	Same as above

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1995

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Gamma Spectroscopy (Cont'd)	GW	Quarterly grab sample or quarterly composite of monthly grab samples which are collected with a hand bailer or from a faucet	3.5 liters (if possible)	TMI-EA 6510-IMP-4592.06 6510-OPS-4591.04	Sample decanted and liquid portion placed in counting container for gamma isotopic analysis. Potable samples are mixed (not decanted) prior to analysis
			1 liter (if possible)	TBE-Westwood PRO-042-5	Same as above
	AQS	Semiannual composite of three or more grab samples collected with a dredge sampler	1 kg (if possible)	TMI-EA 6510-IMP-4592.04 6510-OPS-4591.04	Dried and sieved sample placed in counting container for gamma isotopic analysis
			1 kg (if possible)	TBE-Westwood PRO-042-5	Same as above
	FP, GAD	Grab sample annually or more frequently	1 kg (if possible)	TMI-EA 6510-IMP-4592.03 6510-OPS-4591.04	Edible portion placed in counting container for gamma isotopic analysis. Only root vegetables and fruits washed prior to analysis
			1 kg (if possible)	TBE-Westwood PRO-042-5	Same as above
Tritium	SW, EW	Monthly composite of grabs or biweekly or weekly samples which are automatically composited on a timed frequency	7-10 mL	TMI-EA 6510-IMP-4592.02 6510-OPS-4591.05 6510-OPS-4591.08	Sample filtered, mixed with scintillation fluid for scintillation counting. Distillation may be performed if impurities are found to be present
			2 mL	TBE-Westwood PRO-052-35	Same as above

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Tritium (Cont'd)	AQF	Composite sample semiannually by feeding types (bottom feeder and predator) collected by either electrofishing or hook and line	7-10 mL	TMI-EA 6510-IMP-4592.02 6510-IMP-4592.03 6510-OPS-4591.05 6510-OPS-4591.08	Edible portion is freeze-dried in order to extract liquid for counting by liquid scintillation
			2 mL	TBE-Westwood PRO-052-2 PRO-052-57	Same as above
	GW	Monthly or quarterly grab or more frequent sample according to sampling site using a hand bailer, a faucet or a dedicated bladder-type pump	7-10 mL	TMI-EA 6510-IMP-4592.02 6510-IMP-4591.05 6510-IMP-4591.08	Sample is filtered, mixed with scintillation fluid for scintillation counting.
			2 mL or 10 mL	TBE-Westwood PRO-052-2 PRO-052-35	Same as above except distillation may be performed if impurities are found to be present

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
I-131	SW, EW	Biweekly or weekly composite using an automatic compositor set for sampling on a preset timed frequency. One SW station is a biweekly or weekly composite of grab samples collected twice per week	3.5 liters	TMI-EA 6510-IMP-4592.06	Sample is concentrated on anion exchange resin, the resin is analyzed by gamma spectroscopy
			1 liter	TBE-Westwood PRO-032-11	Anion-exchange, chemical reduction, CCl_4 extraction, palladium precipitation, low-level beta counting
	FP	Grab sample annually or more frequently	1 kg (if possible)	TMI-EA 6510-IMP-4592.03 6510-OPS-4591.04	Edible portion placed in counting container for gamma isotopic analysis
			1 kg (if possible)	TBE-Westwood PRO-032-12	Carrier added, leached, evaporated and fused, residue dissolved, filtered and reduced with hydroxylamine hydrochloride, precipitated as palladium iodide for counting on low-level beta counter
	M	Biweekly grab sample of one or more milkings	3.5 liters	TMI-EA 6510-IMP-4592.06 6510-OPS-4591.04	Same as I-131 in SW, EW
			1 liter	TBE-Westwood PRO-032-11	Same as I-131 in SW, EW

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Sr-89, Sr-90	AP	Semiannual composite of filter paper collected weekly	26 weeks of filters per sampling site (14,800 Cubic Meters)	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Sample is leached and strontium in sample is separated through a series of precipitations and then purified using an extraction material in a chromatographic column. The total strontium is dried on a planchet and counted in a low background beta counter. After a period of time, the Yttrium-90, which has ingrown from the Sr-90, is separated from the sample and counted to determine the Sr-90 activity. The total strontium minus the Sr-90 will determine Sr-89 activity.
			26 weeks of filters per sampling site (14,800 cubic meters)	TBE-Westwood PRO-032-24	Sample is leached and strontium in sample is separated through a series of precipitations, Sr-90 inferred Y-90 on yttrium oxalate precipitate after 5 days or more ingrowth, low-level beta counting follows. After yttrium separation sample is precipitated with $SrCO_3$ mounted on nylon planchet for counting on low background beta counter for Sr-89 activity.
	AQF	Composite sample semiannually by feeding types (bottom feeders and predators) collected by either electrofishing or hook and line	250 g	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Similar to TBE-Westwood Sr-89, Sr-90 in AP except sample (edible portion) is dried and ashed prior to separation.
			1 kg (if possible)	TBE-Westwood PRO-032-85	Similar to TMI-EA Sr-89, Sr-90 in AP except sample (edible portion) is dried and ashed prior to separation.
	AQS	Composite of at least three grab samples collected annually using a dredge sampler	25 kg	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Similar to TMI-EA Sr-89, Sr-90 in AP except sample is dried prior to separation
			1 kg	TBE-Westwood PRO-032-25	Similar to TBE-Westwood Sr-89, Sr-90 in AP except sample is dried prior to separation

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Sr-89, Sr-90 (Cont'd)	SW, EW	Semiannual composite of grabs or biweekly or weekly samples which are automatically composited on a timed frequency	1liter	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Similar to TMI-EA Sr-89, Sr-90 in AP.
			1 liter	TBE-Westwood PRO-032-16	Similar to TBE-Westwood Sr-89, Sr-90 in AP.
	FP (Broad Leaf Veg. only)	Grab sample annually or more frequently	250g	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Similar to TMI-EA Sr-89, Sr-90 in AP except sample (edible portion) is dried and ashed prior to separation.
			1 kg (if possible)	TBE-Westwood PRO-032-23	Similar to TBE-Westwood Sr-89, Sr-90 in AP except sample (edible portion) is dried and ashed prior to separation.
	GW	Semiannual composite of monthly grab samples or quarterly grab samples all of which are collected with a hand bailer, a submersible pump or by a faucet.	1 liter (if possible)	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Similar to TMI-EA Sr-89, Sr-90 but sample analyzed for Sr-90 only.
			1 liter	TBE-Westwood PRO-032-16	Similar to TBE-Westwood Sr-89, Sr-90 but sample analyzed for Sr-90 only.
	M	Quarterly composite of biweekly grab samples	1 liter	TMI-EA 6510-IMP-4592.12 6510-OPS-4591.01	Similar to TMI-EA Sr-89, Sr-90 in AP except sample is dried and ashed prior to separation.
			1 liter	TBE-Westwood PRO-032-105	The method adds a stable strontium carrier, ashes the sample in a muffle furnace and precipitates the phosphates. Strontium then is purified using an extraction material in a chromatographic column. Sample mounting and counting are similar to TBE-Westwood Sr-89, Sr-90 in AP.

TABLE L

TMINS Radiological Environmental Monitoring Program
Summary of Sample Collection and Analysis Methods 1996

Analysis	Sample* Medium	Sampling Method	Approximate Sample Size Analyzed	Analysis Procedure Number	Procedure Abstract
Gamma (Direct Radiation)	ID	Dosimeters exchanged quarterly	2 TLDs/8 Elements	TMI-Dosimetry 6610-OPS-4243.01	Thermoluminescent dosimetry using optical heating of crystals and PM tube for light measurement.
			1 TLD/4 Elements	TBE-Westwood PRO-342-17	Same as above

* Identificaton Key	Approximate Sample Size Collected per Station **
AI = Air Iodine	1 Cartridge (570 Cubic Meters) per week
AP = Air Particulate	1 Filter (570 Cubic Meters) per week
AQF = Finfish	1 kg semiannually
AQS = Aquatic Sediment	1 kg semiannually
EW = Effluent Water	4 liters biweekly or weekly
FP = Food Products (Fruits & Vegetables)	1 kg annually or more frequently
GAD = Game (Deer)	1 kg annually or more frequently (if possible)
GW = Ground Water	4 liters (if available) monthly or quarterly. 250 mL as needed for tritium analysis only
ID = Immersion Dose (TLD)	4 TLDs/8 Elements quarterly
M = Milk	4 liters biweekly
SW = Surface/Drinking Water	4 liters biweekly or weekly

** Sample size is for the main laboratory samples. An additional sample of the same size (except for TLDs) is collected at those stations which also are analyzed for quality control (QC) purposes. The QC TLD stations only have one additional dosimeter (4 elements) for QC purposes.

APPENDIX M

1996 TLD Quarterly Data

TABLE M
1996 TLD Quarterly Data
mR Per Std Month ± 2σ

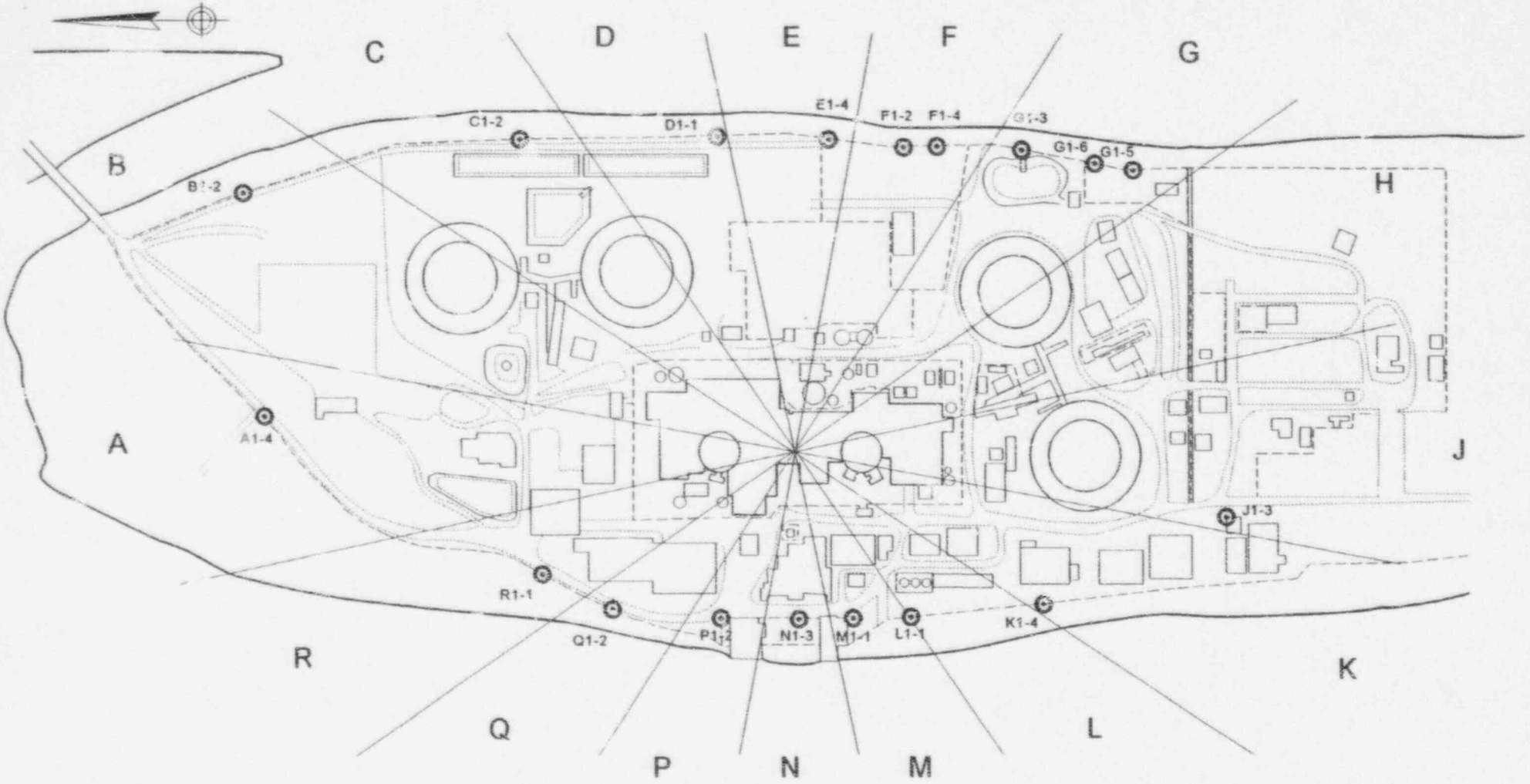
Station	Historical	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
A1-4	4.3±0.3	3.7±0.3	3.5±0.2	3.4±0.2	3.8±0.4
A3-1	4.3±1.6	3.6±0.3	3.5±0.2	3.4±0.4	3.6±0.3
A5-1	5.5±0.9	4.6±0.4	4.6±0.2	4.5±0.5	4.8±0.6
A9-3	0.0±0.0	3.8±0.5	3.5±0.2	3.6±0.4	3.7±0.5
B1-1	4.4±1.4	3.8±0.2	3.5±0.3	3.7±0.3	3.5±0.2
B1-2	4.3±0.7	3.6±0.2	3.4±0.4	3.4±0.3	3.6±0.2
B2-1	0.0±0.0	3.7±0.2	3.4±0.5	3.6±0.3	3.8±0.4
B5-1	5.3±1.0	4.4±0.3	4.3±0.5	4.4±0.3	4.6±0.4
B10-1	5.1±0.8	4.3±0.4	4.3±0.4	4.1±0.3	4.6±0.3
C1-1	5.2±0.9	4.2±0.2	4.0±0.4	4.0±0.3	4.2±0.6
C1-2	4.3±0.9	3.7±0.4	3.4±0.3	3.4±0.4	3.7±0.4
C2-1	0.0±0.0	4.2±0.3	4.0±0.4	3.9±0.5	4.1±0.3
C5-1	5.1±0.9	4.4±0.4	4.3±0.4	4.4±0.4	4.5±0.3
C8-1	5.9±0.9	4.7±0.4	4.5±0.8	4.3±0.3	4.7±0.7
D1-1	4.6±0.8	3.9±0.1	3.6±0.3	3.5±0.5	3.7±0.3
D1-2	5.4±2.1	4.4±0.5	4.0±0.6	4.1±0.5	4.2±0.3
D2-2	0.0±0.0	5.2±0.4	4.8±0.7	4.9±0.4	5.4±0.8
D6-1	6.4±1.3	5.0±0.3	4.7±0.3	5.0±0.1	5.4±0.6
D15-1	5.7±1.3	4.5±0.4	4.4±0.4	4.2±0.3	4.8±0.4
E1-2	4.9±1.7	4.3±0.4	3.8±0.4	3.8±0.4	4.1±0.3
E1-4	5.7±1.3	4.1±0.4	3.5±0.3	3.4±0.3	3.7±0.3
E2-3	0.0±0.0	4.6±0.6	4.5±0.6	4.8±0.3	5.0±0.3
E5-1	5.3±0.8	4.3±0.4	4.2±0.3	4.4±0.4	4.5±0.4
E7-1	5.2±1.0	4.4±0.6	4.5±0.4	4.4±0.3	4.5±0.4
F1-1	5.0±1.1	4.4±0.4	3.8±0.2	4.1±0.3	4.2±0.3
F1-2	0.0±0.0	5.0±0.3	4.4±0.2	4.1±0.4	4.3±0.4
F1-4	0.0±0.0	5.0±0.4	4.4±0.2	4.2±0.4	4.2±0.3
F2-1	0.0±0.0	4.8±0.7	4.7±0.6	4.9±0.5	5.1±0.5
F5-1	6.0±1.1	0.0±0.0	4.8±0.3	4.8±0.2	5.0±0.4
F10-1	6.3±1.1	5.6±0.7	5.4±0.6	5.4±0.6	5.8±0.3
F25-1	5.6±1.0	4.7±0.5	4.4±0.5	4.4±0.4	4.9±0.3
G1-2	4.9±1.0	4.2±0.4	4.1±0.3	4.3±0.5	4.5±0.4
G1-3	6.9±3.6	4.3±0.4	3.8±0.3	3.5±0.8	3.9±0.3
G1-5	0.0±0.0	4.4±0.3	3.9±0.4	3.8±0.7	4.2±0.3
G2-4	0.0±0.0	5.0±0.7	5.1±0.4	5.2±0.3	5.4±0.5
G5-1	5.1±2.0	4.2±0.4	3.8±0.4	3.9±0.5	4.2±0.6
G10-1	7.6±1.6	6.1±0.8	5.9±0.6	6.1±0.8	6.6±0.7
G15-1	6.4±2.3	4.6±0.6	4.4±0.3	4.3±0.3	4.9±0.2
H1-1	5.3±2.0	4.2±0.5	4.1±0.3	4.0±0.4	4.2±0.5
H3-1	4.1±1.1	3.4±0.3	3.0±0.3	3.1±0.6	3.4±0.4
H5-1	4.1±0.9	3.6±0.3	3.2±0.4	3.3±0.6	3.5±0.3
H8-1	7.9±1.4	6.9±0.4	6.7±0.5	6.4±0.7	6.9±0.6
H15-1	5.8±1.1	5.1±0.5	4.7±0.3	4.9±0.9	5.4±0.8
J1-1	5.3±1.4	3.9±0.4	3.5±0.4	3.5±0.4	3.8±0.4
J1-3	3.7±0.4	3.3±0.5	3.0±0.3	3.0±0.3	3.1±0.3
J3-1	0.0±0.0	3.7±0.3	3.8±0.4	3.9±0.2	4.1±0.4
J5-1	5.7±1.3	4.8±0.7	4.8±0.5	4.5±0.7	5.1±0.2
J7-1	4.7±1.1	5.1±0.2	4.9±0.5	4.6±0.3	5.0±0.6
J15-1	6.1±1.7	5.2±0.5	4.9±0.5	4.8±0.4	5.3±0.4

TABLE M
1996 TLD Quarterly Data
mR Per Std Month ± 2σ

Station	Historical	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
K1-4	4.7±1.5	3.8±0.4	3.6±0.3	3.4±0.3	3.5±0.4
K2-1	5.8±1.2	0.0±0.0	4.7±0.4	0.0±0.0	4.9±0.7
K3-1	0.0±0.0	3.5±0.4	3.7±0.4	3.6±0.4	3.8±0.4
K5-1	6.9±1.2	4.7±0.5	4.8±0.5	4.7±0.7	5.1±0.6
K8-1	5.4±1.3	4.9±0.2	4.6±0.5	4.4±0.5	4.8±0.6
K15-1	4.8±1.3	3.4±0.3	3.4±0.4	3.2±0.3	3.4±0.4
L1-1	5.1±1.9	4.1±0.4	3.8±0.4	3.7±0.4	4.0±0.3
L1-2	4.3±1.1	0.0±0.0	3.8±0.4	3.6±0.4	3.9±0.2
L2-1	5.5±1.3	4.3±0.3	4.4±0.4	4.2±0.4	4.6±0.6
L5-1	4.5±1.0	0.0±0.0	4.0±0.3	3.7±0.3	4.1±0.4
L8-1	5.0±0.9	3.7±0.7	4.1±0.3	3.9±0.5	4.3±0.2
L15-1	5.2±1.4	4.1±0.3	4.3±0.4	4.0±0.4	4.4±0.2
M1-1	0.0±0.0	3.6±0.4	3.3±0.2	3.4±0.5	3.6±0.3
M1-2	0.0±0.0	0.0±0.0	3.7±0.3	3.7±0.6	3.8±0.4
M2-1	4.3±1.5	3.5±0.4	3.2±0.2	3.3±0.4	3.6±0.4
M5-1	5.2±1.1	3.9±0.4	3.7±0.6	3.6±0.6	3.8±0.3
M9-1	6.5±1.2	5.0±0.4	5.0±0.7	4.9±0.6	5.2±0.6
N1-1	4.8±1.4	0.0±0.0	3.7±0.4	3.7±0.5	4.1±0.3
N1-3	4.6±1.2	3.7±0.4	3.3±0.2	3.2±0.5	3.7±0.2
N2-1	5.3±1.0	3.6±0.4	3.6±0.6	3.3±0.4	3.7±0.4
N5-1	5.3±1.3	3.2±0.4	3.4±0.3	3.2±0.4	3.5±0.3
N8-1	5.4±1.2	4.4±0.4	4.5±0.6	4.3±0.6	4.6±0.6
N15-2	5.9±0.9	5.1±0.3	4.8±0.4	4.8±0.4	5.1±0.8
P1-1	4.7±1.3	0.0±0.0	3.9±0.5	3.8±0.5	4.1±0.3
P1-2	0.0±0.0	3.7±0.4	3.5±0.3	3.2±0.4	3.7±0.5
P2-1	5.4±1.2	4.8±0.5	4.7±0.4	4.5±0.6	4.9±0.4
P5-1	4.8±1.0	4.2±0.3	4.2±0.3	3.9±0.5	4.3±0.4
P8-1	4.7±1.0	3.9±0.3	3.8±0.4	3.8±0.5	4.2±0.6
Q1-1	4.6±1.0	0.0±0.0	3.7±0.5	3.7±0.5	4.0±0.5
Q1-2	4.4±0.8	3.5±0.3	3.1±0.2	3.1±0.2	3.3±0.1
Q2-1	5.4±1.1	3.9±0.4	3.8±0.4	3.7±0.4	4.0±0.5
Q5-1	4.9±1.2	4.3±0.6	3.9±0.3	3.8±0.5	4.3±0.4
Q9-1	5.3±1.2	4.2±0.6	4.0±0.4	4.0±0.5	4.4±0.2
Q15-1	5.9±1.1	4.5±0.3	4.5±0.6	4.5±0.5	4.9±0.5
R1-1	4.8±1.2	4.0±0.5	3.5±0.3	3.5±0.6	3.7±0.4
R1-2	4.2±1.2	0.0±0.0	3.4±0.3	3.4±0.4	3.6±0.4
R3-1	0.0±0.0	5.2±0.6	4.9±0.5	4.4±0.5	5.1±0.5
R5-1	5.1±0.9	4.8±0.4	4.6±0.6	4.4±0.3	4.7±0.5
R9-1	5.2±0.9	4.6±0.6	4.6±0.6	4.3±0.4	4.6±0.4
R15-1	4.4±1.0	3.6±0.3	3.4±0.3	3.5±0.4	0.0±0.0

NOTES: 1) A Value of Zero Indicates No Data
2) Some Newer Stations Have No Historical Data

Figure M-1
Onsite TLD Station Locations at TMINS



Stations H1-1 and J1-1 are located off the map to the south.

NO SCALE