YANKEE NUCLEAR POWER STATION
INDEPENDENT SPENT FUEL STORAGE INSTALLATION

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

January - December 2007

April 2008

Prepared by:

Radiological Safety & Control Services

91 Portsmouth Avenue

Stratham, NH 03885-2468

EXECUTIVE SUMMARY

Yankee Nuclear Power Station (YNF'S) was permanently shutdown in 1991. Activities at the site are now focused on fuel storage. By the end of 2006, decommissioning of the site was complete. The facility contains fuel element assemblies and irradiated components from the site's former reactor internals. The report provided here is a summary of the radiological environmental activities and analysis that are specific to the Yankee ISFSI for the full year of the monitoring period. The radiological monitoring through the REMP was substantially reduced to only include direct radiation by the end of 2006.

A radiological environmental monitoring program was conducted for the Yankee Independent Spent Fuel Storage Installation (ISFSI) to assess the levels of radiation or radioactivity in the Yankee environment. More than 12 samples were collected (TLDs) over the course of the year. The samples collected as part of this program include direct radiation measurements at 6 onsite locations. All samples taken were collected in the immediate vicinity of the Independent Spent Fuel Storage Installation with exception to the offsite control location for monitoring background radiation.

During this monitoring period, there were no changes made to the facilities Radiological Environmental Monitoring Program.

TABLE OF CONTENTS

1.0 INTRODUCTION **1**

2.0 NATURALLY OCCURRING AND MAN-MADE BACKGROUND RADIOACTIVITY **2**

2.1 NATURALLY OCCURRING BACKGROUND RADIOACTIVITY 2
2.2 MAN-MADE BACKGROUND RADIOACTIVITY 3

3.0 GENERAL ISFSI AND SITE INFORMATION **4**

4.0 PROGRAM DESIGN **4**

4.1 MONITORING ZONES 5
4.2 PATHWAYS MONITORED 5
4.3 DESCRIPTIONS OF MONITORING PROGRAMS 5
4.3.1 Direct Radiation *5*
4.3.3 Special Monitoring *5*

5.0 RADIOLOGICAL DATA SUMMARY TABLES **11**

6.0 ANALYSIS OF ENVIRONMENTAL RESULTS **18**

6.1 SAMPLING PROGRAM DEVIATIONS 18
6.2 DATA ANALYSIS BY MEDIA TYPE 18
6.2.1 Direct Radiation Pathway *18*

8.0 REFERENCES **19**

LIST OF TABLES

Table	Title	Page
4.1	Radiological Environmental Monitoring Program	6
4.2	Radiological Environmental Monitoring Locations (TLD)	7
5.1	Environmental Radiological Program Summary	12
5.2	Environmental TLD Data Summary	13

LIST OF FIGURES

Figure	Title	Page
4.1	Onsite Direct Radiation Monitoring Locations	8
4.2	Direct Radiation Monitoring Locations (Within 1 mile)	9
4.3	Offsite Control Location (TLD)	10
5.1	ISFSI Environmental TLD Measurements	14
5.2	Historical Trend of Environmental TLD Measurements	15

1.0 INTRODUCTION

This report summarizes the findings of the Radiological Environmental Monitoring Program (REMP) conducted by Yankee ISFSI in the vicinity of the Independent Spent Fuel Storage Installation in Rowe, Massachusett's during the calendar year. It is submitted annually in compliance with the Offsite Dose Calculation Manual (ODCM). The remainder of this report is organized as follows:

Section 2: Provides an introduction to the background radioactivity and radiation that is detected in the Yankee environs.

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

Section 4: Provides a description of the overall REMP design. Included is a summary of the ODCM requirements for REMP sampling, tables listing routine sampling and TLD monitoring locations with compass sectors and distances from the plant, and maps showing the location of each of the sampling and TLD monitoring locations.

Section 5: Consists of the summarized data as required by the ODCM, in the format specified by the NRC Branch Technical Position on Environmental Monitoring (Reference 1). Also included are complete environmental TLD data.

Section 6: Provides the results of the calendar year monitoring program. The performance of the program in meeting ODCM requirements is discussed, and the data acquired during the year is analyzed.

Section 8: Summarizes the requirements

Section 9: References

2.0 NATURALLY OCCURRING AND MAN-MADE BACKGROUND RADIOACTIVITY

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

2.1 Naturally Occurring Background Radioactivity

Natural radiation and radioactivity in the environment, which provide the major source of human radiation exposure, may be subdivided into three separate categories: "primordial radioactivity," "cosmogenic radioactivity" and "cosmic radiation." "Primordial radioactivity" is made up of those radionuclides that were created with the universe and that have a sufficiently long half-life to be still present on the earth. Included in this category are the radionuclides that these elements have decayed into. A few of the more important radionuclides in this category are Uranium-238 (U-238), Thorium-232 (Th-232), Rubidium-87 (Rb-87), Potassium-40 (K-40), Radium-226 (Ra-226), and Radon-222 (Rn-222). Uranium-238 and Thorium-232 are readily detected in soil and rock, whether through direct field measurements or through laboratory analysis of samples. Radium-226 in the earth can find its way from the soil into ground water, and is often detectable there. Potassium-40 comprises about 0.01 percent of all natural potassium in the earth, and is consequently detectable in most biological substances, including the human body. There are many more primordial radionuclides found in the environment in addition to the major ones discussed above (Reference 2).

The second category of naturally-occurring radiation and radioactivity is "cosmogenic radioactivity." This is produced through the nuclear interaction of high energy cosmic radiation with elements in the earth's atmosphere, and to a much lesser degree in the earth's crust. These radioactive elements are then incorporated into the entire geosphere and atmosphere, including the earth's soil, surface rock, biosphere, sediments, ocean floors, polar ice and atmosphere. The major radionuclides in this category are Carbon-14 (C-14), Hydrogen-3 (H-3 or Tritium), Sodium-22 (Na-22), and Beryllium-7 (Be-7).

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

2.2 Man-Made Background Radioactivity

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

The radioactivity produced by these detonations was deposited worldwide. The amount of fallout deposited in any given area is dependent on many factors, such as the explosive yield of the device, the latitude and altitude of the detonation, the season in which it occurred, and the timing of subsequent rainfall which washes fallout from the troposphere (Reference 4). Most of this fallout has decayed into stable elements, but the residual radioactivity is still detectable at low levels in environmental samples worldwide. The two predominant radionuclides are Cesium-137 (Cs-137) and Strontium-90 (Sr-90) and can be found in soil and in vegetation.

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

3.0 GENERAL ISFSI AND SITE INFORMATION

The Yankee Atomic Electric Company's Rowe (YR) site is located on over 1800 acres in a predominantly rural area of northwestern Massachusetts, three-quarters of a mile south of the Vermont border. The site resides in the town of Rowe, Massachusetts, approximately 9 air miles east-northeast of North Adams, Massachusetts. The surrounding area is heavily forested and lightly populated. Hills bounding the river valley rise 500 to 1000 feet above the site, reaching elevations of 2100 feet.

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

The former nuclear power plant was voluntarily shut down on October 1, 1991 after 31 years of operation. The site was involved in the process of decommissioning over the years which involved the disassembly and removal of the plant components and structures and was completed in 2006. This process took place in strict conformance with USNRC regulations. Oversight of the site closure process also took place from the U.S. Environmental Protection Agency, the Massachusetts Department of Environmental Protection, and Massachusetts Department of Public Health.

4.0 PROGRAM DESIGN

The Radiological Environmental Monitoring Program (REMP) for the Yankee ISFSI was designed with the following specific objectives in mind. These objectives will continue to be in force, to varying degrees, throughout its operation.

- To provide an early indication of the appearance or accumulation of any radioactive material in the environment caused by ISFSI operation.
- To provide assurance to regulatory agencies and the public that the station's environmental impact is known and within anticipated limits.
- To provide standby monitoring capability for rapid assessment of risk to the general public in the event of unanticipated or accidental releases of radioactive material.

The REMP is a requirement of the ISFSI ODCM. The detailed sampling requirements of the REMP are given in the ODCM. This table is summarized in this report as Table 4.1.

The required sampling locations are identified in the ODCM. The locations actually monitored are shown on Tables 4.2, as well as Figures 4.1 through 4.3 of this report. The locations in these tables and figures consist of the required locations specified in the ODCM for the monitoring period of this report.

4.1 Monitoring Zones

The REMP is designed to allow comparison of levels of radioactivity in samples from the area possibly influenced by the ISFSI to levels found in areas not influenced by the ISFSI. The first area is called the "indicator " stations. The second area is called the "control" locations. The distinction between the two is based on relative direction from the plant and distance. Analysis of survey data from the two zones aids in determining if there is a significant difference between the two areas. It can also help in differentiating between radioactivity or radiation due to releases and that due to other fluctuations in the environment, such as seasonal variations in the natural background.

4.2 Pathways Monitored

Based on the design of the ISFSI, only one the direct radiation exposure pathway is monitored by the REMP. This category is monitored by the collection of the sample media listed below, and are described in more detail in this section:

Direct Radiation Pathway;
TLD Monitoring

4.3 Descriptions of Monitoring Programs

4.3.1 Direct Radiation

Direct gamma radiation exposure was continuously monitored with the use of thermoluminescent dosimeters (TLDs). Dosimeters' at each monitoring location are sealed and attached to an object such as a tree, fence or utility pole. The TLDs are posted and retrieved on a semi-annual basis. All TLDs are provided and processed by a NVLAP Certified Vendor.

The TLDs are placed around the perimeter of the Independent Spent Fuel Storage Insulation (ISFSI). This type of monitoring was implemented for the ISFSI prior to the start of ISFSI operations (i.e. the time in which the initial source term (reactor internals) was placed at the ISFSI. The ISFSI TLDs are classified as GM-# in Table 4.2 of this report

4.3.2 Special Monitoring

On occasion, special samples are taken that are not required as a part of the Radiological Environmental Monitoring Program (REMP) or the ODCM. The sample locations vary from year to year and do not appear in the Offsite Dose Calculation Manual, nor do they appear in Table 4.1 or 4.2 of this report. For the monitoring period, no special samples were collected as part of the Yankee ISFSI Radiological Environmental Monitoring Program.

TABLE 4.1

ISFSI Radiological Environmental Surveillance Program
(as required by the ODCM)

Exposure Pathway and/or Sample Media	Collection			Analysis	
	Number of Sample Locations	Routine Sampling Mode	Collection Frequency	Analysis Type	Analysis Frequency
1. Direct Radiation (TLD)	Total Locations: 7 (6 around perimeter of the site and 1 offsite control location)	Continuous	Semi-annual	Gamma dose	Each TLD

TABLE 4.2

ISFSI Radiological Environmental Monitoring Locations (TLD)

Station Code	Station Description	Zone*	Distance From ISFSI (km)	Direction From ISFSI
GM-27	Number Nine Road (O)*	2	7.60	ENE
GM-02	Observation Stand (O)**	1	0.50	NW
GM-06	Readsboro Road Barrier (O)**	1	1.30	N
GM-15	Onsite Perimeter (I)**	1	0.24	NW
GM-16	Onsite Perimeter (I)**	1	0.22	NNW
GM-17	Onsite Perimeter (I)**	1	0.13	NNE
GM-21	Onsite Perimeter (I)**	1	0.17	WSW

*2 = Control TLD; 1 = Indicator TLD

**I = Inner Ring TLD; O = Outer Ring TLD

Figure 4.1

Onsite Direct Radiation Monitoring Locations

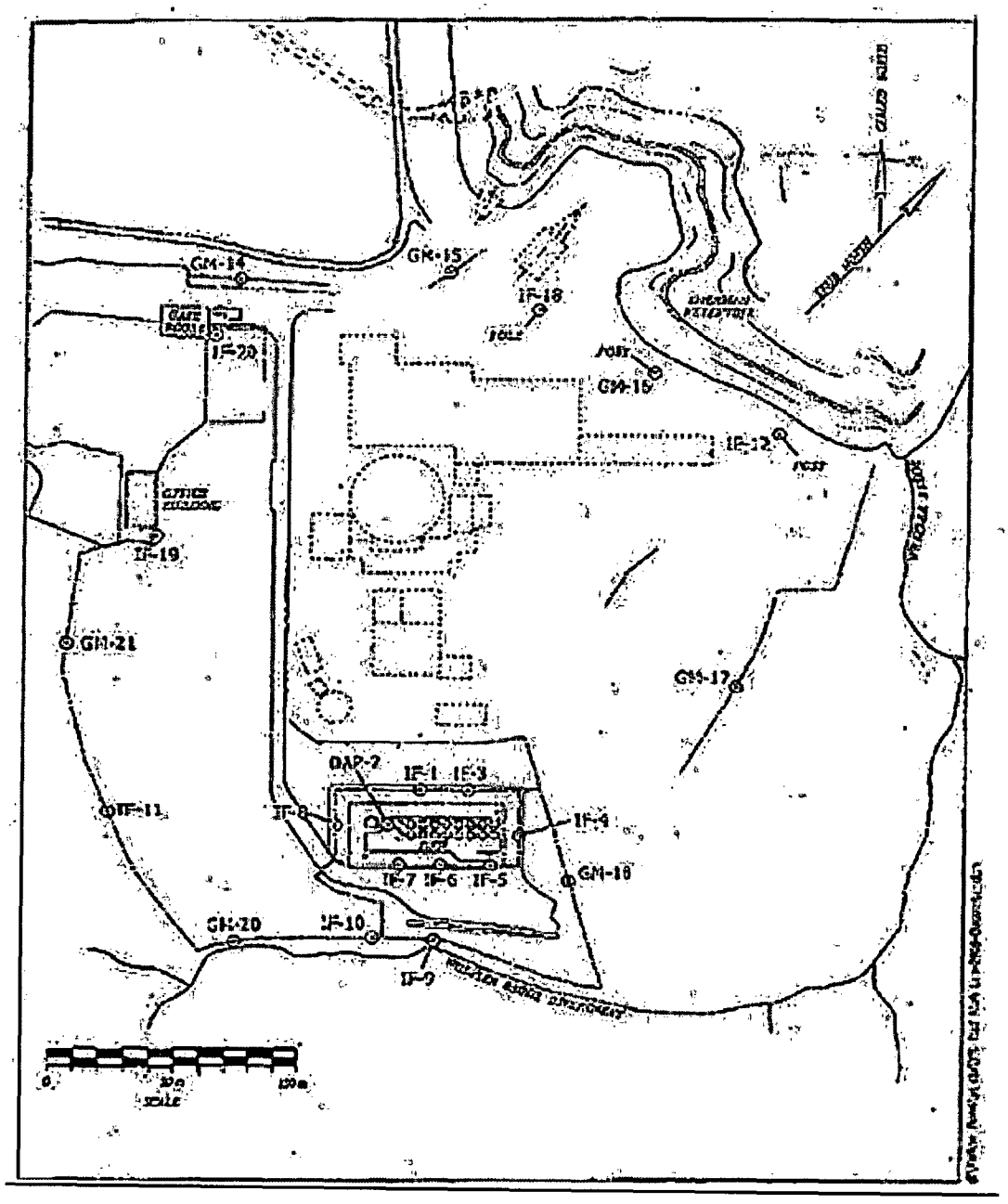


Figure 4.2

Direct Radiation Monitoring Locations (Within 1 mile)

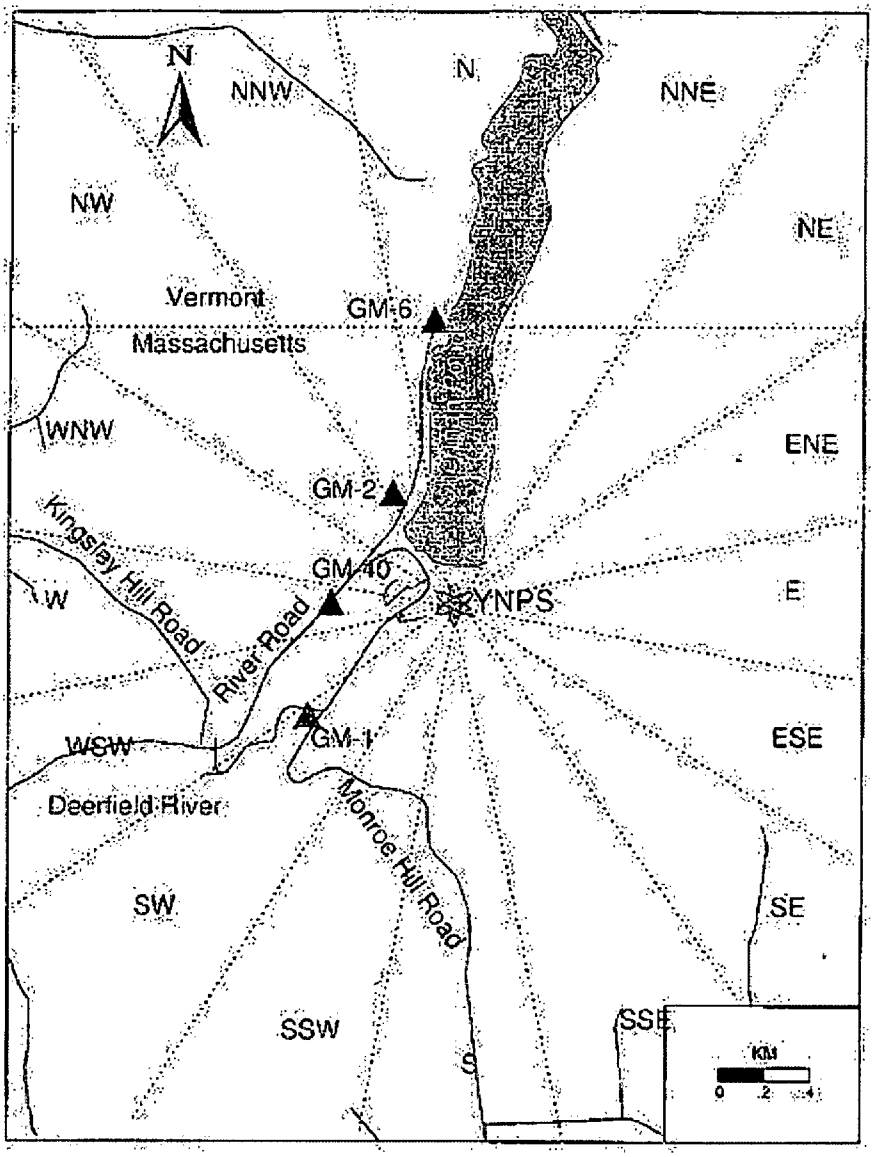
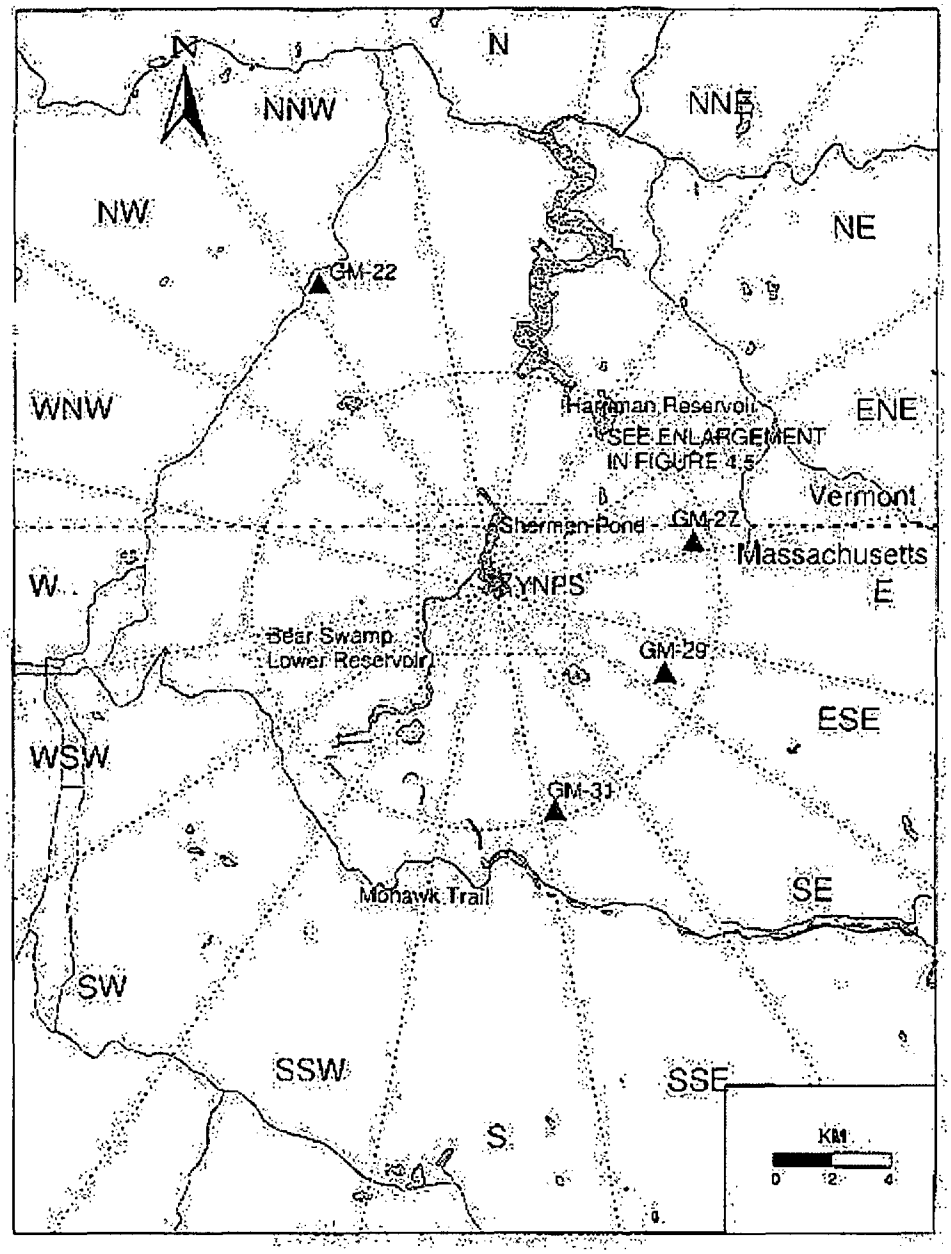


Figure 4.3 Offsite Control Location (TLD)



5.0 RADIOLOGICAL DATA SUMMARY TABLES

This section summarizes the analytical results of the environmental samples, which were collected during the monitoring period. These results, shown in Table 5.1, are presented in a format similar to that prescribed in the NRC's Radiological Assessment Branch Technical Position on Environmental Monitoring (Reference 1).

The complete listing of TLD data is provided in Table 5.2

Table 5.1
ENVIRONMENTAL TLD DATA SUMMARY
YANKEE ATOMIC ISFSI, ROWE, MA
(JANUARY - DECEMBER 2007)
(μR/hr)

INNER RING TLDs	**(CONTROL TLD'S)**	**STATION WITH HIGHEST MEAN**	
MEAN (RANGE) (NO. MEASUREMENTS)*	MEAN (RANGE) (NO. MEASUREMENTS)*	STA. NO.	MEAN (RANGE) (NO. MEASUREMENTS)*
8.66 (7.61 – 10.07) (12)	6.46 (6.33 – 6.6) (2)	GM-15	10.03 (10.0 – 10.07) (2)

* Each "measurement" is based on semi-annual readings

TABLE 5.2

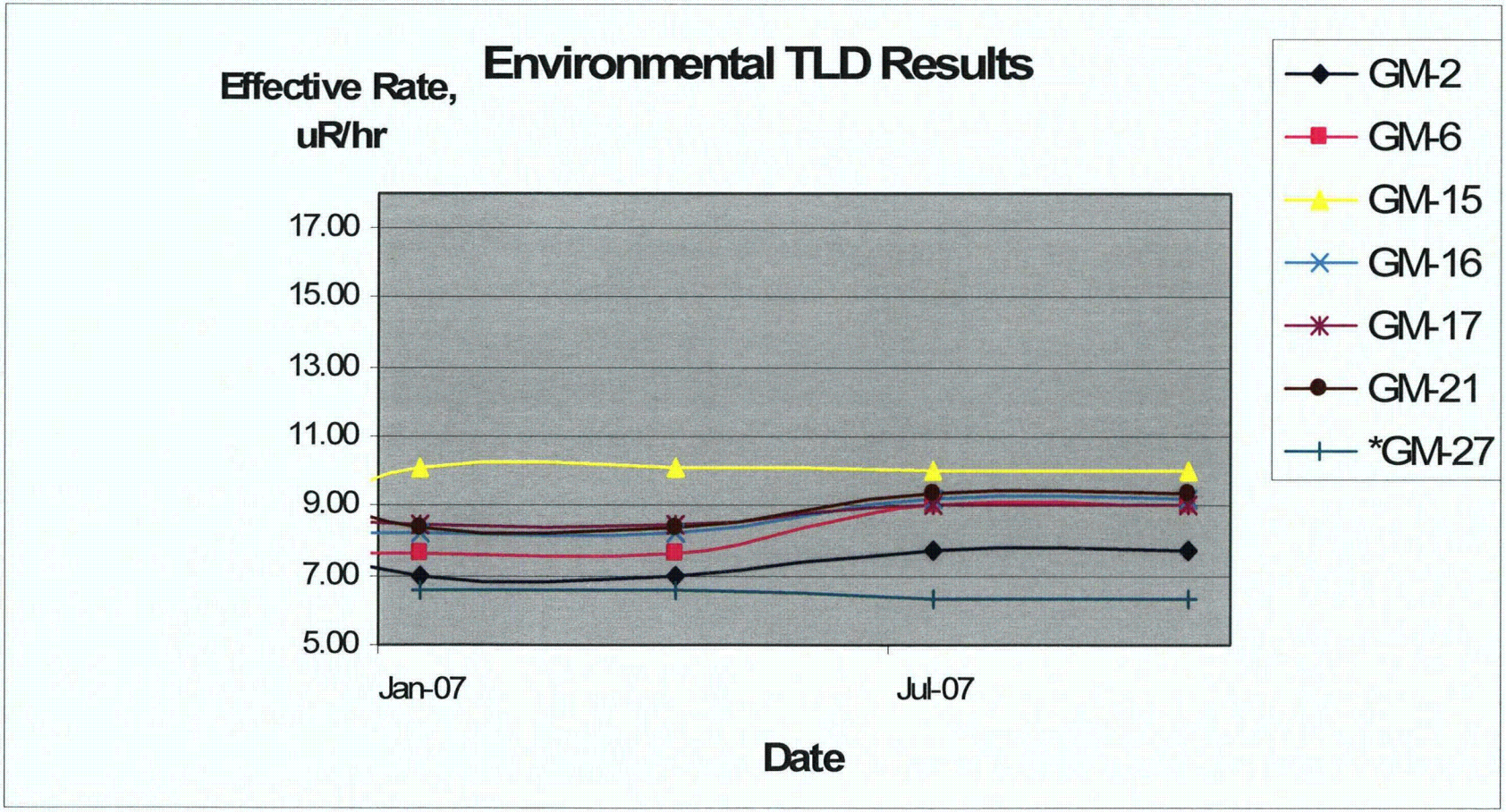
Environmental TLD Measurements
(Micro-R per hour)

Sta. No.	Description	1st Half-Year Exp.	2nd Half-Year Exp.	Annual Ave. Exp.
GM-2	NW	6.98	7.7	7.34
GM-6	N	7.61	9.0	8.30
GM-15	NW	10.07	10.0	10.03
GM-16	NNW	8.23	9.2	8.71
GM-17	NNE	8.49	9.0	8.74
GM-21	WSW	8.34	9.4	8.87
Control Station				
GM-27	N (number 9 road)	6.33	6.6	6.46

FIGURE 5.1

ISFSI Environmental TLD Measurements

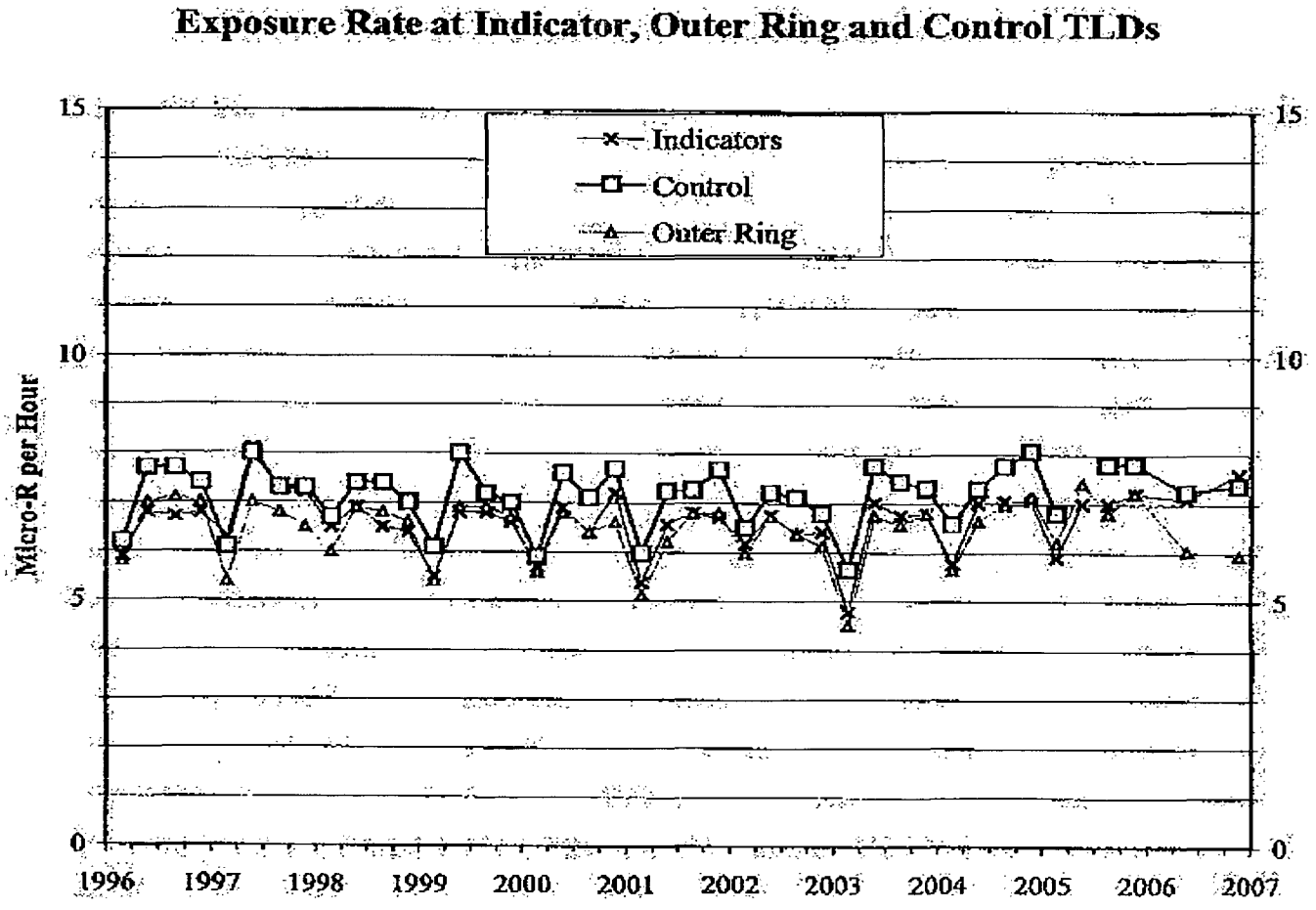
(GM-2 – GM-27)



NOTE: TLD's are changed out twice per year in accordance with the Yankee Rowe ODCM
No background subtraction has been applied to the results
*GM-27 is the offsite control location

FIGURE 5.2

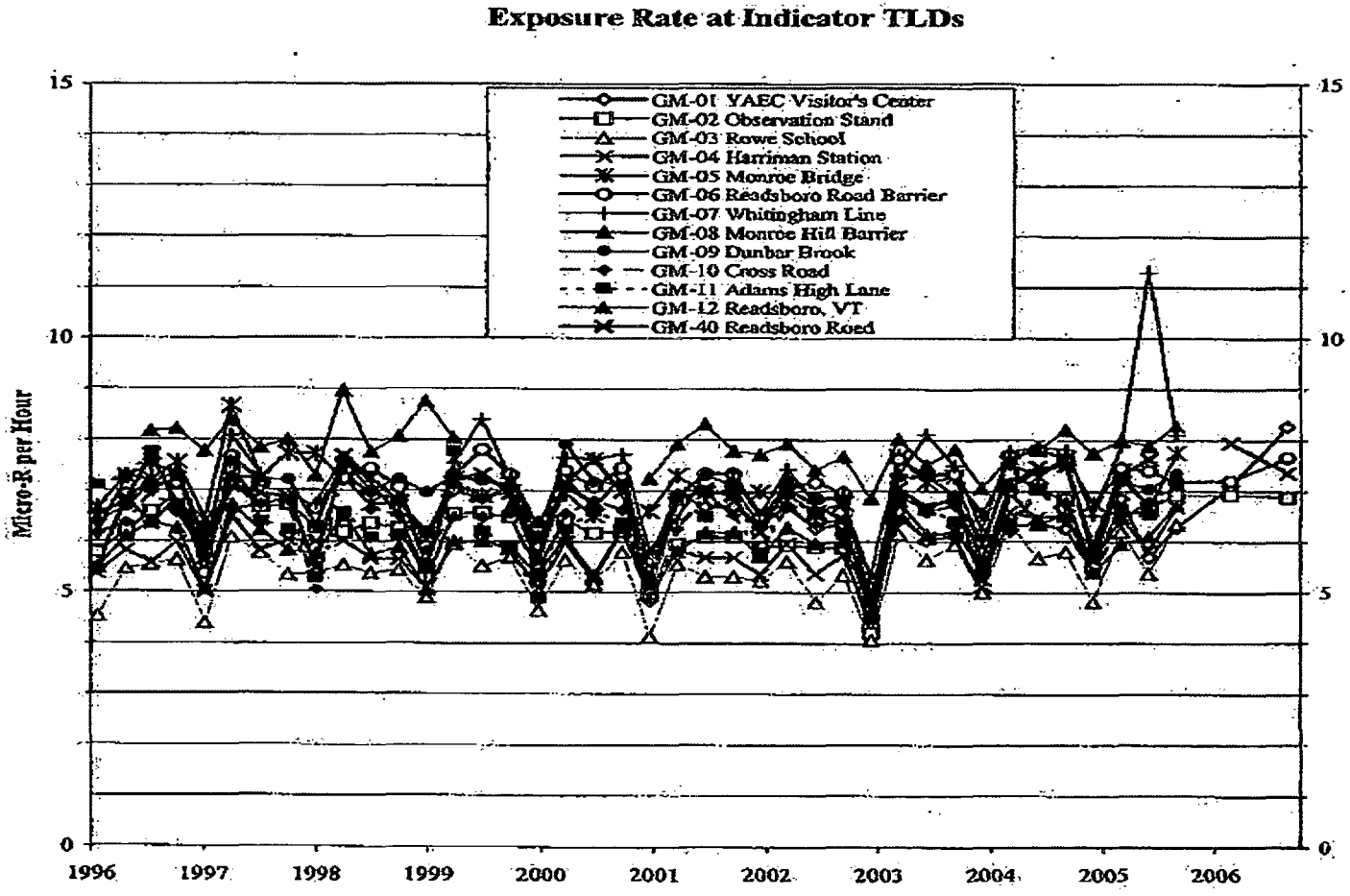
Historical Trend of Environmental TLD Measurements
(Micro-R per hour)



Background correction is not applied

FIGURE 5.2 Continued

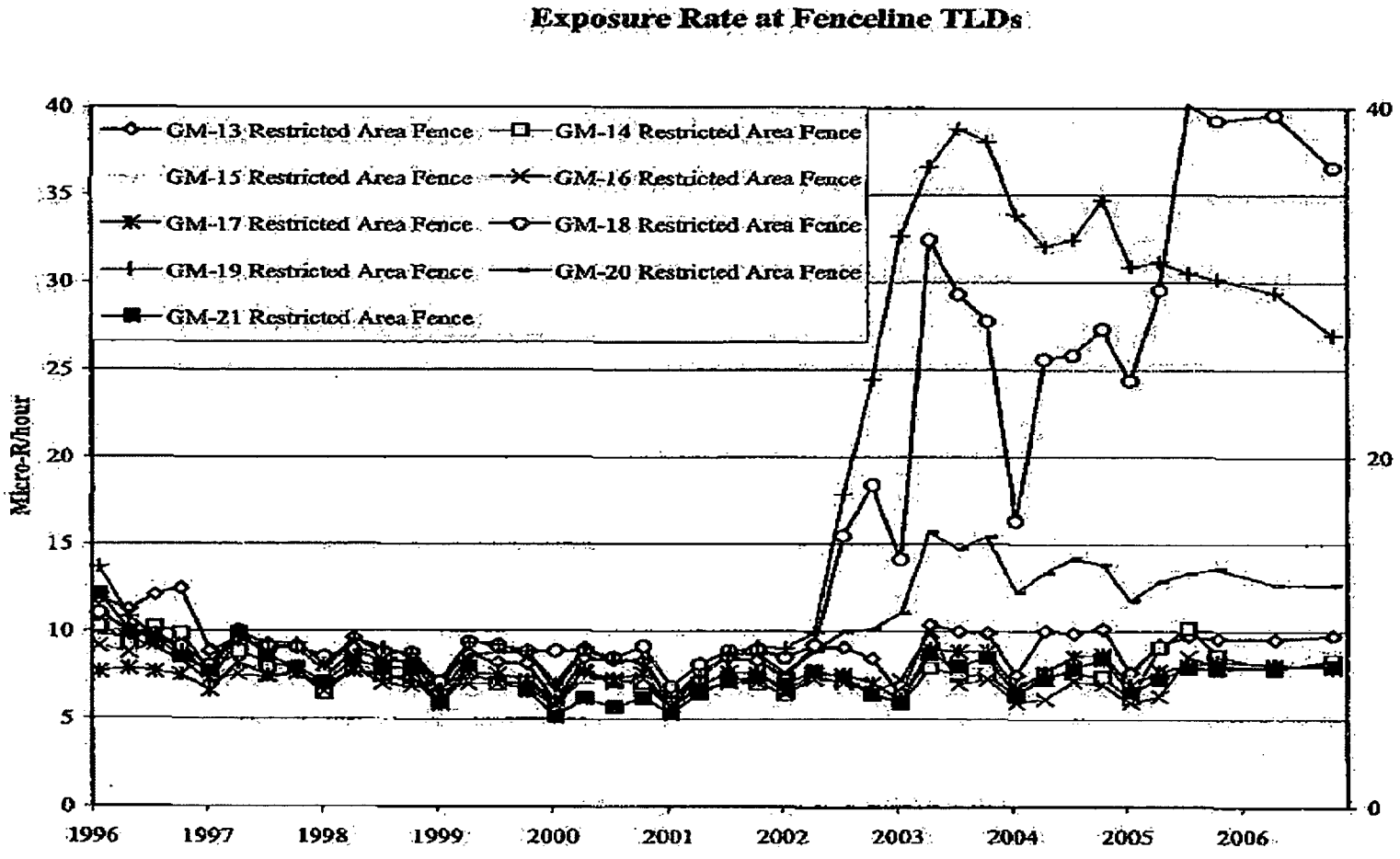
Historical Trend of Environmental TLD Measurements
(Micro-R per hour)



Background correction is not applied

FIGURE 5.2 Continued

Historical Trend of Environmental TLD Measurements
(Micro-R per hour)



Background correction is not applied

6.0 ANALYSIS OF ENVIRONMENTAL RESULTS

6.1 Sampling Program Deviations

The REMP allows for deviations in the REMP sampling schedule "if samples are unobtainable due to hazardous conditions, to seasonal unavailability or to malfunction of sampling equipment." Such deviations do not compromise the program's effectiveness and in fact are considered insignificant with respect to what is normally anticipated for any radiological environmental monitoring program.

No deviations of the sampling requirements occurred during this monitoring period.

6.2 Data Analysis by Media Type

The REMP data for each media type collected during the monitoring period is discussed below. Whenever a specific measurement result is presented, it is given as the concentration plus or minus one standard deviation. This standard deviation represents only the random uncertainty associated with the radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the analytical procedure. A sample is considered to yield a "detectable measurement" when the concentration exceeds three times its associated standard deviation.

6.2.1 Direct Radiation Pathway

Direct radiation is continuously measured at 6 locations surrounding the Yankee Rowe ISFSI using thermoluminescent dosimeters (TLDs). These dosimeters are collected semi-annually for readout at the dosimetry services vendor and compared against the offsite control location dosimeter/s.

As can be seen from the direct radiation results, there is a distinct annual cycle at both indicator and control locations. This is due primarily to the attenuating effect of the snow cover on radon emissions and on direct irradiation by naturally-occurring radionuclides in the soil. Differing amounts of these naturally-occurring radionuclides in the underlying soil, rock or nearby building materials result in different radiation levels between one field site and another.

During the 2007 monitoring period, all monitoring locations were slightly elevated above the background at the control location GM-27. However, these elevated readings are well below the dose limit of 25 mrem per year to a member of the public specified in 40 CFR 190.

8.0 REFERENCES

1. USNRC Radiological Assessment Branch Technical Position, "An Acceptable Radiological Environmental Monitoring Program," Revision 1, November 1979.

2. NCRP Report No. 94, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, National Council on Radiation Protection and Measurements, 1987.

3. *Ionizing Radiation: Sources and Biological Effects*, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1982 Report to the General Assembly.

4. Kathren, Ronald L., *Radioactivity and the Environment - Sources, Distribution, and Surveillance*, Harwood Academic Publishers, New York, 1984.

5. NRC Generic Letter 89-01, Subject: Implementation of Programmatic Controls for Radiological Effluent Technical Specifications in the Administrative Controls Section of the Technical Specifications and the Relocation of Procedural Details of RETS to the Offsite Dose Calculation Manual or to the Process Control Program. Dated January 31, 1989.

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