MINNESOTA DEPARTMENT OF HEALTH

2002 - 2003 ENVIRONMENTAL RADIATION DATA REPORT

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Acknowledgement

Thanks to Dan Vanhorn for collecting the environmental samples and to the staff in the Radiochemical Analysis Unit for analyzing them.

Summary and Conclusion

The Minnesota Department of Health (MDH) Radiation Control Unit in the Section of Asbestos, Indoor Air, Lead and Radiation monitors environmental radioactivity in Minnesota. If any increases in radiation in the environment are identified, corrective actions are recommended to ensure that amounts do not exceed safe levels. Monitoring also allows the MDH to develop a database on radioactivity within the state that can be used as a baseline during emergencies.

The environmental monitoring program consists of sample collection (currently focused on the two nuclear-generating plants, see Figure 1 for locations), measurement of gamma radiation near the nuclear-generating plants, surveying of spent fuel storage casks, radiochemical analysis of the samples (by the MDH Public Health Laboratory staff), interpretation of the data, and estimation of dose.

No new findings of unexpected radioactivity were detected in Minnesota during 2002. In 2003, radioactive tritium was detected downstream of the Prairie Island Nuclear Generating Plant on September 15th and December 8th. These were due to planned releases allowed by US Nuclear Regulatory Commission (NRC) license. The levels of tritium that were detected were below the drinking water standard.

No federal or state standards or guidelines were exceeded anywhere in the state, including near the nuclear electricity-generating plants.

Data show that levels of strontium-90 in milk that resulted from above ground nuclear testing are low and decreasing. Values for strontium-90 did not exceed National Primary *Drinking Water* Regulations (40 CFR 141) for strontium-90 of 8 pCi per liter. There is no specific standard for strontium-90 in milk, so the standard for strontium-90 in drinking water is used. Median values for strontium-90 also were well within recommended safe levels according to the U.S. Food and Drug Administration (FDA) emergency guidelines for milk.

Data from radiation detection equipment at Prairie Island indicate that neutron levels remained the same. No additional spent fuel was placed into storage.

Dose calculations indicate that individuals in Minnesota receive less than 1 millirem per year from human-made radiation detected in the environment, such as strontium-90 in milk. The National Council on Radiation Protection and Measurements (NCRP) considers an annual dose of 1 mrem to be negligible.

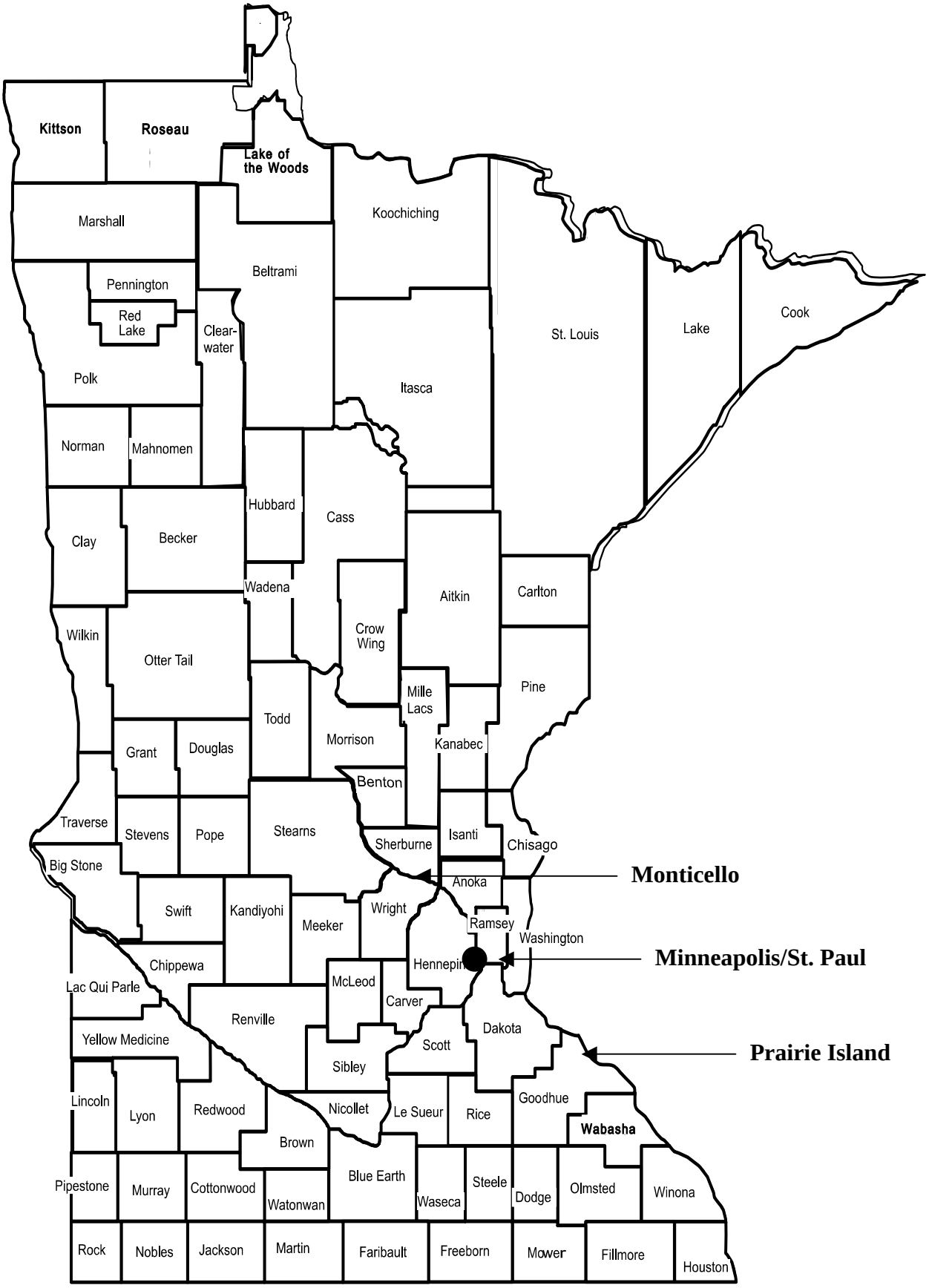


Figure 1. Monticello and Prairie Island Nuclear Generating Plants

Interpretation of Results

MDH Radiation Control staff continuously compares the levels of radionuclides detected by the MDH Public Health Laboratory with previous five-year trends. If higher levels than usual are observed, they are compared with maximum permissible effluent concentrations for radioactive materials licensees, which is in the Code of Federal Regulations (10 CFR 20, Appendix B) and regulations and guides issued by state and federal agencies to determine if they pose a health risk.

The National Primary Drinking Water Regulations (40 CFR 141) apply to water. The limit for concentrations of radioactivity in air is the maximum permitted by the NRC for unrestricted areas (10 CFR 20, Appendix B) and is 100 picocuries of beta activity per cubic meter of air.

Sampling results are plotted annually on a log-normal scale (for example, see Figure 4). A straight line forms if a single source of radioactivity exists (for example, natural background). If another source were present (for example, emissions from a nuclear-generating plant), the line would not be straight.

Average Dose to an Individual

Radiation dose estimates are made using exposure-to-dose conversion factors from Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11, 1988; and the Shultis report for neutrons (J. K. Shultis and R. E. Faw, "Neutron Skyshine Analysis," July 15, 1998).

Only exposures to human-made radioactivity are used. Examples include fallout from atmospheric nuclear tests and emissions and effluents from nuclear-generating plants. Exposures from naturally occurring radioactivity (for example, potassium-40 in milk) are not considered.

Data Analyses Results

Findings from the environmental monitoring program during 2002 and 2003 are presented and compared with findings from the previous three years.

Statewide Sampling Results

Milk

Values for strontium-90 in 2002 and 2003 for samples taken at each of the seven sites did not exceed National Primary *Drinking Water* Regulations (40 CFR 141) for strontium-90 of 8 pCi per liter (see Table 1). Because there is no specific standard for strontium-90 in milk, the standard for strontium-90 in drinking water is used. Median values for strontium-90 also were well within recommended safe levels according to the U.S. Food and Drug Administration (FDA) emergency guidelines for milk. The FDA recommends that during an emergency, protective actions be taken only when levels exceed 4,000 pCi per liter (Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies, Food and Drug Administration, August 13, 1998).

Strontium-90 is a fallout product of atmospheric weapons testing. The physical half-life of strontium-90 is 28 years. The average strontium-90 level has been fluctuating, but slowly decreasing. Beginning in 2000, the St. Cloud milk was collected in Little Falls. The fluctuations observed are believed to result from sampling errors, measurement errors, and the statistical nature of the analyses.

Table 1.
MEDIAN STRONTIUM-90 LEVELS IN MILK
1999 - 2003

pCi/l

MDH District	1999	2000	2001	2002	2003
St. Cloud/Little Falls	0.9	1.4	1.8	1.0	1.3
Duluth	1.6	1.8	1.9	1.9	1.6
Bemidji	0.9	0.8	1.0	0.9	1.1
Rochester	0.8	0.8	1.0	0.9	1.0
Hastings	0.9	1.1	1.2	0.9	1.0
Norwood	0.9	0.8	0.8	0.9	<0.8
St. Paul	0.8	1.1	1.1	0.9	1.0
Median	0.9	1.1	1.1	0.9	1.0

In 2002 and 2003, potassium-40 was found in all milk samples. Levels ranged from about 1000 to 1500 pCi per liter. Potassium-40 is a naturally occurring radionuclide present at the earth's creation (physical half life of 1.3 billion years). No other nuclides were detected.

Air

The median gross beta activity measured in Minneapolis air was 0.029 pCi per cubic meter in 2002; in 2003, it was 0.028 pCi per cubic meter. In 2001, this activity was 0.026 pCi per cubic meter of air. Data were plotted on a log-normal scale, which resulted in a straight line, indicating a single source of radioactivity (that is, natural background). No reactor-produced isotopes (for example, iodine-131) were detected.

Monticello Nuclear Generating Plant

Sampling locations are shown on Figure 2.

Milk

In 2002 and 2003, the only gamma emitter detected was potassium-40 (in all monthly samples) at concentrations ranging from 1000 to 1500 pCi per liter. This isotope occurs naturally. No reactor-produced isotopes (for example, iodine-131) were detected.

Air

Biweekly air samples were collected near the Xcel Training Center. Gross beta concentrations in air are shown in Table 2 and compared with concentrations in Minneapolis.

Table 2.
MEDIAN GROSS BETA CONCENTRATION IN MONTICELLO AIR SAMPLES
1999 - 2003

pCi/m^3

	1999	2000	2001	2002	2003
Monticello (MDH)	0.018	0.027	0.023	0.022	0.026
Monticello (NMC)	0.023	0.027	0.024	0.027	unavailable
Minneapolis(MDH)	0.018	0.022	0.026	0.029	0.028

Data were plotted on a log-normal scale. The plot followed a straight line, indicating one source of radioactivity (natural background).

Surface Water

Median gross beta concentrations are shown in Table 3 for upstream and downstream water samples. The increase over the last five years will be further examined in 2004.

Table 3

MEDIAN GROSS BETA CONCENTRATION IN MISSISSIPPI RIVER WATER NEAR MONTICELLO 1999 - 2003					
pCi/l					
	1999	2000	2001	2002	2003
Upstream	2.4	2.6	2.9	3.3	4.2
Downstream	2.2	2.7	2.8	3.0	3.9

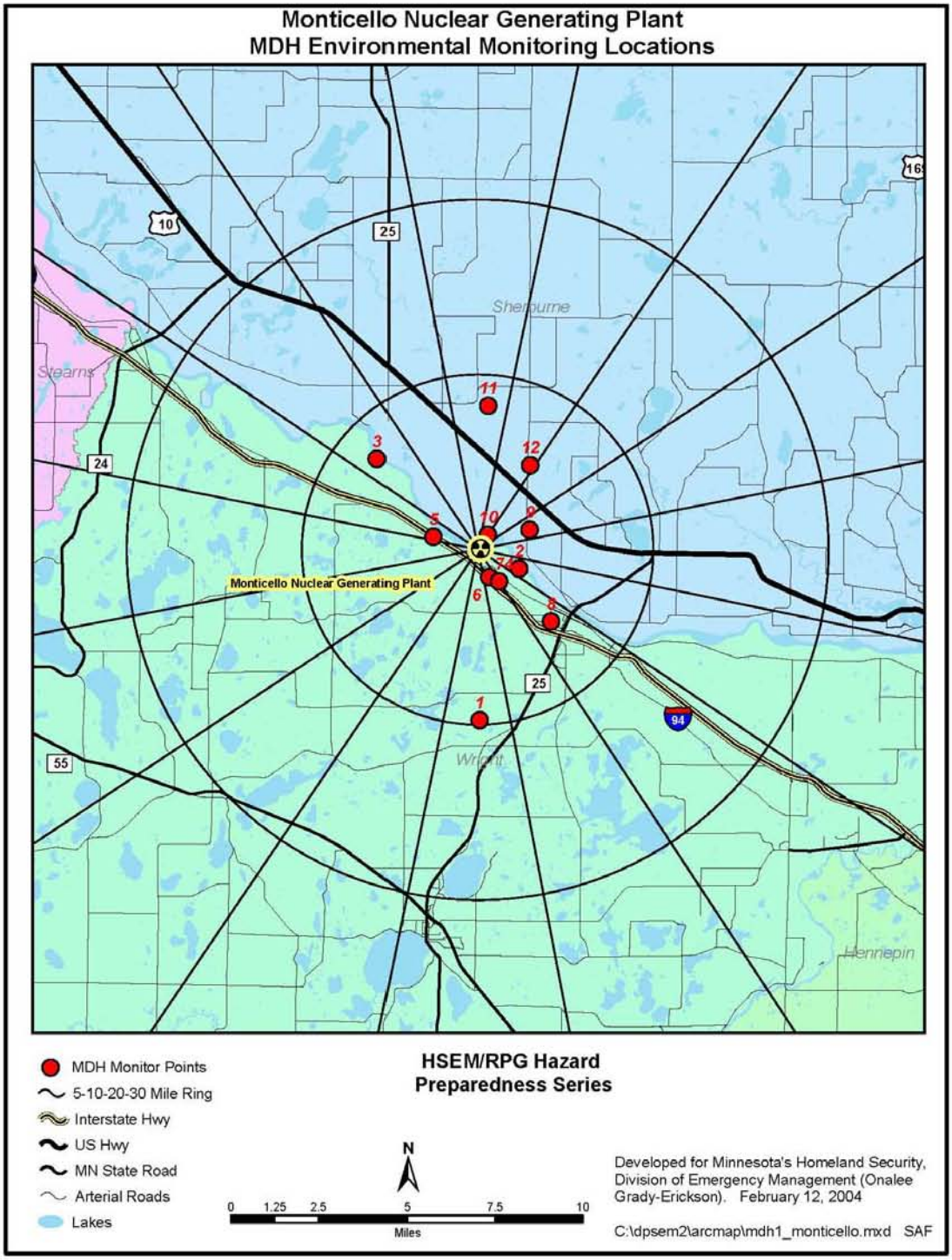
In February of 2002, strontium-90 was detected in one downstream sample (2.2 pCi per liter). It is a fallout product of atmospheric weapons testing with a 28-year physical half-life and was occasionally found in previous years.

Crops/Vegetation

During the growing season, apples grown near the plant were sampled; small amounts of potassium-40 (K-40) and beryllium-7 were detected. K-40 occurs naturally inside crops, whereas Be-7 occurs in the atmosphere from cosmic ray interactions and settles on crops. Neither K-40 nor Be-7 is an indicator of a nuclear generating plant effect, but rather a laboratory calibration control. Table 4 summarizes the K-40 levels. In 2002, cesium-137 was detected in mushrooms (0.05 pCi per gram), most likely from fallout from weapons testing or the Chernobyl accident. Cesium-137 is occasionally found in vegetation and crop samples.

In 2004, cabbage will be collected as well.

Table 4 POTASSIUM-40 CONCENTRATION IN VEGETATION/CROPS NEAR MONTICELLO 1999 - 2003					
pCi/gram					
	1999	2000	2001	2002	2003
Apples	NA	NA	1.0	1.5	1.2



1. Milk Sampling
2. Downstream Water Sampling
3. Upstream Water Sampling
4. Air Sampling
5. TLD
6. TLD
7. TLD
8. TLD
9. TLD
10. TLD
11. TLD
12. TLD

Figure 2. Monticello Monitoring Locations.

Sediment

One sample was collected downstream each September. Small amounts of radioactivity were detected. Table 5 summarizes the isotopes and activities identified. Radionuclides associated with plant operations (for example, cesium-134) were not detected.

Table 5.
NATURALLY OCCURRING RADIONUCLIDE LEVELS IN SEDIMENT DOWNSTREAM OF MONTICELLO

pCi/gram

	2002	2003
Beryllium-7	0.2	0.2
Potassium-40	10	10
Cesium-137	0.05	0.04
Lead-210	<0.7	0.7
Lead-212	0.3	0.3
Lead-214	0.2	0.3
Bismuth-212	0.3	0.4
Bismuth-214	0.2	0.3
Thallium-208	0.1	0.1
Radium-224	0.2	<0.2
Radium-226	0.4	0.5

Thermoluminescent Dosimetry (TLD)

TLD were changed quarterly. Figure 2 shows locations of TLD. Median values for exposure (milliroentgens per 13-week quarter) are presented in Table 6 for each location. No effect from the Monticello plant is indicated.

Table 6.
MEDIAN GAMMA EXPOSURE RATES NEAR MONTICELLO
1999 - 2003

mR/quarter

Location	1999	2000	2001	2002	2003
Monticello Training Ctr.	14.6	14.7	15.0	14.7	15.2
South Sector	13.8	12.3	13.8	13.4	13.6
Deer Street	13.5	13.8	13.8	13.7	14.2
Municipal Building	13.6	14.1	14.2	14.6	15.2
Orrock (Control)	13.2	12.5	13.4	12.8	13.3
Northwest Pines	13.0	12.7	13.5	13.2	13.0
Pole #F85	15.1	12.9	14.9	14.9	14.3
Pole #F33	13.8	11.6	13.5	13.5	13.5

Prairie Island Nuclear Generating Plant

Sampling locations are shown on Figure 3.

Milk

In 2002 and 2003, the only gamma emitter detected was potassium-40 (in all monthly samples) at concentrations ranging from 1000 to 1500 pCi per liter. This isotope occurs naturally. No reactor-produced isotopes (for example, iodine-131) were detected.

Air

Biweekly air samples were collected near Lock and Dam No. 3. The median gross beta activities are presented in Table 7. Data were plotted on a log-normal scale. The plot followed a straight line, indicating one source of radioactivity (natural background).

Table 7.
MEDIAN GROSS BETA CONCENTRATION IN PRAIRIE ISLAND AIR
1999-2003

pCi/m^3
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Location	1999	2000	2001	2002	2003
Prairie Island (MDH)	0.019	0.023	0.023	0.024	0.025
Prairie Island (NMC)	0.024	0.025	0.023	0.028	unavailable
Minneapolis (MDH)	0.018	0.022	0.026	0.029	0.028

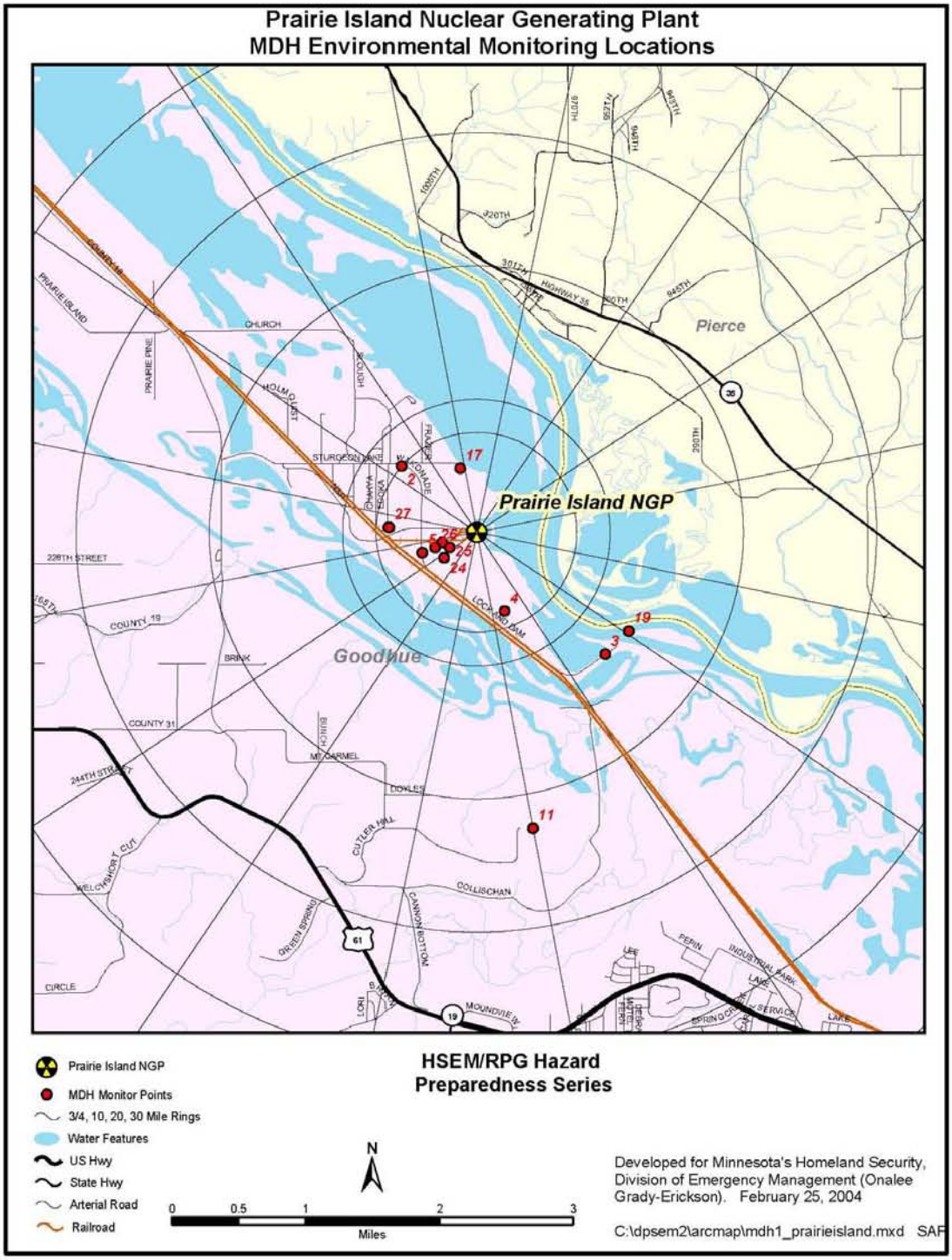
River Water

Median gross beta concentrations are shown in Table 8 for up and downstream samples. The data are plotted in Figure 4. The plot followed a straight line, indicating one source of radioactivity (natural background).

Table 8.
MEDIAN GROSS BETA CONCENTRATION IN MISSISSIPPI RIVER WATER NEAR PRAIRIE ISLAND
1999 - 2003

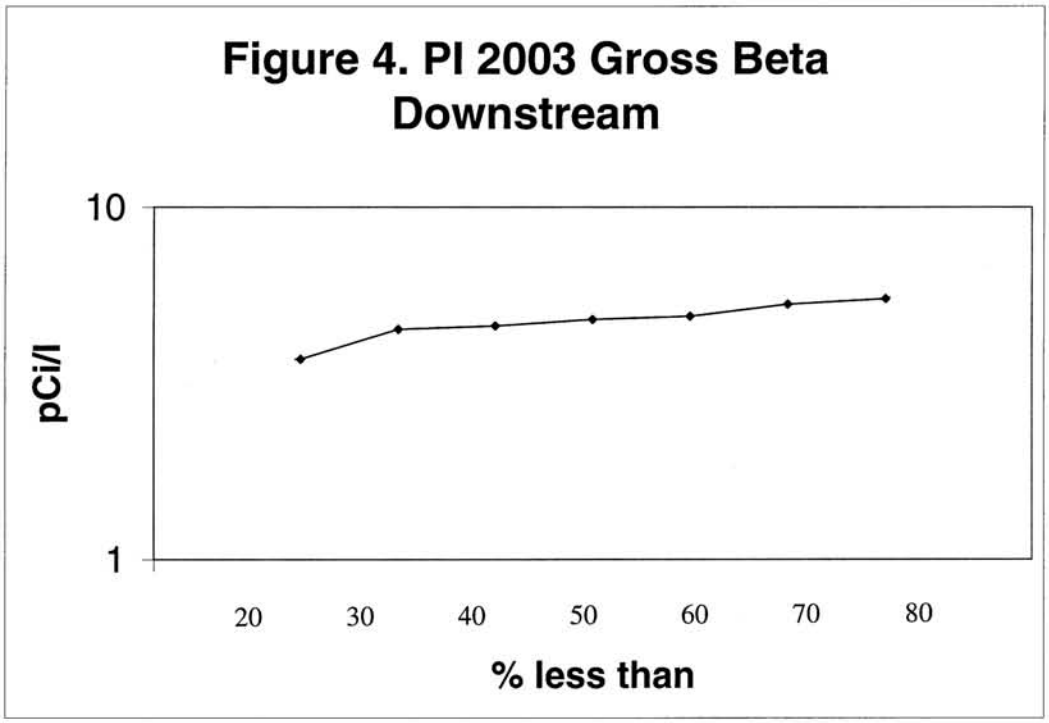
pCi/l

	1999	2000	2001	2002	2003
Upstream	5.0	5.4	6.0	5.3	7.4
Downstream	4.7	5.0	5.1	5.1	4.9



1. TLD – Hastings (Not shown)
2. TLD
3. TLD and Air Sampling
4. TLD and Groundwater
5. TLD
11. TLD and Milk Sampling
12. TLD - Red Wing (Not shown)
19. Downstream Water Sampling
22. Upstream Water Sampling
23. TLD
24. TLD
25. TLD
26. TLD
27. TLD
28. Sediment Sampling – Red Wing (Not shown)

Figure 3. Prairie Island Monitoring Locations.



Groundwater

In 2003, four quarterly samples of well water were collected from the nearest resident to the plant. The results are presented in Table 9. (Note that in 2002, the detection limit for tritium was 500 pCi per liter. The higher limit was caused by a higher instrument background in a new location).

Table 9.
MEDIAN TRITIUM VALUES IN WELL WATER NEAR THE PRAIRIE ISLAND PLANT
1995 – 2003

pCi/l

1995	1996	1997	1998	1999	2000	2001	2002	2003
110	63	32	<32	36	42	45	<500	<180

For reference, the National Primary Drinking Water Regulation (40 CFR 141) for tritium is 20,000 pCi per liter (annual average).

Food/Crops

During the growing season, apples and hay grown near the plant were sampled; small amounts of potassium-40 (K-40) and beryllium-7 were detected. K-40 occurs naturally inside crops, whereas Be-7 occurs in the atmosphere from cosmic ray interactions and settles on crops. Neither K-40 nor Be-7 is an indicator of a nuclear generating plant effect, but rather a laboratory calibration control. Table 10 summarizes the K-40 levels.

Table 10.
POTASSIUM-40 CONCENTRATION IN VEGETATION/CROPS NEAR PRAIRIE ISLAND
1999 – 2003

pCi/gram

	1999	2000	2001	2002	2003
Apples	NA	1.2	1.2	1.5	1.2
Hay	NA	1.8	7.6	5.0	4.1

Sediment

One sample was collected downstream each September. Small amounts of radioactivity were detected. Table 11 summarizes the isotopes and activities identified. Radionuclides associated with plant operations (for example, cesium-134) were not detected.

Table 11.
RADIOACTIVITY LEVELS IN SEDIMENT DOWNSTREAM OF PRAIRIE ISLAND

pCi/gram

	2002	2003
Beryllium-7	<0.1	<0.06
Potassium-40	8	6
Cesium-137	0.01	<0.006
Lead-210	<0.3	0.4
Lead-212	0.2	0.2
Lead-214	0.2	0.1
Bismuth-212	0.3	0.3
Bismuth-214	0.2	0.1
Thallium-208	0.1	0.09
Radium-224	0.2	0.2
Radium-226	0.4	<0.2

Thermoluminescent Dosimetry (TLD)

TLD were changed quarterly during 2002 and 2003. Median values for exposure (milliroentgen per quarter) are presented in Table 12 for each location.

Beginning in 1993, the Department began background monitoring at the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) in anticipation of dry cask storage monitoring in 1995. Two TLD are located inside the earthen berm and four TLD are located outside the berm. The two inside, ISFSI #3 and ISFSI #4, show above background gamma exposures that are consistent with the NMC computer model. Two TLD on Xcel Energy property but outside the berm (ISFSI #1, ISFSI #2) indicated above background levels of radiation that are also consistent with the computer model. The Prairie Island Community and ISFSI #6 TLD indicate exposures that are normal (natural background).

Table 12.
MEDIAN GAMMA EXPOSURE RATES NEAR PRAIRIE ISLAND
1999 - 2003

mR/quarter

Location	1999	2000	2001	2002	2003
Nearest Resident	13.2	13.6	12.5	12.9	13.5
Northwest Sector	11.2	11.4	11.2	11.4	11.3
Lock and Dam No. 3	11.9	12.1	11.6	12.1	12.2
Mount Carmel Road	12.8	14.0	13.1	13.7	13.7
Red Wing	13.5	13.8	13.7	13.7	14.3
Hastings (Control)	13.4	13.9	13.1	13.8	13.2
ISFSI #1 (Control)	16.9	17.5	16.6	17.3	16.4
ISFSI #2 (Outside Berm)	16.2	18.3	17.3	17.1	19.0
ISFSI #3 (Inside Berm)	24.0	28.9	35.8	43.6	49.0
ISFSI #4 (Inside Berm)	18.3	18.3	18.0	18.0	18.0
Prairie Island Community	13.1	12.9	11.9	12.0	12.5
ISFSI #6 (Outside Berm)	12.9	12.9	12.5	13.8	14.2

Independent Spent Fuel Storage Installation (ISFSI)

Pressurized Ionization Chambers (PIC)

Throughout 2002 and 2003, radiation data near the ISFSI were collected by the PIC system, which was installed in January 1995. The system consists of two ion chambers, computer memories and modems that are accessed every 15 minutes by MDH computers in St. Paul. The computers automatically page MDH staff if unusual readings occur.

One chamber is located about 100 feet north of the spent-fuel casks and the other is located about 100 feet south.

The normal background level was recorded at the time of installation and ranged from 5 to 15 micro Roentgen per hour. The first three loaded casks were placed on the ISFSI pad during 1995. The fourth loaded spent fuel cask was placed on the pad during the second quarter of 1996. The fifth cask was placed on the pad during the fourth quarter of 1996. The sixth and seventh casks were placed in the first quarter of 1997. In 1999, the eighth cask was placed in the first quarter and the ninth cask was placed in the second quarter. In 2000, the 10th cask was placed in the first quarter and the 11th and 12th casks were placed in the fourth quarter. In 2001, the 13th cask was placed in the third quarter and the 14th cask was placed in the fourth quarter.

In 2002, the 15th cask was placed in the first quarter and the 16th and 17th casks were placed in the third quarter.

The annual average readings for PIC #1 are shown in Table 13; the readings for PIC #2 are shown in Table 14.

Table 13.
PIC #1 ANNUAL READINGS
1999 - 2003

microR/hr

	1999	2000	2001	2002	2003
	86.4	93.9	95.1	100.1	99.2
No. of Casks	9	12	14	17	17

Table 14.
PIC #2 ANNUAL READINGS
1999 - 2003

microR/hr

	1999	2000	2001	2002	2003
	76.5	86.3	91.9	93.9	91.2
No. of Casks	9	12	14	17	17

Dose to Average Individual

Individuals receive radiation doses from natural and human-made sources. Estimates of dose resulting from human activities are discussed here. These activities include exposure to strontium-90 that still exists from atmospheric nuclear testing in the 1950's and scatter radiation from the Prairie Island ISFSI. Strontium-90 exposure occurs via the milk pathway; scatter radiation from the ISFSI is mostly from neutrons. Because strontium-90 is not naturally occurring, and varies in its concentration in the environment, in some cases exposure can be reduced; for example, by utilizing a different source of milk. Similarly, spending less time near the ISFSI can lessen neutron exposure.

The dose estimates are presented in Table 15. For milk, MDH assumed a consumption of two liters per day. Because MDH continues to find strontium-90 in milk, average annual dose has been estimated. In 2003, this dose from drinking milk in Minnesota is estimated to be 0.10 mrem per year (committed effective dose equivalent). For the dose from the ISFSI, MDH assumed continuous presence of an individual 700 meters from the center.

Table 15.
AVERAGE DOSE ESTIMATE FROM HUMAN-MADE RADIOACTIVITY MEASURED IN MINNESOTA ENVIRONMENTAL SAMPLES
1999 - 2003

Committed Effective Dose Equivalent, mrem per year					
Media & Isotope	1999	2000	2001	2002	2003
Milk--Strontium-90	0.09	0.11	0.11	0.09	0.10
Scatter--Neutron	0.02	0.02	0.03	0.03	0.03

These estimates are based on exposure-to-dose conversion factor of 142.5 mrem per micro Curie of strontium-90 (EPA Federal Guidance Report No. 11, 1988) and the Shultis report for neutrons (J. K. Shultis and R. E. Faw, "Neutron Skyshine Analysis," July 15, 1998).

The doses in Table 15 are below the Negligible Individual Dose of 1.0 mrem per year, as defined by the NCRP (NCRP Report No. 116, 1993).