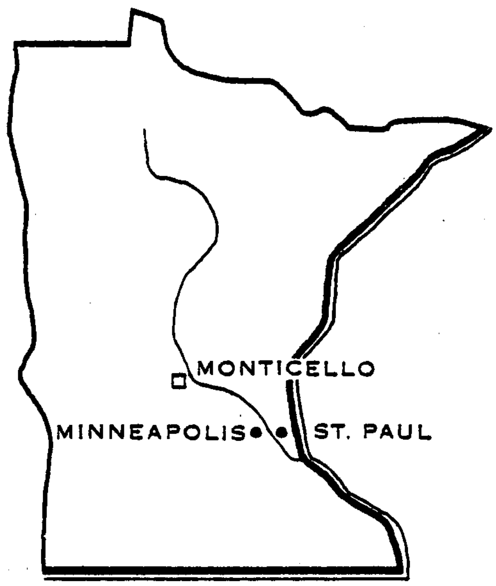
MONTICELLO NUCLEAR GENERATING PLANT

Monticello, Minnesota

UNIT I



ANNUAL REPORT

to the

UNITED STATES NUCLEAR REGULATORY COMMISSION

Radiation Environmental Monitoring Program

January 1, 1984 to December 31, 1984

NORTHERN STATES POWER COMPANY

MINNEAPOLIS. MINNESOTA

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MINNEAPOLIS, MINNESOTA

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DOCKET NO. 50-263 LICENSE NO. DPR-22

ANNUAL REPORT
TO THE
UNITED STATES NUCLEAR REGULATORY COMMISSION

Radiation Environmental Monitoring Program
January 1, 1984 to December 31, 1984

Prepared Under Contract
by
TELEDYNE ISOTOPES MIDWEST LABORATORY
Project No. 8010

Approved by: L. G. Huebner
L. G. Huebner
General Manager

27 February 1985

PREFACE

The staff of Teledyne Isotopes Midwest Laboratory (formerly Hazleton Environmental Sciences) was responsible for the acquisition of the data presented in this report. Samples were collected by members of the staff of the Monticello Nuclear Generating Plant.

This report was prepared by T. Patton-Baker under the direction of L.G. Huebner, General Manager, Teledyne Isotopes Midwest Laboratory. She was assisted in the report preparation by other staff members of this laboratory.

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1.0 INTRODUCTION

This report summarizes and interprets results of the Radiation Environmental Monitoring Program (REMP) conducted by Teledyne Isotopes Midwest Laboratory at the Monticello Nuclear Generating Plant, Monticello, Minnesota, during the period January - December, 1984. This Program monitors the levels of radioactivity in the air, terrestrial, and aquatic environments in order to assess the impact of the Plant on its surroundings.

Tabulation of the individual analyses made during the year are not included in this report. These data are included in a reference document (Teledyne Isotopes Midwest Laboratory, 1985) available at Northern States Power Company, Nuclear Generation Department.

Monticello Nuclear Generating Plant is a 545 MWe boiling water reactor located on the Mississippi River in Wright County, Minnesota, and operated by Northern States Power Company. Initial criticality was achieved on 10 December 1970. Full power was achieved on 5 March 1971 and commercial operation began on 30 June 1971.

2.0 SUMMARY

The Radiation Environmental Monitoring Program (REMP) required by the U.S. Nuclear Regulatory Commission (NRC) Technical Specifications for the Monticello Nuclear Generating Plant is described. Results for 1984 are summarized and discussed.

Program findings show background levels of radioactivity in the environmental samples collected in the vicinity of the Monticello Nuclear Generating Plant.

No effect on the environment due to the operation of the Monticello Generating Plant is indicated.

3.0 RADIATION ENVIRONMENTAL MONITORING PROGRAM (REMP)

3.1 Program Design and Data Interpretation

The purpose of the Radiation Environmental Monitoring Program (REMP) at the Monticello Nuclear Generating Plant is to assess the impact of the Plant on its environment. For this purpose, samples are collected from the air, terrestrial, and aquatic environments and analyzed for radioactive content. In addition, ambient gamma radiation levels are monitored by thermoluminescent dosimeters (TLDs).

Sources of environmental radiation include the following:

(1) natural background radiation arising from cosmic rays and primordial radionuclides;

(2) fallout from atmospheric nuclear detonations;

(3) releases from nuclear power plants;

(4) industrial and medical radioactive waste.

In interpreting the data, effects due to the Plant must be distinguished from those due to other sources.

A major interpretive aid in assessment of these effects is the design of the monitoring program at the Monticello Plant which is based on the indicator-control concept. Most types of samples are collected both at indicator locations (nearby, downwind, or downstream) and at control locations (distant, upwind, or upstream). A plant effect would be indicated if the radiation level at an indicator location was significantly larger than that at the control location. The difference would have to be greater than could be accounted for by typical fluctuations in radiation levels arising from other sources.

An additional interpretive technique involves analyses for specific radionuclides present in environmental samples collected from the Plant site. The Plant's monitoring program includes analyses for tritium and iodine-131. Most samples are also analyzed for gamma-emitting isotopes with results for the following groups quantified: zirconium-95, cesium-137, cerium-144, beryllium-7, and potassium-40. The first three gamma-emitting isotopes were selected as radiological impact indicators because of the different characteristic proportions in which they appear in the fission product mix produced by a nuclear reactor and that produced by a nuclear detonation. Each of the three isotopes is produced in roughly equivalent amounts by a reactor: each constitutes about 10% of the total activity of fission products 10 days after reactor shutdown. On the other hand, 10 days after a nuclear explosion, the contributions of zirconium-95, cerium-144, and cesium-137 to the activity of the resulting debris are in the approximate ratio 4:1:0.03 (Eisenbud, 1963). Beryllium-7 is of cosmogenic origin and potassium-40 is a naturally-occurring isotope. They were chosen as calibration monitors and should not be considered as radiological impact indicators.

The other group quantified consists of niobium-95, ruthenium-103 and -106, cesium-134, barium-lanthanum-140, and cerium-141. These isotopes are released in small quantities by nuclear power plants, but to date their major source of injection into the general environment has been atmospheric nuclear testing. Nuclides of the final group, manganese-54, iron-59, cobalt-58 and -60, and zinc-65, are activation products and arise from activation of corrosion products. They are typical components of nuclear power plant's effluents, but are not produced in significant quantities by nuclear detonations.

Other means of distinguishing sources of environmental radiation can be employed in interpreting the data. Current radiation levels can be compared with previous levels, including those measured before the plant became operational. Results of the Plant's Monitoring Program can be related to those obtained in other parts of the world. Finally, results can be related to events known to cause elevated levels of radiation in the environment, e.g., atmospheric nuclear detonations.

3.2 Program Description

The sampling and analysis schedule for the Radiation Environmental Monitoring Program (REMP) at the Monticello Plant is summarized in Table 5.1 and briefly reviewed below. Table 5.2 defines the sampling location codes used in Table 5.1 and specifies for each location its type (indicator or control) and its distance, direction, and sector relative to the reactor site. To assure that sampling is carried out in a reproducible manner, detailed sampling procedures have been prescribed (Hazleton Environmental Sciences, 1983).

To monitor the air environment, airborne particulates are collected on membrane filters by continuous pumping at five locations. Also, airborne iodine is collected by continuous pumping through charcoal filters at all of these locations. Filters are changed and counted weekly.

Particulate filters are analyzed for gross beta activity and charcoal filters for iodine-131. Quarterly composites of particulate filters from each location are gamma-scanned on a Ge or Ge(Li) detector. One of the five locations is a control (M-1), and four are indicators (M-2, M-3, M-4, M-5). One of the indicators is located in the geographical sector expected to be most susceptible to any atmospheric emissions from the Plant (highest X/Q sector).

As a "Lessons Learned" commitment, ambient gamma radiation is monitored at thirty-seven (37) locations using three (3) LiF_2 chips at each location: fourteen (14) in an inner ring in the general area of the site boundary, sixteen (16) in the outer ring within 4-5 mi radius, six (6) at special interest locations and one control location, 11.1 mi distant from the plant. They are replaced and measured quarterly. Also, a complete emergency set of TLDs for all locations is placed in the field at the same time as regular sets. The emergency set is returned to TIML quarterly for annealing and repackaging.

Milk samples are collected monthly from five farms (four indicator and one control). If the milch animals are on pasture, the milk is collected biweekly during the growing season (May - November). All samples are analyzed for iodine-131 and gamma-emitting isotopes.

Leafy green vegetables (cabbage) are collected annually from a garden nearest the Plant and a control location (M-10) and analyzed for iodine-131. Corn is collected annually from the highest X/Q dairy farm and a control location and analyzed for gamma-emitting isotopes. Potatoes are collected annually from the highest X/Q dairy farm that produces potatoes and a control location. Analysis is for gamma-emitting isotopes.

The terrestrial environment is also monitored by collection of well water (quarterly). All samples are analyzed for tritium and gamma-emitting isotopes.

River water is collected weekly at two locations, one upstream of the Plant and one downstream. Monthly composites are analyzed for gamma-emitting isotopes. Quarterly composites are analyzed for tritium.

Drinking water is collected weekly from the City of Minneapolis water supply, which is taken from the Mississippi River downstream of the Plant. Monthly composites are analyzed for gross beta, iodine-131, and gamma-emitting isotopes. Quarterly composites are analyzed for tritium.

The aquatic environment is also monitored by semi-annual upstream and downstream collections of fish, algae or aquatic insects, and bottom sediments. Shoreline sediment is collected semi-annually from one location. All samples are analyzed for gamma-emitting isotopes.

3.3 Program Execution

The Program was executed as described in the preceding section with the following exceptions:

(1) There were no TLD data for the second, third, and fourth quarters for location M-04S because TLDs were lost in the field. This location changed slightly to eliminate this problem.

(2) There were no TLD data for the third quarter for location M-01B because TLDs were lost in the field.

(3) There was no air particulate datum from location M-3 for the week ending 10-01-84 because the air pump motor burned out within 9 hours after the filter was changed.

Deviations from the program are summarized in Table 5.3.

3.4 Laboratory Procedures

The iodine-131 analyses in milk were made using a sensitive radiochemical procedure which involves separation of the iodine using an ion-exchange method and solvent extraction and finally beta counting.

All gamma-spectroscopic analyses were performed with a Ge or Ge(Li) detector. Levels of iodine-131 in cabbage and natural vegetation were determined by Ge or Ge(Li) spectrometry. Levels of airborne iodine-131 in charcoal samples were measured by Ge or Ge(Li) spectrometry.

Tritium levels were determined by a liquid scintillation technique.

Analytical procedures used by the Teledyne Isotopes Midwest Laboratory are specified in detail elsewhere (Teledyne Isotopes Midwest Laboratory, 1984). Procedures are based on those prescribed by the National Center for Radiological Health of the U.S. Public Health Serivce (U.S. Public Health Service, 1967) and by the Health and Safety Laboratory of the U.S. Atomic Energy Commission (U.S. Atomic Energy Commission, 1972).

Teledyne Isotopes Midwest Laboratory has a comprehensive quality control/quality assurance program designed to assure the reliability of data obtained. Details of TIML's QA Program are presented elsewhere (Hazleton Environmental Sciences, 1982, presently under revision). The TIML QA Program includes participation in laboratory intercomparison (crosscheck) programs. Results obtained in crosscheck programs are presented in Appendix A.

3.5 Program Modifications

Early in the 1984 growing season, a survey to determine dairy animal pasturing revealed that only one location, the Kirchenbauer Farm (M-10), had actually turned his dairy animals into a pasture area for any length of time. A decision was also made to collect biweekly milk samples from the milking herds if they were fed "freshly cut hay" taken from a field adjacent to the farm. This process could parallel the grazing concept for concentration of radionuclides in the raw milk.

3.6 Land Use Census

In accordance with the Technical Specifications 4.16 Paragraph B1 a land use census shall be conducted and shall identify the location of the nearest milk animal, the nearest residence, and the nearest garden of greater than 500 ft^2 producing fresh leafy vegetables, in each of the 16 meteorological sectors within a distance of 5 miles. The census shall also identify the locations of all milk animals and all 500 ft^2 or greater gardens producing broad leaf vegetation in each of the meteorological sectors within a distance of three miles. This census shall be conducted at least once per year between the dates of May 1 and October 31. New locations shall be added to the radiation environmental monitoring program within 30 days and sampling locations having lower calculated doses or a lower dose commitment may be deleted from this monitoring program after October 31 of the year in which the land use census was conducted.

The 1984 land use census was completed on July 5, 1984. This census did not identify any locations of exposure pathways different from those used in the program during the first six months of the year.

4.0 RESULTS AND DISCUSSION

All of the scheduled collections and analyses were made except those listed in Table 5.3.

All results are summarized in Table 5.4 in a format recommended by the Nuclear Regulatory Commission in Regulatory Guide 4.8. For each type of analysis of each sampled medium, this table lists the mean and range for all indicator locations and for all control locations. The locations with the highest mean and range are also shown.

4.1 Atmospheric Nuclear Detonations

There were no reported atmospheric nuclear tests in 1984. The last reported test was conducted by the People's Republic of China on 16 October 1980. The reported yield was in the 200 kiloton to 1 megaton range.

4.2 Program Findings

Program findings show background levels of radioactivity in the environmental samples collected in the vicinity of the Monticello Nuclear Generating Plant. No Plant effect on the environment was indicated.

Ambient Radiation (TLDs)

Ambient radiation was measured in the general area of site boundary, at outer ring 4 - 5 mi distant from the Plant, at special interest areas, and at one control location. The means were identical at both inner and outer rings (13.6 mR/91 days). The mean at special locations was 13.4 mR/91 days, the same as at control location. The differences are not statistically significant. The dose rates measured were similar to those observed in 1978, and in 1983 (12.3 and 12.5 mR/91 days, respectively). No Plant effect on ambient gamma radiation was indicated.

Air Particulates

The average annual gross beta activity in airborne particulates was similar at both indicator (0.025 pCi/m^3) and control locations (0.024 pCi/m^3) and was about the same as in 1982 (0.026 pCi/m^3) and in 1983 (0.023). The highest averages for gross beta were for the month of December and the fourth quarter, as in 1983.

The reason for the elevated activity in December and the fourth quarter is not clear. It probably is attributable to the increased use of wood burning stoves. The spring peak, which usually is observed in April - May (2nd quarter) was not observed in 1984. This peak has been observed almost annually (1976, 1979, 1980, and 1983 were also exceptions) for many years (Wilson et al., 1969). The spring peak has been attributed to fallout of nuclides from the stratosphere (Gold et al., 1964).

Two pieces of evidence indicate conclusively that the elevated activity observed during the fourth quarter was not attributable to the plant. In the first place, elevated activity of similar size occurred simultaneously at both the indicator and control locations. Secondly, an identical pattern was observed at the Prairie Island Nuclear Generating Plant, about 100 miles distant from the Monticello Nuclear Generating Plant (Northern States Power Company, 1985).

Except for beryllium-7, which is produced continuously in the upper atmosphere by cosmic radiation (Arnold and Al-Salih, 1955), all other gamma-emitting isotopes were below their respective LLD levels. None of the activities detected were attributable to the Plant operation.

Airborne Iodine

Airborne iodine-131 results were below the detection limit of 0.07 pCi/m^3 in all samples. Thus there were no indication of a Plant effect.

Milk

Iodine-131 results were below the detection limit of 1.0 pCi/l in all samples.

Cesium-137 results were below the LLD level of 15 pCi/l in all samples. Cesium-137 is a long-lived component (with a half-life of 30.24 years) of worldwide fallout and is found in the environment in trace quantities.

No other gamma-emitting isotopes, except potassium-40, were detected in any of the milk samples. This is consistent with the finding of the National Center for Radiological Health that most radiocontaminants in feed do not find their way into milk due to the selective metabolism of the cow. The common exceptions are radioisotopes of potassium, cesium, strontium, barium, and iodine (National Center for Radiological Health 1968).

In summary, the milk data for 1984 show no radiological effects of the Plant operation.

River Water and Drinking Water

Tritium was below the LLD of 330 pCi/l in all samples. Gross beta in Minneapolis drinking water averaged 2.8 pCi/l and was similar to the average level observed in 1977 (3.4 pCi/l), in 1978 (3.8 pCi/l), in 1979 (3.4 pCi/l), in 1980 (3.2 pCi/l), in 1981 (3.5 pCi/l), and in 1982 (2.9 pCi/l), and in 1983 (3.3 pCi/l). Comparisons with gross beta data reported by EPA for Minneapolis drinking water sample collected in 1975, 1976, 1977, and 1978 indicates that concentrations of these nuclides are remaining fairly constant and are in the range of drinking water levels in other parts of the country (U.S. Environmental Protection Agency, 1975, 1976, 1977, 1978). Gamma-emitting isotopes were below detection limits in all surface water samples. There was no indication of a Plant effect.

Well Water

The tritium level was below the LLD level of 330 pCi/l in all samples. All of the gamma scan results were below detection limits. There was no indication of a Plant effect.

Crops

Corn and potatoes were collected in August and analyzed for gamma-emitting isotopes. Cabbage was also collected in August and analyzed for iodine-131. All results, except for potassium-40, were below detection limits. There was no indication of a Plant effect.

Fish

Fish samples were collected in June and September. Flesh was separated from the bones and gamma scanned. Potassium-40, the naturally-occuring isotope, was found to be similar in upstream and downstream samples (2.49 and 3.13 pCi/g wet weight, respectively). All other gamma-emitting isotopes were below their respective LLD levels. There was no indication of a Plant effect.

Invertebrates

Two samples were collected in June and two in September. The samples were analyzed for gamma-emitting isotopes. All of the isotopes, except naturally occuring K-40, were below detection limits.

Potassium-40 measured 2.11 pCi/g wet weight at the control location and was below the detection limit at the indicator location. There was no indication of a Plant effect.

Bottom and Shoreline Sediments

Bottom and shoreline sediment collections were made in May and September, and analyzed for gamma-emitting isotopes. Cesium-137 was detected in one downstream bottom sediment samples (0.078 pCi/g dry weight), and in one of the shoreline sediment sample (0.574 pCi/g dry weight), indicating the influence of fallout deposition. Similar levels of activities and distribution were observed in 1978-1983. The only other gamma-emitting isotope detected was naturally-occuring potassium-40. There was no indication of a Plant effect.

5.0 TABLES

Table 5.1. Sample Collection and analysis program 1984.

Medium	Locations		Collection Type and Frequency[b]	Analysis Type (and Frequency)[c]
	No.	Codes (and Type)[a]		
Ambient Radiation (TLDs)	37	M-01A - M-14A M-01B - M-16B M-01S - M-06S M-01C	C/Q	Ambient Gamma
Airborne Particulates	5	M-1(C), M-2, M-3, M-4, M-5	C/W	GB, GS (QC of each location)
Airborne Iodine	5	M-1(C), M-2, M-3, M-4, M-5	C/W	I-131
Milk	5	M-10(C), M-18, M-24, M-26, M-28	G/M[d]	I-131, GS
River Water	2	M-8(C), M-9	G/W	GS(MC), H-3(QC)
Drinking Water	1	M-14	G/W	GB(MC), I-131(MC) GS(MC), H-3(QC)
Well Water	4	M-10(C), M-11 to M-13	G/Q	H-3, GS
Edible Cultivated Crops - Cabbage	2	M-10(C), M-27	G/A	I-131
Edible Cultivated Crops - Corn	2	M-10(C), M-18	G/A	GS

Table 5.1. (continued)

<u>Monticello</u>

Medium	Locations No.	Locations Codes (and Type)[a]	Collection Type and Frequency[b]	Analysis Type (and Frequency)[c]
Edible Cultivated Crops - Potatoes	2	M-10(C), M-21	G/A	GS
Fish (One Species, Edible Portion)	2	M-8(C), M-9	G/SA	GS
Algae or Aquatic Insects	2	M-8(C), M-9	G/SA	GS
Bottom Sediment	2	M-8(C), M-9	G/SA	GS
Shoreline Sediment	1	M-15	G/SA	GS

[a] Location codes are defined in Table 5.2. Control stations are indicated by (C). All other stations are indicators.

[b] Collection type is coded as follows: C/ = continuous, G/ = Grab. Collection frequency is coded as follows: W = weekly, M = monthly, Q = quarterly, SA = semi-annually, A = annually.

[c] Analysis type is coded as follows: GB = gross beta, GS = Gamma spectroscopy, H-3 = tritium, I-131 = iodine-131. Frequency is coded as follows: MC = monthly composite, QC = quarterly composite.

[d] Milk is collected biweekly during the grazing season (May - November) if milch animals are on pasture.

Table 5.2. Sampling locations. Monticello

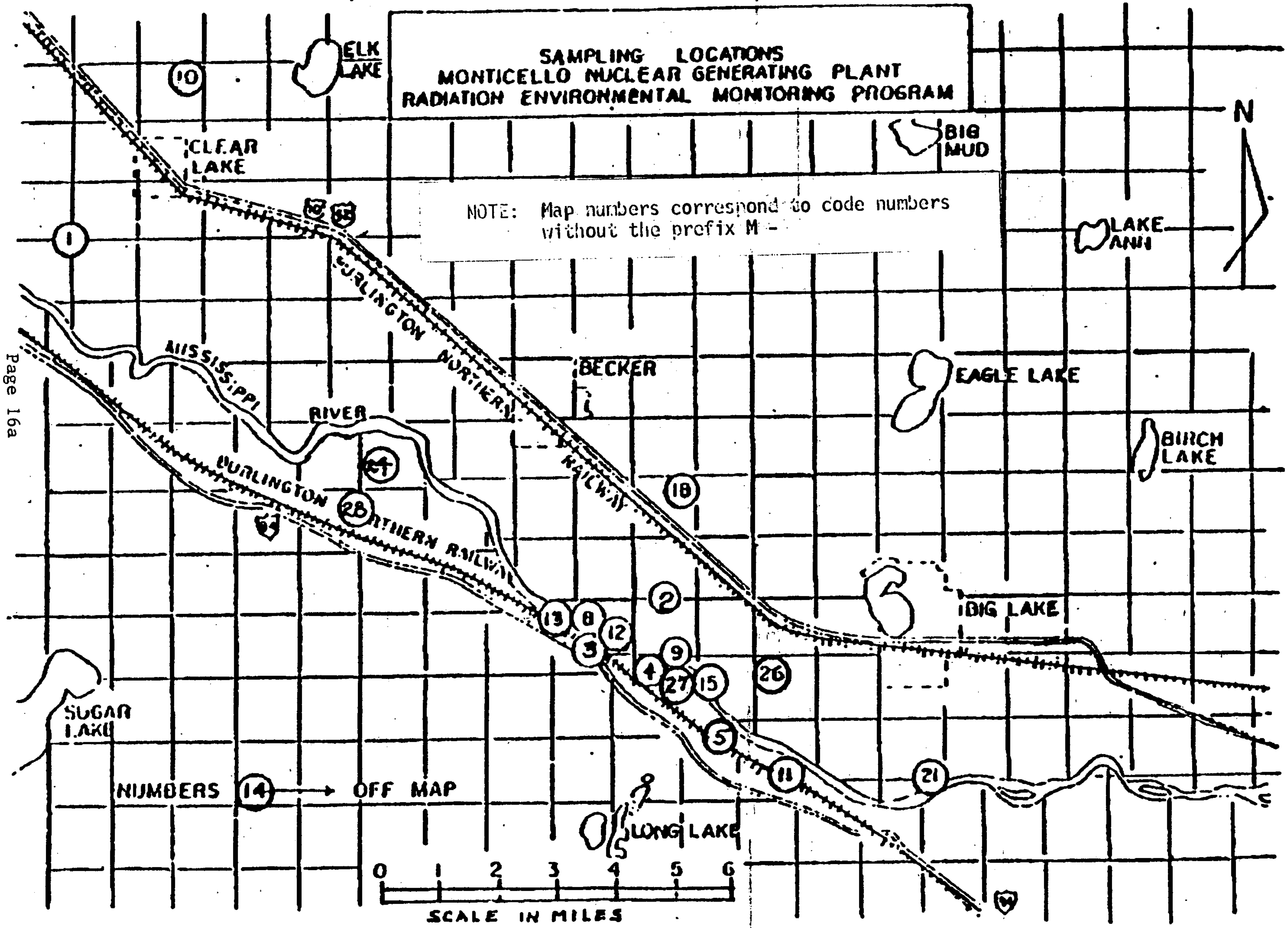
Code	Type[a]	Name	Location
M-1	C	Air Station M-1	11.1 mi @ 306°/NW
M-2		Air Station M-2	0.8 mi @ 23°/NNE
M-3		Air Station M-3	0.5 mi @ 181°/S
M-4		Air Station M-4	0.9 mi @ 150°/SSE
M-5		Air Station M-5	2.7 mi @ 136°/SE
M-8	C	Upstream of Plant	0.19 mi @ 285°/WNW
M-9		Downstream of Plant	0.19 mi @ 62°/ENE
M-10	C	Kirchenbauer Farm	11.5 mi @ 323°/NW
M-11		City of Monticello	3.2 mi @ 128°/SE
M-12		Plant Well #1	0.2 mi @ 267°/W
M-13		Hartung Residence	0.3 mi @ 214°/SW
M-14		City of Minneapolis	36 mi @ 128°/SE
M-15		Montisippi Park	1.6 mi @ 117°/ESE
M-18		Olson Farm	2.5 mi @ 24 °/NNE
M-21		Ewing Farm	4.9 mi @ 115°/ESE
M-24		Anderson Farm	3.6 mi @ 308°/NW
M-26		Peterson Farm	2.3 mi @ 111°/ESE
M-27		Hageman Residence	1.4 mi @ 131°/SE
M-28		Hoglund Farm	3.8 mi @ 300°/WNW
M-01A		North Boundary Road	0.7 mi @ 353°/N
M-02A		North Boundary Road	0.8 mi @ 23°/NNE
M-03A		North Boundary Road	1.0 mi @ 43°/NE
M-04A		Biology Station Road	0.7 mi @ 92°/E
M-05A		Biology Station Road	0.6 mi @ 112°/ESE
M-06A		Biology Station Road	0.6 mi @ 133°/SE
M-07A		County Road 75	0.5 mi @ 158°/SSE
M-08A		County Road 75	0.5 mi @ 183°/S
M-09A		County Road 75	0.4 mi @ 203°/SSW
M-10A		County Road 75	0.3 mi @ 225°/SW
M-11A		County Road 75	0.4 mi @ 250°/WSW
M-12A		County Road 75	0.7 mi @ 273°/W
M-13A		North Boundary Road	1.1 mi @ 317°/NW
M-14A		North Boundary Road	0.8 mi @ 338°/NNW
M-01B		Sherco #1 Air Station	4.6 mi @ 02°/N
M-02B		County Road 11	4.4 mi @ 17°/NNE
M-03B		Intersection of County Road and 81	4.5 mi @ 49°/NE
M-04B		Sherco #6 Air Station	4.2 mi @ 67°/ENE
M-05B		City of Big Lake	4.4 mi @ 87°/E
M-06B		County Road #14 and 196th St.	4.3 mi @ 116°/ESE
M-07B		Monte Industrial Drive	4.4 mi @ 135°/SE
M-08B		Dale K. Larson Res.	4.6 mi @ 162°/SSE
M-09B		Norbert Weinand Farm	4.7 mi @ 180°/S
M-10B		John Reisewitz Farm	4.4 mi @ 206°/SSW
M-11B		Clifford Vanlith Farm	4.2 mi @ 225°/SW
M-12B		Lake Maria State Park	4.4 mi @ 253°/WSW
M-13B		Bridgewater Station	4.1 mi @ 271°/W

Table 5.2 (continued) Monticello

Code	Type[a]	Name	Location
M-14B		Richard K Anderson Residence	4.5 mi @ 228°/WNW
M-15B		Gary Williamson Residence	4.5 mi @ 308°/NW
M-16B		Sand Plain Research Farm	4.3 mi @ 338°/NNW
M-01S		Floyd Hartung Residence	0.5 mi @ 213°/SSW
M-02S		Edgar Klucas Residence	0.7 mi @ 142°/SE
M-03S		Big Oaks Park	1.3 mi @ 89°/E
M-04S		Pinewood School	2.3 mi @ 132°/SE
M-05S		Roman Greener Residence	2.5 mi @ 112°/ESE
M-06S		Monte Service Center	2.7 mi @ 136°/SE
M-01C		Kirchenbauer Farm	11.5 mi @ 323°/NW

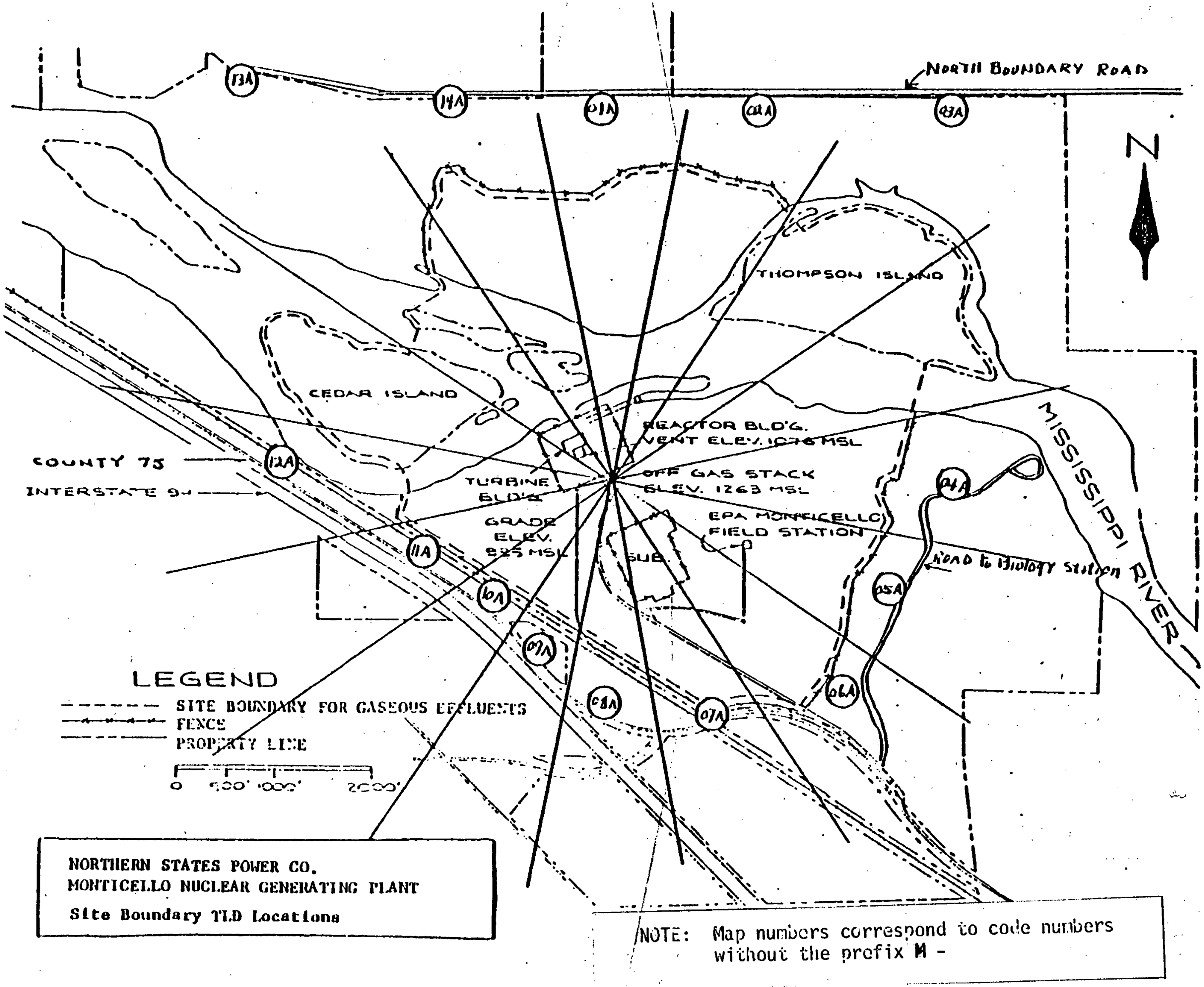
[a] "C" denotes control location. All other locations are indicators.

TABLE 5.2



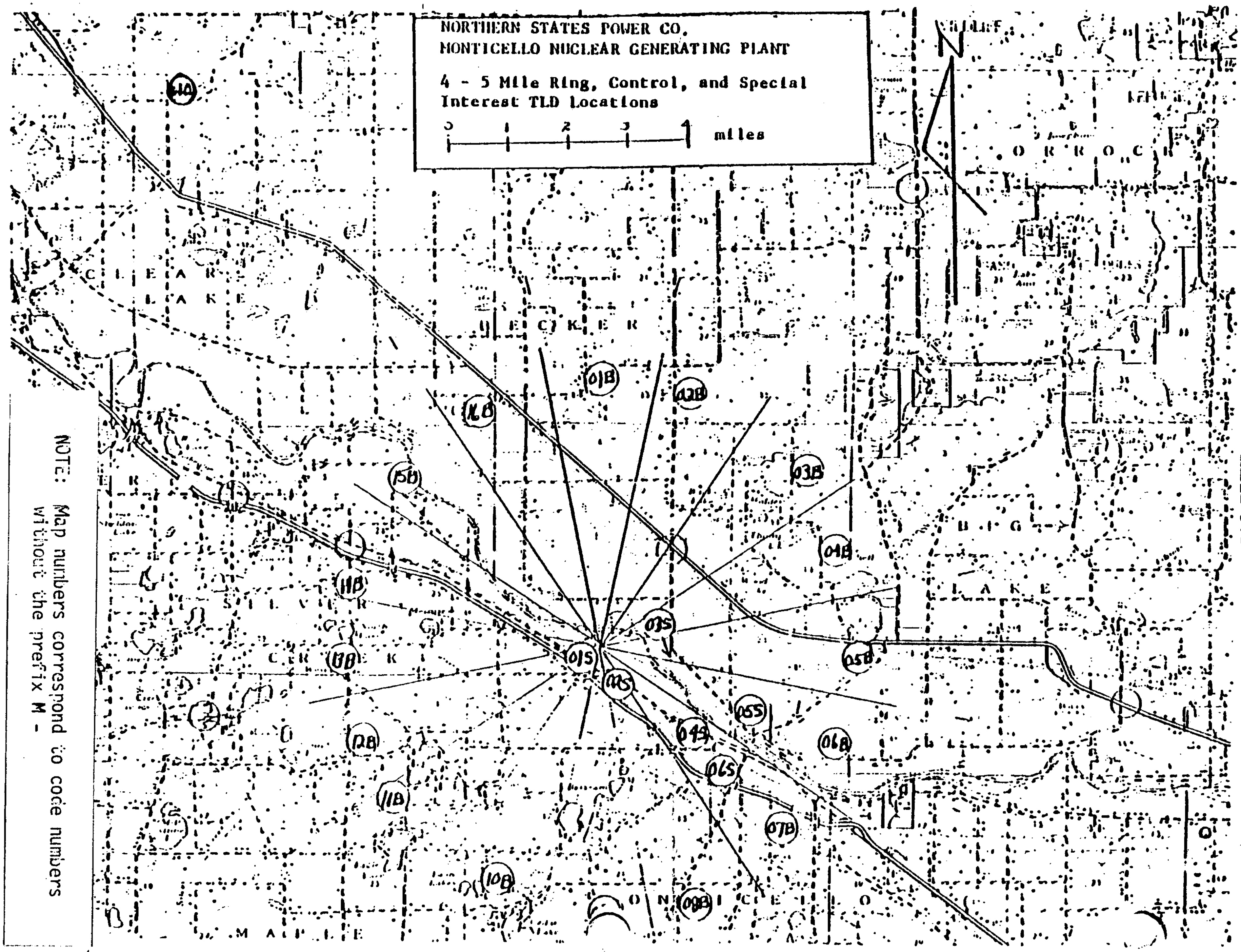
SAMPLING LOCATIONS
MONTICELLO NUCLEAR GENERATING PLANT
RADIATION ENVIRONMENTAL MONITORING PROGRAM
NOTE: Map numbers correspond to code numbers without the prefix M -
N
ELK LAKE
CLEAR LAKE
BIG MUD
LAKE ANN
BURLINGTON NORTHERN RAILWAY
MISSISSIPPI RIVER
BECKER
EAGLE LAKE
BIRCH LAKE
BIG LAKE
SUGAR LAKE
LONG LAKE
NUMBERS 14 → OFF MAP
0 1 2 3 4 5 6
SCALE IN MILES
10
1
18
28
2
13
8
12
3
9
4
27
15
26
5
11
21

TABLE 5.2



NORTH BOUNDARY ROAD
13A
14A
01A
02A
03A
N
THOMPSON ISLAND
CEDAR ISLAND
MISSISSIPPI RIVER
COUNTY 75
INTERSTATE 94
REACTOR BLD'G.
VENT ELEV.
OFF GAS STACK
ELEV. 1263 MSL
TURBINE
BLD'G
GRADE
ELEV.
EPA MONTICELLO
FIELD STATION
SUB.
Road to Biology Station
04A
05A
06A
07A
08A
09A
10A
11A
12A
LEGEND
SITE BOUNDARY FOR GASEOUS EFFLUENTS
FENCE
PROPERTY LINE
0
500'
1000'
2000'
NORTHERN STATES POWER CO.
MONTICELLO NUCLEAR GENERATING PLANT
Site Boundary TLD Locations
NOTE: Map numbers correspond to code numbers without the prefix M -

TABLE 5.2



NOTE: Map numbers correspond to code numbers without the prefix M -

Table 5.3. Missed collections and analyses for 1984 at Monticello NGP. All required samples were collected and analyzed except the following:

Sample	Location	Collection Date or Period	Comments
Thermoluminescent Dosimeters (TLDs)	M-01B	3rd Qtr.	Lost in the field.
	*M-04S	2nd Qtr.	Lost in the field.
	*M-04S	3rd Qtr.	Lost in the field.
	*M-04S	4th Qtr.	Lost in the field.
Airborne Particulate	M-3	10-01-84	No sample received; (motor burned out)

* This location has been moved slightly to eliminate this problem.

Table 5.4 Environmental Radiological Monitoring Program Summary.
Name of facility Monticello Nuclear Generating Plant Docket No. 50-263
Location of facility Wright, Minnesota (County, State) Reporting Period January-December 1984

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean(F) Range	Number of Non-routine Results[e]
					Location[d]	Mean(F) Range		
TLD (mR/91 days) (Inner Ring, General Area at Site Boundary)	Gamma	56	3.0	13.6 (56/56) (9.5-18.7)	M-12A, County Road 75 0.7 mi @ 273°/W	14.8 (4/4) (12.4-17.0)	(See control below)	0
TLD (mR/91 days (Outer ring, 4-5 miles distant)	Gamma	63	3.0	13.6 (63/63) (7.2-18.7)	M-05B, City of Big Lake Garage 4.4 mi @ 87°/E	16.6 (4/4) (13.4-18.7)	(See control below)	0
TLD (mR/91 days (Special Interest Areas)	Gamma	21	3.0	13.4 (21/21) (10.7-17.4)	M-06S, Monte Service Center 0.7 mi @ 142°/SE	14.9 (4/4) (11.9-16.5)	(See control below)	0
TLD (mR/91 days) (Control)	Gamma	4	3.0	None	M-01C, Kirchenbauer Farm 11.5 mi @ 323°/NW	13.4 (4/4) (10.8-17.8)	13.4 (4/4) (10.8-17.8)	0
Airborne Particulates (pCi/m³)	GB	259	0.003	0.025 (206/207) (0.010-0.048)	M-3, Station M-3 0.5 mi @ 181°/S	0.026 (51/51) (0.010-0.048)	0.024 (52/52) (0.013-0.048)	0
					M-5, Station M-5 (Nearest Res.-Air) 2.7 mi @ 136°/SE	0.026 (50/51) (0.013-0.044)		
	GS	20						
	Be-7		0.060	0.094 (5/16) (0.062-0.128)	M-5, Station M-5 2.7 mi @ 136°/SE	0.090 (2/4) (0.062-0.117)	0.077 (2/4) (0.061-0.093)	0
	Mn-54		0.0034	<LLD	-	-	<LLD	0
	Co-58		0.0063	<LLD	-	-	<LLD	0
	Co-60		0.0045	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean(F) Range	Control Locations Mean(F) Range	Number of Non-routine Results[e]
Airborne Particulates	Zn-65	0.092	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.014	<LLD	-	-	<LLD	0
	Ru-103	0.012	<LLD	-	-	<LLD	0
	Ru-106	0.029	<LLD	-	-	<LLD	0
	Cs-134	0.0025	<LLD	-	-	<LLD	0
	Cs-137	0.0036	<LLD	-	-	<LLD	0
	Ba-La-140	0.0062	<LLD	-	-	<LLD	0
	Ce-141	0.014	<LLD	-	-	<LLD	0
	Ce-144	0.016	<LLD	-	-	<LLD	0
Airborne Iodine (pCi/m^3)	I-131 259	0.07[f]	<LLD	-	-	<LLD	0
Milk (pCi/l)	I-131 69	1.0	<LLD	-	1330 (13/13) (1150-1620)	<LLD	0
	GS 69						
	K-40	200	1290 (52/52) (1040-1620)	M-24, Anderson 3.6 mi @ 308°/NW M-28, Hoglund 3.8 mi @ 300°/WNW	1330 (13/13) (1070-1450)	1200 (17/17) (870-1360)	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	15	<LLD	-	-	<LLD	0
	Ba-La-140	15	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean(F) Range	Number of Non-routine Results[e]
					Location[d]	Mean(F) Range		
River Water (pCi/l)	H-3	8	330	<LLD	-	-	<LLD	0
	GS	24						
	Mn-54		15	<LLD	-	-	<LLD	0
	Fe-59		30	<LLD	-	-	<LLD	0
	Co-58		15	<LLD	-	-	<LLD	0
	Co-60		15	<LLD	-	-	<LLD	0
	Zn-65		30	<LLD	-	-	<LLD	0
	Zr-Nb-95		15	<LLD	-	-	<LLD	0
	Cs-134		15	<LLD	-	-	<LLD	0
	Cs-137		18	<LLD	-	-	<LLD	0
	Ba-La-140		15	<LLD	-	-	<LLD	0
	Ce-144		80	<LLD	-	-	<LLD	0
Drinking Water (pCi/l)	GB	12	1.0	2.8 (12/12) (2.0-4.0)	M-14, Minneapolis 36 mi @ 128°/SE	2.8 (12/12) (2.0-4.0)	None	0
	I-131	12	1.0	<LLD	-	-	None	0
	H-3	4	330	<LLD	-	-	None	0
	GS	12						
	Mn-54		15	<LLD	-	-	None	0
	Fe-59		30	<LLD	-	-	None	0
	Co-58		15	<LLD	-	-	None	0
	Co-60		15	<LLD	-	-	None	0
	Zn-65		30	<LLD	-	-	None	0
	Zr-Nb-95		15	<LLD	-	-	None	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean(F) Range	Number of Non-routine Results[e]
				Location[d]	Mean(F) Range		
Drinking Water (pCi/l) (Cont'd)	Cs-134	10	<LLD	-	-	None	0
	Cs-137	10	<LLD	-	-	None	0
	Ba-La-140	15	<LLD	-	-	None	0
	Ce-144	67	<LLD	-	-	None	0
Well Water (pCi/l)	H-3 16	330	<LLD	-	-	<LLD	0
	GS 16						
	Mn-54	15	<LLD	-	-	<LLD	0
	Fe-59	30	<LLD	-	-	<LLD	0
	Co-58	15	<LLD	-	-	<LLD	0
	Co-60	15	<LLD	-	-	<LLD	0
	Zn-65	30	<LLD	-	-	<LLD	0
	Zr-Nb-95	15	<LLD	-	-	<LLD	0
	Cs-134	10	<LLD	-	-	<LLD	0
	Cs-137	10	<LLD	-	-	<LLD	0
	Ba-La-140	15	<LLD	-	-	<LLD	0
	Ce-144	64	<LLD	-	-	<LLD	0
Crops-Potatoes (pCi/g wet)	GS 2						
	Be-7	1.27	<LLD	-	-	<LLD	0
	K-40	0.5	3.21 (1/1) -	M-10, Kirchenbauer 11.5 mi @ 323°/NW	3.32 (1/1) -	3.32 (1/1) -	0
	Mn-54	0.028	<LLD	-	-	<LLD	0
	Co-58	0.11	<LLD	-	-	<LLD	0
	Co-60	0.025	<LLD	-	-	<LLD	0
	Zn-65	0.096	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean(F) Range	Control Locations Mean(F) Range	Number of Non-routine Results[e]
Crops-Potatoes (pCi/g wet) (Cont'd)	Zr-Nb-95	0.58	<LLD	-	-	<LLD	0
	Ru-103	0.35	<LLD	-	-	<LLD	D
	Ru-106	0.23	<LLD	-	-	<LLD	0
	Cs-134	0.024	<LLD	-	-	<LLD	0
	Cs-137	0.028	<LLD	-	-	<LLD	0
	Ba-La-140	0.039	<LLD	-	-	<LLD	0
	Ce-141	0.85	<LLD	-	-	<LLD	0
	Ce-144	0.14	<LLD	-	-	<LLD	0
Crops-Cabbage (pCi/g wet	I-131 2	0.021	<LLD	-	-	<LLD	0
Crops-Corn (pCi/g wet)	GS 2						
	Be-7	0.17	<LLD	-	-	<LLD	0
	K-40	0.16	2.11 (1/1) -	M-10, Kirchenbauer 11.5 mi @ 323°/NW	2.25 (1/1) -	2.25 (1/1) -	0
	Mn-54	0.021	<LLD	-	-	<LLD	0
	Co-58	0.024	<LLD	-	-	<LLD	0
	Co-60	0.025	<LLD	-	-	<LLD	0
	Zn-65	0.062	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.025	<LLD	-	-	<LLD	0
	Ru-103	0.022	<LLD	-	-	<LLD	0
	Ru-106	0.17	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean(F) Range	Number of Non-routine Results[e]
				Location[d]	Mean(F) Range		
Crops-Corn (pCi/g wet) (Cont'd)	Cs-134	D.019	<LLD	-	-	<LLD	0
	Cs-137	0.021	<LLD	-	-	<LLD	0
	Ba-La-140	0.024	<LLD	-	-	<LLD	D
	Ce-141	0.035	<LLD	-	-	<LLD	0
	Ce-144	0.14	<LLD	-	-	<LLD	0
Fish (pCi/g wet))	GS 6						
	K-40	0.1	2.49 (3/3) (2.39-2.57)	M-8, Upstream of Plant 0.19 mi @ 285°/WNW	3.13 (3/3) (2.74-3.40)	3.13 (3/3) (2.74-3.40))	0
	Mn-54	0.024	<LLD	-	-	<LLD	0
	Fe-59	0.26	<LLD	-	-	<LLD	0
	Co-58	0.057	<LLD	-	-	<LLD	0
	Co-60	0.025	<LLD	-	-	<LLD	0
	Zn-65	0.065	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.25	<LLD	-	-	<LLD	0
	Cs-134	0.D19	<LLD	-	-	<LLD	0
	Cs-137	0.019	<LLD	-	-	-	0
	Ba-La-140	0.D36	<LLD	-	-	<LLD	0
Invertebrates (pCi/g wet)	GS 4						
	Be-7	2.97	<LLD	-	-	-	0
	K-40	D.9	<LLO -	M-8, Upstream of Plant 0.19 mi @ 285°/NW	2.11 (1/2) -	2.11 (1/2) -	0
	Mn-54	0.26	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean(F) Range	Control Locations Mean(F) Range	Number of Non-routine Results[e]
Invertebrates (pCi/g wet) (cont'd)	Co-58	0.26	<LLD	-	-	<LLD	0
	Co-60	0.09	<LLD	-	-	<LLD	0
	Zn-65	0.25	<LLD	-	-	<LLD	0
	Zr-Nb-95	1.37	<LLD	-	-	<LLD	0
	Ru-103	0.78	<LLD	-	-	<LLD	0
	Ru-106	D.72	<LLD	-	-	<LLD	0
	Cs-134	0.08	<LLD	-	-	<LLD	0
	Cs-137	0.07	<LLD	-	-	<LLD	0
	Ba-La-140	0.11	<LLD	-	-	<LLD	0
	Ce-141	1.46	<LLD	-	-	<LLD	0
	Ce-144	0.33	<LLD	-	-	<LLD	0
Bottom and Shoreline Sediments (pCi/g dry)	GS 6						
	Be-7	0.56	<LLD	-	-	<LLD	0
	K-40	0.5	8.70 (4/4) (7.38-9.80)	M-9, Downstream of Plant 0.19 mi @ 62°/ENE	8.80 (2/2) (8.53-9.07)	8.89 (2/2) (8.76-9.02)	0
	Mn-54	0.039	<LLD	-	-	<LLD	0
	Co-58	D.056	<LLD	-	-	<LLD	0
	Co-60	D.045	<LLD	-	-	<LLD	0
	Zn-65	0.12	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.090	<LLD	-	-	<LLD	0
	Ru-103	D.089	<LLD	-	-	<LLD	0
	Ru-106	0.46	<LLD	-	-	<LLD	0
	Cs-134	0.040	<LLD	-	-	<LLD	0
	Cs-137	0.026	0.326 (2/4) (0.078-0.574)	M-15, Montissippi Park 1.6 mi @ 117°/ESE	0.574 (1/2) -	<LLD -	0

Table 5.4 (Continued)
Name of facility Monticello Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean(F) Range	Number of Non-routine Results[e]
				Location[d]	Mean(F) Range		
Bottom and Shoreline Sediments (pCi/g dry) (cont'd)	Ba-La-140	0.065	<LLD	-	-	<LLD	0
	Ce-141	0.18	<LLD	-	-	<LLD	0
	Ce-144	0.34	<LLD	-	-	<LLD	0

[a] GB = gross beta; GS = gamma scan.
[b] LLD = nominal lower limit of detection based on 4.66 sigma error for background sample.
[c] Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (F).
[d] Locations are specified (1) by name and code (Table 2) and (2) distance, direction, and sector relative to reactor site.
[e] Nonroutine results are those which exceed ten times the control station value. If no control station value is available, the result is considered nonroutine if it exceeds ton times the preoperational value for the location.
[f] Six results have been excluded in the determination of the LLD of airborne iodine-131. Five results were excluded because of the delay in receiving the samples (Greyhound bus strike) and one result was excluded due to apparent pump malfunction.

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Appendix A

Interlaboratory Comparison Program Results

Appendix A

Interlaboratory Comparison Program Results

Teledyne Isotopes Midwest Laboratory (formerly Hazleton Environmental Sciences) has participated in interlaboratory comparison (crosscheck) programs since the formulation of its quality control program in December 1971. These programs are operated by agencies which supply environmental-type samples (e.g., milk or water) containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Participant laboratories measure the concentrations of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

The results in Table A-1 were obtained through participation in the environmental sample crosscheck program for milk, water, air filters, and food samples during the period 1980 through 1984. This program has been conducted by the U. S. Environmental Protection Agency Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

The results in Table A-2 were obtained for thermoluminescent dosimeters (TLD's) during the period 1976, 1977, 1979, 1980, and 1981 through participation in the Second, Third, Fourth, and Fifth International Intercomparison of Environmental Dosimeters under the sponsorships listed in Table A-2.

Table A-1. U.S. Environmental Protection Agency's crosscheck program, comparison of EPA and Teledyne Isotopes Midwest Laboratory results for milk, water, air filters, and food samples, 1980 through 1984.[a]

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STW-206	Water	Jan. 1980	Gross Alpha	19.0±2.0	30.0±8.0
			Gross Beta	48.0±2.0	45.0±5.0
STW-208	Water	Jan. 1980	Sr-89	6.1±1.2	10.0±0.5
			Sr-90	23.9±1.1	25.5±1.5
STW-209	Water	Feb. 1980	Cr-51	112±14	101±5.0
			Co-60	12.7±2.3	11±5.0
			Zn-65	29.7±2.3	25±5.0
			Ru-106	71.7±1.5	51±5
			Cs-134	12.0±2.0	10±5.0
			Cs-137	30.0±2.7	30±5.0
STW-210	Water	Feb. 1980	H-3	1800±120	1750±340
STW-211	Water	March 1980	Ra-226	15.7±0.2	16.0±2.4
			Ra-228	3.5±0.3	2.6±0.4
STM-217	Milk	May 1980	Sr-89	4.4±2.69	5±5
			Sr-90	10.0±1.0	12±1.5
STW-221	Water	June 1980	Ra-226	2.0±0.0	1.7±0.8
			Ra-228	1.6±0.1	1.7±0.8
STW-223	Water	July 1980	Gross Alpha	31±3.0	38±5.0
			Gross Beta	44±4	35±5.0
STW-224	Water	July 1980	Cs-137	33.9±0.4	35±5.0
			Ba-140	<12	0
			K-40	1350±60	1550±78
			I-131	<5.0	0
STW-225	Water	Aug. 1980	H-3	1280±50	1210±329
STW-226	Water	Sept. 1980	Sr-89	22±1.2	24±8.6
			Sr-90	12±0.6	15±2.6
STW-228	Water	Sept. 1980	Gross Alpha	NA[e]	32.0±8.0
			Gross Beta	22.5±0.0	21.0±5.0
STW-235	Water	Dec. 1980	H-3	2420±30	2240±604

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STW-237	Water	Jan. 1981	Sr-89	13.0±1.0	16±8.7
			Sr-90	24.0±0.6	34±2.9
STM-239	Milk	Jan. 1981	Sr-89	<210	0
			Sr-90	15.7±2.6	20±3.0
			I-131	30.9±4.8	26±10.0
			Cs-137	46.9±2.9	43±9.0
			Ba-140	<21	0
			K-40	1330±53	1550±134
STW-240	Water	Jan. 1981	Gross alpha	7.3±2.0	9±5.0
			Gross beta	41.0±3.1	44±5.0
STW-243	Water	Mar. 1981	Ra-226	3.5±0.06	3.4±0.5
			Ra-228	6.5±2.3	7.3±1.1
STW-245	Water	Apr. 1981	H-3	3210±115	2710±355
STW-249	Water	May 1981	Sr-89	51±3.6	36±8.7
			Sr-90	22.7±0.6	22±2.6
STW-251	Water	May 1981	Gross alpha	24.0±5.3	21±5.2
			Gross beta	16.1±1.9	14±5.0
STW-252	Water	Jun. 1981	H-3	2140±95	1950±596
STW-255	Water	Jul. 1981	Gross alpha	20±1.5	22±9.5
			Gross beta	13.0±2.0	15±8.7
STW-259	Water	Sep. 1981	Sr-89	16.1±1.0	23±5
			Sr-90	10.3±0.9	11±1.5
STW-265	Water	Oct. 1981	Gross alpha	71.2±19.1	80±20
			Gross beta	123.3±16.6	111±5.6
			Sr-89	14.9±2.0	21±5
			Sr-90	13.1±1.7	14.4±1.5
			Ra-226	13.0±2.0	12.7±1.9
STW-269	Water	Dec. 1981	H-3	2516±181	2700±355

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STW-270	Water	Jan. 1982	Sr-89	24.3±2.0	21.0±5.0
			Sr-90	9.4±0.5	12.0±1.5
STW-273	Water	Jan. 1982	I-131	8.6±0.6	8.4±1.5
STW-275	Water	Feb. 1982	H-3	1580±147	1820±342
STW-276	Water	Feb. 1982	Cr-51	<61	0
			Co-60	26.0±3.7	20±5
			Zn-65	<13	15±5
			Ru-106	<46	20±5
			Cs-134	26.8±0.7	22±5
			Cs-137	29.7±1.4	23±5
STW-277	Water	Mar. 1982	Ra-226	11.9±1.9	11.6±1.7
STW-278	Water	Mar. 1982	Gross alpha	15.6±1.9	19±5
			Gross beta	19.2±0.4	19±5
STW-280	Water	Apr. 1982	H-3	2690±80	2860±360
STW-281	Water	Apr. 1982	Gross alpha	75±7.9	85±21
			Gross beta	114.1±5.9	106±5.3
			Sr-89	17.4±1.8	24±5
			Sr-90	10.5±0.6	12±1.5
			Ra-226	11.4±2.0	10.9±1.5
			Co-60	<4.6	0
STW-284	Water	May 1982	Gross alpha	31.5±6.5	27.5±7
			Gross beta	25.9±3.4	29±5
STW-285	Water	June 1982	H-3	1970±1408	1830±340
STW-286	Water	June 1982	Ra-226	12.6±1.5	13.4±3.5
			Ra-228	11.1±2.5	8.7±2.3
STW-287	Water	June 1982	I-131	6.5±0.3	4.4±0.7
STW-290	Water	Aug. 1982	H-3	3210±140	2890±619
STW-291	Water	Aug. 1982	I-131	94.6±2.5	87±15

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STW-292	Water	Sept 1982	Sr-89	22.7±3.8	24.5±8.7
			Sr-90	10.9±0.3	14.5±2.6
STW-296	Water	Oct. 1982	Co-60	20.0±1.0	20±8.7
			Zn-65	32.3±5.1	24±8.7
			Cs-134	15.3±1.5	19.0±8.7
			Cs-137	21.0±1.7	20.0±8.7
STW-297	Water	Oct. 1982	H-3	2470±20	2560±612
STW-298	Water	Oct. 1982	Gross alpha	32±30	55±24
			Gross beta	81.7±6.1	81±8.7
			Sr-89	<2	0
			Sr-90	14.1±0.9	17.2±2.6
			Cs-134	<2	1.8±8.7
			Cs-137	22.7±0.6	20±8.7
			Ra-226	13.6±0.3	12.5±3.2
			Ra-228	3.9±1.0	3.6±0.9
STW-301	Water	Nov. 1982	Gross alpha	12.0±1.0	19.0±8.7
			Gross beta	34.0±2.7	24.0±8.7
STW-302	Water	Dec. 1982	I-131	40.0±0.0	37.0±10
STW-303	Water	Dec. 1982	H-3	1940±20	1990±345
STW-304	Water	Dec. 1982	Ra-226	11.7±0.6	11.0±1.7
			Ra-228	<3	0
STW-306	Water	Jan. 1983	Sr-89	20.0±8.7	29.2±5
			Sr-90	21.7±8.4	17.2±1.5
STW-307	Water	Jan. 1983	Gross alpha	29.0±4.09	29.0±13
			Gross beta	29.3±0.6	31.0±8.7
STM-309	Milk	Feb. 1983	Sr-89	35±2.0	37±8.7
			Sr-90	13.7±0.6	18±2.6
			I-131	55.7±3.2	55±10.4
			Cs-137	29±1.0	26±8.7
			Ba-140	<27	0
			K-40	1637±5.8	1512±131

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STW-310	Water	Feb. 1983	H-3	2470±80	2560±612
STW-311	Water	March 1983	Ra-226	11.9±1.3	12.7±3.3
			Ra-228	<2.7	0
STW-312	Water	March 1983	Gross alpha	31.6±4.5[g]	31±13.4
			Gross beta	27.0±2.0	28±8.7
STW-313	Water	April 1983	H-3	3240±80	3330±627
STW-316	Water	May 1983	Gross alpha	94±7	64±19.9
			Gross beta	133±5	149±12.4
			Sr-89	19±1	24±8.7
			Sr-90	12±1	13±2.6
			Ra-226	7.9±0.4	8.5±2.25
			Co-60	30±2	30±8.7
			Cs-134	27±2	33±8.7
			Cs-137	29±1	27±8.7
STW-317	Water	May 1983	Sr-89	59.7±2.1	57±8.7
			Sr-90	33.7±1.5	38±3.3
STW-318[f]	Water	May 1983	Gross alpha	12.8±1.5	11±8.7
			Gross beta	49.4±3.9	57±8.7
STM-320	Milk	June 1983	Sr-89	20±0	25±8.7
			Sr-90	10±1	16±2.6
			I-131	30±1	30±10.4
			Cs-137	52±2	47±8.7
			K	1553±57	1486±129
STW-321	Water	June 1983	H-3	1470±89	1529±583
STW-322	Water	June 1983	Ra-226	4.3±0.2	4.8±1.24
			Ra-228	<2.5	0
STW-323	Water	July 1983	Gross alpha	3±1	7±8.7
			Gross beta	21±0	22±8.7
STW-324	Water	August 1983	I-131	13.3±0.6	14±10.4

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STAF-326	Air Filter	August 1983	Gross beta	42±2	36±8.7
			Sr-90	14±2	10±2.6
			Cs-137	19±1	15±8.7
STW-328	Water	Sept. 1983	Gross alpha	2.3±0.6	5±8.7
			Gross beta	10.7±1.2	9±8.7
STW-329	Water	Sept. 1983	Ra-226	3.0±0.2	3.1±0.81
			Ra-228	3.2±0.7	2.0±0.52
STW-331	Water	Oct. 1983	H-3	1300±30	1210±570
STW-335	Water	Dec. 1983	I-131	19.6±1.9	20±10.4
STW-336	Water	Dec. 1983	H-3	2870±100	2389±608
STAF-337	Air Filter	Nov. 1983	Gross alpha	18.0±0.2	19±8.7
			Gross beta	58.6±1.2	50±8.7
			Sr-90	10.9±0.1	15±2.6
			Cs-137	30.1±2.5	20±8.7
STW-339	Water	Jan. 1984	Sr-89	47.2±1.9	36±8.7
			Sr-90	22.5±4.0	24±2.6
STW-343	Water	Feb. 1984	H-3	2487±76	2383±607
STM-347	Milk	March 1984	I-131	5.3±1.1	6±1.6
STW-349	Water	March 1984	Ra-226	4.0±0.2	4.1±1.06
			Ra-228	3.6±0.3	2.0±0.52
STW-350	Water	March 1984	Gross alpha	3.8±1.1	5±8.7
			Gross beta	24.2±2.0	20±8.7
STW-354	Water	April 1984	H-3	3560±50	3508±630
STW-355	Water	April 1984	Gross alpha	21.0±4.1	35±15.2
			Gross beta	127.8±4.1	147±12.7
			Sr-89	29.3±2.0	23±8.7
			Sr-90	16.6±0.7	26±2.6
			Ra-226	4.0±1.0	4.0±1.04
			Co-60	32.3±1.4	30±8.7
			Cs-134	33.6±3.1	30±8.7
			Cs-137	33.3±2.2	26±8.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STW-358	Water	May 1984	Gross alpha	3.0±0.6	3±8.7
			Gross beta	6.7±1.2	6±8.7
STM-366	Milk	June 1984	Sr-89	21±3.1	25±8.7
			Sr-90	13±2.0	17±2.6
			I-131	46±5.3	43±10.4
			Cs-137	38±4.0	35±8.7
			K-40	1577±172	1496±130
STW-368	Water	July 1984	Gross alpha	5.1±1.1	6±8.7
			Gross beta	11.9±2.4	13±8.7
STW-369	Water	August 1984	I-131	34.3±5.0	34.0±10.4
STW-370	Water	August 1984	H-3	3003±253	2817±617
STF-371	Food	July 1984	Sr-89	22.0±5.3	25.0±8.7
			Sr-90	14.7±3.1	20.0±2.6
			I-131	<172	39.0±10.4
			Cs-137	24.0±5.3	25.0±8.7
			K-40	2503±132	2605±226.0
STAF-372	Air Filter	August 1984	Gross alpha	15.3±1.2	17±8.7
			Gross beta	56.0±0.0	51±8.7
			Sr-90	14.3±1.2	18±2.4
			Cs-137	21.0±2.0	15±8.7
STW-375	Water	Sept. 1984	Ra-226	5.1±0.4	4.9±1.27
			Ra-228	2.2±0.1	2.3±0.60
STW-377	Water	Sept. 1984	Gross alpha	3.3±1.2	5.0±8.7
			Gross beta	12.7±2.3	16.0±8.7
STW-379	Water	Oct. 1984	H-3	2860±312	2810±356
STW-380	Water	Oct. 1984	Cr-51	<36	40±8.7
			Co-60	20.3±1.2	20±8.7
			Zn-65	150±8.1	147±8.7
			Ru-106	<30	47±8.7
			Cs-134	31.3±7.0	31±8.7
			Cs-137	26.7±1.2	24±8.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±3σ, n=1[d]
STM-382	Milk	Oct. 1984	Sr-89	15.7±4.2	22±8.7
			Sr-90	12.7±1.2	16±2.6
			I-131	41.7±3.1	42±10.4
			Cs-137	31.3±6.1	32±8.7
			K-40	1447±66	1517±131
STW-384	Water (Blind)	Oct. 1984 Sample A	Gross alpha	9.7±1.2	14±8.7
			Ra-226	3.3±0.2	3.0±0.8
			Ra-228	3.4±1.6	2.1±0.5
			Uranium	NA[e]	5±10.4
		Sample B	Gross beta	48.3±5.0	64±8.7
			Sr-89	10.7±4.6	11±8.7
			Sr-90	7.3±1.2	12±2.6
			Co-60	16.3±1.2	14±8.7
			Cs-134	<2	2±8.7
			Cs-137	16.7±1.2	14±8.7
STW-389	Water	Dec. 1984	H-3	3583±110	3182±624

[a] Results obtained by Teledyne Isotopes Midwest Laboratory as a participant in the environmental sample crosscheck program operated by the Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, (EPA), Las Vegas, Nevada.

[b] All results are in pCi/l, except for elemental potassium (K) data which are in mg/l, and air filter samples which are in pCi/filter.

[c] Unless otherwise indicated, the TIML results are given as the mean ±2 standard deviations for three determinations.

[d] USEPA results are presented as the known values ± control limits of 3 for n=3.

[e] NA = Not analyzed.

[f] Analyzed but not reported to the EPA.

[g] Results after calculations corrected (error in calculations when reported to EPA).

Table A-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement	mR		
			Teledyne Result ±2σ [a]	Known Value	Average ±2σ [d] (all participants)
2nd International Intercomparison[b]					
115-2[b]	CaF_2:Mn Bulb	Gamma-Field	17.0±1.9	17.1[c]	16.4±7.7
		Gamma-Lab	20.8±4.1	21.3[c]	18.8±7.6
3rd International Intercomparison[e]					
115-3[e]	CaF_2:Mn Bulb	Gamma-Field	30.7±3.2	34.9±4.8[f]	31.5±3.0
		Gamma-Lab	89.6±6.4	91.7±14.6[f]	86.2±24.0
4th International Intercomparison[g]					
115-4[g]	CaF_2:Mn Bulb	Gamma-Field	14.1±1.1	14.1±1.4[f]	16.09.0
		Gamma-Lab (Low)	9.3±1.3	12.2±2.4[f]	12.0±7.6
		Gamma-Lab (High)	40.4±1.4	45.8±9.2[f]	43.9±13.2
5th International Intercomparison[h]					
115-5A[h]	CaF_2:Mn Bulb	Gamma-Field	31.4±1.8	30.0±6.0[i]	30.2±14.6
		Gamma-Lab at beginning	77.4±5.8	75.2±7.6[i]	75.8±40.4
		Gamma-Lab at the end	96.6±5.8	88.4±8.8[i]	90.7±31.2

Table A-2. (Continued)

Lab Code	TLD Type	Measurement	mR Teledyne Result ±2σ[a]	Known Value	Average ± 2σ[d] (all participants)
115-5B[h]	LiF-100 Chips	Gamma-Field	30.3±4.8	30.0±6[i]	30.2±14.6
		Gamma-Lab at beginning	81.1±7.4	75.2±7.6[i]	75.8±40.4
		Gamma-Lab at the end	85.4±11.7	88.4±8.8[i]	90.7±131.2

[a] Lab result given is the mean ±2 standard deviations of three determinations.

[b] Second International Intercomparison of Environmental Dosimeters conducted in April of 1976 by the Health and Safety Laboratory (GASL), New York, New York, and the School of Public Health of the University of Texas, Houston, Texas.

[c] Value determined by sponsor of the intercomparison using continuously operated pressurized ion chamber.

[d] Mean ±2 standard deviations of results obtained by all laboratories participating in the program.

[e] Third International Intercomparison of Environmental Dosimeters conducted in summer of 1977 by Oak Ridge National Laboratory and the School of Public Health of the University of Texas, Houston, Texas.

[f] Value ±2 standard deviations as determined by sponsor of the intercomparison using continuously operated pressurized ion chamber.

[g] Fourth International Intercomparison of Environmental Dosimeters conducted in summer of 1979 by the School of Public Health of the University of Texas, Houston, Texas.

[h] Fifth International Intercomparison of Environmental Dosimeter conducted in fall of 1980 at Idaho Falls, Idaho and sponsored by the School of Public Health of the University of Texas, Houston, Texas and Environmental Measurements Laboratory, New York, New York, U.S. Department of Energy.

[i] Value determined by sponsor of the intercomparison using continuously operated pressurized ion chamber.

Appendix B

Data Reporting Conventions

Data Reporting Conventions

1.0. All activities are decay corrected to collection time.

2.0. Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where x = value of the measurement;

s = 2σ counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is found to be below the lower limit of detection L it is reported as

$$<L \; .$$

where L = is the lower limit of detection based on 4.66 uncertainty for a background sample.

3.0. Duplicate Analyses

3.1. Individual results: $x_1 \pm s_1$
$x_2 \pm s_2$

Reported result: $x \pm s$

where $x = (1/2)\ (x_1 + x_2)$

$s = (1/2) \sqrt{s_1^2 + s_2^2}$

3.2. Individual results: $<L_1$
$<L_2$

Reported result: $<L$

where L = lower of L_1 and L_2

3.3. Individual results: $x \pm s$
$<L$

Reported result: $x \pm s$ if $x \geqslant L$;
$<L$ otherwise

4.0. Computation of Averages and Standard Deviations

4.1 Averages and standard deviations listed in the tables are computed from all of the individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average $\bar{x}$ and standard deviations of a set of n numbers $x_1, x_2, \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n}\Sigma\ x$$

$$s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$$

4.2 Values below the highest lower limit of detection are not included in the average.

4.3 If all of the values in the averaging group are less than the highest LLD, the highest LLD is reported.

4.4 If all but one of the values are less than the highest LLD, the single value x and associated two sigma error is reported.

4.5. In rounding off, the following rules are followed:

4.5.1. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example, 11.443 is rounded off to 11.44.

4.5.2 If the figure following those to be retained is greater than 5, the figure is dropped, and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45.

4.5.3. If the figure following those to be retained is 5, and if there are no figures other than zeros beyond the five, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42.

Appendix C

Maximum Permissible Concentrations

of Radioactivity in Air and Water

Above Background in Unrestricted Areas

Table C-1. Maximum permissible concentrations of radioactivity in air and water above natural background in unrestricted areas.[a]

Air			Water	
Gross alpha	3	pCi/m^3	Strontium-89	3,000 pCi/l
Gross beta	100	pCi/m^3	Strontium-90	300 pCi/l
Iodine-131[b]	0.14	pCi/m^3	Cesium-137	20,000 pCi/l
			Barium-140	20,000 pCi/l
			Iodine-131	300 pCi/l
			Potassium-40[c]	3,000 pCi/l
			Gross alpha	30 pCi/l
			Gross beta	100 pCi/l
			Tritium	3×10^6 pCi/l

[a] Taken from Code of Federal Regulations Title 10, Part 20, Table II and appropriate footnotes. Concentrations may be averaged over a period not greater than one year.

[b] From 10 CFR 20 but adjusted by a factor of 700 to reduce the dose resulting from the air-grass-cow-milk-child pathway.

[c] A natural radionuclide.