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MINNEAPOLIS, MINNESOTA

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
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ANNUAL REPORT
to the
UNITED STATES NUCLEAR REGULATORY COMMISSION

Radiation Environmental Monitoring Program
January 1, 1987 to December 31, 1987

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

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PREFACE

The staff of Teledyne Isotopes Midwest Laboratory was responsible for the acquisition of data presented in this report. Samples were collected by members of the staff of the Environmental & Regulatory Activities Department.

The report was prepared by L. G. Huebner, General Manager, Teledyne Isotopes Midwest Laboratory. He 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 Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, during the period January - December, 1987. 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.

Tabulations 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, 1987) available at Northern States Power Company, Nuclear Generation Department.

Prairie Island Nuclear Generating Plant is located on the Mississippi River in Goodhue County, Minnesota, and operated by Northern States Power Company. The plant has two 550 MWe pressurized water reactors. Unit 1 achieved initial criticality on 1 December 1973. Commercial operation at full power began on 16 December 1973. Unit 2 achieved initial criticality on 17 December 1974. Commercial operation at full power began on 21 December 1974.

2.0 SUMMARY

The Radiation Environmental Monitoring Program (REMP) required by the U.S. Nuclear Regulatory Commission (NRC) Technical Specifications for the Prairie Island Nuclear Generating Plant is described. Results for 1987 are summarized and discussed.

Program findings show background levels of radioactivity in the environmental samples collected in the vicinity of the Prairie Island Nuclear Generating Plant. No effect on the environment due to the operation of the 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 Prairie Island 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; and

(5) Fallout from nuclear accidents.

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 Prairie Island 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 the 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 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 a 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 environmental radiation monitoring program at Prairie Island 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 (Teledyne Isotopes Midwest Laboratory, 1987).

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. A monthly composite of all particulate filters is gamma-scanned on an HP Ge or Ge(Li) detector. One of the five locations is a control (P-1), and four are indicator (P-2, P-3, P-4, and P-6). One of the indicators (P-3) is located near the residence expected to be most susceptible to any atmospheric emissions from the plant (highest D/Q residence).

As a "Lessons Learned" commitment, ambient gamma radiation is monitored at thirty-two (32) locations, using $CaSo_4$:Dy dosimeter with four sensitive areas at each location: ten (10) in an inner ring in the general area of the site boundary, fifteen (15) in the outer ring within 4-5 mile radius, six (6) at special interest locations and one control location, 11.1 miles 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.

For additional monitoring of the terrestrial environment, leafy green vegetables (cabbage) are collected annually from the highest D/Q garden and a control location (P-25) and analyzed for iodine-131. Corn is collected annually only from fields irrigated with river water and a control location (P-25) and analyzed for gamma-emitting isotopes. Also, well water is collected quarterly from four locations and analyzed for tritium and gamma-emitting isotopes.

River water is collected weekly at two locations, one upstream of the plant (P-5) and one downstream (P-6, Lock and Dam No. 3). Monthly composites are analyzed for gamma-emitting isotopes. Quarterly composites are analyzed for tritium.

Drinking water is collected weekly from the City of Red Wing well. 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, periphyton or invertebrates, 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. The TLD data for the first quarter of 1987 for Locations P-04A, P-05A, and P-06A were not available because TLDs were lost in the field.

2. The TLD data for the fourth quarter of 1987 for Locations P-03S and P-05S were not available because the TLDs were lost in the field.

Deviations from the program are summarized in Table 5.3.

The cases of TLDs lost in the field over the last three years were reviewed to determine whether action was necessary to prevent future recurrences. Two locations showed multiple occurrences during that time period - P10B and P5S. Relocation to less obvious or less accessible locations is being considered as a corrective measure.

3.4 Laboratory Procedures

All iodine-131 analyses in milk and drinking water were made by using a sensitive radiochemical procedure which involves separation of the element by use of an ion-exchange resin and subsequent beta counting.

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

Tritium levels were determined by liquid scintillation technique.

Analytical procedures used by the Teledyne Isotopes Midwest Laboratory are specified in detail elsewhere (Teledyne Isotopes Midwest Laboratory, 1985). Procedures are based on those prescribed by the National Center for Radiological Health of the U. S. Public Health Service (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 Quality Assurance Program are presented

elsewhere (Teledyne Isotopes Midwest Laboratory, 1985). The TIML Quality Assurance Program includes participation in Interlaboratory Comparison (Crosscheck) Programs. Results obtained in crosscheck programs are presented in Appendix A.

3.5 Program Modifications

During the growing season, milk producers were monitored to determine when the dairy animals were on pasture or fresh cut feed. The frequency of milk samples was increased to semimonthly at one indicator location (Gustafson) during the period because animals were on pasture or fresh cut feed.

3.6 Land Use Census

In accordance with Technical Specification 4.10, paragraph B1, a land use census is conducted in order to 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. This census is conducted at least once per 12 months between the dates of May 1 and October 31. New locations are added to the radiological 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.

This land use census insures the updating of the radiation environmental monitoring program should sampling locations change within the 5 mile radius from the plant.

The 1987 Land Use Census was completed on June 9, 1987. 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. Milk and garden sample locations did not change due to the requirements of the land use census.

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 and Nuclear Accidents

There were no reported atmospheric nuclear tests in 1987. The last reported test was conducted on October 16, 1980 by the People's Republic of China. The reported yield was in the 200 kiloton to 1 megaton range.

There was an accident at Reactor No. 4 of the Chernobyl Nuclear Plant complex in the U.S.S.R. The accident occurred on April 26, 1986. The releases of radioactive isotopes continued for ten days. On May 6, 1986, the reactor was sealed and releases to the atmosphere were reduced to negligible amounts.

There were no reported accidents at nuclear reactor facilities in 1987.

4.2 Program Findings

Results obtained show background levels of radioactivity in the environmental samples collected in the vicinity of the Prairie Island Nuclear Generating Plant in 1987.

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 ranged from 16.5 mR/91 days at inner ring locations to 17.2 mR/91 days at outer ring locations. The mean at special locations was 15.9 mR/91 days and 17.0 mR/91 days at the control location. The differences are not statistically significant. The dose rates measured at all indicator and control locations were similar to those observed in 1978 (12.1 and 15.1 mR/91 days, respectively; in 1979 (12.6 and 15.3 mR/91 days, respectively); in 1980 (11.2

and 13.5 mR/91 days, respectively),; in 1981 (13.0 and 14.5 mR/91 days, respectively); in 1982 (12.0 and 13.0 mR/91 days, respectively),; in 1983 (13.0 and 14.9 mR/91 days, respectively); in 1984 (13.9 and 15.3 mR/91 days, respectively); in 1985 (13.9 and 15.3 mR/91 days, respectively); and in 1986 (16.6 and 17.0 mR/91 days, respectively). No plant effect on ambient gamma radiation was indicated.

Airborne Particulates

The average annual gross beta concentration in airborne particulates measured 0.024 pCi/m^3 at indicator locations and 0.023 pCi/m^3 at control locations and was similar to the levels observed in 1982 (0.026 pCi/m^3), 1983 (0.023 pCi/m^3), 1984 (0.024 pCi/m^3), 1985 (0.025 pCi/m^3), and 1986 (0.025 pCi/m^3). The average of 0.025 pCi/m^3 for 1986 does not include the results from May 19 to June 9, 1986, which were influenced by the accident at Chernobyl.

A spring peak in beta activity had been observed almost annually for many years (Wilson et al., 1969). It had been attributed to fallout of nuclides from the stratosphere (Gold et al., 1964). It was pronounced in 1981, occurred to a lesser degree in 1982, and did not occur in 1983, 1984, 1985, or 1987. In 1986, the spring peak could not be identified because it was oversnadowed by the releases of radioactivity from Chernobyl. The highest averages for gross beta were for the month of December and the fourth quarter, as in 1983, 1984, 1985, and 1986 (exclusive of the period between May 19, 1986 and June 9, 1986.

Two pieces of evidence indicate conclusively that the elevated activity observed during the fourth quarter was not attributable to the Plant operation. In the first place, elevated activity of similar size occurred simultaneously at both indicator and control locations. Secondly, an identical pattern was observed at the Monticello Nuclear Generating Plant, about 100 miles distant from the Prairie Island Nuclear Generating Plant (Northern States Power Company, 1988).

Gamma spectroscopic analysis of quarterly composites of air particulate filters yielded similar results for indicator and control locations. Beryllium-7, which is produced continously in the upper atmosphere by cosmic radiation (Arnold and Al-Salih, 1955), was detected in all samples. All other gamma-emitting isotopes were below their respective LLD limits.

Airborne Iodine

Weekly levels of airborne iodine-131 were below the lower limit of detection (LLD) of 0.07 pCi/m^3 in all samples.

Milk

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

Cs-137 results were below the LLD level of 15 pCi/l in all samples. No other gamma-emitting isotopes, except potassium-40, were detected in any 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 the 1987 show no radiological effects of the plant operation.

Drinking Water

In drinking water from the City of Red Wing well, tritium activity was below the LLD level of 330 pCi/l in all samples. Iodine-131 activity was also below the LLD level at 1.0 pCi/l in all samples. As with the other well water samples, all analyses for gamma-emitting isotopes yielded results below detection limits. Gross beta averaged 7.9 pCi/l and was similar to the levels observed in 1979 (10.5 pCi/l), 1980 (11.8 pCi/l), 1981 (10.7 pCi/l), 1982 (8.9 pCi/l), 1983 (8.0 pCi/l), 1984 (7.9 pCi/l), 1985 (7.1 pCi/l), and 1986 (6.8 pCi/l).

River Water

At the upstream and downstream collection sites, quarterly composite tritium levels were below the LLD level of 330 pCi/l in all samples.

River water was also analyzed for gamma-emitting isotopes. All gamma-emitting isotopes were below their respective detection limits. There was no indication of a plant effect.

Well Water

At the control well P-25, Kinneman Farm and three indicator wells (P-8, Community Center; P-10, Lock and Dam No. 3; and P-9, Plant Well No. 2) no tritium was detected above LLD level of 330 pCi/l in all samples.

Gamma-emitting isotopes were below the detection limits in all samples.

Crops

Two samples of cabbage were collected in August and analyzed for I-131. The I-131 leel was below 0.014 pCi/g wet weight in both samples. There was no indication of a plant effect.

Fish

Fish samples were collected in July and September, 1987. The only isotope detected was naturally-occuring potassium-40 and there was no significant difference between upstream and downstream results. There was no indication of a plant effect.

Aquatic Insects or Periphyton

Aquatic insects (invertebrates) or periphyton were collected in June, July, and September, 1987. The samples were analyzed for gamma-emitting isotopes. All gamma-emitting isotopes, except for naturally-occuring potassium-40, were below their respective LLDs. No plant effect was indicated.

Bottom and Shoreline Sediments

Sediment collections were made in May and October, 1987. The samples were analyzed for gamma-emitting isotopes.

Cs-137 was detected in two bottom sediment upstream samples and averaged 0.088 pCi/g dry weight.

All other gamma-emitting isotopes, except naturally-occurring potassium-40, were below their respective LLDs. No plant effect was indicated.

5.0 TABLES

Table 5.1 Sample collection and analysis program, 1987. Prairie Island

Medium	Locations No.	Locations Codes (and Type)[a]	Collection Type and Frequency[b]	Analysis Type and Frequency[c]
Ambient radiation (TLDs)	32	P-01A - P-10A P-01B - P-15B P-01S - P-06S P-01C	C/Q	Ambient gamma
Airborne particulates	5	P-1(C), P-2, P-3, P-4, P-6	C/W	GB, GS (QC of each location)
Airborne iodine	5	P-1(C), P-2, P-3 P-4, P-6	C/W	I-131
Milk	5	P-16 to P-18, P-25(C), P-14	G/M[d]	I-131, GS
River water	2	P-5(C), P-6	G/W	GS(MC), H-3(QC)
Drinking water	1	P-11	G/W	GB(MC), I-131(MC) GS(MC), H-3(QC)
Well water	4	P-25(C), P-6, P-8, P-9	G/Q	H-3, GS
Edible cultivated crops - leafy green vegetables	2	P-25(C), P-24	G/A	I-131

Table 5.1. Sample collection and analysis program, 1987 (continued) Prairie Island

Medium	Locations No.	Locations Codes (and Type)[a]	Collection Type and Frequency[b]	Analysis Type and Frequency[c]
Edible cultivated crops - corn	2	P-25(C), P-20	G/A	GS
Fish (one species edible portion)	2	P-5(C), P-6	G/SA	GS
Periphyton or invertebrates	2	P-5(C), P-6	G/SA	GS
Bottom sediment	2	P-5(C), P-6	G/SA	GS
Shoreline sediment	1	P-12	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. Analysis 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. Prairie Island

Code	Type[a]	Name	Location
P-1	C	Air Station P-1	16.5 mi @ 348°/NNW
P-2		Air Station P-2	0.5 mi @ 294°/WNW
P-3		Air Station P-3	0.8 mi @ 313°/NW
P-4		Air Station P-4	0.4 mi @ 359°/N
P-5	C	Upstream of Plant	0.6 mi @ 60°/ENE
P-6		Lock & Dam #3 & Air Station P-6	1.6 mi @ 129°/SE
P-8		Community Center	1.0 mi @ 304°/NW
P-9		Plant Well #2	0.3 mi @ 306°/NW
P-11		City of Red Wing	7.1 mi @ 135°/SE
P-12		Recreational Area	3.4 mi @ 116°/ESE
P-14		Gustafson Farm	2.2 mi @ 168°/SSE
P-16		Johnson Farm	2.6 mi @ 60°/ENE
P-17		Place Farm	3.5 mi @ 25°/NNE
P-18		Christensen Farm	3.7 mi @ 88°/E
P-20		River Irrigated Corn Field*	
P-24		Highest D/Q Garden**	
P-25	C	Kinneman Farm	11.1 mi @ 331°/NNW
P-01A		Property Line	0.4 mi @ 359°/N
P-02A		Property Line	0.3 mi @ 19°/NNE
P-03A		Property Line	0.5 mi @ 183°/S
P-04A		Property Line	0.4 mi @ 204°/SSW
P-05A		Property Line	0.4 mi @ 225°/SW
P-06A		Property Line	0.4 mi @ 249°/WSW
P-07A		Property Line	0.4 mi @ 268°/W
P-08A		Property Line	0.4 mi @ 291°/NNW
P-09A		Property Line	0.7 mi @ 317°/NW
P-10A		Property Line	0.5 mi @ 333°/NNW
P-01B		Thomas Killian Residence	4.7 mi @ 355°/N
P-02B		Roy Kinneman Farm	4.8 mi @ 17°/NNE
P-03B		Wayne Anderson Farm	4.9 mi @ 46°/NE
P-04B		Nelson Drive (Road)	4.2 mi @ 61°/ENE
P-05B		County Road E and Coulee	4.1 mi @ 97°/E
P-06B		William Houschildt Residence	4.4 mi @ 112°/ESE
P-07B		Red Wing Service Center	4.7 mi @ 140°/SE
P-08B		David Wnuk Residence	4.1 mi @ 165°/SSE
P-09B		Highway 19 South	4.2 mi @ 187°/S
P-10B		Cannondale Farm	4.9 mi @ 200°/SSW

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

* Collected only if river water is used to irrigate the cornfields (Technical Specification Revision No. 80, effective 11-14-86).

** This location is not determined until after the Land Use Census is completed.

Table 5.2. Sampling locations (continued) Prairie Island

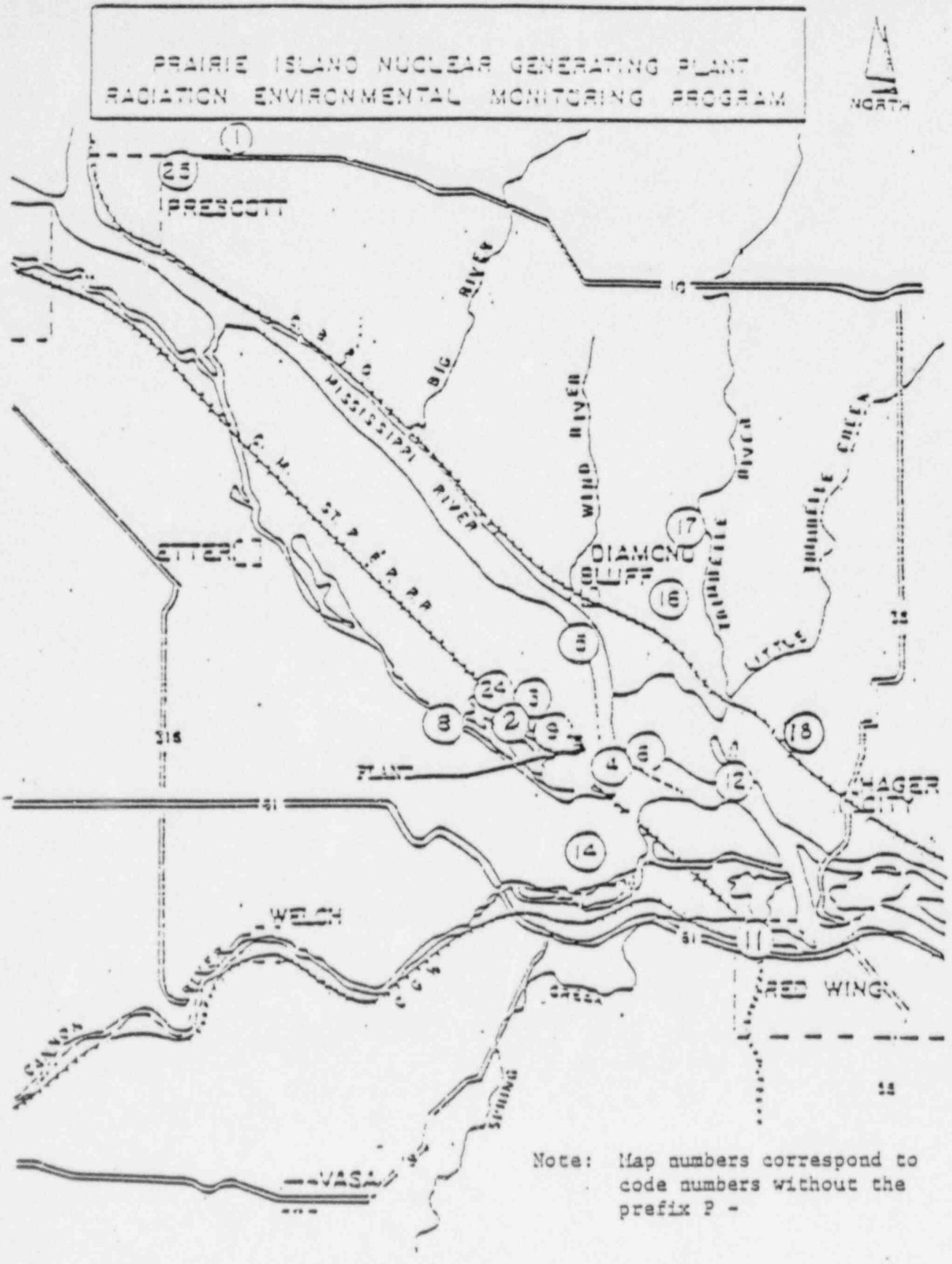
Code	Type[a]	Name	Location
P-11B		Wallace Weberg Farm	4.5 mi @ 221°/SW
P-12B		Roy Gergen Farm	4.5 mi @ 247°/WSW
P-13B		Thomas O'Rourke Farm	4.4 mi @ 270°/W
P-14B		David J. Anderson Farm	4.9 mi @ 306°/NW
P-15B		Holst Farms	4.2 mi @ 347°/NNW
P-01S		Federal Lock & Dam #3	1.6 mi @ 129°/SE
P-02S		Charles Suter Residence	0.6 mi @ 158°/SSE
P-03S		Carl Gustafson Farm	2.2 mi @ 168°/SSE
P-04S		Richard Burt Residence	2.0 mi @ 228°/SW
P-05S		Kenney Store	2.0 mi @ 270°/W
P-06S		Earl Flynn Farm	2.5 mi @ 299°/WNW
P-01C		Robert Kinnemen Farm	11.1 mi @ 331°/NNW

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

Table 5.3. Missed collections and analyses, 1987. Prairie Island Nuclear Generating Plant. All required samples were collected and analyzed as scheduled except the following.

Sample	Analysis	Location	Collection Date or Period	Comments
Thermoluminescent Dosimeters (TLDs)	Ambient Radiation	P-04A	1st Qtr. 1987	Lost in the field.
		P-05A	1st Qtr. 1987	Lost in the field.
		P-06A	1st Qtr. 1987	Lost in the field.
		P-03S	4th Qtr. 1987	Lost in the field.
		P-05S	4th Qtr. 1987	Lost in the field.

TABLE 5.2



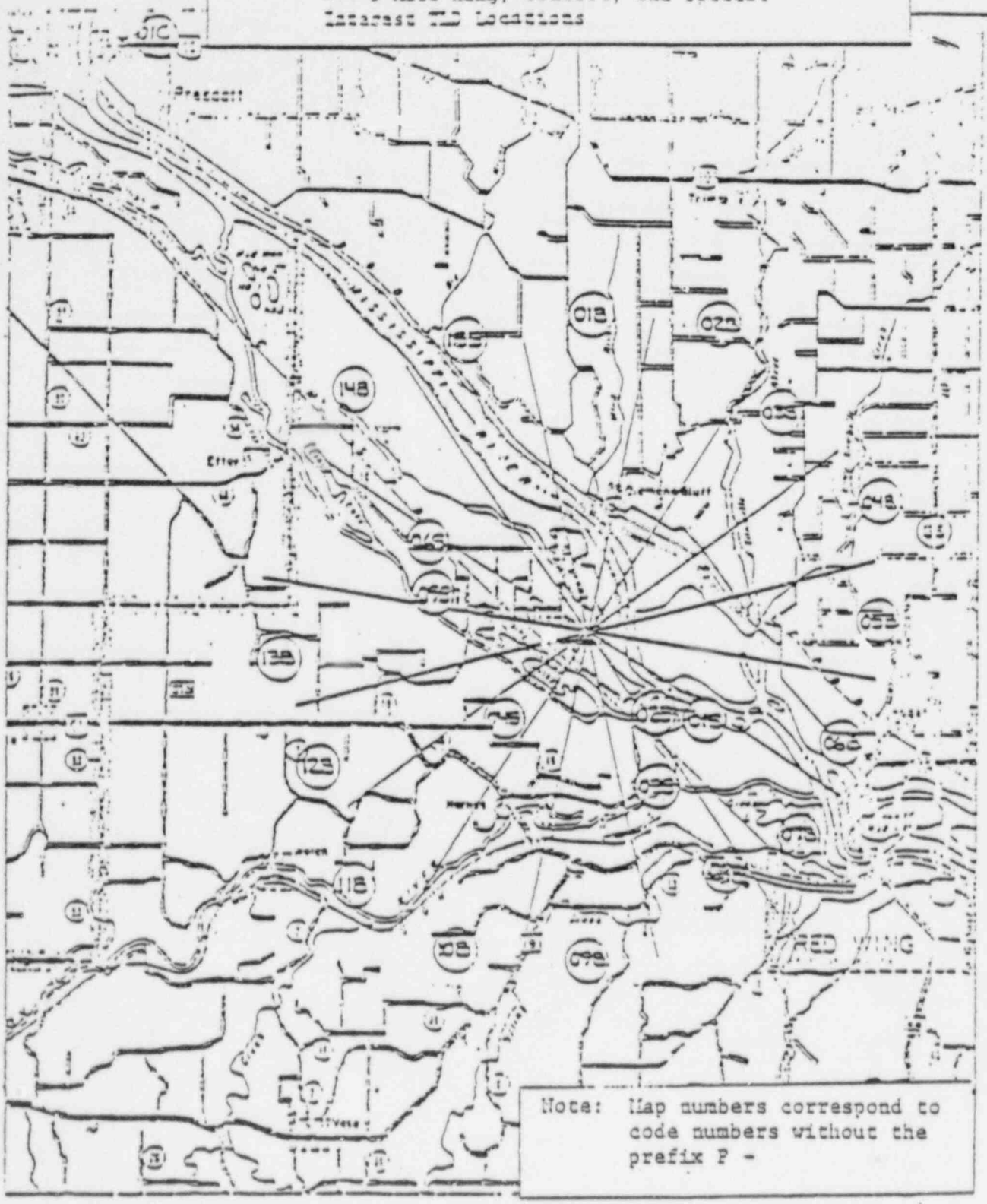
Note: Map numbers correspond to code numbers without the prefix P -

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Site Boundary TLD Locations

Note: Map numbers correspond to code numbers without the prefix P -

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT

4 - 5 Mile Ring, Control, and Special Interest TLD Locations



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SCALE IN MILES

Environmental Radiological Monitoring Program Summary.

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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]
TLD (mR/91 days) (Inner Ring, General Area at Site Boundary)	Gamma 57	3.0	16.5 (37/37) (12.1-20.1)	P-03A, Property Line 0.5 mi @ 183°/S	18.7 (4/4) (16.5-20.1)	(See control below)	0
TLD (mR/91 days) (Outer ring, 4-5 miles distant)	Gamma 60	3.0	17.2 (60/60) (12.1-22.5)	P-04B, Nelson Drive Road 4.2 mi @ 61°/ENE	19.5 (4/4) (16.2-22.5)	(See control below)	0
TLD (mR/91 days) (Special Interest Areas)	Gamma 22	3.0	15.2 (22/22) (10.8-19.4)	P-04S, R. Burt Residence 2.0 mi @ 228°/SW	17.2 (4/4) (14.6-19.4)	(See control below)	0
TLD (mR/91 days) (control)	Gamma 4	3.0	None	P-01C, R. Kinneman Farm 11.1 mi @ 331°/NNW	17.0 (4/4) (14.7-18.6)	17.0 (4/4) (14.7-18.6)	0
Airborne Particulates (pCi/m^3)	GB 260	0.002	0.024 (203/203) (0.007-0.054)	P-6, Station P-6 1.6 mi @ 129°/NNW	0.028 (52/52) (0.016-0.050)	0.023 (52/52) (0.011-0.051)	0
	GS 20						
	Be-7	0.022	0.068 (16/16) (0.033-0.10)	P-6, Station P-6 1.6 mi @ 129°/NNW	0.082 (4/4) (0.040-0.10)	0.064 (4/4) (0.029-0.08)	
	Mn-54	0.0015	<LLD	-	-	<LLD	0
	Co-58	0.002	<LLD	-	-	<LLD	0
	Co-60	0.002	<LLD	-	-	<LLD	0
	Zn-65	0.004	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.002	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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		
Airborne Particulates (pCi/m^3) (continued)	Ru-103	0.002	<LLD	-	-	<LLD	0
	Ru-106	0.016	<LLD	-	-	<LLD	0
	Cs-134	0.0015	<LLD	-	-	<LLD	0
	Cs-137	0.002	<LLD	-	-	<LLD	0
	Ba-La-140	0.012	<LLD	-	-	<LLD	0
	Ce-141	0.0034	<LLD	-	-	<LLD	0
	Ce-144	0.0074	<LLD	-	-	<LLD	0
Airborne Iodine (pCi/m^3)	I-131 260	0.07	<LLD	-	-	<LLD	0
Milk (pCi/l)	I-131 68	1.0	<LLD	-	-	<LLD	0
	GS 68						
	K-40	100	1330 (56/56) (1130-1580)	P-25, Kinneman Farm 11.1 mi @ 331°/NNW	1380 (13/13) (1210-1520)	1380 (13/13) (1210-1520)	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	15	<LLD	-	-	<LLD	0
	Ba-La-140	15	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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)	GB 12	1.0	7.9 (12/12) (5.6-13.9)	P-11, City of Red Wing 7.1 mi @ 135°/SE	7.9 (12/12) (5.0-9.0)	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
	Cs-134	10	<LLD	-	-	None	0
	Cs-137	10	<LLD	-	-	None	0
	Ba-La-140	15	<LLD	-	-	None	0
	Ce-144	64	<LLD	-	-	None	0
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

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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) (continued)	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	18	<LLD	-	-	<LLD	0
	Ba-La-140	15	<LLD	-	-	<LLD	0
	Ce-144	56	<LLD	-	-	<LLD	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	61	<LLD	-	-	<LLD	0
Crops-Cabbage (pCi/g wet)	I-131 2	0.014	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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	Mean (F) Range		
Fish - Flesh (pCi/g wet)	GS 4						
	K-40	0.1	2.30 (2/2) (2.15-2.46)	P-5(C), Upstream of Plant 0.6 mi @ 60°/ENE	2.76 (2/2) (2.68-2.84)	2.76 (2/2) (2.66-2.84)	0
	Mn-54	0.025	<LLD	-	-	<LLD	0
	Fe-59	0.12	<LLD	-	-	<LLD	0
	Co-58	0.038	<LLD	-	-	<LLD	0
	Co-60	0.024	<LLD	-	-	<LLD	0
	Zn-65	0.063	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.040	<LLD	-	-	<LLD	0
	Cs-134	0.023	<LLD	-	-	<LLD	0
	Cs-137	0.024	<LLD	-	-	<LLD	0
	Ba-La-140	0.29	<LLD	-	-	<LLD	0
Invertebrates (pCi/g wet)	GS 4						
	Be-7	1.47	<LLD	-	-	<LLD	0
	K-40	0.31[f]	2.14 (2/2) (1.66-2.41)	-	-	<LLD	0
	Mn-54	0.17	<LLD	-	-	<LLD	0
	Co-58	0.18	<LLD	-	-	<LLD	0
	Co-60	0.16	<LLD	-	-	<LLD	0
	Zn-65	0.40	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.20	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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		
Invertebrates (pCi/g wet) (continued)	GS 4						
	Cu-103	0.19	<LLD	-	-	<LLD	0
	Ru-106	1.40	<LLD	-	-	<LLD	0
	Cs-134	0.18	<LLD	-	-	<LLD	0
	Cs-137	0.16	<LLD	-	-	<LLD	0
	Ba-La-140	0.35	<LLD	-	-	<LLD	0
	Ce-141	0.22	<LLD	-	-	<LLD	0
	Ce-144	0.82	<LLD	-	-	<LLD	0
Bottom and Shoreline Sediments (pCi/g dry)	GS 6						
	Be-7	0.33	<LLD	P-5(C), Upstream of Plant, 0.6 mi @ 60°/ENE	0.91 (1/2) -	0.91 (1/2) -	0
	K-40	1.0	8.99 (4/4) (8.36-9.67)	P-12, Recreational Area, 3.4 mi @ 116°/ESE	9.01 (2/2) (8.36-9.67)	8.60 (2/2) (8.05-9.16)	0
	Mn-54	0.039	<LLD	-	-	<LLD	0
	Co-58	0.040	<LLD	-	-	<LLD	0
	Co-60	0.054	<LLD	-	-	<LLD	0
	Zn-65	0.11	<LLD	-	-	<LLD	0
	Zr-Nb-95	0.043	<LLD	-	-	<LLD	0

Table 5.4. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Prairie Island Nuclear Generating Plant Docket No. 50-282, 50-306

Location of Facility Goodhue, Minnesota (County, State) Reporting Period January - December 1987

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) (continued)	GS 6						
	Ru-103	0.039	<LLD	-	-	<LLD	0
	Ru-106	0.30	<LLD	-	-	<LLD	0
	Cs-134	0.036	<LLD	-	-	<LLD	0
	Cs-137	0.044	<LLD	P-5(C), Upstream of Plant, 0.6 mi @ 60°/ENE	0.088 (2/2) (0.066-0.11)	0.088 (2/2) (0.066-0.11)	0
	Ba-La-140	0.078	<LLD	-	-	<LLD	0
	Ce-141	0.060	<LLD	-	-	<LLD	0
	Ce-144	0.17	<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 location 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] Non-routine results are those which exceed ten times the control station value. If no control station value is available, the result is considered non-routine if it exceeds ten times the preoperational value for the location.
[f] One result (<3.70 pCi/g wet weight) was excluded from the determination of LLDs. The elevated LLD resulted from small sample size.

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Appendix A

Interlaboratory Comparison Program Results

NOTE: Appendix A is updated twice a year and the complete Appendix is included in January and July monthly reports only. Please refer to January and July Reports for information.

January, 1988

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 May 1984 through December 1987. 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, 1984, and 1985-1986 through participation in the Second, Third, Fourth, Fifth, Seventh, and Eighth International Intercomparison of Environmental Dosimeters under the sponsorships listed in Table A-2.

Table A-3 lists results of the analyses on in-house spiked samples.

Table A-4 lists results of the analyses on in-house "blank" samples.

Attachment B lists acceptance criteria for "spiked" samples.

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, 1984 through 1987.[a]

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STW-358	Water	May 1984	Gr. alpha	3.0±0.6	3±5.0	0.0-11.7
			Gr. beta	6.7±1.2	6±5.0	0.0-14.7
STM-366	Milk	June 1984	Sr-89	21±3.1	25±5.0	16.3-33.7
			Sr-90	13±2.0	17±1.5	14.4-19.6
			I-131	46±5.3	43±6.0	32.6-53.4
			Cs-137	38±4.0	35±5.0	26.3-43.7
			K-40	1577±172	1496±75	1336-1626
STW-368	Water	July 1984	Gr. alpha	5.1±1.1	6±5.0	0.0-14.7
			Gr. beta	11.9±2.4	13±5.0	4.3-21.7
STW-369	Water	August 1984	I-131	34.3±5.0	34.0±6.0	23.6-44.4
STW-370	Water	August 1984	H-3	3003±253	2817±356	2200-3434
STF-371	Food	July 1984	Sr-89	22.0±5.3	25.0±5.0	14.3-33.7
			Sr-90	14.7±3.1	20.0±1.5	17.4-22.6
			I-131	<172	39.0±6.0	28.6-49.4
			Cs-137	24.0±5.3	25.0±5.0	14.3-33.7
			K-40	2503±132	2605±130	2379-2831
STAF-372	Air Filter	August 1984	Gr. alpha	15.3±1.2	17±5.0	8.3-25.7
			Gr. beta	56.0±0.0	51±5.0	42.3-59.7
			Sr-90	14.3±1.2	18±1.5	15.6-20.4
			Cs-137	21.0±2.0	15±5.0	6.3-23.7
STW-375	Water	Sept 1984	Ra-226	5.1±0.4	4.9±0.7	3.6-6.2
			Ra-228	2.2±0.1	2.3±0.4	1.7-2.9
STW-377	Water	Sept 1984	Gr. alpha	3.3±1.2	5.0±5.0	0.0-13.7
			Gr. beta	12.7±2.3	16.0±5.0	7.3-24.7
STW-379	Water	Oct 1984	H-3	2860±312	2810±205	2454-3166
STW-380	Water	Oct 1984	Cr-51	<36	40±5.0	31.3-48.7
			Co-60	20.3±1.2	20±5.0	11.3-28.7
			Zn-65	150±8.1	147±5.0	138.3-155.7
			Ru-106	<30	47±5.0	36.3-55.7
			Cs-134	31.3±7.0	31±5.0	22.3-39.7
			Cs-137	26.7±1.2	24±5.0	15.3-32.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STM-382	Milk	Oct 1984	Sr-89	15.7±4.2	22±5.0	13.3-30.7
			Sr-90	12.7±1.2	16±1.5	13.4-18.6
			I-131	41.7±3.1	42±6.0	31.6-42.4
			Cs-137	31.3±6.1	32±5.0	23.3-40.7
			K-40	1447±66	1517±76	1386-1648
STW-384	Water (Blind)	Oct 1984 Sample A	Gr. alpha	9.7±1.2	14±5.0	5.3-22.7
			Ra-226	3.3±0.2	3.0±0.5	2.2-3.8
			Ra-228	3.4±1.6	2.1±0.3	1.6-2.6
			Uranium	NA[e]		0.0-15.4
		Sample B	Gr. beta	48.3±5.0	64±5.0	55.3-72.7
			Sr-89	10.7±4.6	11±5.0	2.3-19.7
			Sr-90	7.3±1.2	12±1.5	9.4-14.6
			Co-60	16.3±1.2	14±5.0	5.3-22.7
			Cs-134	<2	2±5.0	0.0-10.7
			Cs-137	16.7±1.2	14±5.0	5.3-22.7
STAF-387	Air Filter	Nov 1984	Gr. alpha	18.7±1.2	15±5.0	6.3-23.7
			Gr. beta	59.0±5.3	52±5.0	43.3-60.7
			Sr-90	18.3±1.2	21±1.5	18.4-23.6
			Cs-137	10.3±1.2	10±5.0	1.3-18.7
STW-388	Water	Dec 1984	I-131	28.0±2.0	36±6.0	25.6-36.4
STW-389	Water	Dec 1984	H-3	3583±110	3182±360	2550-3806
STW-391	Water	Dec 1984	Ra-226	8.4±1.7	8.6±1.3	6.4-10.8
			Ra-228	3.1±0.2	4.1±0.6	3.0-5.2
STW-392	Water	Jan 1985	Sr-89	<3.0	3.0±5.0	0.0-11.7
			Sr-90	27.3±5.2	30.0±1.5	27.4-32.6
STW-393	Water	Jan 1985	Gr. alpha	3.3±1.2	5±5.0	0.0-13.7
			Gr. beta	17.3±3.0	15±5.0	6.3-23.7
STS-395	Food	Jan 1985	Gr. alpha	4.7±2.3	6.0±5.0	0.0-14.7
			Gr. beta	11.3±1.2	15.0±5.0	6.3-23.7
			Sr-89	25.3±6.4	34.0±5.0	25.3-42.8
			Sr-90	27.0±8.8	26.0±1.5	23.4-28.6
			I-131	38.0±2.0	35.0±6.0	24.6-45.4
			Cs-137	32.7±2.4	29.0±5.0	20.3-37.7
			K-40	1410±212	1382±120	1174-1590

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STW-397	Water	Feb 1985	Cr-51	<29	48±5.0	39.3-56.7
			Co-60	21.3±3.0	20±5.0	11.3-28.7
			Zn-65	53.7±5.0	55±5.0	46.3-63.7
			Ru-106	<23	25±5.0	16.3-33.7
			Cs-134	32.3±1.2	35±5.0	26.3-43.7
			Cs-137	25.3±3.0	25±5.0	16.3-33.7
STW-398	Water	Feb 1985	H-3	3869±319	3796±634	3162-4430
STM-400	Milk	March 1985	I-131	7.3±2.4	9.0±0.9	7.4-10.6
STW-402	Water	March 1985	Ra-226	4.6±0.6	5.0±0.8	3.7-6.3
			Ra-228	<0.8	9.0±1.4	6.7-11.3
		Reanalysis	Ra-228	9.0±0.4		
STW-404	Water	March 1985	Gr. alpha	4.7±2.3	6±5.0	0.0-14.7
			Gr. beta	11.3±1.2	15±5.0	6.3-23.7
STAF-405	Air Filter	March 1985	Gr. alpha	9.3±1.0	10.0±5.0	1.3-18.7
			Gr. beta	42.0±1.1	36.0±5.0	27.3-44.7
			Sr-90	13.3±1.0	15.0±1.5	12.4-17.6
			Cs-137	6.3±1.0	6.0±5.0	0.0-14.7
STW-407	Water	April 1985	I-131	8.0±0.0	7.5±0.8	6.2-8.8
STW-408	Water	April 1985	H-3	3399±150	3559±630	2929-4189
STW-409	Water	April 1985				
	(Blind) Sample A		Gr. alpha	29.7±1.8	32.0±5.0	23.3-40.7
			Ra-226	4.4±0.2	4.1±0.6	3.1-5.1
			Ra-228	NA[e]	6.2±0.9	4.6-7.8
			Uranium	NA[e]	7.0±6.0	0.0-17.4
	Sample B		Gr. beta	74.3±11.8	72.0±5.0	63.3-80.7
			Sr-89	12.3±7.6	10.0±5.0	1.3-18.7
			Sr-90	14.7±2.4	15.0±1.5	12.4-17.6
			Co-60	14.7±2.4	15.0±5.0	6.3-23.7
			Cs-134	12.0±2.0	15.0±5.0	6.3-23.7
			Cs-137	14.0±2.0	12.0±5.0	3.3-20.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-413	Water	May 1985	Sr-89	36.0±12.4	39.0±5.0	30.3-47.7
			Sr-90	14.3±4.2	15.0±1.5	12.4-17.6
STW-414	Water	May 1985	Gr. alpha	8.3±4.1	12.0±5.0	3.3-20.7
			Gr. beta	8.7±1.2	11.0±5.0	2.3-19.7
STW-416	Water	June 1985	Cr-51	44.7±6.0	44.0±5.0	45.3-52.7
			Co-60	14.3±1.2	14.0±5.0	5.3-22.7
			Zn-65	50.3±7.0	47.0±5.0	38.3-55.7
			Ru-106	55.3±5.8	62.0±5.0	53.3-70.7
			Cs-134	32.7±1.2	35.0±5.0	26.3-43.7
			Cs-137	22.7±2.4	20.0±5.0	11.3-28.7
STW-418	Water	June 1985	H-3	2146±132	2416±351	1807-3025
STM-421	Milk	June 1985	Sr-89	10.3±4.6	11.0±5.0	2.3-19.7
			Sr-90	9.0±2.0	11.0±1.5	8.4-13.6
			I-131	11.7±1.2	11.0±6.0	0.6-21.4
			Cs-137	12.7±1.2	11.0±5.0	2.3-19.7
			K-40	1512±62	1525±132	1393-1657
STW-423	Water	July 1985	Gr. alpha	5.0±0.0	11.0±5.0	2.3-19.7
			Gr. beta	5.0±2.0	8.0±5.0	0.0-16.7
STW-425	Water	August 1985	I-131	25.7±3.0	33.0±6.0	22.6-43.4
STW-426	Water	August 1985	H-3	4363±83	4480±447	3704-5256
STAF-427	Air Filter	August 1985	Gr. alpha	11.3±0.6	13.0±5.0	4.3-21.7
			Gr. beta	46.0±1.0	44.0±5.0	35.3-52.7
			Sr-90	17.7±0.6	18.0±1.5	15.4-20.6
			Cs-137	10.3±0.6	8.0±5.0	0.0-16.7
STW-429	Water	Sept 1985	Sr-89	15.7±0.6	20.0±5.0	11.3-28.7
			Sr-90	7.0±0.0	7.0±1.5	4.4-9.6
STW-430	Water	Sept 1985	Ra-226	8.2±0.3	8.9±1.3	6.6-11.1
			Ra-228	4.1±0.3	4.6±0.7	3.4-5.8
STW-431	Water	Sept 1985	Gr. alpha	4.7±0.6	8.0±5.0	0.0-16.7
			Gr. beta	4.7±1.2	8.0±5.0	0.0-16.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-433	Water	Oct 1985	Cr-51	<13	21.0±5.0	12.3-29.7
			Co-60	19.3±0.6	20.0±5.0	11.3-28.7
			Zn-65	19.7±0.6	19.0±5.0	10.3-27.7
			Ru-106	<19	20.0±5.0	11.3-28.7
			Cs-134	17.0±1.0	20.0±5.0	11.3-28.7
			Cs-137	19.3±1.2	20.0±5.0	11.3-28.7
STW-435	Water	Oct 1985	H-3	1957±50	1974±345	1376-2572
STW-436 437	Water (Blind)	Oct 1985				
	Sample A		Gr. alpha	53.0±1.0	52.0±13	29.4-74.6
			Ra-226	5.9±0.1	6.3±1.0	4.1-7.9
			Ra-228	8.2±0.1	10.1±1.5	7.5-12.7
			Uranium	NA[e]	8.0±10.4	0.0-18.4
	Sample B		Gr. beta	85.7±2.5	75.0±5.0	76.3-83.7
			Sr-89	21.3±1.5	27.0±5.0	18.3-35.7
			Sr-90	10.3±0.6	9.0±1.5	6.4-11.6
			Co-60	18.3±1.2	18.0±5.0	9.3-26.7
			Cs-134	16.3±1.2	18.0±5.0	9.3-26.7
			Cs-137	19.0±1.0	18.0±5.0	9.3-26.7
STM-439	Milk	Oct 1985	Sr-89	50.3±0.6	48.0±5.0	39.3-56.7
			Sr-90	23.3±0.6	26.0±1.5	23.4-28.6
			I-131	45.7±3.2	42.0±6.0	31.6-52.4
			Cs-137	60.7±0.6	56.0±5.0	47.3-64.7
			K-40	1547±29	1540±77	1406-1674
STW-441	Water	Nov 1985	Gr. alpha	5.3±0.6	10.0±5.0	1.3-18.7
			Gr. beta	11.7±1.2	13.0±5.0	4.3-21.7
STW-443	Water	Dec 1985	I-131	46.7±2.1	45.0±6.0	34.6-55.4
STW-444	Water	Dec 1985	Ra-226	6.5±0.1	7.1±1.1	5.2-9.0
			Ra-228	6.1±0.1	7.3±1.1	5.4-9.2
STW-445	Water	Jan 1986	Sr-89	29.7±2.5	31.0±5.0	22.3-39.7
			Sr-90	13.7±0.6	15.0±1.5	12.4-17.6
STW-446	Water	Jan 1986	Gr. alpha	3.0±0.0	3.0±5.0	0.0-11.7
			Gr. beta	5.3±0.6	7.0±5.0	0.0-15.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-447	Food	Jan 1986	Sr-89	24.3±2.5	25.0±5.0	16.3-33.7
			Sr-90	17.3±0.6	10.0±1.5	7.4-12.6
			I-131	22.7±2.3	20.0±6.0	9.6-30.4
			Cs-137	16.3±0.6	15.0±5.0	6.3-23.7
			K-40	927±46	950±144	701-1199
STW-448	Water	Feb 1986	Cr-51	45.0±3.6	38.0±5.0	29.3-46.7
			Co-60	19.7±1.5	18.0±5.0	9.3-26.7
			Zn-65	44.0±3.5	40.0±5.0	31.3-48.7
			Ru-106	<9.0	0.0±5.0	0.0-8.7
			Cs-134	28.3±2.3	30.0±5.0	21.3-38.7
			Cs-137	23.7±0.6	22.0±5.0	13.3-30.7
STW-449	Water	Feb 1986	H-3	5176±48	5227±525	4317-6137
STW-450	Water	Feb 1986	U total	8.0±0.0	9.0±6.0	0.0-19.4
STW-451	Milk	Feb 1986	I-131	7.0±0.0	9.0±6.0	0.0-19.4
STW-452	Water	March 1986	Ra-226	3.8±0.1	4.1±0.6	3.0-5.2
			Ra-228	11.0±0.5	12.4±1.8	9.2-15.5
STW-453	Water	March 1986	Gr. alpha	6.7±0.6	15.0±5.0	6.3-23.7
			Gr. beta	7.3±0.6	8.0±5.0	0.0-16.7
STW-454	Water	April 1986	I-131	7.0±0.0	9.0±6.0	0.0-19.4
STW-455 456	Water (Blind)	April 1986				
	Sample A		Gr. alpha	15.0±1.0	17.0±5.0	8.3-25.7
			Ra-226	3.1±0.1	2.9±0.4	2.1-3.7
			Ra-228	1.5±0.2	2.0±0.3	1.5-2.5
			Uranium	4.7±0.6	5.0±6.0	0.0-15.4
	Sample B		Gr. beta	28.7±1.2	35.0±5.0	26.3-43.7
			Sr-89	5.7±0.6	7.0±5.0	0.0-15.7
			Sr-90	7.0±0.0	7.0±1.5	4.4-9.6
			Co-60	10.7±1.5	10.0±5.0	1.3-18.7
			Cs-134	4.0±1.7	5.0±5.0	0.0-13.7
			Cs-137	5.3±0.6	5.0±5.0	0.0-13.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STAF-457	Air Filter	April 1986	Gr. alpha	13.7±0.6	15.0±5.0	6.3-23.7
			Gr. beta	46.3±0.6	47.0±5.0	38.3-55.7
			Sr-90	14.7±0.6	18.0±1.5	15.4-20.6
			Cs-137	10.7±0.6	10.0±5.0	1.3-18.7
STU-458	Urine	April 1986	Tritium	4313±70	4423±189	4096-4750
STW-459	Water	May 1986	Sr-89	4.3±0.6	5.0±5.0	0.0-13.7
			Sr-90	5.0±0.0	5.0±1.5	2.4-7.6
STW-460	Water	May 1986	Gr. alpha	5.3±0.6	8.0±5.0	0.0-16.7
			Gr. beta	11.3±1.2	15.0±5.0	6.3-23.7
STW-461	Water	June 1986	Cr-51	<9.0	0.0±5.0	0.0-8.7
			Co-60	66.0±1.0	66.0±5.0	57.3-74.7
			Zn-65	87.3±1.5	86.0±5.0	77.3-94.7
			Ru-106	39.7±2.5	50.0±5.0	41.3-58.7
			Cs-134	49.3±2.5	49.0±5.0	40.3-57.7
			Cs-137	10.3±1.5	10.0±5.0	1.3-18.7
STW-462	Water	June 1986	Tritium	3427±25	3125±361	2499-3751
STM-464	Milk	June 1986	Sr-89	<1.0	0.0±5.0	0.0-8.7
			Sr-90	15.3±0.6	16.0±1.5	13.4-18.6
			I-131	48.3±2.3	41.0±6.0	30.6-51.4
			Cs-137	43.7±1.5	31.0±5.0	22.3-39.7
			K-40	1567±114	1600±80	1461-1739
STW-465	Water	July 1986	Gr. alpha	4.7±0.6	6.0±5.0	0.0-14.7
			Gr. beta	18.7±1.2	18.0±5.0	9.3-26.7
STW-467	Water	August 1986	I-131	30.3±0.6	45.0±6.0	34.4-55.4
STW-468	Water	August 1986	Pu-239	11.3±0.6	10.1±1.0	8.3-11.9
STW-469	Water	August 1986	Uranium	4.0±0.0	4.0±6.0	0.0-14.4
STAF-470	Air Filter	Sept 1986	Gr. alpha	19.3±1.5	22.0±5.0	13.3-30.7
471			Gr. beta	64.0±2.6	66.0±5.0	57.3-74.7
472			Sr-90	22.0±1.0	22.0±5.0	19.4-24.6
			Cs-137	25.7±1.5	22.0±5.0	13.3-30.7
STW-473	Water	Sept 1986	Ra-226	6.0±0.1	6.1±0.9	4.5-7.7
			Ra-228	8.7±1.1	9.1±1.4	6.7-11.5

Table A-1. (continued).

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-474	Water	Sept 1986	Gr. alpha	16.3±3.2	15.0±5.0	6.3-23.7
			Gr. beta	9.0±1.0	8.0±5.0	0.0-16.7
STW-475	Water	Oct 1986	Cr-51	63.3±5.5	59.0±5.0	50.3-67.7
			Co-60	31.0±2.0	31.0±5.0	22.3-39.7
			Zn-65	87.3±5.9	85.0±5.0	76.3-93.7
			Ru-106	74.7±7.4	74.0±5.0	65.3-82.7
			Cs-134	25.7±0.6	28.0±5.0	19.3-36.7
			Cs-137	46.3±1.5	44.0±5.0	35.3-52.7
STW-476	Water	Oct 1986	H-3	5918±60	5973±597	4938-7008
SPW-477 478	Water (Blind)	Oct 1986				
	Sample A		Gr. alpha	34.0±6.0	40.0±5.0	31.3-48.7
			Ra-226	5.8±0.2	6.0±0.9	4.4-7.6
			Ra-228	2.7±1.0	5.0±0.8	3.7-6.3
			Uranium	11.0±0.0	10.0±6.0	0.0-20.4
	Sample B		Gr. beta	38.7±1.2	51.0±5.0	42.3-59.7
			Sr-89	5.0±0.0	10.0±5.0	1.3-18.7
			Sr-90	3.0±0.0	4.0±1.5	1.4-6.6
			Co-60	24.7±1.2	24.0±5.0	15.3-32.7
			Cs-134	11.0±2.0	12.0±5.0	3.3-20.7
			Cs-137	9.3±1.2	8.0±5.0	0.0-16.7
STM-479	Milk	Nov 1986	Sr-89	7.7±1.2	9.0±5.0	0.3-17.7
			Sr-90	1.0±0.0	0.0±1.5	0.0-2.6
			I-131	52.3±3.1	49.0±6.0	38.6-59.4
			Cs-137	45.7±3.1	39.0±5.0	30.3-47.7
			K-40	1489±104	1565±78	1430-1700
STU-480	Urine	Nov 1986	H-3	5540±26	5257±912	4345-6169
STW-481	Water	Nov 1986	Gr. alpha	12.0±4.0	20.0±5.0	11.3-28.7
			Gr. beta	20.0±3.5	20.0±5.0	11.3-28.7
STW-482	Water	Dec 1986	Ra-226	6.7±0.2	6.8±1.0	5.0-8.6
			Ra-228	5.2±0.2	11.1±1.7	8.2-14.0
STW-483	Water	Jan 1987	Sr-89	19.7±5.0	25.0±5.0	16.3-33.7
			Sr-90	21.0±2.0	25.0±1.5	22.4-27.6

Table A-1. (continued).

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STW-484	Water	Jan 1987	Pu-239	17.0±2.3	16.7±1.7	13.8-19.6
STF-486	Food	Jan 1987	Sr-90	36.0±4.0	49.0±10.0	31.7-66.3
			I-131	78.0±3.4	78.0±8.0	64.1-91.9
			Cs-137	89.7±3.0	84.0±5.0	75.3-92.7
			K-40	942±56	980±49	895-1065
STF-487	Food (BlanK)	Jan 1987	SR-90	2.0±0.0	---	
			I-131	<3	---	
			Cs-137	<2	---	
			K-40	993±102	---	
STW-488	Water	Feb 1987	Co-60	49.0±0.0	50.0±5.0	41.3-58.7
			Zn-65	96.0±7.2	91.0±5.0	82.3-99.7
			Ru-106	92.0±20.2	100.0±5.0	91.3-108.7
			Cs-134	53.0±3.4	59.0±5.0	50.3-67.7
			Cs-137	89.3±4.6	87.0±5.0	78.3-95.7
STW-489	Water	Feb 1987	H-3	4130±140	4209±420	3479-4939
STW-490	Water	Feb 1987	Uranium	8.3±1.2	8.0±6.0	0.0-18.4
STM-491	Milk	Feb 1987	I-131	10.0±0.0	9.0±0.9	7.4-10.6
STW-492	Water	Mar 1987	Gr. alpha	3.7±1.2	3.0±5.0	0.0-11.7
			Gr. beta	11.3±1.2	13.0±5.0	4.3-21.7
STW-493	Water	Mar 1987	Ra-226	7.0±0.1	7.3±1.1	5.4-9.2
			Ra-228	7.1±2.3	7.5±1.1	5.5-9.5
STW-494	Water	Apr 1987	I-131	8.0±0.0	7.0±0.7	5.8-8.2
STAF-495	Air Filter	Apr 1987	Gr. alpha	15.0±0.0	14.0±5.0	5.3-22.7
			Gr. beta	41.0±2.0	43.0±5.0	34.3-51.7
			Sr-90	16.3±1.2	17.0±1.5	14.4-19.6
			Cs-137	7.0±0.0	8.0±5.0	0.0-16.7
STW-496 497	Water (Blind)	Apr 1987				
	Sample A		Gr. alpha	30.7±1.2	30.0±8.0	16.1-43.9
			Ra-226	3.9±0.2	3.9±0.6	2.9-4.9
			Ra-228	4.9±0.9	4.0±0.6	3.0-5.0
			Uranium	5.0±0.0	5.0±6.0	0.0-15.4

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STW-496 497	Water (Blind)	Apr 1987				
	Sample B		Gr. Beta	69.3±9.4	66.0±5.0	57.3-74.7
			Sr-89	16.3±3.0	19.0±5.0	10.3-27.7
			Sr-90	10.0±0.0	10.0±1.5	7.4-12.6
			Co-60	8.3±3.0	8.0±5.0	0.0-16.7
			Cs-134	19.0±2.0	20.0±5.0	11.3-28.7
			Cs-137	14.7±1.2	15.0±5.0	6.3-23.7
STU-498	Urine	Apr 1987	H-3	6017±494	5620±795	4647-6593
STW-499	Water	May 1987	Sr-89	38.0±6.0	41.0±5.0	32.3-49.7
			Sr-90	21.0±2.0	20.0±1.5	17.4-22.6
STW-500	Water	May 1987	Gr. alpha	9.0±3.4	11.0±5.0	2.3-19.7
			Gr. beta	10.3±1.2	7.0±5.0	0.0-15.7
STW-501	Water	June 1987	Cr-51	40.0±8.0	41.0±5.0	32.3-49.7
			Co-60	60.3±3.0	64.0±5.0	55.3-72.7
			Zn-65	11.3±5.0	10.0±5.0	1.3-18.7
			Ru-106	78.3±6.4	75.0±5.0	66.3-83.7
			Cs-134	36.7±3.0	40.0±5.0	31.3-48.7
			Cs-137	80.3±4.2	80.0±5.0	71.3-88.7
STW-502	Water	June 1987	H-3	2906±86	2895±357	2277-3513
STW-503	Water	June 1987	Ra-226	6.9±0.1	7.3±1.1	5.4-9.2
			Ra-228	13.3±1.0	15.2±2.3	11.2-19.2
STW-504	Milk	June 1987	Sr-89	57.0±4.3	69.0±5.0	60.3-77.7
			Sr-90	32.0±1.0	35.0±1.5	32.4-37.6
			I-131	64.0±2.0	59.0±6.0	48.6-69.4
			Cs-137	77.7±0.6	74.0±5.0	65.3-82.7
			K	1383±17	1525±76	1393-1657
STW-505	Water	July 1987	Gr. alpha	2.3±0.7	5.0±5.0	0.0-13.7
			Gr. beta	4.0±1.0	5.0±5.0	0.0-13.7
STF-506	Food	July 1987	I-131	82.7±4.6	80.0±8.0	66.1-93.9
			Cs-137	53.7±3.0	50.0±5.0	41.3-58.7
			K	1548±57	1680±84	1534-1826
STW-507	Water	Aug 1987	I-131	45.7±4.2	48.0±6.0	37.6-58.4
STW-508	Water	Aug 1987	Pu-239	5.8±0.2	5.3±0.5	4.4-6.2

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STW-509	Water	Aug 1987	Uranium	13.3±0.3	13.0±6.0	2.6-23.4
STAF-510	Air Filter	Aug 1987	Gr. alpha	9.7±0.4	10.0±5.0	1.3-18.7
			Gr. beta	28.3±0.6	30.0±5.0	21.3-38.7
			Sr-90	10.0±0.9	10.0±1.5	7.4-12.6
			Cs-137	10.0±1.0	10.0±5.0	1.3-18.7
STW-511	Water	Sept 1987	Ra-226	9.9±0.1	9.7±1.5	7.2-12.2
			Ra-228	8.1±1.4	6.3±1.0	4.6-8.0
STW-512	Water	Sept 1987	Gr. alpha	2.0±0.6	4.0±5.0	0.0-12.7
			Gr. beta	11.3±1.3	12.0±5.0	3.3-20.7
STW-513	Water	Oct 1987	H-3	4473±100	4492±449	3714-5270
STW-514	Water A	Oct 1987	Gr. alpha	29.3±2.6	28.0±7.0	15.9-40.1
			Ra-226	4.9±0.1	4.8±0.7	3.6-6.1
			Ra-228	4.2±1.0	3.6±0.5	2.7-4.5
			Uranium	3.0±0.1	3.0±6.0	0.0-13.4
STW-515	Water B	Oct 1987	Gr. beta	72.3±2.7	72.0±5.0	63.3-80.7
			Sr-89	14.3±1.3	16.0±5.0	7.3-24.7
			Sr-90	9.7±0.4	10.0±1.5	7.4-12.6
			Co-60	16.7±3.0	16.0±5.0	7.3-24.7
			Cs-134	16.7±2.3	16.0±5.0	7.3-24.7
			Cs-137	24.3±3.3	24.0±5.0	15.3-32.7
STW-516	Water	Oct 1987	Cr-51	80.3±17.5	70.0±5.0	61.3-78.7
			Co-60	16.0±2.3	15.0±5.0	6.3-23.7
			Zn-65	46.3±5.6	46.0±5.0	37.3-54.7
			Ru-106	57.3±15.4	61.0±5.0	52.3-69.7
			Cs-134	23.7±2.5	25.0±5.0	16.3-33.7
			Cs-137	51.7±3.2	51.0±5.0	42.3-59.7
STU-517	Urine	Nov 1987	H-3	7267±100	7432±743	6145-8719
STW-519	Water	Dec 1987	I-131	26.0±3.0	26.0±6.0	15.6-36.4

[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 Vegan, Nevada.

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

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

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

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	mR: Average ±2 σ[d] (all participants)
2nd International Intercomparison[b]					
115-2	CaF_2:Mn Bulb	Field	17.0±1.9	17.1	16.4±7.7
		Lab	20.8±4.1	21.3	18.8±7.6
3rd International Intercomparison[e]					
115-3	CaF_2:Mn Bulb	Field	30.7±3.2	34.9±4.8	31.5±3.0
		Lab	89.6±6.4	91.7±14.6	86.2±24.0
4th International Intercomparison[f]					
115-4	CaF_2:Mn Bulb	Field	14.1±1.1	14.1±1.4	16.0±9.0
		Lab (Low)	9.3±1.3	12.2±2.4	12.0±7.6
		Lab (High)	40.4±1.4	45.8±9.2	43.9±13.2
5th International Intercomparison[g]					
115-5A	CaF_2:Mn Bulb	Field	31.4±1.8	30.0±6.0	30.2±14.6
		Lab at beginning	77.4±5.8	75.2±7.6	75.8±40.4
		Lab at end	96.6±5.8	88.4±8.8	90.7±31.2

Table A-2. (Continued)

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	mR: Average ±2σ[d] (all participants)
115-5B	LiF-100 Chips	Field	30.3±4.8	30.0±6.0	30.2±14.6
		Lab at beginning	81.1±7.4	75.2±7.6	75.8±40.4
		Lab at the end	85.4±11.7	88.4±8.8	90.7±31.2
7th International Intercomparison[h]					
115-7A	LiF-100 Chips	Field	75.4±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	80.0±3.5	79.9±4.0	77.9±27.6
		Lab (Cs-137)	66.6±2.5	75.0±3.8	73.0±22.2
115-7B	CaF_2:Mn Bulbs	Field	71.5±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	84.8±6.4	79.9±4.0	77.9±27.6
		Lab (Cs-137)	78.8±1.6	75.0±3.8	73.0±22.2
115-7C	$CaSO_4$:Dy Cards	Field	76.8±2.7	75.8±6.0	75.1±29.8
		Lab (Co-60)	82.5±3.7	79.9±4.0	77.9±27.6
		Lab (Cs-137	79.0±3.2	75.0±3.8	73.0±22.2

Table A-2. (Continued)

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	mR: Average ±2σ[d] (all participants)
8th International Intercomparison[i]					
115-8A	LiF-100 Chips	Field Site 1	29.5±1.4	29.7±1.5	28.9±12.4
		Field Site 2	11.3±0.8	10.4±0.5	10.1±9.06
		Lab (Cs-137)	13.7±0.9	17.2±0.9	16.2±6.8
115-8B	CaF_2:Mn Bulbs	Field Site 1	32.3±1.2	29.7±1.5	28.9±12.4
		Field Site 2	9.0±1.0	10.4±0.5	10.1±9.0
		Lab (Cs-137)	15.8±0.9	17.2±0.9	16.2±6.8
115-8C	$CaSO_4$:Dy Cards	Field Site 1	32.3±0.7	29.7±1.5	28.9±12.4
		Field Site 2	10.6±0.6	10.4±0.5	10.1±9.0
		Lab (Cs-137	18.1±0.8	17.2±0.9	16.2±6.8

[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] Fourth International Intercomparison of Environmental Dosimeters conducted in summer of 1979 by the School of Public Health of the University of Texas, Houston, Texas.
[g] 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.
[h] Seventh International Intercomparison of Environmental Dosimeters conducted in the spring and summer of 1984 at Las Vegas, Nevada, and sponsored by the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency.
[i] Eighth International Intercomparison of Environmental Dosimeters conducted in the fall and winter of 1985-1986 at New York, New York, and sponsored by the U.S. Department of Energy.

Table A-3. In-house spiked samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l		
				TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
QC-MI-6	Milk	Feb. 1986	Sr-89	6.0±1.9	6.4±3.0	8.7
			Sr-90	14.2±1.7	12.9±2.0	5.2
			I-131	34.2±3.8	35.2±3.5	10.4
			Cs-134	32.0±1.8	27.3±5.0	8.7
			Cs-137	35.8±2.1	35.0±5.0	8.7
QC-W-14	Water	Mar. 1986	Sr-89	1.6±0.4	1.6±1.0	7.1
			Sr-90	2.4±0.2	2.4±2.0	4.2
QC-W-15	Water	Apr. 1986	I-131	44.9±2.4	41.5±7.0	10.6
			Co-60	10.6±1.7	12.1±5.0	7.1[b]
			Cs-134	30.2±2.4	25.8±8.0	7.1[b]
			Cs-137	21.9±1.9	19.9±5.0	7.1[b]
QC-MI-7	Milk	Apr. 1986	I-131	39.7±3.3	41.5±7.0	10.4
			Cs-134	28.7±2.8	25.8±8.0	8.7
			Cs-137	21.2±2.8	19.9±5.0	8.7
SPW-1	Water	May 1986	Gross alpha	15.8±1.8	18.0±5.0	5[c]
QC-W-16	Water	June 1986	Gross alpha	16.2±0.7	16.9±2.5	8.7
			Gross beta	38.4±3.5	30.2±5.0	8.7
QC-MI-9	Milk	June 1986	Sr-89	<1.0	0.0	7.1[b]
			Sr-90	12.6±1.8	13.3±3.0	4.2[b]
			I-131	38.9±7.0	34.8±7.0	10.4
			Cs-134	33.0±3.4	36.1±5.0	8.7
			Cs-137	38.5±2.8	39.0±5.0	8.7
SPW-2	Water	June 1986	Gross alpha	16.8±1.8	18.0±5.0	5[c]
SPW-3	Water	June 1986	Gross alpha	17.7±0.8	18.0±5.0	5[c]
QC-W-18	Water	Sep. 1986	Cs-134	34.7±5.6	31.3±5.0	8.7
			Cs-137	51.1±7.0	43.3±8.0	8.7
QC-W-19	Water	Sep. 1986	Sr-89	13.6±4.1	15.6±3.5	7.1[b]
			Sr-90	6.4±1.6	6.2±2.0	4.2[b]

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
QC-W-21	Water	Oct. 1986	Co-60	19.2±2.2	18.5±3.0	8.7
			Cs-134	31.7±5.2	25.6±8.0	8.7
			Cs-137	23.8±1.0	21.6±5.0	8.7
QC-MI-11	Milk	Oct 1986	Sr-89	12.3±1.8	14.3±3.0	8.7
QC-W-20	Water	Nov. 1986	H-3	3855±180	3960±350	520[b]
QC-W-22	Water	Dec. 1986	Gross alpha	9.8±1.4	11.2±4.0	8.7
			Gross beta	21.7±2.0	23.8±5.0	8.7
QC-W-23	Water	Jan. 1987	I-131	29.8±2.5	27.9±3.0	10.4
QC-MI-12	Milk	Jan. 1987	I-131	36.5±1.3	32.6±5.0	10.4
			Cs-137	32.6±4.2	27.4±8.0	8.7
SPM-13	Milk	Jan 1987	Sr-89	10.4±2.1	12.2±4.0	8.7
			Sr-90	14.6±1.6	12.6±3.0	5.2
			I-131	49.5±1.2	54.9±8.0	10.4
			Cs-134	<1.6	0.0	8.7
			Cs-137	33.3±0.6	27.4±8.0	8.7
SPW-24	Water	Mar 1987	Sr-89	24.7±3.6	25.9±5.0	8.7
			Sr-90	23.9±3.8	22.8±8.0	5.2
SPW-25	Water	Apr 1987	I-131	28.0±1.9	29.3±5.0	10.6
SPM-14	Milk	Apr 1987	I-131	25.0±2.2	23.9±5.0	10.4
			Cs-134	<2.1	0.0	8.7
			Cs-137	34.2±2.0	27.2±7.0	8.7
SPW-26	Water	Jun 1987	H-3	3422±100	3362±300	520
			Co-60	24.8±1.4	26.5±7.0	8.7
			Cs-134	<2.0	0.0	8.7
			Cs-137	21.2±0.5	21.6±7.0	8.7
SPW-27	Water	Jun 1987	Gr. alpha	8.5±1.9	10.1±4.0	8.7
			Gr. beta	22.6±1.9	21.2±5.0	8.7
SPW-28	Water	Jun 1987	Gr. alpha	8.7±1.3	10.1±4.0	8.7
			Gr. beta	12.2±5.2	9.4±3.0	8.7

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
SPW-29	Water	Jun 1987	Gr. alpha	16.4±1.3	18.9±5.0	8.7
			Gr. beta	15.9±4.0	11.8±4.0	8.7
SPM-15	Milk	Jul 1987	Sr-89	19.4±1.6	18.8±3.5	5.2
			I-131	43.5±0.7	45.3±7.0	10.4
			Cs-134	17.9±2.2	16.0±5.3	8.7
			Cs-137	25.4±1.8	22.7±5.0	8.7
SPW-30	Water	Sep 1987	Sr-89	17.5±3.0	14.3±5.0	8.7
			Sr-90	18.4±2.2	17.5±2.2	5.2
SPW-31	Water	Oct 1987	H-3	2053±93	2059±306	520

[a] n=3 unless noted otherwise.
[b] n=2.
[c] n=1.

Table A-4. In-house "blank" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l Results (4.66σ)	Concentration in pCi/l Acceptance Criteria (4.66σ)
BL-1	D.I. Water	Nov. 1985	Gross alpha	<0.1	<1
			Gross beta	<0.4	<4
BL-2	D.I. Water	Nov. 1985	Cs-137 (gamma)	<1.9	<10
BL-3	D.I. Water	Nov. 1985	Sr-89	<0.5	<5
			Sr-90	<0.6	<1
BL-5	D.I. Water	Nov. 1985	Ra-226	<0.4	<1
			Ra-228	<0.4	<1
SPW-2265	D.I. Water	Apr. 1985	Gross alpha	<0.6	<1
			Gross beta	<2.2	<4
			Sr-89	<0.2	<5
			Sr-90	<0.4	<1
			I-131	<0.2	<1
			Cs-137 (gamma)	<7.4	<10
BL-6	D.I. Water	Apr. 1986	Gross alpha	<0.4	<1
BL-7	D.I. Water	Apr. 1986	Gross alpha	<0.4	<1
BL-8	D.I. Water	June 1986	Gross alpha	<0.4	<1
BL-9	D.I. Water	June 1986	Gross alpha	<0.3	<1
SPW-3185	D.I. Water	Jan 1987	Ra-226	<0.1	<1
			Ra-228	<0.9	<1
SPS-3292	Milk	Jan 1987	I-131	<0.1	<1
			Cs-134	<6.2	<10
			Cs-137	<6.4	<10
SPW-3554	D.I. Water	Feb 1987	H-3	<180	<300
			Gross beta	<2.6	<4
SPS-3555	Milk	Feb 1987	Sr-89	<0.6	<5
			Sr-90	1.9±0.4[a]	<1
SPS-3731	Milk	Mar 1987	Cs-134	<2.2	<10
			Cs-137	<2.5	<10

[a] Low level (1 - 4 pCi/l) of Sr-90 concentration in milk is not unusual.

Table A-4. In-house "blank" samples (continued).

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l Results (4.66σ)	Concentration in pCi/l Acceptance Criteria (4.66σ)
SPS-3732	D.I. Water	Mar 1987	Sr-89	<0.9	<5
			Sr-90	<0.8	<1
			I-131	<0.3	<1
			Co-60	<2.3	<10
			Cs-134(G)	<2.2	<10
			Cs-137(G)	<2.4	<10
			Ra-226	<0.7	<1
			Ra-228	<1.0	<1
			Np-237	<0.04	<1
			Th-230	<0.05	<0.1
			Th-232	<0.02	<0.1
			U-234	<0.05	<0.1
			U-235	<0.03	<0.1
			U-238	<0.03	<0.1
SPS-4023	Milk	May 1987	I-131	<0.1	<1
SPS-4203	D.I. Water	May 1987	Gross alpha	<0.7	<1
			Gross beta	<1.7	<4
SPS-4204	Milk	May 1987	Sr-89	<0.5	<5
			Sr-90	2.4±0.6[a]	<1
SPS-4390	Milk	Jun 1987	Cs-134	<4.7	<10
			Cs-137	<5.2	<10
SPS-4391	D.I. Water	Jun 1987	Sr-89	<0.4	<5
			Sr-90	<0.4	<1
			I-121	<0.1	<1
			Co-60	<3.8	<10
			Cs-137	<5.7	<10
			Ra-226	<0.1	<1
			Ra-228	<0.9	<1
SPW-4627	D.I. Water	Aug 1987	Gross alpha	<0.6	<1
			Gross beta	<1.4	<4
			Tritium	<150	
SPS-4628	Milk	Aug 1987	Sr-89	<0.6	<5
			Sr-90	2.4±0.6	<1
SPS-4847	Milk	Sep 1987	Cs-134	<4.4	<10
			Cs-137	<5.3	<10

[a] Low level (1 - 4 pCi/l) of Sr-90 concentration in milk is not unusual.

Table A-4. In-house "blank" samples (continued).

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l Results (4.66 σ)	Acceptance Criteria (4.66 σ)
SPS-4848	D.I. Water	Sep 1987	I-131	<0.2	<1
SPW-4849	D.I. Water	Sep 1987	Co-60	<4.1	<10
			Cs-134	<4.8	<10
			Cs-137	<4.0	<10
			Sr-89	<0.7	<5
			Sr-90	<0.7	<1
SPW-4850	D.I. Water	Sep 1987	Th-228	<0.04	<1
			Th-232	<0.8	<1
			U-234	<0.03	<1
			U-235	<0.03	<1
			U-238	<0.02	<1
			Am-241	<0.06	<1
			Cm-242	<0.04	<1
			Ra-226	<0.1	<1
			Ra-228	<1.0	<2
SPW-4859	D.I. Water	Oct 1987	Fe-55	<0.5	<1
SPS-5348	Milk	Dec 1987	Cs-134	<2.3	<10
			Cs-137	<2.5	<10
SPW-5384	Water	Dec 1987	Co-60	<2.8	<10
			Cs-134	<2.6	<10
			Cs-137	<2.8	<10
			I-131	<0.2	<1
			Ra-226	<0.1	<1
			Ra-228	<1.2	<2
			Sr-89	<0.5	<1
			Sr-90	<0.4	<1
SPW-5385	Water	Nov 1987	Gr. alpha	<0.4	<1
			Gr. beta	<2.2	<4
			Fe-55	<0.3	<1
SPS-5386	Milk	Jan 1988	I-131	<0.1	<1
SPW-5448	"Dead" Water	Jan 1988	H-3	<177	<300

ATTACHMENT B

ACCEPTANCE CRITERIA FOR "SPIKED" SAMPLES

LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES[a]

Analysis	Level	One Standard Deviation for Single Determination
Gamma Emitters	5 to 100 pCi/liter or kg >100 pCi/liter or kg	5 pCi/liter 5% of known value
Strontium-89[b]	5 to 50 pCi/liter or kg >50 pCi/liter or kg	5 pCi/liter 10% of known value
Strontium-90[b]	2 to 30 pCi/liter or kg >30 pCi/liter of kg	3.0 pCi/liter 10% of known value
Potassium	>0.1 g/liter or kg	5% of known value
Gross Alpha	<20 pCi/liter >20 pCi/liter	5 pCi/liter 25% of known value
Gross Beta	<100 pCi/liter >100 pCi/liter	5 pCi/liter 5% of known value
Tritium	<4,000 pCi/liter >4,000 pCi/liter	1s = (pCi/liter) = 169.85 x (known).0933 10% of known value
Radium-226, Radium-228	<0.1 pCi/liter	15% of known value
Plutonium	0.1 pCi/liter, gram, or sample	10% of known value
Iodine-131, Iodine-129[b]	<55 pCi/liter >55 pCi/liter	6 pCi/liter 10% of known value
Uranium-238, Nickel-63[b], Technetium-99[b]	<35 pCi/liter >35 pCi/liter	6 pCi/liter 15% of known value
Iron-55[b]	50 to 100 pCi/liter	10 pCi/liter 10% of known value

[a] From EPA publication, "Environmental Radioactivity Laboratory Intercomparison Studies Program, Fiscal Year 1981-1982, EPA-600/4-81-004.
[b] TIML limit.

Appendix B

Data Reporting Conventions

Data Reporting Conventions

1.0. All activities, except gross alpha and gross beta, are decay corrected to collection time or the end of the collection period.

2.0. Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where x = value of the measurement;

$s = 2\sigma$ 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 4.66σ 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 $x \geq L$;
$<L$ 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 deviation(s) 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.