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Radiation Environmental Monitoring Program
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PREFACE

The staff members of the Nuclear Sciences Department of Hazleton Environmental Sciences, a Division of Hazleton Laboratories America, Inc. (HES), were responsible for the acquisition of data presented in this report. The staff includes L. Kuckla, N. Lamich, D. Rieter, J. Woods, and S. Yamagata. Environmental samples were collected by personnel of Northern States Power Company.

The report was prepared by L. G. Huebner, Director, Nuclear Sciences. He was assisted in the report preparation by C. A. Galioto, Group Leader, and C. R. Marucut, Section Supervisor, Nuclear Sciences.

TABLE OF CONTENTS

LIST OF TABLES

In addition, the following tables are in the Appendix:

Appendix A

Appendix C

1.0 INTRODUCTION

This report summarizes and inteprets results of the Radiation Environmental Monitoring Program (REMP) conducted by Hazleton Environmental Sciences at the Prairie Island Nuclear Generating Plant, Red Wing, Minnesota, during the period January - December, 1980. 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.

Tabluation of the individual analyses made during the year are not included in this report. These data are included in a reference document (Hazleton Environmental Sciences 1981) available at Northern States Power Company, Nuclear Support Services 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 1980 are summarized and discussed.

No effect on the environment due to the operation of the Prairie Island Plant is indicated. There was, however, a slight effect of the fallout from the atmospheric nuclear detonation on 16 October 1980 of a device in the 200 kiloton to 1 megaton range which resulted in an elevated gross beta activity in airborne particulates during the last quarter of 1980 and the presence of a small amount of iodine-131 in two milk samples collected 19 November 1980. The presence of the long-lived fission products, strontium-90 and cesium-137, in several sampling media indicated a long range fallout effect from previous atmospheric nuclear detonations.

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 (TLD's).

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.

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 raidation 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, strontium-89, strontium-90, 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, 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 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 (Hazleton Environmental Sciences Corporation, 1978c).

To monitor the air environment, airborne particulates are collected on membrane filters by continuous pumping at four locations. Also, airborne iodine is collected by continuous pumping through charcoal filters at three 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 a Ge(Li) detector. Two of the four locations are indicators, and two are controls (P-1 and P-2). One of the indicators (P-3) is located near the residence expected to be most susceptible to any atmospheric emissions from the Plant (highest X/Q residence).

Ambient gamma radiation is monitored at the same four air sampling locations using CaF_2:Mn thermoluminescent dosimeters (TLD's). The sensors are placed in pairs at each location and are collected and measured quarterly.

In addition, as a "Lessons Learned" commitment, ambient gamma radiation is monitored at thirty-two (32) special locations, using three (3) LiF_2 chips mounted in the card: ten (10) in an inner ring in the general area of the site boundary, fifteen (15) 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 TLD's for all locations, including four air sampling locations, is kept in the shield at the Plant. The emergency set is returned to the HES laboratory quarterly for annealing and repackaging.

Milk samples are collected monthly from five farms (four indicator and one control). All samples are analyzed for iodine-131. In addition, samples from the control location (P-25, Kinneman Farm) and the highest X/Q location (P-14, Gustafson Farm) are analyzed for strontium-89, strontium-90, and for gamma-emitting isotopes.

For additional monitoring of the terrestrial environment, natural vegetation (such as grass) is collected semi-annually from three locations (including the highest X/Q milk location P-14 and the milk control location P-25). Samples are analyzed for gamma-emitting isotopes including iodine-131. Cabbage is collected annually from a garden nearest the Plant and a control location (P-25) and analyzed for iodine-131. Corn is collected annually from the highest X/Q farm (P-14) and a control location (P-25) and analyzed for gamma-emitting isotopes. Also, well water is collected quarterly and analyzed for tritium and gamma-emitting isotopes. Finally, topsoil is collected every three years and analyzed for strontium-90 and gamma-emitting isotopes. The latest collection of soil was made in 1979.

River water is collected weekly at two locations, one upstream of the Plant (P-5) and one downstream (P-6, Lock and Dam #3). Monthly composites are analyzed for gamma-emitting isotopes. Quarterly composites are analyzed for tritium, strontium-89, and strontium-90.

Drinking water is collected weekly from the City of Red Wing well. Monthly composites are analyzed for gross beta activity 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 macroinvertebrates, aquatic vegetation, and bottom sediments. Shoreline sedment is collected semi-annually.

3.3 Program Execution

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

(1) TLD data was not available for the third quarter of 1980 for location P-1 because of theft of the dosimeters.

(2) Airborne particulate gross beta data from location P-2 for the period 1-21 to 1-29-80 was not available due to pump malfunction.

These deviations from the Program are summarized in Table 5.3.

3.4 Laboratory Procedures

All strontium-89, strontium-90, and iodine-131 analyses in milk 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 a Ge(Li) detector. Levels of iodine-131 in cabbage and natural vegetation were determined by Ge(Li) spectrometry. Levels of airborne iodine-131 in charcoal samples were measured by Ge(Li) spectrometry.

Tritium levels were determined by liquid scintillation technique.

Analytical procedures used by the Nuclear Sciences Department of Hazleton Environmental Sciences are specified in detail elsewhere (NALCO Environmental sciences, 1977a). 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).

Hazleton Environmental Sciences has a comprehensive quality control/quality assurance program designed to assure the reliability of data obtained. Details of Hazleton's QA Program are presented elsewhere (NALCO Environmental Sciences 1971a, 1971b, 1975, and Hazleton Environmental Sciences, 1980). The HES QA Program includes participation in laboratory intercomparison (crosscheck) programs. Results obtained in crosscheck programs are presented in Appendix A.

3.5 Program Modifications

Beginning 1 January 1980, thirty-two (32) new TLD locations were added to the program as a "Lessons Learned" commitment. Ten (10) of these locations were selected in an inner ring in the general area of the site boundary, fifteen (15) in the outer ring within 4-5 mi radius of the plant, six (6) at special areas of interest, and one (1) at a control location, 11.1 mi distant from the plant. Three LiF_2 chips mounted in the card were placed at each location and were exchanged and read quarterly.

In addition, a complete set of TLD cards for all locations, including four air sampling locations are kept in the shield at the plant for emergency purposes. The cards are returned to the HES laboratory quarterly for annealing and repackaging.

Several additional sample collections which are not a part of the program were performed in 1980. Nine goat's milk samples were collected from mid June through the second part of November 1980 from three farms and analyzed for iodine-131. Also, one collection of clams was performed in September in the vicinity of the site.

3.6 Census of Milch Animals

In accordance with Technical Specification 4.10, paragraph B, several surveys of milch animals were conducted in the area of the Plant during 1980. On 6 June 1980 an extensive survey was conducted within a one mile radius of the Plant (or 15 mrem/year distance). Most cattle observed were used for beef rather than milk production. No new milk producing herds were found.

On 18 June 1980 a census for milk cows within a five mile radius was completed. With the assistance of the Agricultural Agent of Goodhue and Pierce Counties, it was determined that several milk herds in Wisconsin had discontinued operations. Current raw milk sampling locations were not affected. No new herds were identified.

On 18 June and 25 June 1980 a census of goat herds within a 15 mile radius of the Plant was completed. After visits with three county agricultural agents, a county 4-H Agent, and several members of the Wisconsin Dairy Goat Association, it was determined that there were no reliable suppliers of goat milk in the area. Most herds in the area are kept as hobbies or as part of youth education programs conducted by 4-H organizations. Although goat milk sampling is not a part of the routine program, certain goat milk samples, when available, were collected and analyzed.

On 27 August and 2 September 1980, the mid-season census of milch producing animals was completed. No new herds were identified. None of the surveys resulted in changes of milk sampling locations.

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 The Effect of Chinese Atmospheric Nuclear Detonation

One atmospheric nuclear detonation was reported during 1980. The 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. Gross beta results for air particulates indicate that the effect of the fallout in the central United States was not noticeable until two weeks after the test. During the previous Chinese tests in 1977 and 1978, the effect was noticed about one week after the test. This delay is probably attributable to dry weather following the test postponing the rainout of radioactive particles until second or subsequent passes of the radioactive cloud over the United States. Presence of low level of iodine-131 in only two milk samples and only moderate increase of beta activity in airborne particulates supports this assumption.

The usual spring peak, a phenomenon that is observed worldwide almost annually (Wilson et al., 1969) was not evident in 1980 (1976 and 1979 were also an exception). These spring peaks have been attributed to fallout of nuclides from the stratosphere (Gold et al., 1964).

4.2 Program Findings

A number of program findings reflect effects of the latest Chinese and previous worldwide atmospheric nuclear tests. The chief environmental indicators of test effects were airborne particulates and, to a lesser degree, milk.

Ambient Radiation (TLD's)

At four regular air sampling locations, indicator TLD's averaged 13.3 mrem/91 days and control TLD's averaged 15.9 mrem/91 days. The doses measured by control TLD's were about 20% higher than indicator TLD's. Higher readings at control locations are due to higher readings at location P-2, which historically yielded about 40% higher readings than the second control

location, P-1. The means at special locations were similar to those measured at regular air sampling locations and ranged from 11.2 mrem/91 days at inner ring locations to 13.5 mrem/91 days at outer ring locations. The differences are not statistically significant. The dose rates measured were similar to those observed in 1978 (12.1 and 15.1 mrem/91 days, respectively and in 1979 (12.6 and 15.3 mrem/91 days, respectively). No Plant effect on ambient gamma radiation was indicated.

Air Particulates

The average annual gross beta activity in airborne particulates was 0.032 pCi/m^3 at indicator locations and 0.033 pCi/m^3 at control locations and was 60% lower than in 1978 (0.093 pCi/m^3) and about 15% lower than in 1979 (0.038 pCi/m^3). In the first quarter of 1980 weekly gross beta activity averaged 0.032 pCi/m^3, then leveled off at about 0.023 pCi/m^3 during the second and third quarters and rose to about 0.053 pCi/m^3 during the fourth quarter.

Increase of the gross beta activity during the fourth quarter is attributable to the fallout form the nuclear test conducted 16 October 1980.

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 Monticello Generating Plant, some 100 miles distant from the Prairie Island Generating Plant (Northern States Power Company, 1981).

Trace amounts of niobium-95, ruthenium-103, and cerium-141 were detected in November and December composite samples. Presence of these isotopes in airborne particulates is also attributable to the fallout from the recent nuclear test. Except for beryllium-7, all other gamma-emitting isotopes were below their respectiv 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 was no indication of a Plant effect.

Milk

All results for iodine-131, except two cow's milk samples, were below the LLD of 0.25 pCi/l, including five goat's milk samples. The mea-

sured activity, 0.4 pCi/l and 5.4 pCi/l was detected in samples collected 19 November 1980, approximately four weeks after the nuclear test. Since detected activity was observed at both control (0.4 pCi/l) and indicator (5.4 pCi/l) locations, and since a similar pattern was observed a week earlier at the Monticello Nuclear Generating Plant 100 miles distant from Prairie Island , it is clearly attributable to the latest Chinese nuclear test.

Strontium-90 results averaged slightly higher at the control location (P-25, Kinneman Farm), and all detectable results were in the range 1.9-4.9 pCi/l, a range consistent with 1976, 1977, 1978, and 1979 observations at Prairie Island. Strontium-90 levels in this range are attributable to worldwide fallout from previous atmospheric nuclear tests and reflect the long half-life (28.6 yrs) of this isotope.

Cesium-137 results were below the LLD level of 15 pCi/l in all samples. Cesium-137 is also a long-lived component (with a half-life of 30.24 years) of worldwide fallout and is found in the environment in trace quantities. Finally, all strontium-89 results in 1980 were <3.8 pCi/l, in agreement with 1976, 1977, 1978, and 1979 measurements.

No significant changes were seen in strontium-90 levels in milk and were similar to those observed in 1979. This absence of an effect is consistent with the low initial production of these isotopes in nuclear explosions (Eisenbud, 1963). Also 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 1980 show no radiological effects of the Plant operation, but the presence of strontium-90 in milk samples does exhibit a long range residual effect of previous atmospheric nuclear tests. Also, presence of iodine-131 in two milk samples exhibits short range effect of the recent nuclear test conducted 16 October 1980.

Drinking Water

In drinking water from the City of Red Wing well, no tritium was detected. Results ranged from <160 to <390 pCi/l. As with the other well water samples, all analyses for gamma-emitting isotopes yielded results below detection limits. Gross beta averaged 11.8 pCi/l and was similar to the level observed in 1979 (10.5 pCi/l).

River Water

At the upstream collection site, quarterly composite tritium levels ranged from <130 to <390 pCi/l and were similar to the range observed in 1979 (<150 to 340 pCi/l).

At the downstream site (Lock and Dam #3), quarterly composite tritium levels ranged from 130 to 300 pCi/l. The differences in levels between upstream and downstream samples were not significant.

Analyses of river water were also made for gamma-emitting isotopes, strontium-89, and strontium-90. All gamma-emitting isotopes and strontium -89 were below detection limits. Strontium-90 was detected in one downstream sample (1.3 pCi/l) and was barely above the LLD level of 1.1 pCi/l. There was no indication of a Plant effect.

Well Water

At the control well P-25, Kinneman Farm, tritium levels averaged 270 pCi/l, almost identical to the level observed in 1979 (260 pCi/l). For two of the indicator wells (P-8, Kinney Store, and P-10, Lock and Dam #3) no tritium was detected above LLD level of 280 pCi/l in any of the analyses. The results ranged from <120 to <280 pCi/l and were consistent with the results obtained in 1979. At the remaining indicator well (P-9, Plant Well #2), tritium was detected in three quarterly samples and ranged from <180 to 520 pCi/l, averaging 420 pCi/l, exactly the same as in 1979. This is about 150 pCi/l above the control level of 270 pCi/l.

The difference between the Plant well and the control well was not statistically significant since uncertainty in the measurement is about at the same magnitude as the difference. The highest tritium activity detected in the well (520 pCi/l) was about forty times lower than the annual average concentration allowed by the EPA National Interim Primary Drinking Water Regulation. (40 CFR 141) and was 0.005% of maximum permissible concentration for tritium above background level in unrestricted areas (3,000,000 pCi/l). Gamma-emitting isotopes were in all cases below detection limits.

An investigation was begun in May 1978 to determine ground water flow patterns in the affected area. This investigation showed a general slope from the Mississippi River to the Vermillion River past the immediate area of Plant Well #2. This would indicate that surface water recharge from the Mississippi River may be intercepted by Well #2. Several plant water system sampling locations have been established in order to monitor possible migration of activity to Well #2. So far this investigative effort is inconclusive.

Tritium is released by the Plant to the river; however, tritium is also produced by nuclear weapon tests and by cosmic radiation and brought to the ground by precipitation. At this point in time, it is not at all evident which source or sources may be contributing to the negligible elevated tritium levels in Well #2.

Crops

Cabbage samples were collected on 2 September 1980, and analyzed for iodine-131. Corn samples were also collected on 2 September 1980, and analyzed for gamma-emitting isotopes. All results, except for potassium -40, were below detection limits. There was no indication of a Plant effect.

Natural Vegetation

Natural vegetation was collected on 6 May and 2 September 1980. No iodine-131 was observed in either collection. Trace amount of cesium-137 was detected in one sample collected in September at the control location P-25. Also, one sample contained trace amounts of zirconium-95, reflecting the long range deposition effect from previous atmospheric nuclear tests. All other gamma-emitting isotopes, except beryllium-7, which is constantly produced in the upper atmosphere by cosmic rays, and naturally-occurring potassium-40 were below detection limits. Thus, no Plant effect is indicated.

Topsoil

Topsoil was not collected in 1980. In accordance with Technical Specifications, soil is collected every three years. The last collection was made in 1979.

Fish

Fish samples were collected in May, June, and September 1980. There was no significant difference between upstream and downstream results. There was no indication of a Plant effect.

Aquatic Insects and Periphyton

Aquatic insects (macroinvertebrates) and periphyton were collected on 3 June and 9 September 1980. The samples were analyzed for strontium-89, strontium-90 and gamma-emitting isotopes. Strontium-89 and all gamma -emitting isotopes were below limits of detection. Mean strontium-90 level was at the LLD level in upstream samples (0.03 pCi/g wet weight) and 0.06 pCi/g wet weight in downstream sample. The difference between

the downstream and upstream samples was not statistically significant since uncertainty in the measurement is about at the same magnitude as the difference. No Plant effect was indicated.

Aquatic Vegetation

Aquatic vegetation was collected on 30 June and 9 September 1980 and analyzed for gamma-emitting isotopes. All results, except for potassium -40, were below detection limits. No Plant effect was indicated.

Bottom and Shoreline Sediments

Sediment collections were made on 3 June and 9 September 1980. The samples were analyzed for strontium-90 and gamma-emitting isotopes. Strontium-90 was detected in one control sample (0.034 pCi/g dry weight) and in two indicator samples (0.013 pCi/g dry weight). Cesium-137 was detected in one control sample and one indicator sample. Distribution and ratios for cesium-137 were similar to those for strontium -90. The only other gamma-emitting isotope detected was naturally-occuring potassium -40. No Plant effect was indicated.

Clams

A Special collection of clams was made 15 September 1980 in the vicinity of the site. The sample was analyzed for gross beta and gamma-emitting isotopes. Gross beta measured 1.45 pCi/g wet weight. All gamma-emitting isotopes were below detection limits. No Plant effect was indicated.

5.0 TABLES

Table 5.1 Sample collection and analysis program, 1980. Prairie Island

Medium	Locations No.	Locations Codes (and Type)[a]	Collection Type and Frequency[b]	Analysis Type (and Frequency)[c]
Ambient Radiation (TLD's)	7	P-1(C), P-2(C), P-3, P-4	C/Q	Ambient gamma
	37	P-01A - P10A P-01B - P-15B P-01S - P-06S P-01(C)	C/Q	Ambient gamma
Airborne particulates	7	P-1(C), P-2(C), P-3, P-4	C/W	GB, GS (MC of all locations)
Airborne iodine	3	P-1(C), P-3, P-4	C/W	I-131
Milk	3	P-16 to P-18	G/M	I-131
	2	P-25(C), P-14	G/M	I-131, Sr-89, Sr-90, GS
River water	2	P-5(C), P-6	G/W	GS(MC), H-3(QC) Sr-89 (QC) Sr-90 (QC)
Drinking Water	1	P-11	G/W	GB, GS(MC), H-3 (QC)
Well water	4	P-25(C), P-8 to P-10	G/Q	H-3, GS
Edible cultivated crops - green leafy vegetables	2	P-25(C), P-24	G/A	I-131

Table 5.1 (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-14	G/A	GS
Natural Vegetation	3	P-25(C), P-14, P-15	G/SA	I-131, GS
Fish (two species, edible portion)	2	P-5(C), P-6	G/SA	GS
Periphyton or Macroinvertebrates	2	P-5(C), P-6	G/SA	Sr-89, Sr-90 GS
Aquatic Vegetation	2	P-5(C), P-6	G/SA	GS
Bottom Sediment	2	P-5(C), P-6	G/SA	GS, Sr-90
Shoreline Sediment	1	P-12	G/SA	GS, Sr-90
Topsoil[d]	9	P-1(C), P-2(C) P-3, P-4, P-19 to P-23	G/ETY	GS, Sr-90

[a] Location codes are defined in Table D-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, ETY = every three years.

[c] Analysis type is coded as follows: GB = gross beta, GS = gamma spectroscopy, H-3 = tritium, Sr-89 = strontium-89, Sr-90 = strontium-90, I-131 = iodine-131. Analysis frequency is coded as follows: MC = monthly composite, QC = quarterly composite.

[d] Collected in 1979. Next scheduled collection is in 1982.

Table 5.2 Sampling locations. Prairie Island

Code	Type[a]	Name	Location
P-1	C	Station P-1 (Control-Air)	16.5 mi @ 348°/NNW
P-2	C	Station P-2 (Control-Air)	10.9 mi @ 47°/NE
P-3		Station P-3 (X/Q res, Comm-Air)	0.8 mi @ 313°/NW
P-4		Station P-4 (X/Q-Air)	1.6 mi @ 129°/SE
P-5		Upstream of Plant (1000')	0.6 mi @ 60°/ENE
P-6		Lock & Dam #3	1.6 mi @ 129°/SE
P-7[b]	C	Most Farm Well	11.4 mi @ 320°/NW
P-8		Kinney Store	2.0 mi @ 280°/W
P-9		Plant Well #2 (on-site)	0.3 mi @ 306°/NW
P-10		Lock & Dam #3 Well	1.6 mi @ 129°/SE
P-11		City of Red Wing (Drinking Water)	7.1 mi @ 135°/SE
P-12		Recreational Area	3.4 mi @ 116°/ESE
P-13[b]	C	Most Farm (Prescott)	11.4 mi @ 320°/NW
P-14		Gustafson Farm (X/Q-milk)	2.2 mi @ 168°/SSE
P-15		Downwind Field	0.6 mi @ 162°/SSE
P-16		A. Dosdahl Farm	2.5 mi @ 39°/NE
P-17		Place Farm	3.5 mi @ 25°/NNE
P-18		Birk Farm	3.5 mi @ 181°/S
P-19		Commissary Point Park	1.0 mi @ 156°/SSE
P-20		Meteorology Station	0.4 mi @ 296°/WNW
P-21		Sturgeon Lake Access	0.4 mi @ 344°/NNW
P-22		Former TLD #14 Location	0.5 mi @ 230°/SW
P-23		Former TLD #15 Location	0.5 mi @ 184°/S
P-24		H. Larson Residence (Nearest Garden)	1.6 mi @ 287°/WNW
P-25[c]	C	Kinneman Farm (Control-Milk, etc)	11.1 mi @ 331°/NNW
P-26[c]		Augustine Farm	5.7 mi @ 24°/NNE
P-27[c]		Murphy Farm	2.8 mi @ 42°/NE
P-01A		Property Line	North Sector. Sampler is on the side of the fence adjacent to corp of Engineers public access parking area and facing the plant.
P-02A		Property Line	NNE Sector. Sampler at a corner of the property line fence near the biology station.
P-03A		Property Line	South Sector. Sampler is adjacent the SE end of a guard rail along the road near a river pole.

Table 5.2 (continued) Prairie Island

Code	Type[a]	Name	Location
P-04A		Property Line	SSW Sector. Sampler is adjacent ot the NW end of a guard rail along the roadway next to a small access road.
P-05A		Property Line	SW Sector. Sampler is inside the fence area adjacent to a transmission tower.
P-06A		Property Line	WSW Sector. Sampler is inside the fenced area adjacent to a telephone junction box and south of an underground cable warning sign.
P-07A		Property Line	West Sector. Sampler is inside the fenced area about 75 feet North of the railroad entrance gate adjacent to a fence sign.
P-08A		Property Line	WNW Sector. Sampler is adjacent to the last power polw that serves the Meteorological station along the property line.
P-09A			NW Sector. Sampler is in north west corner of the property fenced area, just inside the fence and facing the plant.
P-10A		Property Line	NNW Sector. Sampler is inside the fence west of the north entrance gate facing the plant adjacent to a transmission tower.
P-01B		Thomas Killian Residence	North Sector. Sampler is adjacent to a power pole north of the driveway.
P-02B		Ray Kinneman Farm	NNE Sector. Sampler is south of the driveway adjacent to a telephone junction box.

Table 5.2 (continued) Prairie Island

Code	Type[a]	Name	Location
P-03B		Wayne Anderson Farm	NE Sector. Sampler is in the front yard adjacent to a power pole facing toward the plant.
P-04B		Nelson Drive (Road)	ENE Sector. Sampler is adjacent to a power pole and a telephone junction box, about 15 feet south of the road.
P-05B		Country Road E near Goodwin Coulee Road	East Sector. Sampler is north of Country Road E and about 300 ft. NW of the Goodwin Coulee Road (near a power pole that has a "Danger High Voltage" sign on it and about 25 ft. NW of the Richard Enberg mail box).
P-06B		William Hauschildt Residence	ESE Sector. Sampler is between a power pole and telephone junction box on the east side of the driveway.
P-07B		Red Wing Service Center	SE Sector. (North Highway 61 on Tyler Road) Sampler is adjacent to a corner transmission pole and the Railroad right-of-way close to a chain link fence.
P-08B		David Wnuk Residence	SSE Sector. Sampler is on the west edge of property adjacent to a telephone box. Pole is opposite a new bridge on the east side of Highway 19.
P-09B		Highway 19, South of 61	South Sector. Sampler is adjacent to a pole supporting a telephone junction box and opposite a new bridge on the east side of highway 19.

Table 5.2 (continued) Prairie Island

Code	Type[a]	Name	Location
P-10B		Cannodale Farm (Lesson Lane-James Byron)	SSW Sector. Sampler is adjacent to a corner fence post and near a "Speed Limit 30" road sign.
P-11B		Wallace Weberg Farm	SW Sector. (Farm is on top of the bluff). Sampler is adjacent to a power pole and the telephone junction box facing the plant (ease of driveway).
P-12B		Ray Gergen, Jr. Farm	WSW Sector. Sampler is north of driveway in the farmyard on the east end of a storage shed facing the plant.
P-13B		Thomas O'Rourke Farm	West Sector. Sampler is adjacent to a power pole and a telephone junction box outside a stock fence area.
P-14B		David J. Anderson Farm	NW Sector. Sampler is near the front year south of a red cedar tree (not located in the main road for protection).
P-15B		Holst Farm Station	NNW Sector. Sampler is east of residence near a corner post of a fenced area.
P-01S		Federal Lock & Dam #3	SE Sector. Sampler is north of the fenced air sampling station (#4) and facing the plant.
P-02S		Charles Suter Residence	SSE Sector. Sampler on the north side of a power pole in the farm yard and facing the plant.
P-03S		Carl Gustafson Farm	SSE Sector. Sampler is near the north side of the road in the last curve before the farmyard. (Close to the corner power pole and a fence post).

Table 5.2 (continued) Prairie Island

Code	Type[a]	Name	Location
P-04S		Near Richard Burt Residence	SW Sector Sampler is to a tree about 15 feet away from the curve in the road.
P-05S		Kenney Store - Trailer Park	West Sector. Sampler is at the north end of a redwood fence and adjacent to a telephone junction box.
P-06S		Earl Flynn Farm	WNW Sector. Sampler is on the east side of the house adjacent to a hyge stump and facing the plant.
P-01C		Robert Kinneman Farm	NNW Sector. Sampler is about 250 ft. east of the residence adjacent to a corner fence post and facing the plant.

[a]"C" denotes control location. All other locations are indicators.
[b]P-13 discontinued after March 1978.
[c]P-25 added in April 1978.
[d]P-26 and P-27 added in July 1978 (Goat's Milk).

Table 5.3 Missed collections and analyses, 1980; Prairie Island NGP
All required samples collected and analyzed except the following:

Sample	Analysis	Location	Coll. Date or Period	Comments
Thermoluminescent Dosimeters (TLD's)	Ambient gamma	P-1	3rd quarter 1980	TLD bulbs and cards were lost to thieves in the field.
Airborne particulate	Gross Beta	P-2	1-21 to 1-29-80	No sample due to pump malfunction.

Table 5.4 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 1980

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]	Mean(F) Range	Control Locations Mean(F) Range	Number of Non-routine Results[e]
TLD (mrem/91 days)	Gamma 15	1.0	13.3 (8/8) (11.3-15.3)	P-2 Station P-2 10.9 mi @ 47° NE	18.4 (4/4) (14.7-20.4)	15.9 (7/7) (11.9-20.4)	0
TLD (mrem/91 days) (Inner Ring, General Area at Site Boundary)	Gamma 40	3.0	11.2 (40/40) (5.8-14.0)	P-05A, Property Line, SW Sector	12.4 (4/4) (9.6-13.7)	(See control below)	0
TLD (mrem/91 days) (Outer ring, 4 -5 miles distant)	Gamma 60	3.0	13.5 (60/60) (8.0-18.5)	P-04B Nelson Drive Road, ENE Sector	14.9 (4/4) (10.4-18.4)	(See control below)	0
TLD (mrem/91 days) (Special Interest Areas)	Gamma 24	3.0	11.4 (24/24) (7.1-15.6)	P-03S, Carl Gustafson Farm, SSE Sector	13.0 (4/4) (8.6-15.6)	(See control below)	0
TLD (mrem/91 days) (control)	Gamma 4	3.0	None	P-01C-R. Kinneman Farm, NNW Sector	13.2 (4/4) (10.7-14.7)	13.2 (4/4) (10.7-14.7)	0
Airborne Particulates (pCi/m^3)	GB 155	0.001	0.032 (104/104) (0.009-0.158)	P-1, Station P-1 16.5 mi @ 348° NNW	0.034 (52/52) (0.012-0.113)	0.033 (103/103) (0.010-0.113)	0
				P-4, Station P-4 1.6 mi @ 129° SE	0.034 (52/52) (0.011-0.158)	None	0
	GS 12						
	Be-7	0.008	0.091 (12/12) (0.068-0.165)	NA[f]	-	None	0
	Mn-54	0.0026	<LLD	-	-	None	0
	Co-58	0.0028	<LLD	-	-	None	0
	Co-60	0.0023	<LLD	-	-	None	0
	Zn-65	0.0060	<LLD	-	-	None	0
	Nb-95	0.0019	0.0075 (2/12) (0.004-0.011)	NA	-	None	0

Table 5.4 (Continued)
Name of facility Prairie Island 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		
Airborne Particulates (pCi/m^3) (cont'd)	Zr-95		0.0100	<LLD	-	-	None	0
	Ru-103		0.057	0.006 (1/12) -	NA	-	None	0
	Ru-106		0.0248	<LLD	-	-	None	0
	Cs-134		0.0023	<LLD	-	-	None	0
	Cs-137		0.0020	<LLD	-	-	None	0
	Ba-140		0.0264	<LLD	-	-	None	0
	La-140		0.0056	<LLD	-	-	None	0
	Ce-141		0.0028	0.009 (2/12) (0.007-0.011)	NA	-	None	0
	Ce-144		0.0110	<LLD	-	-	None	0
Airborne Iodine (pCi/m^3)	I-131	156	0.07	<LLD	-	-	<LLD	0
Milk (pCi/l)	I-131	69	0.25	5.4 (1/57) -	P-16 Dosdahl Farm, 2.5 mi @ 39° NE	5.4 (1/57) -	0.4 (1/12) -	0
	Sr-89	24	3.8	<LLD	-	-	<LLD	0
	Sr-90	24	1.0	2.8 (12/12)	P-14 Gustafson Farm 2.2 mi @ 168° SSE	2.8 (12/12) (1.9-3.8)	3.6 (12/12) (2.2-4.9)	0
	GS	24						
	K-40		100	1310 (12/12) (1160-1470)	P-14 Gustafson Farm 2.2 mi @ 168°SSE	1310 (12/12) (1160-1470)	1260 (12/12) (1150-1430)	0
	Cs-134		15	<LLD	-	-	<LLD	0
	Cs-137		15	<LLD	-	-	<LLD	0
	Ba-140		15	<LLD	-	-	<LLD	0
	La-140		15	<LLD	-	-	<LLD	0
Drinking Water (pCi/l)	GB	12	1	11.8 (12/12) (8.6-16.6)	P-11 City of Red Wing 7.1 mi @ 135° SE	11.8 (12/12) (7.6-16.6)	None	0
	H-3	4	390	<LLD	-	-	None	0
	GS	12						

Table 5.4 (Continued)
Name of facility Prairie Island Nuclear Generating Plant

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean(F)[c] Range	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]
Drinking Water (pCi/l) (cont'd)	Mn-54	15	<LLD	-	-	None	0
	Co-58	15	<LLD	-	-	None	0
	Co-60	15	<LLD	-	-	None	0
	Zn-65	30	<LLD	-	-	None	0
	Nb-95	15	<LLD	-	-	None	0
	Zr-95	15	<LLD	-	-	None	0
	Cs-134	15	<LLD	-	-	None	0
	Cs-137	18	<LLD	-	-	None	0
	Ba-140	15	<LLD	-	-	None	0
	La-140	15	<LLD	-	-	None	0
	Ce-144	50	<LLD	-	-	None	0
River Water (pCi/l)	H-3 8	390	<LLD	-	-	<LLD	0
	Sr-89 8	1.8	<LLD	-	-	<LLD	0
	Sr-90 8	1.1	1.3 (1/4) -	P-6 Lock & Dam #3 1.6 mi @ 129° SE	1.3 (1/4) -	<LLD	0
	GS 24						
	Mn-54	15	<LLD	-	-	<LLD	0
	Co-58	15	<LLD	-	-	<LLD	0
	Co-60	15	<LLD	-	-	<LLD	0
	Zn-65	30	<LLD	-	-	<LLD	0
	Nb-95	25	<LLD	-	-	<LLD	0
	Zr-95	19	<LLD	-	-	<LLD	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	18	<LLD	-	-	<LLD	0
	Ba-140	15	<LLD	-	-	<LLD	0
	La-140	15	<LLD	-	-	<LLD	0
	Ce-144	90	<LLD	-		<LLD	0

Table 5.4 (Continued)
Name of facility Prairie Island 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		
Well Water (pCi/l)	H-3 16	280	420 (3/12) (350-520)	P-9 Plant Well #2 0.3 mi @ 306° NW	420 (4/12) (350-520)	370 (1/4) -	0
	GS						
	Mn-54	15	<LLD	-	-	<LLD	0
	Co-58	15	<LLD	-	-	<LLD	0
	Co-60	15	<LLD	-	-	<LLD	0
	Zn-65	30	<LLD	-	-	<LLD	0
	Nb-95	15	<LLD	-	-	<LLD	0
	Zr-95	26	<LLD	-	-	<LLD	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	18	<LLD	-	-	<LLD	0
	Ba-140	15	<LLD	-	-	<LLD	0
	La-140	15	<LLD	-	-	<LLD	0
	Ce-144	90	<LLD	-	-	<LLD	0
Crops-Cabbage (pCi/g wet)	I-131 3	0.016	<LLD	-	-	<LLD	0
Crops-Corn (pCi/g wet)	I-131 2	0.028	<LLD	-	-	<LLD	0
	GS 2						
	Be-7	0.16	<LLD	-	-	<LLD	0
	K-40	0.5	2.11 (1/1) -	P-25 Kinneman Farm 11.1 mi @ 331° NNW	2.2 (1/1) -	2.17 (1/1) -	0
	Mn-54	0.022	<LLD	-	-	<LLD	0
	Co-58	0.019	<LLD	-	-	<LLD	0
	Zn-65	0.036	<LLD	-	-	<LLD	0
	Nb-95	0.019	<LLD	-	-	<LLD	0
	Zr-95	0.043	<LLD	-	-	<LLD	0
	Ru-103	0.023	<LLD	-	-	<LLD	0
	Ru-106	0.15	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Prairie Island 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-Corn (pCi/g wet) (cont'd)	Cs-134	0.019	<LLD	-	-	<LLD	0
	Cs-137	0.017	<LLD	-	-	<LLD	0
	Ba-140	0.068	<LLD	-	-	<LLD	0
	La-140	0.019	<LLD	-	-	<LLD	0
	Ce-141	0.031	<LLD	-	-	<LLD	0
	Ce-144	0.16	<LLD	-	-	<LLD	0
Natural Vegetation (pCi/g wet)	I-131 6	0.031	<LLD	-	-	<LLD	0
	GS 6						
	Be-7	0.19	<LLD	P-25 Kinneman Farm 11.1 mi @ 331° NNW	4.6 (1/2) -	4.6 (1/2) -	0
	K-40	0.3	5.3 (4/4) (3.9-6.8)	P-25 Kinneman Farm 11.1 mi @ 331° NNW	6.3 (2/2) (5.6-7.0)	6.3 (2/2) (5.6-7.0)	0
	Mn-54	0.029	<LLD	-		<LLD	
	Co-58	0.019	<LLD	-	-	<LLD	0
	Co-60	0.031	<LLD	-	-	<LLD	0
	Zn-65	0.050	<LLD	-	-	<LLD	0
	Nb-95	0.025	<LLD	-	-	<LLD	0
	Zr-95	0.040	0.103 (1/4) -	P-15 Downwind Field 0.6 mi @ 162° SSE	0.103 (1/4) -	<LLD	0
	Ru-103	0.026	<LLD	-	-	<LLD	0
	Ru-106	0.19	<LLD	-	-	<LLD	0
	Cs-134	0.023	<LLD	-	-	<LLD	0
	Cs-137	0.033	<LLD	P-25 Kinneman Farm 11.1 mi @ 331° NNW	0.053 (1/2) -	0.053 (1/2) -	0
	Ba-140	0.099	<LLD	-	-	<LLD	0
	La-140	0.023	<LLD	-	-	<LLD	0
	Ce-141	0.043	<LLD	-	-	<LLD	0
	Ce-144	0.22	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Prairie Island Nuclear Generating Plant

Sample Type (Unit)	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]
Fish-Flesh (pCi/g wet)	GS 8						
	K-40	0.1	2.69 (8/8) (1.94-3.35)	P-6 Lock & Dam #3 1.6 mi @ 129° SE	2.69 (8/8) (1.94-3.35)	2.30 (8/8) (1.94-2.92)	0
	Mn-54	0.050	<LLD	-	-	<LLD	0
	Co-58	0.062	<LLD	-	-	<LLD	0
	Co-60	0.045	<LLD	-	-	<LLD	0
	Zn-65	0.13	<LLD	-	-	<LLD	0
	Nb-95	0.12	<LLD	-	-	<LLD	0
	Zr-95	0.13	<LLD	-	-	<LLD	0
	Cs-134	0.14	<LLD	-	-	<LLD	0
	Cs-137	0.036	0.048 (1/8) -	P-6 Lock & Dam #3 1.6 mi @ 129° SE	0.048 (1/8) -	<LLD	0
	Ba-140	0.12	<LLD	-	-	<LLD	0
	La-140	0.025	<LLD	-	-	<LLD	0
Periphyton (pCi/g wet)	Sr-89 4	0.079	<LLD	-	-	<LLD	0
	Sr-90 4	0.03	0.06 (2/2) (0.06-0.06)	P-6 Lock & Dam #3 1.6 mi @ 129° SE	0.06 (2/2) (0.06-0.06)	0.03 (2/2) (0.01-0.04)	0
	GS 4						
	Be-7	2.2	<LLD	-	-	<LLD	0
	K-40	2.9	<LLD	-	-	<LLD	0
	Mn-54	0.081	<LLD	-	-	<LLD	0
	Co-58	0.14	<LLD	-	-	<LLD	0
	Co-60	0.10	<LLD	-	-	<LLD	0
	Zn-65	0.30	<LLD	-	-	<LLD	0
	Nb-95	0.47	<LLD	-	-	<LLD	0
	Zr-95	0.22	<LLD	-	-	<LLD	0
	Ru-103	0.23	<LLD	-	-	<LLD	0
	Ru-106	1.04	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Prairie Island 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		
Periphyton (pCi/g wet) (cont'd)	Cs-134	0.11	<LLD	-	-	<LLD	0
	Cs-137	0.15	<LLD	-	-	<LLD	0
	Ba-140	0.33	<LLD	-	-	<LLD	0
	La-140	0.59	<LLD	-	-	<LLD	0
	Ce-141	0.45	<LLD	-	-	<LLD	0
	Ce-144	0.81	<LLD	-	-	<LLD	0
Aquatic Vegetation (pCi/g wet)	GS 4						
	Be-7	0.39	<LLD	-	-	<LLD	0
	K-40	0.64	1.88 (1/1) -	P-5 Upstream 1000' 0.6 mi @ 60° ENE	2.79 (2/2) (1.70-3.88)	2.79 (2/2) (1.70-3.88)	0
	Mn-54	0.042	<LLD	-	-	<LLD	0
	Co-58	0.034	<LLD	-	-	<LLD	0
	Co-60	0.045	<LLD	-	-	<LLD	0
	Zn-65	0.045	<LLD	-	-	<LLD	0
	Nb-95	0.053	<LLD	-	-	<LLD	0
	Zr-95	0.073	<LLD	-	-	<LLD	0
	Ru-103	0.039	<LLD	-	-	<LLD	0
	Ru-106	0.36	<LLD	-	-	<LLD	0
	Cs-134	0.045	<LLD	-	-	<LLD	0
	Cs-137	0.039	<LLD	-	-	<LLD	0
	Ba-140	0.11	<LLD	-	-	<LLD	0
	La-140	0.042	<LLD	-	-	<LLD	0
	Ce-141	0.056	<LLD	-	-	<LLD	0
	Ce-144	0.22	<LLD	-	-	<LLD	0

Table 5.4 (Continued)
Name of facility Prairie Island 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]
Bottom and Shoreline Sediments (pCi/g dry)	Sr-90 6	0.012	0.013 (2/4)	P-5, Upstream 1000' 0.6 mi @ 60° ENE	0.034 (1/2) -	0.034 (1/2) -	0
	GS 6						
	Be-7	0.45	<LLD	-	-	<LLD	0
	K-40	1.0	11.3 (4/4) (10.3-12.1)	P-5 Upstream 1000' 0.6 mi @ 60° ENE	13.3 (2/2) (11.3-15.3)	13.3 (2/2) (11.3-15.3)	0
	Mn-54	0.034	<LLD	-	-	<LLD	0
	Co-58	0.074	<LLD	-	-	<LLD	0
	Co-60	0.042	<LLD	-	-	<LLD	0
	Zn-65	0.067	<LLD	-	-	<LLD	0
	Nb-65	0.084	<LLD	-	-	<LLD	0
	Zr-95	0.15	<LLD	-	-	<LLD	0
	Ru-103	0.11	<LLD	-	-	<LLD	0
	Ru-106	0.39	<LLD	-	-	<LLD	0
	Cs-134	0.051	<LLD	-	-	<LLD	0
	Cs-137	0.036	0.062 (1/6) -	P-5 Upstream 1000' 0.6 mi @ 60°ENE	0.27 (1/6) -	0.27 (1/6) -	0
	Ba-140	0.098	<LLD	-	-	<LLD	0
	La-140	0.031	<LLD	-	-	<LLD	0
	Ce-141	0.16	<LLD	-	-	<LLD	0
	Ce-144	0.22	<LLD	-	-	<LLD	0
Clams (pCi/g wet) (Special Collection)	GB 1	0.5	1.45 (1/1) -	Site Area	1.45 (1/1) -	None	0
	1						
	K-40	0.43	<LLD	-	-	None	0
	Mn-54	0.020	<LLD	-	-	None	0
	Co-58	0.074	<LLD	-	-	None	0
	Co-60	0.015	<LLD	-	-	None	0

Table 5.4 (Continued)
Name of facility Prairie Island 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		
Clams (pCi/g wet) (Special Collection) (cont'd)	Zn-65	0.088	<LLD	-	-	<LLD	0
	Nb-95	0.070	<LLD	-	-	<LLD	0
	Zr-95	0.11	<LLD	-	-	<LLD	0
	Cs-134	0.025	<LLD	-	-	<LLD	0
	Cs-137	0.017	<LLD	-	-	<LLD	0
	Ba-140	0.045	<LLD	-	-	<LLD	0
	La-140	0.028	<LLD	-	-	<LLD	0

[a]GB = gross beta; BS = gamma scan.
[b]LLD = nominal lower limit of detection based on 3 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 ten times the preoperational value for the location.
[f]Monthly composites from all locations were gamma scanned together. Thus the location with the highest annual mean cannot be identified.

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Appendix A

Crosscheck Program Results

Appendix A

Crosscheck Program Results

The Nuclear Sciences Department of 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 privide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Participant laoratories 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 and water samples during the period 1975 through 1980. 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, and 1979 through participation in the Second, Third, and Fourth 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 Hazleton ES results for milk and water samples, 1975 through 1980[a].

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2 σ[c]	EPA Result ±3 σ, n=1
STM-40	Milk	Jan. 1975	Sr-89	<2	0±15
			Sr-90	73±2.5	75±11.4
			I-131	99±4.2	101±15.3
			Cs-137	76±0.0	75±15
			Ba-140	<3.7	0±15.0
			K(mg/l)	1470±5.6	1510±228
STW-45	Water	Apr. 1975	Cr-51	<14	0
			Co-60	421±6	425±63.9
			Zn-65	487±6	497±74.7
			Ru-106	505±16	497±74.7
			Cs-134	385±3	400±60.0
			Cs-137	468±3	450±67.5
STW-47	Water	Jun. 1975	H-3	1459±144	1499±1002
STW-48	Water	Jun. 1975	H-3	2404±34	2204±1044
STW-49	Water	Jun. 1975	Cr-51	<14	0
			Co-60	344±1	350±53
			Zn-65	330±5	327±49
			Ru-106	315±7	325±49
			Cs-134	291±1	304±46
			Cs-137	387±2	378±57
STW-53	Water	Aug. 1975	H-3	3317±64	3200±1083
STW-54	Water	Aut. 1975	Cr-51	223±11	225±38
			Co-60	305±1	307±46
			Zn-65	289±3	281±42
			Ru-106	346±5	279±57
			Cs-134	238±1	256±38
			Cs-137	292±2	307±46
STW-58	Water	Oct. 1975	H-3	1283±80	1203±988
STM-61	Milk	Nov. 1975	Sr-90	68.9±2.1	74.6±11.2
			I-131	64.6±3.8	75±15
			Cs-137	75.6±20	75±15
			Ba-140	<3.7	0
			K(Mg/l)	1435±57	1549±233

Table A-1. (continued)

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2σ [c]	EPA Result ±3σ , n=1[d]
STW-63	Water	Dec. 1975	H-3	1034±39	1002±972
STW-64	Water	Dec. 1975	Cr-51	<14	0
			Co-60	221±1	203±30.5
			Zn-65	215±6	201±30.2
			Ru-106	171±9	181±27.2
			Cs-134	198±2	202±30.3
			Cs-137	152±4	151±22.7
STW-68	Water	Feb. 1976	H-3	1124±31	1080±978
STW-78	Water	Jun. 1976	H-3	2500±44	2502±1056
STW-84	Water	Aug. 1976	H-3	3097±21	3100±1080
STM-86	Milk	Spe. 1975	Sr-89	29±2.0	45±15
			Sr-90	30±1.0	30±4.5
			I-131	100±8.6	120±18
			Ba-140	50±10.1	85±15
			Cs-137	17±1.5	20±15
			K(mg/l)	-	1540±231
STM-91	Milk	Nov. 1976	I-131	83±0.6	85±15
			Ba-140	<4	0
			Cs-137	12±1.7	11±15
			K(mg/l)	1443±31	1510±228
STW-93	Water	Dec. 1976	Cr-51	105±15	104±15
			Co-60	<4	0
			Zn-65	97±4	102±15
			Ru-106	87±3	99±15
			Cs-134	85±4	93±15
			Cs-137	103±4	101±15
STW-94	Water	Dec. 1976	H-3	2537±15	2300±1049
STM-97	Milk	Mar. 1977	I-131	55±2.5	51±15
			Ba-140	<6	0
			Cs-137	34±1	29±15
			K(mg/l)	1520±35	1550±233
STW-101	Water	Apr. 1977	H-3	1690±62	1760±1023

Table A-1 (continued)

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2 σ[c]	EPA Result ±3 σ, n=1[d]
STM-130	Milk	May 1977	Sr-89	38±2.6	44±15
			Sr-90	12±2.1	10±4.5
			I-131	59±2.1	50±15
			Ba-140	53±4.4	72±15
			Cs-137	14±1.2	10±15
			K(mg/l)	1533±21	1560±234
STW-105	Water	Jun. 1977	Cr-51	<14	0
			Co-60	29±1	29±15
			Zn-65	74±7	74±15
			Ru-106	64±8	62±15
			Cs-134	41±1	44±15
			Cs-137	35±3	35±15
STW-107	Water	Jun. 1977	Ra-226	4.7±0.3	5.1±2.42
STW-113	Water	Aug. 1977	Sr-89	13±0[e]	14±15
			Sr-90	10±2[e]	10±4.5
STW-116	Water	Sep.1977	Gross Alpha	12±6	10±15
			Gross Beta	32±6	30±15
STW-118	Water	Oct. 1977	H-3	1475±29	1650±1017
STW-119	Water	Oct. 1977	Cr-51	132±14	153±24
			Co-60	39±2	38±15
			Zn-65	51±5	53±15
			Ru-106	63±6	74±15
			Cs-134	30±3	30±15
			Cs-137	26±1	25±15
STW-136	Water	Feb. 1978	H-3	1690±270	1680±1020
STW-137	Water	Feb. 1978	Cr-51	<27	0
			Co-60	36±2	34±15
			Zn-65	32±4	29±15
			Ru-106	41±2	36±15
			Cs-134	47±2	52±15
			Cs-137	<2	0

Table A-1. (continued)

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2 σ[c]	EPA Result ±3 σ, n=1[d]
STW-138g	Water	Mar. 1978	Ra-226	5.4±0.1	5.5±0.6
			Ra-228	NA[f]	16.7±2.5
STW-150	Water	Apr. 1978	H-3	1250±220	2220±1047
STW-151	Water	Apr. 1978	Gross Alpha	20±1	20±15
			Gross Beta	56±4	59±15
			Sr-89	19±2	21±15
			Sr-90	8±1	10±4.5
			Ra-226	NA[f]	-
			Ra-228	NA[f]	-
			H-3	112±12	0
			Co-60	19±3	20±15
			Cs-134	16±1	15±15
			Cs-137	<2	0
STM-152	Milk	Apr.1978	Sr-89	85±4	101±15
			Sr-90	8±1	9±4.5
			I-131	78±1	82±15
			Cs-137	29±3	23±15
			Ba-140	<11	0
			K(mg/l)	1503±90	1500±225
STW-154g	Water	May 1978	Gross Alpha	12±1	13±15
			Gross Beta	21±4	18±15
STW-157g	Water	Jun. 1978	Ra-226	4.0±1.0	3.7±0.6
			Ra-228	NA[f]	5.6±0.8
STW-159g	Water	Jul. 1978	Gross Alpha	19±3	22±6
			Gross Beta	28±3	30±5
STW-162	Water	Aug. 1978	H-3	1167±38	1230±990
STW-165g	Water	Sep. 1978	Gross Alpha	4±1	5±5
			Gross Beta	13±1	10±5

Table A-1 (continued)

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2 σ[c]	EPA Result ±3 σ, n=1[d]
STW-167	Water	Oct. 1978	Gross Alpha	19±2	19±15
			Gross Beta	36±2	34±15
			Sr-89	9±1	10±15
			Sr-90	4±0	5±2.4
			Ra-226	5.5±0.3	5.0±2.4
			Ra-228	NA[f]	5.4±2.4
			Cs-134	10±1	10±15
			Cs-137	15±1	13±15
STW-170	Eater	Dec. 1978	Ra-226	11.5±0.6	9.2±1.4
			Ra-228	NAlefld	8.9±4.5
STW-172	Water	Jan. 1979	Sr-89	11±2	14±15
			Sr-90	5±2	6±4.5
STW-175	Water	Feb. 1979	H-3	1344±115	1280±993
STW-176	Water	Feb. 1979	Cr-51	<22	0
			Co-60	10±2	9±15
			Zn-65	26±5	21±15
			Rn-106	<16	0
			Cs-134	8±2	6±15
			Cs-137	15±2	12±15
STW-178	Water	Mar. 1979	Gross Alpha	6.3±3	10±15
			Gross Beta	15±4	16±15
STW-195g	Water	Aug. 1979	Gross Alpha	6.3±1.2	5±5
			Gross Beta	42.7±7.0	40±4
STW-193	Water	Sep. 1979	Sr-89	5.0±1.2	3.0±1.5
			Sr-90	25.0±2.7	28.0±4.5
STW-196	Water	Oct. 1979	Cr-51	135±5.0	113±18
			Co-60	7.0±1.0	6±5
			Cs-134	7.3±0.6	7±15
			Cs-137	12.7±1.2	11±15
STW-198	Water	Oct. 1979	H-3	1710±140	1560±1111

Table A-1. (continued)

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2 σ[c]	EPA Result ±3 σ, n=1[d]
STW-199	Water	Oct. 1979	Gross Alpha	16.0±3.6	21±15
			Gross Beta	36.3±1.2	49±15
			Sr-89	10.7±0.6	12±15
			Sr-90	5.7±0.6	7±15
			Ra-226	11.1±0.3	11±5
			Ra-228	1.6±0.7	0
			Co-60	35.0±1.0	33±15
			Cs-134	50.7±2.3	56±15
			Cs-137	<3	0
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
STW-215	Water	April 1980	Gross Alpha	NA[f]	98.0±24.5
			Gross Beta	NA[f]	100.0±5.0
			Sr-89	3.7±0.6	4±5.0
			Sr-90	<1.0	0.001±0.1
			Ra-226	NA[f]	16.0±2.4
			Ra-228	NA[f]	21.3±3.2
			Co-60	10.0±1.0	6±5
			Cs-134	14.0±1.0	8±5
			Cs-137	21.7±1.5	18±5
STM-217	Milk	May 1980	Sr-89	4.4±2.6[g]	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

Table A-1. (continued)

Lab Code	Sample Type	Date Coll.	Analysis	Concentration in pCi/l[b] HES Result ±2 σ[c]	EPA Result ±3 σ, n=1[d]
STW-223	Water	July 1980	Gross Alpha	31±3.0	38±5.0
			Gross Beta	44±4	35±5.0
STW-224	Water	July1980	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[f]	32.0±8.0
			Gross Beta	22.5±0.0	21.0±5.0

[a]Results obtained by the Nuclear Sciences Department of Hazleton Environmental Sciences 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.

[c]Unless otherwise indicated, the HES results 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=1.

[e]Mean ± 2 standard deviations of two determinations.

[f]NA = Not analyzed.

[g]Analyzed but not reported to the EPA.

Table A-2. Crosscheck program results, thermoluminescent dosimeters (TLD's).

Lab Code	TLD Type	Measurement	mR: Hazleton Result ±2[a]	mR: Known Value	mR: 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

[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 Univeristy of Texas, Houston, Texas.
[c]Value determined by sponsor of the intercomprison.
[d]Mean ± 2 standard deviationsof results obtained by all laboratories participating in 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.
[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.

Appendix B

Data Reporting Conventions

Data Reporting Conventions

1. All activities are corrected to collection time.

2. Single Measuements

   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

   $$< L \ .$$

   Detection limits are based on 4.66σ background counting uncertainties.

3. Duplicate measurements, the average result is reported as follows:

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

   Reported result: $x \pm s$

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

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

   b. Individual Results: $< L_1$

   $< L_2$

   Reported result: $< L$

   where L = lower of L_1 and L_2

c. Individual results: $x \pm s$

$<L$

Reported result: $x \pm s$ if $x \leq L$;

$<L$ otherwise

4. Unless otherwide indicated, the "cumulative average" for a location is the average of all measurements from the beginning of the current year through the date of the last entered result. "Less-than" values are ignored in the computation of the average. If all results are less-than values, the highest value is reported.

5. Unless otherwise indicated, the "previous average" for a location is the average obtained during the previous year.

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

   a. 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.

   b. 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.

   c. 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 of 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 priod 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.