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REPORT
TO
IOWA ELECTRIC LIGHT & POWER COMPANY
CEDAR RAPIDS, IOWA

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM FOR THE DUANE ARNOLD ENERGY CENTER CEDAR RAPIDS, IOWA Docket No. 50-331

ANNUAL REPORT - PART I
SUMMARY AND INTERPRETATION
JANUARY - DECEMBER 1986

FOR SUBMITTAL TO
THE NUCLEAR REGULATORY COMMISSION

PREPARED AND SUBMITTED
BY
TELEDYNE ISOTOPES MIDWEST LABORATORY
PROJECT NO. 8001

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General Manager

24 February 1987

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PREFACE

The staff members of the Teledyne Isotopes Midwest Laboratory were responsible for the acquisition of data presented in this report with the exception of Appendices D and E which were completed by Iowa Electric personnel. All environmental samples, with the exception of aquatic, were collected by personnel of DAEC. Aquatic samples were collected by University of Iowa Hygenic Laboratory personnel.

The report was prepared by L. G. Huebner, General Manager of the TIML, with the exception of Appendices D and E, which were prepared by Iowa Electric personnel. He was assisted in the report preparation by other staff members of the laboratory.

TABLE OF CONTENTS

LIST OF TABLES

In addition, the following tables are in the Appendices:

Appendix A

Appendix C

LIST OF FIGURES

1.0 INTRODUCTION

This report summarizes and interprets results of the Environmental Radiological Monitoring Program conducted by Teledyne Isotopes Midwest Laboratory at the Duane Arnold Energy Center, Cedar Rapids, Iowa, during the period January - December, 1986. This Program monitors the levels of radioactivity in the air, terrestrial, and aquatic environments in order to assess the impact of the Plant on its surroundings.

Tabulation of the individual analyses made during the year are included in Part II of this report.

Duane Arnold Energy Center (DAEC) is located in Linn County on the Cedar River, Iowa, and is operated by Iowa Electric Light and Power Company. Duane Arnold Nuclear Station is a 565.7 MW(e) boiling water reactor. Initial criticality was attained on 23 March 1974. The reactor reached 100% power on 12 August 1974. Commercial operation began on 1 February 1975.

2.0 SUMMARY

The Environmental Radiological Monitoring Program required by the U.S. Nuclear Regulatory Commission (NRC) Technical Specifications for the Duane Arnold Energy Center is described. Results for 1986 are summarized and discussed.

Program findings show background levels of radioactivity in the environmental samples collected in the vicinity of the Duane Arnold Energy Center. No effect on the environment due to the operation of the Duane Arnold Nuclear Plant is indicated.

There was a small effect on environmental radioactivity resulting from an accident at the Chernobyl Nuclear Reactor (USSR) on April 26, 1986. The sampling media affected were air, milk and vegetation. The effect is discussed below.

Air Particulates

Gross beta activity in air particulates collected between May 15, 1986 and June 12, 1986 had elevated levels ranging from 0.032 to 0.375 pCi/m^3 and averaged 0.154 pCi/m^3 for all locations. In comparison, gross beta activity for 1986, exclusive of the period between May 15, 1986 and June 12, 1986, averaged 0.024 pCi/m^3, the same as the average for 1985.

Gamma spectroscopic analyses of the second quarter composites showed the presence of three isotopes: Ru-103, Cs-134 and Cs-137, averaging 0.012, 0.0055 and 0.013 pCi/m^3, respectively. These isotopes were below their respective LLD levels in the first, third, and fourth quarter composites.

Airborne Iodine

Iodine-131 was detected in seventeen (17) samples collected between May 15, 1986 and May 29, 1986. The activity ranged from 0.12 to 1.58 pCi/m^3 and averaged 0.60 pCi/m^3 for all samples. Iodine-131 was below the LLD level of 0.07 pCi/m^3 in the rest of the samples collected in 1986.

Milk

Of 153 samples analyzed, forty (40) samples collected between May 20, 1986 and July 8, 1986 had detectable I-131 in varous concentrations. The concentrations ranged from 1.1 to 70.6 pCi/l and averaged 13.5 pCi/l for all samples with detectable levels. The I-131 concentration in the rest of the samples collected in 1986 was below the LLD level of 1.0 pCi/l.

Cs-134 was detected in one sample collected June 3, 1986 and measured 17.3 pCi/l.

During the same period, May 20, 1986 to July 8, 1986, Cs-137 was detected in twelve (12) samples. The concentration ranged from 18 to 30 pCi/l and averaged 24 pCi/l. In the rest of the samples collected in 1986, the Cs-137 concentration was below the LLD level of 15 pCi/l.

Vegetation

Cs-134 was detected in one sample collected September 3, 1986 and measured 0.052 pCi/g wet weight. Cs-137 was detected in three samples collected September 2 and 3, 1986. The activity ranged from 0.041 to 0.22 pCi/g wet weight and averaged 0.12 pCi/g wet weight.

3.0 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

3.1 Program Design and Data Interpretation

The purpose of the Environmental Radiological Monitoring Program at the Duane Arnold Energy Center (DAEC) 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; and

(4) Industrial and medical radioactive waste.

In interpreting the data, effects due to the DAEC operation 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 DAEC 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 station 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 DAEC site. The DAEC's monitoring program includes analyses for strontium-89, strontium-90, and iodine-131, which are fission products, and tritium, which is produced by cosmic rays, atmospheric nuclear detonations, and also by nuclear power plants. Most samples are also analyzed for gamma-

emitting isotopes with results for the following groups quantified: zirconium-95, cesium-137, and cerium-144. These 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 ten (10) days after reactor shutdown. On the other hand, ten (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).

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 next 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 effluents, but are not produced in significant quantities by nuclear detonations. Nuclides of the final group, beryllium-7, which is of cosmogenic origin, and potassium-40, a naturally-occuring isotope, were chosen as calibration monitors and should not be considered radiological impact indicators.

Characteristic properties of isotopes quantified in gamma-spectroscopic analyses are presented in Table 5.1. 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 DAEC'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 radiological monitoring program at the DAEC is summarized in Table 5.2 and is briefly reviewed below. Table 5.3 defines the sampling location codes used in Table 5.2 and specifies for each location its type (indicator or control) and its distance, direction, and sector relative to the reactor site. The types of samples collected at each location and the frequency of collections are presented in Table 5.4 using codes defined in Table 5.5.

To monitor the air environment, airborne particulates are collected on membrane filters by continuous pumping at twelve (12) locations. Also, airborne iodine is collected by continuous pumping through charcoal filters at six (6) of these locations. Nine (9) of the twelve (12) locations are indicators and three (3) are controls (D-1, D-2, and D-13). Filters are changed and counted weekly. Particulate filters are analyzed for gross beta activity. If gross beta activity exceeds 10 times the yearly mean of the control samples gamma isotopic analysis is performed. Quarterly composites of airborne particulates from each location are gamma scanned on a germanium detector.

All charcoal filters are analyzed weekly for I-131 on all samples.

Ambient gamma radiation is monitored at twelve (12) air sampling locations. In addition, gamma radiation is monitored at thirty-two (32) special locations: seventeen (17) in a circle within 0.5 mi radius of the DAEC stack; six (6) in 22.5° sectors within 1 mi of the DAEC stack; and nine (9) in 22.5° sectors between 1 and 3 miles of the DAEC stack. The sensors are placed in quadruplicate at each location and are exchanged and analyzed quarterly.

Precipitation samples are collected monthly from one location and analyzed for gamma-emitting isotopes. Quarterly composites are analyzed for tritium.

Milk samples are collected monthly from eight (8) locations during the non-grazing season, October through April, and biweekly during the grazing season, May 1 through September 30. One of the locations is a control (D-105) and the rest are indicators. All samples are analyzed for I-131 and gamma-emitting isotopes.

For additional monitoring of the terrestrial environment, grain, hay, and broad leaf natural vegetation samples are collected annually from nine (9) locations: one control (D-105) and eight (8) indicators (D-16, D-57, D-58, D-63, D-72, D-93, D-94, and D-106). Grain, hay, and broad leaf (green leafy) vegetation samples are analyzed for gamma-emitting isotopes and at least one broad leaf vegetation is analyzed for iodine-131. Meat is collected annually during or immediately following a grazing period from animals grazing on site. The sample is analyzed for gamma-emitting isotopes. Also, potable ground water is collected quarterly from a treated municipal water system (D-53), the inlet to the municipal water treatment system (D-54), and four (4) additional ground water locations (D-55, D-57, D-58, and D-60). The samples are analyzed for gross beta and tritium. If gross beta activity exceeds 10 times yearly mean of the control samples, gamma isotopic, strontium-89, and strontium-90 analyses are performed.

Soil samples are collected once per year at two control locations (D-15 and D-16). The samples are analyzed for strontium-90 and gamma-emitting isotopes.

Surface water is collected monthly from five (5) river, pond and sewage effluent locations, one (1) control (D-49) and four (4) indicator (D-50, D-51, D-99, and D-107). All monthly samples are analyzed for gamma-emitting isotopes. Tritium analyses are performed on quarterly composites from each location. In addition, all samples from Location D-107 (plant sewage discharge) are analyzed for K-40 by flame photometry.

The aquatic environment is also monitored by upstream and downstream (D-49 and D-61) semiannual collections of fish. River sediment is also collected semiannually at the plant's intake and discharge (D-50 and D-51). The 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) No TLD data were available for Location D-41 for the third quarter of 1986 because they were lost in the field.

(2) No TLD data were available for Location D-85 for the fourth quarter of 1986 because they were lost in the field.

(3) No milk was collected from Location D-106 on 08-19-86, 09-03-86, and 09-16-86 because it was temporarily unavailable.

(4) No milk was collected from Location D-93 on 12-02-86 because the goat was dry.

(5) No well water was collected from Location D-60 during the third and fourth quarter of 1986 because the pump was inoperative.

3.4 Laboratory Procedures

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

All gamma-spectroscopic analyses were performed with high resolution germanium detectors. Levels of iodine-131 in natural vegetation were determined by germanium spectrometry. Levels of airborne iodine-131 in charcoal samples were measured by germanium spectrometry.

Tritium levels were determined by the liquid scintillation technique.

Analytical Procedures used by TIML 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).

Details of TIML's QA Program are presented elsewhere (Teledyne Isotopes Midwest Laboratory, 1985). The TIML QA Program includes participation in the Interlaboratory Comparison (Crosscheck) Program. Results obtained in the crosscheck program are presented in Appendix A.

3.5 Program Modifications

The following program modifications were made beginning in January, 1986.

a. Analyses for Sr-89 and Sr-90 were eliminated from the program, except in soil samples (for Sr-90 only) and ground water when gross beta is greater than 10 times the yearly mean of control samples.

b. The number of air particulate sampling locations was reduced from sixteen (16) to twelve (12).

c. The number of air iodine sampling locations was reduced from eight (8) to six (6). Analysis for I-131 was changed from two (2) composites to every sample.

d. The number of TLD locations was reduced from sixty-three (63) to forty-four (44).

e. The number of milk locations was reduced from nine (9) to seven (7) initially and increased to eight (8) in April with the addition of D-101.

f. The collection and analysis of poultry, wildlife, and periphyton was dropped from the program.

g. The number of soil sampling locations was reduced from thirteen (13) to two (2). The frequency of collection was changed from three times per year to once a year.

h. The number of surface water sampling locations was reduced from seven (7) to five (5).

i. Meat sampling was changed from annually during or immediately following a grazing period from animals fed on crops grown inside and outside ten miles of DAEC to annually from animals grazing on site.

4.0 RESULTS AND DISCUSSION

All of the scheduled collections and analyses were made on schedule except those listed in Table 5.6.

All results are summarized in Table 5.7 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 of all indicator and control locations. The locations with the highest mean and range are also shown.

The tabulated results of all measurements made in 1986 are not included in this section, although references to these results will be made in the discussion. The complete tabulation of the 1986 results is contained in Part II of the 1986 Annual Report on the Environmental Radiological Monitoring Program for the Duane Arnold Energy Center.

4.1 Atmospheric Nuclear Detonations and Nuclear Accidents

There were no reported atmospheric nuclear tests in 1986. The last reported test was conducted by the People's Republic of China on October 16, 1980. 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 following is a brief description of the reactor, its location, and the chronology of events.

Location

The Chernobyl nuclear complex is located in the semirural area known as the Byelorussian-Ukrainian Woodlands on the Pripyat River in the Soviet Ukraine. The nearest town is Pripyat, six miles away, with a population of about 25,000. An additional 25,000 people live within twenty miles, many of them in the old town of Chernobyl. Eighty miles to the south lies Kiev, the capital city of the Ukraine, with a population of 2.5 million.

Reactor

Reactor No. 4 is one of six similar reactors at the Chernobyl site. It is a graphite-moderated, light-water-cooled pressure tube reactor, RBMK-1000, with 1000 MW(e) and 3200 MW(th) capacity. Reactors No. 1 and 2 went into operation in 1977, and Reactors No. 3 and 4 went into operation in 1983; construction of Reactors No. 5 and 6 began in 1981 but have not been completed. All four completed reactors were in operation at the time of the accident. There are fourteen RBMK-1000 reactors and one BBMK-1500 [1500 MW(e)] in operation within the Soviet Union.

Out of approximately fifty operating reactors in the U.S.S.R., about half are graphite-moderated and half are water-moderated, similar to Western design. In the United States, the only reactor similar to the RBMK-1000 is the graphite-moderated reactor in Hanford, Washington, which is used exclusively for the production of weapons-grade plutonium. Another major difference between Western and Soviet reactors is that Western reactors have a steel and concrete containment surrounding the complete reactor while Soviet reactors do not. There are certain advantages and disadvantages of the Chernobyl-type reactors. The advantages are:

a) The absence of cumbersome pressure vessels;

b) Fuel elements can be withdrawn for exchange, repair, or extraction of plutonium without necessitating reactor shutdown; and

c) Only about 2% enrichment with U-235 is required, in comparison with 4% for water-moderated reactors.

The disadvantages are:

a) High sensitivity of the neutron field, requiring a complicated control system in order to stabilize the power density distribution in the core;

b) Complex branching of the coolant delivery and removal system for each channel, which is subject to frequent small-scale failures;

c) A large amount of heat energy accumulating in the metal structures, fuel elements, and graphite structure, and slightly radioactive steam in the turbine; and

d) Inherent danger of hydrogen production when leaks or a breakdown of channels carrying hot steam and water can bring hot steam in contact with graphite, which can lead to a chemical explosion (and did).

At the time of the accident, 75% of the fuel elements were first-load bundles. It is estimated that the reactor was in operation for about 400 to 600 days. This means that the core had a large and nearly maximum inventory of radioactive fission products and that the accident could not have happened under worse conditions.

Chronology of Events

The reactor was in the process of being shut down for the maintenance of one of two turbogenerators and to perform a test. The test was designed to determine how long the turbogenerator could provide electrical power utilizing the mechanical energy of the rotor without steam supply.

April 25, 1986

0100 hr.: Shut down started.

1305 hr.: Turbogenerator No. 7 switched off. Electrical needs for feed pumps and other equipment switched to turbogenerator No. 8 (to be tested).

1400 hr.: Emergency core cooling system disconnected, but unit continued to operate.

2300 hr.: Power reduction resumed. At this time, the power level dropped to about 30 MW(th), which is an unstable condition. The operators brought it up to 200 MW(th) by withdrawing control rods and then by reducing the cooling water flow. The reactivity increased very rapidly and the reactor started to heat up very quickly. Since all automatic controls were turned off, the reactor could not scram itself.

April 26, 1986

0123 hr.: Some of the fuel rods and water tubes burst and steam reacted with zirconium and graphite, producing large quantities of hydrogen and other gases. There were two explosions, one after the other.

There were three stages of releases.

Stage 1 During this stage, occurring immediately after the explosion, parts of irradiated fuel and gases escaped to the atmosphere Some of the burning debris fell on the adjoining buildings and started a fire. Also, graphite which was enclosed in a stainless steel container was exposed to the atmosphere and started burning.

Stage 2 This stage lasted from April 26, 1986 to May 2, 1986. The releases of radioactivity were similar to those during Stage 1. The temperature inside the reactor continued to rise.

Stage 3 This stage lasted from May 2, 1986 to May 6, 1986. During this stage, there was a sharp increase in the rate of fission products releases due to the high temperature (2000° C) caused by burning graphite.

On May 6, 1986, the reactor was sealed and releases of fission products to the atmosphere were reduced to negligible amounts. Soviet scientists (IAEA Report, 1986) have estimated that about 50 MCi of radioactivity (excluding noble gases) were released during these three stages and constituted about 3.5% of the total inventory of isotopes in the reactor. It should be noted that most or all of the noble gases and volatile elements (Kr, Xe, I, Te, Cs) escaped from the reactor. The estimated releases are listed below. For comparison, releases from the Three Mile Island and Windscale accidents and from a 20 KT nuclear test are also listed.

Incident	Releases (in megacuries)			
	Noble Gas	I-131	Cs-137	Sr-90
Chernobyl*	100-200	10-50	1-6	0.001-0.007
Three Mile Island	10	0.00017	<0.0001	<0.0001
Windscale	0.3-0.4	0.2	0.001	--
20 KT ground atomic bomb test	5	2	0.004	0.004

* Evaluation error ±50%.

Because of the high temperature, gases and aerosols went straight up and reached an estimated height of 16,000 feet. The dispersion pattern was similar to that of a tall stack of a coal plant; it reduced local fallout while increasing deposition at distant downwind locations.

In addition to the aforementioned isotopes, the following isotopes and their total releases (from April 26 to May 6, 1986) were estimated in megacuries.

Isotope	Total Release* (Estimated in MCi)	Isotope	Total Release* (Estimated in MCi)
Xe-133	45	Ce-141	2.8
Kr-85m	--	Ce-144	2.4
Kr-86	0.9	Sr-89	2.2
I-131	7.3	Sr-90	0.22
Te-132	1.3	Pu-238	0.0008
Cs-134	0.5	Pu-239	0.0007
Cs-137	1.0	Pu-240	0.0011
Mo-99	3.0	Pu-241	0.14
Zr-95	3.8	Pu-242	0.000002
Ru-103	3.2	Cm-241	0.021
Ru-106	1.6	Np-239	1.2
Ba-140	4.3		

* Evaluation error ± 50%.

The prevailing wind direction at the time of the accident was in a northwesterly direction. It is estimated that the radioactive cloud reached the Polish border on April 26, 1986 and arrived over Sweden in the afternoon of April 27, approximately eighteen (18) hours before it was detected at the Forsmark Nuclear Plant, located 125 miles northwest of Stockholm.

On May 7-8, 1986, the wind changed to a southerly direction, causing radioactive fallout in that direction.

The fallout from Chernobyl was extremely non-uniform and strongly depended on local rainfall during the passage of the radioactive cloud. For example, the region just north of Stockholm, Sweden, had heavy rainfall on April 27 and 28. Ground radiation levels varied by more than a factor of 10 over just a few tenths of a mile (C. Hohenemser, et al, 1986).

I-131 levels in milk reached values as high as 13,500 pCi/l at rainfall locations as far as 900 or more miles distant from Chernobyl. Because in many cases cows were kept from open pasture, milk values show high variability (C. Hohenemser, et al, 1986).

During the period from ten to thirty days after the accident, the following radionuclides were identified in the close-in zone of Chernobyl's fallout trail: Mo-99, Zr-95, Nb-95, Ce-141, Ce-144, I-131, Te-132, I-132, Ru-103, Ru-106, Ba-La-140, Cs-134, Cs-137, Sr-89, Sr-90, and Y-91. Also, plutonium isotopes were found on the ground surface (I.A.E.C., 1986).

In the Kiev reservoir which supplies water to the city and is located just north of Kiev, gross beta concentration during the period May 13-20, 1986 was in the range of 1,000 - 5,000 pCi/l. The highest I-131 concentration in the Kiev reservoir was observed on May 3, 1986 and reached 28,000 pCi/l. The highest I-131 concentration in the Pripyat River, north of the plant, was observed on May 2, 1986 and reached 120,000 pCi/l.

In the midwestern states of the U.S.A., the radioactivity released during the accident was detected about two weeks after the accident. Radionuclides detected were Ru-103, Ru-106, I-131, Cs-134, and Cs-137 in such media as air, milk, precipitation, and vegetation. The highest level of I-131 in milk was in the milk collected May 15, 1986 in Illinois and analyzed by Teledyne Isotopes Midwest Laboratory.

By mid-June, levels of I-131 (and gross beta in the air particulates) in the Midwest fell below the detection limit (I-131) or returned to the pre-Chernobyl level (gross beta). The level of cesium isotopes decreased but was still detected sporadically in grass and milk.

As a result of the accident (as of August, 1986), thirty-one (31) people died, two (2) from the explosion and twenty-nine (29) from radiation sickness; two hundred ninety-nine (299) people were hospitalized; and one thousand people were injured. The long range effects of the accident are yet to be determined.

4.2 Program Findings

Results obtained show background levels of radioactivity in the environmental samples collected in 1986, with the exception of air and milk.

There was some effect on the environmental radioactivity resulting from the nuclear accident at Chernobyl (U.S.S.R.) on April 26, 1986. Low levels of Ru-103, I-131, Cs-134, and Cs-137 were detected in aerosols; I-131, Cs-134, and Cs-137 were detected in milk samples.

Airborne Particulates

The average annual gross beta concentration in airborne particulates was similar at indicator and control locations (0.036 and 0.040 pCi/m^3, respectively) and was higher than in 1982 (0.026 pCi/m^3), 1983 (0.022 and 0.024 pCi/m^3, respectively), 1984 (0.025 and 0.026 pCi/m^3, respectively) and in 1985 (0.024 pCi/m^3 at both locations).

The increase in average gross beta activity is attributable to the nuclear accident at Chernobyl.

The radioactive debris was first detected in air particulates in samples collected on May 15, 1986 and the elevated levels continued through the collection period ending June 12, 1986. Analyses of air particulates collected on June 19, 1986 showed that gross beta activity returned to the pre-Chernobyl level.

Gross beta activity during this period ranged from 0.032 to 0.375 pCi/m^3 and averaged 0.154 pCi/m^3. In comparison, gross beta activity for 1986, exclusive of the period between May 15, 1986 and June 12, 1986, averaged 0.024 pCi/m^3, the same as the average for 1985.

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, or 1985. In 1986, the spring peak could not be identified because it was overshadowed by the releases of radioactivity from Chernobyl.

There was a slight increase in gross beta activity in the fourth quarter as compared to the first, second, and third quarters, exclusive of the period between May 15, 1986 and June 12, 1986.

Two pieces of evidence indicate conclusively that the elevated observed activity during the fourth quarter was not attributable to the Plant operation. First, elevated activity of similar size occurred simultaneously at both indicator and control locations. Secondly, a similar pattern was observed at other nuclear power plant locations in the Midwest.

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 during the first, third, and fourth quarters.

During the second quarter of 1986, four gamma-emitting isotopes (Ru-103, Ru-106, Cs-134, and Cs-137) were identified and averaged 0.010, 0.011, 0.0055, and 0.013 pCi/m^3, respectively. It should be noted that the ratio of Cs-134 to Cs-137 in air particulates was about 1:2, the same as in the mix of gases released at the time of the accident at Chernobyl.

Airborne Iodine

Weekly levels of airborne iodine-131 were below the lower limit of detection (LLD) of 0.07 pCi/m^3 in 294 of 312 samples analyzed. The LLD of 0.07 pCi/m^3 could not be reached in one sample (<0.366 pCi/m^3) because of the low volume resulting from a pump malfunction.

Iodine-131 levels in seventeen (17) samples collected between May 15 and May 29, 1986 ranged from 0.12 to 1.58 pCi/m^3 and averaged 0.60 pCi/m^3 for all locations.

The presence of airborne I-131 in the aerosols in May, 1986 is attributable to the Chernobyl Accident.

Ambient Radiation (TLDs)

At twelve (12) air sampling locations, the TLD readings averaged 14.9 mR/quarter at indicator locations and 13.6 mR/quarter at control locations. At locations within 0.5 mile, 1.0 mile, and 3.0 mile radius of the stack, the measurements averaged 16.6 mR/quarter, 18.9 mR/quarter, and 16.0 mR/quarter. The average for all locations was 16.5 mR/quarter. This is slightly lower than the estimated average natural background radiation for Middle America, 19.5 mR/quarter, which is based on data on Pages 71 and 108 of the report, "Natural Background Radiation in the United States" (National Council on Radiation Protection and Measurements, 1975). The terrestrial absorbed dose (uncorrected for structural and body shielding) ranges from 8.8 to 18.8 mrad/quarter and averages 11.5 mrad/quarter for Middle America. Cosmic radiation and cosmogenic radionuclides contribute 8.0 mrad/quarter for a total average of 19.5 mrad/quarter. No plant effect was indicated.

Precipitation

In precipitation, the tritium concentration was below the LLD of 330 pCi/l in all samples. All gamma-emitting isotopes were below their respective LLDs.

Milk

A total of 153 analyses for iodine-131 were performed during the reporting period. One hundred thirteen (113) samples had I-131 concentrations below the LLD level of 1.0 pCi/l.

Forty (40) samples, collected between May 20 and July 8, 1986, contained I-131 in various concentrations. The level ranged from 1.1 pCi/l to 70.6 pCi/l and averaged 13.5 pCi/l for all locations. The variability in concentration of I-131 in milk depended on the local precipitation during the deposition of I-131 on the ground and the method of feeding the milch animals.

Cs-134 (17.3 pCi/l) was detected in one sample collected June 3, 1986.

Cs-137 was detected in twelve (12) of one hundred fifty-three (153) samples and averaged 24.8 pCi/l at indicator locations and 20.8 pCi/l at control locations. 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 Radiologocial Health, 1968).

In summary, the milk data for 1986 show no radiological effects of the plant operation, but the presence of I-131, Cs-134, and Cs-137 in milk samples does exhibit the effect of the nuclear accident at Chernobyl.

Ground Water

The annual mean for gross beta activity measured 2.7 pCi/l and was similar to the levels observed in 1980 through 1985. The location with the higher mean, 4.8 pCi/l, was D-58, a farm 1.0 miles distant from the plant. Tritium was below the LLD of 330 pCi/l in all samples. No plant effect was indicated.

Meat

In one meat sample, naturally-occurring potassium-40 was the only gamma-emitting isotope detected. All other gamma-emitting isotopes were below their respective LLDs. Thus, no plant effect was indicated.

Vegetation

Iodine-131 results in broad leaf vegetation were below the LLD level of 0.057 pCi/g wet weight in all samples.

Cesium-134 was detected in one sample (0.052 pCi/g wet weight) and Cesium-137 was detected in three samples, averaging 0.12 pCi/g wet weight. Presence of radiocesium in vegetation is attributable to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Except for potassium-40, which was observed in all samples (broadleaf vegetation, corn, hay, and soybeans), all other gamma-emitting isotopes were below detection limits in all samples. No plant effect was indicated.

Soil

Strontium-90 was detected in both samples and averaged 0.124 pCi/g dry weight.

The only gamma-emitting isotopes detected was potassium-40 and averaged 8.43 pCi/g dry weight. All other gamma-emitting isotopes were below their respective LLDs. No plant effect was indicated.

Surface Water

Tritium was below the LLD level of 330 pCi/l in all samples but one. The level in one sample was barely above the LLD and measured 360 pCi/l. Because of the associated error of measurement (±130 pCi/l), the elevated level is not significant.

All gamma-emitting isotopes were below their respective LLDs.

K-40 was measured at one location, D-107 (plant sewage discharge onsite). The concentration ranged from 17.07 to 35.02 pCi/l and averaged 23.94 pCi/l.

No plant effect on the radioactivity of surface water was indicated.

Fish

All gamma-emitting isotopes, except naturally-occurring potassium-40, in edible portions were below detection limits. The potassium-40 level was essentially identical at both indicator and control locations (3.78 and 3.80 pCi/g wet weight, respectively). No plant effect on fish was indicated.

River Sediments

River sediments were collected in May and October and analyzed for gamma-emitting isotopes. All gamma-emitting isotopes, except potassium-40, were below detection limits in all samples. Potassium-40 ranged from 7.64 to 8.35 pCi/g dry weight and averaged 7.91 pCi/g dry weight. There was no indication of plant effect.

5.0 TABLES AND FIGURES

Table 5.1 Characteristic properties of isotopes quantified in gamma-spectroscopic analyses.

Designation	Comments	Isotope	Half-life[a]
I. Naturally-occurring			
A. Cosmogenic	Produced by interaction of cosmic rays with atmosphere	Be-7	53.2 d
B. Terrestrial	Primordial	K-40	1.26×10^9 y
II. Fission Products[b]	Nuclear detonations constitute the major environmental source		
A. Short-lived		I-131	8.04 d
		Ba-140	12.8 d
B. Other than short-lived		Nb-95	35.15 d
		Zr-95	65 d
		Ru-103	39.35 d
		Ru-106	368.2 d
		Cs-134	2.061 y
		Cs-137	30.174 y
		Ce-141	32.5 d
		Ce-144	284.31 d
III. Activation Products	Typically found in nuclear power plant effluents	Mn-54	312.5 d
		Co-58	70.78 d
		Co-60	5.26 y
		Zn-65	245 d

[a] Half-lives are taken from Appendix E of Environmental Quarterly, 1 January 1978, EML-334 (U. S. Department of Energy, 1978).
[b] Includes fission-product daughters.

Table 5.2. Sample collection and analysis program, 1986.

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
Airborne Particulates	1	Cedar Rapids	Continuous operation of sampler with sample collection at least once per week or as required by dust loading.	Analyze for gross beta activity more than 24 hours after filter change. Perform gamma isotopic analysis[a] on each sample having gross beta activity greater than ten times the yearly mean of the control samples. Composite weekly samples to form a quarterly composite (by location). Analyze quarterly composite for gamma isotopic.
	2	Marion		
	3	Hiawatha		
	5	Palo		
	6	Center Point		
	7	Shellsburg		
	8	Urbana		
	10	Atkins		
	11	Toddville		
	13	Alburnett		
	15	On-site North		
	16	On-site South		
Airborne Iodine	2	Marion	Continuous operation of sampler with sample collection at least once per week.	Analyze each cartridge individually for iodine-131.
	5	Palo		
	7	Shellsburg		
	8	Urbana		
	11	Toddville		
	15	On-site North		
Ambient Radiation	1-3, 5-8, 10,11, 13	Air Particulate Locations	Two dosimeters continuously at each location. Both dosimeters are changed at least quarterly.	Read gamma radiation dose quarterly on one dosimeter. Anneal and repackage the second dosimeter.
	15,16, 18-23, 28-32 82-86 91	Within 0.5 mile of stack		

Table 5.2. Sample collection and analysis program, 1986 (continued)

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
Ambient Radiation (continued)	33-41	Within 3.0 miles of stack	Two dosimeters continuously at each location. Both dosimeters are changed at least quarterly.	Read gamma radiation dose quarterly on one dosimeter. Anneal and repackage the second dosimeter.
	43-48	Within 1.0 mile of stack		
Surface Water	49	Lewis Access	Once per month.	Gamma isotopic analyses of each sample (by location).
	50	Plant Intake		
	51	Plant Discharge		
	99	Pleasant Creek		Composite monthly samples to form quarterly composite (by location). Analyze quarterly composite for tritium.
	107	Plant Sewage Discharge		
Ground Water (Potable)	53	Treated Municipal Water	Grab sample at least once per quarter.	Gross beta and tritium activity analysis on quarterly sample. If gross beta is greater than ten times the yearly mean of control samples, perform gamma isotopic and Sr-89 and Sr-90 analyses.
	54	Inlet to Municipal Water Treatment System		
	55	On-site well		
	57,58	Wells off-site		
	60	and within 4 km of DAEC		

Table 5.2. Sample collection and analysis program, 1986 (continued)

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
River Sediment	50 51	Plant Intake Plant Discharge	At least once every six months	Gamma isotopic analysis of each sample.
Vegetation	16, 57, 58, 63, 72, 93, 94, 105, 106	Farms that raise food crops	Annually at harvest time. One sample of each: grain, green leafy, and forage. At least one sample should be broadleaf vegetation.	Gamma isotopic analysis of edible portions. I-131 analysis on broadleaf vegetation.
Fish	49	Cedar River upstream of DAEC not influenced by effluent	One sample per 6 months (once during January through July and once during August through December).	Gamma isotopic analysis on edible portions.
	61	Downstream of DAEC in influence of effluent		

Table 5.2. Sample collection and analysis program, 1986 (continued)

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
Milk[b]	105	Control farm near Amana, Iowa	At least once per two weeks during the grazing season.	During the grazing season: Gamma isotopic and iodine-131 analyses of each sample.
	63, 72, 93, 94, 96, 101, 106	Dairy farms within 10 miles of site	At least once per month during non-grazing season.	During the non-grazing season: gamma isotopic and iodine-131 analyses of each sample
Precipitation		On-site	Monthly	Gamma isotopic on all samples.
		On-site		Tritium on quarterly composites.
Meat	On-site		Annually	Gamma isotopic.
Soil	15, 16	On-site	Annually	Gamma isotopic and Sr-90.

[a] Gamma isotopic analysis and analysis for gamma-emitting nuclides refer to high resolution gamma ray spectrum analysis. Any radionuclide detected at a concentration greater than the lower limit of detection (LLD) should be reported quantitatively. Conversely, any radionuclide concentration less than the LLD should not be reported.

[b] The grazing season is considered to be May 1 through September 30.

Table 5.3 Sampling locations, Duane Arnold Energy Center.

Code	Type[a]	Sampling Location: Sampling Point	Sampling Location: Location Description	Sampling Location: Distance and Direction from Site Stack
D-1	C	1	Cedar Rapids	11 mi @135° SE
D-2	C	2	Marion	11 mi @125° ESE
D-3		3	Hiawatha	7 mi @130° SE
D-5		5	Palo	3 mi @200° SSW
D-6		6	Center Point	7 mi @ 0° N
D-7		7	Shellsburg	6 mi @255° W
D-8		8	Urbana	10 mi @345° NW
D-10		10	Atkins	9 mi @210° SSW
D-11		11	Toddville	4 mi @ 90° E
D-13	C	13	Alburnett	9 mi @ 70° ENE
D-15		15	On-site, Northwest	0.5 mi @305° NW
D-16		16	On-site, South	0.5 mi @190° SSE
D-18		18		0.5 mi NNE
D-19		19		0.5 mi NE
D-20		20		0.5 mi ENE
D-21		21		0.5 mi ENE
D-22		22		0.5 mi E
D-23		23		0.5 mi ESE
D-28		28		0.5 mi WSW
D-29		29		0.5 mi W
D-30		30		0.5 mi WNW
D-31		31		0.5 mi NW
D-32		32		0.5 mi NNW
D-33		33		3.0 mi N
D-34		34		3.0 mi NNE
D-35		35		3.0 mi NE
D-36		36		3.0 mi ENE
D-37		37		3.0 mi E
D-38		38		3.0 mi ESE
D-39		39		3.0 mi SE
D-40		40		3.0 mi SSE
D-41		41		3.0 mi S
D-43		43		1.0 mi SSW
D-44		44		1.0 mi WSW
D-45		45		1.0 mi W
D-46		46		1.0 mi WNW
D-47		47		1.0 mi WNW
D-48		48		1.0 mi NW
D-49	C	49	Lewis Access, upstream of DAEC	4.0 mi NNW

Table 5.3 Sampling locations, Duane Arnold Energy Center (continued)

Code	Type[a]	Sampling Location: Sampling Point	Sampling Location: Location Description	Sampling Location: Distance and Direction from Site Stack
D-50		50	Plant Intake	
D-51		51	Plant Discharge	
D-53		53	Treated Municipal Water	
D-54		54	Inlet to Municipal Water Treatment System	
D-55		55	On-site Well	
D-57		57	Farm (Off-site well)	1.0 mi WSW
D-58		58	Farm (Off-site well)	0.5 mi WSW-SW
D-60		60	Farm, Off-site well)	1.0 mi SSW
D-61		61	0.5 mi downstream of plant discharge	
D-63		63	Farm,	1.5 mi WNW
D-72		72	Farm	2.0 mi SSW
D-82		82		0.5 mi SE
D-83		83		0.5 mi SSE
D-84		84		0.5 mi S
D-85		85		0.5 mi SSW
D-86		86		0.5 mi SW
D-91		91		0.5 mi N
D-93		93	Farm	2.8 mi NNE
D-94		94	Farm	2.7 mi N
D-96		96	Farm	8.0 mi SSW
D-99		99	Pleasant Creek Lake	2.5 mi WNW
D-101		101	Farm	4.0 mi E
D-105	C	105	Farm	21.3 mi SSW
D-106		106	Farm	4.5 mi SE
D-107		107	Sewage System	Onsite

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

Table 5.4 Type and frequency of collection.

Location	Location Type[a]	Weekly	Monthly	Quarterly	Semi-Annually	Annually
D-1	C	AP		TLD		
D-2	C	AP,AI		TLD		
D-3		AP		TLD		
D-5		AP,AI		TLD		
D-6		AP		TLD		
D-7		AP,AI		TLD		
D-8		AP,AI		TLD		
D-10		AP		TLD		
D-11		AP,AI		TLD		
D-13	C	AP		TLD		
D-15		AP,AI		TLD		SO
D-16		AP		TLD		SO, G[b]
D-18 through D-23				TLD		
D-28 through D-41				TLD		
D-43 through D-48				TLD		
D-49	C		SW		F	
D-50			SW		BS	
D-51			SW		BS	
D-53			WW			
D-54			WW			
D-55			WW			
D-57			WW			G[b]
D-58			WW			G[b]
D-60			WW			
D-61					F	
D-63			M[c]			G[b]
D-72			M[c]			G[b]
D-82 through D-86				TLD		
D-91				TLD		
D-93			M[c]			G[b]
D-94			M[c]			G[b]
D-96			M[c]			
D-99			SW			

Table 5.4 Type and frequency of collection (continued)

Location	Location Type[a]	Weekly	Monthly	Quarterly	Semi-Annually	Annually
D-101			M[c]			
D-105	C		M[c]			G[b]
D-106			M[c]			G[b]
D-107			SW			
On-site			P			ME

[a] Control locations are indicated by a "C" in this column. All other locations are indicators.
[b] Vegetation (G) includes broad leaf vegetation and grain.
[c] Monthly from October through April; weekly from May through September.

Table 5.5. Sample codes used in Table 5.4.

Code	Description
AP	Airborne Particulates
AI	Airborne Iodine
TLD	Thermoluminescent Dosimeter
P	Precipitation
M	Milk
WW	Well Water
G	Vegetation (broad leaf and grain)
ME	Meat
SO	Soil
SW	Surface Water
F	Fish
BS	River Sediment

Table 5.6. Missed collections and analyses, Duane Arnold Energy Center, 1986.

Sample	Analysis	Location	Collection Date or Period	Comments
TLD	Gamma	D-41	3rd Quarter	Lost in the field.
TLD	Gamma	D-85	4th Quarter	Lost in the field.
Milk		D-106	08-19-86 09-03-86 09-16-86	Sample temporarily unavailable.
Milk		D-93	12-02-86	Goat dried up.
Well Water		D-60	3rd Quarter 4th Quarter	Pump inoperative.

Table 5.7. Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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)	GB 624	0.004[f]	0.036 (464/468) (0.004-0.375)	D-6, Center Point 7 mi N	0.041 (52/52) (0.014-0.375)	0.040 (156/156) (0.012-0.348)	0
				D-1, Cedar Rapids 11 mi SE	0.041 (52/52) (0.016-0.284)		
	GS 48						
	Be-7	0.037	0.07 (30/36) (0.040-0.12)	D-1, Cedar Rapids 11 mi SE	0.095 (4/4) (0.054-0.13)	0.087 (12/12) (0.045-0.13)	0
	Nb-95	0.0054	<LLD	-	-	<LLD	0
	Zr-95	0.0076	<LLD	-	-	<LLD	0
	Ru-103	0.0082	0.010 (8/36) (0.0062-0.014)	D-16, On-site 0.5 mi SSE	0.014 (1/4) -	0.010 (2/12) (0.0077-0.013)	0
	Ru-106	0.020	0.011 (1/36)	D-5, Palo 3.0 mi SSW	0.011 (1/4)	<LLD	0
	Cs-134	0.0043	0.0055 (9/36) (0.0036-0.0071)	D-3, Hiawatha 7.0 mi SE	0.0071 (1/4) -	0.0055 (2/12) (0.0044-0.0065)	0
	Cs-137	0.0023	0.013 (9/36) (0.0075-0.017)	D-3, Hiawatha 7.0 mi SE	0.017 (1/4) -	0.013 (3/12) (0.011-0.014)	0
	Ce-141	0.0084	<LLD	-	-	<LLD	0
	Ce-144	0.012	<LLD	-	-	<LLD	0
Airborne Iodine (pCi/m^3)	I-131 312	0.0739	0.65 (14/260) (0.12-1.58)	D-8, Urbana 10 mi NW	0.82 (3/52) (0.26-1.58)	0.34 (3/52) (0.24-0.45)	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F) Range	Number of Non-routine Results[e]
					Location[d]	Mean (F) Range		
TLD AP Locations (mR/Qtr.)	Gamma	48	1	14.9 (36/36) (11.6-18.5)	D-10, Atkins 9 mi SSW	17.0 (4/4) (15.8-18.5)	13.6 (12/12) (10.0-15.2)	0
TLD, Within 0.5 mi radius of stack (mR/Qtr.)	Gamma	67	1	16.6 (67/67) (12.4-22.4)	D-29, On-site 0.5 mi W	19.0 (4/4) (16.5-21.1)	None	0
					D-31, On-site 0.5 mi NW	19.0 (4/4) (13.4-22.0)		
TLD, Within 1.0 mi radius of stack (mR/Qtr.)	Gamma	24	1	18.9 (24/24) (12.9-22.9)	D-44, 1.0 mi WSW	20.5 (4/4) (17.1-22.9)	None	0
TLD, Within 3.0 mi radius of stack (mR/Qtr.)	Gamma	35	1	16.0 (35/35) (10.2-22.5)	D-37, 3.0 mi E	20.4 (4/4) (18.4-22.5)	None	0
Precipitation (pCi/l)	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
	Nb-95		15	<LLD	-	-	None	0
	Zr-95		30	<LLD	-	-	None	0
	I-131		500	<LLD	-	-	None	0
	Cs-134		15	<LLD	-	-	None	0
	Cs-137		18	<LLD	-	-	None	0
	Ba-140		60	<LLD	-	-	None	0
	La-140		15	<LLD	-	-	None	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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		
Milk (pCi/l)	I-131 153	1.0	15.2 (34/133) (1.3-70.6)	D-93, Farm 2.8 mi NNE	23.6 (5/19) (1.5-70.6)	3.6 (6/20) (1.1-6.9)	0
	GS 153						
	K-40	100	1420 (133/133) (950-2180)	D-101, Farm 4.0 mi E	1800 (17/17) (1520-2180)	1280 (20/20) (1040-1590)	0
	Cs-134	15	17.3 (1/133)	D-72, Farm 2.0 mi SSW	17.3 (1/20) -	<LLD	0
	Cs-137	15	24.8 (11/133) (18-30)	D-72, Farm 2.0 mi SSW	29.5 (2/20) (29-30)	20.8 (1/20) -	0
	Ba-La-140	15	<LLD	-	-	<LLD	0
Ground Water (pCi/l)	Gross Beta 22	0.9	2.7 (19/22) (0.9-8.2)	D-58, Farm 1.0 mi WSW-SW	4.8 (4/4) (1.2-8.2)	None	0
	H-3 22	330	<LLD	-	-	None	0
Meat (pCi/g wet)	GS 1						
	K-40	1.0	1.98 (1/1) -	On-site	1.98 (1/1) -	None	0
	Mn-54	0.013	<LLD	-	-	None	0
	Co-58	0.019	<LLD	-	-	None	0
	Co-60	0.012	<LLD	-	-	None	0
	Nb-95	0.031	<LLD	-	-	None	0
	Zr-95	0.037	<LLD	-	-	None	0
	Ru-103	0.025	<LLD	-	-	None	0
	Ru-106	0.10	<LLD	-	-	None	0
	Cs-134	0.011	<LLD	-	-	None	0
	Cs-137	0.012	<LLD	-	-	None	0
	Ce-141	0.044	<LLD	-	-	None	0
	Ce-144	0.068	<LLD	-	-	None	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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		
Broad Leaf Vegetation (pCi/g wet)	I-131 8	0.057	<LLD	-	-	<LLD	0
	GS40 8						
	K-40	0.5	4.62 (7/7) (2.10-6.41)	D-94, Farm 2.7 mi N	6.41 (1/1) -	2.78 (1/1) -	0
	Mn-54	0.040	<LLD	-	-	<LLD	0
	Co-58	0.043	<LLD	-	-	<LLD	0
	Co-60	0.045	<LLD	-	-	<LLD	0
	Nb-95	0.039	<LLD	-	-	<LLD	0
	Zr-95	0.073	<LLD	-	-	<LLD	0
	Ru-103	0.038	<LLD	-	-	<LLD	0
	Ru-106	0.35	<LLD	-	-	<LLD	0
	Cs-134	0.040	<LLD	-	-	<LLD	0
	Cs-137	0.044	<LLD	-	-	<LLD	0
	Ce-141	0.098	<LLD	-	-	<LLD	0
	Ce-144	0.43	<LLD	-	-	<LLD	0
Vegetation - Corn (pCi/g wet)	GS 8						
	K-40	0.5	3.03 (7/7) (1.64-4.19)	D-58, Farm 1.0 mi WSW-SW	4.19 (1/1) -	2.94 (1/1) -	0
	Mn-54	0.044	<LLD	-	-	<LLD	0
	Co-58	0.044	<LLD	-	-	<LLD	0
	Co-60	0.052	<LLD	-	-	<LLD	0
	Nb-95	0.044	<LLD	-	-	<LLD	0
	Zr-95	0.088	<LLD	-	-	<LLD	0
	Ru-103	0.043	<LLD	-	-	<LLD	0
	Ru-106	0.38	<LLD	-	-	<LLD	0
	Cs-134	0.046	<LLD	-	-	<LLD	0
	Cs-137	0.046	<LLD	-	-	<LLD	0
	Ce-141	0.064	<LLD	-	-	<LLD	0
	Ce-144	0.26	<LLD	-	-	<LLD	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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		
Vegetation - Soybeans (pCi/g wet)	GS 1						
	K-40	0.5	13.11 (1/1) -	D-16, On-site 0.5 mi SSE	13.11 (1/1) -	None	0
	Mn-54	0.11	<LLD	-	-	None	0
	Co-58	0.11	<LLD	-	-	None	0
	Co-60	0.12	<LLD	-	-	None	0
	Nb-95	0.11	<LLD	-	-	None	0
	Zr-95	0.20	<LLD	-	-	None	0
	Ru-103	0.085	<LLD	-	-	None	0
	Ru-106	0.82	<LLD	-	-	None	0
	Cs-134	0.12	<LLD	-	-	None	0
	Cs-137	0.11	<LLD	-	-	None	0
	Ce-141	0.071	<LLD	-	-	None	0
	Ce-144	0.28	<LLD	-	-	None	0
Vegetation - Hay (pCi/g wet)	GS 7						
	K-40	0.5	17.99 (6/6) (12.62-24.20)	D-93, Farm 2.8 mi NNE	24.20 (1/1) -	15.30 (1/1) -	0
	Mn-54	0.063	<LLD	-	-	<LLD	0
	Co-58	0.088	<LLD	-	-	<LLD	0
	Co-60	0.067	<LLD	-	-	<LLD	0
	Nb-95	0.17	<LLD	-	-	<LLD	0
	Zr-95	0.16	<LLD	-	-	<LLD	0
	Ru-103	0.14	<LLD	-	-	<LLD	0
	Ru-106	0.70	<LLD	-	-	<LLD	0
	Cs-134	0.076	0.052 (1/6) -	D-94, Farm 2.7 mi N	0.052 (1/6) -	<LLD	0
	Cs-137	0.080	0.12 (3/6) (0.041-0.22)	D-94, Farm 2.7 mi N	0.22 (1/1) -	<LLD	0
	Ce-141	0.33	<LLD	-	-	<LLD	0
	Ce-144	0.50	<LLD	-	-	<LLD	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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]
Soil (pCi/g dry)	Sr-90 2	0.03	0.124 (2/2) (0.016-0.231)	D-16, On-site 0.5 mi SSE	0.231 (1/1) -	None	0
	GS 2						
	K-40	0.5	8.43 (2/2) (8.16-8.70)	D-15, On-site 0.5 mi NW	8.70 (1/1) -	None	0
	Mn-54	0.024	<LLD	-	-	None	0
	Co-58	0.033	<LLD	-	-	None	0
	Co-60	0.029	<LLD	-	-	None	0
	Nb-95	0.060	<LLD	-	-	None	0
	Zr-95	0.074	<LLD	-	-	None	0
	Ru-103	0.051	<LLD	-	-	None	0
	Ru-106	0.17	<LLD	-	-	None	0
	Cs-134	0.021	<LLD	-	-	None	0
	Cs-137	0.020	<LLD	-	-	None	0
	Ce-141	0.11	<LLD	-	-	None	0
	Ce-144	0.13	<LLD	-	-	None	0
Surface Water (pCi/l)	H-3 20	330	360 (1/20) -	D-107, On-site Sewage Effluent	360 (1/4) -	<LLD	0
	K-40 12	0.5	23.94 (12/12) (17.07-35.02)	D-107, On-site Sewage Effluent	23.94 (12/12) -	None	0
	GS 60						
	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
	Nb-95	15	<LLD	-	-	<LLD	0
	Zr-95	30	<LLD	-	-	<LLD	0
	I-131	500	<LLD	-	-	<LLD	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	18	<LLD	-	-	<LLD	0
	Ba-140	60	<LLD	-	-	<LLD	0
	La-140	15	<LLD	-	-	<LLD	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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 Sediments (pCi/g dry)	GS 4						
	K-40	1.0	7.91 (4/4) (7.64-8.35)	D-51, Downstream of Plant Discharge	8.12 (2/2) (7.88-8.35)	None	0
	Mn-54	0.025	<LLD	-	-	None	0
	Co-58	0.025	<LLD	-	-	None	0
	Co-60	0.024	<LLD	-	-	None	0
	Nb-95	0.026	<LLD	-	-	None	0
	Zr-95	0.043	<LLD	-	-	None	0
	Ru-103	0.024	<LLD	-	-	None	0
	Ru-106	0.18	<LLD	-	-	None	0
	Cs-134	0.029	<LLD	-	-	None	0
	Cs-137	0.033	<LLD	-	-	None	0
	Ce-141	0.038	<LLD	-	-	None	0
	Ce-144	0.16	<LLD	-	-	None	0
Fish (Edible portion) (pCi/g wet)	GS 12						
	K-40	0.5	3.78 (6/6) (2.96-4.59)	D-49, Lewis access 4.0 mi NNW	3.81 (6/6) (3.25-4.24)	3.81 (6/6) (3.25-4.24)	0
	Mn-54	0.032	<LLD	-	-	<LLD	0
	Co-58	0.051	<LLD	-	-	<LLD	0

Table 5.7. Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Duane Arnold Energy Center Docket No. 50-331

Location of Facility Linn, Iowa (County, State) Reporting Period January - December, 1986

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		
Fish (Edible portion) (pCi/g wet) (continued)	Co-60	0.035	<LLD	-	-	<LLD	0
	Nb-95	0.085	<LLD	-	-	<LLD	0
	Zr-95	0.080	<LLD	-	-	<LLD	0
	Ru-103	0.072	<LLD	-	-	<LLD	0
	Ru-106	0.30	<LLD	-	-	<LLD	0
	Cs-134	0.040	<LLD	-	-	<LLD	0
	Cs-137	0.036	<LLD	-	-	<LLD	0
	Ce-141	0.12	<LLD	-	-	<LLD	0
	Ce-144	0.21	<LLD	-	-	<LLD	0

[a] GB = Gross beta; GS = Gamma scan.
[b] LLD = Nominal lower limit of detection based on 4.66 sigma error for background sample.
[c] Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (F).
[d] Locations are specified by: (1) name and code (Table 5.3); and (2) distance, direction, and sector relative to reactor site.
[e] Nonroutine results are those which exceed ten times the control station value. If a control station value is available, the result is considered nonroutine if it exceeds ten times the preoperational value for the location.
[f] One (1) result has been excluded in the determination of LLD for gross beta. Higher than normal LLD (<0.036 pCi/m^3) resulted from low volume due to pump malfunction.
[g] One (1) result (<0.366 pCi/m^3) has been excluded in the determination of LLD for I-131 in charcoal. It resulted from low volume due to a pump malfunction.

Figure 5-1 Radiological Environmental Monitoring Program Sampling Stations near the Duane Arnold Energy Center.

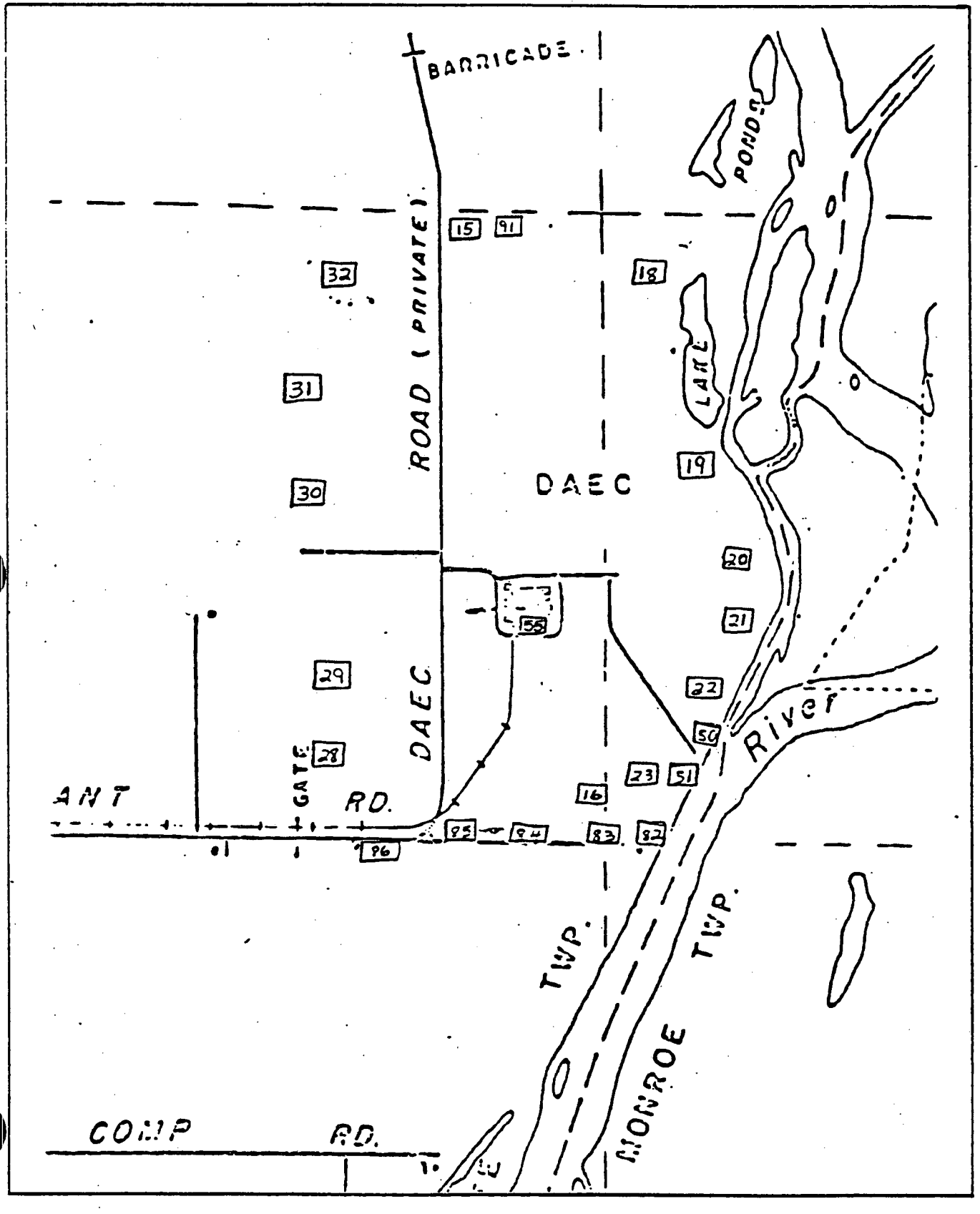
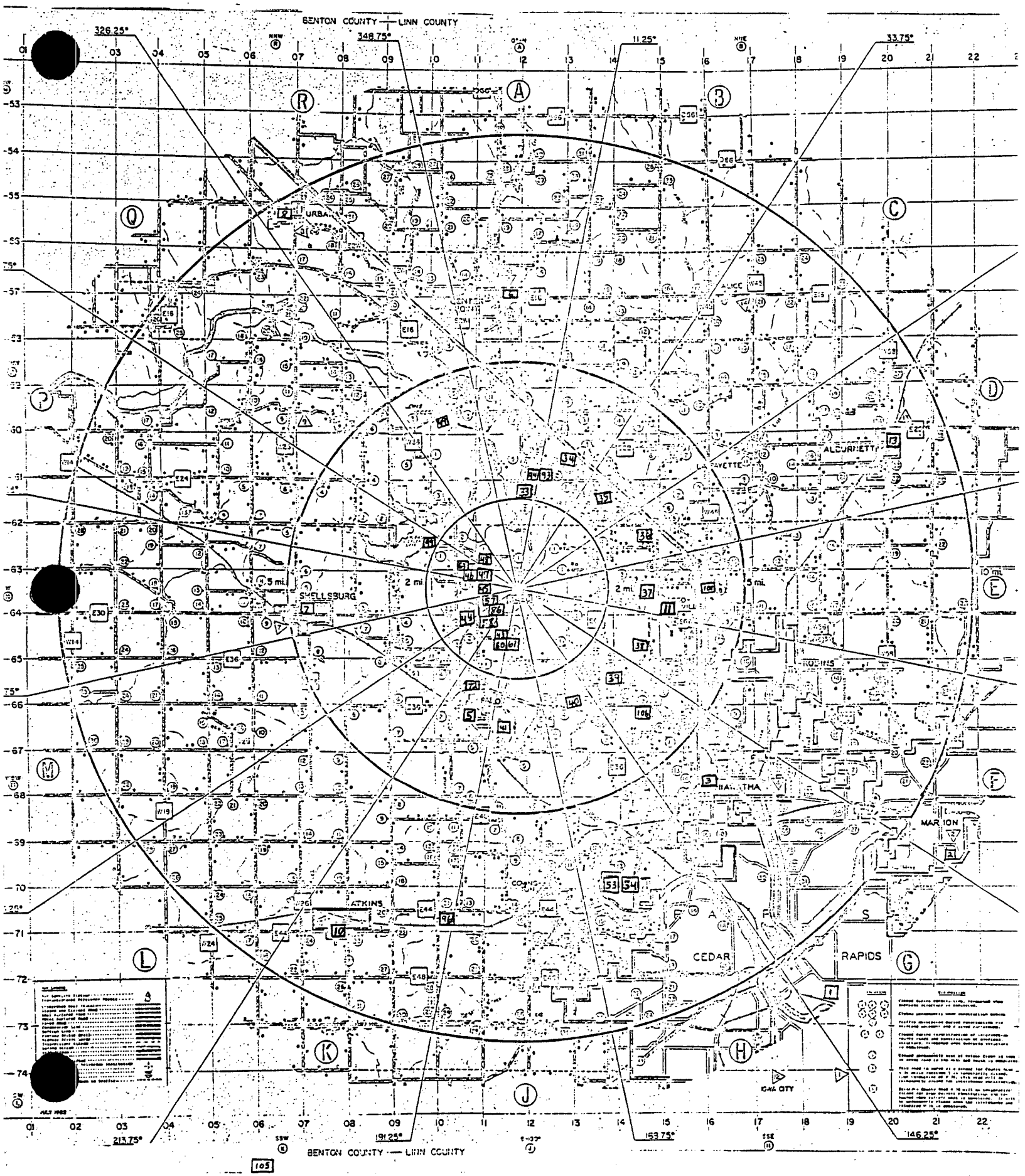


Figure 5-2 Radiological Environmental Monitoring Program Sampling Stations outside 0.5 miles.



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Appendix A

Interlaboratory Comparison Program Results

Appendix A

Interlaboratory Comparison Program Results

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

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

The results in Table A-1 were obtained through participation in the environmental sample crosscheck program for milk, water, air filters, and food samples during the period May 1984 through November 1986. This program has been conducted by the U. S. Environmental Protection Agency Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

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

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

Table A-4 lists results of the analyses on in-house "blank" 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 1986.[a]

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

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±1σ, n=3[d]
STM-382	Milk	Oct. 1984	Sr-89	15.7±4.2	22±8.7
			Sr-90	12.7±1.2	16±2.6
			I-131	41.7±3.1	42±10.4
			Cs-137	31.3±6.1	32±8.7
			K-40	1447±66	1517±131
STW-384	Water (Blind)	Oct. 1984 Sample A	Gross alpha	9.7±1.2	14±8.7
			Ra-226	3.3±0.2	3.0±0.8
			Ra-228	3.4±1.6	2.1±0.5
			Uranium	NA[e]	5±10.4
		Sample B	Gross beta	48.3±5.0	64±8.7
			Sr-89	10.7±4.6	11±8.7
			Sr-90	7.3±1.2	12±2.6
			Co-60	16.3±1.2	14±8.7
			Cs-134	<2	2±8.7
			Cs-137	16.7±1.2	14±8.7
STAF-387	Air Filter	Nov. 1984	Gross alpha	18.7±1.2	15±8.7
			Gross beta	59.0±5.3	52±8.7
			Sr-90	18.3±1.2	21±2.6
			Cs-137	10.3±1.2	10±8.7
STW-388	Water	Dec. 1984	I-131	28.0±2.0	36±10.4
STW-389	Water	Dec. 1984	H-3	3583±110	3182±624
STW-391	Water	Dec. 1984	Ra-226	8.4±1.7	8.6±2.2
			Ra-228	3.1±0.2	4.1±1.1
STW-392	Water	Jan. 1985	Sr-89	<3.0	3.0±8.7
			Sr-90	27.3±5.2	30.0±2.6
STW-393	Water	Jan. 1985	Gross alpha	3.3±1.2	5±8.7
			Gross beta	17.3±3.0	15±8.7
STS-395	Food	Jan. 1985	Gross alpha	4.7±2.3	6.0±8.7
			Gross beta	11.3±1.2	15.0±8.7
			Sr-89	25.3±6.4	34.0±8.7
			Sr-90	27.0±8.8	26.0±2.6
			I-131	38.0±2.0	35.0±10.4
			Cs-137	32.7±2.4	29.0±8.7
			K-40	1410±212	1382±208

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	Concentration in pCi/l[b] EPA Result ±1σ, n=3[d]
STW-397	Water	Feb. 1985	Cr-51	<29	48±8.7
			Co-60	21.3±3.0	20±8.7
			Zn-65	53.7±5.0	55±8.7
			Ru-106	<23	25±8.7
			Cs-134	32.3±1.2	35±8.7
			Cs-137	25.3±3.0	25±8.7
STW-398	Water	Feb. 1985	H-3	3869±319	3796±634
STM-400	Milk	March 1985	I-131	7.3±2.4	9.0±1.6
STW-402	Water	March 1985	Ra-226	4.6±0.6	5.0±1.3
			Ra-228	<0.8	9.0±2.3
		Reanalysis	Ra-228	9.0±0.4	
STW-404	Water	March 1985	Gross alpha	4.7±2.3	6±8.7
			Gross beta	11.3±1.2	15±8.7
STAF-405	Air Filter	March 1985	Gross alpha	9.3±1.0	10.0±8.7
			Gross beta	42.0±1.1	36.0±8.7
			Sr-90	13.3±1.0	15.0±2.6
			Cs-137	6.3±1.0	6.0±8.7
STW-407	Water	April 1985	I-131	8.0±0.0	7.5±1.3
STW-408	Water	April 1985	H-3	3399±150	3559±630
STW-409	Water	April 1985			
	(Blind) Sample A		Gross alpha	29.7±1.8	32.0±8.7
			Ra-226	4.4±0.2	4.1±1.0
			Ra-228	NA[e]	6.2±1.6
			Uranium	NA[e]	7.0±10.4
	Sample B		Gross beta	74.3±11.8	72.0±8.7
			Sr-89	12.3±7.6	10.0±8.7
			Sr-90	14.7±2.4	15.0±2.6
			Co-60	14.7±2.4	15.0±8.7
			Cs-134	12.0±2.0	15.0±8.7
			Cs-137	14.0±2.0	12.0±8.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	Concentration in pCi/l[b] EPA Result ±1σ, n=3[d]
STW-413	Water	May 1985	Sr-89	36.0±12.4	39.0±8.7
			Sr-90	14.3±4.2	15.0±2.6
STW-414	Water	May 1985	Gross alpha	8.3±4.1	12.0±8.7
			Gross beta	8.7±1.2	11.0±8.7
STW-416	Water	June 1985	Cr-51	44.7±6.0	44.0±8.7
			Co-60	14.3±1.2	14.0±8.7
			Zn-65	50.3±7.0	47.0±8.7
			Ru-106	55.3±5.8	62.0±8.7
			Cs-134	32.7±1.2	35.0±8.7
			Cs-137	22.7±2.4	20.0±8.7
STW-418	Water	June 1985	H-3	2446±132	2416±609
STM-421	Milk	June 1985	Sr-89	10.3±4.6	11.0±8.7
			Sr-90	9.0±2.0	11.0±2.6
			I-131	11.7±1.2	11.0±10.4
			Cs-137	12.7±1.2	11.0±8.7
			K-40	1512±62	1525±132
STW-423	Water	July 1985	Gross alpha	5.0±0.0	11.0±8.7
			Gross beta	5.0±2.0	8.0±8.7
STW-425	Water	August 1985	I-131	25.7±3.0	33.0±10.4
STW-426	Water	August 1985	H-3	4363±83	4480±776
STAF-427	Air Filter	August 1985	Gross alpha	11.3±0.6	13.0±8.7
			Gross beta	46.0±1.0	44.0±8.7
			Sr-90	17.7±0.6	18.0±2.6
			Cs-137	10.3±0.6	8.0±8.7
STW-429	Water	Sept. 1985	Sr-89	15.7±0.6	20.0±8.7
			Sr-90	7.0±0.0	7.0±2.6
STW-430	Water	Sept. 1985	Ra-226	8.2±0.3	8.9±2.3
			Ra-228	4.1±0.3	4.6±1.2
STW-431	Water	Sept. 1985	Gross alpha	4.7±0.6	8.0±8.7
			Gross beta	4.7±1.2	8.0±8.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±1σ, n=3[d]
STW-433	Water	Oct. 1985	Cr-51	<13	21.0±8.7
			Co-60	19.30.6	20.0±8.7
			Zn-65	19.7±0.6	19.0±8.7
			Ru-106	<19	20.0±8.7
			Cs-134	17.0±1.0	20.0±8.7
			Cs-137	19.3±1.2	20.0±8.7
STW-435	Water	Oct. 1985	H-3	1957±50	1974±598
STW-436 437	Water (Blind)	Oct. 1985			
	Sample A		Gross alpha	53.0±1.0	52.0±22.6
			Ra-226	5.9±0.1	6.3±1.6
			Ra-228	8.2±0.1	10.1±2.6
			Uranium	NA[e]	8.0±10.4
	Sample B		Gross beta	85.7±2.5	75.0±8.7
			Sr-89	21.3±1.5	27.0±8.7
			Sr-90	10.3±0.6	9.0±2.6
			Co-60	18.3±1.2	18.0±8.7
			Cs-134	16.3±1.2	18.0±8.7
			Cs-137	19.0±1.0	18.0±8.7
STM-439	Milk	Oct. 1985	Sr-89	50.3±0.6	48.0±8.7
			Sr-90	23.3±0.6	26.0±2.6
			I-131	45.7±3.2	42.0±10.4
			Cs-137	60.7±0.6	56.0±8.7
			K-40	1547±29	1540±134
STW-441	Water	Nov. 1985	Gross alpha	5.3±0.6	10.0±8.7
			Gross beta	11.7±1.2	13.0±8.7
STW-443	Water	Dec. 1985	I-131	46.7±2.1	45.0±10.4
STW-444	Water	Dec. 1985	Ra-226	6.5±0.1	7.1±1.9
			Ra-228	6.1±0.1	7.3±1.9
STW-445	Water	Jan. 1986	Sr-89	29.7±2.5	31.0±8.7
			Sr-90	13.7±0.6	15.0±2.6
STW-446	Water	Jan. 1986	Gross alpha	3.0±0.0	3.0±8.7
			Gross beta	5.3±0.6	7.0±8.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	Concentration in pCi/l[b] EPA Result ±1σ, n=3[d]
STW-447	Food	Jan. 1986	Sr-89	24.3±2.5	25.0±8.7
			Sr-90	17.3±0.6	10.0±2.6
			I-131	22.7±2.3	20.0±10.4
			Cs-137	16.3±0.6	15.0±8.7
			K-40	927±46	950±249
STW-448	Water	Feb. 1986	Cr-51	45.0±3.6	38.0±8.7
			Co-60	19.7±1.5	18.0±8.7
			Zn-65	44.0±3.5	40.0±8.7
			Ru-106	<9.0	0.0±8.7
			Cs-134	28.3±2.3	30.0±8.7
			Cs-137	23.7±0.6	22.0±8.7
STW-449	Water	Feb. 1986	H-3	5176±48	5227±910
STW-450	Water	Feb. 1986	U total	8.0±0.0	9.0±10.4
STW-451	Milk	Feb. 1986	I-131	7.0±0.0	9.0±10.4
STW-452	Water	March 1986	Ra-226	3.8±0.1	4.1±1.1
			Ra-228	11.0±0.5	12.4±3.2
STW-453	Water	March 1986	Gross alpha	6.7±0.6	15.0±8.7
			Gross beta	7.3±0.6	8.0±8.7
STW-454	Water	April 1986	I-131	7.0±0.0	9.0±10.4
STW-455 456	Water (Blind)	April 1986			
	Sample A		Gross alpha	15.0±1.0	17.0±8.7
			Ra-226	3.1±0.1	2.9±0.8
			Ra-228	1.5±0.2	2.0±0.5
			Uranium	4.7±0.6	5.0±10.4
	Sample B		Gross beta	28.7±1.2	35.0±8.7
			Sr-89	5.7±0.6	7.0±8.7
			Sr-90	7.0±0.0	7.0±2.6
			Co-60	10.7±1.5	10.0±8.7
			Cs-134	4.0±1.7	5.0±8.7
			Cs-137	5.3±0.6	5.0±8.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±1σ, n=3[d]
STAF-457	Air Filter	April 1986	Gross alpha	13.7±0.6	15.0±8.7
			Gross beta	46.3±0.6	47.0±8.7
			Sr-90	14.7±0.6	18.0±2.6
			Cs-137	10.7±0.6	10.0±8.7
STU-458	Urine	April 1986	Tritium	4313±70	4423±327
STW-459	Water	May 1986	Sr-89	4.3±0.6	5.0±8.7
			Sr-90	5.0±0.0	5.0±2.6
STW-460	Water	May 1986	Gross alpha	5.3±0.6	8.0±8.7
			Gross beta	11.3±1.2	15.0±8.7
STW-461	Water	June 1986	Cr-51	<9.0	0.0±8.7
			Co-60	66.0±1.0	66.0±8.7
			Zn-65	87.3±1.5	86.0±8.7
			Ru-106	39.7±2.5	50.0±8.7
			Cs-134	49.3±2.5	49.0±8.7
			Cs-137	10.3±1.5	10.0±8.7
STW-462	Water	June 1986	Tritium	3427±25	3125±626
STM-464	Milk	June 1986	Sr-89	<1.0	0.0±8.7
			Sr-90	15.3±0.6	16.0±2.6
			I-131	48.3±2.3	41.0±10.4
			Cs-137	43.7±1.5	31.0±8.7
			K-40	1567±114	1600±139
STW-465	Water	July 1986	Gross alpha	4.7±0.6	6.0±8.7
			Gross beta	18.7±1.2	18.0±8.7
STW-467	Water	August 1986	I-131	30.3±0.6	45.0±10.4
STW-468	Water	August 1986	Pu-239	11.3±0.6	10.1±1.8
STW-469	Water	August 1986	Uranium	4.0±0.0	4.0±10.4
STAF-470	Air Filter	September 1986	Gross alpha	19.3±1.5	22.0±8.7
471			Gross beta	64.0±2.6	66.0±8.7
472			Sr-90	22.0±1.0	22.0±2.6
			Cs-137	25.7±1.5	22.0±8.7
STW-473	Water	September 1986	Ra-226	6.0±0.1	6.1±1.6
			Ra-228	8.7±1.1	9.1±2.4

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/l[b] TIML Result ±2σ[c]	EPA Result ±1σ, n=3[d]
STW-474	Water	September 1986	Gross alpha	16.3±3.2	15.0±8.7
			Gross beta	9.0±1.0	8.0±8.7
STW-475	Water	October 1986	Cr-51	63.3±5.5	59.0±8.7
			Co-60	31.0±2.0	31.0±8.7
			Zn-65	87.3±5.9	85.0±8.7
			Ru-106	74.7±7.4	74.0±8.7
			Cs-134	25.7±0.6	28.0±8.7
			Cs-137	46.3±1.5	44.0±8.7
STW-476	Water	October 1986	H-3	5918±60	5973±1035
STM-479	Milk	November 1986	Sr-89	7.7±1.2	9.0±8.7
			Sr-90	1.0±0.0	0.0±2.6
			I-131	52.3±3.1	49.0±10.4
			Cs-137	45.7±3.1	39.0±8.7
			K-40	1489±104	1565±135
STU-480	Urine	November 1986	H-3	5540±26	5257±912
STW-481	Water	November 1986	Gross alpha	12.0±4.0	20.0±8.7
			Gross beta	20.0±3.5	20.0±8.7

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

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

[d] USEPA results are presented as the known values ± control limits of 1σ for n = 3.

[e] NA = Not analyzed.

[f] Analyzed but not reported to the EPA.

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

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

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	mR: Average ±2σ[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 the 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]	Known Value[c]	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	Teledyne Result ±2σ [a] (mR)	Known Value [c] (mR)	Average ± 2σ [d] (all participants) (mR)
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

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

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

Lab Code	Sample Type	Oate 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

Appendix B

Data Reporting Conventions

Data Reporting Conventions

1.0. All activities are decay corrected to collection time.

2.0. Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where x = value of the measurement;

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

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

$$<L$$

where L = is the lower limit of detection based on 4.66σ 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 $x = (1/2)\ (x_1 + x_2)$

$$s = \sqrt{s_1^2 + s_2^2}$$

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.

Appendix D

Summary of the Land Use Census

APPENDIX D

SUMMARY OF THE LAND USE CENSUS

The 1986 Land Use Census was conducted during the month of June 1986. It consisted of a farm by farm inspection and a boat trip down the Cedar River from the plant discharge to identify land and river usage within a three (3) mile radius of the Duane Arnold Energy Center. In some sectors it was necessary to expand the census to five (5) miles.

The river census showed that the main usage was recreation and sport fishing. However, one location about three (3) miles downstream was being used for irrigation of strawberries. This parameter was added to the Off-site Dose Assessment Manual as well as to the Dose Calculation Program.

The land census revealed three (3) previously occuppied residences were vacant and there were no new residences. The three (3) vacant residences are located in the south, south southwest, and the west southwest sectors, at distances of 1.0, 1.1, and 2.0 miles respectively.

The comparison of the monthly dose calculations to the current sampling locations revealed that all pathways are adequately covered in that sampling locations existed in the vicinity of the highest calculated dose. In all cases the yearly calculated dose was insignificant.

Appendix E

Annual Radiation Dose Assessment

The annual offsite radiation dose to a member of the public was determined using environmental dosimeters and by monitoring of effluent releases. The direct dose to a member of the public is discussed in Section A and the dose contribution from effluent releases is discussed in Section B.

Section A. Dose Contribution from Direct Radiation

Direct radiation from DAEC was recorded by TLDs placed at locations around the plant. Observations from the collected data are discussed below:

1. Pre-operational and 1986 environmental TLDs were compared. A paired difference test was performed to detect any statistically significant difference between the pre-operational and 1986 data at 0.5, 1, and 3 miles from DAEC. Using a confidence level of 99%, no difference was detected. Thus, a member of the public, outside of the site boundary, received no dose from direct radiation from the DAEC.

Section B. Dose Contribution from Effluent Releases

The contribution of dose to a member of the public from effluent releases was calculated by the MIDAS computer program in accordance with the DAEC Offsite Dose Assessment Manual (ODAM). The ODAM calculational methods follow those prescribed by Reg. Guide 1.109 and NUREG-0133. Results of these calculations are discussed below:

1. There were no liquid releases for the calendar year 1986.

2. The doses from noble gas releases were 2.3E-3 mrad from gamma radiation and 4.6E-4 mrad from beta radiation. The maximum dose equivalent that would have been received by an individual from all other pathways other than noble gases (e.g., ingestion) was 1.4E-1 mrem. These results are well within the maximum dose rate limits specified in 10 CFR 50.

3. The maximum offsite dose rates in mrem/year were 2.4E-3 for the whole body, 3.4E-3 for the skin and 3.9E-1 from particulates and radionuclides other than noble gases. These results are well within the maximum dose rate limits specified in 10 CFR 20.

Conclusion

The maximum dose to any individual outside of the DAEC site boundary was 0.14 mrem for 1986. This number includes the contributions from direct radiation and from effluent releases and assumes a quality factor of 1 for all radiation types.

SUMMARY TABLE

TYPE	DOSE OR DOSE EQUIVALENT
Direct Radiation	0
Liquid Releases	0
Noble Gases	
Gamma	0.0023 mrad
Beta	0.00056 mrad
Particulates	0.14 mrem
TOTAL	.14 mrem

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REPORT

TO

IOWA ELECTRIC LIGHT AND POWER
CEDAR RAPIDS, IOWA

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM FOR THE DUANE ARNOLD ENERGY CENTER CEDAR RAPIDS, IOWA

Docket No. 50-331

ANNUAL REPORT - PART II
DATA TABULATIONS AND ANALYSES
JANUARY - DECEMBER 1986

PREPARED AND SUBMITTED
BY
TELEDYNE ISOTOPES MIDWEST LABORATORY
PROJECT NO. 8001

Approved by: L. G. Huebner

L. G. Huebner
General Manager

27 February 1987

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

1.0 INTRODUCTION

The following constitutes a Supplement to the Annual Report for the Radiological Environmental Monitoring Program conducted at the Duane Arnold Energy Center, Cedar Rapids, Iowa. Results of completed analyses are presented in the attached tables.

For information regarding sampling locations, type and frequency of collection, and sample codes, please see Tables 5.3 - 5.5 and Figures 5-1 and 5-2 of Part I.

2.0 LISTING OF MISSED SAMPLES

Sample Type	Location	Expected Collection Date	Reason
Milk	D-106	08-19-86 09-03-86 09-16-86	Sample temporarily unavailable.
Well water	D-60	3rd Qtr. 4th Qtr.	Pump inoperative.
TLD	D-41	3rd Qtr.	Lost in the field.
Milk	D-93	12-02-86	Goat was dry.
TLD	D-85	4th Qtr.	Lost in the field.

3.0 DATA TABLES

Table 1. Airborne particulates collected at Location D-1, (Cedar Rapids), analysis for gross beta. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	284	0.023±0.003	07-10-86	279	0.018±0.003
01-16-86	285	0.024±0.004	07-17-86	276	0.021±0.004
01-23-86	286	0.033±0.004	07-24-86	277	0.022±0.004
01-30-86	286	0.031±0.004	07-31-86	276	0.022±0.004
02-06-86	285	0.023±0.004	08-07-86	278	0.020±0.003
02-13-86	287	0.035±0.004	08-14-86	277	0.022±0.004
02-20-86	286	0.036±0.004	08-21-86	277	0.032±0.004
02-27-86	285	0.042±0.004	08-28-86	277	0.022±0.004
03-06-86	284	0.017±0.003	09-04-86	276	0.037±0.004
03-13-86	284	0.021±0.004	09-11-86	278	0.026±0.004
03-20-86	286	0.018±0.004	09-18-86	276	0.023±0.004
03-27-86	285	0.019±0.004	09-25-86	277	0.022±0.004
04-03-86	285	0.024±0.004	10-02-86	277	0.019±0.003
1st Qtr. mean ± s.d.		0.027±0.008	3rd Qtr. mean ± s.d.		0.024±0.005
04-10-86	286	0.016±0.002	10-09-86	270	0.022±0.004
04-17-86	285	0.018±0.003	10-16-86	268	0.023±0.004
04-24-86	286	0.017±0.003	10-23-86	269	0.045±0.005
05-01-86	284	0.021±0.003	10-30-86	270	0.042±0.005
05-08-86	285	0.016±0.003	11-06-86	269	0.032±0.004
05-15-86	280	0.252±0.010[a]	11-13-86	268	0.029±0.004
05-22-86	281	0.284±0.010[a]	11-20-86	269	0.043±0.005
05-29-86	278	0.103±0.006[a]	11-26-86	232[b]	0.043±0.005
06-05-86	281	0.105±0.006[a]	12-04-86	307[c]	0.026±0.004
06-12-86	278	0.047±0.005[a]	12-11-86	268	0.032±0.004
06-19-86	281	0.025±0.004	12-18-86	269	0.041±0.005
06-26-86	279	0.023±0.004	12-26-86	305[c]	0.046±0.004
07-03-86	280	0.019±0.004	12-31-86	198[d]	0.050±0.006
2nd Qtr. mean ± s.d.		0.073±0.092	4th Qtr. mean ± s.d.		0.039±0.010

[a] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[b] Pump ran six days.
[c] Pump ran eight days.
[d] Pump ran five days.

Table 2. Airborne particulates collected at Location D-2, (Marion), analysis for gross beta and iodine-131[a]. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.032±0.004	07-10-86	287	0.022±0.004
01-16-86	297	0.021±0.004	07-17-86	284	0.019±0.003
01-23-86	298	0.032±0.004	07-24-86	284	0.021±0.003
01-30-86	285	0.024±0.004	07-31-86	281	0.024±0.004
02-06-86	285	0.020±0.003	08-07-86	283	0.018±0.003
02-13-86	286	0.023±0.003	08-14-86	283	0.021±0.004
02-20-86	285	0.031±0.004	08-21-86	283	0.031±0.004
02-27-86	285	0.030±0.004	08-28-86	283	0.023±0.004
03-06-86	286	0.019±0.003	09-04-86	281	0.037±0.004
03-13-86	285	0.018±0.004	09-11-86	284	0.022±0.004
03-20-86	286	0.012±0.003	09-18-86	282	0.027±0.004
03-27-86	286	0.018±0.004	09-25-86	282	0.019±0.003
04-03-86	284	0.020±0.004	10-02-86	283	0.020±0.003
1st Qtr. mean ± s.d.		0.023±0.006	3rd Qtr. mean ± s.d.		0.023±0.005
04-10-86	286	0.013±0.002	10-09-86	284	0.020±0.003
04-17-86	285	0.014±0.003	10-16-86	281	0.020±0.003
04-24-86	279	0.017±0.003	10-23-86	274	0.044±0.005
05-01-86	284	0.022±0.003	10-30-86	277	0.030±0.004
05-08-86	286	0.015±0.003	11-06-86	273	0.029±0.004
05-15-86	286	0.266±0.010[b]	11-13-86	274	0.025±0.004
05-22-86	286	0.300±0.010[b]	11-20-86	274	0.036±0.004
05-29-86	284	0.102±0.006[b]	11-26-86	235[c]	0.042±0.005
06-05-86	287	0.110±0.006[b]	12-04-86	313[d]	0.027±0.004
06-12-86	284	0.046±0.004[b]	12-11-86	275	0.030±0.004
06-19-86	286	0.028±0.004	12-18-86	275	0.040±0.004
06-26-86	285	0.024±0.004	12-26-86	312[d]	0.046±0.004
07-03-86	285	0.031±0.004	12-31-86	195[e]	0.051±0.006
2nd Qtr. mean ± s.d.		0.076±0.097	4th Qtr. mean ± s.d.		0.034±0.010

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix A.

[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

[c] Pump ran six days.

[d] Pump ran eight days.

[e] Pump ran five days.

Table 3. Airborne particulates collected at Location D-3, (Hiawatha), analysis for gross beta. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.025±0.004	07-10-86	278	0.025±0.004
01-16-86	285	0.018±0.003	07-17-86	276	0.020±0.004
01-23-86	286	0.035±0.004	07-24-86	301	0.016±0.003
01-30-86	285	0.028±0.004	07-31-86	298	0.018±0.003
02-06-86	285	0.021±0.003	08-07-86	300	0.019±0.003
02-13-86	286	0.038±0.004	08-14-86	301	0.019±0.004
02-20-86	285	0.034±0.004	08-21-86	300	0.029±0.004
02-27-86	285	0.037±0.004	08-28-86	300	0.017±0.003
03-06-86	286	0.020±0.003	09-04-86	299	0.031±0.004
03-13-86	285	0.023±0.004	09-11-86	300	0.023±0.003
03-20-86	286	0.014±0.003	09-18-86	299	0.022±0.003
03-27-86	285	0.018±0.004	09-25-86	300	0.020±0.003
04-03-86	286	0.026±0.004	10-02-86	300	0.020±0.003
1st Qtr. mean ± s.d.		0.026±0.008	3rd Qtr. mean ± s.d.		0.021±0.005
4-10-86	286	0.017±0.002	10-09-86	301	0.015±0.003
4-17-86	285	0.018±0.003	10-16-86	270	0.018±0.003
04-24-86	285	0.018±0.003	10-23-86	271	0.039±0.004
05-01-86	284	0.023±0.003	10-30-86	274	0.033±0.004
05-08-86	286	0.016±0.003	11-06-86	270	0.024±0.004
05-15-86	276	0.267±0.010[a]	11-13-86	150[b,c]	0.023±0.006
05-22-86	278	0.335±0.011[a]	11-20-86	253[d]	0.035±0.004
05-29-86	277	0.122±0.007[a]	11-26-86	250[d]	0.037±0.004
06-05-86	278	0.112±0.006[a]	12-04-86	336[e]	0.021±0.003
06-12-86	275	0.047±0.005[a]	12-11-86	295	0.026±0.004
06-19-86	277	0.028±0.004	12-18-86	295	0.034±0.004
06-26-86	278	0.027±0.004	12-26-86	335[e]	0.032±0.004
07-03-86	276	0.034±0.004	12-31-86	210[f]	0.038±0.005
2nd Qtr. mean ± s.d		0.082±0.104	4th Qtr. mean ± s.d.		0.029±0.008

[a] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[b] Low volume due to pump malfunction.
[c] Pump ran four days.
[d] Pump ran six days.
[e] Pump ran eight days.
[f] Pump ran five days.

Table 4. Airborne particulates collected at Location D-5, (Palo), analysis for gross beta and iodine-131[a]. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.030±0.004	07-10-86	287	0.018±0.003
01-16-86	286	0.024±0.004	07-17-86	284	0.020±0.003
01-23-86	286	0.031±0.004	07-24-86	283	0.007±0.003
01-30-86	285	0.026±0.004	07-31-86	282	0.026±0.004
02-06-86	285	0.018±0.003	08-07-86	282	0.022±0.003
02-13-86	286	0.025±0.004	08-14-86	283	0.018±0.004
02-20-86	284	0.029±0.004	08-21-86	283	0.032±0.004
02-27-86	286	0.028±0.004	08-28-86	283	0.020±0.003
03-06-86	285	0.015±0.003	09-04-86	283	0.034±0.004
03-13-86	286	0.021±0.004	09-11-86	251[c]	0.032±0.004
03-20-86	286	0.012±0.003	09-18-86	314[d]	0.021±0.003
03-27-86	285	0.016±0.003	09-25-86	282	0.019±0.003
04-03-86	285	0.021±0.004	10-02-86	282	0.021±0.003
1st Qtr. mean ± s.d.		0.023±0.006	3rd Qtr. mean ± s.d.		0.022±0.007
4-10-86	285	0.013±0.002	10-09-86	284	0.018±0.003
4-17-86	286	0.012±0.003	10-16-86	288	0.018±0.003
04-24-86	285	0.016±0.003	10-23-86	288	0.042±0.004
05-01-86	283	0.021±0.003	10-30-86	290	0.031±0.004
05-08-86	285	0.016±0.003	11-06-86	288	0.022±0.004
05-15-86	285	0.234±0.009[b]	11-13-86	288	0.022±0.004
05-22-86	284	0.284±0.010[b]	11-20-86	288	0.030±0.004
05-29-86	285	0.097±0.006[b]	11-26-86	246[c]	0.032±0.004
06-05-86	287	0.091±0.006[b]	12-04-86	330[d]	0.020±0.003
06-12-86	284	0.040±0.004[b]	12-11-86	289	0.023±0.004
06-19-86	285	0.020±0.003	12-18-86	288	0.031±0.004
06-26-86	286	0.021±0.004	12-26-86	329[d]	0.032±0.004
07-03-86	284	0.031±0.004	12-31-86	206[e]	0.039±0.005
2nd Qtr. mean ± s.d.		0.069±0.089	4th Qtr. mean ± s.d.		0.028±0.008

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix A.
[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[c] Pump ran six days.
[d] Pump ran eight days.
[e] Pump ran five days.

Table 5. Airborne particulates collected at Location D-6, (Center Point), analysis for gross beta. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.034±0.004	07-10-86	267	0.020±0.004
01-16-86	286	0.025±0.004	07-17-86	273	0.024±0.004
01-23-86	286	0.032±0.004	07-24-86	275	0.016±0.003
01-30-86	285	0.029±0.004	07-31-86	274	0.023±0.004
02-06-86	285	0.023±0.004	08-07-86	273	0.022±0.004
02-13-86	286	0.035±0.004	08-14-86	275	0.020±0.004
02-20-86	284	0.039±0.004	08-21-86	274	0.031±0.004
02-27-86	286	0.042±0.004	08-28-86	274	0.020±0.003
03-06-86	285	0.022±0.004	09-04-86	275	0.028±0.004
03-13-86	285	0.019±0.004	09-11-86	241[b]	0.023±0.004
03-20-86	286	0.018±0.004	09-18-86	307[c]	0.020±0.003
03-27-86	285	0.018±0.004	09-25-86	274	0.020±0.003
04-03-86	286	0.025±0.004	10-02-86	274	0.022±0.004
1st Qtr. mean ± s.d.		0.028±0.008	3rd Qtr. mean ± s.d.		0.022±0.004
04-10-86	286	0.014±0.002	10-09-86	295	0.014±0.003
04-17-86	285	0.018±0.003	10-16-86	294	0.016±0.003
04-24-86	285	0.016±0.003	10-23-86	294	0.037±0.004
05-01-86	284	0.023±0.003	10-30-86	296	0.028±0.004
05-08-86	286	0.016±0.003	11-06-86	294	0.023±0.004
05-15-86	265	0.290±0.011[a]	11-13-86	294	0.020±0.003
05-22-86	277	0.375±0.012[a]	11-20-86	294	0.033±0.004
05-29-86	265	0.114±0.007[a]	11-26-86	250[b]	0.032±0.004
06-05-86	268	0.119±0.007[a]	12-04-86	336[c]	0.021±0.003
06-12-86	264	0.056±0.005[a]	12-11-86	294	0.046±0.005
06-19-86	265	0.022±0.004	12-18-86	295	0.036±0.004
06-26-86	267	0.022±0.004	12-26-86	335[c]	0.038±0.004
07-03-86	264	0.026±0.004	12-31-86	209[d]	0.036±0.005
2nd Qtr. mean ± s.d.		0.085±0.117	4th Qtr. mean ± s.d.		0.029±0.010

[a] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[b] Pump ran six days.
[c] Pump ran eight days.
[d] Pump ran five days.

Table 6. Airborne particulates collected at Location D-7, (Shellsburg), analysis for gross beta and iodine-131[a]. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.034±0.004	07-10-86	272	0.009±0.003
01-16-86	286	0.028±0.004	07-17-86	270	0.011±0.003
01-23-86	286	0.038±0.004	07-24-86	297	0.008±0.003
01-30-86	285	0.027±0.004	07-31-86	296	0.008±0.003
02-06-86	285	0.023±0.004	08-07-86	296	0.006±0.002
02-13-86	286	0.023±0.003	08-14-86	298	0.015±0.003
02-20-86	284	0.032±0.004	08-21-86	297	0.018±0.003
02-27-86	286	0.033±0.004	08-28-86	297	0.018±0.003
03-06-86	285	0.016±0.003	09-04-86	297	0.006±0.003
03-13-86	285	0.016±0.004	09-11-86	263[c]	0.008±0.003
03-20-86	286	0.012±0.003	09-18-86	331[d]	0.027±0.003
03-27-86	285	0.016±0.003	09-25-86	296	0.022±0.003
04-03-86	285	0.018±0.004	10-02-86	297	0.021±0.003
1st Qtr. mean ± s.d.		0.024±0.008	3rd Qtr. mean ± s.d.		0.014±0.007
[illegible]4-10-86	285	0.011±0.002	10-09-86	298	0.017±0.003
[illegible]4-17-86	286	0.016±0.003	10-16-86	296	0.007±0.002
04-24-86	285	0.008±0.003	10-23-86	285	0.017±0.003
05-01-86	283	0.015±0.003	10-30-86	287	0.037±0.004
05-08-86	285	0.007±0.003	11-06-86	286	0.030±0.004
05-15-86	271	0.145±0.008[b]	11-13-86	285	0.020±0.003
05-22-86	271	0.131±0.007[b]	11-20-86	285	0.034±0.004
05-29-86	271	0.046±0.005[b]	11-26-86	244[c]	0.039±0.005
06-05-86	274	0.068±0.005[b]	12-04-86	326[d]	0.030±0.004
06-12-86	270	0.033±0.004	12-11-86	286	0.028±0.004
06-19-86	271	0.012±0.003	12-18-86	285	0.022±0.004
06-26-86	272	0.016±0.003	12-26-86	326[d]	0.034±0.004
07-03-86	270	0.029±0.004	12-31-86	204[e]	0.042±0.006
2nd Qtr. mean ± s.d.		0.041±0.046	4th Qtr. mean ± s.d.		0.027±0.010

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix A.
[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[c] Pump ran six days.
[d] Pump ran eight days.
[e] Pump ran five days.

Table 7. Airborne particulates collected at Location D-8, (Urbana), analysis for gross beta and iodine-131[a]. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.028±0.004	07-10-86	275	0.024±0.004
01-16-86	286	0.018±0.003	07-17-86	264	0.015±0.003
01-23-86	286	0.030±0.004	07-24-86	266	0.016±0.003
01-30-86	285	0.024±0.004	07-31-86	285	0.019±0.004
02-06-86	285	0.018±0.003	08-07-86	265	0.020±0.004
02-13-86	286	0.025±0.004	08-14-86	235	0.015±0.004
02-20-86	284	0.022±0.004	08-21-86	266	0.026±0.004
02-27-86	286	0.033±0.004	08-28-86	265	0.018±0.003
03-06-86	285	<0.004	09-04-86	266	0.027±0.004
03-13-86	285	0.018±0.004	09-11-86	234[c]	0.020±0.004
03-20-86	286	0.018±0.004	09-18-86	297[d]	0.020±0.003
03-27-86	285	0.016±0.003	09-25-86	265	0.012±0.003
04-03-86	285	0.022±0.004	10-02-86	265	0.018±0.003
1st Qtr. mean ± s.d.		0.023±0.005	3rd Qtr. mean ± s.d.		0.019±0.004
4-10-86	286	0.014±0.002	10-09-86	295	0.020±0.003
4-17-86	285	0.014±0.003	10-16-86	294	0.020±0.003
04-24-86	285	0.016±0.003	10-23-86	294	0.044±0.004
05-01-86	284	0.021±0.003	10-30-86	296	0.032±0.004
05-08-86	286	0.016±0.003	11-06-86	294	0.024±0.004
05-15-86	274	0.267±0.010[b]	11-13-86	294	0.022±0.003
05-22-86	275	0.334±0.011[b]	11-20-86	294	0.033±0.004
05-29-86	273	0.114±0.007[b]	11-26-86	251[c]	0.041±0.005
06-05-86	276	0.112±0.006[b]	12-04-86	337[d]	0.018±0.003
06-12-86	272	0.057±0.005[b]	12-11-86	294	0.029±0.004
06-19-86	274	0.024±0.004	12-18-86	295	0.034±0.004
06-26-86	275	0.022±0.004	12-26-86	334[d]	0.033±0.004
07-03-86	273	0.025±0.004	12-31-86	209[e]	0.043±0.006
2nd Qtr. mean ± s.d.		0.080±0.105	4th Qtr. mean ± s.d.		0.030±0.009

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix A.

[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

[c] Pump ran six days.

[d] Pump ran eignt days.

[e] Pump ran five days.

Table 8. Airborne particulates collected at Location D-10, (Atkins), analysis for gross beta. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	284	0.034±0.004	07-10-86	293	0.013±0.003
01-16-86	286	0.028±0.004	07-17-86	294	0.016±0.003
01-23-86	285	0.030±0.004	07-24-86	294	0.014±0.003
01-30-86	252[a]	0.014±0.003	07-31-86	282	0.027±0.004
02-06-86	253[a]	0.019±0.004	08-07-86	284	0.023±0.004
02-13-86	287	0.033±0.004	08-14-86	286	0.019±0.004
02-20-86	287	0.037±0.004	08-21-86	282	0.031±0.004
02-27-86	284	0.039±0.004	08-28-86	282	0.022±0.004
03-06-86	286	0.020±0.003	09-04-86	41[a]	0.032±0.018
03-13-86	284	0.020±0.004	09-11-86	248[c]	0.024±0.004
03-20-86	286	0.018±0.004	09-18-86	282	0.023±0.004
03-27-86	284	0.020±0.004	09-25-86	287	0.018±0.003
04-03-86	285	0.024±0.004	10-02-86	289	0.015±0.003
1st Qtr. mean ± s.d.		0.026±0.008	3rd Qtr. mean ± s.d.		0.021±0.006
04-10-86	286	0.014±0.003	10-09-86	290	0.015±0.003
04-17-86	287	0.016±0.003	10-16-86	288	0.019±0.003
04-24-86	283	0.018±0.003	10-23-86	276	0.040±0.004
05-01-86	284	0.019±0.003	10-30-86	278	0.029±0.004
05-08-86	286	0.013±0.003	11-06-86	277	0.026±0.004
05-15-86	293	0.219±0.009[b]	11-13-86	282	0.020±0.003
05-22-86	294	0.248±0.009[b]	11-20-86	278	0.028±0.004
05-29-86	294	0.080±0.005[b]	11-26-86	251[c]	0.029±0.004
06-05-86	294	0.079±0.005[b]	12-04-86	318[d]	0.022±0.003
06-12-86	293	0.037±0.004	12-11-86	277	0.025±0.004
06-19-86	294	0.019±0.003	12-18-86	278	0.029±0.004
06-26-86	295	0.016±0.003	12-26-86	315[d]	0.033±0.004
07-03-86	295	0.023±0.004	12-31-86	199[e]	0.030±0.005
2nd Qtr. mean ± s.d.		0.062±0.080	4th Qtr. mean ± s.d.		0.027±0.007

[a] Low volume due to pump malfunction.
[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[c] Pump ran six days.
[d] Pump ran eight days.
[e] Pump ran five days.

ble 9. Airborne particulates collected at Location D-11, (Toddville), analysis for gross beta and iodine-131.[a] Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.034±0.004	07-10-86	267	0.021±0.004
01-16-86	286	0.022±0.004	07-17-86	264	0.015±0.003
01-23-86	286	0.008±0.002	07-24-86	266	0.015±0.003
01-30-86	285	<0.004	07-31-86	271	0.028±0.004
02-06-86	285	0.025±0.004	08-07-86	271	0.023±0.004
02-13-86	286	0.033±0.004	08-14-86	272	0.019±0.004
02-20-86	284	0.030±0.004	08-21-86	271	0.032±0.004
02-27-86	286	0.037±0.004	08-28-86	271	0.021±0.004
03-06-86	286	0.022±0.004	09-04-86	272	0.034±0.004
03-13-86	285	0.023±0.004	09-11-86	236[c]	0.024±0.004
03-20-86	286	0.017±0.004	09-18-86	306[d]	0.023±0.003
03-27-86	285	0.018±0.004	09-25-86	271	0.020±0.003
04-03-86	286	0.020±0.004	10-02-86	271	0.019±0.003
1st Qtr. mean ± s.d.		0.024±0.008	3rd Qtr. mean ± s.d.		0.023±0.006
[illegible]-10-86	286	0.017±0.003	10-09-86	272	0.017±0.003
[illegible]-17-86	285	0.019±0.003	10-16-86	311	0.020±0.003
04-24-86	285	0.014±0.003	10-23-86	311	0.051±0.004
05-01-86	284	0.019±0.003	10-30-86	313	0.038±0.004
05-08-86	286	0.015±0.003	11-06-86	311	0.027±0.004
05-15-86	265	0.240±0.010[b]	11-13-86	311	0.028±0.004
05-22-86	264	0.300±0.011[b]	11-20-86	311	0.017±0.003
05-29-86	265	0.087±0.006[b]	11-26-86	267[c]	0.040±0.004
06-05-86	281	0.090±0.006[b]	12-04-86	356[d]	0.026±0.003
06-12-86	264	0.045±0.005[b]	12-11-86	311	0.004±0.002
06-19-86	265	0.036±0.004	12-18-86	313	0.026±0.004
06-26-86	267	0.022±0.004	12-26-86	354[d]	0.019±0.003
07-03-86	264	0.029±0.004	12-31-86	221[e]	0.032±0.005
2nd Qtr. mean ± s.d.		0.074±0.099	4th Qtr. mean ± s.d.		0.027±0.012

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix A.
[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[c] Pump ran six days.
[d] Pump ran eight days.
[e] Pump ran five days.

Table 10. Airborne particulates collected at Location D-13, (Alburnett), analysis for gross beta. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.022±0.003	07-10-86	267	0.020±0.004
01-16-86	286	0.026±0.004	07-17-86	276	0.022±0.004
01-23-86	285	0.032±0.004	07-24-86	278	0.019±0.003
01-30-86	286	0.026±0.004	07-31-86	276	0.022±0.004
02-06-86	285	0.025±0.004	08-07-86	276	0.024±0.004
02-13-86	286	0.036±0.004	08-14-86	277	0.019±0.004
02-20-86	284	0.043±0.004	08-21-86	277	0.028±0.004
02-27-86	286	0.032±0.004	08-28-86	277	0.019±0.003
03-06-86	285	0.022±0.004	09-04-86	277	0.031±0.004
03-13-86	285	0.024±0.004	09-11-86	242[b]	0.026±0.004
03-20-86	286	0.012±0.003	09-18-86	312[c]	0.019±0.003
03-27-86	285	0.020±0.004	09-25-86	276	0.017±0.003
04-03-86	286	0.022±0.004	10-02-86	277	0.020±0.003
1st Qtr. mean ± s.d.		0.026±0.008	3rd Qtr. mean ± s.d.		0.022±0.004
04-10-86	286	0.017±0.003	10-09-86	298	0.008±0.002
04-17-86	285	0.016±0.003	10-16-86	282	0.023±0.004
04-24-86	285	0.019±0.003	10-23-86	283	0.046±0.004
05-01-86	284	0.018±0.003	10-30-86	285	0.036±0.004
05-08-86	286	0.017±0.003	11-06-86	283	0.030±0.004
05-15-86	265	0.242±0.010[a]	11-13-86	283	0.021±0.004
05-22-86	266	0.348±0.012[a]	11-20-86	283	0.036±0.404
05-29-86	265	0.093±0.006[a]	11-26-86	243[b]	0.044±0.005
06-05-86	268	0.104±0.006[a]	12-04-86	323[c]	0.025±0.003
06-12-86	264	0.054±0.005[a]	12-11-86	283	0.032±0.004
06-19-86	265	0.024±0.004	12-18-86	283	0.043±0.004
06-26-86	267	0.024±0.004	12-26-86	322[c]	0.044±0.004
07-03-86	264	0.022±0.004	12-31-86	202[d]	0.043±0.006
2nd Qtr. mean ± s.d		0.077±0.104	4th Qtr. mean ± s.d.		0.033±0.011

[a] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[b] Pump ran six days.
[c] Pump ran eight days.
[d] Pump ran five days.

Table 11. Airborne particulates collected at Location D-15, (On-site), analysis for gross beta and iodine-131.[a] Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.021±0.003	07-10-86	294	0.017±0.003
01-16-86	286	0.007±0.003	07-17-86	294	0.014±0.003
01-23-86	285	0.030±0.004	07-24-86	294	0.019±0.003
01-30-86	285	0.026±0.004	07-31-86	305	0.020±0.003
02-06-86	286	0.016±0.003	08-07-86	305	0.007±0.002
02-13-86	286	0.029±0.004	08-14-86	306	0.016±0.003
02-20-86	284	0.030±0.004	08-21-86	306	0.022±0.003
02-27-86	286	0.031±0.004	08-28-86	305	0.016±0.003
03-06-86	285	0.007±0.003	09-04-86	305	0.023±0.003
03-13-86	285	0.018±0.004	09-11-86	308	0.016±0.003
03-20-86	286	0.011±0.003	09-18-86	302	0.020±0.003
03-27-86	285	0.015±0.003	09-25-86	305	0.015±0.003
04-03-86	285	0.015±0.003	10-02-86	305	0.017±0.003
1st Qtr. mean ± s.d.		0.020±0.009	3rd Qtr. mean ± s.d.		0.017±0.004
04-10-86	285	0.014±0.003	10-09-86	305	0.012±0.003
04-17-86	286	<0.004	10-16-86	291	0.017±0.003
04-24-86	285	0.009±0.003	10-23-86	291	0.034±0.004
05-01-86	284	0.013±0.003	10-30-86	293	0.030±0.004
05-08-86	285	0.015±0.003	11-06-86	291	0.025±0.004
05-15-86	294	0.182±0.008[b]	11-13-86	292	0.020±0.003
05-22-86	292	0.232±0.009[b]	11-20-86	279	0.024±0.004
05-29-86	294	0.098±0.006[b]	11-26-86	250[c]	0.037±0.004
06-05-86	294	0.077±0.005[b]	12-04-86	247[c]	0.022±0.004
06-12-86	294	0.038±0.004[b]	12-11-86	38[e]	<0.036
06-19-86	294	0.021±0.003	12-18-86	291	0.022±0.004
06-26-86	294	0.018±0.003	12-26-86	333[d]	0.036±0.004
07-03-86	294	0.017±0.003	12-31-86	202[f]	0.038±0.005
2nd Qtr. mean ± s.d.		0.061±0.074	4th Qtr. mean ± s.d.		0.026±0.008

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix A.

[b] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

[c] Pump ran six days.

[d] Pump ran eight days.

[e] Low volume and elevated gross beta LLD due to pump malfunction.

[f] Pump ran five days.

Table 12. Airborne particulates collected at Location D-16, (Onsite), analysis for gross beta. Collection: Weekly.

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-09-86	285	0.023±0.003	07-10-86	306	0.022±0.003
01-16-86	286	0.019±0.004	07-17-86	305	0.018±0.003
01-23-86	285	0.027±0.004	07-24-86	292	0.020±0.003
01-30-86	285	0.023±0.004	07-31-86	291	0.020±0.004
02-06-86	285	0.018±0.003	08-07-86	290	0.019±0.003
02-13-86	285	0.023±0.003	08-14-86	292	0.016±0.004
02-20-86	276	0.031±0.004	08-21-86	291	0.025±0.004
02-27-86	286	0.029±0.004	08-28-86	291	0.019±0.003
03-06-86	285	0.013±0.003	09-04-86	291	0.026±0.004
03-13-86	285	0.017±0.004	09-11-86	294	0.021±0.003
03-20-86	286	0.019±0.004	09-18-86	288	0.023±0.004
03-27-86	285	0.014±0.003	09-25-86	291	0.016±0.003
04-03-86	285	0.020±0.004	10-02-86	291	0.021±0.003
1st Qtr. mean ± s.d.		0.021±0.005	3rd Qtr. mean ± s.d.		0.020±0.003
04-10-86	286	0.014±0.003	10-09-86	300	0.016±0.003
04-17-86	286	0.016±0.003	10-16-86	300	0.018±0.003
04-24-86	285	0.016±0.003	10-23-86	300	0.043±0.004
05-01-86	284	0.023±0.003	10-30-86	301	0.034±0.004
05-08-86	285	0.016±0.003	11-06-86	299	0.025±0.004
05-15-86	305	0.260±0.010[a]	11-13-86	301	0.024±0.004
05-22-86	305	0.362±0.011[a]	11-20-86	300	0.032±0.004
05-29-86	306	0.117±0.006[a]	11-26-86	255[b]	0.045±0.005
06-05-86	306	0.099±0.006[a]	12-04-86	343[c]	0.023±0.003
06-12-86	306	0.032±0.004	12-11-86	300	0.028±0.004
06-19-86	305	0.018±0.003	12-18-86	299	0.040±0.004
06-26-86	305	0.020±0.003	12-26-86	343[c]	0.042±0.004
07-03-86	305	0.019±0.003	12-31-86	214[d]	0.045±0.006
2nd Qtr. mean ± s.d.		0.078±0.111	4th Qtr. mean ± s.d.		0.032±0.010

[a] Elevated gross beta activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.
[b] Pump ran six days.
[c] Pump ran eight days.
[d] Pump ran five days.

Table 13. Airborne particulate samples, quarterly composites of weekly samples, analysis for gamma emitting isotopes.

Location	Isotope	Sample Description and Activity (pCi/m^3) 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
D-1	Lab Code	DAP-73	DAP-226	DAP-333	DAP-433
	Volume (m^3)	3708	3664	3601	3462
	Be-7	0.086±0.013	0.11±0.02	0.13±0.02	0.054±0.010
	Nb-95	<0.0019	<0.0023	<0.0037	<0.0017
	Zr-95	<0.0034	<0.0031	<0.0064	<0.0028
	Ru-103	<0.0028	<0.0082	<0.0047	<0.0015
	Ru-106	<0.017	<0.018	<0.018	<0.013
	Cs-134	<0.0014	<0.0043	<0.0023	<0.0014
	Cs-137	<0.0015	0.014±0.002[a]	<0.0018	<0.0014
	Ce-141	<0.0020	<0.0066	<0.0062	<0.0015
	Ce-144	<0.0058	<0.0077	<0.0083	<0.0036
D-2	Lab Code	DAP-74	DAP-227	DAP-334	DAP-434
	Volume (m^3)	3733	3703	3680	3542
	Be-7	0.045±0.008	0.11±0.01	0.12±0.02	0.073±0.008
	Nb-95	<0.0012	<0.0017	<0.0035	<0.0012
	Zr-95	<0.0017	<0.0038	<0.0076	<0.0025
	Ru-103	<0.0010	0.013±0.002[a]	<0.0034	<0.0013
	Ru-106	<0.0054	<0.014	<0.020	<0.0097
	Cs-134	<0.0008	0.0065±0.0008[a]	<0.0019	<0.0009
	Cs-137	<0.0007	0.014±0.001[a]	<0.0023	<0.0012
	Ce-141	<0.0009	<0.0044	<0.0061	<0.0013
	Ce-144	<0.0021	<0.0056	<0.012	<0.0025

[a] Elevated activity due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 13. (continued)

Location	Isotope	Sample Description and Activity (pCi/m^3) 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
D-3	Lab Code	DAP-75	DAP-228	DAP-335	DAP-435
	Volume (m^3)	3710	3641	3852	3510
	Be-7	0.073±0.011	0.090±0.030	0.062±0.013	0.046±0.010
	Nb-95	<0.0019	<0.0054	<0.0016	<0.0021
	Zr-95	<0.0025	<0.0050	<0.0021	<0.0031
	Ru-103	<0.0023	0.010±0.003[a]	<0.0022	<0.0024
	Ru-106	<0.013	<0.015	<0.0060	<0.015
	Cs-134	<0.0013	0.0071±0.0014[a]	<0.0010	<0.0014
	Cs-137	<0.0014	0.017±0.002[a]	<0.0012	<0.0018
	Ce-141	<0.0034	<0.0077	<0.0035	<0.0024
	Ce-144	<0.0074	<0.011	<0.0053	<0.0078
D-5	Lab Code	DAP-77	DAP-229	DAP-336	DAP-436
	Volume (m^3)	3710	3704	3679	3702
	Be-7	0.053±0.006	0.11±0.01	0.081±0.020	0.050±0.008
	Nb-95	<0.0007	<0.0011	<0.0032	<0.0012
	Zr-95	<0.0018	<0.0020	<0.0032	<0.0030
	Ru-103	<0.0015	0.011±0.001[a]	<0.0028	<0.0012
	Ru-106	<0.0064	0.011±0.005[a]	<0.0098	<0.010
	Cs-134	<0.0008	0.0065±0.0007[a]	<0.0013	<0.0012
	Cs-137	<0.0008	0.013±0.008[a]	<0.0014	<0.0011
	Ce-141	<0.0014	<0.0021	<0.0027	<0.0012
	Ce-144	<0.0032	<0.0029	<0.0044	<0.0031

[a] Elevated activity due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 13. (continued)

Location	Isotope	Sample Description and Activity (pCi/m^3)			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
D-6	Lab Code	DAP-78	DAP-230	DAP-337	DAP-437
	Volume (m^3)	3710	3561	3556	3780
	Be-7	<0.012	0.11±0.01	0.096±0.017	0.042±0.009
	Nb-95	<0.0020	<0.0009	<0.0026	<0.0017
	Zr-95	<0.0027	<0.0018	<0.0036	<0.0021
	Ru-103	<0.0018	0.013±0.002[a]	<0.0037	<0.0011
	Ru-106	<0.010	<0.0074	<0.015	<0.0084
	Cs-134	<0.0010	0.0065±0.0007[a]	<0.0012	<0.0009
	Cs-137	<0.0011	0.015±0.001[a]	<0.0017	<0.0010
	Ce-141	<0.0021	<0.0018	<0.0042	<0.0012
	Ce-144	<0.0050	<0.0023	<0.0074	<0.0029
D-7	Lab Code	DAP-79	DAP-231	DAP-338	DAP-438
	Volume (m^3)	3709	3594	3807	3693
	Be-7	0.049±0.008	0.063±0.015	0.040±0.011	<0.010
	Nb-95	<0.0016	<0.0019	<0.0023	<0.0017
	Zr-95	<0.0028	<0.0026	<0.0022	<0.0028
	Ru-103	<0.0016	<0.0047	<0.0016	<0.0014
	Ru-106	<0.011	<0.011	<0.0082	<0.0075
	Cs-134	<0.0015	0.0036±0.0008[a]	<0.0008	<0.0010
	Cs-137	<0.0012	0.0075±0.0008[a]	<0.0008	<0.0010
	Ce-141	<0.0012	<0.0047	<0.0019	<0.0014
	Ce-144	<0.0033	<0.0056	<0.0030	<0.0038

[a] Elevated activity due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 13. (continued)

Location	Isotope	Sample Description and Activity (pCi/m^3)			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
D-8	Lab Code	DAP-80	DAP-232	DAP-339	DAP-439
	Volume (m^3)	3709	3618	3448	3781
	Be-7	<0.037	0.082±0.017	0.090±0.016	0.043±0.009
	Nb-95	<0.0019	<0.0034	<0.0029	<0.0014
	Zr-95	<0.0036	<0.0033	<0.0055	<0.0019
	Ru-103	<0.0029	0.0081±0.0024[a]	<0.0044	<0.0012
	Ru-106	<0.013	<0.011	<0.016	<0.0072
	Cs-134	<0.0015	0.0047±0.0010[a]	<0.0019	<0.0008
	Cs-137	<0.0015	0.013±0.001[a]	<0.0017	<0.0009
	Ce-141	<0.0018	<0.0048	<0.0053	<0.0010
	Ce-144	<0.0053	<0.0061	<0.0086	<0.0029
D-10	Lab Code	DAP-82	DAP-233	DAP-340	DAP-440
	Volume (m^3)	3644	3778	3444	3607
	Be-7	0.046±0.011	0.082±0.024	0.12±0.02	0.042±0.011
	Nb-95	<0.0023	<0.0025	<0.0018	<0.0028
	Zr-95	<0.0029	<0.0031	<0.0033	<0.0036
	Ru-103	<0.0018	0.0062±0.0044[a]	<0.0026	<0.0017
	Ru-106	<0.011	<0.0090	<0.014	<0.014
	Cs-134	<0.0013	0.0054±0.0015[a]	<0.0015	<0.0013
	Cs-137	<0.0012	0.012±0.002[a]	<0.0012	<0.0014
	Ce-141	<0.0032	<0.0044	<0.0021	<0.0027
	Ce-144	<0.0082	<0.0060	<0.0033	<0.0072

[a] Elevated activity due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 13. (continued)

Location	Isotope	Sample Description and Activity (pCi/m^3) 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
D-11	Lab Code	DAP-83	DAP-234	DAP-341	DAP-441
	Volume (m^3)	3711	3561	3509	3962
	Be-7	<0.013	0.10±0.01	0.049±0.015	0.077±0.007
	Nb-95	<0.0020	<0.0014	<0.0026	<0.0012
	Zr-95	<0.0028	<0.0022	<0.0031	<0.0023
	Ru-103	<0.0019	0.010±0.001[a]	<0.0019	<0.0014
	Ru-106	<0.0085	<0.0083	<0.0093	<0.011
	Cs-134	<0.0011	0.0046±0.0007[a]	<0.0010	<0.0009
	Cs-137	<0.0010	0.012±0.001[a]	<0.0010	<0.0017
	Ce-141	<0.0022	<0.0019	<0.0024	<0.0013
	Ce-144	<0.0048	<0.0024	<0.0037	<0.0030
D-13	Lab Code	DAP-85	DAP-235	DAP-342	DAP-442
	Volume (m^3)	3710	3550	3588	3643
	Be-7	0.063±0.008	0.090±0.019	0.088±0.011	0.077±0.012
	Nb-95	<0.0009	<0.0039	<0.0013	<0.0015
	Zr-95	<0.0012	<0.0042	<0.0019	<0.0029
	Ru-103	<0.0012	0.0077±0.0026[a]	<0.0013	<0.0027
	Ru-106	<0.0065	<0.012	<0.0073	<0.013
	Cs-134	<0.0008	0.0044±0.0011[a]	<0.0006	<0.0015
	Cs-137	<0.0007	0.011±0.002[a]	<0.0008	<0.0018
	Ce-141	<0.0014	<0.0052	<0.0020	<0.0027
	Ce-144	<0.0030	<0.0072	<0.0035	<0.0069

[a] Elevated activity due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 13. (continued)

Location	Isotope	Sample Description and Activity (pCi/m^3) 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
D-15	Lab Code	DAP-87	DAP-236[a]	DAP-343	DAP-443
	Volume (m^3)	3709	3775	3934	3403
	Be-7	0.056±0.011	0.084±0.025	0.083±0.014	<0.025
	Nb-95	<0.0018	<0.0060	<0.0018	<0.0023
	Zr-95	<0.0024	<0.0053	<0.0038	<0.0030
	Ru-103	<0.0024	0.0094±0.0043[b]	<0.0025	<0.0017
	Ru-106	<0.011	<0.017	<0.010	<0.012
	Cs-134	<0.0010	0.0060±0.0013[b]	<0.0015	<0.0015
	Cs-137	<0.0012	0.011±0.002[b]	<0.0012	<0.0014
	Ce-141	<0.0029	<0.0084	<0.0035	<0.0013
	Ce-144	<0.0075	<0.011	<0.0056	<0.0041
D-16	Lab Code	DAP-88	DAP-237	DAP-344	DAP-444
	Volume (m^3)	3699	3869	3813	3855
	Be-7	<0.012	0.098±0.017	0.065±0.016	0.051±0.011
	Nb-95	<0.0022	<0.0020	<0.0032	<0.0017
	Zr-95	<0.0028	<0.0032	<0.0031	<0.0041
	Ru-103	<0.0017	0.014±0.003[b]	<0.0023	<0.0029
	Ru-106	<0.0094	<0.013	<0.010	<0.014
	Cs-134	<0.0010	0.0054±0.0009[b]	<0.0008	<0.0016
	Cs-137	<0.0010	0.013±0.001[b]	<0.0010	<0.0018
	Ce-141	<0.0029	<0.0050	<0.0024	<0.0038
	Ce-144	<0.0069	<0.0064	<0.0043	<0.0079

[a] Corrected results.
[b] Elevated activity due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 14. Ambient gamma radiation (TLD), quarterly exposure.

Location No.	mR/91 days 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Air Particulate Locations				
D-1	14.1±0.6	13.0±0.8	15.2±0.6	14.3±0.6
D-2	14.1±0.7	14.2±0.9	14.0±0.4	13.8±0.7
D-3	13.7±0.7	13.2±0.9	13.9±0.6	12.7±0.4
D-5	13.0±0.7	14.3±0.5	16.1±0.6	15.4±0.9
D-6	12.6±0.5	13.5±0.6	14.3±0.6	13.0±0.4
D-7	14.4±0.5	15.6±0.6	17.5±1.0	15.0±0.6
D-8	13.6±0.7	16.4±0.6	18.5±0.7	15.8±0.5
D-10	15.8±0.8	17.4±0.6	18.5±0.5	16.1±0.4
D-11	11.6±0.7	14.8±0.6	15.4±0.6	15.6±0.7
D-13	10.0±0.5	12.4±0.7	14.9±0.7	13.0±0.9
D-15	13.4±0.5	15.6±0.8	16.1±0.6	14.9±0.7
D-16	14.4±0.4	14.0±0.5	14.4±0.5	14.4±0.5
Mean ± s.d.	13.4±1.5	14.5±1.5	15.7±1.7	14.5±1.2
Within 0.5 mile of stack				
D-18	14.6±0.5	17.2±0.7	17.6±0.4	16.3±0.6
D-19	14.4±0.5	16.4±0.7	16.8±0.6	16.4±0.8
D-20	15.2±0.7	16.9±0.8	18.7±0.7	16.6±0.8
D-21	14.2±0.7	15.4±0.8	16.7±0.6	15.4±0.6
D-22	14.1±0.5	15.1±0.6	16.9±0.5	15.9±0.7
D-23	13.8±0.5	13.6±0.7	16.3±0.5	14.2±0.6
D-28	15.9±0.7	19.3±1.6	19.8±1.1	17.9±0.4
D-29	16.5±0.9	19.9±0.9	21.1±0.7	18.3±0.5
D-30	14.1±0.8	19.6±0.8	22.4±0.8	18.7±0.7
D-31	13.4±0.6	20.9±0.5	22.0±1.1	19.5±0.8
D-32	14.9±0.5	18.9±0.5	20.4±0.6	17.7±0.4
D-82	12.4±0.6	13.6±0.5	15.2±0.6	13.5±0.4
D-83	13.9±0.8	16.8±0.5	17.3±0.7	16.0±0.4
D-84	14.0±0.7	16.1±0.8	17.0±0.7	15.7±0.6
D-85	14.2±0.6	16.3±0.7	16.8±0.4	ND[a]
D-86	16.7±0.7	19.3±1.0	19.5±0.6	17.9±1.2
D-91	13.0±0.9	16.7±0.8	15.3±0.5	15.6±0.9
Mean ± s.d.	14.4±1.1	17.2±2.2	18.2±2.3	16.6±1.6

[a] ND = No data; TLD lost in the field.

Table 14. (continued)

Location No.	mR/91 days 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Within 1.0 mile of stack				
D-43	12.9±0.5	16.0±0.7	15.9±0.4	16.0±0.5
D-44	17.1±0.9	20.8±0.6	22.9±1.1	21.0±1.3
D-45	15.1±0.9	19.4±0.7	20.8±0.6	19.3±0.7
D-46	15.4±0.7	22.2±0.8	21.8±0.7	21.2±0.6
D-47	16.0±0.7	20.7±0.9	22.1±0.7	19.5±1.0
D-48	14.8±0.7	21.6±1.0	21.1±0.7	20.6±1.1
Mean ± s.d.	15.2±1.4	20.1±2.2	20.8±2.5	19.6±1.9
Within 3.0 miles of stack				
D-33	11.5±0.6	13.6±0.7	14.3±0.7	13.0±0.4
D-34	10.2±0.6	14.7±0.8	14.0±0.8	14.2±0.7
D-35	11.5±0.6	14.8±0.7	13.2±0.5	14.0±0.5
D-36	14.2±0.5	18.2±1.0	17.9±0.6	16.4±0.6
D-37	18.4±0.6	20.9±0.8	22.5±0.5	19.6±1.1
D-38	14.7±0.9	19.3±0.7	19.2±1.1	18.4±0.7
D-39	15.4±0.7	19.4±0.9	19.8±1.1	18.6±0.9
D-40	14.2±0.7	11.8±1.0	17.5±0.6	15.3±1.3
D-41	14.0±0.5	17.3±I.4	ND[a]	17.8±0.7
Mean ± s.d.	13.8±2.5	16.7±3.1	17.3±3.2	16.4±2.4

[a] ND = No data; TLD lost in the field.

Table 15. Milk samples, analyses for I-131 and gamma-emitting isotopes.
Collection: Monthly during non-grazing season (October 1 through April 30); biweekly during grazing season (May 1 through September 30)

Location and Date Collected	Lab Code	Concentration (pCi/l) I-131	Cs-134	Cs-137	Ba-140	La-140	K-40
Indicator							
D-63							
01-07-86	DMI-1932	<1.0	<15	<18	<60	<15	1240±70
02-04-86	1985	<1.0	<15	<18	<60	<15	1860±110
03-04-86	2046	<1.0	<15	<18	<60	<15	1410±90
04-01-86	2106	<1.0	<15	<18	<60	<15	1340±80
05-06-86	2214	<1.0	<15	<18	<60	<15	1320±160
05-20-86	2305	38.9±1.2[a]	<15	21±5[a]	<60	<15	1370±60
06-03-86	2406	11.9±0.6[a]	<15	18±5[a]	<60	<15	1410±110
06-10-86	2454	4.0±0.4[a]	<15	<18	<60	<15	1430±90
06-17-86	2500	2.1±0.3[a]	<15	<18	<60	<15	1340±60
06-24-86	2553	<1.0	<15	<18	<60	<15	1230±140
07-08-86	2643	<1.0	<15	<18	<60	<15	1250±130
07-22-86	2735,6	<1.0	<15	<18	<60	<15	1210±110
08-05-86	2810,1	<1.0	<15	<18	<60	<15	1330±80
08-19-86	2903	<1.0	<15	<18	<60	<15	1480±160
09-03-86	2967	<1.0	<15	<18	<60	<15	1270±80
09-16-86	3079	<1.0	<15	<18	<60	<15	1420±120
09-30-86	3138	<1.0	<15	<18	<60	<15	1410±120
10-07-86	3182	<1.0	<15	<18	<60	<15	1220±100
11-04-86	3348	<1.0	<15	<18	<60	<15	1230±100
12-02-86	3429,30	<1.0	<15	<18	<60	<15	1200±100
D-72							
01-07-86	DMI-1933	<1.0	<15	<18	<60	<15	1310±240
02-04-86	1986	<1.0	<15	<18	<60	<15	1120±140
03-04-86	2047	<1.0	<15	<18	<60	<15	1670±120
04-01-86	2107	<1.0	<15	<18	<60	<15	1330±60
05-06-86	2215	<1.0	<15	<18	<60	<15	1330±60
05-20-86	2306	4.8±0.6[a]	<15	30±5[a]	<60	<15	1340±120
06-03-86	2407	37.8±0.9[a]	17±3[a]	29±4[a]	<60	<15	1290±90
06-10-86	2455	17.5±0.8[a]	<15	<18	<60	<15	1190±70
06-17-86	2501	5.8±0.5[a]	<15	<18	<60	<15	1130±120
06-24-86	2554	1.7±0.2[a]	<15	<18	<60	<15	1180±70
07-08-86	2644	<1.0	<15	<18	<60	<15	1210±60
07-22-86	2737	<1.0	<15	<18	<60	<15	1300±70
08-05-86	2812	<1.0	<15	<18	<60	<15	1310±140
08-19-86	2904	<1.0	<15	<18	<60	<15	1360±90
09-03-86	2968	<1.0	<15	<18	<60	<15	1130±70
09-16-86	3080	<1.0	<15	<18	<60	<15	1240±80
09-30-86	3139	<1.0	<15	<18	<60	<15	1210±70
10-07-86	3183	<1.0	<15	<18	<60	<15	1200±150
11-04-86	3349	<1.0	<15	<18	<60	<15	1360±80
12-02-86	3431	<1.0	<15	<18	<60	<15	1240±70

[a] Elevated I-131, Cs-134 and Cs-137 activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 15. Milk samples, analysis for iodine-131 and gamma-emitting isotopes (continued)

Location and Date Collected	Lab Code	Concentration (pCi/l) I-131	Cs-134	Cs-137	Ba-140	La-140	K-40
Indicator							
D-93							
01-07-86	DMI-1934,5	<1.0	<15	<18	<60	<15	1330±130
02-04-86	1987	<1.0	<15	<18	<60	<15	1780±90
03-04-86	2048	<1.0	<15	<18	<60	<15	1800±90
04-01-86	2108	<1.0	<15	<18	<60	<15	1450±30
05-06-86	2216	<1.0	<15	<18	<60	<15	1700±80
05-20-86	2307	70.6±17.3[a]	<15	26±7[a]	<60	<15	1610±170
06-03-86	2408,9	28.6±4.4[a]	<15	26±4[a]	<60	<15	1700±80
06-10-86	2456	13.4±0.6[a]	<15	20±4[a]	<60	<15	1660±70
06-17-86	2502	3.9±0.4[a]	<15	<18	<60	<15	1710±50
06-24-86	2555	1.5±0.2[a]	<15	<18	<60	<15	1740±100
07-08-86	2645	<1.0	<15	<18	<60	<15	1740±90
07-22-86	2738	<1.0	<15	<18	<60	<15	1780±90
08-05-86	2813	<1.0	<15	<18	<60	<15	1610±150
08-19-86	2905,6	<1.0	<15	<18	<60	<15	1520±120
09-03-86	2969	<1.0	<15	<18	<60	<15	1870±170
09-16-86	3081	<1.0	<15	<18	<60	<15	1510±80
09-30-86	3140	<1.0	<15	<18	<60	<15	1760±80
10-07-86	3184	<1.0	<15	<18	<60	<15	1820±100
11-04-86	3350	<1.0	<15	<18	<60	<15	1370±150
12-02-86	NS[b]	--	--	--	--	--	--
D-94							
01-07-86	DMI-1936	<1.0	<15	<18	<60	<15	1360±240
02-04-86	1988	<1.0	<15	<18	<60	<15	1370±170
03-04-86	2049	<1.0	<15	<18	<60	<15	1340±60
04-01-86	2109	<1.0	<15	<18	<60	<15	1350±40
05-06-86	2217	<1.0	<15	<18	<60	<15	1270±80
05-20-86	2308	31.9±9.9[a]	<15	<18	<60	<15	1320±150
06-03-86	2410	9.3±0.7[a]	<15	<18	<60	<15	1140±80
06-10-86	2457	3.3±0.4[a]	<15	<18	<60	<15	1270±140
06-17-86	2503	2.5±0.3[a]	<15	<18	<60	<15	1310±100
06-24-86	2556	<1.0	<15	<18	<60	<15	1420±150
07-08-86	2646,7	<1.0	<15	<18	<60	<15	1250±60
07-22-86	2739	<1.0	<15	<18	<60	<15	1220±70
08-05-86	2814	<1.0	<15	<18	<60	<15	1300±80
08-19-86	2907	<1.0	<15	<18	<60	<15	1260±110
09-03-86	2970	<1.0	<15	<18	<60	<15	1210±110
09-16-86	3082	<1.0	<15	<18	<60	<15	1380±80
09-30-86	3141	<1.0	<15	<18	<60	<15	1280±70
10-07-86	3185	<1.0	<15	<18	<60	<15	1350±130
11-04-86	3351	<1.0	<15	<18	<60	<15	1320±80
12-02-86	3432	<1.0	<15	<18	<60	<15	1360±90

[a] Elevated I-131 and Cs-137 activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

[b] NS = No sample; goat was dry.

Table 15. Milk samples, analysis for iodine-131 and gamma-emitting isotopes (continued)

Location and Date Collected	Lab Code	Concentration (pCi/l) I-131	Cs-134	Cs-137	Ba-140	La-140	K-40
Indicator							
D-96							
01-07-86	DMI-1937	<1.0	<15	<18	<60	<15	1350±240
02-04-86	1989	<1.0	<15	<18	<60	<15	1330±130
03-04-86	2050	<1.0	<15	<18	<60	<15	1450±150
04-01-86	2110	<1.0	<15	<18	<60	<15	1480±60
05-06-86	2218	<1.0	<15	<18	<60	<15	1340±140
05-20-86	2309	1.3±0.4[a]	<15	<18	<60	<15	1310±50
06-03-86	2411	45.4±1.0[a]	<15	<18	<60	<15	1370±50
06-10-86	2458	10.0±0.6[a]	<15	<18	<60	<15	1500±80
06-17-86	2504	11.0±0.8[a]	<15	<18	<60	<15	1210±100
06-24-86	2557	2.0±0.2[a]	<15	<18	<60	<15	1230±60
07-08-86	2648	<1.0	<15	<18	<60	<15	1360±100
07-22-86	2740	<1.0	<15	<18	<60	<15	1390±130
08-05-86	2815	<1.0	<15	<18	<60	<15	1210±140
08-19-86	2908	<1.0	<15	<18	<60	<15	1260±110
09-03-86	2971	<1.0	<15	<18	<60	<15	1380±120
09-16-86	3083	<1.0	<15	<18	<60	<15	1290±120
09-30-86	3142	<1.0	<15	<18	<60	<15	1720±100
10-07-86	3186	<1.0	<15	<18	<60	<15	1310±130
11-04-86	3352	<1.0	<15	<18	<60	<15	1280±90
12-02-86	3433	<1.0	<15	<18	<60	<15	1190±160
D-101[b]							
04-01-86	DMI-2111,2	<1.0	<15	<18	<60	<15	1520±30
05-06-86	2219	<1.0	<15	<18	<60	<15	1640±90
05-20-86	2310	51.4±12.7[a]	<15	<18	<60	<15	1570±130
06-03-86	2412	44.7±1.1[a]	<15	25±9[a]	<60	<15	2130±220
06-10-86	2459,60	24.0±0.6[a]	<15	28±4[a]	<60	<15	1850±100
06-17-86	2505,6	5.0±0.3[a]	<15	23±3[a]	<60	<15	1730±70
06-24-86	2560	3.5±0.6[a]	<15	27±3[a]	<60	<15	1700±70
07-08-86	2651	1.8±0.4[a]	<15	<18	<60	<15	1720±160
07-22-86	2743	<1.0	<15	<18	<60	<15	1810±180
08-05-86	2816	<1.0	<15	<18	<60	<15	1810±130
08-19-86	2909	<1.0	<15	<18	<60	<15	2050±150
09-03-86	2972,3	<1.0	<15	<18	<60	<15	1780±70
09-16-86	3084	<1.0	<15	<18	<60	<15	1930±120
09-30-86	3143,4	<1.0	<15	<18	<60	<15	1610±60
10-07-86	3187	<1.0	<15	<18	<60	<15	2180±100
11-04-86	3353	<1.0	<15	<18	<60	<15	1800±160
12-02-86	3434	<1.0	<15	<18	<60	<15	1740±180

[a] Elevated I-131 and Cs-137 activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

[b] Collection began in April.

Table 15. Milk samples, analysis for iodine-131 and gamma-emitting isotopes (continued)

Location and Date Collected	Lab Code	Concentration (pCi/l) I-131	Cs-134	Cs-137	Ba-140	La-140	K-40
Indicator							
D-106							
01-07-86	DMI-1939	<1.0	<15	<18	<60	<15	1320±160
02-04-86	1991	<1.0	<15	<18	<60	<15	1250±230
03-04-86	2052,3	<1.0	<15	<18	<60	<15	1350±100
04-01-86	2114	<1.0	<15	<18	<60	<15	1740±60
05-06-86	2222	<1.0	<15	<18	<60	<15	1120±60
05-20-86	2312	3.2±0.3[a]	<15	<18	<60	<15	1300±70
06-03-86	2414	12.0±0.7[a]	<15	<18	<60	<15	1170±120
06-10-86	2462	8.6±0.5[a]	<15	<18	<60	<15	1320±140
06-17-86	2508	3.1±0.5[a]	<15	<18	<60	<15	1230±70
06-24-86	2559	<1.0	<15	<18	<60	<15	1200±50
07-08-86	2650	1.8±0.5[a]	<15	<18	<60	<15	1130±160
07-22-86	2742	<1.0	<15	<18	<60	<15	1020±120
08-05-86	2818	<1.0	<15	<18	<60	<15	950±110
08-19-86	NS[b]	--	--	--	--	--	--
09-03-86	NS[b]	--	--	--	--	--	--
09-16-86	NS[b]	--	--	--	--	--	--
09-30-86	3146	<1.0	<15	<18	<60	<15	1290±130
10-07-86	3189,90	<1.0	<15	<18	<60	<15	1070±80
11-04-86	3355	<1.0	<15	<18	<60	<15	1150±140
12-02-86	3436	<1.0	<15	<18	<60	<15	1440±150
Control							
D-105							
01-07-86	DMI-1938	<1.0	<15	<18	<60	<15	1120±80
02-04-86	1990	<1.0	<15	<18	<60	<15	1310±240
03-04-86	2051	<1.0	<15	<18	<60	<15	1590±120
04-01-86	2113	<1.0	<15	<18	<60	<15	1250±20
05-06-86	2220,1	<1.0	<15	<18	<60	<15	1320±80
05-20-86	2311	1.1±0.3[a]	<15	<18	<60	<15	1400±90
06-03-86	2413	1.2±0.3[a]	<15	<18	<60	<15	1150±50
06-10-86	2461	6.6±0.5[a]	<15	<18	<60	<15	1430±60
06-17-86	2507	6.9±0.5[a]	<15	<18	<60	<15	1280±130
06-24-86	2558	3.3±0.4[a]	<15	<18	<60	<15	1460±160
07-08-86	2649	2.2±0.4[a]	<15	<18	<60	<15	1320±70
07-22-86	2741	<1.0	<15	<18	<60	<15	1240±70
08-05-86	2817	<1.0	<15	<18	<60	<15	1170±60
08-19-86	2910	<1.0	<15	<18	<60	<15	1280±30
09-03-86	2974	<1.0	<15	20.8±4.7	<60	<15	1040±100
09-16-86	3085	<1.0	<15	<18	<60	<15	1270±70
09-30-86	3145	<1.0	<15	<18	<60	<15	1240±100
10-07-86	3188	<1.0	<15	<18	<60	<15	1270±70
11-04-86	3354	<1.0	<15	<18	<60	<15	1310±150
12-02-86	3435	<1.0	<15	<18	<60	<15	1260±160

[a] Elevated I-131 activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

[b] NS = No sample; sample temporarily unavailable.

Table 16. Ground water samples, analysis for gross beta and tritium.
Collection: Quarterly.

Location and Period Collected	Lab Code	Concentration (pCi/l) Gross Beta	H-3
D-53			
Treated Municipal Water			
1st Qtr., 1986	DWW-6014	1.6±0.4	<330
2nd Qtr., 1986	7298	2.5±0.6	<330
3rd Qtr., 1986	8208	1.9±0.5	<330
4th Qtr., 1986	9230	1.8±0.5	<330
Annual Mean ± s.d.		2.0±0.4	<330
D-54			
Inlet to Municipal Water Treatment			
1st Qtr., 1986	DWW-6015	3.2±0.9	<330
2nd Qtr., 1986	7299	3.1±1.0	<330
3rd Qtr., 1986	8209	4.5±1.1	<330
4th Qtr., 1986	9231,2	3.4±0.5	<330
Annual Mean ± s.d.		3.6±0.6	<330
D-55			
On-site Well			
1st Qtr., 1986	DWW-6016	<0.7	<330
2nd Qtr., 1986	7300	<0.9	<330
3rd Qtr., 1986	8210	0.9±0.5	<330
4th Qtr., 1986	9233	<0.8	<330
Annual Mean ± s.d.		0.9±0.5	<330
D-57			
Bull Farm			
1st Qtr., 1986	DWW-6017	1.5±0.7	<330
2nd Qtr., 1986	7301	2.0±0.8	<330
3rd Qtr., 1986	8211	1.6±0.5	<330
4th Qtr., 1986	9234	1.6±0.5	<330
Annual Mean ± s.d.		1.7±0.2	<330

Table 16. (continued).

Location and Date Collected	Lab Code	Concentration (pCi/l) Gross Beta	H-3
D-58			
Frantz Farm			
1st Qtr., 1986	DWW-6018	5.2±0.9	<330
2nd Qtr., 1986	7302	4.8±1.0	<330
3rd Qtr., 1986	8212	8.2±0.8	<330
4th Qtr., 1986	9235	1.2±0.4	<330
Annual Mean ± s.d.		4.8±2.9	<330
D-60			
Comp Farm			
1st Qtr., 1986	DWW-6019	1.1±0.4	<330
2nd Qtr., 1986	7303	1.6±0.5	<330
3rd Qtr., 1986	NS[a]	--	--
4th Qtr., 1986	NS[a]	--	--
Annual Mean ± s.d.		1.4±0.4	<330

[a] NS = No sample; pump inoperative.

Table 17. Vegetation samples (broad leaf), analysis for I-131 and gamma-emitting isotopes.
Collection: Annually.

Sample Description and Activity (pCi/g wet)

	Indicator			
Location	D-57	D-58	D-63	D-72
Date Collected	07-23-86	07-23-86	07-23-86	07-23-86
Type	Cabbage	Cabbage	Cabbage	Cabbage
Lab Code	DVe-51	DVe-52	DVe-53	DVe-54
I-131	<0.017	<0.016	<0.040	<0.023
K-40	2.10±0.21	2.47±0.29	5.64±0.68	5.03±0.27
Mn-54	<0.014	<0.014	<0.039	<0.018
Co-58	<0.013	<0.017	<0.041	<0.018
Co-60	<0.012	<0.017	<0.041	<0.023
Nb-95	<0.012	<0.016	<0.039	<0.020
Zr-95	<0.024	<0.030	<0.068	<0.036
Ru-103	<0.013	<0.014	<0.036	<0.020
Ru-106	<0.12	<0.14	<0.34	<0.17
Cs-134	<0.012	<0.015	<0.040	<0.021
Cs-137	<0.014	<0.015	<0.038	<0.024
Ce-141	<0.032	<0.021	<0.049	<0.033
Ce-144	<0.15	<0.093	<0.22	<0.15

	Indicator			Control
Location	D-93	D-94	D-106	D-105
Date Collected	07-23-86	07-23-86	07-23-86	07-23-86
Type	Cabbage	Cabbage	Cabbage	Cabbage
Lab Code	DVE-55	DVe-56	DVe-58	DVe-57
I-131	<0.034	<0.057	<0.021	<0.027
K-40	4.82±0.63	6.41±0.65	5.90±0.44	2.78±0.45
Mn-54	<0.040	<0.038	<0.021	<0.025
Co-58	<0.034	<0.043	<0.022	<0.025
Co-60	<0.045	<0.036	<0.027	<0.028
Nb-95	<0.034	<0.039	<0.020	<0.019
Zr-95	<0.061	<0.073	<0.034	<0.043
Ru-103	<0.030	<0.038	<0.019	<0.019
Ru-106	<0.27	<0.35	<0.20	<0.18
Cs-134	<0.032	<0.037	<0.020	<0.022
Cs-137	<0.032	<0.044	<0.021	<0.024
Ce-141	<0.039	<0.098	<0.027	<0.029
Ce-144	<0.16	<0.43	<0.12	<0.12

Table 18. Vegetation samples analysis for gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g wet)

	Indicator			
Location	D-57	D-63	D-72	D-93
Date Collected	09-02-86	09-03-86	09-03-86	09-02-86
Type	Hay	Hay	Hay	Hay
Lab Code	DVe-124	DVe-125	DVe-126,7	DVe-128
K-40	17.70±0.36	20.48±0.46	19.35±0.67	24.20±1.18
Mn-54	<0.024	<0.045	<0.037	<0.045
Co-58	<0.039	<0.072	<0.061	<0.079
Co-60	<0.024	<0.039	<0.032	<0.050
Nb-95	<0.045	<0.092	<0.12	<0.17
Zr-95	<0.073	<0.14	<0.12	<0.16
Ru-103	<0.063	<0.14	<0.098	<0.13
Ru-106	<0.19	<0.37	<0.30	<0.36
Cs-134	<0.024	<0.050	<0.030	<0.037
Cs-137	0.041±0.010[a]	0.091±0.024[a]	<0.030	<0.035
Ce-141	<0.12	<0.28	<0.19	<0.21
Ce-144	<0.15	<0.29	<0.20	<0.21

	Indicator		Control
Location	D-94	D-106	D-105
Date Collected	09-03-86	09-02-86	09-03-86
Type	Hay	Hay	Hay
Lab Code	DVe-129	DVe-131	DVe-130
K-40	13.60±0.78	12.62±0.70	15.30±0.62
Mn-54	<0.040	<0.063	<0.053
Co-58	<0.072	<0.059	<0.088
Co-60	<0.032	<0.067	<0.020
Nb-95	<0.13	<0.074	<0.17
Zr-95	<0.13	<0.12	<0.16
Ru-103	<0.12	<0.092	<0.13
Ru-106	<0.37	<0.70	<0.44
Cs-134	0.052±0.025[a]	<0.076	<0.045
Cs-137	0.22±0.03[a]	<0.080	<0.050
Ce-141	<0.29	<0.15	<0.33
Ce-144	<0.36	<0.50	<0.43

[a] Elevated Cs-134 and Cs-137 activity is due to fallout from the Chernobyl Nuclear Plant (USSR) accident on April 26, 1986.

Table 18. Vegetation samples, analysis for gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/g wet)

	Indicator				
Location	D-16	D-57	D-58	D-63	D-72
Date Collected	11-05-86	11-05-86	11-05-86	11-05-86	11-05-86
Type	Soybeans	Corn	Corn	Corn	Corn
Lab Code	DVe-170[a]	DVe-171	DVe-172	DVe-173	DVe-174
K-40	13.11±0.88	2.10±0.30	4.19±0.32	1.64±0.29	2.48±0.24
Mn-54	<0.11	<0.030	<0.044	<0.030	<0.021
Co-58	<0.11	<0.032	<0.044	<0.037	<0.022
Co-60	<0.12	<0.027	<0.052	<0.029	<0.028
Nb-95	<0.11	<0.034	<0.044	<0.035	<0.024
Zr-95	<0.20	<0.051	<0.088	<0.061	<0.048
Ru-103	<0.085	<0.028	<0.043	<0.034	<0.023
Ru-106	<0.82	<0.28	<0.38	<0.30	<0.21
Cs-134	<0.12	<0.026	<0.046	<0.028	<0.027
Cs-137	<0.11	<0.031	<0.046	<0.030	<0.022
Ce-141	<0.071	<0.053	<0.064	<0.057	<0.041
Ce-144	<0.28	<0.22	<0.26	<0.23	<0.15

	Indicator			Control
Location	D-93	D-94	D-106	D-105
Date Collected	11-05-86	11-05-86	11-05-86	11-05-86
Type	Corn	Corn	Corn	Corn
Lab Code	DVe-175,6	DVe-177	DVe-179	DVe-178
K-40	3.48±0.33	3.66±0.38	3.68±0.29	2.94±0.22
Mn-54	<0.029	<0.033	<0.033	<0.023
Co-58	<0.036	<0.036	<0.030	<0.016
Co-60	<0.022	<0.039	<0.044	<0.020
Nb-95	<0.029	<0.036	<0.028	<0.018
Zr-95	<0.052	<0.062	<0.065	<0.030
Ru-103	<0.033	<0.032	<0.025	<0.018
Ru-106	<0.25	<0.34	<0.22	<0.17
Cs-134	<0.031	<0.038	<0.032	<0.022
Cs-137	<0.037	<0.035	<0.028	<0.021
Ce-141	<0.028	<0.048	<0.043	<0.026
Ce-144	<0.10	<0.21	<0.17	<0.11

[a] Elevated LLDs due to small samples size.

Table 19. Surface water samples, analysis for gamma-emitting isotopes. Collection: Monthly.

Location	Sample Description and Activity (pCi/l)			
Indicator - Plant Intake				
D-50	Date Collected	01-22-86	02-26-86	03-25-86	04-22-86
	Lab Code	DSW-5256,7	DSW-5654	DSW-6009	DSW-6321
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	05-28-86	06-30-86	07-28-86	08-29-86
	Lab Code	DSW-6714	DSW-7305	DSW-7503	DSW-7898
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<530[a]	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	09-22-86	10-28-86	11-24-86	12-08-86
	Lab Code	DSW-8203	DSW-8754	DSW-8940	DSW-9226
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15

[a] Elevated LLD due to delay in counting.

Table 19. Surface water samples, analysis for gamma-emitting isotopes (continued)

Location	Sample Description and Activity (pCi/l)			
Indicator - Plant Discharge				
D-51	Date Collected	01-22-86	02-26-86	03-25-86	04-22-86
	Lab Code	DSW-5258	DSW-5655	DSW-6010	DSW-6322
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	05-28-86	06-30-86	07-28-86	08-29-86
	Lab Code	DSW-6715,6	DSW-7306,7	DSW-7504	DSW-7899
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<819[a]	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	09-22-86	10-28-86	11-24-86	12-08-86
	Lab Code	DSW-8204,5	DSW-8755	DSW-8941	DSW-9227
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15

[a] Elevated LLD due to delay in counting.

Table 19. Surface water samples, analysis for gamma-emitting isotopes (continued)

Location	Sample Description and Activity (pCi/l)			
Indicator - Pleasant Creek				
D-99	Date Collected	01-22-86	02-26-86	03-25-86	04-22-85
	Lab Code	DSW-5259	DSW-5656	DSW-6011	DSW-6323
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	05-28-86	06-30-86	07-28-86	08-29-86
	Lab Code	DSW-6717	DSW-7308	DSW-7505	DSW-7900
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	09-22-86	10-28-86	11-24-86	12-08-86
	Lab Code	DSW-8206	DSW-8756	DSW-8942	DSW-9228
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15

Table 19. Surface water samples, analysis for gamma-emitting isotopes (continued)

Location	Sample Description and Activity (pCi/l)			
Indicator - Plant Sewage Discharge				
D-107	Date Collected	01-22-86	02-26-86	03-25-86	04-22-86
	Lab Code	DSW-5260	DSW-5657	DSW-6012,3	DSW-6324
	K-40[a]	25.78	25.34	24.46	24.20
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	05-28-86	06-30-86	07-28-86	08-29-86
	Lab Code	DSW-6718	DSW-7309	DSW-7506	DSW-7901,2
	K-40[a]	22.88	17.07	17.51	24.24
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15

[a] Analyzed by flame photometry.

Table 19. Surface water samples, analysis for gamma-emitting isotopes (continued)

Location	Sample Description and Activity (pCi/l)			
Indicator - Plant Sewage Discharge				
D-107	Date Collected	09-22-86	10-28-86	11-24-86	12-08-86
	Lab Code	DSW-8202	DSW-8757,8	DSW-8943	DSW-9229
	K-40[a]	20.86	22.84	27.10	35.02
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15

[a] Analyzed by flame photometry.

Table 19. Surface water samples, analysis for gamma-emitting isotopes (continued)

Location	Sample Description and Activity (pCi/l)			
Control - Lewis Access				
D-49	Date Collected	01-22-86	02-26-86	03-25-86	04-22-86
	Lab Code	DSW-5255	DSW-5653	DSW-6008	DSW-6320
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	05-28-86	06-30-86	07-28-86	08-29-86
	Lab Code	DSW-6713	DSW-7304	DSW-7502	DSW-7897
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15
	Date Collected	09-22-86	10-28-86	11-24-86	12-08-86
	Lab Code	DSW-8202	DSW-8753	DSW-8939	DSW-9225
	Mn-54	<15	<15	<15	<15
	Fe-59	<30	<30	<30	<30
	Co-58	<15	<15	<15	<15
	Co-60	<15	<15	<15	<15
	Zn-65	<30	<30	<30	<30
	Nb-95	<15	<15	<15	<15
	Zr-95	<30	<30	<30	<30
	I-131	<500	<500	<500	<500
	Cs-134	<15	<15	<15	<15
	Cs-137	<18	<18	<18	<18
	Ba-140	<60	<60	<60	<60
	La-140	<15	<15	<15	<15

Table 20. Surface water samples, quarterly composites of monthly samples, analysis for tritium.

Location and Period Collected	Lab Code	Concentration (pCi/l) H-3
Indicator		
D-50		
1st Q, 1986	DSW-5967	<330
2nd Q, 1986	7049	<330
3rd Q, 1986	8047	<330
4th Q, 1986	9237	<330
Annual Mean ± s.d.		<330
D-51		
1st Q, 1986	DSW-5968	<330
2nd Q, 1986	7050	<330
3rd Q, 1986	8048,9	<330
4th Q, 1986	9238	<330
Annual Mean ± s.d.		<330
D-99		
1st Q, 1986	DSW-5969,70	<330
2nd Q, 1986	7051	<330
3rd Q, 1986	8050	<330
4th Q, 1986	9239	<330
Annual Mean ± s.d.		<330
D-107		
1st Q, 1986	DSW-5971	<330
2nd Q, 1986	7052	360±130
3rd Q, 1986	8051	<330
4th Q, 1986	9240	<330
Annual Mean ± s.d.		360±130
Control		
D-49		
1st Q, 1986	DSW-5966	<330
2nd Q, 1986	7048	<330
3rd Q, 1986	8046	<330
4th Q, 1986	9236	<330
Annual Mean ± s.d.		<330

Table 21. Fish samples, analysis of edible portion for gamma-emitting isotopes. Collection: Semiannually.

Sample Description and Activity (pCi/g wet)			
	Indicator		
	Downstream D-61		
Date Collected	05-08-86	05-08-86	05-08-86
Type	Bigmouth Buffalo	River Carpsucker	Carp
Lab Code	DF-27	DF-28	DF-29
K-40	2.96±0.10	4.59±0.27	4.15±0.12
Mn-54	<0.010	<0.024	<0.012
Co-58	<0.020	<0.051	<0.022
Co-60	<0.009	<0.022	<0.010
Nb-95	<0.023	<0.047	<0.021
Zr-95	<0.043	<0.080	<0.044
Ru-103	<0.036	<0.072	<0.033
Ru-106	<0.078	<0.20	<0.089
Cs-134	<0.010	<0.023	<0.010
Cs-137	<0.008	<0.017	<0.009
Ce-141	<0.082	<0.096	<0.044
Ce-144	<0.056	<0.076	<0.036
Date Collected	11-05-86	11-05-86	11-05-86
Type	River Carpsucker	Smallmouth Buffalo	Carp
Lab Code	DF-167	DF-168	DF-169
K-40	3.41±0.48	3.90±0.32	3.64±0.42
Mn-54	<0.032	<0.025	<0.028
Co-58	<0.036	<0.030	<0.028
Co-60	<0.035	<0.033	<0.031
Nb-95	<0.036	<0.030	<0.033
Zr-95	<0.068	<0.050	<0.060
Ru-103	<0.034	<0.021	<0.026
Ru-106	<0.30	<0.21	<0.23
Cs-134	<0.035	<0.035	<0.040
Cs-137	<0.036	<0.026	<0.034
Ce-141	<0.050	<0.022	<0.023
Ce-144	<0.21	<0.086	<0.11

Table 21. Fish samples, analysis of edible portion for gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/g wet)			
	Control		
	Upstream D-49		
Date Collected	05-08-86	05-08-86	05-08-86
Type	Bigmouth Buffalo	River Carpsucker	Carp
Lab Code	DF-24	DF-25	DF-26
K-40	4.24±0.16	4.24±0.13	3.25±0.25
Mn-54	<0.014	<0.014	<0.018
Co-58	<0.032	<0.025	<0.034
Co-60	<0.014	<0.011	<0.017
Nb-95	<0.031	<0.022	<0.085
Zr-95	<0.052	<0.046	<0.069
Ru-103	<0.053	<0.039	<0.065
Ru-106	<0.11	<0.097	<0.14
Cs-134	<0.013	<0.010	<0.014
Cs-137	<0.010	<0.010	<0.014
Ce-141	<0.069	<0.053	<0.12
Ce-144	<0.047	<0.039	<0.095
Date Collected	11-05-86	11-05-86	11-05-86
Type	Carp	Shorthead Redhorse	River Carpsucker
Lab Code	DF-163,4	DF-165	DF-166
K-40	3.25±0.18	3.81±0.25	4.04±0.38
Mn-54	<0.019	<0.016	<0.031
Co-58	<0.024	<0.016	<0.036
Co-60	<0.026	<0.016	<0.034
Nb-95	<0.022	<0.016	<0.035
Zr-95	<0.036	<0.030	<0.041
Ru-103	<0.021	<0.016	<0.028
Ru-106	<0.18	<0.15	<0.29
Cs-134	<0.024	<0.016	<0.032
Cs-137	<0.025	<0.017	<0.035
Ce-141	<0.028	<0.023	<0.028
Ce-144	<0.12	<0.098	<0.097

Table 22. Bottom sediment samples, analysis for gamma-emitting isotopes. Collection: Semiannually.

Sample Description and Activity (pCi/g dry)		
	Indicator	
Location	D-51	D-51
Date Collected	05-09-86	10-01-86
Lab Code	DBS-27,8	DBS-108,9
K-40	7.88±0.16	8.35±0.23
Mn-54	<0.017	<0.024
Co-58	<0.022	<0.023
Co-60	<0.018	<0.023
Nb-95	<0.020	<0.023
Zr-95	<0.039	<0.042
Ru-103	<0.019	<0.019
Ru-106	<0.13	<0.18
Cs-134	<0.019	<0.029
Cs-137	<0.019	<0.026
Ce-141	<0.026	<0.027
Ce-144	<0.073	<0.10
	Indicator	
Location	D-50	D-50
Date Collected	05-09-86	10-01-86
Lab Code	DBS-26	DBS-107
K-40	7.64±0.25	7.77±0.32
Mn-54	<0.020	<0.025
Co-58	<0.021	<0.025
Co-60	<0.021	<0.024
Nb-95	<0.024	<0.026
Zr-95	<0.043	<0.042
Ru-103	<0.020	<0.024
Ru-106	<0.15	<0.18
Cs-134	<0.023	<0.029
Cs-137	<0.021	<0.033
Ce-141	<0.030	<0.038
Ce-144	<0.079	<0.16

Table 23. Precipitation samples, analysis for gamma-emitting isotopes. Collection: Monthly, 1986.

Sample Description and Concentration (pCi/l)				
Collection Period Lab Code	January DP-2	February DP-17	March DP-32	April DP-62
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zn-65	<30	<30	<30	<30
Nb-95	<15	<15	<15	<15
Zr-95	<30	<30	<30	<30
I-131	<500	<500	<500	<500
Cs-134	<15	<15	<15	<15
Cs-137	<18	<18	<18	<18
Ba-140	<60	<60	<60	<60
La-140	<15	<15	<15	<15
Collection Period Lab Code	May DP-72	June DP-95	July DP-115	August DP-134
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zn-65	<30	<30	<30	<30
Nb-95	<15	<15	<15	<15
Zr-95	<30	<30	<30	<30
I-131	<500	<500	<500	<500
Cs-134	<15	<15	<15	<15
Cs-137	<18	<18	<18	<18
Ba-140	<60	<60	<60	<60
La-140	<15	<15	<15	<15
Collection Period Lab Code	September DP-144	October DP-165	November DP-178,9	December DP-197
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zn-65	<30	<30	<30	<30
Nb-95	<15	<15	<15	<15
Zr-95	<30	<30	<30	<30
I-131	<500	<500	<500	<500
Cs-134	<15	<15	<15	<15
Cs-137	<18	<18	<18	<18
Ba-140	<60	<60	<60	<60
La-140	<15	<15	<15	<15

Table 24. Precipitation samples, quarterly composites of monthly samples, analysis for tritium.

Location and Period Collected	Lab Code	Concentration (pCi/l) H-3
1st Qtr. 1986	DP-33	<330
2nd Qtr. 1986	DP-105	<330
3rd Qtr. 1986	DP-145	<330
4th Qtr. 1986	DP-198	<330

Table 25. Meat samples, analysis of edible portion for gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g wet)	
Location	Onsite
Date Collected	01-15-86
Type	Beef
Lab Code	DME-85,86
K-40	1.98±0.14
Mn-54	<0.013
Co-58	<0.019
Co-60	<0.012
Nb-95	<0.031
Zr-95	<0.037
Ru-103	<0.025
Ru-106	<0.10
Cs-134	<0.011
Cs-137	<0.012
Ce-141	<0.044
Ce-144	<0.068

Table 26. Soil samples, analysis for strontium-90 and gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g dry)		
Location	D-15	D-16
Date Collected	10-29-86	10-29-86
Lab Code	DSO-54	DSO-55
Sr-90	0.016±0.006	0.231±0.028
K-40	8.70±0.41	8.16±0.26
Mn-54	<0.018	<0.024
Co-58	<0.033	<0.032
Co-60	<0.020	<0.029
Nb-95	<0.060	<0.041
Zr-95	<0.058	<0.074
Ru-103	<0.041	<0.051
Ru-106	<0.17	<0.017
Cs-134	<0.021	<0.019
Cs-137	<0.017	<0.020
Ce-141	<0.088	<0.11
Ce-144	<0.12	<0.13

APPENDIX A

Elevated Airborne Iodine Activity
Resulting from
Chernobyl Nuclear Plant Accident (USSR)
on April 26, 1986

Elevated Airborne Iodine-131 Activity

Resulting from

Chernobyl Nuclear Plant Accident (USSR)

on April 26, 1986

Location	Date	Concentration (pCi/m^3)
D-2	05-15-86	0.45±0.04
D-7	05-15-86	0.17±0.03
D-8	05-15-86	1.58±0.17
D-11	05-15-86	1.34±0.10
D-15	05-15-86	0.43±0.04
D-2	05-22-86	0.34±0.05
D-5	05-22-87	0.98±0.09
D-7	05-22-86	0.36±0.04
D-8	05-22-86	0.26±0.05
D-11	05-22-86	0.38±0.06
D-15	05-22-86	1.15±0.13
D-2	05-29-86	0.24±0.03
D-5	05-29-86	0.12±0.03
D-7	05-29-86	0.58±0.19
D-8	05-29-86	0.63±0.17
D-11	05-29-86	0.67±0.30
D-15	05-29-86	0.44±0.08