27
7-13-81
Ma
27-10-71 T/S
B 5566

(1)

MASTER

IS 4768
UC-20e

Environmental Monitoring at Ames Laboratory

Calendar Year 1980

Milo D. Voss

Date Transmitted: April 1981

Ames Laboratory
Iowa State University
Ames, Iowa 50011

Prepared For
The U. S. Department of Energy
Under Contract W-7405-eng -82

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

IS-4768
UC-20e

ENVIRONMENTAL MONITORING AT AMES LABORATORY

Calendar Year 1980

Milo D. Voss

Ames Laboratory, USDOE
Iowa State University
Ames, IA 50011

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Program Associates

Air & Instrumentation: L. K. Mathison
Water & Laboratory: J. F. Barry

Prepared for the U.S. Department of Energy
Division of Research

Under Contract No. W-7405-eng-82

Date of Transmittal: April 1981

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Printed in the United States of America

Available from
National Technical Information Service
U.S. Department of Commerce
5265 Port Royal Road
Springfield, VA 22161

Price: Microfiche: \$3.50

Full size: 6.00

IS-4768
UC-20e

Previous research reports in this series are:

TID-20369
IS-1098
IS-1320
IS-1523
IS-1647
IS-1776
IS-1924
IS-2025
IS-2154
IS-2260
IS-2393
IS-2541
IS-2658
IS-2791
IS-2926
IS-3048
IS-3313
IS-3613
IS-3856
IS-4139
IS-4365
IS-4679
IS-4734

Environmental Monitoring at Ames Laboratory:

Calendar Year 1980

ABSTRACT

This is an annual report summarizing the effluent and environmental monitoring program at the Ames Laboratory of the Department of Energy. Effluent and environmental monitoring is an operational requirement of the Department of Energy.

Earlier reports in this series concerned only environmental radioactivity and were each entitled "Survey of Environmental Radioactivity."

The 1974 report was the first in the present series of reports. An inventory of the radioactive materials released to the environment is included. A summary of the radioactivity found in the environment is presented. An estimate of the radiation dose to the public resulting from the operations of the Ames Laboratory is stated.

The environmental program was modified in July of 1976, and again in 1978.

TABLE OF CONTENTS

	<u>Page</u>
I. Summary	1
II. Ames Laboratory Facilities and Locality	3
III. Definition of Terms	9
IV. Quality Assurance	12
V. Radiological Monitoring Program	13
A. Effluents	14
B. Environmental	18
C. Impact	24
VI. Sample Site Locations	26
VII. Maps	28
VIII. References	32
IX. Acknowledgements	33
 APPENDIX A. Applicable Standards	 34
APPENDIX B. Radiological Results for Specific Sites	35
 Distribution List	 48

1. Summary

The results and conclusions from the Ames Laboratory environmental monitoring programs for the Ames Laboratory Research Reactor (ALRR) and other Laboratory facilities are presented in this report.* These programs are required by the Department of Energy (DOE) Manual Chapter 0513, "Effluent and Environmental Monitoring and Reporting," (1) to assure compliance with other policies, standards and requirements related to these areas. The major areas of radiological monitoring were ALRR effluent air, environmental air, effluent water and environmental water.

The ALRR ceased operation on December 1, 1977. Decommissioning activities began January 3, 1978, and are scheduled for completion October 1, 1981. Analysis of air samples collected at the ALRR on-site station showed no radioactivity that could be attributed to ALRR operations. The radioisotope of significance in the ALRR stack effluent was tritium (H-3). The yearly individual dose from H-3 at the exclusion fence was estimated to be 0.016 mRem and the estimated dose to the entire population within an 80 Km (50 mile) radius of the ALRR was 26.6 man-Rem. These values are 0.0032% and 0.026%, respectively, of the doses derived from the concentration guides (2).

*The environmental monitoring program was changed on July 1, 1976. The changes which were made are shown in a previous environmental monitoring report, IS-4139 (3). These changes were made in order to improve the cost effectiveness of the program in accord with the minimal impact of the ALRR on the surrounding environment. Media and sites which had shown no previous impact or correlation with reactor operations were eliminated. A new site was added, and the media and sites which could show impacts were retained. The changes are subject to consideration and agreement with the Chicago Operations Regional Office of the Department of Energy.

On September 1, 1978, the ALRR site was connected to the City of Ames sanitary sewage system. All liquids (except building foundation and roof water) from the ALRR complex are now discharged to the sewage system negating the requirement for monitoring chemical constituents of effluent and environmental waters.

In the radioactive liquid waste released to the City of Ames sewage system from the ALRR complex, H-3 was the predominant isotope. After dilution with other waste water from the ALRR complex, the potential dose was not more than 0.68% of the dose derived from the concentration guide. Building foundation and roof water are discharged to a drainage gulch on site.

11. Ames Laboratory Facilities and Locality

Ames is located in central Iowa where the Squaw Creek and Skunk River come together (Figures 3 and 4). The land is gently rolling "swell and swale". The flat upland is only a little greater than 30.5 m (100 feet) above the river flood plain. The general area is about 274 m (900 feet) above sea level. The City of Ames covers 42.5 Km² (16.4 square miles). The I.S.U. student population of about 22,000 is included in the Ames population numbering 44,983*. The major portion of Iowa State University and parts of Ames lie within a 3.2 Km (2 mile) radius of the Ames Laboratory Research Reactor. Within the 3.2 Km (2 mile) circle, the land usage is 33% residential (Ames and I.S.U.), 25% wooded, and 42% agricultural.

The area around Ames is generally rural with farming producing important yields of corn, soybeans, and wheat. The neighboring towns (Figure 3) are mostly small communities.

<u>City</u>	<u>Population</u> *	<u>From Ames</u>
Nevada	5,893	11 Km (7 miles) east
Ankeny	15,410	35 Km (22 miles) south
Boone	12,504	21 Km (13 miles) west
Story City	2,764	23 Km (14 miles) north

The capital of Iowa, Des Moines, population 190,910* lies 48 Km (30 miles) south of Ames.

The total population within a circle of 80 Km (50 miles) radius is 600,500*

*From 1980 census (preliminary)

The climatology of the area is temperate and continental subject to wide seasonal range in temperature, precipitation and wind. The average annual temperature is 9.4°C (49°F). The average annual precipitation is 18.3 cm (32 inches): 90% rain, 10% snow, with small amounts of sleet and hail.

In the colder months, the winds are mostly from the northwest sector averaging 29-32 Km/hour (18-20 miles/hour); in the warmer months, winds are from the southeast sector averaging 19-23 Km/hour (12-14 miles/hour).

One characterization of winds is the fraction of time the wind blows from a certain direction. In the Ames area, the variation of a given wind direction between the least time or frequency and the greatest time is about a factor of two. (See wind-rose, page 5)

The average wind speed at 3 m (10 feet) above the ground is estimated at 14.4 Km/hour (9 miles/hour) and at 30.5 m (100 feet) it is 20.9 Km/hour (13 miles/hour).

The sources of water supply for Ames and Iowa State University are sand and gravel aquifers lying within two buried bedrock valleys, the Squaw and the Skunk. Water is pumped for storage and distribution from a number of wells which are 30.5-39.6 m (100-130 feet) deep. The City of Ames pumped 8.3×10^9 liters (2198×10^6 gallons) from the well field in 1980. Surface water contributes to the recharge of the system as water is pumped from the wells. The travel time of water from the Skunk River to the well area is estimated at one year. The contribution to the recharge from Squaw Creek is less than that from the Skunk River. Recharge water from Squaw Creek passes through

0 5 10 15 20
AVERAGE WIND VELOCITY, MPH

0 2 4 6 8 10 12
PERCENT FREQUENCY

ALL VALUES ARE MEASURED FROM THE CENTER CIRCLE
AVERAGE WIND VELOCITY AND FREQUENCY OF WIND DIRECTION
FROM JUNE 1950 TO JULY 1955 (43,824 OBSERVATIONS)
DES MOINES, IOWA

absorbing and filtering material, a mixture of clay, silt and sand which lies over the waterbearing sand and gravel.

The surface streams of particular interest to the Ames Laboratory are the Onion Creek Gulch, Onion Creek, Squaw Creek and the Skunk River. Onion Creek and Onion Creek Gulch are intermittent and non-classified streams. Squaw Creek and the Skunk River are classed as B, fresh warm water, and thus protected for wildlife, fish, aquatic and semi-aquatic life and secondary contact recreation. The classifications have been established by the Department of Environmental Quality, Iowa Water Quality Commission (4). The Skunk River is changed to a Class C, protected raw water source of potable water supply, at the point of withdrawal at Oskaloosa, Iowa, 137 Km (85 river miles) downstream from Ames.

The facilities of the Ames Laboratory include offices, laboratories, warehouses and service buildings located among university buildings on the campus of Iowa State University (I.S.U.) in Ames, Iowa. In addition to the facilities on campus, the Ames Laboratory Research Reactor (ALRR) together with a waste handling-decontamination facility and an office-warehouse is located on a 16.2 hectares (40 acre) site (Figure 1, page 28) approximately 2.4 Km (1.5 miles) northwest of the I.S.U. campus (Figure 2) and 4.8 Km (3 miles) west and north of downtown Ames (City Hall). The site of the ALRR is about 305 m (1,000 feet) above sea level and is enclosed by an exclusion fence at 213 m (700 feet) or more centered on the reactor. The nearest non-residential building (I.S.U.) is about 244 m (800 feet) east of the reactor and the nearest residential lot is about 381 m (1250 feet) south of the ALRR.

Research programs carried out at the ALRR included neutron diffraction studies, short life time fission product studies using an on-line isotope separator and various neutron activation studies. On December 31, 1977, the Ames Laboratory Research Reactor ceased operation. Decommissioning began on January 3, 1978, with expected completion by the end of 1981. All fuel elements, heavy water (D_2O), and thermal shield light water have been removed from the site and transferred to another Department of Energy (D.O.E.) facility. All experiments have either been transferred to other D.O.E. facilities or have been placed in storage. Current status of the ALRR is one of near completion of removal of all reactor related equipment and materials with termination of decommissioning operations to be October 1, 1981. A survey of the site and buildings will be made to document the radiological status of the decommissioned reactor facility. It is expected that this survey will be completed in 1981.

The laboratories associated with the reactor and those in the Ames Laboratory complex on the Iowa State University campus use relatively small amounts of radioactive materials. The majority of the work deals with tracer studies employing relatively small amounts of radioisotopes (Ca-45, Cl-36, Co-60, Fe-59, Hf-175, Mn-54 and others).

Liquids released from the I.S.U. campus facilities are handled through the sanitary sewer system. The liquid and solid radioactive wastes generated at these facilities are collected and transferred to the reactor site waste disposal facility for processing. Airborne releases are eliminated or minimized by experiment system design or source limitation. The liquid and solid contamination wastes generated at the reactor site are also transferred to the waste disposal facility for processing.

The waste disposal/decontamination facility houses a decontamination booth and special sinks with systems for complete collection of the cleanings, a solid waste compactor, tank storage for liquids (water) with filtration and ion exchange processing systems, and evaporation and distillation systems. The output of this facility is clean equipment for reuse and packaged solid waste for shipment to a radioactive waste burial site. As of September 1, 1978, the waste disposal and the ALRR facility were connected to the City of Ames sanitary sewer system.

Prior to September 1, 1978, all liquid effluents from the reactor and waste disposal facilities were released to a single outfall site. With the connection to the sanitary sewage system on this date, the only remaining sources of liquid effluent which are released to the outfall site originate from the ALRR building foundation and roof. This site has been and continues to be monitored. During 1980, sample collection was reduced from twice daily to once daily.

The effluent monitoring pertaining to these facilities and the environmental monitoring are presented in this report.

III. Definition of Terms

Average Average as used in this report is the arithmetical mean of all sample results. The activity of a sample was set equal to zero when the count rate was less than background. When the count rate was less than the detection limit, which is a function of the minimum detectable activity (5) (but greater than the instrument background) the calculated activity was used in averaging. The yearly average is based on the summation of all samples.

Confidence Limits The confidence limits given in Table 1 indicate the accuracy of the particular value based on considerations of the count rate, count time and background, not on the distribution of sample values (5). The limits in this table have been derived for and are applicable only to the value which is stated for each media. The values used in Table 1 are typical yearly averages which appear in each media type group; that is, air, water, and bottom sediment.

Table 1
95% Confidence Limits

<u>Media Type</u>	<u>Sample Size</u>	<u>Count Time</u>	<u>Average Activity ($\pm 2\sigma$)</u>
<u>Beta</u>			
Air	152 m ³	50 min	$0.098 (\pm 0.0094) \times 10^{-12} \mu\text{Ci/ml}$
Water	1 l	30 min	$6.07 (\pm 1.35) \times 10^{-9} \mu\text{Ci/ml}$
Bottom Sediment	4 g	30 min	$10.33 (\pm 0.71) \times 10^{-6} \mu\text{Ci/ml}$
<u>Alpha</u>			
Air	Same		$0.0027 (\pm 0.0037) \times 10^{-12} \mu\text{Ci/ml}$
Water	as		$0.59 (\pm 0.76) \times 10^{-9} \mu\text{Ci/ml}$
Bottom Sediment	Beta		$0.66 (\pm 0.26) \times 10^{-6} \mu\text{Ci/ml}$
<u>Tritium</u>			
Water			$2.08 (\pm 0.50) \times 10^{-6} \mu\text{Ci/ml}$

Average Tritium Counting Efficiency = 23%

Detection Limit The minimum detectable activity (limit) is defined as that activity which, in the same counting time, yields a count which is more than the instrument background count by three times the standard deviation of the background count (5).

The detection limit is a value of radioactivity per unit volume or mass based on the sample volume or mass, the counting procedure, and the minimum detectable activity. The detection limit is stated in Table 2 for each media.

Table 2
Detection Limits, Radiological

	Air 10^{-15} $\mu\text{Ci/ml}$	Water 10^{-9} $\mu\text{Ci/ml}$	Bottom Sediment 10^{-9} $\mu\text{Ci/g}$
Beta	4.80	1.00	250.
Alpha	3.20	0.39	100.
Tritium	--	500.	--
Ag-110m	0.13	0.13	8.81
Ba-140	0.38	0.38	25.8
Be-7	1.23	1.20	82.8
Ce-141	0.18	0.17	15.1
Ce-144	0.72	0.67	48.6
Co-60	0.14	0.15	9.6
Cs-134	0.13	0.13	8.32
Cs-137	0.15	0.15	10.4
Eu-152	0.52	0.52	36.4
La-140	0.27	0.26	18.2
Nb-95	0.13	0.13	8.9
Ru-103	0.13	0.13	8.8
Ru-106	2.75	2.70	173.
Sb-124	0.14	0.13	9.2
Sb-125	0.41	0.40	27.4
Zn-65	0.25	0.24	17.1
Zr-95	0.26	0.25	17.3

With respect to the gamma detection limits, typical counting times were 333.3 minutes. Sample volumes for air and water were 1.50×10^{10} ml and 2.2×10^4 ml, respectively. Sample mass for bottom sediment averaged 400 grams.

IV. Quality Assurance

Ames Laboratory participates in quality assurance programs administered by the Department of Energy, Division of Operational and Environmental Safety -- Quality Assurance Program, and the U.S. Environmental Protection Agency, Quality Assurance Branch:

Quality assurance samples and the radiation component analyzed are as follows:

water, soil and air	gamma
water and air	gross beta
water and air	gross alpha
water	tritium

V. Radiological Monitoring Program

The Ames Laboratory radiological program monitors effluent (air particulate and water), environmental air particulate, and river and well water in the Ames area. Gamma analysis is generally performed on composites of samples collected over a month, quarter or the entire year. The samples are analyzed using a Tracor Northern TN-1710 gamma spectrometer/micro-processor with a high resolution Ortec Ge(Li) detector.

Individual samples are submitted to gross beta and alpha analysis. This provides an indication of the activity of the sample within 3 weeks. All alpha and beta determinations are made in a 3-inch gas proportional Sharp Low Betamatic System. The activity concentration is calculated using the following equation:

$$\frac{\mu\text{Ci}}{\text{unit volume}} = \frac{(\text{Counts/Time}) - \text{Background}}{(\text{Counter Efficiency})(\text{Volume})(2.22 \times 10^6 \text{ dpm}/\mu\text{Ci})} \quad (1)$$

Self-absorption was not considered. As such, the results are easily compared to other samples and to previous years. Since the alpha and beta determination is basically a screening process, this purpose is served equally as well without self-absorption corrections.

Tritium activity in aqueous samples is determined by liquid scintillation technique. Five ml samples are analyzed with a dioxane-naphthalene cocktail and a Beckman Liquid Scintillation Counter. The tritium activity concentration is also calculated using equation 1.

A. Effluents

Air

Stack air particulate samples are collected on 5 cm (2 inch) Whatman #41 filter paper using a Gast pump with a flow rate of 85 liters per minute (3 CFM) from a sample point near the top of the ALRR stack (Figure 1). Comments describing the stack sampling program are as follows: (1) The air sampler system as operated in this sampling program, produces a particulate collection efficiency of >97% using the above filter paper, (2) Sampling is continuous with the filters being changed every working day, (3) Both sample and stack flow rates are recorded, (4) Gross beta and alpha activity is determined with the Sharp System after a seven day holding period, (5) Gamma analysis is performed on quarterly composites of the daily samples, (6) H-3 activity is determined daily from moisture in stack air collected with a cold-trap and analyzed by liquid scintillation technique. The Cs-137, Co-60, Eu-152, and Zn-65 isotopes listed were due to ALRR operations. See Appendix B, Tables B5 and B6 for a quarterly summary of the ALRR stack effluent results.

The activity concentration in the ALRR stack for 1980 is shown in Table 3. The stack discharge volume was 1.67×10^{14} ml for 1980.

Table 3
ALRR Stack Effluent
($\mu\text{Ci/ml}$)

Isotope	Concentration
Gross Beta	8.0×10^{-14}
Gross Alpha	1.7×10^{-16}
Co-60	5.25×10^{-14}
Cs-137	1.39×10^{-15}
Eu-152	4.60×10^{-16}
H-3	1.12×10^{-6}
Zn-65	4.13×10^{-14}

Water

Water samples are collected daily, except weekends and holidays, from the ALRR outfall (Site 2R, Figure 1). Alpha and beta activity is determined by evaporating a 1 liter sample onto a 3-inch aluminum planchet and counted in the Sharp System. Tritium is determined in a 5 ml sample with a Beckman Liquid Scintillation Counter and dioxane-naphthalene cocktail. The tritium (H-3) discharge concentration range was from 0.0003 to 0.025 times the concentration guide with an overall average factor of 0.0017. Gamma scan analyses were performed on monthly composites of the outfall samples. The concentration guides, based on radiation dose to individuals in uncontrolled areas, are shown in Appendix A, Table A2. See Appendix B, Table B7 for a monthly summary of the outfall results. A summary for 1980 is shown in Table 4.

Table 4
Radioactivity in the ALRR Outfall
($\mu\text{Ci/ml}$)

	Number of Samples	Average Concentration	% CG ¹	High	Low
Gross Beta, 10^{-9}	177	3.83	0.13	13.3	1.17
Gross Alpha, 10^{-9}	177	0.18	0.60	1.62	NDA ²
H-3, 10^{-6}	177	5.34	0.18	75.6	0.90

¹Concentration Guide

²No Detectable Activity

Liquid radioactive waste is sampled and treated on a batch basis. Alpha and beta activities are determined by evaporating a 100 ml sample and counting. Equation 1, with self-absorption corrections, is used to calculate the alpha and beta activity concentration. Self-absorption corrections are employed because an absolute activity concentration is desired for waste discharge and the sample residue is small, less than 0.1 g, making the corrections relatively low. The tritium activity concentration is determined for a 1 ml sample. The gamma analysis is performed on the residue of an evaporated 3 liter sample. The radioactivity in liquid waste discharged to the Ames sewage system in 1980 is shown in Table 5.

The total volume of radioactive liquid waste discharged from the ALRR waste disposal facility to the Ames sewage system was 5.03×10^8 ml. The total volume of waste water discharged to the Ames sewage system from the ALRR complex was 9.54×10^9 ml. Table 5 concentrations reflect the effect of dilution from waste water discharged to the sewer. The concentration guides which apply in this case are from DOE Manual Chapter 0524, Table 1, Column 2, and are shown in Appendix A, Table A1.

Table 5
Liquid Radioactive Waste Discharged to the Ames Sewage System

Isotope	Amount, μCi	Concentration, $\mu\text{Ci/ml}$	% CG
Gross Beta	412.0	4.32×10^{-8}	0.048
Gross Alpha	5.60	5.87×10^{-10}	0.15
Co-60	67.7	7.09×10^{-9}	7.09×10^{-4}
Cs-134	25.5	2.67×10^{-9}	2.67×10^{-4}
Cs-137	295.0	3.09×10^{-8}	3.09×10^{-3}
H-3	6.59×10^6	6.89×10^{-4}	0.68

All liquid radioactive waste generated at the laboratories located on the I.S.U. campus is collected, evaporated and disposed of as solid radioactive waste.

Liquid effluents leaving the I.S.U. campus facilities and ALRR complex via city sewage lines are sampled at the Ames Water Pollution Control Plant (Site 11R, Figure 3). Effluents are sampled weekly and a composite sludge sample is processed monthly. The effluent liquid is treated the same as a river or outfall sample. The sludge sample is mixed and a 100 ml portion is filtered. After drying, the filter paper is ashed and both portions are counted for gross beta and alpha activity. Gamma analysis is performed on a composite of the year's samples. The tritium concentration is not determined on the sludge samples. The concentration guides in Appendix A, Table A2 apply.

Table 6
Radioactivity in the Water Pollution Control Plant Samples (11R)
($\mu\text{Ci/ml}$)

	Number of Samples	Beta 10^{-9}	% CG	Alpha 10^{-9}	% CG	Number of Samples	Tritium 10^{-6}	% CG
Plant Effluent (Site 11R)	18					18		
Average		10.1	0.33	0.12	0.40		3.03	0.10
High		13.7		0.30			14.5	
Low		NDA		NDA			1.26	
Sludge Soluble	10							
Average		40.3		1.14			Not Determined	
High		55.9		2.40				
Low		31.5		NDA				
Sludge Insoluble	10							
Average		66.7		12.7			Not Determined	
High		106.0		16.8				
Low		24.7		7.2				

Gamma analysis of a composite sample of all soluble and insoluble sludge indicated the presence of Cs-137 at 4.79×10^{-9} $\mu\text{Ci/ml}$, which is 0.02% of the concentration guide and is probably due to fallout from past nuclear tests.

B. Environmental

Air Samples

Air samples are collected from two different locations at the Ames Laboratory on a daily (except weekends) basis for the purpose of monitoring the particulate radioactivity content of the atmosphere. The sites are located at the ALRR weather tower site (Site 1A, Figure 2) and the roof of Spedding Hall (Site 2A, Figure 3). Air samples are collected on Whatman #41 7.62 cm (3 inch) diameter filter paper using a Gast pump with a flow rate of 116 liters per minute (4.1 CFM). Samples are collected over a 24 hour period, held for 7 days to allow short-lived activities to decay and then analyzed for gross α and β activity using a Sharp Low Betamatic three-inch gas proportional system. The filter papers are then retained until a composite sample for 90 days is collected. The composite sample is then analyzed for specific gamma emitting isotope content using a Ge(Li) detector/4096 channel analyzer. The isotopic activity that was detectable on the 1980 composites is summarized in Table 7 and shown quarterly in Appendix B, Tables B2 and B4. The gross beta and alpha activity is summarized in Table 8 and shown monthly in Appendix B, Tables B1 and B3. The fission isotopes shown were due to fallout received from past atmospheric nuclear testing.

Table 7
Gamma Analysis of Air Samples
(10^{-15} μ Ci/ml)

Isotope	ALRR - Site 1A		Spedding Hall - Site 2A	
	Avg	% CG	Avg	% CG
Be-7	41.1	1.03×10^{-4}	37.3	9.33×10^{-5}
Ce-141	0.65	1.30×10^{-4}	0.54	1.08×10^{-4}
Ce-144	NDA		0.30	1.50×10^{-4}
Cs-137	0.25	5.00×10^{-5}	0.24	4.80×10^{-5}
Nb-95	1.23	4.10×10^{-4}	1.41	4.70×10^{-4}
Ru-103	0.56	1.87×10^{-5}	0.70	2.33×10^{-5}
Zr-95	0.56	5.6×10^{-4}	0.55	5.50×10^{-4}

Table 8
Radioactivity in Air
(10^{-12} μ Ci/ml)

	Number of Samples	Beta	% CG	Alpha	% CG
ALRR -- Site 1A	182				
Average		0.033	0.033	0.001	5.0
High		0.132		0.015	
Low		0.002		NDA	
Spedding Hall -- Site 2A	138				
Average		0.032	0.032	0.0012	6.0
High		0.149		0.0056	
Low		0.007		NDA	

River Water Samples

River water samples are collected weekly and analyzed for tritium activity and gross alpha and beta activity. Samples are obtained from Onion Creek (Site 3R, 4R, Figure 2), the first flowing creek in the flow route of the ALRR drainage system, and the Skunk River (Site 11R, Figure 3) downstream from both the ALRR drainage system and the Ames Pollution Control

Plant. In addition, samples (Clear Creek) are obtained from outside the ALRR flow route. This constitutes a control site and is numbered nine in the data. Samples are obtained whenever possible. At times the creeks are completely dry in the late summer and fall and frozen solid in the winter. If water is flowing under the ice, a sample is obtained by chopping through the ice. If there is an unusually large amount of suspended material in the sample, the sample is filtered and the soluble and insoluble portions are counted separately; otherwise, the one liter sample is evaporated to near dryness and transferred to a planchet. The planchets are placed directly in the Sharp System for counting. Liquid scintillation technique is used to determine tritium content in 5 ml samples. Gamma analysis is performed on quarterly composites of the weekly samples. The sample results are summarized in Table 9.

Table 9
Radioactivity in River Water
($\mu\text{Ci/ml}$)

	Number of Samples	Beta 10^{-9}	% CG	Alpha 10^{-9}	% CG	Number of Samples	Tritium 10^{-6}	% CG
<u>Downstream</u>								
<u>Sites 4R,</u>								
<u>8R</u>								
Soluble	24					24		
Avg		6.36	0.21	0.55	18.0		2.07	0.06
High		16.3		1.32			4.51	
Low		NDA		NDA			0.45	
Insoluble	0					0		
<u>Upstream</u>								
<u>Sites 1R,</u>								
<u>3R</u>								
Soluble	14					14		
Avg		4.34	0.14	0.27	9.0		2.45	0.08
High		12.3		0.96			5.59	
Low		1.98		NDA			0.90	
Insoluble	0					0		
<u>Control</u>								
<u>Site 9R</u>								
Soluble	9					8		
Avg		5.77	0.19	0.31	10.3		1.75	0.058
High		10.2		0.60			2.52	
Low		3.11		NDA			0.81	
Insoluble	0					0		

Gamma analysis for River Sites 1R, 3R, 4R, 8R, and 9R yielded no detectable isotopes other than naturally occurring radionuclides.

Well Water Samples

Well water samples are obtained monthly from City of Ames wells (1W, Figure 3), Iowa State University (I.S.U.) campus wells (2W, Figure 2), and from a privately owned farm well (Martin) at a location two miles north of the ALRR. The sample size is one liter and is handled in the same manner as the river water samples. No gamma activity was observed in the yearly composites of the well samples other than naturally occurring radio-nuclides. The yearly data are presented in Table 10 and in Appendix B, Table B14.

Table 10
Radioactivity in Well Water Samples
($\mu\text{Ci/ml}$)

	Number of Samples	Beta 10^{-9}	% CG	Alpha 10^{-9}	% CG	Tritium 10^{-6}	% CG
	19						
Average		5.43	0.18	0.41	1.36	1.67	0.06
High		16.7		0.96		4.23	
Low		3.06		NDA		0.27	

Bottom Sediment

Bottom sediment samples are obtained at or near the river water site on a quarterly basis. Samples are analyzed for gross alpha and beta activity. A one-liter sample is obtained from the top 5-8 cm (2-3 inches) of bottom sediment in a semi-quiescent area. The sample is mixed thoroughly and a 3-4 gram counting sample is prepared. The counting samples are dried thoroughly in an oven and then counted directly in the Sharp System. The results for 1980 are shown in Table 11 and Appendix B, Table B15.

Table 11
Radioactivity in Bottom Sediments
(10^{-6} $\mu\text{Ci/g}$)

	Number of Samples	Beta			Alpha		
		Avg	High	Low	Avg	High	Low
Downstream Sites 2R, 2F, 4R, 8R	15	7.62	11.1	6.10	0.35	0.87	0.03
Upstream Sites 1R, 3R	8	6.58	7.67	5.96	0.27	0.35	0.05
Control Site 9R	3	5.98	7.96	4.88	0.22	0.35	0.14

Gamma analysis of bottom sediment samples (200-600 grams) indicated detectable amounts of Cs-137 at Sites 1R, 2F, 2R, and 9R. The presence of this isotope is due to past atmospheric nuclear testing. Detectable amounts (0.15% of the CG) of Co-60 was also indicated at Site 2R and is probably due to reactor operations. The yearly data are presented in Appendix B, Table B16.

C. Impact

From the effluent data, it has been shown that the contribution to the environmental radioactivity in air from Ames Laboratory operations consisted principally of radioactive tritium, H-3.

Applying principles of meteorological diffusion to the stack effluent, particularly section 3-5.5.4, Long-period Average Concentration of "Meteorology and Atomic Energy 1968", USAEC (6) the estimates have been made for the radiation dose at the exclusion fence. The man-Rem dose for the population within an 80 Km (50 mile) radius of the reactor has been estimated using a cylindrical diffusion volume with an 80 Km (50 mile) radius and a height of 305 m (1,000 feet). The height used in the 1974 report was 610 m (2,000 feet).

Average Individual Dose at Fence Line for 1980

	Millirem
H-3 (tritium)	0.0158

The 80 Km (50 mile) man-Rem Dose for 1980 (600,500 population)

	Man-Rem
H-3 (tritium)	26.6

The concentration guide values for an average dose taken as $0.5 \text{ Rem}/3 = 0.17 \text{ Rem}$ yielded 102,085 man-Rem for the population within 80 Km (50 miles). Thus the man-Rem dose, derived from the concentration guide, due to Ames Laboratory operations was 0.0032% of the Radiation Protection Standard (2).

Using the concentration guide value of 500 mRem for an individual at the exclusion fence, the dose was 0.026% of the Radiation Protection Standard.

VI. Sample Site Locations

Table 12
Sample Site Location

AIR

<u>Figure Reference</u>	<u>Map Symbol</u>	
1	1A	The on-site monitoring station is located approximately 122 m (400 feet) south of the reactor.
2	2A	The off-site monitoring station is located on the Spedding Hall roof, approximately 1.6 Km (one mile) southeast of the reactor.

RIVER AND BOTTOM SEDIMENT

<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
1,2	1R	1-DD-U	This on-site sampling point is located just above the mixing zone of the outfall in Onion Creek Gulch.
1,2	2R	Outfall	This site is the outfall and is listed as such. The bottom sediment sample is just below the outfall point in Onion Creek Gulch.
1,2	2F	Fence	Site is approximately 91 m (300 feet) downstream from outfall point at reactor site boundary fence.
2	3R	3-On-U	This site is in Onion Creek upstream from confluence with Onion Creek Gulch.
2	4R	4-On-D	Site is approximately 305 m (1000 feet) downstream from confluence point in Onion Creek.
3	8R	8-Sk-D	Site is in the Skunk River downstream from the Squaw Creek confluence.
2	9R	9-CC	This control site is located outside the flow pattern of ALRR effluent in Clear Creek.
3	11R	11-Sk-S	This is a sample of the Ames Water Pollution Control Plant effluent.

WELLS

<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
3	1W	City	The water wells for the City of Ames are all located east of Squaw Creek. The location indicated is the water treatment plant.
2	2W	I.S.U.	The Iowa State University wells are located west of Squaw Creek.
2	3W	Martin	The Martin site is a private farm well located 3.2 Km (2 miles) north of the ALRR.

Figure 1: Ames Laboratory Research Reactor Site Plan. Map drawn to scale.

Figure 2: Environmental Sampling Sites within 3.2 Km (two miles) of ALRR. Map drawn to scale.

Figure 3: Environmental Sampling Sites within 25.7 Km (sixteen miles) of ALRR. Map drawn to scale.

Figure 4: State of Iowa. Map drawn to scale.

VIII. References

1. DOEM 0513, "Effluent and Environmental Monitoring and Reporting".
2. DOEM 0524, "Standards for Radiation Protection".
3. "Environmental Monitoring at Ames Laboratory", IS-4139, Ames Laboratory USDOE, Iowa State University, Ames, Iowa 50011.
4. Code of Iowa, 1974, Chapter 16, "Water Quality Standards", Department of Environmental Quality, Water Quality Commission.
5. "A Manual of Radioactivity Procedures", National Bureau of Standards Handbook 80, 1961.
6. Slade, D. H., Ed., "Meteorology and Atomic Energy 1968", U.S.A.E.C., 1968.

IX. Acknowledgements

We wish to thank the following organizations and individuals for their cooperation, advice and assistance:

City of Ames - Water Department & Pollution Control Plant

Iowa State University - Physical Plant

Dr. A. F. Voigt, Ames Laboratory

Dr. M. D. Dougal, Director, Iowa State Water Resources Research
Institute

Dr. D. N. Yarger, Associate Professor of Climatology and Meteorology

Dr. E. S. Takle, Assistant Professor of Climatology and Meteorology

Dr. L. V. Sendlein, Professor of Earth Science

Program Assistants: G. P. Jones, Jr.

P. A. Millis

M. D. Savely

W. A. Savely

R. P. Staggs

APPENDIX A. Applicable Standards

The radionuclide concentration standards for air and water applicable to ALRR operations are given in DOE Manual Chapter 0524 (2). A summary of the concentration guides is given in Table A1 and A2. The most restrictive (uncontrolled area) Chapter 0524 Table II value, soluble or insoluble, is reported in Table A2.

Table A1
Concentration Guides
Controlled Area

	In Water ($\times 10^{-9}$ $\mu\text{Ci/ml}$)	In Air ($\times 10^{-12}$ $\mu\text{Ci/ml}$)
Alpha	400	0.6
Beta	90,000	3,000
Be-7	50,000,000	1,000,000
Ce-141	3,000,000	200,000
Co-60	1,000,000	9,000
Cs-134	1,000,000	10,000
Cs-137	1,000,000	10,000
H-3	100,000,000	5,000,000
Nb-95	3,000,000	100
Ru-103	3,000,000	80,000
Sb-125	3,000,000	30,000
Zn-65	5,000,000	60,000
Zr-95	2,000,000	30,000

Table A2
Concentration Guides
Uncontrolled Area

	In Water ($\times 10^{-9}$ $\mu\text{Ci/ml}$)	In Air ($\times 10^{-12}$ $\mu\text{Ci/ml}$)
Alpha	30	0.02
Beta	3,000	100
Be-7	2,000,000	40,000
Ce-141	90,000	500
Ce-144	10,000	200
Co-60	30,000	300
Cs-134	40,000	400
Cs-137	20,000	500
H-3	3,000,000	200,000
Nb-95	100,000	300
Ru-103	80,000	3,000
Sb-125	30,000	900
Zn-65	100,000	2,000
Zr-95	60,000	100

APPENDIX B. Radiological Results for Specific Sites

<u>Table</u>	<u>Title</u>	<u>Page</u>
B1	Air Site 1A, On-Site Station	36
B2	Gamma Analysis Air Site 1A	36
B3	Air Site 2A, Off-Site Station	37
B4	Gamma Analysis Air Site 2A	37
B5	ALRR Stack Effluent	38
B6	Gamma Analysis ALRR Stack Effluent	38
B7	ALRR Outfall Activity (Map Site 2R)	39
B8	River Site 1R, Upstream, Onion Creek Gulch	40
B9	River Site 3R, Upstream, Onion Creek	41
B10	River Site 4R, Downstream, Onion Creek	42
B11	River Site 8R, Downstream, Skunk River	43
B12	River Site 9R, Control, Clear Creek	44
B13	River Site 11R, Ames Water Pollution Control Plant	45
B14	Radioactivity in Wells	46
B15	Radioactivity in Bottom Sediment	46
B16	Gamma Analysis of Bottom Sediment	47

Table B1
Air Site 1A, On-Site Station
(10-12 $\mu\text{Ci/ml}$)

	Number of Samples	Beta	Alpha
Jan	19	0.036	0.0006
Feb	18	0.031	0.0005
Mar	19	0.027	0.0006
Apr	17	0.024	0.0011
May	15	0.026	0.0011
Jun	16	0.029	0.0007
Jul	17	0.029	0.0009
Aug	18	0.026	0.0017
Sep	14	0.022	0.0011
Oct	12	0.028	0.0006
Nov	9	0.072	0.0029
Dec	8	0.081	0.0013
Total	182		
Average		0.0326	0.0010
High		0.132	0.0149
Low		0.002	NDA

Table B2
Gamma Analysis Air Site 1A
On-Site Station
(10-15 $\mu\text{Ci/ml}$)

Isotope	Quarter				Average
	1	2	3	4	
De-7	32.0	60.1	40.9	31.2	41.1
Ce-141	NDA	NDA	NDA	2.58	0.645
Cs-137	NDA	0.61	0.37	NDA	0.245
Ru-103	NDA	NDA	NDA	2.23	0.558
Nb-95	NDA	NDA	NDA	4.92	1.23
Zr-95	NDA	NDA	NDA	2.23	0.558

Table B3
Air Site 2A, Off-Site Station
(10⁻¹² μ Ci/ml)

	Number of Samples	Beta	Alpha
Jan	17	0.036	0.0007
Feb	11	0.029	0.0007
Mar	11	0.023	0.0005
Apr	10	0.021	0.0010
May	13	0.024	0.0013
Jun	12	0.026	0.0010
Jul	13	0.029	0.0014
Aug	13	0.024	0.0016
Sep	10	0.024	0.0010
Oct	12	0.026	0.0012
Nov	9	0.054	0.0016
Dec	7	0.095	0.0023
Total	138		
Average		0.0318	0.0012
High		0.149	0.0056
Low		0.007	NDA

Table B4
Gamma Analysis Air Site 2A
(10⁻¹⁵ μ Ci/ml)

Isotope	Quarter				Average
	1	2	3	4	
Be-7	29.8	48.6	40.0	30.8	37.3
Ce-141	NDA	NDA	NDA	2.14	0.535
Ce-144	NDA	NDA	NDA	1.19	0.298
Ce-137	NDA	0.575	0.372	NDA	0.236
Nb-95	NDA	NDA	NDA	5.65	1.41
Ru-103	NDA	NDA	NDA	2.79	0.698
Zr-95	NDA	NDA	NDA	2.21	0.553

Table B5
ALRR Stack Effluent
(10^{-12} $\mu\text{Ci/ml}$)

	Number of Samples	Beta	Alpha
Jan	19	0.011	0.0001
Feb	20	0.076	0.0005
Mar	19	0.124	0.0014
Apr	21	0.048	0.0018
May	21	0.105	0.0017
Jun	21	0.283	0.0043
Jul	22	0.016	0.0022
Aug	16	0.029	0.0022
Sep	20	0.079	0.0024
Oct	23	0.088	0.0025
Nov	18	0.034	0.0005
Dec	20	0.047	0.0008
Total	240		
Average		0.080	0.0017
High		4.10	0.0598
Low		0.001	NDA

Table B6
Gamma Analysis ALRR Stack Effluent
(10^{-15} $\mu\text{Ci/ml}$)

Isotope	Quarter				Average
	1	2	3	4	
Co-60	38.2	49.7	100.0	21.9	52.5
Cs-137	NDA	2.14	NDA	3.43	1.39
Eu-152	NDA	NDA	NDA	1.84	0.460
Zn-65	NDA	156.0	2.25	6.95	41.3

Table B7
ALRR Outfall Activity (Map Site 2R)
($\mu\text{Ci/ml}$)

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	19	3.21	0.17	19	2.22
Feb	19	3.21	0.16	19	3.03
Mar	18	3.52	0.03	18	2.69
Apr	18	4.07	0.14	16	11.3
May	15	3.98	0.20	15	12.9
Jun	16	4.15	0.23	16	7.12
Jul	17	3.89	0.33	17	5.27
Aug	16	3.78	0.19	16	4.47
Sep	13	3.57	0.16	13	4.74
Oct	12	5.15	0.14	12	3.47
Nov	6	3.52	0.22	6	2.54
Dec	8	4.62	0.22	8	2.23
Total	177			175	
Average		3.83	0.178		5.34
High		13.3	1.62		75.6
Low		1.17	NDA		0.90

No detectable gamma activity other than naturally occurring radio-nuclides.

Table B8
 River Site 1R
 Upstream, Onion Creek Gulch, (Drainage Ditch) (1-DD-U)
 ($\mu\text{Ci/ml}$)
Soluble Portion

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	0	Site Dry		0	
Feb	0	Site Dry		0	
Mar	1	2.47	NDA	1	2.79
Apr	2	2.52	0.15	2	2.65
May	0	Site Dry		0	
Jun	0	Site Dry		0	
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	0	Site Dry		0	
Oct	0	Site Dry		0	
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	3			3	
Average		2.507	0.10		2.703
High		3.063	0.30		2.79
Low		1.98	NDA		2.52

Table B9
 River Site 3R
 Upstream, Onion Creek (3-0n-U)
 ($\mu\text{Ci/ml}$)
Soluble Portion

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	1	4.46	0.18	1	0.90
Feb	1	12.3	0.96	1	1.53
Mar	2	7.75	0.33	2	3.42
Apr	2	4.87	0.69	2	2.79
May	1	4.97	0.06	1	2.25
Jun	2	4.98	0.42	2	1.58
Jul	1	7.03	0.48	1	1.53
Aug	0	Site Dry		0	
Sep	1	3.96	0.30	1	2.25
Oct	0	Site Dry		0	
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	11			11	
Average		6.17	0.44		2.19
High		12.3	0.96		5.59
Low		3.96	0.06		0.90

Table B10
 River Site 4R
 Downstream, Onion Creek (4-On-D)
 ($\mu\text{Ci/ml}$)
Soluble Portion

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	1	5.05	0.48	1	0.90
Feb	1	14.1	0.60	1	1.26
Mar	2	8.42	0.75	2	1.67
Apr	2	4.57	0.54	2	3.20
May	1	4.05	0.42	1	3.24
Jun	2	4.98	0.51	2	2.16
Jul	1	6.22	1.32	1	1.44
Aug	0	Site Dry		0	
Sep	1	3.11	0.30	1	1.44
Oct	0	Site Dry		0	
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	11			11	
Average		6.22	0.61		2.03
High		14.1	1.32		4.51
Low		3.11	0.18		0.81

Table B11
 River Site 8R
 Downstream, Skunk River (8-Sk-D)
 ($\mu\text{Ci/ml}$)
Soluble Portion

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	0	Site Dry		0	
Feb	2	4.71	0.57	2	0.95
Mar	2	10.1	0.33	2	1.98
Apr	2	5.78	0.84	2	2.70
May	1	2.88	0.18	1	3.51
Jun	1	16.3	0.78	1	1.71
Jul	1	6.67	1.08	1	1.62
Aug	0	Site Dry		0	
Sep	1	6.33	NDA	1	2.66
Oct	1	NDA	NDA	1	2.43
Nov	1	4.73	0.90	1	1.44
Dec	0	Site Dry		0	
Total	13			13	
Average		6.49	0.49		2.10
High		16.3	1.08		3.51
Low		NDA	NDA		0.45

Table B12
 River Site 9R
 Control, Clear Creek (9-CC)
 ($\mu\text{Ci/ml}$)
Soluble Portion

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	1	3.10	0.06	1	0.81
Feb	1	10.2	0.42	1	1.62
Mar	3	7.19	0.22	2	1.62
Apr	2	4.03	0.48	2	2.16
May	0	Site Dry		0	
Jun	1	4.28	0.54	1	2.52
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	1	4.69	0.12	1	1.53
Oct	0	Site Dry		0	
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	9			8	
Average		5.77	0.31		1.75
High		10.2	0.60		2.52
Low		3.11	NDA		0.81

Table B13
 River Site 11R
 Ames Water Pollution Control Facility Effluent (11-Sk-S)
 ($\mu\text{Ci/ml}$)
Soluble Portion

	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	1	11.3	0.24	1	1.53
Feb	2	10.2	0.12	2	2.52
Mar	3	10.9	0.02	3	2.46
Apr	2	10.1	0.06	2	2.52
May	1	11.1	0.24	1	2.97
Jun	2	5.34	0.15	2	8.37
Jul	1	10.4	0.06	1	2.07
Aug	0	Site Dry		0	
Sep	2	10.8	0.09	2	3.15
Oct	2	11.0	0.15	2	2.16
Nov	1	10.8	0.24	1	1.89
Dec	1	10.3	0.24	1	1.26
Total	18			18	
Average		10.1	0.12		3.03
High		13.7	0.30		14.5
Low		NDA	NDA		1.26

Table B14
Radioactivity in Wells
($\mu\text{Ci/ml}$)

Site	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Tritium 10^{-6}
City	8	4.08	0.35	1.67
Martin	8	6.32	0.22	1.76
I.S.U.	8	5.89	0.67	1.57
Total	24			
Average		5.43	0.41	1.67
High		16.7	0.96	4.32
Low		3.06	NDA	0.27

No detectable gamma activity other than naturally occurring radionuclides.

Table B15
Radioactivity in Bottom Sediment
($\mu\text{Ci/gm}$)

	Number of Samples	Beta 10^{-6}	Alpha 10^{-6}
<u>Upstream</u>			
1-DD-U	4	6.57	0.20
3-On-U	3	6.58	0.34
Total	7		
Average		6.58	0.27
High		7.67	0.35
Low		5.96	0.05
<u>Downstream</u>			
Outfall	4	9.01	0.61
2F-DD-D	3	7.33	0.31
4-On-D	4	6.55	0.14
8-Sk-D	4	7.60	0.35
Total	15		
Average		7.62	0.35
High		11.1	0.87
Low		6.1	0.03
<u>Control</u>			
9-CC	3		
Average		5.98	0.22
High		7.96	0.35
Low		4.88	0.14

Table B16
Gamma Analysis of Bottom Sediment
(10^{-9} $\mu\text{Ci/gm}$)

	Number of Samples	Cs-137	Co-60
<u>Upstream</u>			
1-DD-U	4	72.8	NDA
3-On-U	4	NDA	NDA
Total	8		
Average		36.4	
High		115	
Low		NDA	
<u>Downstream</u>			
2F-DD-D	3	109	NDA
4-On-D	4	NDA	NDA
8-Sk-D	4	NDA	NDA
Total	11		
Average		29.9	
High		238	
Low		NDA	
<u>Control</u>			
9-CC	4		NDA
Average		23.4	
High		67.2	
Low		26.2	
<u>Outfall</u>			
Site 2R	4		
Average		86.5	44.4
High		227	90.4
Low		NDA	87.3

Distribution List

	<u>Copies</u>
Dr. B. D. Shipp Safety Division Chicago Operations & Regional Office U.S. Department of Energy 9800 South Cass Avenue Argonne, IL 60439	16
Iowa Department of Environmental Quality Des Moines, IA	1
Dr. G. A. Jacobson U.S. Environmental Protection Agency 1735 Baltimore Kansas City, MO 64108	1
Iowa Department of Health Des Moines, Iowa	1
Milo Voss	25
Technical Information Center, DOE	27
Ames Laboratory Document Library	12
Chicago Operations & Regional Office (patent office)	1
Jack Corley Battelle Pacific Northwest Laboratories P. O. Box 999 Richland, WA 99352	2
	<hr/> 84