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ENVIRONMENTAL MONITORING

AT AMES LABORATORY:

Calendar Year 1974

Milo D. Voss

AMES LABORATORY, USERDA

IOWA STATE UNIVERSITY

AMES, IOWA

MASTER

Date of Transmittal: May 1975

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ENVIRONMENTAL MONITORING AT AMES LABORATORY:
Calendar Year 1974

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Environmental Monitoring at Ames Laboratory:
Calendar Year 1974

ABSTRACT

This is an annual report summarizing the effluent and environmental monitoring program at the Ames Laboratory of the United States Energy Research and Development Administration.

Earlier reports in this series concerned only environmental radioactivity and were each entitled "Survey of Environmental Radioactivity". The report for 1973 included some information on effluents, both radioactive and non-radioactive, with an assessment of the radiation dose to the public.

This report for 1974 is the first in the series showing the transition to the use of specific isotopic analyses for all effluent sampling, as well as for some specific environmental sampling.

An inventory of the radioactive materials and certain chemicals 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 has been stated.

IS-3613

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

1. Summary

The radioisotopes which were detected by gamma spectrum analyses in the sampling of the ALRR air exhaust stack but which were not detected in environment air samples included sodium-22, zirconium-95, ruthenium-103 and cerium-141. Of these isotopes the highest concentration in the stack air was only 3.8 millionths of the concentration guide value in ERDA Manual Chapter Appendix 0524, Table II, Column 1 (uncontrolled areas). Of all other isotopes detected in both stack and environmental air by the gamma spectrum analyses, the isotopic concentration levels in the stack were less than the levels in environmental air. These isotopes added nothing to the environmental background radiation; in fact, the stack air lowered this part of the background ever so slightly.

In addition to the specific isotopes unique to the stack exhaust and the radioisotopes common to stack and environmental air, the stack air contained radioactive argon (Ar-41), a gas, and radioactive hydrogen (H-3 or tritium), as tritiated normal or heavy water vapor. While the concentration of these two radioisotopes were relatively high in the stack air, when they passed to the uncontrolled areas the concentrations were 0.43% (Ar-41) and 0.008% (H-3) of the concentration guide values.

The outfall which discharges waste water from the reactor site facilities was monitored over the whole calendar year for tritium, gross beta radioactivity, and gross alpha radioactivity. During the period June-December 1974, the composited outfall samples were also analyzed by gamma spectrum analysis. The gamma spectrum analyses showed only cesium-137 and cobalt-60 present at 7.8 millionths and 6.5 millionths of the concentration guide values, respectively. Assigning the most restrictive

concentration guide values to the gross beta and gross alpha activities, the outfall concentrations were for beta, 0.28% of the concentration guide, and for alpha, 1.47%. The tritium concentration in the outfall waste water was 0.64% of the concentration guide value.

The gross beta and gross alpha activity include naturally occurring radioisotopes. Cesium-137 is likely due to the ubiquitous presence of the isotope from nuclear testing by various countries. The operations of the Ames Laboratory contribute the tritium and probably contribute the cobalt-60. The outfall waste water is much better than required by Iowa Water Quality Standards for Class C, protected raw source of potable water supply, with respect to radioactivity.

The outfall water and two stream sites were monitored for non-radioactive constituents and characteristics. There are two types of standards which apply to discharges, (1) the requirements of the National Pollution Discharge Elimination System permit of the Environmental Protection Agency (Permit #IA-0000370) apply to the discharges directly and (2) the Iowa Water Quality Standards which apply directly to the receiving streams and indirectly to the specific discharge.

The Iowa Water Quality Standards for Class C, protected raw source of potable water supply, are met. For chromium (hexavalent) and pH upstream and downstream samples are equal, having no impact on Onion Creek. Zinc, turbidity and chloride after mixing contribute less than 5% of the water quality standard in receiving stream.

Interim conditions of the discharge permit, IA-0000370 have been met. The permit became effective December 26, 1974.

The operations of the Ames Laboratory have been conducted in such a way that the air and water quality have been maintained at a level much better than the minimum applicable standards.

11. Ames Laboratory Facilities and Locality

The facilities of the Ames Laboratory include offices, laboratories, warehouses and service buildings located among university buildings on the campus of Iowa State University 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 40 acre site approximately 1.5 miles northwest of the I.S.U. campus and 3 miles west and north of downtown Ames (City Hall). The site of the ALRR is about 1,000 feet above sea level and is enclosed by an exclusion fence at 700 feet or more centered on the reactor. The nearest non-residential building (I.S.U.) is about 800 feet east of the reactor and the nearest residential lot is about 1250 feet south of the ALRR.

Ames is located in central Iowa where the Squaw Creek and Skunk River come together. The land is gently rolling "swell and swale". The flat upland is only a little greater than 100 feet above the river flood plain. The general area is about 900 feet above sea level. The City of Ames covers 16.4 square miles. The I.S.U. student population of about 19,000 is included in the Ames population numbering 40,000.* The major portion of Iowa State University and parts of Ames lie within a 2-mile radius of the Ames Laboratory Research Reactor. Within the two-mile circle the land usage is 33% residential (Ames and ISU), 25% wooded, and 42% agricultural.

The climatology of the area is temperate and continental subject to wide seasonal ranges in temperature, precipitation and winds. The average annual temperature is 49° F. The average annual precipitation is 32 inches: 90% rain, 10% snow, with small amounts of sleet and hail.

*From 1970 census

In the colder months the winds are mostly from the northwest sector averaging 18-20 miles/hour; in the warmer months winds are from the southeast sector averaging 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 variations between the least time or frequency and the greatest time is about a factor of two.

The average wind speed at 10 feet above the ground is estimated as 4.0 meters/sec (9 miles/hr) and at 100 feet it is 5.8 meters/sec (13 miles/hr).

An inversion is an atmospheric condition which limits the upward rise of effluents from ventilation and smokestacks. This condition occurs in varying degrees about 290 times per year with an average duration of 14 hours.

The sources of water supply for Ames and Iowa State University are deposits of sand and gravel 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 100-130 feet deep. The city of Ames pumped $1,519 \times 10^6$ gallons from the well field in 1974. In addition, Iowa State University pumped 506×10^6 gallons in the same period, making the total pumped from the well field $2,025 \times 10^6$ gallons. 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 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 Iowa Water Quality Commission. 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, 85 river miles downstream from Ames.

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

<u>City</u>	<u>Population</u> [*]	<u>From Ames</u>
Nevada	5,000	7 miles east
Ankeny	9,000	22 miles south
Boone	12,500	13 miles west
Story City	2,100	14 miles north

The capitol of Iowa, Des Moines, population 201,400^{*} lies 30 miles south of Ames. Fort Dodge, 31,000^{*}, one of our sampling locations, lies 43 miles northwest of Ames.

The total population within a circle of 50 mile radius is 590,500.^{*}

^{*}From 1970 census.

The Reactor and Waste Disposal Decontamination Facilities

The Ames Laboratory Research Reactor is fueled with uranium-235, with circulating heavy water as the coolant and moderator. The primary coolant, heavy water (D_2O), is circulated through the reactor in a closed system with a heat exchanger. The secondary heat removal system uses normal city supplied softened water circulated through the heat exchanger and an open cooling tower.

The reactor operates at 5,000 kilowatts thermal power level on a continuous schedule. The reactor produces up to 10^{14} neutrons/cm²/sec in various experimental facilities. The principal uses of the reactor are the production of fission products which are separated and studied, the irradiation of crystals for the study of structures and energy levels by neutron diffraction, the irradiation of materials, especially metals, for the study of radiation effects, the production of radioisotopes which are used in a variety of tracer studies, and activation of elements in materials for analytical studies.

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 re-use, Class C or better water for release to the environment, and packaged solid waste for shipment to a burial site.

There are laboratories associated with the reactor and also in the Ames Laboratory complex on the Iowa State University campus. Some of these laboratories are used for tracer studies with radioisotopes.

The principal potential sources for release of radioisotopes and chemicals to the environment are the research reactor and the waste-disposal/decontamination facility. Liquids released on the I.S.U. campus Ames Laboratory facilities are handled through the sanitary sewer system. Liquid and solid radioactive wastes in these facilities are collected and taken 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 contaminated wastes generated at the reactor site are transferred to the waste disposal facility for processing. The liquid and solid wastes generated at the reactor site are transferred to the waste-disposal facility for processing. Irradiated air systems of the reactor are filtered before release and are monitored. The liquid effluents from the reactor site are monitored at a single outfall site where all such wastes are released.

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. No yearly average is the mean of the monthly averages.

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 (4). 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 yearly averages which appear in each media type group; that is, air, water, soil and vegetation.

Table 1
95% Confidence Limits

<u>Media Type</u>	<u>Sample Size</u>	<u>Count Time</u>	<u>Average ($\pm 2\sigma$)</u>
<u>Beta</u>			
Air	152 m ³	50 min	$0.15 (\pm 0.01) \times 10^{-12} \mu\text{Ci/ml}$
Water	1 l	30 min	$4.75 (\pm 1.26) \times 10^{-9} \mu\text{Ci/ml}$
Soil, Bottom Sediment	4 g	30 min	$10.54 (\pm 0.72) \times 10^{-6} \mu\text{Ci/g}$
Veget.	0.8 g	30 min	$30.73 (\pm 2.84) \times 10^{-6} \mu\text{Ci/g}$
<u>Alpha</u>			
Air	Same		$0.0038 (\pm 0.0036) \times 10^{-12} \mu\text{Ci/ml}$
Water	as		$0.61 (\pm 0.76) \times 10^{-9} \mu\text{Ci/ml}$
Soil, Bottom Sediment	Beta		$0.67 (\pm 0.26) \times 10^{-6} \mu\text{Ci/g}$
Veget.			$0.32 (\pm 0.88) \times 10^{-6} \mu\text{Ci/g}$
<u>Tritium</u>			
Water	5 ml	100 min	$3.49 (\pm 0.50) \times 10^{-6} \mu\text{Ci/ml}$

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 background count by three times the standard deviation of the background count (4).

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.

With respect to the gamma detection limits, typical counting times were 1333.3 minutes. Sample volumes for air and water were 1.50×10^{10} ml and 2.2×10^4 ml, respectively. Sample mass for soil and bottom sediment averaged 400 grams.

High All highs given in this report are individual sample highs

Low All lows given in this report are individual sample lows

Table 2
Detection Limits

Media Type	Beta	Alpha	Tritium	Gamma									
				<u>Be-7</u>	<u>Ce-141</u>	<u>Ce-144</u>	<u>Co-60</u>	<u>Cs-137</u>	<u>Na-22</u>	<u>Nb-95</u>	<u>Ru-103</u>	<u>Ru-106</u>	<u>Zr-95</u>
Air (10^{-15} μ Ci/ml)	4.80	3.20		1.46	0.95	0.58	0.31	0.22	0.27	0.18	0.16	3.86	0.36
Water (10^{-10} μ Ci/ml)	10.00	3.90	5,000	17.10	1.34	6.59	3.68	2.73	3.20	2.64	1.94	46.81	4.27
Soil, Bottom Sediment (10^{-8} μ Ci/g)	25.00	10.00		15.40	1.63	6.53	3.00	2.31	2.74	2.33	1.75	38.5	4.03
Vegetation (10^{-7} μ Ci/g)	20.70	7.80	5.00 μ Ci/ml										

IV. Radiological Monitoring Program

A gamma scan analysis program was started in November , 1974. Gamma analysis was performed on all air samples, effluent and environmental, for 1974 and the outfall water samples for June through December of 1974. Other representative samples were also considered and appear in the report. It is anticipated that the 1975 report will have more balanced and complete gamma scan analysis.

A. Effluents

Stack Monitor Air Samples

Air samples are collected on a 2 inch Whatman #41 filter paper using a Gast pump with a flow rate of 3 CFM from a sample point near the top of the ALRR stack. Total stack rate is also recorded. After being held for 7 days the samples are counted for 10 minutes in a 2 inch gas proportional system for gross Beta and Alpha activity. From this information the total particulate activity discharged for a 24 hour period is calculated. The samples are retained for a period of 3 months and analyzed using a Gamma spectrometer with a Ge(Li) detector. A computer program based on ICPEAX (5) is used to determine peak energies and areas based on a gaussian fitting routine. The isotopes for which the filters are examined are: Ce-141, Ce-144, Cs-137, Na-22, Nb-95, Ru-103, Zr-95 plus any other unknown which might be observed. Stack volume for 1974 was 2.67×10^{14} ml.

Table 3

ALRR Stack Effluent

($\mu\text{Ci/ml}$)

<u>Isotope</u>	<u>Concentration</u>	<u>% CG</u>
Gross Beta	1.15×10^{-13}	1.15×10^{-1}
Gross Alpha	9.15×10^{-16}	4.58

Table 3 Cont.

<u>Isotope</u>	<u>Concentration</u>	<u>% CG</u>
Ar-41	1.90×10^{-15}	4.75×10^4
Ce-141	1.80×10^{-16}	3.60×10^{-6}
Ce-144	4.37×10^{-15}	2.18×10^{-3}
Cs-137	2.06×10^{-15}	4.12×10^{-4}
H-3	1.78×10^{-6}	8.90×10^2
Na-22	1.13×10^{-15}	3.77×10^{-4}
Nb-95	1.80×10^{-14}	6.00×10^{-4}
Ru-103	3.38×10^{-15}	1.13×10^{-4}
Zr-95	1.72×10^{-15}	1.72×10^{-4}

Water -- Outfall

Outfall water samples are collected twice daily, except weekends and holidays. Alpha and Beta activity is determined by evaporating a 1 liter sample into a 3 inch aluminum planchet and counting in a Sharp Low Beta-matic. Tritium is determined on a 5 ml sample with a Beckman Scintillation Counter and dioxane-naphthalene cocktail. The outfall results for 1974 are shown in Table 4.

Table 4

Radioactivity in the ALRR Outfall

($\mu\text{Ci/ml}$)

	<u>Number of Samples</u>	<u>Beta, 10⁻⁹</u>	<u>% CG</u>	<u>Alpha, 10⁻⁹</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium, 10⁻⁶</u>	<u>% CG</u>
Average	490	8.25	0.28	0.44	1.47	451	19.11	0.64
High		854.10 ¹		152.60 ¹			3,280.00 ²	
Low		0.00		0.00			0.04	

¹ Both the beta and alpha high values for 1974 resulted from a maintenance operation at the ALRR site. In the process of replacing the lime in the

acid neutralization pit, some of lime and sediment was washed out the outfall. Gamma analysis showed that much of the activity was due to Co-60 and Cs-137.

²The high tritium concentration was present in the outfall for approximately 20 minutes of a 225 minute waste disposal operation (9% of the time). The average tritium concentration for the operation was $1.83 \times 10^{-3} \mu\text{Ci/ml}$ (61% CG).

A gamma scan analysis was performed on composite AM and composite PM outfall samples for June-December, 1974. The principle isotopes observed were Cs-137, detectable on 4 of 14 samples, $0.16 \times 10^{-9} \mu\text{Ci/ml}$ (0.001% CG) and Co-60, detectable on 5 of 14 samples, $0.19 \times 10^{-9} \mu\text{Ci/ml}$ (0.0006% CG)

Liquid radioactive waste is treated and sampled on a batch basis. Alpha and Beta activities are determined by evaporating a 100 ml sample and counting. Tritium is determined on 1 ml samples. The absence of I-129 is shown by a radiochemical separation and a beta count of AgI precipitate. All radioactive waste generated at the laboratories located on the I.S.U. campus is collected, evaporated and disposed of as solid waste. The radioactivity in liquid waste released to the environment in 1974 is shown in Table 5.

Table 5

Liquid Radioactive Waste Released to the Environment

Beta	51.11 microcuries
Alpha	2.22 microcuries
Tritium	1.97 curies

The outfall flow rate was measured during the month of December. The flow averaged 4.04×10^4 liters per day. This would be a minimum since the reactor cooling tower was not in operation. The blowdown from this would probably add at least 5.0×10^4 liters per day. Using the minimum

flow, 4.04×10^4 liters per day, the average beta, alpha and tritium activities were 3.48×10^{-9} $\mu\text{Ci/ml}$ (0.12% CG), 1.51×10^{-10} $\mu\text{Ci/ml}$ (0.50% CG) and 1.34×10^{-4} $\mu\text{Ci/ml}$ (4.47% CG), respectively.

In monitoring effluent from the I.S.U. campus facilities, the Ames Water Pollution Control Plant effluent is sampled weekly and a composite sludge sample is process monthly. The effluent is treated the same as a river or outfall sample. The sludge sample is mixed and a 100 ml portion is filtered. After drying, both portions are counted for gross beta and alpha. Tritium concentration is not determined.

Table 6

Radioactivity in the Water Pollution Control Plant Samples (11-Sk-S)

($\mu\text{Ci/ml}$)

	<u>Number of Samples</u>	<u>Beta, 10⁻⁹</u>	<u>% CG</u>	<u>Alpha, 10⁻⁹</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium, 10⁻⁶</u>	<u>% CG</u>
Plant Effluent (Site R11)	52					11		
Average		9.56	0.32	0.18	0.60		3.60	0.12
High		20.72		0.60			13.80	
Low		0.00		0.00			0.28	
Sludge Soluble Portion	12							
Average		34.05	1.14	1.30	4.33		Not Determined	
High		50.00		3.00				
Low		26.58		0.00				
Sludge Insoluble Portion	12							
Average		154.88	5.16	17.42	58.07		Not Determined	
High		290.10		28.83				
Low		26.58		7.81				
Sludge--Ft. Dodge								
Soluble	1	18.00	0.60	1.20	4.00		Not Determined	
Insoluble	1	732.00	24.40	72.70	242.33		Not Determined	

A gamma analysis was performed on 100 ml sewage sludge samples for July, November and December. Of Co-60 and Cs-137 only the December sample had a detectable amount of Cs-137, $3.76 \times 10^{-8} \mu\text{Ci/ml}$ (0.19% CG).

B. Environmental

Air

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 and the roof of Spedding Hall. Samples are collected over a 24 hour period, held for 7 days to allow short-lived activities to decay and then analyzed. Samples are collected on Whatman #41 3 inch diameter filter paper using a Gast pump with a flow rate of 4.1 CFM. The samples are placed directly in a Sharp Low Beta-matic three inch gas proportional system and counted for gross Alpha and Beta activity. 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 specific isotopes for which the filter papers are examined are: Be-7, Ce-144, Cs-137, Nb-95 and Ru-106, plus any other unknown which might be observed.

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

Isotope	ALRR--Site 1A Ave.	% CG	Spedding Hall--Site 2A Ave.	% CG
Be-7	90.70	2.27×10^{-11}	125.20	3.13×10^{-4}
Ce-144	18.80	9.40×10^{-3}	19.90	9.95×10^{-3}
Cs-137	5.36	1.07×10^{-3}	2.70	5.40×10^{-4}
Nb-95	234.20	7.81×10^{-3}	220.50	7.35×10^{-3}
Ru-106	2.65	1.32×10^{-3}	8.20	4.10×10^{-3}

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

	<u>Number of Samples</u>	<u>Beta</u>	<u>% CG</u>	<u>Alpha</u>	<u>% CG</u>
ALRR--Site 1A	237				
Ave.		0.11	0.11	0.0018	9.00
High		0.40		0.0181	
Low		0.01		0.0	
Spedding Hall-- Site 2A	171				
Ave		0.15	0.15	0.0038	19.00
High		0.63		0.0846	
Low		0.02		0.0	

Precipitation Samples

Precipitation samples are collected on an "as it happens basis" and analyzed for tritium and gross alpha and beta activity. The sampling site is the weather observation tower near the ALRR. The samples are handled in the same manner as the river water samples. Gamma analysis for June, July and August indicated 3.48×10^{-5} μ Ci/ml Cs-137 and no detectable Co-60 on 12.33 liters.

Table 9
Radioactivity in Precipitation
(μ Ci/ml)

	<u>Number of Samples</u>	<u>Beta 10^{-9}</u>	<u>% CG</u>	<u>Alpha 10^{-9}</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium 10^{-6}</u>	<u>% CG</u>
Ave.	31	47.78	1.59	2.72	9.07	14	8.94	0.10
High		416.20		25.92			41.40	
Low		0.00		0.00			0.43	

River Water Samples

River water samples are collected weekly and analyzed for gross alpha and beta activity. Analysis for tritium is on a monthly basis except for the Onion Creek sites which have been on a weekly basis since August. Samples are obtained from each river or creek in the flow route of the ALRR drainage system. In addition, two samples are obtained from streams outside the ALRR flow route. These constitute control samples and are numbers nine and ten in the data. Samples are obtained at each site until the creeks go dry in late summer and until the rivers are frozen solid in winter. If water is flowing under 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. Tritium is determined with a 5 ml sample using liquid scintillation.

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

	<u>Number of Samples</u>	<u>Beta 10⁻⁹</u>	<u>% CG</u>	<u>Alpha 10⁻⁹</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium 10⁻⁶</u>	<u>% CG</u>
<u>Downstream</u>								
<u>Sites 4,6,8</u>								
Soluble								
Ave	123	4.75	0.16	0.61	2.03	63	3.49	0.12
High		14.95		1.86			17.70	
Low		0.0		0.0			0.0	
Insoluble								
Ave	6	23.18	0.77	1.46	4.87			
High		56.76		2.10				
Low		3.87		0.84				
<u>Upstream</u>								
<u>Sites 1,3,5,7</u>								
Soluble								
Ave	186	5.62	0.19	0.60	2.00	57	3.39	0.11
High		22.79		2.76			17.40	
Low		0.00		0.00			1.46	
Insoluble								
Ave	13	23.34	0.79	1.75	5.83			
High		51.17		4.80				
Low		5.36		0.72				
<u>Control</u>								
<u>Sites 9,10</u>								
Soluble								
Ave	104	5.74	0.19	0.56	1.87	21	3.51	0.12
High		25.99		2.52			17.6	
Low		0.0		0.0			0.62	
Insoluble								
Ave	6	26.36	0.88	1.80	6.00			
High		58.51		3.06				
Low		3.11		0.90				

Gamma analysis for River Sites 3 (3-On-U) and 4(4-On-D) on 4th quarter samples indicated no detectable activity was present for Co-60 or Cs-137.

Soil Samples

Soil samples are collected once each year. Circles surrounding the ALRR site were divided into quadrants on the basis of wind frequencies. The annuli were chosen on the basis of simplicity for defining sampling area. One sample was taken in each sector of each annulus (see maps).

Reference samples were collected at Fort Dodge, Iowa. The number-letter designations on the data sheets are our codes for sample locations. One-quart samples are collected from the 0-2 inches of top soil. The samples are dried thoroughly in a 100°C drying oven and mixed thoroughly, with large stones and roots being removed. A 3-4 gram counting sample is made from the dried soil, placed in a 3-inch aluminum planchet and counted directly in the Sharp System for gross alpha and beta activity.

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

	<u>Number of Samples</u>	<u>Beta</u>			<u>Alpha</u>		
		<u>Ave</u>	<u>High</u>	<u>Low</u>	<u>Ave</u>	<u>High</u>	<u>Low</u>
Sites 1 - 12	12	10.54	13.01	8.69	0.67	0.96	0.38
Sites 13 - 24	12	10.58	11.87	7.66	0.55	0.69	0.39
Fort Dodge	2	11.90	12.14	11.66	0.76	0.81	0.72

Gamma analysis on soil sites 1S, 2S, 4S, 6S and 7S yielded an average Cs-137 activity of $8.63 \times 10^{-7} \mu\text{Ci/g}$ with no detectable Co-60 activity. The Fort Dodge control site had a Cs-137 activity of $2.94 \times 10^{-7} \mu\text{Ci/g}$ with no detectable Co-60 activity.

Vegetation

Vegetation samples are collected once each year. Samples are obtained at soil sample locations which are designated SV. Date of collection is correlated to the maximum growth period which is July to August for this area. Samples are not collected directly after precipitation of any kind to minimize surface contamination. Generally, the vegetation is confined to grasses and none of the root system is included in the sample. Corn samples were obtained at Soil Sites 2, 8, 10, 12 and Fort Dodge.

For each sample, one portion is used to determine moisture content and gross alpha and beta activity. These samples are dried, ground to a fine powder, and weighed into ~ 0.8 gram counting samples on 3-inch aluminum planchets. Samples are counted for gross alpha and beta activity in the Sharp System. The other portion is frozen for freeze-drying at a later time. The tritium concentration is determined by liquid scintillation counting on the water obtained in the freeze-drying operation. The tritium concentration determined by this method represents only the tritium which is in the plant in the form of molecular water.

Table 12
Radioactivity in Vegetation
(10^{-6} $\mu\text{Ci/g}$)

	<u>Number of Samples</u>	<u>Beta</u>	<u>Alpha</u>	<u>Tritium</u>
<u>General Vegetation</u>				
Sites 3,9,10,11,12	5			
Ave		30.73	0.32	1.57
High		41.27	0.83	2.47
Low		22.18	0.08	0.83
Sites 13,15,17,19, 21,22,24	7			
Ave		35.52	0.32	3.03
High		54.00	0.83	4.23
Low		26.58	0.00	1.72
Fort Dodge	2			
Ave		28.96	0.22	4.62
High		30.91	0.45	4.85
Low		27.00	0.00	4.39
<u>Corn</u>				
Sites 2,8,10,12	4			
Ave		22.54	0.34	5.11
High		23.20	0.60	7.22
Low		21.57	0.22	3.61
Fort Dodge	1	14.81	0.08	6.32

Pond Water

Pond water samples are collected monthly from three sites; the George Todd site four miles northeast of the ALRR; the Izaak Walton League site three miles east of the ALRR; and the Kelley site six miles south of the ALRR. The sample size is one liter and is handled in the same manner as the river water samples.

Table 13
Radioactivity in Pond Water
($\mu\text{Ci/ml}$)

	<u>Number of Samples</u>	<u>Beta 10⁻⁹</u>	<u>% CG</u>	<u>Alpha 10⁻⁹</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium 10⁻⁶</u>	<u>% CG</u>
Ave	36	9.84	0.33	0.42	1.40	33	3.23	0.11
High		26.26		1.02			14.40	
Low		2.34		0.00			0.64	

Well Water Samples

Well water samples are obtained monthly from City of Ames wells, Iowa State University (I.S.U.) campus wells, and from a personal farm well 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.

Table 14
Radioactivity in Well Water Samples
($\mu\text{Ci/ml}$)

	<u>Number of Samples</u>	<u>Beta 10⁻⁹</u>	<u>% CG</u>	<u>Alpha 10⁻⁹</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium 10⁻⁶</u>	<u>% CG</u>
Ave	36	5.16	0.17	0.40	1.33	31	3.67	0.12
High		8.20		1.38			14.20	
Low		2.97		0.00			0.04	
Fort Dodge	1	10.20	0.34	1.00	3.33	1	0.00	0.00

Bottom Sediment

Bottom sediment samples are obtained at or near the river water and pond water sites on a quarterly basis. Samples are analyzed for gross alpha and beta activity. A one-quart sample is obtained from the top 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 1974 are shown in Table 15.

Table 15
Radioactivity in Bottom Sediments
(10^{-6} $\mu\text{Ci/g}$)

	Number of Samples	Ave	Beta High	Low	Ave	Alpha High	Low
Ponds	12	9.50	13.75	5.72	0.54	1.14	0.22
Downstream sites 2R, 4R,6R,8R	16	8.26	11.99	6.05	0.40	0.89	0.12
Upstream sites 1R,3R, 5R,7R	16	7.99	10.98	5.07	0.39	0.80	0.00
Control sites 9R,10R	8	8.12	11.34	6.36	0.40	0.75	0.12

Gamma analysis of bottom sediment just above the outfall in Onion Creek Gulch yielded no detectable activity. Cs-137, 1.62×10^{-7} $\mu\text{Ci/g}$, and Co-60, 20.20×10^{-7} $\mu\text{Ci/g}$, were present in sediment taken just below the outfall. At the ALRR perimeter site fence Co-60 was not detectable and the Cs-137 activity was 0.84 $\mu\text{Ci/g}$. Downstream in Onion Creek, Site 4R (4-On-D), Cs-137 or Co-60 could not be detected.

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 Ar-41 and tritium.

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 (5) the estimates have been made for the radiation dose at the exclusion fence. The man-rem dose for the population within a 50-mile radius of the reactor has been estimated using a cylindrical diffusion volume with a 50-mile radius and a height of 2,000 feet.

Individual Dose at Fence Line for 1974

	Millirem (max)	Millirem (Avg)
Ar-41	2.86	2.15
H-3 (tritium)	0.05	0.04
TOTAL	2.91	2.19

50-mile man-rem dose for 1974 (590,500 population)

	Man-rem
Ar-41	0.6
H-3 (tritium)	<u>56</u>
TOTAL	56.6

The concentration guide value for an average dose taken as 0.5 Rem/3 = 0.17 Rem yields 100,385 man-Rem for the population within 50 miles. Thus the man-Rem dose due to Ames Laboratory operation is 0.0006 or 6 hundredths of 1 percent of the CG.

Using the concentration guide value of 500 mRem for an individual at the exclusion fence, the ratio is 0.006, 6 tenths of 1 percent of the CG.

The average dose to other population groups will be less than 1.2% of the dose derived from the concentration guide value.

The apparent reversal in the Ar-41 and H-3 doses under the two conditions above is due to the decay of Ar-41 during the diffusion time to distribute the Ar-41. The models for the fence line case and the 50 mile radius case are also different. The doses are based on the relationship of the concentration guide level exposure to the radiation protection standard in ERDA Manual Chapter 0524.

There are no realistic models for the exposure due to the concentrations of radionuclides in the streams. However, in no individual case can the operations of the Ames Laboratory contribute more than 0.64% of the dose derived from the concentration guide. After mixing in the receiving stream the dose could not be more than an average of 0.02% of that derived from the concentration guide.

V. Non-Radiological Monitoring Program

A. Effluents

Water-Outfall

Outfall water samples for chemical analysis are collected weekly. Each sample is analyzed for chloride, sodium, hexavalent chromium, zinc and turbidity. Daily temperature and twice daily pH measurements are performed on the outfall effluent.

The pH measurements are made using a Beckman pH Meter. The temperature measurements are taken at the point of withdrawal with a standard laboratory mercury centigrade thermometer. The turbidity is determined using a Hach Turbidimeter. The sodium content is determined by the Ames Laboratory Analytical Services Group I. They use atomic absorption for sodium analysis. The chloride concentration is determined by the titration of the chloride containing a potassium chromate indicator by standard silver nitrate. The end point is indicated by the formation of red silver chromate. This is the Argentometric method described on p. 96 of the 13th Edition of Standard Methods (3). The hexavalent chromium and zinc analysis are performed with a Hach DR Colorimeter using Hach's procedures and chemicals. Hach's method for hexavalent chromium is based on the 1,5-Diphenylcarbohydrazide method which appears on p. 156 of Standard Methods (3). Hach's zinc analysis is based on the Zincon method.

The results for 1974 are shown in Table 16:

TABLE 16

Non-Radioactive Effluent Results
1974

	<u>Number of Samples</u>	<u>Yearly Ave</u>	<u>Individual High</u>	<u>Individual Low</u>
Chlorides	52	388 mg/l	2735 mg/l	4 mg/l
Chromium (hexavalent)	52	0.94 mg/l	6.00 mg/l	0.01 mg/l
Zinc	30	0.24 mg/l	1.90 mg/l	0.02 mg/l
Sodium	52	341 mg/l	2360 mg/l	36 mg/l
Turbidity	52	5.2	130	0.3
pH	483	7.6	12.1	6.4
Temperature	225	21°C	30°C (Jul, Sep)	10°C (Dec)

B. Environmental (Non-Radiological)

Beginning in April, 1974 the hexavalent chromium concentration and pH was determined for samples from Sites 3 (upstream) and 4 (downstream). The sampling and analytical procedures are as described previously. The results for 1974 are shown in Table 17:

TABLE 17

Non-Radioactive Environmental Results
1974

	<u>Number of Sample</u>	<u>Yearly Ave</u>	<u>Individual High</u>	<u>Individual Low</u>
Site 3 -- Upstream				
Chromium (hexavalent)	27	0.02 mg/l	0.03 mg/l	0 mg/l
pH	30	7.9	8.3	7.2

TABLE 17 Cont.

	<u>Number of Sample</u>	<u>Yearly Ave</u>	<u>Individual High</u>	<u>Individual Low</u>
Site 4 -- Downstream				
Chromium (hexavalent)	29	0.02 mg/l	0.04 mg/l	0 mg/l
pH	31	7.9	8.3	7.1

C. Impact (Non-Radiological)

The upstream and downstream averages for hexavalent chromium were equal (0.02 mg/l, 40% of Class C Standards) indicating no measurable addition of hexavalent chromium to Onion Creek by ALRR operations. The upstream and downstream pH averages were also equal indicating no significant pH contribution.

The average zinc effluent concentration was 0.24 mg/l, 24% of Class C standards, before any mixing with Onion Creek. The average turbidity was 5.2, 21% of Class C standards, before mixing with Onion Creek. The average chloride effluent concentration was 388 mg/l, 155% of Class C standards, before mixing. However, if a minimum Onion Creek dilution factor of two is applied, the chloride concentration is 77.5% of Class C standards. The actual Onion Creek dilution factor is approximately 40.

Considering that Onion Creek is a non-classified stream and that the standards applied were for the most stringent conditions, sources of potable water, the ALRR site is not detrimental in any way to Onion Creek. The non-radiological impact of ALRR operations on Onion Creek and subsequent streams is negligible.

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

1

Figure 3: Environmental Sampling Sites Within Sixteen Miles of ALRR. Map drawn to scale.

AIR

- 1A The on-site monitoring station is located approximately 400 feet south of the reactor.
- 2A The off-site monitoring station is located on the Spedding Hall roof approximately one mile southeast of the reactor.

RIVER AND BOTTOM SEDIMENT

<u>Maps</u>	<u>Tables</u>
-------------	---------------

1R	1-DD-U	This on-site sampling point is located just above the mixing zone of the outfall in Onion Creek Gulch.
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.
3R	3-On-U	This site is in Onion Creek upstream from confluence with Onion Creek Gulch.
4R	4-On-D	Site is approximately 1000 feet downstream from the confluence point in Onion Creek.
5R	5-Sq-U	Site is in Squaw Creek upstream from the confluence with Onion Creek.
6R	6-Sq-D	Site is in Squaw Creek downstream from the Onion Creek confluence.
7R	7-Sk-U	Site is in the Skunk River upstream from the Squaw Creek confluence.
8R	8-Sk-D	Site is in the Skunk River downstream from the Squaw Creek confluence.
9R	9-CC	This control site is located outside the flow pattern of ALRR effluent in Clear Creek.
10R	10-DM	This control site is located approximately 15 miles west of the reactor in the Des Moines River.
11R	11-Sk-S	This is a sample of the Ames Water Pollution Control Plant effluent.

SOIL & VEGETATION

The 24 soil and vegetation sampling sites consists of six groups. Each succeeding group is further away from the ALRR, Group 1 being the nearest to the reactor. Four sites, each in a different direction (northwest, northeast, southwest, southeast) make up each group.

	<u>Maps</u>	<u>Tables</u>	
Group 1:	1S	1S-SE1	Soil site, southeast
	2S	2S-SW1	Soil site, southwest
	3S	3SV-NW1	Soil and vegetation site, northwest
	4S	4S-NE1	Soil site, northeast
Group 2:	5S	5S-SE2	Soil site, southeast
	6S	6S-SW2	Soil site, southwest
	7S	7S-NW2	Soil site, northwest
	8S	8S-NE2	Soil site, northeast
Group 3:	9SV	9SV-SE3	Soil and vegetation site, southeast
	10SV	10SV-SW3	Soil and vegetation site, southwest
	11SV	11SV-NW3	Soil and vegetation site, northwest
	12SV	12SV-NE3	Soil and vegetation site, northeast
Group 4:	13SV	13SV-SE4	Soil and vegetation site, southeast
	14S	14S-SW4	Soil site, southwest
	15SV	15SV-NW4	Soil and vegetation site, northwest
	16S	16S-NE4	Soil site, northeast
Group 5:	17SV	17SV-SE5	Soil and vegetation site, southeast
	18S	18S-SW5	Soil site, southwest
	19SV	19SV-NW5	Soil and vegetation site, northwest
	20S	20S-NE5	Soil site, northeast

Group 6: 21SV	21SV-SE6	Soil and vegetation site, southeast
22SV	22SV-SW6	Soil and vegetation site, southwest
23S	23S-NW6	Soil site, northwest
24SV	24SV-NE6	Soil and vegetation site, northeast

PONDS AND WELLS

Maps Tables

1P	Todd	The George Todd pond site is located four miles north-east of the ALRR.
2P	Walton	The Izaak Walton League pond site is located three miles east of the ALRR.
3P	Kelley	The Kelley pond site is located six miles south of the ALRR.
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.
2W	I.S.U.	The Iowa State University wells are located west of Squaw Creek.
3W	Martin	The Martin site is a personal farm well located two miles north of the ALRR.

VII. References

1. AECM 0524, "Standards for Radiation Protection". (Now ERDAM 0524)
2. Iowa Departmental Rules, "Water Quality Standards," Chapter 16, Feb. 12, 1974.
3. "Standard Methods for the Examination of Water and Wastewaters", 13th Edition, 1971 American Public Health Association, New York, New York 10019.
4. "A Manual of Radioactivity Procedures", National Bureau of Standards Handbook 80, 1961.
5. Korthoven, P. J. M., ICPEAX, A Computer Program for the Automatic Analysis of Gamma Ray Spectra Obtained with High Resolution Semiconductor Detectors. I.R.I.; 133-70-4.
6. Slade, D. H., Ed., "Meteorology and Atomic Energy 1968", U.S.A.E.C., 1968.

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APPENDIX A. Applicable Standards

The radionuclides concentration standards for air and water applicable to ALRR operations are the Concentration Guides (CG's) given in Chapter 0524 of the AEC Manual (1). A summary of the concentration guides is given in Table 1. The lowest Chapter 0524 Table II value, soluble or insoluble, is reported in Table 1.

Table 1
Concentration Guides (CG's)

	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
Tritium	3,000,000	200,000
Ar-41	--	40,000
Be-7	2,000,000	40,000
Ce-141	90,000	5,000
Ce-144	10,000	200
Co-60	30,000	300
Cs-137	20,000	500
Na-22	30,000	300
Nb-95	100,000	3,000
Ru-103	80,000	3,000
Ru-106	10,000	200
Zr-95	60,000	1,000

There are currently no standards applicable to non-radioactive pollutants (parameters) in the effluent discharged to the drainage ditch and thence to Onion Creek. There are water quality standards for some parameters in Chapter 16 of the Iowa Departmental Rules, "Water Quality Standards" adopted February 12, 1974. (2)

Table 2

Iowa Water Quality Standards

Chemical Constituents	Class C Standard
Chlorides	250 mg/l
Chromium (hexavalent)	0.05 mg/l
Sodium	no listing
Zinc	1.0 mg/l
Turbidity	<25
pH	6.5-9.0
Temperature	<5°F Increase for Class B Water

APPENDIX B. Radiological Results for Specific Sites

Table 1

Air Site 1A

On-Site Station

 $(10^{-12} \mu\text{Ci/ml})$

	Number of Samples	Beta, 10^{-12}	Alpha, 10^{-12}
Jan	22	0.070	0.0019
Feb	17	0.094	0.0027
Mar	20	0.128	0.0012
Apr	20	0.222	0.0037
May	22	0.195	0.0024
Jun	20	0.198	0.0017
Jul	19	0.115	0.0024
Aug	22	0.089	0.0018
Sep	20	0.058	0.0009
Oct	22	0.042	0.0008
Nov	16	0.053	0.0009
Dec	17	0.068	0.0015
Total	237		
Average		0.112	0.0018
High		0.401	0.0181
Low		0.009	0.0000

Table 2
Gamma Analysis Air Site 1A
On-Site Station
(10⁻¹⁵ μ Ci/ml)

Quarter	Number of Samples	Ce-144	Be-7	Ru-106	Cs-137	Nb-95
1	58	6.38	NDA	NDA	0.82	NDA
2	62	23.70	NDA	10.60	5.02	871.30
3	64	33.50	63.30	NDA	NDA	NDA
4	44	11.80	299.60	NDA	15.60	65.40
Total	228					
Average		18.80	90.70	2.65	5.36	234.20

(NDA = No Detectable Activity as defined by the Detection Limit in Section III)

Table 3
 Air Site 2A
 Off-Site Station
 ($\mu\text{Ci/ml}$)

	Number of Samples	Beta, 10^{-12}	Alpha, 10^{-12}
Jan	19	0.100	0.0046
Feb	16	0.107	0.0028
Mar	16	0.165	0.0024
Apr	15	0.303	0.0066
May	16	0.227	0.0103
Jun	14	0.250	0.0032
Jul	12	0.181	0.0028
Aug	14	0.122	0.0025
Sep	13	0.079	0.0021
Oct	14	0.059	0.0015
Nov	11	0.065	0.0017
Dec	11	0.083	0.0022
Total	171		
Average		0.148	0.0038
High		0.629	0.0846
Low		0.023	0.0000

Table 4
 Gamma Analysis Air Site 2A
 Off-Site Station
 (10^{-15} $\mu\text{Ci/ml}$)

Quarter	Number of Samples	Ce-144	Be-7	Ru-106	Cs-137	Nb-95
1	52	7.16	NDA	NDA	1.39	NDA
2	45	40.80	NDA	29.60	4.60	786.10
3	42	13.80	NDA	3.37	1.86	NDA
4	26	18.00	500.80	NDA	2.91	96.20
Total	165					
Average		19.90	125.20	8.20	2.70	220.50

Table 5
Gamma Analysis ALRR Stack Results
(10⁻¹⁵ µCi/ml)

Quarter	Number of Samples	Ce-144	Be-7	Ru-106	Cs-137	Nb-95	Ru-103	Zr-95	Na-22
1	58	NDA	NDA	NDA	NDA	NDA	NDA	NDA	NDA
2	55	1.60	143.00	NDA	4.04	23.90	NDA	* NDA	NDA
3	68	10.90	30.50	NDA	2.15	21.90	NDA	NDA	NDA
4	88	3.38	534.00	NDA	1.09	20.90	15.60	7.94	5.20
Total	269								
Average*		3.97	176.87	NDA	1.82	16.68	3.90	1.99	1.30

* Non-weighted Quarterly Average

Table 6

River Site 1R

Upstream, Onion Creek Gulch (Drainage Ditch) (1-DD-U)

 $(\mu\text{Ci/ml})$

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	0			0	
Feb	1	2.30	0.24	0	
Mar	4	4.50	0.33	1	3.15
Apr	5	2.89	0.22	1	1.46
May	4	5.78	0.24	1	3.00
Jun	4	2.86	0.14	1	3.84
Jul	4	3.74	0.18	1	1.77
Aug	2	3.29	0.33	0	
Sep	0			0	
Oct	0			0	
Nov	2	3.45	0.00	1	3.57
Dec	3	1.56	0.02	0	
Total	30			6	
Average		6.08	0.19		2.80
High		8.56	0.90		3.84
Low		0.00	0.00		1.46

<u>Insoluble Portion</u>			
Mar	1	29.46	2.10

Table 7
 River Site 3R
 Upstream, Onion Creek (3-0n-U)
 ($\mu\text{Ci/ml}$)

	Number of Samples	<u>Soluble Portion</u>		Number of Samples	Tritium, 10^{-6}
		Beta, 10^{-9}	Alpha, 10^{-9}		
Jan	5	3.90	0.76	0	
Feb	4	3.85	0.54	1	2.04
Mar	4	4.18	0.72	1	2.09
Apr	5	4.12	0.49	1	1.11
May	4	9.54	0.89	2	2.75
Jun	4	7.17	0.56	1	2.94
Jul	5	4.02	0.48	5	4.81
Aug	4	4.44	0.60	3	7.59
Sep	5	5.06	0.49	3	4.72
Oct	4	6.49	0.48	4	2.88
Nov	4	3.43	0.50	4	1.18
Dec	4	2.41	0.32	4	0.94
Total	52			29	
Average		4.84	0.57		3.26
High		12.84	1.68		16.20
Low		0.00	0.00		0.00

Table 7 Cont.

	Number of Samples	<u>Insoluble Portion</u>		Number of Samples	Tritium, 10 ⁻⁶
		Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹		
Feb	1	5.36	1.26		
Mar	1	9.09	.721		
May	2	41.28	1.89		
Total	4				
Average		24.25	1.44		
High		51.17	1.92		
Low		5.36	.721		

Table 8

River Site 4R

Downstream, Onion Creek (4-On-D)

 $(\mu\text{Ci/ml})$

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	2	2.43	0.72	0	
Feb	3	3.95	0.70	0	
Mar	4	2.27	0.50	1	1.88
Apr	5	4.04	0.59	1	0.91
May	1	2.52	0.54	1	2.00
Jun	4	6.55	0.62	1	3.77
Jul	5	3.61	0.48	5	4.52
Aug	4	4.34	0.45	3	9.30
Sep	3	4.10	0.34	3	5.01
Oct	4	5.70	0.60	4	3.42
Nov	4	3.55	0.56	4	1.25
Dec	4	3.49	0.42	4	1.01
Total	43			27	
Average		4.03	0.52		3.58
High		10.90	1.20		17.70
Low		0.00	0.00		0.00

Table 8 Cont.

<u>Insoluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Feb	1	3.87	1.41		
Mar	1	4.23	0.84		
Total	2				
Average		4.05	1.12		
High		4.23	1.41		
Low		3.87	0.84		

Table 9
River Site 5R
Upstream, Squaw Creek (5-Sq-U)
($\mu\text{Ci/ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	4.20	0.69	0	
Feb	4	4.67	0.62	1	2.00
Mar	4	3.71	0.78	1	1.47
Apr	5	5.96	0.66	1	0.35
May	4	10.61	0.83	1	2.60
Jun	4	9.88	0.75	1	3.29
Jul	5	5.58	0.58	1	2.14
Aug	4	5.12	0.48	1	17.40
Sep	5	4.48	0.41	1	2.58
Oct	4	4.67	0.63	1	7.55
Nov	4	3.58	0.60	1	1.95
Dec	4	3.02	0.24	1	1.17
Total	52			11	
Average		5.62	0.60		3.86
High		14.91	1.50		17.40
Low		0.00	0.00		0.346

Table 9 Cont.

<u>Insoluble Portion</u>					
	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Feb	1	19.05	1.26		
Mar	1	10.18	1.08		
May	2	32.66	1.11		
Total	4				
Average		23.64	1.14		
High		39.28	1.38		
Low		10.18	0.84		

Table 10
 River Site 6R
 Downstream, Squaw Creek (6-Sq-D)
 ($\mu\text{Ci/ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	4	3.81	0.47	2	0.12
Feb	4	4.43	0.90	3	0.91
Mar	4	4.28	0.83	4	0.53
Apr	5	4.32	0.77	5	1.49
May	4	10.63	1.22	4	3.42
Jun	4	10.69	0.80	3	7.12
Jul	5	4.60	0.71	3	4.83
Aug	4	6.36	0.66	1	15.60
Sep	5	4.04	0.30	1	2.14
Oct	4	4.89	0.57	1	7.41
Nov	4	3.75	0.54	1	2.55
Dec	4	3.58	0.32	1	1.49
Total	51			29	
Average		5.12	0.67		3.21
High		14.95	1.86		15.60
Low		0.00	0.00		0.00

Table 10 Cont.

<u>Insoluble Portion</u>					
	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Feb	1	20.00	1.14		
Mar	1	11.67	1.74		
May	2	49.66	1.95		
Total	4				
Average		32.75	1.69		
High		56.76	2.10		
Low		11.67	1.14		

Table 11
 River Site 7R
 Upstream, Skunk River (7-Sk-U)
 ($\mu\text{Ci/ml}$)

	<u>Soluble Portion</u>				
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	4.68	1.32	0	
Feb	4	5.18	0.75	1	1.06
Mar	4	4.40	0.83	1	1.39
Apr	5	6.61	0.78	1	0.48
May	4	9.53	1.14	1	1.90
Jun	4	12.17	0.95	1	3.17
Jul	5	8.59	1.02	1	2.49
Aug	4	5.81	0.68	1	15.90
Sep	5	4.06	0.30	1	2.62
Oct	4	4.80	0.66	1	7.50
Nov	4	4.51	0.75	1	2.70
Dec	4	3.24	0.59	1	0.22
Total	52			11	
Average		6.20	0.86		3.59
High		22.79	2.76		15.90
Low		1.44	0.00		0.22

Table 11 Cont.

<u>Insoluble Portion</u>					
	Number of Sample	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Feb	1	16.17	1.74		
Mar	1	13.02	1.92		
May	2	26.60	3.33		
Total	4				
Average		20.60	2.58		
High		27.52	4.80		
Low		13.02	1.74		

Table 12
River Site 8R
Downstream, Skunk River (8-Sk-D)
($\mu\text{Ci}/\text{ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	2	1.78	0.39	0	
Feb	1	7.12	1.44	0	
Mar	3	0.95	0.31	0	
Apr	5	1.05	0.07	1	0.62
May	2	4.28	0.38	1	3.00
Jun	1	7.88	1.26	1	2.77
Jul	3	1.68	0.28	1	2.66
Aug	4	1.47	0.24	1	16.60
Sep	3	1.44	0.05	1	1.72
Oct	2	2.91	0.29	1	2.62
Nov	2	1.93	0.21	0	
Dec	1	5.14	0.66	0	
Total	29			7	
Average		5.18	0.65		4.29
High		11.08	1.44		16.60
Low		0.00	0.00		0.62

Table 13

River Site 9R

Control, Clear Creek (9-CC)

($\mu\text{Ci/ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	3.86	0.26	0	
Feb	4	2.68	0.27	1	1.25
Mar	4	2.87	0.45	1	2.35
Apr	5	3.68	0.29	1	0.80
May	4	14.16	1.28	1	2.30
Jun	4	5.57	0.74	1	2.67
Jul	5	3.21	0.24	1	1.74
Aug	4	6.23	0.62	1	16.30
Sep	5	5.37	0.26	1	1.02
Oct	4	7.22	0.60	0	
Nov	4	2.84	0.33	1	2.74
Dec	4	2.78	0.17	1	1.73
Total	52			10	
Average		4.96	0.44		3.29
High		25.99	2.52		16.30
Low		0.00	0.00		0.79

Table 13 Cont.

<u>Insoluble Portion</u>					
	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Feb	1	3.11	0.90		
Mar	1	11.22	1.20		
May	2	53.49	2.58		
Total	4				
Average		30.30	1.81		
High		58.51	3.06		
Low		3.11	0.90		

Table 14

River Site 10R

Control, Des Moines River (10-DM)

(μCi/ml)

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Jan	5	4.40	0.87	0	
Feb	4	5.25	0.65	1	1.58
Mar	4	3.72	0.93	1	1.39
Apr	5	8.33	0.64	1	0.62
May	4	8.78	0.86	1	2.70
Jun	4	9.84	0.80	1	2.74
Jul	5	7.48	0.90	1	3.35
Aug	4	6.58	0.59	1	17.60
Sep	5	6.50	0.42	1	1.76
Oct	4	6.43	0.42	1	4.33
Nov	4	5.48	0.63	1	3.40
Dec	4	5.18	0.27	1	1.29
Total	52			11	
Average		6.51	0.67		3.70
High		16.22	1.44		17.60
Low		0.00	0.00		0.62

Table 14 Cont.

<u>Insoluble Portion</u>					
	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Mar	1	15.27	2.10		
May	1	21.67	1.44		
Total	2				
Average		18.47	1.77		
High		21.67	2.10		
Low		15.27	1.44		

Table 15

River Site 11R

Ames Water Pollution Control Plant Effluent (11-Sk-S)

 $(\mu\text{Ci/ml})$

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	3.00	0.31	0	
Feb	4	13.90	0.08	1	1.98
Mar	4	5.88	0.05	1	2.44
Apr	5	9.79	0.18	1	0.28
May	4	7.39	0.20	1	2.00
Jun	4	7.76	0.27	1	2.35
Jul	5	7.50	0.13	1	2.78
Aug	4	10.62	0.27	1	13.80
Sep	5	12.53	0.00	1	2.06
Oct	4	13.78	0.18	1	5.28
Nov	4	13.08	0.38	1	5.29
Dec	4	10.88	0.17	1	1.37
Total	52			11	
Average		9.56	0.18		3.60
High		20.72	0.60		13.80
Low		0.00	0.00		0.28

Table 16
ALRR Outfall (Map Site 2R)
($\mu\text{Ci/ml}$)

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	44	6.26	0.26	29	1.62
Feb	38	6.59	0.12	33	1.32
Mar	40	4.43	0.10	39	12.60
Apr	42	7.23	0.18	42	10.20
May	44	29.39	3.73	41	9.87
Jun	40	7.87	0.05	40	8.32
Jul	43	5.46	0.08	43	11.50
Aug	44	7.57	0.15	41	124.00
Sep	40	4.78	0.03	38	11.60
Oct	45	6.07	0.09	37	7.81
Nov	34	6.33	0.15	34	5.60
Dec	36	5.02	0.07	34	11.00
Total	490			451	
Average		8.25	0.44		19.11
High		854.10	152.60		3280.00
Low		0.00	0.00		0.04

Table 17

Gamma Analysis ALRR Outfall (Map Site 2R)

 $(10^{-10} \mu\text{Ci/ml})$

		Number of Samples	Cs-137	Co-60
Jun	AM	18	4.70	NDA
	PM	18	2.45	NDA
Jul	AM	22	NDA	NDA
	PM	20	NDA	NDA
Aug	AM	22	NDA	7.27
	PM	22	6.32	NDA
Sep	AM	20	NDA	NDA
	PM	20	NDA	1.31
Oct	AM	22	NDA	NDA
	PM	22	NDA	NDA
Nov	AM	19	NDA	6.68
	PM	17	NDA	NDA
Dec	AM	19	NDA	6.16
	PM	17	8.40	5.72
Total		278		
Average			1.56	1.94

Table 18
Radioactivity in Wells
($\mu\text{Ci/ml}$)

Site	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
City	12	4.58	0.40	10	4.48
Martin	12	6.44	0.30	11	3.37
I.S.U.	12	4.46	0.50	10	3.20
Total	36			31	
Average		5.16	0.40		3.67
High		8.20	1.38		14.20
Low		2.97	0.00		0.04

Table 19
Radioactivity in Ponds
($\mu\text{Ci/ml}$)

Site	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Todd	12	5.15	0.51	11	3.38
Walton	12	18.49	0.34	11	3.61
Kelly	12	5.86	0.42	11	2.69
Total	36			33	
Average		9.84	0.42		3.23
High		26.26	1.02		14.40
Low		2.34	0.00		0.64

Table 20

Radioactivity in Precipitation

 $(\mu\text{Ci/ml})$

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	2	84.88	15.01	0	
Feb	1	32.20	3.54	1	4.16
Mar	2	28.44	5.04	0	
Apr	2	217.76	6.68	0	
May	3	36.92	0.57	1	13.80
Jun	5	35.55	0.68	2	7.55
Jul	4	43.97	0.97	2	6.17
Aug	6	22.42	1.37	2	9.96
Sep	1	7.25	0.28	1	5.67
Oct	2	50.16	2.28	2	3.85
Nov	2	13.64	0.55	2	2.54
Dec	1	52.14	4.07	1	41.40
Total	31			14	
Average		47.78	2.72		8.94
High		416.20	25.92		41.40
Low		0.00	0.00		0.43

Gamma Analysis for June, July and August
 Total Volume = 12.33 liters

Co-60 NDA
 Cs-137 2.82×10^{-9} Ci/ml

Table 21
Radioactivity in Bottom Sediment
(10^{-6} $\mu\text{Ci/g}$)

Site	Number of Samples	Beta	Alpha
<u>Upstream</u>			
1-DD-U	4	6.81	0.29
3-ON-U	4	6.99	0.18
5-Sq-U	4	9.11	0.52
7-Sk-U	4	9.06	0.56
Total	16		
Average		7.99	0.39
High		10.98	0.80
Low		5.07	0.00
<u>Downstream</u>			
Outfall	4	8.02	0.28
4-On-D	4	6.96	0.22
6-Sq-D	4	8.79	0.52
8-Sk-D	4	9.28	0.59
Total	16		
Average		8.26	0.40
High		11.99	0.89
Low		6.05	0.12

Table 21 Cont.

Site	Number of Samples	Beta	Alpha
<u>Control</u>			
9-CC	4	6.95	0.24
10-DM	4	9.28	0.55
Total	8		
Average		8.12	0.40
High		11.34	0.75
Low		6.36	0.12
<u>Ponds</u>			
Todd	4	10.08	0.74
Walton	4	8.73	0.27
Kelly	4	9.68	0.60
Total	12		
Average		9.50	0.54
High		13.75	1.14
Low		5.72	0.22

Table 22

Gamma Analysis of Bottom Sediment

 $(10^{-7} \mu\text{Ci/g})$

Site	Sample Weight	Cs-137	Co-60
1-DD-U	509 g	NDA	NDA
Outfall	620 g	1.62	20.20
Perimeter Fence	218 g	0.84	NDA
4-On-D	341 g	NDA	NDA

Table 23
Radioactivity in Vegetation
8-28-74
(10^{-6} $\mu\text{Ci/g}$)

Site	Beta	Alpha	Tritium	Per Cent Moisture
3SV-NW1	29.22	0.22	0.99	73
9SV-SE3	27.48	0.83	0.83	77
10SV-SW3	22.18	0.22	1.68	69
11SV-NW3	33.50	0.22	2.47	76
12SV-NE3	41.27	0.08	1.91	76
13SV-SE4	34.85	0.60	1.72	78
15SV-NW4	27.42	0.15	2.43	72
17SV-SE5	37.89	0.08	4.23	83
19SV-NW5	36.04	0.45	2.58	79
21SV-SE6	54.00	0.00	3.38	85
22SV-SW6	26.58	0.15	3.30	72
24SV-NE6	31.87	0.83	3.60	80
Average	33.53	0.32	2.43	77
High	54.00	0.83	4.23	85
Low	22.18	0.00	0.83	69
Fort Dodge 1	30.91	0.00	4.85	77
Fort Dodge 2	27.00	0.45	4.39	72

Table 24

Radioactivity in Corn

9-9-74

 $(10^{-6} \mu\text{Ci/g})$

Site	Beta	Alpha	Tritium	Per Cent Moisture
25-SW1	21.57	0.22	5.09	76
8S-NE2	22.64	0.22	3.61	86
10SV-SW3	23.20	0.30	7.22	86
12SV-NE3	22.75	0.60	4.50	85
Average	22.54	0.34	5.11	83
High	23.20	0.60	7.22	86
Low	21.57	0.22	3.61	76
Fort Dodge	14.81	0.08	6.32	80

Table 25
Radioactivity in Soil

8-28-74

 $(10^{-6} \mu\text{Ci/g})$

Site	Beta	Alpha
1S-SE1	11.09	0.92
2S-SW1	10.44	0.69
3SV-NW1	12.22	0.57
4S-NE1	10.93	0.48
5S-SE2	10.09	0.96
6S-SW2	11.25	0.62
7S-NW2	8.69	0.74
8S-NE2	13.01	0.80
9SV-SE3	9.17	0.54
10SV-SW3	10.37	0.38
11SV-NW3	9.03	0.74
12SV-NE3	10.18	0.57
13SV-SE4	11.49	0.60
14S-SW4	7.66	0.41
15SV-NW4	11.14	0.54
16S-NE4	10.23	0.68
17SV-SE5	10.30	0.62
18S-SW5	8.94	0.48
19SV-NW5	11.34	0.51
20S-NE5	11.60	0.60

Table 25 Cont.

Site	Beta	Alpha
21SV-SE6	11.32	0.50
22SV-SW6	11.87	0.39
23SV-NW6	11.04	0.65
24SV-NE6	10.08	0.69
Average	10.56	0.61
High	13.01	0.96
Low	7.66	0.38
Fort Dodge 1	11.66	0.81
Fort Dodge 2	12.14	0.72

Table 26
Gamma Analysis of Soil Samples
(10^{-7} $\mu\text{Ci/g}$)

Site	Sample Weight (g)	Cs-137	Co-60
1S	336	8.39	NDA
2S	332	11.00	NDA
4S	500	11.00	NDA
6S	341	9.91	NDA
7S	426	2.86	NDA
Fort Dodge 2	336	2.94	NDA

APPENDIX C. Non-Radiological Results for Specific Sites

Table 1

Chemical Analysis

ALRR Outfall (Map Site 2R)

	Number of Samples	mg/l				Average Turbidity
		Ave Cl ⁻	Ave Na ⁺	Ave Cr ⁺⁶	Ave Zn ⁺²	
Jan	4	658	390	0.75		9.0
Feb	4	350	350	1.38		2.2
Mar	5	81	241	0.92		3.2
Apr	4	65	162	2.38		0.8
May	5	557	351	0.29		28.3
Jun	4	750	318	0.35	0.18	1.0
Jul	4	160	201	0.53	0.06	0.8
Aug	5	241	237	1.05	0.34	3.1
Sep	4	138	234	0.44	0.09	2.2
Oct	5	723	773	0.24	0.45	4.7
Nov	4	842	546	1.78	0.39	1.4
Dec	4	78	233	1.42	0.10	0.7
Total	52				30	
Average		388	341	0.94	0.24	5.2
High		2735	2360	6.00	1.90	130.0
Low		4	36	0.01	0.02	0.3

Table 2
pH and Temperature
ALRR Outfall (Map Site 2R)

	Number of Samples	Total pH Ave	<u>Individual</u> High Low		Number of Samples	Average Temp, °C	High	Low
Jan	44	7.6	8.5	6.6	21	16	22(22)*	12(2)*
Feb	38	7.9	10.2	6.9	19	20	21(5)	11(25)
Mar	41	7.7	12.1	6.7	14	18	20(5)	16(14)
Apr	42	7.4	9.3	6.7	17	19	22(22)	14(30)
May	41	7.3	8.6	6.9	18	20	25(30)	12(9)
Jun	40	7.4	9.1	6.8	14	23	26(4)	17(11)
Jul	43	7.6	11.2	6.5	22	26	30(23)	21(29)
Aug	44	7.5	8.2	6.4	22	24	27(19)	19(30)
Sep	37	7.8	8.5	6.4	19	25	30(27)	22(3)
Oct	45	8.1	9.0	6.5	23	25	29(28)	21(30)
Nov	32	7.6	8.7	6.7	18	16	28(1)	12(25)
Dec	36	7.7	8.7	6.9	18	15	20(11)	10(9)
Total	483				225			
Average		7.6				21		
High		12.1				30		
Low		6.4				10		

*Number in parentheses is date of high or low reading

Table 3
pH and Cr⁺⁶ Concentrations
Onion Creek

	Site 3R -- Upstream (3-On-U)				Site 4R -- Downstream (4-On-D)			
	Number of Samples	Cr ⁺⁶ mg/l	Number of Samples	pH	Number of Samples	Cr ⁺⁶ mg/l	Number of Samples	pH
Apr	2	0.00	2	7.8	2	0.01	2	7.8
May	1	0.02	1	8.0	1	0.03	1	8.1
Jun	4	0.02	4	8.0	4	0.02	4	8.1
Jul	3	0.02	4	8.0	4	0.02	5	8.0
Aug	3	0.02	4	8.0	4	0.02	4	8.1
Sep	2	0.02	3	7.6	2	0.02	3	7.6
Oct	4	0.02	4	7.8	4	0.02	4	7.8
Nov	4	0.02	4	7.9	4	0.02	4	8.0
Dec	4	0.02	4	7.7	4	0.02	4	7.8
Total	27		30		29		31	
Average		0.02		7.9		0.02		7.9
High		0.03		8.3		0.04		8.3
Low		0.00		7.2		0.00		7.1