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SUMMARY OF SELECTED AEC CONTRACTOR
ENVIRONMENTAL SURVEILLANCE
TECHNIQUES AND CAPABILITIES

Battelle

Pacific Northwest Laboratories
Richland, Washington 99352

SEPTEMBER 1974

MASTER

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SUMMARY OF SELECTED AEC CONTRACTOR ENVIRONMENTAL SURVEILLANCE TECHNIQUES AND CAPABILITIES

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INTRODUCTION

The Atomic Energy Commission, through its Division of Operational Safety, has provided funding to Battelle-Pacific Northwest Laboratories to conduct a study to:

1. Delineate the capabilities and limitations of the various effluent and environmental monitoring systems for radioactivity currently used by AEC contractors.
2. Provide recommended standard methods and procedures to bring uniformity and comparability to AEC contractor environmental monitoring and reporting systems.
3. Provide the Division of Operational Safety with a draft handbook of environmental monitoring procedures.

The objectives of the first phase of this study were to: (1) determine the capabilities and limitations of environmental radiation monitoring methods and reporting procedures currently in use by AEC contractors; (2) identify the component parts of a total program; and (3) identify where additional guidance is needed for comparability.

This report summarizes the results of this survey of existing environmental surveillance procedures at 19 major AEC installations, and provides benchmarks for future recommendations concerning standardization of comparable methods and procedures for environmental monitoring and reporting. It should be emphasized throughout this report that, while the information gathered relates to both effluent and environmental

*Currently employed by Radiation Management Corporation, Philadelphia, Pennsylvania

monitoring, the latter is emphasized here. Information on effluent monitoring was used only as it amplified environmental surveillance programs or was deemed necessary for estimation of radiation doses to persons living in the environs of the facility. However, the data collected on effluent monitoring systems at the sites visited has been compiled and is shown in a series of tables as Appendix B to this report. No attempt was made to categorize the many effluent streams at the sites, but only those considered typical and most significant in terms of potential environmental effect.

The goals for the next phase of this study are to: (a) in consultation experts on various aspects of environmental monitoring, define recommended and accepted procedures for the various categories of environmental surveillance at AEC installations; (b) provide a discussion of the various surveillance methods with a view toward specifying the capabilities, limitations and conclusions that one would expect from such surveillance techniques; and (c) incorporate these details and guidance into a Handbook. It is expected that such a Handbook will provide a reference to assist Headquarters and field office and contractor management and staff in evaluating and comparing environmental monitoring and reporting programs at AEC contractor facilities.

Information Gathering

To determine current effluent and environmental monitoring capabilities, a comprehensive discussion outline (Appendix) was developed. A copy of the discussion outline was sent in advance to each site to help prepare for the site visit and ensuing discussion. Concurrently, telephone contacts were made with each of the AEC Operations Offices. Following these telephone contacts, visits were scheduled with health physics and environmental evaluations personnel at the AEC installations. The group of AEC installations chosen to visit were selected on the basis of those whose programs would be representative of the variety and complexity of surveillance activities being conducted by AEC contractors. These contractors are listed in Table 1.

TABLE 1. AEC Installations and Contractors Visited to Discuss
Effluent and Environmental Monitoring Practices

Ames Laboratory	Ames, Iowa
Argonne National Laboratory	Argonne, Ill.
Atomics International	Canoga Park, Calif.
Battelle Columbus Labs.	Columbus, Ohio
Brookhaven National Laboratory	Upton, N.Y.
Hanford Site	Richland, Wash.
Atlantic Richfield Hanford Company	
Battelle - Pacific Northwest Labs.	
Hanford Engineering Development Lab.	
United Nuclear Industries	
La Crosse Boiling Water Reactor	La Crosse, Wisc.
Lawrence Berkeley Laboratory	Berkeley, Calif.
Lawrence Livermore Laboratory	Livermore, Calif.
Los Alamos Scientific Laboratory	Los Alamos, New Mexico
Mound Laboratory	Miamisburg, Ohio
National Accelerator Laboratory	Batavia, Illinois
National Reactor Testing Station	Idaho Falls, Idaho
Allied Chemical Corporation	
Aerojet Nuclear Company	
Health Services Laboratory	
Nevada Test Site	Mercury, Nevada
Oak Ridge Facilities	Oak Ridge, Tenn.
Oak Ridge Gaseous Diffusion Plant	
Oak Ridge National Laboratory	
Oak Ridge Y-12 Plant	
Paducah Gaseous Diffusion Plant	Paducah, Kentucky
Portsmouth Gaseous Diffusion Plant	Piketon, Ohio
Pinellas Plant	St. Petersburg, Fla.
Rocky Flats Plant	Golden, Colo.
Savannah River Plant	Aiken, S. Carolina
Stanford Linear Accelerator Center	Stanford, California

The information collected at each site was based on surveillance programs (not research and development or specialty programs) and the information published in the respective 1972 environmental monitoring reports as compiled by the AEC.⁽¹⁾

All sites visited were classified according to the existing or anticipated radionuclide composition of their effluent streams (Table 2). This classification depends primarily upon the type of operation(s) conducted at the respective facilities and does not take into account the quantity or degree of potential for release. However, some of the obvious factors which affect the relative level of surveillance, but which are not included here, are:

1. The potential hazard of the materials being handled.
2. The extent to which facility operations are routine and unchanging.
3. The size of the total operation, since even a modest surveillance effort at a very small facility represents a significant fraction of the total operating effort.

The content of the environmental surveillance programs of the 19 sites included in this study is a function of the individual facility operations. Therefore, a brief description of the operations carried out at these facilities is given below:

Uranium and Transuranium Facilities

These process large quantities of natural and enriched uranium, and plutonium, both as oxides and metals. Included are gaseous diffusion, feed and production plant, and major weapon facilities.

Major Production and Research Facilities

These include chemical processing and radioisotope production plants, nuclear reactors, research laboratories, transuranium facilities, and support facilities. The operations at these facilities include nuclear research projects with most radionuclides. The nature, extent, and hazards of the materials involved require that much of the work be confined to hot cells and glove boxes.

TABLE 2. Site Categorization by Effluent

<u>Contaminant</u>	<u>No. of Sites* in Which Listed Contaminant Could be Part of Effluent</u>	
	<u>Gaseous</u>	<u>Liquid</u>
Tritium	17	16
Noble Gas	16	
Halogens	14	14
Activation or Mixed Fission Products	16	16
Uranium	13	14
Transuranics	13	13

*Total number of sites included in study - 19.

Research Reactors

These are utilized for fuel and reactor development studies, irradiation of materials, and some medical applications.

Small Nuclear Research Facilities

Those included here are involved in research and development activities with most radionuclides, with emphasis on the specialty areas, such as biology.

Accelerator Facilities

These are devoted to theoretical and experimental research in high energy physics. The potential environmental problems are the release of noble or activation gases and external neutron and gamma radiation.

Power Reactors

Those included here are located on river sites where waterborne nuclides and airborne noble gases represent the primary environmental surveillance problems.

For the 19 sites visited, 28 individual contractors were represented. The number of contractor facilities represented by each of the above categories are listed in Table 3.

TABLE 3. Classification of Facilities Visited

<u>Type of Facility</u>	<u>Number of Facilities</u>
Uranium and Transuranium	8
Major Production and Research	6
Research Reactor	6
Nuclear Research	3
Accelerator	3
Power Reactor	2

Terminology

In this report the following terminology has been used: DETECT means to determine the presence of radiation or radioactivity while MEASURE means to determine the quantity. MONITORING is defined as the periodic or continuous surveillance of the radiation level or quantity of radioactive material present. This can be accomplished by periodic instrument surveys or by a radiation detector whose signal is recorded, such as an air monitor or an ambient gamma background monitor. To SAMPLE means to remove a portion of an environmental medium for future analysis, typically in a laboratory. The sample can be CONTINUOUS or GRAB. The sample is PROPORTIONAL if a known fraction of the medium is withdrawn and it is REPRESENTATIVE if the sample withdrawn has the same characteristics as the source.

RESULTS

The environmental surveillance techniques in use by the various AEC contractors, as determined from the site visits, discussions, and 1972 annual reports, are summarized in Tables 4 through 16. In general, the environmental surveillance programs were divided into two geographical areas: onsite, which includes the area between the security fences surrounding each operating facility and the site boundaries; and offsite, which is the area beyond the property boundaries of the respective sites.

For each environmental medium, only those parameters considered to have the most influence on data evaluation are presented in the summary tables. These parameters include sampling rationale, location, medium, collection (and analytical, if different) frequency, sample handling or preparation, and analysis. Since data handling and interpretation typically were unique to each site, the results thereof are shown separately in Table 17. Under the title of each table is shown the number of sites (19 maximum) collecting that type of sample. The number of those particular sites whose methods, etc. match the listed categories are shown in the respective columns. In a number of instances more than one parameter applied at a given site, e.g. more than one rationale statement applied to the collection of air samples, samples were collected

at more than a single location, and more than one analysis was performed on each sample. Thus, the sum of the tabulated values in any given table frequently exceeds the total number of sites shown at the top.

In addition to the routine sampling and analytical methods shown in Tables 4 through 16, several novel or unique methods were observed which are specifically listed below for future reference:

1. Collecting airborne tritium oxide by immersing a metal (aluminum) strip in a thermos bottle containing liquid nitrogen.⁽²⁾
2. Using a freeze-dry technique to collect tritium oxide from various solid media.⁽³⁾
3. Collecting environmental noble gas samples in an evacuated marinelli beaker followed by gamma ray spectrometry.
4. Using a hypodermic needle in a weighted polyethylene jug to obtain an integrated water sample.⁽⁴⁾
5. Analyzing for plutonium in environmental samples by a liquid scintillation technique.⁽⁵⁾

DISCUSSION OF RESULTS

The results, as expected, indicate striking variations in the relative surveillance efforts within the wide spectrum of operations considered. Variations in effort between similar facilities were, however, generally not significant. At most sites sampling of surface water, air particulates, and vegetation is conducted and direct radiation is measured in the environs. Since only two sites reported routine collection of noble gases, and two reported meat or poultry sampling, these items are not reported in the tables. Otherwise, all media which are routinely sampled at more than two sites have been included in the summary tables.

Although the choice of distances in the "location" column was arbitrary, the overwhelming majority of environmental samples are collected either onsite or within 10 miles of the respective site boundaries. Most sites also utilize "background" stations for the

collection of several media. These are often located more than 50 miles from the site. The routine sampling at these background and other distant sites is commonly performed by others and samples are shipped to the respective laboratories for analysis. Only two of the 19 sites reported the analysis of their samples was performed by an independent laboratory.

Based on this study it is our contention that while the selection of sampling equipment and the techniques used to collect environmental samples are important, the evaluation of the resulting analytical data are of even greater importance. The choice of sampling equipment, methods of sample preparation, and counting instruments are dependent on the radionuclides involved and their relative concentrations. Table 18 summarizes the routine detection capabilities for the various environmental nuclide/medium combinations reported by the 19 sites (Tables 4 through 16). With samples being analyzed by several different laboratories, it is necessary that similar detection capabilities be available to assure comparability.

The greatest diversity between facilities in areas related to environmental surveillance were for meteorology and dose evaluation. Several major installations reported rather sophisticated meteorological data collection systems, i.e. the capability to measure wind speed, wind direction, and temperature at several elevations and at several locations within the site boundary. At two sites the data are telemetered to a central location where dispersion calculations can be made in the event of an accident. On the other hand, most of the smaller sites rely on meteorological data collected offsite at a local airport or weather bureau station.

Estimates of population dose based on effluent releases were published in the 1972 annual reports of most of the sites considered here. Typically, these calculations were only a product of the appropriate annual dose limit for the critical organ (e.g. 500 or 1,500 mrem) and the ratio of calculated concentrations in air or water to the respective MPC. At none of the sites visited were estimates of individual

or population dose based solely on environmental data. This is not wholly unexpected since the direct measurement of external dose or concentrations of radionuclides in environmental media attributable to the discharge of radionuclides from normal operations are often masked by variations in natural background levels. Except for the direct radiation pathway, most environmental dose estimates were based on effluent data and theoretical calculations of dispersion (air) or dilution (water) and standard man inhalation or ingestion parameters as appropriate.

SUMMARY

The radiological environmental surveillance procedures used at 19 major AEC contractor sites---including 8 uranium and transuranium facilities, 6 major production and research facilities, 6 research reactors, 3 nuclear research facilities, and 2 power reactors---were reviewed. A wide variation was observed in the types, capabilities, and radiological evaluation techniques currently practiced for routine environmental surveillance.

No glaring deficiencies were noted at any of the sites visited. However, the fact that variation from site to site in sampling, analysis, and data handling was the rule rather than the exception, indicates the need for definitive performance criteria.

These criteria should provide a sound basis to define the specific rationale for media, location, and frequency; for minimum acceptable detection limits; and for data handling and reporting. Specific items requiring further research or study are listed below under the same subheadings as shown in Tables 4 through 16. Concern for a number of these items was expressed during the site visits and discussions.

EVALUATION

The identification and priority ranking of environmental surveillance areas needing additional research or decisions were accomplished by involving the site visitation teams in a three-step evaluation process.

First, each site visitor was asked to register his evaluation of site-to-site comparability of rationale, sampling, analysis and interpretation aspects of environmental surveillance by rating from 1 to 4 each combination included in Table 19. Based on printed reports and experiences at the visited sites, the consensus is indicated in Table 19. The column and row totals were included to indicate nuclide/medium combinations or aspects of environmental surveillance which may warrant special attention from the outset. This tabulation also reveals which surveillance aspects are comparable and which are not, which have the most problems and which are the most refined.

Table 20 represents the relative importance of sampling specific environmental nuclide/medium combinations, considering typical yearly releases from nuclear facilities and potential exposure pathways, based on probable importance as a trend indicator, or as a source of population dose. The greatest importance of any combination is reflected by a relative importance factor of 5 in the lefthand column and a 1 reflects least importance.

By combining the results of Tables 19 and 20, a ranking of needs for additional guidance or research, based on comparability evaluations, is obtained as weighted by relative dose importance results. Table 21, therefore, indicates in a task unspecific fashion the priorities on which environmental surveillance problems should be attacked. As an example, this tabulation suggests that since noble gas releases to the environs of AEC installations represent the major dose pathway to man and also has a relatively low comparability rating, it should have top investigational priority for providing additional guidance.

Extending this procedure and utilizing the data from the Tables 19-21, a list of priority needs was derived. This list (Table 22) encompasses rationale, methodology, analysis and interpretation of data relating principally to direct radiation, atmospheric tritium, aquatic and terrestrial biota, soil and decomposition.

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TABLE 4. Summary of Environmental Surveillance Techniques at Selected AEC Contractor Installations-Air, Particulates

(15 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Orientation</u>	<u>No. of Sites</u>	<u>Sample Preparation</u>	<u>No. of Sites</u>
Meteorology	6	On-Site	12 (10)*	One Meter	11	None	
Demography	4	Perimeter	11 (6)	Over One Meter	3	Composite	9
Surround. Site	11	0-5 Miles	6 (8)	Horizontal	4	Dissolve	4
Power Available	13	5-10 Miles	4 (4)	Vertical Down	6	Leach	2
		10-50 Miles	8 (5)	Vertical Up	2		
		Over 50 Miles	4 (3)				

<u>Collecting Medium</u>	<u>Filter Size</u>						
	<u>1" Dia.</u>	<u>2" Dia.</u>	<u>3" Dia.</u>	<u>4" Dia.</u>	<u>8" Dia.</u>	<u>4x9"</u>	<u>8x10"</u>
Cellulose			1	2			1
Cellulose/Asbestos	1	2				3	
Glass Fiber			1	1			
Membrane		3					
Polystyrene			1	1	1	1	

<u>Collection Frequency</u>	<u>Flow Rate</u>			
	<u><1 cfm</u>	<u>1-2 cfm</u>	<u>2-5 cfm</u>	<u>>10 cfm</u>
Daily	1	1	2	3
Weekly		4	4	2
Bi-Weekly		2		2

<u>Analytical Frequency</u>	<u>Analysis Performed</u>					
	<u>NaI</u>	<u>GeLi</u>	<u>Sr</u>	<u>Po</u>	<u>U</u>	<u>Pu</u>
Only if Gross Analysis is above Action Level	3					
Weekly		1				1
Monthly	3	2	1	1	2	5
Quarterly	1		2		1	1
Semi-Annually & Annually	1					

<u>Gross Analysis</u>	<u>Elapsed Time Prior to Analysis</u>							
	<u>4-24 hr.</u>	<u>3d</u>	<u>4d</u>	<u>5d</u>	<u>6d</u>	<u>7d</u>	<u>10d</u>	<u>12d</u>
Alpha	3	2	2	2	1	3	2	
Beta	4	2	2	3	1	4	1	1

*Number shown in parentheses represents the average number of samplers located within given range per site.

TABLE 5. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Air, Iodine

(9 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Sample Analysis</u>	<u>No. of Sites</u>	<u>Collecting Medium</u>	<u>No. of Sites</u>
Meteorology	3	On-Site	6 (15)*	NRA [†]	1	Charcoal Impreg-	
Demography	3	Perimeter	5 (8)	NaI	7	nated Paper	2
Surround. Site	6	0-5 Miles	1 (1)	GeLi		Activated Charcoal	
Release Inventory	3	5-10 Miles	1 (2)	Gross Beta	3	Cartridge	7
Near a Dairy		10-50 Miles	3 (7)			Scrubbers	1
Power Available	3	Over 50 Miles	3 (2)				

<u>Collection Frequency</u>	<u>Flow Rate</u>			
	<u>1 cfm</u>	<u><1-2 cfm</u>	<u>2-5 cfm</u>	<u>>10 cfm</u>
Daily	1			2
Weekly		3	2	
Bi-Weekly		1	1	1

*Number shown in parentheses represents the average number of samplers located within given range per site.

[†]Not routinely analyzed.

TABLE 6. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Air, Tritium
(7 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Collection Medium</u>	<u>No. of Sites</u>	<u>Sample Prep. & Analysis</u>	<u>No. of Sites</u>
Meteorology	2	On-Site	6 (4)*	Cryogenic	1	Distillation	3
Surround. Site	2	Perimeter	5 (4)	Silica gel	4	Electrolysis	1
Power Available	3	0-5 Miles	2 (8)	Ethylene glycol	1	Liquid Scin- tillation	6
Pathway to Man	5	5-10 Miles	2 (3)	Molecular Sieve	1		
Background	1	10-50 Miles	2 (7)	Evaluation Chamber	1		
		Over 50 Miles	2 (1)				

FLOW RATE

<u>Collection Frequency</u>	<u><100 cc/min</u>	<u>100-500 cc/min</u>	<u>>1000 cc/min</u>
Weekly	2	1	1
Biweekly		1	
Monthly		1	

*Number shown in parentheses represents the average number of samplers located within given range per site.

TABLE 7. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Milk

(10 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Collection Medium</u>	<u>No. of Sites</u>
Meteorology	2	0-5 Miles	3	Raw Milk	10
Surround. Site	3	5-10 Miles	4	Processed Milk	5
Nearest Farm/ Dairy	9	10-50 Miles	5		
Background Site	1	Over 50 Miles	2		

Specific Analysis

<u>Collection Frequency</u>	<u>No. of Sites</u>	<u>Analytical Frequency</u>	<u>I</u>	<u>H-3</u>	<u>Sr</u>	<u>Cs</u>	<u>Pu</u>
Weekly	2	Weekly	1		1	1	
Biweekly	3	Biweekly	3		1	1	
Monthly	6	Monthly	1	1	3	2	
Bimonthly	2	Bimonthly		2		1	1
Quarterly	1	Quarterly	1		3		
		Semi-Annually			1		

TABLE 8. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Groundwater
(10 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Collection Frequency</u>	<u>No. of Sites</u>	<u>Analysis</u>	<u>No. of Sites</u>
Trend Indicator	5	On-Site	4	Biweekly	1	Gross Alpha	7
Pathway to Man	7	Site Perimeter	4	Monthly	7	Gross Beta	9
Hydrology	3	Point of		Quarterly	1	Gamma Scan	4
		Nearest Use	7	Semi-Annually	5	H-3	8
						Sr	3
						Ra	2
						U	1
						Pu	2

TABLE 9. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Drinking Water
(11 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Collection Frequency</u>	<u>No. of Sites</u>	<u>Analysis</u>	<u>No. of Sites</u>
Pathway to Man	11	Weekly	3	Gross Alpha	8
Hydrology	7	Biweekly	1	Gross Beta	9
Demography	2	Monthly	4	Gamma Scan	2
		Quarterly	2	H-3	6
		Semi-Annually	4	Sr	1
		Annually	1	Pu	3

TABLE 10. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Surface Water
(18 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Collection Frequency</u>	<u>No. of Sites</u>	<u>Sample Preparation</u>	<u>No. of Sites</u>
Hydrology	10	Upstream	8	Daily	2	Pretreat Jug	3
Trend Indicator	18	Downstream	6	Weekly	8	Ion Exchange	2
Pathway to Man	11	Background		Biweekly	2	Filter	4
		Stream	2	Monthly	8	Centrifuge	1
		Waste Ponds	8	Bimonthly	3	Evaporate	14
				Quarterly	5	Composite	3
				Semi-Annually	2		
				Annually	1		

Analysis

<u>Analytical Frequency</u>	<u>Gross Alpha</u>	<u>Gross Beta</u>	<u>Gamma Scan</u>	<u>H-3</u>	<u>Sr</u>	<u>I</u>	<u>Po</u>	<u>Ra</u>	<u>Th</u>	<u>U</u>	<u>Pu</u>
Weekly	6	7	2	2							
Biweekly	1	1	1	1		1					
Monthly	6	5	3	4	2			1	1	1	
Bimonthly	1				1						2
Quarterly		1		1			1				2
Semi-Annually	1	1	1	1							1
Annually								1		1	

**TABLE 11. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Aquatic Biota**

(6 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Locations</u>	<u>No. of Sites</u>	<u>Medium Sampled</u>	<u>No. of Sites</u>	<u>Sample Analysis</u>	<u>No. of Sites</u>
Pathway to Man	6	Upstream	4	Fish	6 (70)*	H-3	1
Trend Indicator	3	Downstream	5	Shellfish	1 (NA) [†]	Sr	2
Hydrology	5	Background		Waterfowl	2 (70)	U	1
		Stream	1	Plants	1 (NA)	Pu	2
		Waste Pond	4			Gamma Scan	4

*Number shown in parentheses represents the average number of samples collected annually of each medium per site.

[†]Not applicable.

**TABLE 12. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Sediment**

(6 Sites)

<u>Basis Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Sampling Frequency</u>	<u>No. of Sites</u>	<u>Analysis</u>	<u>No. of Sites</u>
Trend Indicator	6	Upstream	4	Monthly	1	Gross Alpha	2
Hydrology	5	Downstream	5	Quarterly	3	Gross Beta	2
Pathway to Man	1	Effluent		Annually	3	Gamma Scan	4
		Outfall	3			Th, U	1
						Pu	3

TABLE 13. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Soil

(13 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Collection Frequency</u>	<u>No. of Sites</u>
Meteorology	3	On-Site	7	Monthly	1
Surround. Site	4	Perimeter	5	Quarterly	2
Release Inventory	6	0-5 Miles	7	Semi-Annually	2
Trend Indicator	4	5-10 Miles	4	Annually	7
		10-50 Miles	2	1-5 yr Interval	3
		Over 50 Miles	2		

<u>Sampling Depth</u>	<u>No. of Sites</u>	<u>Sample Preparation</u>	<u>No. of Sites</u>	<u>Number Samples/ Location</u>	<u>No. of Sites</u>
0-1"	2	None	1	1	4
0-2"	8	Air Dry	2	2	1
0-12"	4	Oven Dry	10	5	4
0-18"	1	Sieve/Screen	4	9	2
Profile	4	Dry Ash/Fuse	3	10	2
		Leach	6		
		Dissolve	1		

Analytical Technique

<u>Aliquot Size</u>	<u>Gross Alpha</u>	<u>Gross Beta</u>	<u>NaI</u>	<u>GeLi</u>	<u>H-3</u>	<u>Sr</u>	<u>Po</u>	<u>Th</u>	<u>U</u>	<u>Pu</u>
<5 gm	2	2		1	1	1				1
10 gm	1	1	1							2
50 gm										1
100 gm								1	1	1
>300 gm			4			2	1		2	4

*All samples were composited (if necessary), blended, and homogenized prior to the techniques shown.

TABLE 14. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Fruits, Vegetables
(15 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Medium Sampled</u>	<u>No. of Sites</u>
Pathway to Man	6	On-Site	11	Livestock Feed	2
Trend Indicator	15	Perimeter	5	Produce*	4
Meteorology	2	0-5 Miles	7	Native Vegetation	11
Surround. Site	5	5-10 Miles	5	(primarily grasses)	
Accessibility	6	10-50 Miles	4		
Background Site	3	Over 50 Miles	1		

<u>Collection Frequency</u>	<u>No. of Sites</u>	<u>Sample Preparation</u>	<u>No. of Sites</u>	<u>Analytical Technique</u>	<u>No. of Sites</u>
Monthly	4	None	1	Gross Alpha	4
Quarterly	5	Oven Dry	13	Gross Beta	4
Semi-Annually	2	Freeze Dry	1	Gamma Scan	4
Annually	5	Alcohol Dry	1	H-3	4
		Ash	10	Sr	4
		Leach	7	U	4
		Fuse	1	Pu	6

*Commercially available fruits, vegetables and grains normally used for human consumption.

TABLE 15. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Deposition Measurements

(10 Sites)

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Method</u>	<u>No. of Sites</u>
Surround. Site	1	On-Site	8	Ground Survey	1
Trend Indicator	5	Perimeter	4	Precipitation	
Precipitation		0-5 Miles	1	Collector	9
Scavenging	9	10-50 Miles	2	Sticky Paper	1
				Fallout Tray	3

Sampling Frequency

<u>Sampling Method</u>	<u>Per Storm</u>	<u>Daily</u>	<u>Weekly</u>	<u>Biweekly</u>	<u>Monthly</u>	<u>Quarterly</u>
GM Survey				1	1	1
Precipitation Collector	5		1	1	2	
Fallout Tray (dry)		1	1	1	2	
Sticky Paper		1				

Sample Handling and Preparation

<u>Medium</u>	<u>Water Rinse</u>	<u>Ion Exchange</u>	<u>Filtration</u>	<u>Evaporation</u>	<u>Electrolytic Enrichment</u>	<u>Composite</u>
Dry Deposition	3		1	3		2
Rain/Snow		2	1	9	2	4

Analytical Technique

<u>Analytical Frequency</u>	<u>Gross Alpha</u>	<u>Gross Beta</u>	<u>NaI</u>	<u>H-3</u>	<u>Sr</u>	<u>Pu</u>
Per Sample	2	3		1		
Daily		1				
Weekly		2				
Biweekly				1		
Monthly	2	2	2	2	1	1

**TABLE 16. Summary of Environmental Surveillance Techniques at
Selected AEC Contractor Installations-Direct Radiation
(14 Sites)**

<u>Basis for Sample Location</u>	<u>No. of Sites</u>	<u>Location</u>	<u>No. of Sites</u>	<u>Mounting Height</u>	<u>No. of Sites</u>	<u>Method</u>	<u>No. of Sites</u>
Meteorology	1	On-Site	7 (18)*	One Meter	11	TLD	10
Demography	3	Perimeter	11 (8)	Over One Meter	3	Ion Chambers	3
Surround. Site	8	0-5 Miles	3 (17)	Multiple Heights	1	Scintillation	
Close to Man	6	5-10 Miles	3 (9)			GM Tube	3
Trend Indicator	6	10-50 Miles	4 (7)			NaI	1
Power Not Avail.	1	Over 50 Miles	4 (3)			Intermittent GM	2
Background Area	5					Scintillation	1

MONITORING METHOD	<u>READOUT OR EXCHANGE FREQUENCY</u>							
	<u>Hourly</u>	<u>Daily</u>	<u>Weekly</u>	<u>Biweekly</u>	<u>Monthly</u>	<u>Bimonthly</u>	<u>Quarterly</u>	<u>Semi-Annually</u>
Continuous	1	2	2	1	4	2	5	2
Intermittent			1			1		1

<u>ENERGY DISCRIMINATION</u>				
<u>TLD Material</u>	<u>Shielded**</u>	<u>No. of Sites</u>	<u>Unshielded</u>	<u>No. of Sites</u>
LiF		4		2
CaF ₂		5		3

*Number shown in parentheses represents the average number of samplers located within given range per site.

**TLD's typically were encapsulated in light- and water-tight packets, the number of sites shown in the "shielded" column refer to those using one or more gamma energy filters.

†Methods shown are typically for beta-gamma external radiation. Three sites also were monitoring for fast neutrons using moderated defectors and continuous chart records.

TABLE 17. Summary of Environmental Surveillance Techniques
at Selected AEC Contractor Installations-Data
Handling and Interpretation

<u>Data Handling</u>	<u>No. of Sites</u>
<u>Statistical Evaluation</u>	
Range	8
Normal	3
Log-Normal	3
<u>Use</u>	
Action	3
Control	2
<u>Handling of Less-Than Values</u>	
Zero	1
DL	4
1/2 DL	1
Value	2
Other	1

TABLE 18. Minimum Detection Capabilities for Most Common Radionuclides Observed in Environmental Samples

Media & Nuclide(s)	Minimum Detectable Levels*	
	Typical	Range
(Units of $\mu\text{Ci/ml}$)		
Air		
Gross Alpha	2×10^{-15} (13)	10^{-16} to 9×10^{-15}
Gross Beta	3×10^{-14} (13)	5×10^{-16} to 2×10^{-13}
H-3 (HTO)	2×10^{-12} (8)	2×10^{-13} to 10^{-10}
I-131	3×10^{-14} (7)	5×10^{-15} to 10^{-13}
Pu-238	10^{-18} (4)	5×10^{-19} to 10^{-16}
Pu-239	5×10^{-18} (5)	10^{-18} to 10^{-16}
Gamma Scan**	10^{-15} (23)	10^{-16} to 10^{-13}
(Units of $\mu\text{Ci/ml}$)		
Water		
Gross Alpha	2×10^{-10} (12)	10^{-11} to 10^{-8}
Gross Beta	10^{-9} (12)	6×10^{-10} to 10^{-8}
H-3 (HTO)	10^{-6} (15)	7×10^{-9} to 3×10^{-6}
Sr-89	2×10^{-9} (3)	3×10^{-10} to 5×10^{-9}
Sr-90	2×10^{-10} (6)	10^{-11} to 2×10^{-9}
I-131	10^{-9} (3)	2×10^{-10} to 10^{-9}
Uranium	3×10^{-5} (3) $\mu\text{g/ml}$	10^{-5} to 2×10^{-4} $\mu\text{g/ml}$
Pu-238	5×10^{-12} (5)	5×10^{-13} to 5×10^{-11}
Pu-239	10^{-11} (5)	5×10^{-13} to 5×10^{-11}
Gamma Scan	2×10^{-9} (17)	10^{-11} to 3×10^{-7}
(Units of $\mu\text{Ci/g}$)		
Soil and Sediment		
Gross Alpha	10^{-7} (3)	5×10^{-8} to 10^{-6}
Gross Beta	3×10^{-7} (3)	2×10^{-7} to 3×10^{-6}
Sr-90	4×10^{-9} (2)	NA
Pu-238	3×10^{-9} (4)	3×10^{-11} to 5×10^{-6}
Pu-239	3×10^{-9} (5)	4×10^{-10} to 3×10^{-8}
Gamma Scan	10^{-7} (16)	3×10^{-8} to 2×10^{-6}

*The minimum detectable levels are those reported for the concentrations and mixtures of radionuclides routinely encountered in the environmental media shown. "Typical" values are those most often reported for the analytical procedures and counting equipment used, as reported in Tables 4 through of this summary. The numbers shown in parentheses refer to the number of sites whose detection limits were used to obtain the "typical" and "range" values. The lower detection limits are typically for samples containing only a single radionuclide; i.e., following radiochemical separation and/or sample enrichment prior to counting. The higher detection limits probably represent a combination of factors such as smaller sizes and more complex mixtures of radionuclides.

**Multichannel analyzer with either a NaI (Tl) or Ge(Li) detector; typical nuclides include: Co-60, 58; Zn-65; ZrNb-95, Cs-137, and Ce-144, 141 (soil, sediment, and vegetation), plus Ru-106, 103; and Ba-La-140 (air), and Cr-51 (water).

TABLE 18. (contd)

Minimum Detectable Levels*				
	Typical		Range	
	(Units of $\mu\text{Ci/ml}$)			
Milk				
Sr-89	2×10^{-9}	(4)	10^{-9} to 5×10^{-9}	
Sr-90	2×10^{-9}	(6)	10^{-9} to 3×10^{-9}	
I-131	5×10^{-9}	(7)	10^{-9} to 2×10^{-8}	
Cs-137	6×10^{-9}	(6)	10^{-9} to 3×10^{-8}	
	(Units of $\mu\text{Ci/g}$)			
Vegetation				
Gross Alpha	10^{-7}	(5)	2×10^{-9} to 10^{-6}	
Gross Beta	10^{-6}	(4)	4×10^{-7} to 5×10^{-6}	
H-3 (HTO)	10^{-7}	(3)	10^{-7} to 10^{-6}	
Sr-90	7×10^{-9}	(2)	2×10^{-9} to 2×10^{-8}	
U-Total	5×10^{-2}	(4) $\mu\text{g/g}$	3 to 7×10^{-2}	$\mu\text{g/g}$
Pu-239	10^{-9}	(4)	10^{-11} to 10^{-7}	
Gamma Scan	5×10^{-8}	(18)	10^{-8} to 10^{-6}	
	(Units of $\mu\text{Ci/g}$ (wet weight))			
Fish, Meat, Poultry				
Co-60	5×10^{-8}	(4)	10^{-8} to 2×10^{-7}	
Sr-90	2×10^{-9}	(2)	NA	
Cs-137	5×10^{-8}	(5)	10^{-8} to 2×10^{-7}	

TABLE 19. Summary of AEC Environmental Surveillance Comparability*

Surveillance Medium	Rationale for			Collection Medium	Sampling Methods	Sample Preparation & Analysis	Data Handling & Interpretation	Total	Average
	Sampling (what-isotopes, medium; why)	Location (where; Why)	Frequency (When)						
Direct Radiation	2	3	2	3	3	3	3	19	2.7
Air - Particulate	2	3	2	2	3	2	3	17	2.4
Iodine	2	3	3	2	2	2	2	16	2.3
Tritium	3	3	4	3	2	2/1	2	18.5	2.6
Noble Gas	4	3	3	0	4	4/3	3	20.5	3.4
Water - Surface	2/1	2	3	2	3/2	2	3	16	2.3
Ground	3	3	3	0	3	2	2	16	2.7
Drinking	2/1	2	2	0	2	2	2	11.5	1.9
Milk	2	2	3	0	1	2	2	12	2.0
Food	3	3	3	0	1	2	3	15	2.5
Aquatic & Terrestrial Biota	4/3	4	3	0	1	2	3	16.5	2.8
Soil & Sediment	4	3	3	0	3	2	4	19	3.2
Deposition	3	3	3	3	2	2	3	19	2.7
Precipitation	3	2	2	0	2	2	3	14	2.3
TOTAL	37.5	39	39	15	31.5	30	38		

*The values shown in the table indicate the relative level of knowledge (based on experience) and the consistency of techniques, according to the following numbering system:

- 0 - Not applicable (i.e., when the sampling medium used does not further concentrate the sample).
- 1 - No problems areas encountered.
- 2 - Criteria, methods, etc. are reasonably standardized.
- 3 - Some uniformity or consistency, but some questions still remain.
- 4 - Definitely needs further study (acceptable methods and/or criteria are insufficient or totally lacking).

TABLE 20. Suggested Ranking of Environmental Media as a Function of Effluent Pathway and Identity

Effluent Pathway	Air	Air	Air	Water	Air	Water	Water	Air	Water
Radionuclide(s)	Noble Gas*	Tritium	Iodine (I131)	MFP**	MFP	Tritium	Iodine (I131)	TRU†	TRU
Typical Releases (Ci/y)	10^4-10^5	10^4-10^5	1-5	1-10	1-5	$5 \times 10^3-5 \times 10^4$	1-5	10^{-3}	0.1
5	Direct Rad. Air - NG								
4		Air H-3 Precipitation Vegetables	Milk Vegetables Air Iodine	Fish					
3		Native Grasses	Forage	Waterfowl Surface Water Milk	Air Particulates Vegetables	Drinking and Surface Water			
2				Direct/Soil Sediment Drinking & Groundwater Terrestrial Animals	Milk Soil Deposition Direct Rad.	Vegetables Groundwater	Drinking Water Milk	Air Particulates	
1					Vegetables Forage		Surface Water Vegetables Forage	Deposition Soil Terrestrial Animals	Fish Vegetables Surface & Drinking Water Sediment

RELATIVE IMPORTANCE OF ENVIRONMENTAL MEDIA

*Primarily Kr-41 (Kr-3 & Xe are approx. an order of magnitude less, i.e., $10^3-5 \times 10^3$ Ci/y).

**Mixed Fission Products (primarily Sr-90, Cs-137).

†Transuranic nuclides (primarily Pu-239).

**TABLE 21. Environmental Surveillance Comparability
Weighted by Radiation Dose**

<u>Surveillance Media</u>	<u>Weighted Factor*</u>
Air - Noble Gas	17
Direct Radiation	14
Air - Tritium	10
Foods	10
Air - Iodine	9.2
Precipitation	9.2
Aquatic & Terrestrial Biota	8.4
Milk	8.0
Air Particulates	7.2
Surface Water	6.9
Soil/Sediment	6.4
Drinking Water	5.7
Groundwater	5.4
Deposition	5.4

*Weighted Factor = Average (Table 19) x Relative importance (Table 20)

TABLE 22. Suggested Environmental R&D Priorities

1. Methods, analysis, and interpretation of direct radiation measurements.
2. Atmospheric tritium sampling media (and frequency).
3. Rationale of sampling, location, frequency and species for aquatic and terrestrial biota.
4. Rationale of soil sampling and interpretation (and methods).
5. Rationale, methods, location, frequency, and interpretation of deposition sampling.

(The above categories will require some experimental research.)

6. Rationale of sampling, location, and frequency for foodstuffs (including data handling and interpretation).
7. Location and frequency of sampling for atmospheric iodine.
8. Sampling methods and locations for airborne particulates.
9. Methods, location, and frequency for sampling groundwater.
10. Methods and frequency of sampling surface water.

(The amount of experimental research needed for items 6-10 is judged to be limited, and in some cases not required.)

NOTE: While noble gas sample collection, preparation, and analysis would appear to be very important, it is believed to be of minor significance in light of the "indirect" methods available in direct radiation measurement.

APPENDIX A

Discussion Outline

ENVIRONMENTAL SURVEILLANCE & EFFLUENT MONITORING AT AEC CONTRACTOR SITES

I. Standards and Criteria for Environmental Surveillance

- A. AECM 0524 - Population Criteria; Concentration Guides; or Release Limits.
- B. Other Guides or Criteria.
- C. Derived Working Levels.

II. Dose Evaluation

A. Air Dispersion

- 1. Is meteorological model in routine use? Describe model used.
- 2. Sources of meteorological information?

B. Water Dispersion

- 1. Is hydrological model in routine use? Describe model used.
- 2. Sources of hydrological information?

C. Dose Model

- 1. Is population dose calculated?
- 2. Components of dose model?
- 3. Quantities and sources of information:
 - a. Diet (milk, water, foodstuffs).
 - b. Wildlife (fish, game, wildfowl).
 - c. Occupancy factors.
- 4. Lung model used?

III. Environmental Surveillance Program Design

A. Location

1. Are locations of air and water sampling stations related to models described?
2. Other rationale for determining numbers and locations of stations?

B. Media sampled, frequency, and analyses requested.

1. Relationship to dose model?
2. Rationale of frequency and type of measurement or sample and analyses.
 - a. Air - Particulate, noble gas, tritium, radioiodine.
 - b. Water - Surface water, groundwater.
 - c. Milk.
 - d. Vegetation
 - e. Fish, game, wildfowl, other foodstuffs
 - f. Soil/Sediment
 - g. External exposure - terrestrial, aquatic.

IV. Techniques & Procedures

For each medium (see list in III above) under each subhead, describe rationale and include documentation if available.

1. Equipment used, including vendor information.
2. Special procedures and precautions used in collecting and holding samples and taking measurements.
3. Analytical equipment and procedures used -- is this work subcontracted?

V. Routine Effluent Measurements

1. Is effluent data from this source used to estimate environmental concentrations or population dose?
2. Is sample or monitoring stream flow rate proportional to effluent flow rate?
3. Is sample or monitoring stream flow designed to be representative of entire effluent stream?
4. Is particle size determination made (gaseous effluents only)?
5. Are radioanalyses made routinely by another agency than the operating contractor?
6. Normal effluent flow rate? Sample flow rate?
Frequency of measurement?
7. Sensitivity per nuclide -- minimum detectable concentration, measurable range, instrumentation sampled or monitored (continuous or intermittent)?
8. DOS Effluent Information System Code?

VI. Quality Control & Statistical Analysis

1. Describe quality control program, including audits and calibration.
2. Are control charts routinely maintained for calibrations and audits? For field results? If yes, describe derivation and use.
3. Describe action guides for environmental and effluent measurements, and planned actions.

VII. Reporting

1. Describe routine manipulation of data - compositing, averaging, analyzing for variability.
2. Frequency and type of routine reports?

VIII. References

1. Copy or document number of most recent environmental report(s).
2. Copies or list of document numbers of directly applicable topical reports.

7/25/73

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APPENDIX B

SUMMARY OF EFFLUENT MONITORING PARAMETERS
FOR SELECTED STREAMS AT AEC SITES

As for the tables in the body of this report, the numbers shown in each category and classification will differ from table to table, both because more than one kind of measurement is made on a particular effluent stream and because some data was not readily available.

TABLE B-1. Summary of Effluent Monitoring Techniques at Selected
AEC Contractor Installations - Air, Particulates

(17 Installations)

<u>Collecting Medium</u>	
Cellulose	3
Cellulose/Asbestos	9
Glass fiber	3
Membrane	2
Moving filter tape	3

<u>Sample Collection</u>	
Proportional to flow	6
Not proportional to flow	6

Typical Minimum Detectable Levels

<u>Analytical Frequency</u>	
Continuous	3
0-50 per year	2
50-100 per year	5
100-200 per year	1
>200 per year	6

Gross alpha and beta	10^{-7} to 5×10^{-3} $\mu\text{Ci/cc}$
Gross beta and gamma (NaI)	3×10^{-8} to 6×10^{-4} $\mu\text{Ci/cc}$
GM viewed tape	5×10^{-10} to 3×10^{-8} $\mu\text{Ci/cc}$
Alpha scar (solid state)	10^{-12} to 2×10^{-8} $\mu\text{Ci/cc}$
Gamma scar	10^{-8} to 2×10^{-5} $\mu\text{Ci/cc}$

<u>Analysis Performed</u>	
Gamma scan	6
Gross alpha and beta	8
Gross beta and gamma	1
Alpha scan	6

TABLE B-2. Summary of Effluent Monitoring Techniques at
Selected AEC Contractor Installations -
Air, Tritium

(9 Installations)

<u>Collecting Medium</u>		<u>Typical Minimum Detectable Levels</u>
Monitored but not sampled	5	*Kanne Chamber 5×10^{-6} to $6 \mu\text{Ci/cc}$
Silica gel	2	*Ion Chamber 10^{-7} to 9×10^{-5}
Molecular sieve	1	Liquid 2×10^{-13} to $10^{-10} \mu\text{Ci/cc}$
Cold trap	2	Scintillation
Dehumidifier	1	

Analytical Instrumentation

Kanne Chamber	5	
Ion Chamber	1	*Range of response
Liquid Scintillation	6	

Analytical Frequency

Continuous	6
<10 per year	1
>50 per year	1
Data unavailable	2
When indicated by monitoring	2

TABLE B-3. Summary of Effluent Monitoring Techniques at
Selected AEC Contractor Installations -
Air, Iodine

(7 Installations)

Collecting Medium

Charcoal	5
Scrubber	2

Analytical Frequency

0-50 per year	1
50-100 per year	2
100-200 per year	
>200 per year	2
Data not available	2

Analysis Performed

Gamma Scan	5
Gross Count	2

Typical Minimum Detectable Level

Gamma Scan	5×10^{-15} to 10^{-13} $\mu\text{Ci/cc}$
------------	---

TABLE B-4. Summary of Effluent Monitoring Techniques at
Selected AEC Contractor Installations -
Air, Noble Gas

(8 Installations)

Collecting Medium

Monitored but not sampled	5
Vacuum flask	2
Releases calculated	1

Analytical Frequency

>15 per year	1
<50 per year	1

Analytical Instrumentation

GM in stack	1
NaI in stack	4
GeLi in laboratory	1

Typical Minimum Detectable Levels

GM in stack	2×10^{-7} to 2×10^{-3} $\mu\text{Ci/cc}$
Flow through ion chamber	10^{-4} to 5×10^{-3} $\mu\text{Ci/cc}$
NaI in stack	2×10^{-6} to 4×10^{-3} $\mu\text{Ci/cc}$

TABLE B-5. Summary of Effluent Monitoring Techniques at
Selected AEC Contractor Installations - Liquid

(17 Installations)

<u>Collection Technique</u>		<u>Analyses Performed</u>	
Grab	6	Gamma scan	5
Ion Exchange	1	Gross alpha and beta	6
Continuous-proportional	9	Gross beta and gamma	1
Continuous-non-proportional	2	Alpha scan	2
<u>Analytical Frequency</u>		Dissolved versus suspended	2
		Liquid Scintillation	3
		Uranium	4
		<u>Typical Minimum Detection Levels</u>	
Continuous	1	Gamma Scan	10^{-11} to 3×10^{-7} $\mu\text{Ci/cc}$
0-50 per year	10	Gross beta and gamma	10^{-10} to 10^{-8} $\mu\text{Ci/cc}$
50-100 per year	2	Gross alpha and beta	10^{-11} to 10^{-8} $\mu\text{Ci/cc}$
100-200 per year	1	*U fluorometric	10^{-9} to 10^{-1} $\mu\text{Ci/cc}$
>200 per year	3	Liquid scintillation	7×10^{-9} to 3×10^{-6} $\mu\text{Ci/cc}$
per batched released	1	Alpha scan	5×10^{-13} to 5×10^{-11} $\mu\text{Ci/cc}$

*Range of response

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