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HEALTH & SAFETY

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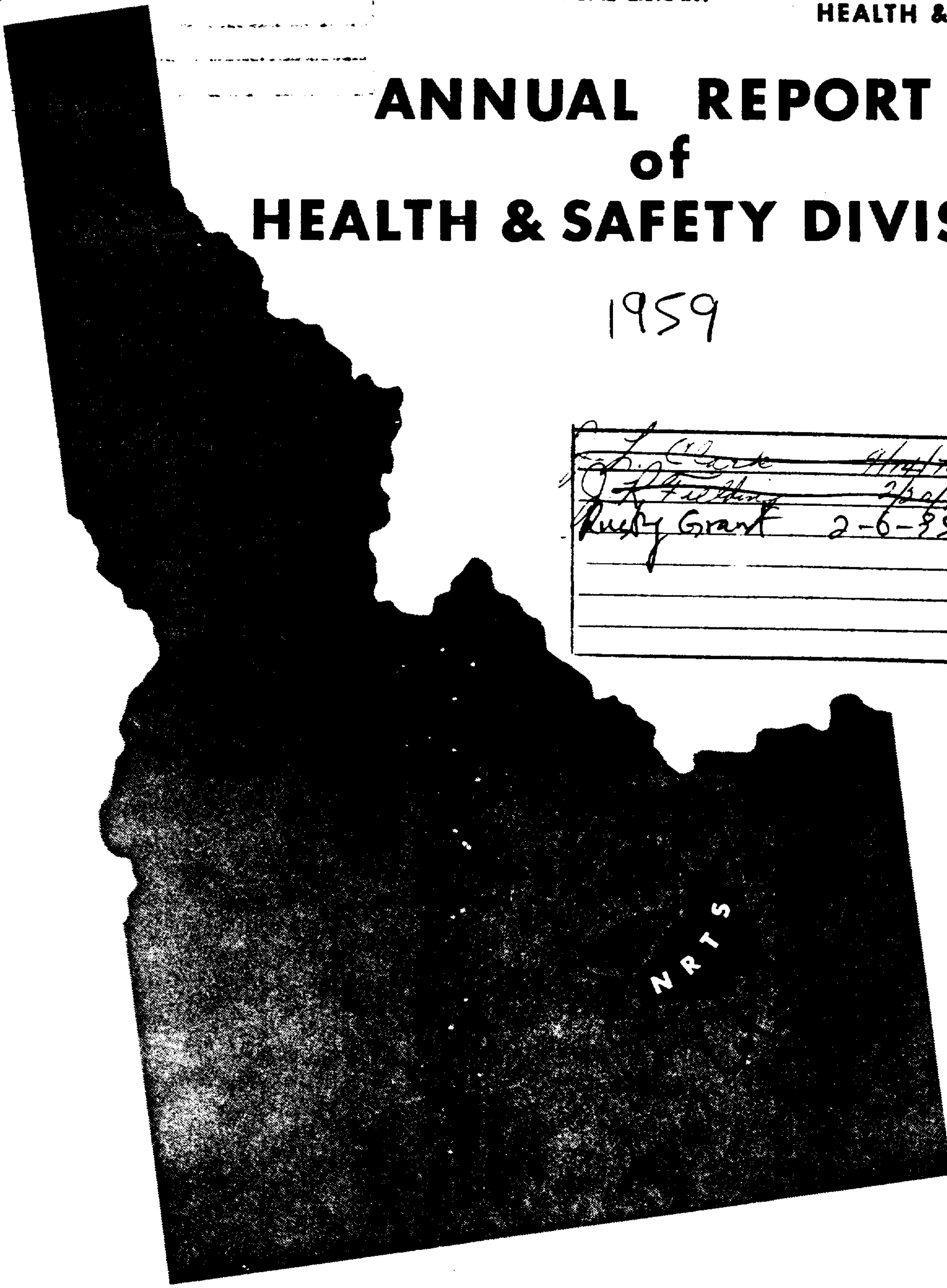
1959



U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE

TABLE OF CONTENTS

		Page
TABLE OF CONTENTS		i
LIST OF TABLES		ii
LIST OF FIGURES		iv
LIST OF ABBREVIATIONS		vii
CHAPTER 1	INTRODUCTION	1
CHAPTER 2	PERSONNEL METERING	5
CHAPTER 3	MEDICAL SERVICES	23
CHAPTER 4	SAFETY AND FIRE PROTECTION	33
CHAPTER 5	ANALYSIS	51
CHAPTER 6	INSTRUMENT AND DEVELOPMENT	71
CHAPTER 7	ECOLOGY	85
CHAPTER 8	SITE SURVEY	110
CHAPTER 9	U. S. GEOLOGICAL SURVEY	151
CHAPTER 10	U. S. WEATHER BUREAU	161
CHAPTER 11	U. S. PUBLIC HEALTH SERVICE	180

LIST OF TABLES

Table No.	Title	Page No.
	Chapter 2 - PERSONNEL METERING	
1	Non-Routine Film Processed 1958 - 1959	18
2	Film Badges Serviced at the NRTS in 1958 and 1959	19
3	Radiation Exposures Received at the NRTS by IDO Personnel (AEC and Contractors)	21
4	Urinalysis Results for 1959	22
	Chapter 3 - MEDICAL SERVICES	
5	Dispensary Visits	25
6	1959 Physical Examinations	27
7	Most Common Diagnoses on 975 Examinations	27
	Chapter 4 - SAFETY AND FIRE PROTECTION	
8	Requests for Industrial Hygiene Surveys by NRTS Contractors in 1959	35
9	NRTS Fire Loss Comparison	37
	Chapter 5 - ANALYSIS	
10	Statistical Summary of Analyses	67
	Chapter 6 - INSTRUMENT AND DEVELOPMENT	
11	Major Instrumentation Systems	80
12	Portable Instrument Inventory	80
13	Portable Instrument Repair Workload	81
	Chapter 7 - ECOLOGY	
14	Ecological Field Samples Collected and Analyzed	87
15	Strontium-90 Activity in Bones of Jack Rabbits and Cattle During the Period August 1956 to December 1959	91
16	Strontium Activity in Bones of Jack Rabbits in Six Areas of the NRTS During 1959	92
17	1959 Winter Quarter Survey of the Gross Gamma Activities of Vegetation (Sage Brush) and Surface Soil Samples from NRTS and Environs	93
18	Estimated Numbers of Small Mammals in Three Areas in 1959 which had been Subjected to Different Levels of Radioactive Contamination	99

LIST OF TABLES

Table No.	Title	Page No.
	Chapter 8 - SITE SURVEY	
19	Curies Released to Atmosphere Due to Rala Operations	111
20	Weapons Test Fallout Program	118
21	Air-Cooled Experiments - ETR - 1959	125
22	Summary of NRTS Off-Site Shipments	128
23	Number of On-Site Shipments - NRTS - 1959	129
24	Liquid Waste Discharged to the Ground at NRTS - 1959	130
25	Liquid Waste Discharged to Ground - MTR-ETR-1959	131
26	Liquid Waste Discharged to Ground - ICPP - 1959	132
27	Liquid Waste Discharged to Ground - SPERT I - III - 1959	133
28	Liquid Waste Discharged to Ground - ANP - 1959	134
29	Liquid Waste Discharged to Ground - NRF - 1959	135
30	Contamination Levels in Monitoring Wells Near ICPP - 1959	138
31	Solid Waste Disposal NRTS Burial Ground 1959	140
32	Summary of Solid Radioactive Waste Disposed of at the NRTS Burial Ground	141
33	Atmospheric Waste Discharged - NRTS - 1959	142
34	Summary of Atmospheric Waste Discharged at NRTS	143
	Chapter 10 - U. S. WEATHER BUREAU	
35	Data from Uranine Dye Tests	169
36	Inversion Heights and Intensities from T-Sonde Measurements.	172

LIST OF FIGURES

Fig. No.	Title	Page N
	Chapter 2 - PERSONNEL METERING	
I	NRTS Security-Film Badge	6
II	Personnel Neutron Threshold Detector	8
III	Mobile Laboratory	9
IV	Interior Arrangement of Mobile Laboratory	10
V	Ra Gamma Calibrations	11
VI	Relative Response of Dupont-508 Emulsion with various Filters	13
VII	Variation of Ratios with Energy	14
VIII	Typical Calculation	15
IX	Automatic Data Processing Room	16
	Chapter 3 - MEDICAL SERVICES	
X	Physical Examinations 1954 - 1959	26
XI	Audiograms Monitor Persons for Early Hearing Loss from Noise Exposure	28
XII	Laboratory Work 1954 - 1959	29
XIII	Periodic Eye Examinations Check for Possible Lens Changes Due to Radiation Exposure	30
	Chapter 4 - SAFETY AND FIRE PROTECTION	
XIV	Fire Prevention Inspections	39
XV	Water Flow Pressure Test	40
XVI	Growth of N.R.T.S. Valuations	41
XVII	National Reactor Testing Station Fire Department Response Distances	42
XVIII	Aerial Ladder Truck	43
XIX	Disabling Injury Frequency Rate Comparison	45
XX	Injury Severity Comparison	46
XXI	Motor Vehicle Accidents for 100,000 Miles of Travel and IDO Vehicle Mileage in Millions	47
XXII	Map of the United States Showing Zones of Approximately Equal Seismic Probability	49
	Chapter 5 - ANALYSIS	
XXIII	Fluorescence Accessory Installed in Sample Compartment	53
XXIV	General View of Two-Man Laboratory	54
XXV	Rack of Eight Proportional Alpha Counters	55
XXVI	Well-Type Scintillation Crystals	56
XXVII	Four pi Counter and Uranium Fluorophotometer	57
XXVIII	Scintillation Spectrometer with Automatic Sample Changers for Liquid Scintillation Counting and Gamma Counting	58
XXIX	Automatic Sample Changer for Gamma Scintillation Counting with a Thallium-Activated Sodium Iodide Crystal	59
XXX	General View of East Counting Room	60
XXXI	General View of West Counting Room	61
XXXII	Display of Environmental Samples and Analytical Techniques	65

LIST OF FIGURES-

Fig. No.	Title	Page No.
	Chapter 6 - INSTRUMENT AND DEVELOPMENT	
XXXIII	Total Body Counter and Associated Equipment	74
XXXIV	Annular Impactor with Associated High Volume Air Sampler	76
XXXV	Aerial Monitoring Equipment	77
XXXVI	Unitized Scintillation Well Counters for Gamma Counting	82
	Chapter 7 - ECOLOGY	
XXXVII	I-131 in Jack Rabbit Thyroids at Two Locations During 1959 and I-131 Released from CPP Stack	88
XXXVIII	1959 Winter Quarter Survey of the I-131 Activities in uuc/g of Jack Rabbit Thyroid at 13 Locations	89
XXXIX	Sample Array of 90 Stations for the Quarterly Biological Monitoring Survey of the Soils, Vegetation, and Animals of the NRTS and Environs	94
XL	Residual Gross Gamma Activity x 10^3 c/m/ft^2 in Surface Soil Collected on the F.E.C.F. Grid During November 1959	96
XLI	Gross Gamma Activities (c/m/g) on Sagebrush from the ETR Release of 6/14/59	97
XLII	Predatory Animal Control on National Reactor Testing Station	102
XLIII	Halogeton Control on National Reactor Testing Station	104
XLIV	Plant Growth Room	109
	Chapter 8 - SITE SURVEY	
XLV	Chilled Carbon Sampler	112
XLVI	Chilled Carbon Sampler	113
XLVII	Two Samplers in Series for Efficiency Tests	113
XLVIII	Initial Survey Following FECF Incident	114
XLIX	Follow-Up Survey of FECF Incident	115
L	Field Cartridge	116
LI	1959 Infinity Thyroid Dose from ICPP Operations	117
LII	Weapons Test Fallout Program	119
LIII	NRTS Film Badge Locations and Gamma Radiation Levels	120
LIV	Ground Survey of Area Surrounding NRF & MTR-ETR	121
LV	Ground Survey of ICPP and Surrounding Area	122
LVI	Aerial Survey of NRTS and Vicinity	124
LVII	Ruthenium-106 Contamination in CPP Production Wells	126
LVIII	Sketch of Observation Wells ICPP Vicinity Showing Isopleths of Radioactive Contamination in Underground Water 450 Feet Below Land Surface	137
LIX	Off-Site Underground Water Sampling Stations	139
LX	Radiological Assistance Team Locations Within Idaho Operations Office Area of Responsibility	144
LXI	Emergency Monitoring Kit	146
LXII	Radiological Assistance Plan Brief Case	146
LXIII	Plan View - Emergency Decontamination Trailer	147
LXIV	Emergency Vehicle with Equipment for Four Men	148
LXV	Two-Wheel Power Generators with Sampling Equipment	148

LIST OF FIGURES

Fig. No.	Title	Page N
	Chapter 9 - U. S. GEOLOGICAL SURVEY	
LXVI	Theoretical Flow Net of Water Table in CPP Area	153
LXVII	Combination Logs of USGS #43	154
LXVIII	Automatic Water Level Recorder Showing Influence of Earthquake on August 17, 1959	155
LXIX	Hydrographs of Wells 5N-31E-14bcl (USGS No. 18, 4N-30E-7adl (USGS No. 12), 3N-30E-31aal (USGS No. 20)	156
LXX	Hydrographs of Wells 2N-31E-15bcl (USGS No. 1), 1S-30E-15bcl (USGS No. 14), and 3S-33E-14bbl (F. J. Webb)	158
LXXI	Equipment for Sampling of Observation Well	159
	Chapter 10 - U. S. WEATHER BUREAU	
LXXII	Mean Annual Isopleths of Air Concentration of I-131 from ICPP and inert gases from the MTR-ETR for year 1959	165
LXXIII	Mean Annual Isopleths of Air Concentration of I-131 from CPP During 1959	166
LXXIV	Sub-Surface Temperature Comparison Between an Asphalt Highway and the Natural Terrain, 1957-1958	167
LXXV	Components of A T-Sonde	172
LXXVI	Meteorological Tower and Instruments with Sampling Grid	175
	Chapter 11 - U. S. PUBLIC HEALTH SERVICE	
LXXVII	Ultra High Volume Air Sampler	181
LXXIX	Aerial Monitoring Equipment	182

LIST OF ABBREVIATIONS

AEC	Atomic Energy Commission
A1W	Large Ship Reactor Prototype
ANP	Aircraft Nuclear Propulsion
BORAX IV	Boiling Reactor Experiment
CFA	Central Facilities Area
CPP	Chemical Processing Plant
ETR	Engineering Test Reactor
EBR-1	Experimental Breeder Reactor No. 1
FECF	Fuel Element Cutting Facility
FET	Flight Engine Test
GCRE	Gas Cooled Reactor Experiment
IDO	Idaho Operations Office
IET	Initial Engine Test Area
LPTF	Low Power Test Facility
MTR	Material Testing Reactor
NAD	Nuclear Accident Dosimetry
NRF	Naval Reactor Facility
NRTS	National Reactor Testing Station
OMRE	Organic Moderated Reactor Experiment
PIF	Process Improvement Facility
S1W	Submarine Reactor Prototype
SL-1	Stationary Low Power Plant No. 1 (Formerly ALPR)
SPERT	Special Power Excursion Reactor Test
USGS	United States Geological Survey

HEALTH & SAFETY DIVISION

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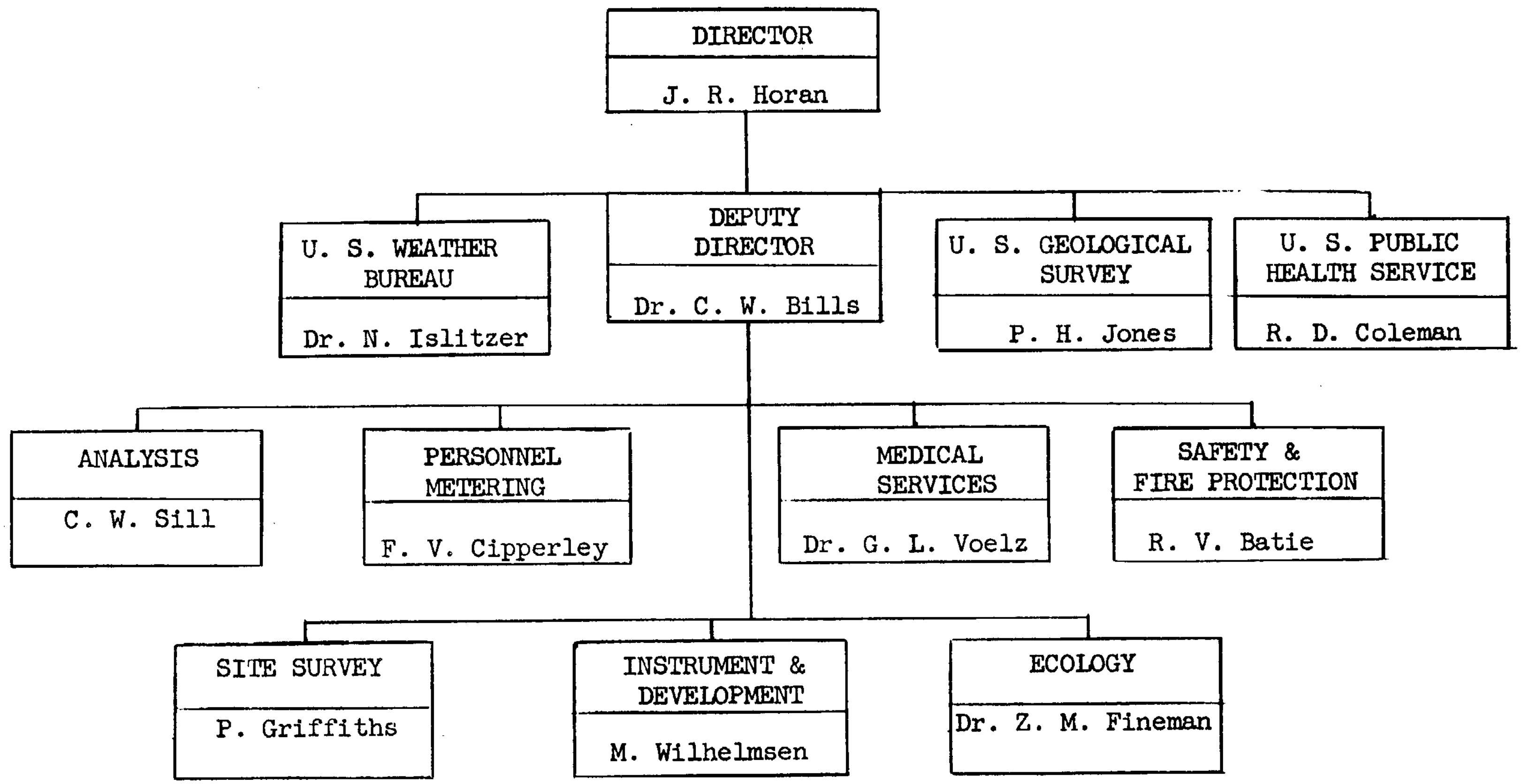

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CHAPTER I

INTRODUCTION

By John R. Horan, Director

The National Reactor Testing Station was established in 1949 as a place where the U. S. Atomic Energy Commission could build, test, operate and evaluate various types of nuclear reactors and allied plants with maximum safety and impunity for all concerned. The Station now comprises 894 square miles of sagebrush desert and basalt fields in Southeastern Idaho. It is one of the Commission's strongholds for developing the peacetime uses of atomic energy. The operating and construction force during 1959 numbered 5,300 workers and the plant investment is $320,000,000. Though originally planned to accommodate only ten reactors by 1964, 25 reactors or critical facilities have been operable and six more are under construction or authorized as of January 1, 1960.

The primary purpose of the Health and Safety Division of Idaho Operations Office is the protection of personnel and property from the deleterious effects of any occupational hazard, whether conventional or nuclear. Safety results from man's mastery of himself and of his environment. We all live in an environment which is potentially dangerous--yes, even lethal. Every person tends, by nature, to conserve life and the faculties with which we are endowed. Most of the causes of accidents and injury are subject to our own control; some are subject to the control of others. Since a "safe" person and a "safe" environment do not exist, we must condition our people to be "safer" than others; we must engineer our environments to be "safer" than others. These goals can be achieved only by alert, informed, and skillful people who respect themselves and value the welfare of others. Safety is won by individual effort and through group cooperation.

For convenience, the effort and cooperative aspects of the Health and Safety program can be divided into the following general categories:

a. Personnel Metering
b. Chemical Analysis
c. Industrial Medicine
d. Physical Monitoring
e. Biological Monitoring
f. Instrumentation
g. Fire Department
h. Safety
i. Industrial Hygiene
j. Waste Management

In addition, the Health and Safety Division also coordinates cooperative programs with other Government agencies, such as the U. S. Geological Survey, Weather Bureau, Public Health Service, and Bureau of Sport Fisheries and Wildlife.

The seven operating contractors also have staffs of health physics and safety personnel to safeguard their employees and the facilities they operate. Approximately 4% of the total complement of personnel at the NRTS are engaged in the evaluation, improvement and control of potentially hazardous conditions.

Over the past ten years, during the performance of 65×10^6 man hours of work, of which 36% was construction, there have been three fatalities and 194 disabling injuries.

AEC AND CONTRACTOR INJURY EXPERIENCE - NRTS

1950 - 1959

NATURE OF INJURY	Part of Body Injured									
	TOTAL	Eye	Head	Arm	Hand	Finger	Leg	Foot	Toe	Trunk
TOTAL	197	13	14	11	4	20	28	14	3	89
Amputations	10	1				8			1	
Asphyxiations										
Burns (except chem.)	9	3	2	1			1			2
Burns (chemical)	4	3	1							
Cuts, Lacer., Bruises	39		4	2	3	5	7	5		12
Dermatitis										
Electric Shock										
Foreign Body (in eye)	6	6								
Fractures	51		3	7		3	13	8	1	16
Hernia	8									8
Infections	11		1	1	1	4	1	1	1	1
Ionizing Radiation	1		1							
Strains or Sprains	53						6			47
Internal Injuries	5		2							3

* Three fatalities.

Only one lost-time injury, a 10% loss of hearing in one ear, has been caused by radiation. The principal causes of fatalities and disabling injuries in the atomic energy program are the same as those experienced by the mining, lumbering chemical, and construction industries. Exotic hazards are not the causes of these accidents, but rather commonplace actions such as falling people or

.lling objects, strains and sprains as the result of improper lifting, ıtomobile accidents, and electrical or chemical burns. The laws of ·avity are a greater threat to an individual's safety than the laws of ıclear physics.

ıwever, a word of caution must be injected. In the experience of the erall AEC, the severity ratio of fatalities to injuries is higher by a ıctor of 3.5 for radiation-involved injuries over that experienced follow- ıg conventional injuries. In addition, the average number of days lost per ın-fatal injury is a factor of 1.8 times greater for a radiation-caused ıjury over all other injuries. In other words, an accidental injury caused radiation results in a greater percentage of fatalities and a longer ·riod of lost time from the job than we have experienced from other types injuries.

ıe following is a summary of the vital statistics for the National Reactor ·sting Station for calendar year 1959: One fatality and 19 disabling ıjuries during 11 x 10^6 man hours of work; radiation exposure of 2,462 ·m to Station employees; six thousand curies of short and intermediate ılf-life material discharged as liquid waste to the soil; twenty-three ıousand curies of intermediate to long half-life material consigned to ıe burial ground; the atmosphere dissipated approximately 200,000 curies short half-life effluents.

ı active physical and biological monitoring program literally samples ·ery living thing in the environment. For example, the following ·neral types of samples were collected and processed during the year: .r, water, soil, milk, vegetation, and animal organs and bones. The ırpose of this program is to evaluate the effect, if any, of NRTS ·erations upon the plant environs or adjacent areas. In addition, the ·llowing monitoring was performed on employees as part of the program · determine the degree of occupational exposure from radioactive or ·her toxic materials:

a. Urinalysis - 11,000 samples, of which less than 3% indicated low-level contamination.

b. Film Badges - 130,000 processed, of which 5% indicated any degree of radiation exposure.

ıat have been the results of this comprehensive monitoring program? ıe goals of the health physics and industrial hygiene professions have ·en achieved. Man and his environment were protected from unwarranted ·posure to toxic or radioactive materials. In fact there were no sig- ·ficant exposures resulting from any routine or experimental discharges material to the environment. The policy of preventing air and water ·llution by control at the source during our daily business has been ıccessful.

ıring 1959 the most important achievement for the Division in fulfilling ts responsibilities in the field of occupational health and safety was ıe strengthening of the technical competence of the various branches ıd broadening the scope of the research programs by the addition of ·illed scientific and technical personnel. This was achieved through

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higher standards for new positions as well as upgrading former positions made available through attrition. Other noteworthy achievements were:

a. Development of an inexpensive personnel neutron threshold detector which was incorporated in every film badge by November 1, 1959

b. Expansion of the scope and intensity of the research effort on the management of low-level liquid waste.

c. Development of new analytical procedures for radium-226 and thorium-230 in support of the Inspection Division's uranium mill program.

d. Publication of a Safety and Fire Protection Design Criteria Manual, IDO-12008, for use by architect-engineer groups in the design of nuclear facilities.

e. Completion of construction of a total body counter with an automatic scanning mechanism in a low-background vault.

f. The acquisition of new equipment such as the liquid scintillation counter, the decontamination trailer, and the plant growth room provides added opportunities for a service organization to develop new skills and improved techniques.

g. Effluent alert and disaster planning received increased emphasis. This advance planning paid dividends during the ICPP nuclear incident of October 16, 1959.

This report is a resume of how the Health and Safety Division fulfilled its moral obligation at the NRTS to protect all living things from injury. Since the past is the prologue to the future, the experience gained as the result of routine operations or accidents yesteryear is synthesized into the ever changing program of tomorrow. Experience has taught that it is not necessary to have accidents to learn how to prevent accidents. By hazard evaluation, preplanning, and employee conditioning, man can obey the first law of nature - Safety.

Chapter 2

PERSONNEL METERING

F. V. Cipperley, Branch Chief

A SCOPE

The Personnel Metering Branch continued to dispatch its responsibilities as a service organization during 1959 by furnishing complete, efficient personnel metering service to fifteen (15) prime contractors at sixteen (16) separate project areas. This was accomplished with 30 persons, two less than were required in 1958 and four less than required in 1957, although the personnel coverages provided increased approximately 29% during the same period. This increased efficiency was made possible through improvement in equipment and methods.

B SUMMARY OF MAJOR PROGRAMS

1. Combination Security-Film Badge

Conversion to the use of the new plastic combination security-film badge in all project areas at the NRTS was completed early in 1959. This badge is a modified version of the Hanford type badge containing filters of 0.0393" Cd, 0.005" Ag and 0.0191" Al, providing absorber thicknesses of 950 mg/cm^2, 203 mg/cm^2 and 175 mg/cm^2 respectively, including the plastic in which they are mounted. The film meter is also a Security Badge. This necessitates an absorber thickness of approximately 100 mg/cm^2 in the open window area which filters out beta radiation with energies below 0.36 MEV. Fig. I shows an exploded view of the badge.

The use of DuPont type 558 film packets and Kodak Type A neutron film packets in NRTS badges provide a detection and measurement capability of approximately 10 mr through 1000 r for beta-gamma and 10 mrem to approximately 20 rem for fast neutrons. Beta-gamma energy determinations are made possible through use of the filter system composed of plastic, aluminum, silver and cadmium.

Although there are several parameters which affect the accuracy of film dosimetry for beta-gamma and x-radiation, the use of simple standard laboratory techniques makes this method both practical and effective. One of the more difficult factors to control is the orientation of the meter during exposure, a difficulty not unique to the film meter. Under normal conditions the X or gamma radiation dose to the meter can be determined within $\pm$ 0.012 rem in the range of 0.01 to 0.04 rem and to within $\pm$ 12% within the range of 0.04 to 1000 rem, while the radiation dose to the meter from Beta particles with energies greater than 0.36 MEV can be determined within $\pm$ 0.012 rem in the range of 0.01 to 0.03 rem, and within $\pm$ 30% above 0.03 rem.

N.R.T.S, SECURITY-FILM BADGE

1. Du Pont 558 Film Packet
2. Security Identification ~ 68 mg/cm
3. 0.0191" Aluminum Filter
4. Open Window
5. 0.005" Silver Filter
6. 0.0393" Cadmium Filter
7. 0.0393" Lead Slug
8. Soft Iron Latch
9. Plastic Slide
10. Plastic Badge Body
11. Personnel Neutron Threshold Detector
12. 0.0393" Lead-Coded Badge Number

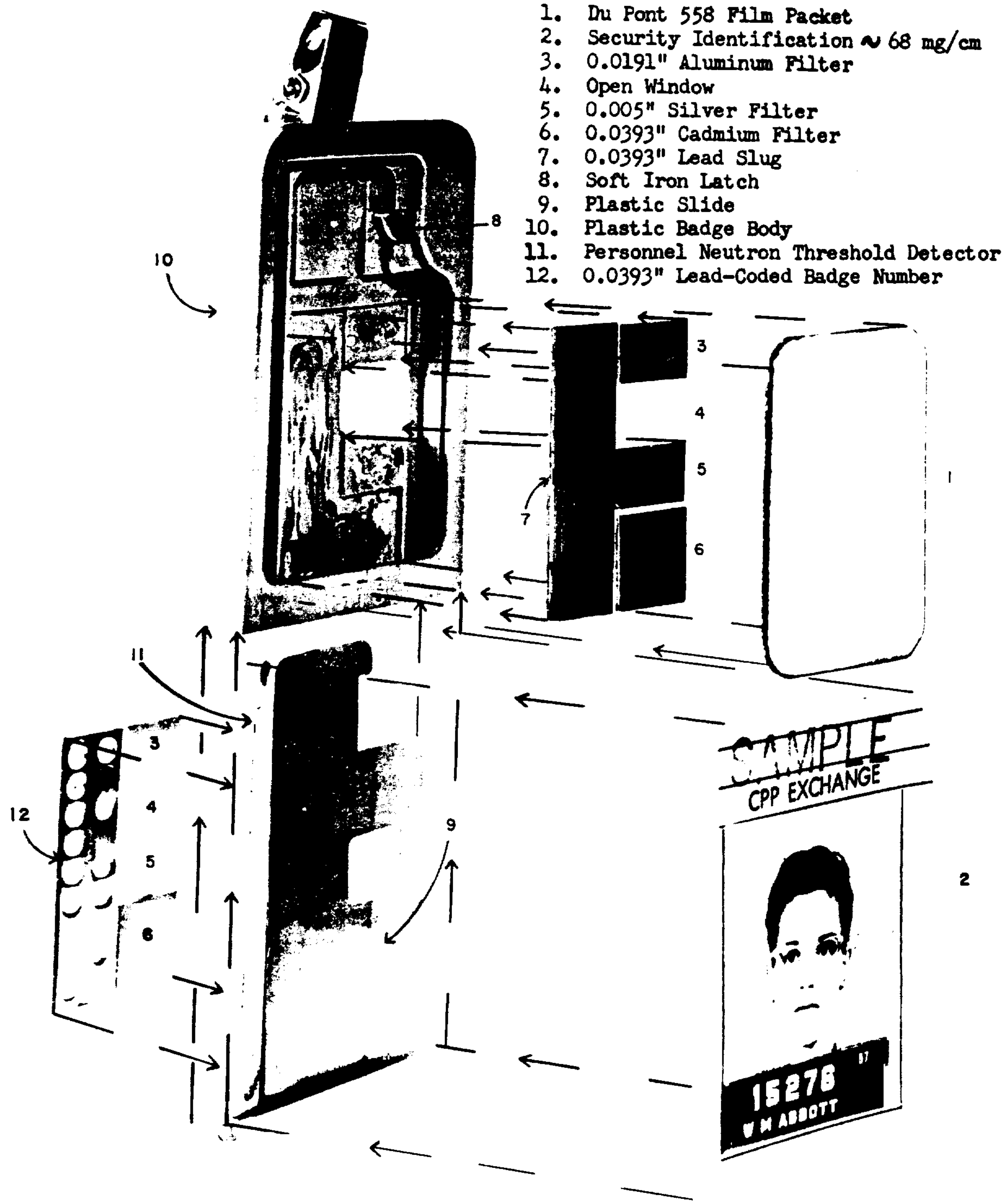

Fig. I.

The accuracy of the fine grain nuclear track (NTA) emulsion routine neutron dose varies with the dose. In general the greater the dose the greater the a[illegible] ment. At approximately 20 [illegible] becomes so dense that tr[illegible] Under controlled co[illegible] the meter can be [illegible] 10 mrem [illegible]

2. Personn[illegible]

[illegible] of 1959, IDO incorporated into each badge a personnel neutron threshold detector [illegible] containing 3.0 gr sulphur, one [illegible] 0.005" and two gold foils 5/32" [illegible], one of which is encased in 0.020" of cadm[illegible]

Detection and measurement of neutron exposures of approxima[illegible] one rad or higher is accomplished through foil counting tech[illegible]s.

The accuracy of these high level neutron measurements depend upon [illegible] concurrent use of Nuclear Accident Dosimetry System [illegible] Fig. [illegible] shows an [illegible] of the NRT Threshold Detector.

Immediate [illegible] of film badges [illegible] accomplished [illegible] checking the indium [illegible] neutron activation with conventional [illegible]

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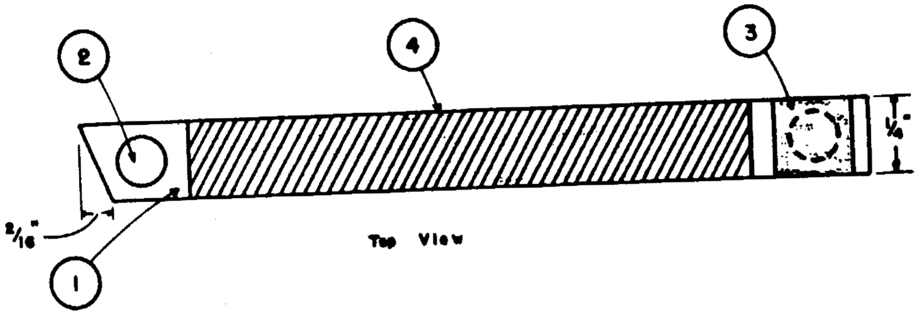
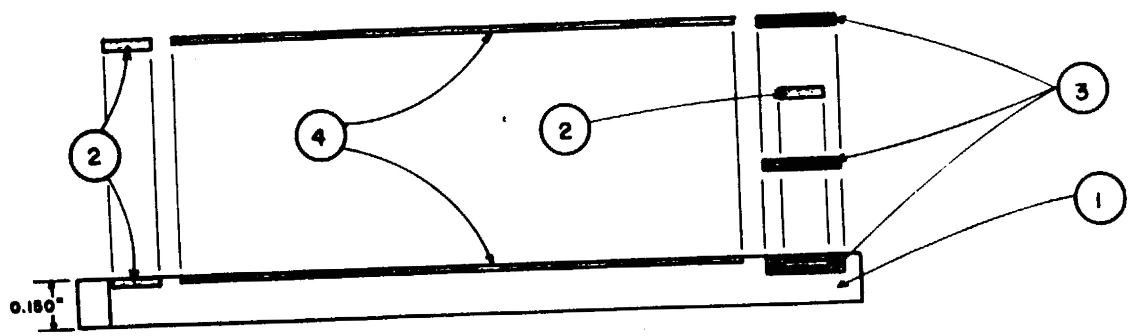
PERSONNEL NEUTRON THRESHOLD DETECTOR

No. Req'd	Pt. No.	Description	Material
1	1	Molded $2\,{}^{9}/_{16}"$ x $1/4"$ x 0.150"	Analytical Grade Sulfur
2	2	Foil 0.005" th'k x $5/32"$ dia.	High Purity Mint Gold
2	3	Foil 0.020" x $1/4"$ x $1/4"$	Cadmium
1	4	Foil 0.005" x $1/4"$ x $1\,{}^{7}/_{8}"$	Indium



Top View

FOILS ARE MOLDED AS AN INTEGRAL PART OF THE DETECTOR.



Gold foil on right must be completely enclosed in Cd. A single piece of Cd. may be used.

Side & Exploded Views

Fig. II.

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3. Mobile Units

To expedite the work of the Branch, two mobile laboratories are used to accomplish certain procedures at the various project areas. These vans are driven by the Personnel Metering Clerks to the areas to service badges, eliminating the time and effort to convey the badges back and forth between the main laboratory and the work areas. This procedure has proven both efficient and economical. The van has a cable on a spring-loaded reel, which plugs into a weatherproof electrical outlet at the gatehouse, Fig. III. This supplies power to the equipment in the van.

Fig. III. Mobile Laboratory

Badges are serviced routinely on a bi-weekly or monthly basis. In addition to the routine processing, badges receive special processing when the contractor health physics representative specifically requests that a particular badge or badges be pulled on a particular day because of the probability of a high reading. These Health Physics Requests and Special Pulls are given priority over routine film and the process is completed as rapidly as possible. Results are telephoned immediately to the area health physicist concerned.

Each van is equipped with an automatic geiger counter for checking badges for contamination, an automatic x-ray unit and shelves for work space.

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The badges are placed on the conveyor belt of the x-ray unit and pass between the detectors of the fixed counter which has been set to 400 counts per minute above observed background. If a reading of this amount or greater is detected, the belt will stop and not start again until the badge is removed and the "start" button pushed. The belt conveys the clean badges into the x-ray machine which x-rays the badge number on the film. The badges continue through the unit and drop into a receptacle placed under the end of the belt. The x-ray machine is set at 50 KV using 10 milliamperes for 1/10 second. These settings are checked, before marking the badges, by exposing several dummy badges and noting the response of the various meters. Fig. IV shows the interior arrangement of the mobile unit.

Fig. IV. Interior Arrangement of Mobile Laboratory

4. Dosimeter Film Standardization

To standardize on a film packet that would meet the requirements of the Personnel Metering Branch, exposure response experiments using several types of personal dosimeter film packets were performed. The DuPont Type 558 which is a combination of 508 sensitive film and 1290 insensitive was selected. The resultant curves of three of these experiments are shown in Fig. V. Films were exposed to Radium Gamma at twelve different dose levels ranging from 50 mr through 800 r. Other experiments using various uranium beta and radium gamma combinations at 10, 20 and 30 mr levels were also performed.

It has been experimentally proven that from a plot of corrected (probit) density versus photon energy for aluminum, open window, and silver after subtracting the corrected cadmium density, any film which has received a gamma exposure only should fall into one of the following three categories:

a. 25 - 55 Kev: Al density is much greater than Ag density and, OW density is 0 to 19% greater than Al density.

b. 55 - 85 Kev: Al and OW densities are approximately equal and, both are greater than the Ag density.

c. Above 85 Kev: All three densities are approximately equal.

It has also been proven that when a film has been exposed to beta radiation from a uranium slab, the ratio of the Al and OW to Ag density will be approximately 2 : 10 : 1, or,

$$\frac{Al}{Ag} = 2 \text{ and, } \quad \frac{OW}{Ag} = 10.$$

When film has been exposed to both beta and soft gamma, the above ratios will not apply and the amount of each must be determined by use of the following procedure:

(1) Make probit correction on all net densities greater than 0.34.

(2) Subtract Cd density from the other three densities.

(3) Inspect remaining densities to determine whether or not they fit either of the three gamma categories or the expected 2 : 10 : 1 ratio of a uranium slab beta exposure. If not, continue to Step 4.

(4) Subtract an estimated beta density (2 : 10 : 1 ratio) from the Al, OW and Ag densities leaving densities which fall into one of the above three gamma categories.

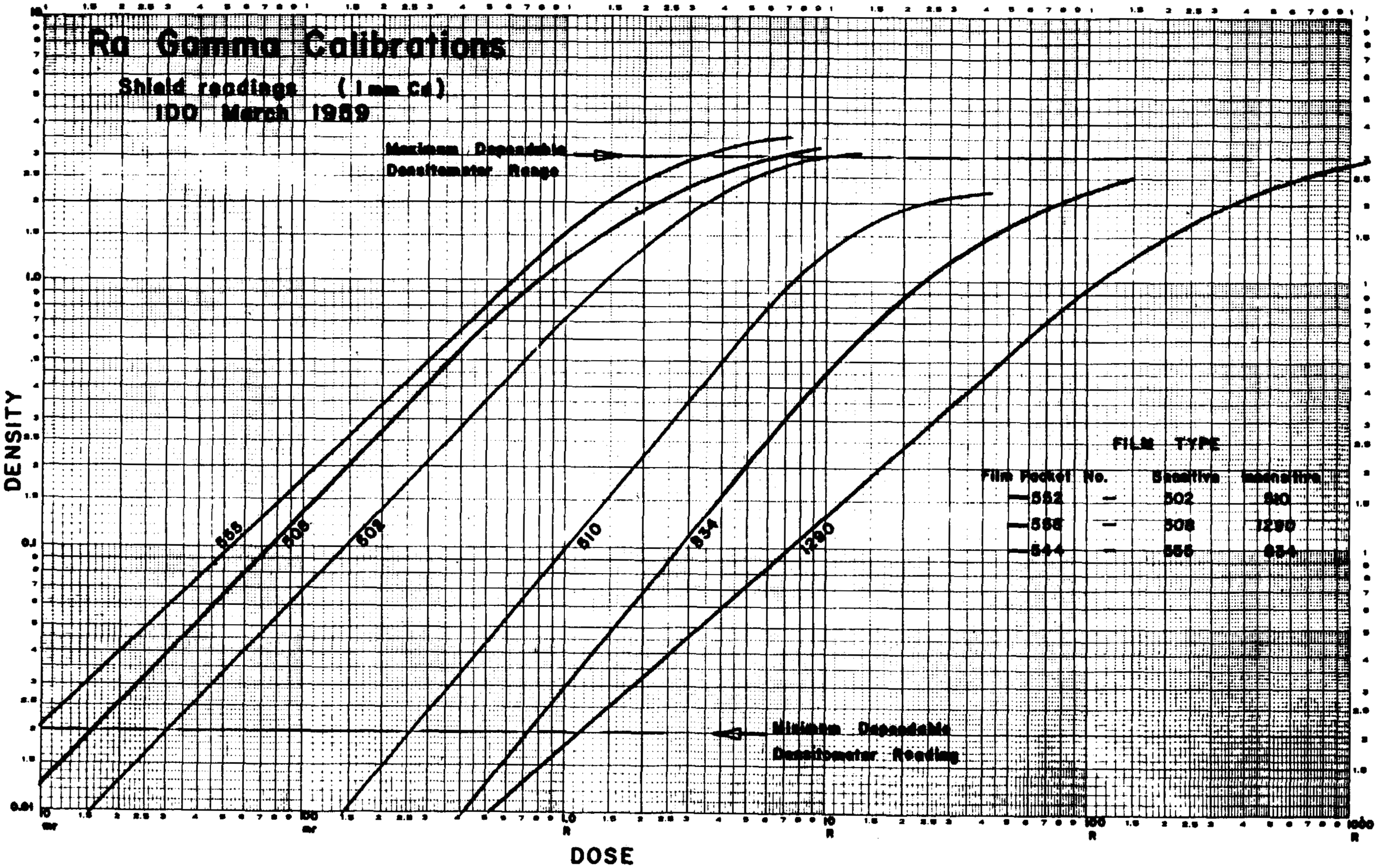
Ra Gamma Calibrations
Shield readings (1 mm Cd)
IDO March 1959
Maximum Dependable Densitometer Range
Minimum Dependable Densitometer Reading
DENSITY
DOSE
565
508
502
510
834
1290
FILM TYPE
Film Packet No. — Sensitive Insensitive
552 — 502 510
556 — 508 1290
544 — 555 834

Fig. V.

5. Energy Determination Procedure

To aid in energy determinations, badges and film were made available to the National Bureau of Standards for a series of exposures to low energy x-rays and cobalt-60. Uranium beta exposures were added to a portion of these films after their return to IDO.

The densities produced behind the various shields, using DuPont 558 packets, is shown in Figure VI.

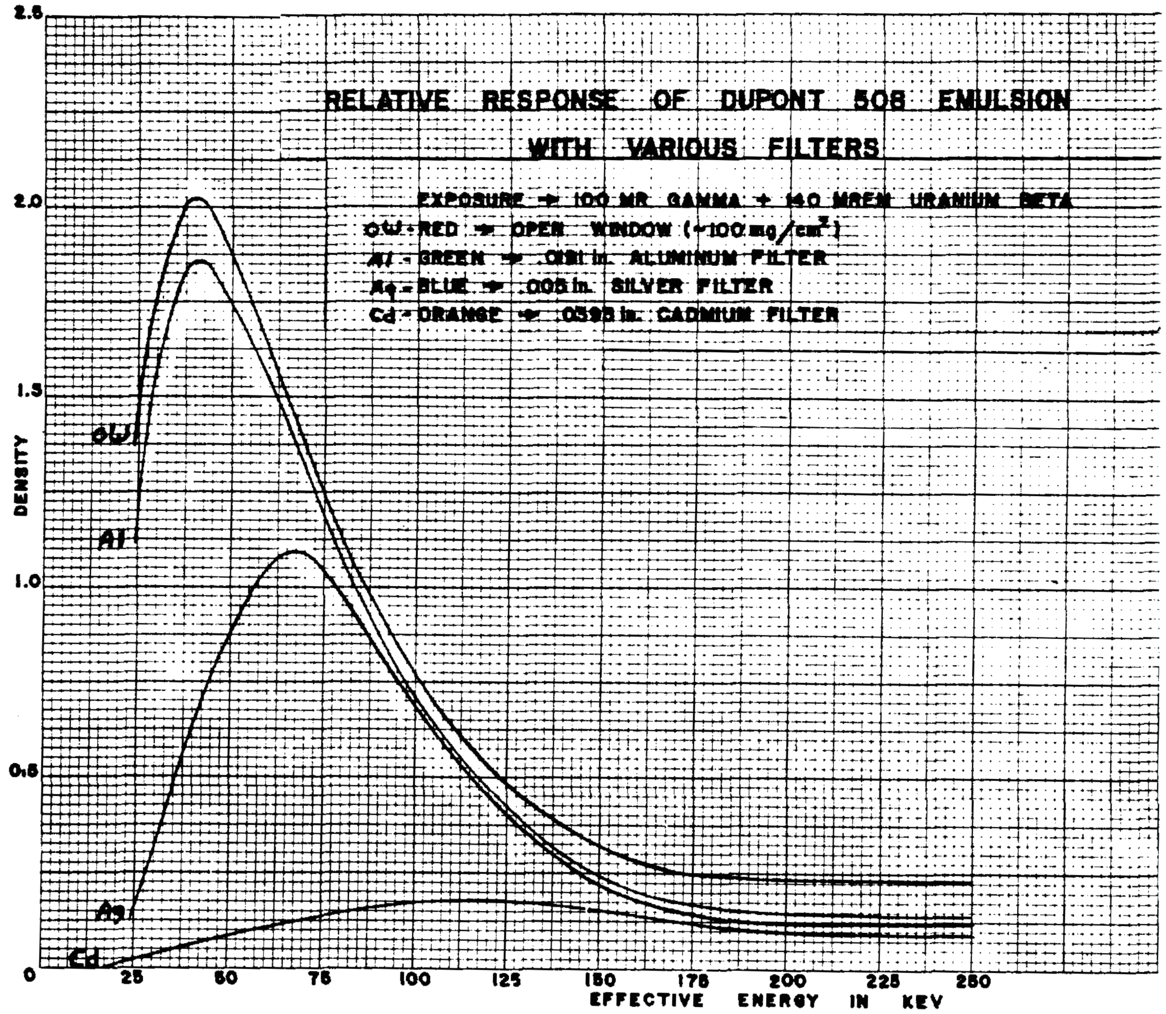

Fig. VI.

(5) Compare the apparent gamma energy indicated by the OW to Al ratio to the apparent energy indicated by the OW to Ag ratio, as shown by graph, Fig. VII.

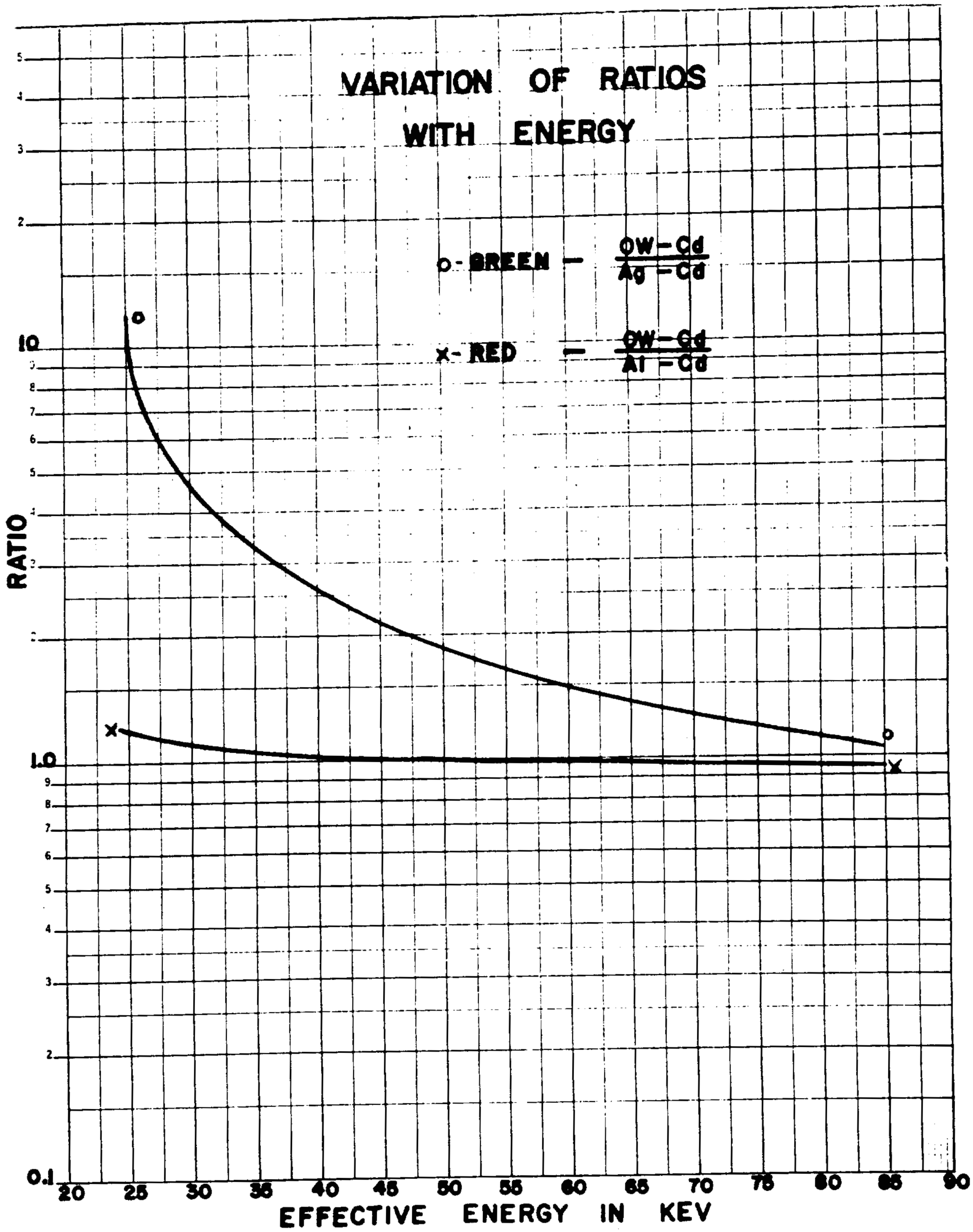

Fig. VII.

(6) If the two ratios do not indicate the gamma energy, adjust the estimated beta exposure and repeat step 4 and 5 until the two ratios indicate the same energy.

(7) Convert densities to dose by using standard calibration curves. Fig. VIII shows a sample calculation.

TYPICAL CALCULATION

		Al	OW	Ag	Cd
	NET DENSITIES	1.12	1.29	0.68	0.48
STEP 1.	Probit correction	1.24	1.45	0.72	0.50
STEP 2.	Subtract Cadmium density from Al, OW & Ag	0.74	0.95	0.22	
STEP 3.	Estimate beta density & subtract	0.03	0.15	0.015	
		0.71	0.80	0.205	

Compare apparent energies

$\frac{OW}{Al} = \frac{0.80}{0.71} = 1.12$ —— 29 Kev. ; $\frac{OW}{Ag} = \frac{0.80}{0.205} = 3.9$ —— 32 Kev.

		Al	OW	Ag	Cd
STEP 4.	Adjust beta density & recalculate	0.74	0.95	0.22	
		0.04	0.20	0.02	
		0.70	0.75	0.20	

$\frac{OW}{Al} = \frac{0.75}{0.70} = 1.07$ —— 33 Kev. ; $\frac{OW}{Ag} = \frac{0.75}{0.20} = 3.75$ —— 33 Kev.

CALCULATED EXPOSURE	ACTUAL EXPOSURE
Beta density of 0.20 = 400 mrem	400 mrem beta (Uranium slab)
Gamma density of 0.50 = 430 mr	400 mr Radium gamma
	37 mr 90 KVP x-ray

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Fig. VIII.

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6. Automatic Data Processing Improvements

The 402 Alphabetical Accounting Machine in the Automatic Data Processing room was converted to a net balance machine and additional counters and type bars were installed to utilize its full capabilities. Fig. IX shows the interior of the Automatic Data Processing room. A 101 Electronic Statistical Machine was installed capable of sorting and counting sixty different categories and printing out any predetermined selection of information. A punched card verifier was also installed for checking all manually punched cards for errors.

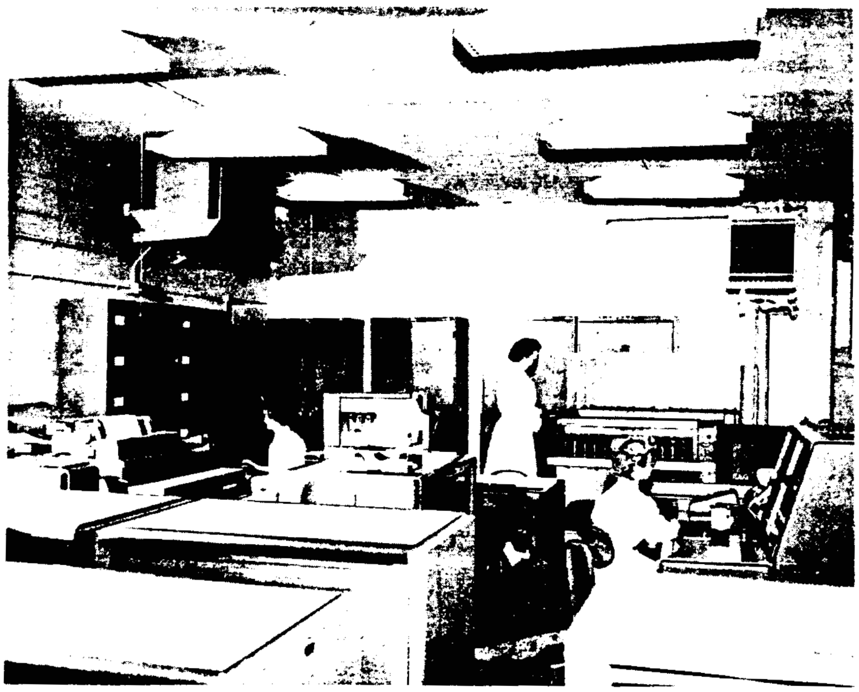

Fig. IX. Automatic Data Processing Room

C SPECIAL ACTIVITIES

1. Calibration of Personnel Neutron Threshold Detectors.

Final design of the detectors was completed by the Personnel Metering Branch early in 1959 and fabricated by the Products Engineering Company of Portland, Oregon (Fig.II). Through the cooperation of Dr. Ed Fast at the MTR Area, several of the detectors were irradiated to various levels in the Reactivity Measurement Facility. Counting techniques were performed by Earl Ebersole of the IDO Analysis Branch and results indicated the ability to detect and measure neutron exposure greater than one (1) rad. The indium foils provide an easily detectable response (> 1 mr) on a GM survey meter at least four (4) hours after exposure to > 1 rad of neutrons. This capability enables rapid scanning of badges to detect significant neutron exposures.

2. Temperature Effect on Dosimeter Film

A thesis titled "The Effect of Temperature During Irradiation on the Latent Image Mechanism with Reference to Personnel Monitoring Film", by Mr. C. H. Cooper was received during the first quarter of 1959. Mr. Cooper carried out his research at the IDO Personnel Metering Laboratory the previous year. All experiments were performed using DuPont type 502 film. It was concluded that there is a temperature effect on the net density of approximately 5% per 10° F., however, this is a very rough approximation and should not be used on any actual temperature corrections. Several correction tables are provided for this purpose. The effect appears to vary greatly with radiation intensity.

A preliminary investigation of the effect of humidity on the latent image mechanism indicated a relatively insignificant effect.

3. Boiler Tube Activity Tests

Several measurements of residual activity in boiler tubes were performed for Westinghouse at the A1W area. This entailed fabrication of special 12" probes from 1/4" square brass tubing, brazing one end and providing a light-tight cap. 1/4" x 12" strips were cut from AA Gamma Graphic sheet film and inserted into these probes. The probes were then inserted in the boiler tubes. Calibration to gamma radiation from radium was performed for use in converting the densities obtained.

4. Primary Shield Tests

Activity measurements to determine efficiency of the primary shield were also performed for Westinghouse at A1W. Lead bricks were machined to accommodate film badges so that all stray radiation from the sides or the back was shielded out. These shielded badges were then placed in selected positions on the shield to measure the penetrating radiation. These special badges were calibrated using radium sources.

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5. Radiological Physics Fellowship Training

The National Reactor Testing Station offers a unique opportunity for the field training of AEC Fellowship students in applied health physics. It has the world's largest and most varied collection of reactors of all types, including: research, testing, pressurized water, boiling water, organic moderated, gas cooled and fast breeder.

The success of the program is largely due to the excellent cooperation the Health and Safety Division has received from the various NRTS Contractors and other Government agencies who are participating in the program. These include Argonne National Laboratory, General Electric Company, Phillips Petroleum Company and the U. S. Weather Bureau. Messrs. Charles Anderson, Carl Jansen, Lawrence Thorp, James Watt, John Baxter, Jack Couch and Dale Crisler, AEC Fellows from Vanderbilt University, received three months training in conjunction with this program during summer 1959.

6. Non-Routine Processing

In addition to the regular activities, the Branch processed various non-routine items used by the Site Survey Branch, Contractors and other groups in fallout studies, special tests, etc. Table 1 lists a comparison of these items processed in 1958 and 1959.

Table 1. Non-Routine Film Processed 1958 - 1959

	5 x 7 Film	14 x 17 Film	Dosimeter Film	Neutron Film	Ring Film	Wrist Badges
1958	292	555	6,631	32,618	2,277	144
1959	112	721	16,803	80,743	1,152	82

D ROUTINE ACTIVITIES

A comparison of routine processing of personnel metering badges in 1958 and 1959 is shown in Table 2.

Table 2. Film Badges Serviced at the NRTS in 1958 and 1959

Month	Regular 1959	Temporary 1959	Total 1959	Approximate Number of PM Coverages 1959
January	11,294	3,074	14,368	6,574
February	11,381	4,818	16,199	6,623
March	12,157	3,288	15,445	6,760
April	11,725	3,536	15,261	6,981
May	11,976	5,133	17,109	8,278
June	12,295	4,347	16,642	7,844
July	14,668	4,505	19,173	8,320
August	13,788	4,668	18,456	8,241
September	11,349	3,479	14,828	7,503
October	13,083	4,371	17,454	8,185
November	11,970	3,463	15,433	7,393
December	12,973	3,760	16,733	7,405
Totals				Average
1958	188,587	31,520	220,107	6,600
1959	148,659	48,442	197,101	7,509

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Table 3 indicates a comparison of exposures received by IDO personnel in 1958 and 1959. These results are for AEC and Contractor personnel engaged on contracts administered by IDO and do not include visitors or personnel employed on contracts administered by other operations offices.

Visitors totaling 25,431 were badged during 1959 with 98% receiving statistical zeros and none approaching recommended maximum permissible levels.

Table 4 shows the radioactivity results of urinalyses performed in 1959. These urinalyses are performed by the Analysis Branch and the results are incorporated in the personnel exposure records of the people concerned by the Personnel Metering Branch. Out of a total of 11,066 performed only 278 yielded statistically significant results, all of which were less than 10% of the permissible body burden.

E FUTURE PROGRAMS

1. Fast Neutron Measurement Utilizing NTA Film Density

   Experiments are being performed to explore the feasibility of using density produced on type NTA film to measure fast neutron exposure. Proton track counting on film exposed to significant amounts of gamma is extremely difficult and a better method of neutron exposure determination is sorely needed. We are hopeful that some system utilizing the equality, total density minus gamma density, can be developed.

2. Reduction of Gamma Fogging on Neutron Emulsion Films

   Experimentation is being carried on in an endeavor to reduce fogging of neutron emulsions due to gamma exposure. Preliminary work is being done on bleaching with peroxide solution and variation in development time and temperature.

3. Solution to Visitor Load Problem

   Studies are continuing on methods and procedures to lessen the large visitor coverage work load. Various possibilities will be explored during the coming year.

By IDO Personnel (AEC and Contractors)

1958 - 1959

Exposure Level, rem	Average Exposure rem (1959)	Group A 1959	Group B 1959	Group C 1959	Group D 1959	Group E 1959	Group F 1959	Total 1958	Total 1959	% 1958	% 1959
0 - .5	0.08	897	432	1,300	26	20	34		2,709		76.87
.5 - 1	0.72	238	3	28	0	8	0	3,001*	277	84.73*	7.86
1 - 2	1.43	229	2	5	0	10	0	277	246	7.82	6.98
2 - 3	2.46	144	0	0	0	6	0	156	150	4.40	4.25
3 - 4	3.43	46	0	0	0	5	0	54	51	1.52	1.45
4 - 5	4.49	35	0	0	0	8	0	25	43	.71	1.21
5 - 6	5.46	18	0	0	0	1	0	11	19	.31	.54
6 - 7	6.52	9						9	9	.25	.26
7 - 8	7.49	9						4	9	.11	.26
8 - 9	8.34	5						4	5	.11	.14
9 - 10	9.88	2						1	2	.03	.06
10 - 15	11.63	2						0	2**	0	.06
> 15	45.31	2						0	2**	0	.06
TOTALS	0.39#	1,636	437	1,333	26	58	34	3,542	3,524		

* Total number and percent of exposures of 0 - 1.0 rem for 1958

** These exposures resulted from a criticality incident at the Chemical Processing Plant

Based on total exposure received by all regularly covered personnel at the NRTS regardless of Contractor

Table 4. Urinalysis Results for 1959

Isotope of Interest	Type of Activity	Total Number Performed	Number Statistically Significant	% of Total Statistically Significant	Highest* Result
	Gross β	8,546	65	0.76	18,820 ± 632 d/m/5ml
	Gross α	2,433	174	7.15	35,972 ± 310 d/m/5ml
Am	α	2	0	0	Insignificant
Ba-139	β	20	16	80.00	120 ± 0.8 d/m/ml
Pu-239	α	18	0	0	Insignificant
Sr-90	β	3	3	100.00	4.12×10^{-2} d/m/ml
Sr-91	β	20	19	95.00	388 ± 1.6 d/m/ml
Th	α	7	0	0	Insignificant
U-233	α	17	1	0.06	180 ± 4.0 d/m/ml
TOTALS		11,066	278	2.51	

* All less than 10% of permissible body burden

Chapter 3

MEDICAL SERVICES

George L. Voelz, M.D., Branch Chief

A SCOPE

The Medical Services Branch conducts a comprehensive preventive industrial medical program for AEC and contractor personnel at the National Reactor Testing Station. During 1959, arrangements were made to service two new operating NRTS contractors, Aerojet General Nucleonics and Combustion Engineers, Incorporated, in addition to those contractors already utilizing Medical Services, namely, Phillips Petroleum Company; Argonne National Laboratory; and Atomics International, Division of North American Aviation, Incorporated. First aid and emergency medical care is provided for construction contractor personnel working at the National Reactor Testing Station. Laboratory and X-ray examinations are provided for Westinghouse Electric Corporation and General Electric Company employees, as requested by their medical departments.

1. Facilities

The AEC Dispensary is located in the Central Facilities Area. Equipment used in performing physical examinations includes an Orthorater (vision testing apparatus), audiometer, electrocardiograph recorder, and a diagnostic X-ray machine. The medical laboratory is equipped to conduct essential routine clinical laboratory examinations. Medical supplies are maintained to provide medical care, including minor surgical procedures, diathermy, and ultrasonic treatments. A room in the dispensary basement is designed and equipped to handle radioactively contaminated personnel. Two ambulances, available for emergency transportation at all times, are operated by the AEC Fire Department under the supervision of the Medical Services physician.

In addition to the Central Facilities Dispensary, Phillips Petroleum Company maintains dispensaries staffed by a registered nurse at the MTR-ETR and the CPP areas during the day shift. These dispensaries are visited for one hour on each of the night shifts by the AEC nurses.

2. Personnel

The Medical Services Branch is staffed with ten AEC employees. No new positions have been filled since 1957. Efforts to secure an additional physician were begun during 1959, but no selection was made by the end of the year. The Branch Chief is a full-time industrial physician registered to practice medicine in the State of Idaho and certified in the field of occupational medicine. The nursing staff consists of a nurse supervisor and five nurses. Four shift nurses provide professional attendance at the dispensary at all times including holidays and week ends. One nurse spends approximately half-time visiting construction areas to provide close liaison with the first-aid attendants and to perform medical revisits at the construction sites. The remainder of her time provides an additional day shift nurse at the main dispensary. One clinical laboratory technician and one X-ray technician operate their respective departments and are trained to relieve each other during annual or sick leave. One secretary types all correspondence and forms, completes Branch reports, and maintains record files.

B SUMMARY OF MAJOR PROGRAMS

1. General

During 1959, the Medical Services Branch performed an increased number of physical examinations as a result of providing medical service for two new contractors and a slight increase in contractor personnel at the NRTS, especially Argonne National Laboratory.

2. Dispensary Visits

A total of 8,397 patients visited the AEC-CFA Dispensary. Of these 5,101 patients received treatment or consultation, while 3,296 were seen for sample collections, vaccinations, and physical examinations. The patients receiving treatment or consultation were from the following employers:

Table 5. Dispensary Visits

Company	Number of Treatments: Occupational	Non-occupational	Total	Per cent
Phillips Petroleum Co.	636	2,436	3,072	60.2
Atomic Energy Commission	69	817	886	17.4
Construction Contractors and Others	367	275	642	12.5
Argonne National Laboratory	33	150	183	3.6
Other Federal Employees*	25	86	111	2.2
Atomics International	29	65	94	1.9
Westinghouse Electric	32	33	65	1.2
Aerojet-General Corporation	9	16	25	0.5
Combustion Engineers	2	24	26	0.5
Totals...	1,202	3,902	5,104	100.0

* Includes all Federal employees except AEC, i. e., U. S. Weather Bureau, U. S. Geological Survey, U. S. Public Health Service, U. S. Navy, etc.

Treatments for job-connected conditions comprized 23.6 per cent of the total, while 76.4 per cent of the visits were for non-occupational conditions. The number of treatments at the CFA Dispensary increased 6 per cent from the previous year. The total visits to the dispensary increased 10 per cent compared to 1958.

The IDO contractor-operated dispensaries, cooperating with the AEC Central Facilities Dispensary, had the following patient treatments during 1959:

	Occupational	Non-occupational	Total
CPP Dispensary (Phillips)	331	1,719	2,050
MTR-ETR Dispensary (Phillips)	1,035	5,417	6,452
Fluor Dispensary (Fluor)	734	1,144	1,878
First-aid Stations (Construction)	390	138	528

The grand total of all patients who passed through the AEC and IDO contractor dispensaries and first-aid stations during 1959 was 23,321 persons. This is a 5.7 per cent increase from 1958. Of this total, 16,009 visits were for treatment or consultation, and the remainder were for collection of laboratory samples and immunizations.

3. Physical Examinations

In 1959, a total of 975 physical examinations were performed. This represents a 14.6 per cent increase over the 1958 total. Physical examinations serve a most important function in a preventive medical program. Pre-employment examinations are performed prior to hiring personnel to insure that the applicant's physical qualifications fit the job. Periodic and termination examinations determine any change in the employee's health status which may result from his occupation or which may necessitate a change in his job. These examinations also provide early diagnosis of unknown conditions which may be treated to prevent progression or future complications. Indirectly, the periodic examinations evaluate plant conditions and direct attention to problem areas which may require industrial hygiene, health physics, or safety consultations.

The increase in physical examinations for the past six years at the CFA Dispensary is shown in Fig. X. Although the total increased substantially the past two years, the periodic examinations have failed to increase proportionately due to the increase in the number of required pre-employment and termination examinations.

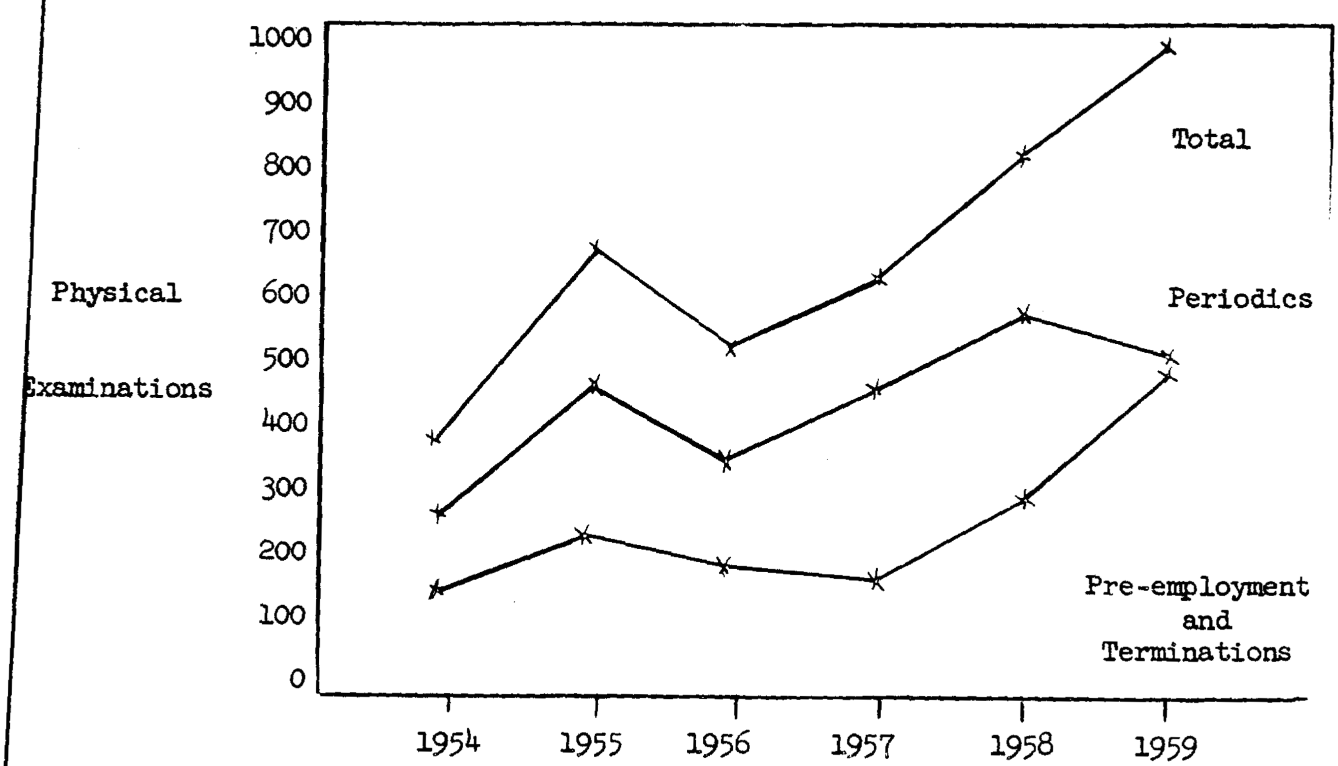

Fig. X. Physical Examinations 1954 - 1959.

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The 1959 examinations have been performed for the NRTS contractors as shown in the following table:

Table 6. 1959 Physical Examinations

	Pre-employment	Periodic	Termination	Total	Per Cent
Phillips Petroleum Company	92	356	179	627	65
Atomic Energy Commission	29	81	20	130	13
Argonne National Laboratory	73		14	87	9
Combustion Engineers	31	8	22	61	6
Atomics International	8	32		40	4
Aerojet-General Corporation	3	25	1	29	3
Diversified Builders			1	1	
Totals...	236	502	237	975	

Review of the physical examinations findings indicates the frequency with which health problems may have a bearing on proper placement of the employee on the job. Only one person out of four was found to be completely normal.

Table 7. Most Common Diagnoses on 975 Examinations

	Number	Per Cent
Normal	254	26
Vision correction required	180	18.2
Overweight	97	9.9
Eye muscle imbalance (phorias)	74	7.6
Hay fever	48	4.9
Hearing loss, over 10% in one year	39	4.0
Color vision defect	33	3.3
Drug sensitivity (penicillin)	27	2.7
Prostate disease	25	2.5
Peptic ulcer or recurrent gastritis	24	2.4
Uncorrected vision loss	23	2.3
High blood pressure	20	2.0
Hearing loss, over 10% in both ears	19	1.9
Asthma	16	1.6
Recurrent back strains	16	1.6

Many of the above diagnoses were known by the individual prior to this examination. However, 61 new significant conditions were discovered on these 975 examinations. Over 90% of these new diagnoses had not caused recognizable symptoms.

Fig. XI. Audiograms Monitor Persons for Early Hearing Loss From Noise Exposure.

Most Frequent New Diagnoses on 975 Examinations	Number	Per Cent
High blood pressure	12	1.2
Heart disease	6	.6
Anemias	6	.6
Prostatitis	5	.5

4. Laboratory Analyses and Diagnostic X-rays

The total number of individuals on which laboratory analyses and X-rays were performed remained relatively constant compared to the previous years. This figure has not increased because duplication has been avoided in instances where recent X-ray or laboratory work is available for termination physical examinations. On some pre-employment physical examinations, recent chest X-rays taken elsewhere have been accepted to avoid unnecessary repetitive chest X-rays.

In 1959, the laboratory began to preserve all blood slides taken at the CFA Dispensary so that future comparisons may be made should an employee develop a blood abnormality.

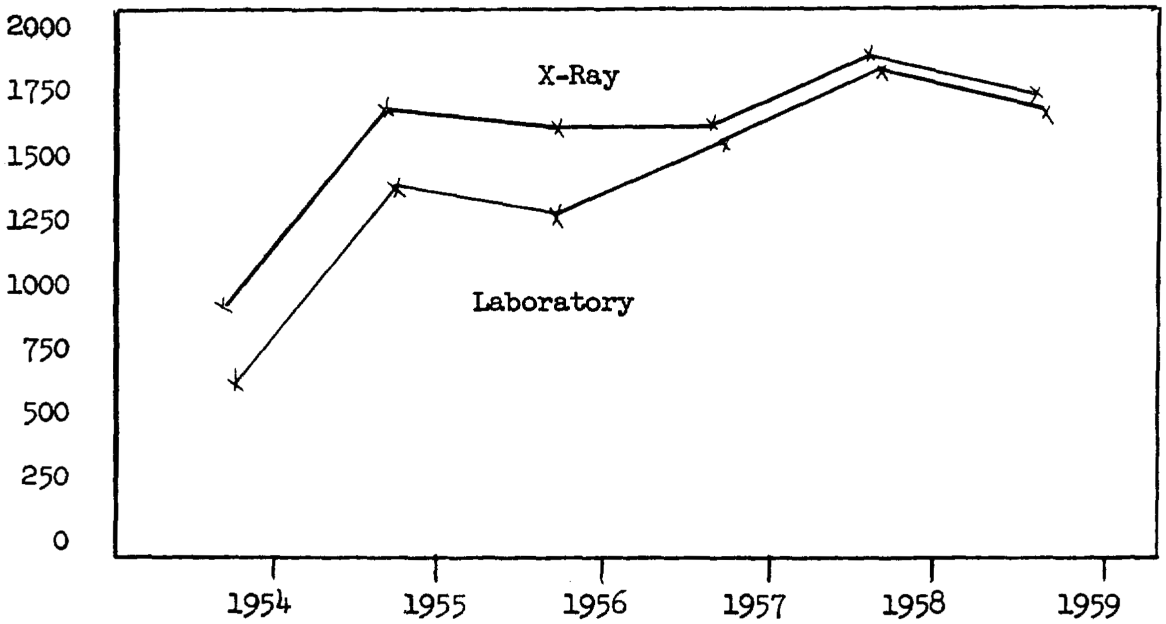

Fig. XII. Laboratory Work 1954 - 1959.

Unsuspected diagnoses were found on about 1 per cent of chest X-rays performed in conjunction with physical examinations. Clinical laboratory tests resulted in 175 determinations which were outside normal limits. Many of these returned to normal on subsequent determinations. Abnormalities were noted on 5.9 per cent of the electrocardiograms performed in conjunction with physical examinations. Seventy-five per cent of these abnormalities were noted for the first time.

5. Health Education

In addition to employee counseling on an individual basis during consultations and physical examinations, health lectures were given to various major employee groups at NRTS. These ranged in subject matter from "Common Summer First-aid Problems" to Criticality Accidents".

C SPECIAL ACTIVITIES

1. Slit Lamp Eye Examinations

Since 1952, special slit lamp examinations for lens changes have been performed on certain employees with potential neutron exposure. Over 500 examinations have been recorded to date. The results of these examinations have been coded on IBM cards for better analysis of the data. No lens changes have been found which can be attributed to occupational radiation exposure. However, a number of conditions have been documented which might cause subsequent confusion if they progress sufficiently to impair vision. The analysis of this data should be completed shortly.

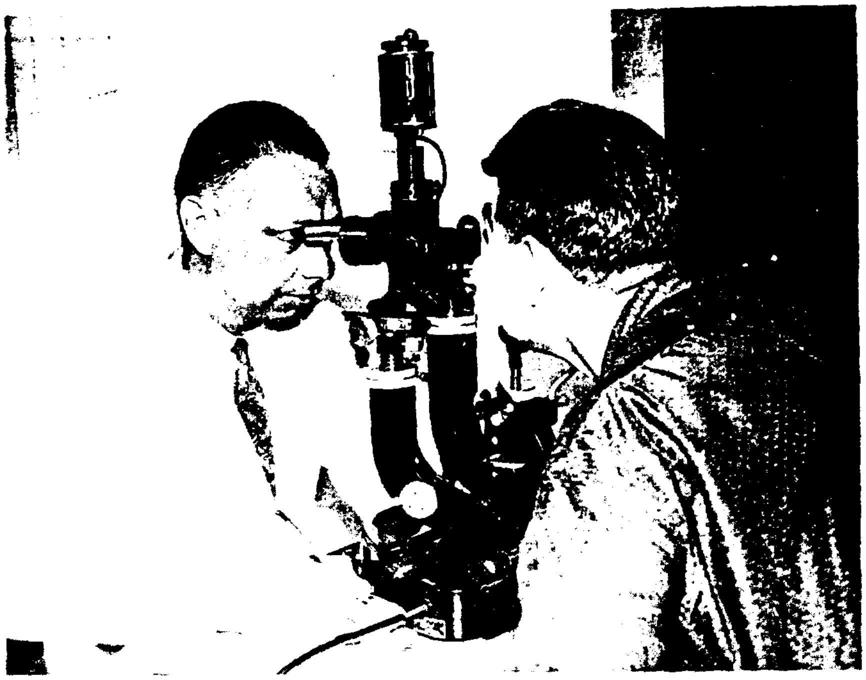

Fig. XIII. Periodic Eye Examinations Check for Possible Lens Changes Due to Radiation Exposure.

2. Medical Consultations

a. CPP Criticality Accident Medical Report

Medical examinations and blood counts were performed on 21 persons involved in the CPP criticality accident of October 16, 1959. No symptoms occurred which could be attributed to radiation exposures. Blood counts on all exposed individuals showed no changes indicative of radiation effect. It was concluded that the radiation dose received by these individuals was not sufficient to produce demonstrable, acute hematologic effects. The radiation dose must necessarily have been below 100 rem and probably below 50 rem. This agreed with the findings by film badge dosimetry and calculations on internal radiation dose.

b. Northway and McVey vs Phillips Petroleum Company

In 1959, the H. E. Northway and J. E. McVey vs Phillips Petroleum Company lawsuit, which resulted from the radioactive contamination of the M. W. Kellogg South Houston laboratory in March, 1957, came to trial. Medical consultation was provided the IDO General Counsel's office to help prepare the defense of this case. In September, Dr. Voelz attended a meeting of medical witnesses in which the medical aspects of the case were reviewed prior to the trial. The suit was successfully defended.

c. Other Medical Consultations

A number of personnel exposure problems or potential problems arose during 1959 for which medical consultation was given. These included problems involving cadmium fumes, Phenoline 302 catalyst, hydrofluoric acid, Orocal dust, beryllium, minor radiation exposures, and noise.

3. Emergency Planning

A brief survey was made of the physical plants of the Idaho Falls hospitals with a view toward handling radioactively contaminated patients without spreading contamination beyond a restricted area. A plan was formulated and forwarded to the hospitals for inclusion in their emergency plans.

4. Presentations

The following presentations were given by the Branch Chief during 1959 in addition to those given for NRTS visiting groups, training courses, and health education lectures.

a. PRINCIPLES OF HANDLING THE RADIOACTIVELY CONTAMINATED PATIENT, was presented at the Sacred Heart Hospital Nurses Meeting.

b. RADIATION AND HEALTH PROBLEMS, was presented at the Idaho Section, American Institute of Chemical Engineers.

c. THE PRACTICE OF OCCUPATIONAL MEDICINE, was presented at the Southeastern Idaho Public Health District Staff Education Meeting.

d. RADIATION AND HEALTH, was presented at the Eastern Idaho District Nurses Meeting.

e. MEDICAL EXPERIENCE FROM CRITICALITY ACCIDENTS, was presented at the Idaho Section, American Nuclear Society.

f. BIOLOGICAL EFFECTS OF RADIATION, was presented at the Naval Reserve Nuclear Seminar.

g. MEDICAL REPORT ON THE CPP CRITICALITY ACCIDENT, was presented at the AEC Health Personnel Meeting, New York City.

D FUTURE PROGRAMS

1. Continued growth of the physical examination program is anticipated. It is particularly desirable that the periodic examinations be expanded. Efforts will be made to increase this program within the limits of the present staff. This continues to be an area of deficiency in our present program since only about 20 per cent of persons in radiation areas are examined during the year.

2. Development of a central system of scheduling physical examinations and annual screening laboratory examinations has become desirable. Better control of the examination schedule will promote better coverage and efficiency of the physical examination program. Screening laboratory tests would be performed on an annual basis for those individuals who are not scheduled for a complete physical examination in a particular year.

   It is anticipated that another future development will be a system of coding our medical records to permit better utilization of the medical data collected on personnel at the NRTS.

Chapter 4

SAFETY AND FIRE PROTECTION

R. V. Batie, Branch Chief

A SCOPE

The Safety and Fire Protection Branch is fundamentally responsible for the development of an effective program encompassing the specialized functions of the five Branch Sections - Nuclear Safety, Industrial Hygiene, Fire Engineering, Safety Engineering and Fire Protection. Program coordination and guidance is furnished as necessary to the IDO staff and operational and construction contractors.

The National Reactor Testing Station complex involves activities and facilities of three AEC Operations Offices in addition to IDO. Since IDO has the only AEC Safety and Fire Protection staff located at the Site, liaison agreements provide Branch services to the other Operations Offices active at the NRTS. The liaison functions include surveys, inspections, reporting, investigation assistance, fire response, vehicle licensing and other mutually helpful provisions.

1. Standards

The Branch formulates and develops the IDO Standard Health and Safety Requirements, as a part of the IDO Manual, which furnishes a basic program and operational guides, and is a specific requirement in all Idaho Operations Office contracts. These Requirements have general application to other Operations Office's activities at the NRTS. The Branch is the authority for interpretation of the Requirements and or reference codes, and is the consultant on field problems.

B SUMMARY OF MAJOR PROGRAMS

1. Nuclear Safety Engineering

A Nuclear Safety Engineer was added to the staff during the final quarter of the year. His assigned duties are to: develop NRTS nuclear safety standards and procedures; evaluate nuclear safety programs; act as consultant to contractors on their nuclear safety problems; serve as a member of the Radiological Assistance Team; review design criteria on handling, storing, processing and transporting fissionable materials; pursue special problems in the fields of nuclear safety and dosimetry.

a. Shipments

Criticality reviews and/or inspections are being accomplished on all shipments of fissionable material from NRTS, and those originating elsewhere which involve use of the NRTS carrier equipment in conjunction with other cargoes. Items of concern, in this regard, are: criticality, safe design of container; physical integrity of unit container; spatial arrangement of containers in carrier with respect to other similar units and to dissimilar materials.

b. Nuclear Accident Dosimetry

Sixty Nuclear Accident Dosimetry (NAD) systems developed by ORNL have been received for installation at the NRTS contractor facilities where there is some reasonable potential for such an accident. These dosimeters will provide a measure of the neutron spectrum-dose as well as the high-range gamma dose, and will aid in personnel dosimetry in the event of exposure.

c. Criticality Accident

A criticality accident involving fissionable uranium occurred on October 16, 1959, at the Idaho Chemical Processing Plant, the first such incident in the 10-year history of the NRTS. (For official report, see IDO-10035). Considerable time was spent in the investigation and review of conditions contributing to the excursion. Corrective measures have been taken at the facility, resulting in alterations to the process equipment control procedures and to the alarm system. Special Nuclear Accident Dosimetry systems will be installed by January 15, 1960 to provide improved area radiation dosimetry.

d. Future Program

A program objective is to obtain energy spectra and neutron-to-gamma dosage ratios from several of the NRTS installations to develop a familiarity with the dosimetry systems, as well as pre-incident information. The number of different criticality and transient facilities at the NRTS offers a unique opportunity for this valuable study. In 1960 surveys will be underway at each contractor facility to review nuclear safety programs. Of interest are: materials handling procedures; storage facilities; mass limits in processing and fabricating areas; alarm instrumentation; evacuation procedures.

2. Industrial Hygiene

The first year's activity of an Industrial Hygiene Engineer permitted development and detail work in noise, ventilation, sanitation and toxicity problems not possible heretofore.

a. Routine Activities

One-hundred-five requests for industrial hygiene services were handled during the year plus fifty calls for consultation on special problems.

Table 8 gives a further breakdown of services furnished. Consultation on special problems consists of ventilation design work, recommendation of the proper types of respirators for specific hazards, interpretation of regulations, etc.

Table 8.

REQUESTS FOR INDUSTRIAL HYGIENE SURVEYS BY N.R.T.S. CONTRACTORS IN 1959.

AREAS	NOISE	VENTILATION	AIR SAMPLING	LIGHT	CONSULTATION SPEC. PROB.	SANITATION
ANP		1	2		4	2 (1)
NRF	2	5 (2)	2	1	5	
MTR/ETR	3 (2)	1	1	2 (1)	5	1
CPP	2 (1)	2	5 (1)		8	1
CF	5 (1)	3 (1)	10 (5)	2	8	5 (4)
SPERT	1				1	1
OMRE	2 (1)	2 (1)	2		2	
EBR-I AREA	2 (1)	1			2	
SL-1		2	2		2	
GCRE	1 (1)	2 (1)	4	1	4	1 (1)
CONSTRUCTION CONTRACTORS	4 (2)	7 (2)	10 (1)		9	2 (2)
TOTAL	22 (9)	26 (7)	38 (7)	6 (1)	50	13 (8)

NOTE: THE FIRST NUMBER INDICATES TOTAL SURVEYS TAKEN; NUMBER ENCLOSED IN PARENTHESES INDICATES NUMBER OF SURVEYS ON WHICH CORRECTIVE ACTION WAS TAKEN.

Additional instruments were purchased to provide the capability to evaluate any feasible industrial hygiene problem at the NRTS. These included: Drager and Kitagawa gas detectors, hydrogen fluoride detector, halide meter, inclined-vertical manometer, hot wire air meter and gas bubblers. A products file of those materials used at the NRTS which may cause a health problem was initiated. Information relating to toxicity, composition, precautions, and fire and explosive characteristics are obtained from the manufacturer by means of special questionnaires.

The Industrial Hygiene Engineer has taken over supervision of the bacteriological water sampling program. Samples are taken every two weeks and have increased from eleven in June to twenty by the end of the year. Two areas were found to be contaminated during that period and corrective action taken. A trailer-mounted chlorinator has been assigned to the Branch for emergency use to supplement the fixed chlorinator units at each site.

An IDO Information Bulletin series was initiated for items of Site-wide interest. Issuances on Industrial Hygiene subjects included: Teflon: Xylene; Laboratory Hood Ventilation; High-Efficiency Filters; and Industrial Hygiene Services Available.

Extensive annual industrial hygiene surveys were conducted in conjunction with safety surveys at all Phillips Petroleum Company areas, the NRF and OMRE. Special detailed cafeteria surveys were completed at ANP and NRF.

Ventilation problems have been of prime concern, from review of existing installations to design of such items as plutonium hoods, metalizing booths, etc. Ventilation requirements for laboratory hoods handling radioactive materials were increased from 100 to 150 feet per minute face velocity. Ventilation requirements for other hood usages were similarly raised to correspond with the latest recommendations of the Committee on Industrial Ventilation of the ACGIH. Redesign work on ventilating systems included the Central Facility Chemical Engineering Laboratory and the MTR Hot Alpha Laboratory.

b. Special Activities

Approximately six weeks were spent with the IDO Inspection Division making uranium mill surveys in Utah, Colorado and New Mexico.

The Harvard University economic survey of air cleaning equipment in use at IDO was coordinated by the Industrial Hygiene Engineer.

c. Future Program

The Industrial Hygiene section of the IDO Standard Health and Safety Requirements will be modified considerably to include program additions and revisions.

Studies to be started in the coming year will be on high efficiency filters, emergency mask development for I-131, sampling methods and toxicity of polyphenols, and acoustical tile specifications. It is anticipated to start a review of all ventilation systems at the NRTS with the thought in mind of learning where future improvements can be made economically.

3. Fire Engineering

The Fire Engineering program is developed to provide "improved risk" standards in the design stage of new facilities and to elevate existing facilities to "improved risk" standards, thereby minimizing fire loss and interruption of operations.

a. Fire Loss Experience

In examining the Fire Loss Data (Table 9) it is noted that the NRTS losses exceeded the AEC average in two of the past five years, although the total overall loss is less than the AEC average for the four years. The NRTS loss during the same period was only a fraction of what might have been suffered if fire had occurred at the national loss rate or the "improved risk" loss rate. However, it should be noted that one large fire loss could reverse this favorable comparison, and it is this type of loss which our fire protection efforts are primarily aimed at preventing.

Table 9. NRTS Fire Loss Comparison

	NRTS Valuation	Actual NRTS Fire Loss	AEC Comparative Loss	"Improved Risk" Comparative Loss	National Comparative Loss
1959	321,800,000	1,821	10,297	87,852	482,703
1958	259,620,000	2,050	8,826	71,000	390,000
1957	204,900,000	22,685	15,200	56,000	308,000
1956	150,000,000	217	44,900	41,000	225,000
1955	118,000,000	5,366	2,120	32,200	177,000

b. Design Criteria

The IDO Safety and Fire Protection Design Criteria Manual (IDO Report #12008) was officially published in April 1959 and the first revision was issued in August 1959. The manual is used as a guide by Archetect Engineer groups in the design of future NRTS facilities and has materially assisted in coordinating safety and fire engineering with our Engineering and Construction Division, other Operations Offices and operating contractor design engineers.

The Fire Protection Engineer acts as the coordinator for the Health and Safety Division to assure that all interested parties have an opportunity to make a thorough review of proposed plans and specifications. During the year 102 sets of engineering drawings, conceptual designs and project proposals were reviewed and comments submitted. Fire protection recommendations total 415.

1186731

c. Surveys

Annual Fire Protection Engineering Surveys of all NRTS facilities in operation were made. The "improved risk" criteria for AEC Fire Protection was used as a guide for these surveys. The purpose of each survey is to determine the adequacy of the Fire Protection program, reliability of the fire protection water supply, protection of vital electrical equipment against fire damage, assurance that building construction is in accordance with national code requirements, review of special hazards, and adequacy of built-in fire protection equipment. A formal report of each survey outlining problems, and recommendations was forwarded to the manager of the appropriate Operations Office. Recommendations on a fire protection improvement program was submitted to IDO contractors and provisions were made for accomplishing the recommended improvements over a three-year period. Funds have already been allocated in FY60 General Plant Projects for correction of the most important items.

d. Major Fire Protection Accomplishments

Automatic wet pipe sprinkler systems were installed in the MTR Reactor Wing Basement and the CPP Maintenance Building. The redwood cooling towers at the MTR and ETR were protected with the installation of automatic deluge sprinkler systems.

Built-in fire protection in new facilities included automatic sprinkler systems in the CPP-PIF Building and the GCRE Cooling Tower, foam sprinkler systems in the ANP-FET Building, automatic dry chemical system in the ETR-WAPD-31 Experiment Dowtherm Cubicle, and automatic fire detection system in the GCRE facility.

A number of minor fire protection improvements were made throughout the NRTS areas such as relocation of flammable liquid tanks from above ground to below ground, improved exit facilities, new stand pipe hose station, alarm boxes, hose houses, etc.

e. Fire Prevention

In re-organization of the Fire Prevention Inspection Unit, the Fire Protection Engineer was designated to supervise and give technical direction to the inspectors during the normal work day.

Routine Safety and Fire reviews of contractors' activities were made to determine the adequacy of compliance with acceptable standards. The Fire Prevention Unit made a total of 1,457 fire prevention inspections covering both operational and construction activities.

Fig. XIV shows a decrease in construction inspections during 1959 due to completion of several contracts and light construction activities during the winter months. The operations figures are comprised of a combination of plant fire prevention inspections and the monthly tests conducted on fixed fire protection devices and fire alarm systems in all areas except the ANP which has its own program. Program emphasis on fixed fire protection and alarm systems plus the completion of new systems and facilities was primarily responsible for the increase in operations inspections. Routine in-plant fire inspections were turned over to the operating contractor at five facilities. Phillips Petroleum Company hired one man to maintain fire extinguishers and perform similar fire inspection functions.

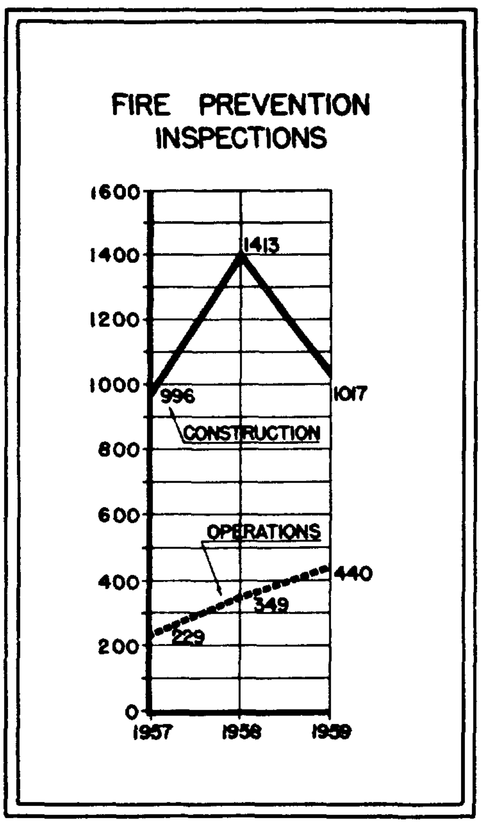

Fig. XIV.

A water flow test program was initiated at all NRTS facilities and included a new system for recording such tests. One of the fire inspectors devised a "water flow test pipe" that assisted in obtaining more reliable data, reduced the number of personnel required for tests and prevented damage to lawns and road shoulders. Fig. XV shows the flow test pipe in operation. A cash award was received by the inspector for this device through the Suggestion Award Committee.

Fig. XV. Water Flow Pressure Test.

f. Future Program

Establish a formal program for inspecting and testing fire doors, sprinkler systems and other built-in fire protection equipment. Although this has been done in the past, the new program will provide more comprehensive testing procedures and record keeping.

Complete Sanborn maps for all NRTS facilities. Sanborn maps are made from facility plot plans and use NFPA plan symbols to show type of building construction, water systems, and all fire protection details.

Establish a formal training program for the Fire Prevention and Inspection Unit.

Revise the IDO Safety and Fire Protection Design Criteria Manual and IDO Health and Safety Requirements Manual to include all new up-to-date standards and provide more comprehensive criteria for the design of fire protection water supplies and flammable liquid storage and handling facilities.

Formulate a fire department training manual encompassing industrial and radiological fire fighting techniques and other unusual fire conditions and exposures relative to NRTS activities,

4. Fire Protection

IDO furnishes fire protection for all NRTS facilities except for the ANP plant complex (for this facility, back-up fire protection is furnished by the plant brigade), and maintains the professional fire department at the Site. This department is supplemented by plant fire brigades, at each facility who are trained by the Fire Department and plant safety personnel.

a. Growth of Fire Protection

The continued expansion of the NRTS has been relatively steady since its inception in 1950. The NRTS facility growth and the corresponding increase in property replacement valuations (Fig. XVI) has demanded an increase of fire protection. The fire department has increased from one fire station in 1957 to three stations in 1959, from 28 personnel to 42, and from four pieces of motorized fire apparatus to six pieces during the same period of time. Yet the ratio of fire department operating costs to property valuations has remained fairly stable.

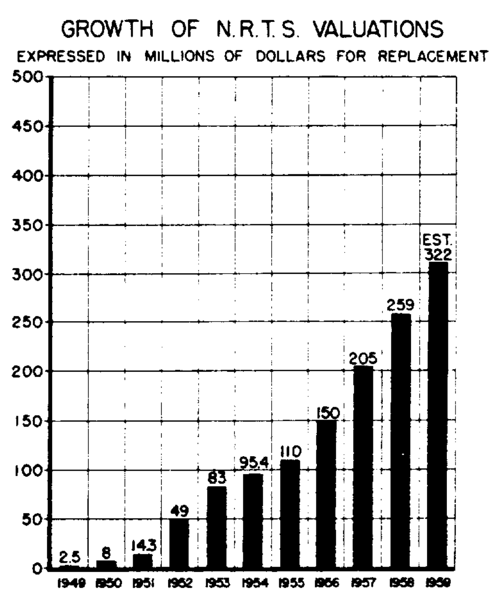

Fig. XVI.

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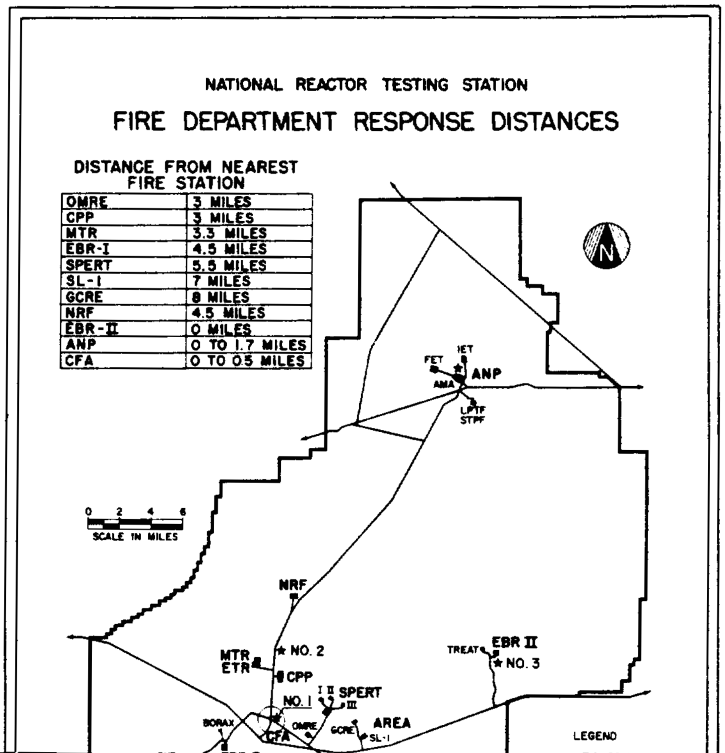
b. Capability of Response

Facilities and areas at the NRTS have purposely been located remote from each other to afford minimum contamination in the event of a radiological incident. Fig.XVII shows the location of fire stations in relation to the NRTS reactor areas.



Adequate fire response under such conditions has necessitated well trained professional fire crews operating from fire stations located within reasonable distances of high value facilities supplied with up-to-date fire fighting equipment such as the new aerial ladder truck (Fig.XVIII), built-in fire protection systems plus on the spot assistance from trained in-plant fire brigade personnel.

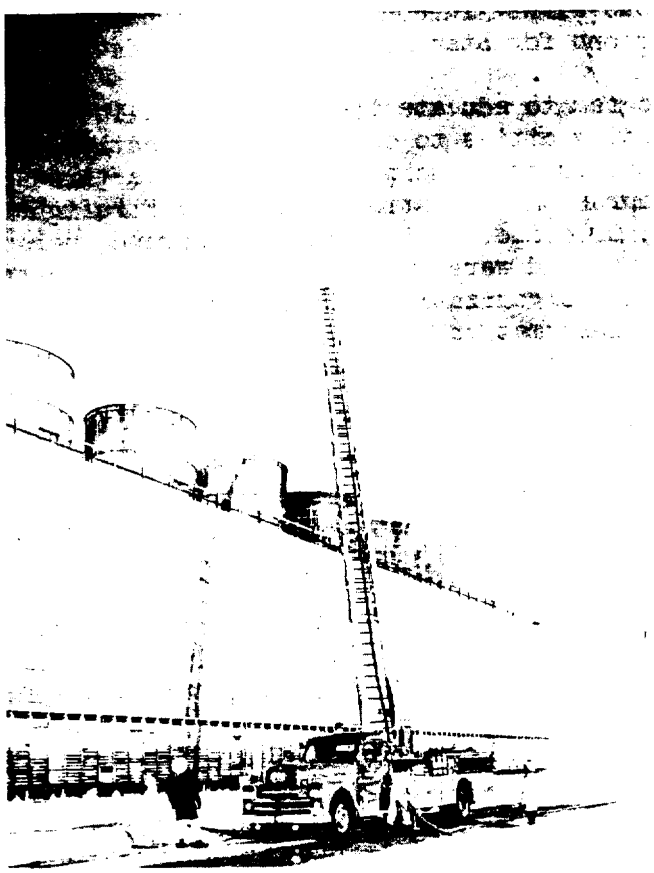


Fig.XVIII. Aerial Ladder Truck

To maintain an alert and capable response fire department personnel received an average of 172 hours of classwork instruction and 74 hours of outside drill work with apparatus and equipment. Fire department officers served as instructors. Officer candidates needed for the expanding department were determined through detailed written examination. The Training Officers conducted 175 hours of group instruction spread among Fire Brigades of the various operating contractors. Program changes in the past year materially improved the general fire brigade capability.

Ambulance service, as a part of the fire department operation was furnished as necessary to industrial cases, personnel illenss and highway accidents. Ninety-eight responses were made with the majority of cases requiring transportation off-site to further medical attention.

c. Training

Fire Department First Aid instructors conducted nine American Red Cross First Aid courses for NRTS personnel, qualifying 162 persons for Standard First Aid cards.

The program to educate the fire and police personnel in surrounding cities to cope with radioactive problems was continued through the presentation of a three-day instructor's course on "Radiation Hazards in Firefighting" in Denver, Colorado. Thirty-seven emergency personnel completed the course and were qualified to serve as instructors in their respective organizations. This program has been modified to include information on the Radiological Assistance Plan for the five state area under the jurisdiction of IDO.

d. Future Program

The Fire Department is presently undergoing changes in their operational program that are intended to standardize methods and improve their over-all operations.

Several phases of field training have suffered due to the lack of adequate training facilities. These are to be built within the coming year, and will be utilized to the fullest extent possible.

5. Safety Engineering

The effectiveness of a safety program is best reflected in the experience records. In the charts that follow "All NRTS Activities" includes all AEC and all operational and construction activities at the National Reactor Testing Station. "All AEC Activities" is an average of all groups reporting to the Atomic Energy Commission.

a. Disabling Injury Experience (see Fig. XIX)

The combined NRTS disabling injury experience reflects a favorable downward trend over the years. The rate of injury at the NRTS has been lower than the average of all units reporting to the AEC for the past four years. The Chemical Industry is most comparable to the NRTS operational activities and according to the Bureau of Labor Statistics the NRTS (including construction) is presently experiencing less than one disabling injury to the chemical industry's four.

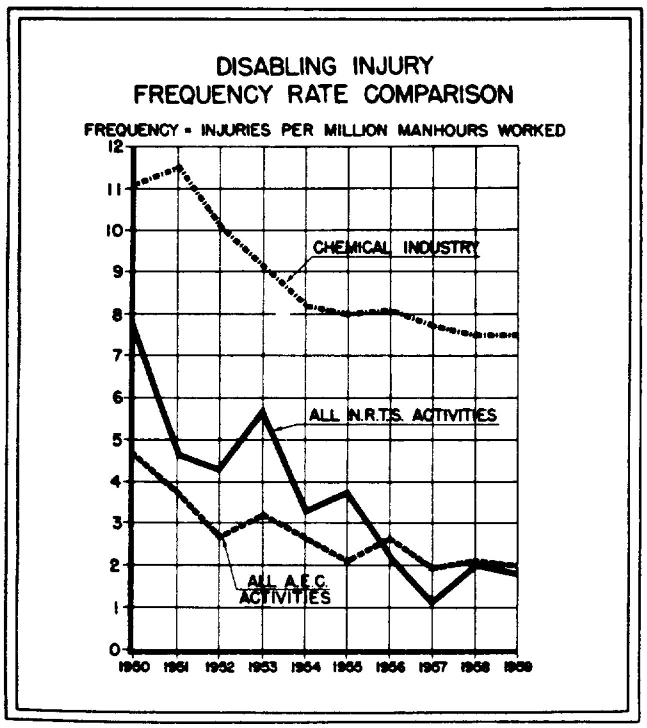


Fig. XIX.

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b. Severity Rate

Two fatalities in 1951 and one in 1959 on construction work were responsible for the two peaks in NRTS Severity experience (Fig. XX) since 6,000 days are charged to each fatality. For all other years the severity of the injuries experienced at the NRTS has been slight, comparatively speaking. The average days lost per million man-hours worked over the past ten years compares favorably

All NRTS Activities	407
All AEC Activities	517
Chemical Industry	979

The fatality in 1959 occurred when a tubular metal scaffold sixty feet high with 5' x 14' cross section equipped with castors was being moved. In the course of the move through the hangar doorway, the employee on top of the scaffold failed to maintain a running tie line. The scaffold, being broadside to the direction of movement and existing gusty winds, became overbalanced and tipped over. The worker rode the scaffold down but sustained fatal injuries.

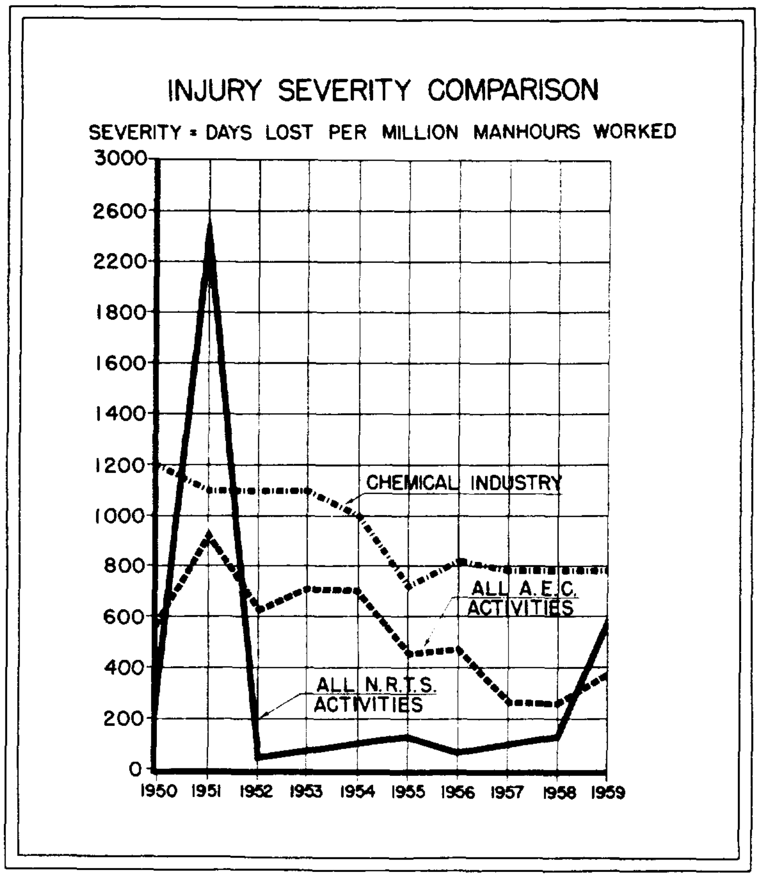


Fig. XX.

c. Motor Vehicle Accidents

NRTS government motor vehicle accident experience compares favorably with the average of all AEC activities primarily because of the outstanding performance of the Phillips Petroleum Company-operated bus and transportation services (Fig. XXI). The rates reflected for NRTS and Phillips Transportation include all accidents regardless of cost. On the all inclusive experience the NRTS accident cost per 1,000 miles of operation was 65¢ as against $1.18 for average of all AEC.

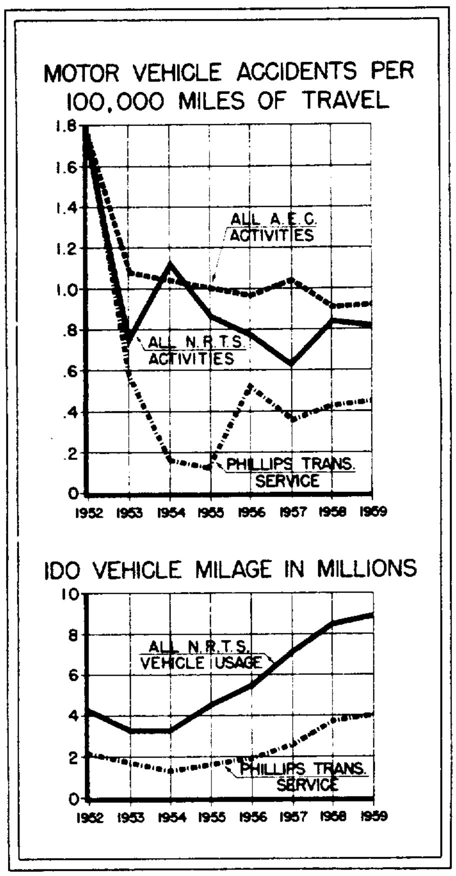


Fig. XXI.

d. Radiological Shipments

The pursuance of physical protection of radiological shipments as required by both ICC and IDO has resulted in no transportation incidents involving radiological material. Approximately two hundred off-site shipments out of a total of eight hundred were personally checked prior to release. The balance were small containers shipped in full compliance with Interstate Commerce or Federal Aviation Agency Regulations. Operating contractors were given responsibility for checking on-site movements of radiological materials in accordance with a modification of IDO standards. Both on and off-site shipment checks were formerly made by IDO.

In conjunction with Headquarters review of the radiological shipment and cask design problems this office started collecting shock and accelerative force data on rail shipments of casks containing spent fuel. Impact recorders with vertical and horizontal registers have been obtained from the Union Pacific Railroad for this use.

e. Routine Activities

IDO Manual Chapter 0502 was revised and referenced to Appendix C, Revision 1, of Idaho Standard Health and Safety Requirements. This revision brings to date instructions on incident reporting, effluent releases and assignment of responsibilities.

Annual safety surveys of all Phillips-operated areas, the NRF and the OMRE were made to evaluate the effectiveness of the operating contractor's safety program and the degree of compliance with AEC policies and standards.

Effective IDO explosive controls were continued with contractor users. Thirty-one blasting permits were issued to qualified powdermen during the year's construction activities.

Site traffic studies were continued with coordination as necessary with State and County codes and engineering groups.

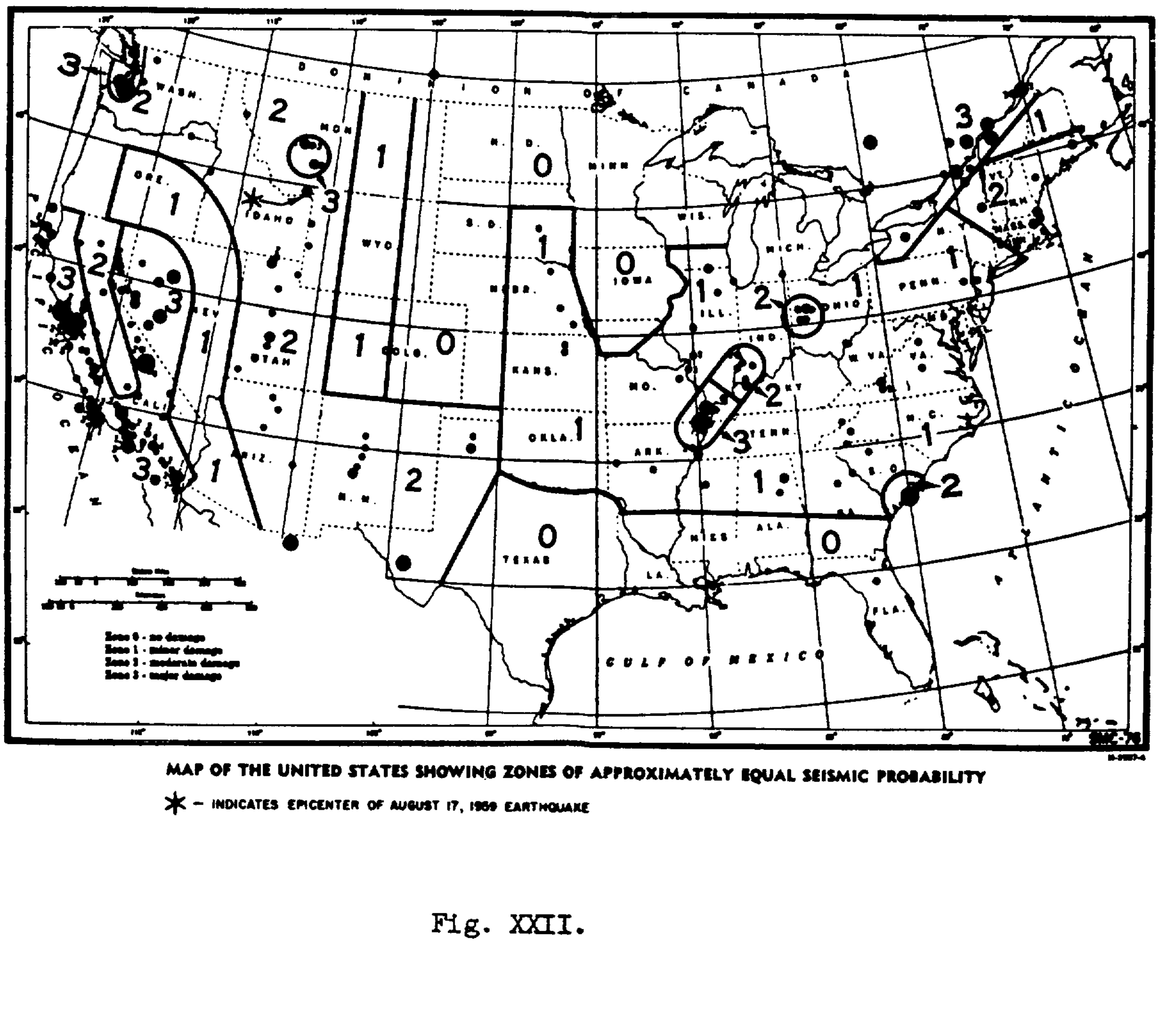
Quarterly seminars of the NRTS Safety and Fire engineers have continued to be an effective medium for exchange of information and coordination of standards and mutual interest projects.

Construction safety and standards familiarization has been emphasized through the regular monthly meetings with AEC Resident Engineers and their Architect-Engineering inspection personnel plus the orientation meetings as conducted with supervision of construction contractors before the beginning of a job.

Monthly meetings with the union business agents were continued as a medium to promote safety education within the unions. The Building and Construction Trades Council representatives have gained a better understanding of the AEC-IDO Standard Health and Safety Requirements and have been able to recognize and bring attention to miscellaneous field problems.

f. Special Activities

An earthquake tentatively rated at intensity VII on the modified Mercallis scale, by Coast and Geodetic Seismological Field Survey, occurred August 17, 1959 with its epicenter located 44°5' N., 111°05' W., north of West Yellowstone, Montana. The felt area covered approximately 600,000 square miles and included all of Montana and Idaho and parts of seven surrounding states and three Canadian provinces. The NRTS was in an area with an intensity (damage) rating of VI; however, no damages were incurred, since all construction at the NRTS is in accordance with Zone II requirements of the Uniform Building Code. Fig.XXII, Uniform Building Code Map of Seismic Probability shows the zone ratings and indicates that the quake occurred in an area of known fault.



MAP OF THE UNITED STATES SHOWING ZONES OF APPROXIMATELY EQUAL SEISMIC PROBABILITY

✱ – INDICATES EPICENTER OF AUGUST 17, 1959 EARTHQUAKE

Fig. XXII.

g. Future Program

A revision in reporting requirements specifically involving contamination clean-up will change the minimum reportable cost figure from $50 to $500. A new form "Report of Radiation Incident", will be used in reporting such incidents and also significant air-borne effluent releases regardless of cost. This change will improve the contractors' reporting capabilities and will provide improved records of such incidents.

The IDO Health and Safety Requirements (Issue #3-1957) will be completely reviewed for applicable revisions and additions. These requirements have proven to be a most effective guide to all construction, operational and AEC activities at the NRTS.

C TALKS AND PUBLICATIONS

1. FIRE HAZARDS OF ATOMIC INDUSTRY, presented by E. Dingman in January 1959 to the Fire Department Representatives from Colorado, meeting held in Denver, Colorado. 37 in attendance.

2. SHIPPING OF RADIOACTIVE MATERIAL and SAFETY PROBLEMS IN THE CONSTRUCTION OF REACTOR CONTAINMENT VESSEL, two talks presented by R. V. Batie in May 1959 to AEC Safety Conference, held in Chicago, Illinois. 300 in attendance.

3. SAFETY PROBLEMS IN THE CONSTRUCTION OF REACTOR CONTAINMENT VESSEL, presented by D. H. Dierks in September 1959 to the Conference of the Idaho Chapter National Safety Council in Idaho Falls, Idaho. 40 in attendance.

4. FIRE HAZARDS OF ATOMIC INDUSTRY, presented by E. Dingman, September 1959 to Fire Department Representatives from Idaho, held in Boise, Idaho. 200 in attendance.

5. SHIPPING OF RADIOACTIVE MATERIAL, presented by R. V. Batie, October 1959 to Sigma XI and Civil Engineers Society in Ft. Collins, Colorado. 200 in attendance

6. SAFETY PROBLEMS IN THE CONSTRUCTION OF REACTOR CONTAINMENT VESSEL, presented by D. H. Dierks, October 1959 at the National Safety Congress meeting held in Chicago, Illinois. 300 in attendance.

7. ICPP CRITICALITY INCIDENT, presented by A. O. Dodd, November 1959 at the Meeting of AEC Industrial Health Personnel, held in New York City. 100 in attendance.

Chapter 5

ANALYSIS

C. W. Sill, Branch Chief

A SCOPE

The Analysis Branch maintains and operates a general purpose analytical laboratory from which all AEC and contractor personnel at the NRTS may obtain analyses for any chemical or radioactive material that may be required. Generally, the analyses are concerned with materials that relate to the general health and safety of personnel working at the NRTS and those living in the neighboring vicinity. The principal effort is directed toward detection of chemically toxic or radioactive materials in urine, air, water, soil, vegetation or other materials taken internally by humans, either directly or indirectly. Analytical problems not related to personnel protection or environmental contamination are accepted as the workload of the Branch permits.

Professional consultation or assistance in the development or evaluation of analytical procedures, sampling methods or on any problems related to chemistry and radiochemistry are available. Considerable time and effort are expended in keeping the Branch abreast of modern developments in the field of analytical chemistry. A seminar is held each week to discuss new techniques and procedures or to review established ones. The technical literature is surveyed extensively with each issue of over fourteen of the top scientific journals in the world devoted to analytical or inorganic chemistry being reviewed. Selected references covering the entire literature survey are then kept on file ready for immediate use thus eliminating the necessity of a separate and time-consuming literature search for each problem as it arises.

A continuing research program for development of new and improved methods of analysis or techniques is an integral part of the Branch operation and philosophy. Each professional member of the staff has a research assignment of his own choosing from projects of mutual interest to the Branch to which a proportionate share of his time is allotted. Publication of the results of the research in the technical literature is strongly encouraged.

B SUMMARY OF MAJOR PROGRAMS

1. Uranium Mill Program

Title 10 part 20 of the Code of Federal Regulations requires effluents from mills processing uranium ores to contain less than 4×10^{-9} uc/ml of radium-226 before they can be released to uncontrolled environments. To ensure compliance with these requirements, analytical procedures are required that are capable of detecting one-tenth of this quantity in the types of samples to be encountered, particularly in mill effluents. One-tenth of Part 20 MPC is only about 2 counts per hour per 100 ml. of sample. Detection of this level of activity is a relatively difficult problem in itself. Obtaining complete recovery of radium with adequate decontamination from interferences complicates the analytical problems greatly.

The Branch was requested by the IDO Division of Inspection to perform analyses for radium-226 and thorium-230 on certain liquid samples of river water and mill effluents to determine the potential hazards resulting from mill operations and to determine compliance with the requirements of 10 CFR 20 by mill operators. Existing procedures involving counting of barium or lead sulfate precipitates were found to be grossly inadequate for application to mill effluents due to severe coprecipitation of thorium-230 with the radium sulfate. Furthermore, it was shown that radium-223 was present in many samples in concentrations much higher than radium-226. A radium determination that does not discriminate among the isotopes will thus lead unequivocally to a gross overestimation of the biological hazard due to radium-226. As a result of experience with the mill program, new procedures have been developed for radium-226 and thorium-230 that are applicable to mill effluents. Equally important, the problem encountered in mill effluents has been defined. A tentative procedure has been written and distributed to interested parties.

Using the new procedures, fourteen synthetic samples prepared by the U. S. Bureau of Standards were analyzed for uranium, radium-226 and thorium-230 at the request of the Division of Biology and Medicine, AEC, Washington, D. C. Results of these analyses agreed extremely well with values furnished subsequently by the Bureau. Analyses were also made on 10 mill samples provided by the IDO Division of Inspection in a comparative study between the Bureau of Standards using their emanation procedure, the Winchester Laboratory and the IDO Analysis Branch using solid-counting procedures. Agreement between IDO and Bureau of Standards results was excellent. The Winchester procedure was inadequate since no provision was made for correcting for the radium-223 present. As further direct assistance to the Division of Inspection in their survey of mill operations, analyses for radium-226 and thorium-230 were performed on about 200 liquid samples and for uranium in 4493 air-dust samples.

2. Development of Analytical Procedures for Beryllium

A recently published procedure[1] for the fluorometric determination of beryllium using morin has been improved significantly and its application has been extended. Stabilization of alkaline solutions of morin toward air has been accomplished without use

[1] Sill, C. W. and Willis, C. P., Anal. Chem., 31, 598 (1959)

of stannite or other reducing agents. As a result, the procedure has been simplified and the interference previously caused by bismuth and mercury has been eliminated. Use of diethylenetriamine pentacetic acid in place of ethylenedinitrilo tetracetic acid prevents formation of fluorescent complexes of morin with scandium, yttrium and lanthanum and increases the selectivity greatly. The formation of nonfluorescent complexes of morin with rare earths is also prevented thus eliminating the serious error produced by this group of metals due to consumption of the reagent. A new combination of primary and secondary filters produces a three-fold increase in the ratio of net beryllium fluorescence to blank fluorescence while requiring an instrumental sensitivity only one-fourth as large as were obtained with the previous combination. Since the exciting wavelengths are entirely in the visible region of the spectrum, errors produced by small quantities of iron or other colorless ions that absorb in the ultraviolet are eliminated entirely. Other errors caused by absorbtion of either the exciting or the emitted radiation are reduced significantly. The fluorescent species is shown to contain beryllium and morin in a mole ratio of 1 to 1. Detailed procedures are presented for determination of beryllium in metallic thorium, zirconium, uranium, and aluminum and in refractory silicates such as beryl that are not decomposed by either pyrosulfate fusion or hydrofluoric acid.

3. Accessory for Determination of Excitation Spectra.

A relatively simple and inexpensive accessory has been developed to permit the determination of excitation spectra of fluorescent materials using a Cary Model 14 recording spectrophotometer. The accessory can be modified easily to permit its use with other spectrophotometers of either the manual or recording type. As shown in Fig. XXIII, the accessory consists fundamentally of three front-surfaced mirrors arranged so that the light from the monochromator is redirected to pass through a sample cell at a right angle to the direction taken by the fluorescent light from the cell to the phototube compartment.

Fig. XXIII. Fluorescence Accessory Installed in Sample Compartment

The signal from the multiplier phototube reflects the change in intensity of fluorescent light as a function of the wave length of the light incident upon the sample. Resolution and stray light characteristics of the excitation spectra are as good as those of the spectrophotometer used. The attachment makes the instrument competitive in performance with specialized instruments built specifically for the purpose and costing considerably more. After correcting for the emission characteristics of the light source, excitation spectra of fluorescent materials parallel closely the absorption spectra and can be used in a similar manner as analytical tool. However, the excitation spectra may be many thousands of times more sensitive. Some care must be exercised to prevent a shift in the position of the maximum through use of too high a concentration or too long a path length.

4. Expansion of Laboratory Facilities

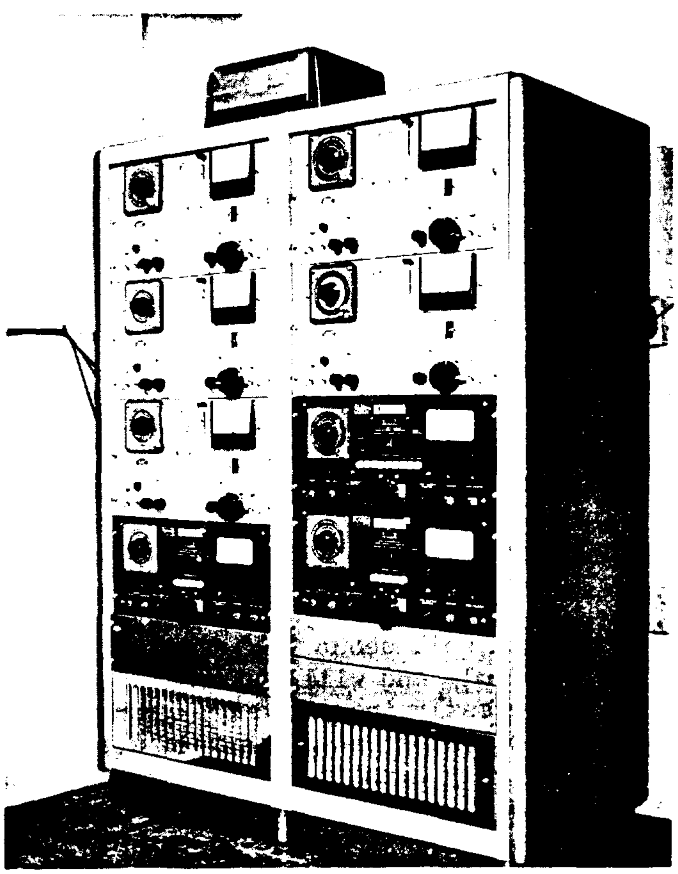
The existing laboratory space has become overcrowded and inadequate to keep abreast of the ever-increasing work load. Furthermore, instances of cross-contamination were beginning to appear more frequently due to the necessity of handling relatively high level activities in the large laboratories originally reserved exclusively for low-level analyses on urine, potable water, bone, etc. An existing building has been remodeled to provide two additional laboratories, office for the chief of the Branch and his assistant and another for the other members of the staff. An interior view of one of the new laboratories is shown in Fig. XXIV.

Fig. XXIV. General View of Two-Man Laboratory.

The laboratories have been designed as two-man labs so that incompatible materials can be isolated and analyses performed under conditions much less susceptible to cross-contamination. Each lab is approximately 11 feet wide and 20 feet long with 12 feet each of hood space and bench space running parallel to each other. Sufficient floor space remains at each end for a desk, large centrifuge, shaking machine for extractions or other equipment that would otherwise have to use up valuable working space on the bench tops. Case cabinets are hung on the walls to contain reagents and special glassware.

5. Instrument Modifications and Additions in the Counting Rooms

With the exception of the total-body counter, most of the instrumental modifications and aquisitions anticipated in the last annual report have been accomplished. One of the most noticeable improvements has resulted from rack-mounting the counting equipment as much as possible. By using more of the vertical space, considerably more instrumentation has been accommodated while increasing the useable floor space. The equipment is more easily accessible for servicing and the compactness results in more efficient use with less wasted time and energy for the operator. The convenience is illustrated by Fig. XXV showing a rack of eight proportional alpha counters.



1186749 Fig. XXV. Rack of Eight Proportional Alpha Counters

Three sizes of well-type scintillation crystals currently in use in this laboratory are shown in Fig. XXVI.

Fig. XXVI. Well-Type Scintillation Crystals.

The smallest one is a standard crystal with a 5/8" x $1\frac{1}{2}$" well and is commercially available. The other two crystals are special ones made up to our own specifications. The middle-sized one is made from a standard 3" x 3" crystal with a well 2" x $2\frac{1}{2}$". After canning, the well dimensions are 1-7/8" x 2-3/4". This well crystal has been the "work horse" of the counting room because 75 ml. of sample in a polystyrene container (shown in Fig. XXIX) can be counted directly at efficiencies as high as 50% without sample treatment or preparation of any kind. This size well is used in the gamma counters and is used for routine screening of urine, water, milk, soil, vegetation, animal parts in the case of large animals or the entire animal with small rodents, etc. The large crystal has a well $3\frac{1}{2}$" x $4\frac{1}{2}$" after canning with a crystal wall about 3/4" thick. The well has a capacity of about 600 ml. and will accommodate small rabbits and other animals. The greatly increased background of this crystal is more than offset by the increased sample size that can be used and increased sensitivity results. The background counting rates of the three crystals in a 3-inch lead shield are about 300 c/m, 450 c/m and 1700 c/m, respectively.

A commercially available 4-pi chamber with its associated amplifier and scaler is shown on the right side of Fig. XXVII.

Fig. XXVII. Four pi Counter and Uranium Fluorophotometer.

The scaler is unique because of its high-speed Burroughs beam-switching input and the transistorized extension scaling strip that replaces the mechanical register. High-speed counting up to approximately three million counts per minute is possible. A uranium fluorophotometer is shown at the left of the same figure. The instrument is the model Q-1165 designed by Oak Ridge National Laboratory that has been unitized in this laboratory. By having the optical unit, electronic assembly and power pack mounted in a single chassis equipped with casters, the unitized instrument can be moved easily to any convenient location for use in addition to eliminating many unsightly cables, transformers, etc. In addition, the potentiometers for adjusting the course high voltage settings have been remounted on the front panel for convenience.

A complete system for scintillation counting of alpha, beta and gamma with automatic sample changing is shown in Fig. XXVIII. A standard Packard Tri-Carb liquid scintillation spectrometer is shown at center with a deepfreeze containing the automatic sample changer at the right.

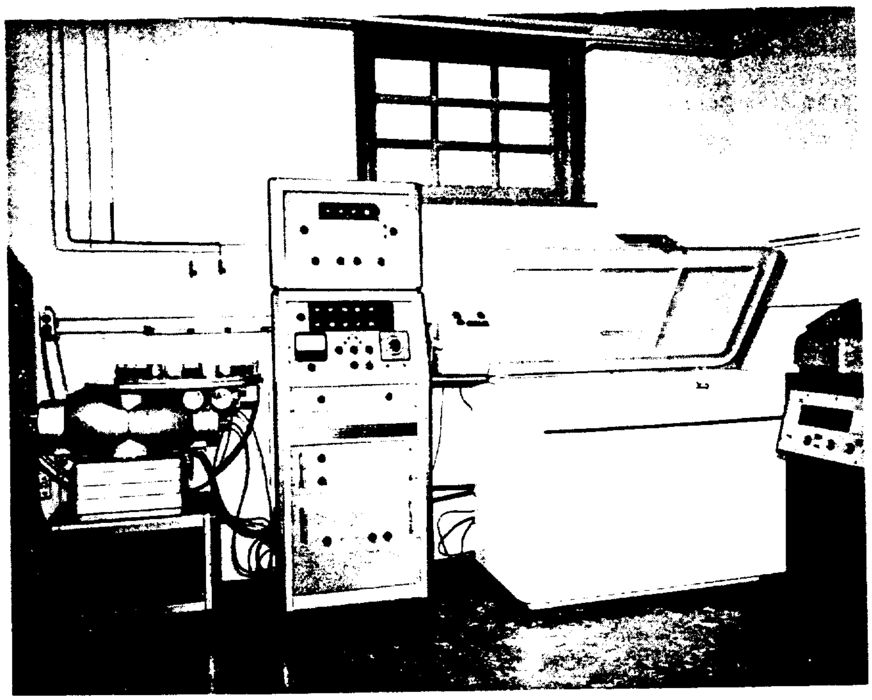


Fig. XXVIII. Scintillation Spectrometer with Automatic Sample Changers for Liquid Scintillation Counting and Gamma Counting

The sample changer is similar to that shown Fig. XXIX. Forty-eight samples with volumes as large as 60 ml. can be counted to either preset count or time completely automatically with four different modes of two-channel energy discrimination and automatic readout on to paper tape. The automatic sample changer for gamma counting is shown at the left of Fig. XXVIII and a closeup in Fig. XXIX. Forty-eight samples with volumes as large as 60 ml. can be counted to either preset count or time completely automatically with four different modes of two-channel energy discrimination and automatic readout on to paper tape. The automatic sample changer for gamma counting is shown at the left of Fig. XXVIII and a closeup in Fig. XXIX.

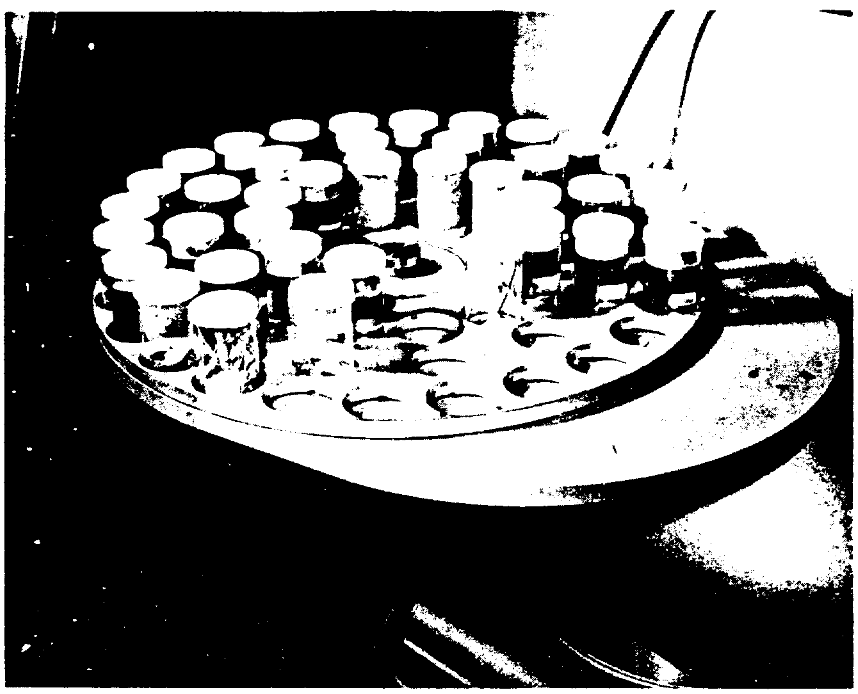


Fig. XXIX. Automatic Sample Changer for Gamma Scintillation Counting with a Thallium-Activated Sodium Iodide Crystal

The changer is a modification of the standard Tri-Carb liquid scintillation changer built to our own specification. Instead of having two multiplier phototubes view the sample contained in a liquid scintillator, the two phototubes look at opposite ends of a thallium-activated sodium iodide crystal in the form of a right cylinder 3 inches in diameter and 4 inches in length. The elevator lowers the sample contained in the same polystyrene counting bottles used with the manual instruments into a hole 2 inches in diameter drilled through the short dimension of the crystal in the center of the longer side. The same electronic control panel and other features of the liquid scintillation spectrometer also apply to the gamma counter including automatic sample changing and readout preset time or count, energy discrimination, etc. Forty-eight samples with volumes up to about 75 ml. can be handled at a time and may include either liquids or solids as shown in Fig. XXIX.

Installation of the total body counter was completed and the instrument turned over to the Analysis Branch for calibration and use at the end of the year. A general view of the transistorized 256-channel pulse height analyzer and scanner control is shown at the left of Fig. XXXIII and the shield, scanning mechanism and detector shown in the separate room at the right. The external shield including the door is constructed of low-background armor-plate steel 11" thick of preatomic bomb vintage obtained from the U. S. Navy. Lights, fresh air supply and a communications system are available at all times to the subject inside the counter. More detailed information will be found in Chapter 6.

A general view of the East Counting Room is shown in Fig. XXX. The following instruments discussed above are shown from left to right: uranium fluorophotometer, 4-pi beta counter and high-speed scaler, transistorized 256-channel pulse height analyzer, scanner control for total body counter, entrance (barely visible) to total body counter room, Frish grid chamber for alpha pulse height analysis, 256-channel pulse height analyzer with logarithmic converter and 10" armorplate shield surrounding 3" x 3" thallium-activated sodium iodide crystal used for gamma spectroscopy.

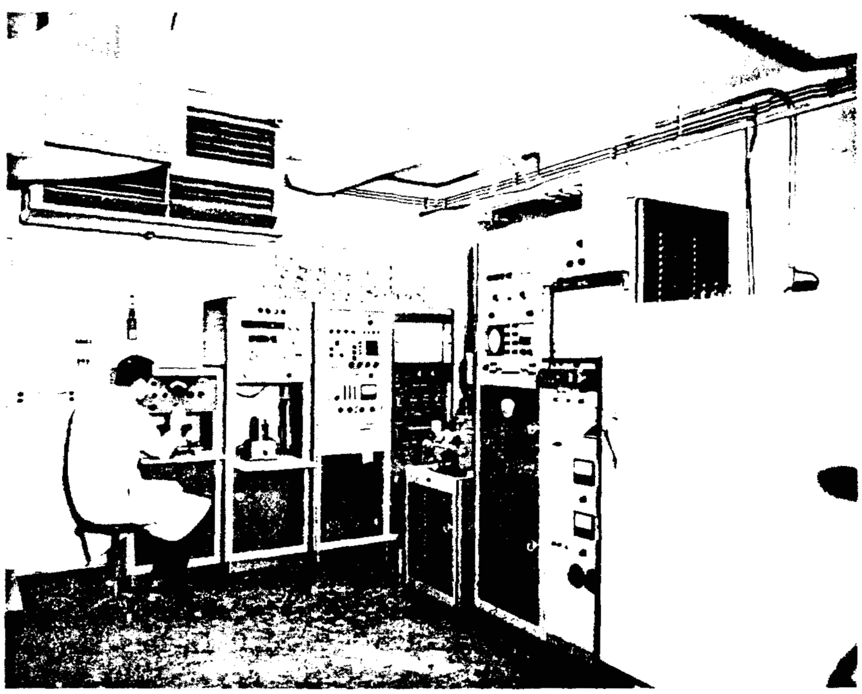


Fig. XXX. General View of East Counting Room

A general view of the West Counting Room is shown in Fig. XXXI. From left to right, the instruments shown are the following: four unitized gamma well counters using the 2" wells, automatic gamma changer, control panel for the liquid scintillation counter and automatic gamma changer, deepfreeze containing automatic changer for liquid scintillation counting, two automatic beta counters and a low-background beta counter.

Fig. XXXI. General View of West Counting Room

C SPECIAL ACTIVITIES

A major portion of the work load of the Analysis Branch involves non-routine types of analyses and problems requiring the knowledge and skill of highly trained and experienced chemists for proper solution and evaluation. Several examples of such problems are discussed below.

1. ICPP Criticality Incident

At approximately 0415 on October 16, 1959 the Analysis Branch was notified that an incident had occurred at the Idaho Chemical Processing Plant. A release of air-borne radioactive iodine was suspected since a Rala operation involving chemical dissolution of short-cooled fuel elements had just been completed two days earlier. Urine samples were collected from the men involved in the incident and immediately sent to the laboratory for analysis. Gamma spectra obtained on the urine samples indicated that strontium-91, yttrium-91m, and barium-139 were the predominant isotopes present. Filter paper from hi-volume air samplers showed the same isotopes. No indication of radioactive iodine was found. Chemical separations for barium strontium, and yttrium were made and the identity of the isotopes in the urine samples was confirmed by 0915. The short half-life of these isotopes and the fact that they are daughters of shorter-lived rare-gas isotopes would lead one to believe that the air-born activity was the result of a criticality incident rather than a spill of four to five-day old fission products stored in the Chemical Processing Plant. The evidence just cited was the first reported which indicated that a criticality incident had occurred and subsequent checking at the Chemical Processing Plant varified that such was the case. No sodium 24 was detected in blood samples, urine samples, or total-body gamma spectra of the men involved in the incident indicating that no appreciable neutron dose was received by the personnel. Maximum internal dose estimates were made from urine excretion data with the lung as the critical organ for the barium-139 and strontium-91 isotopes. The maximum estimated dose received by the man with highest exposure was 1.8 rads to the lungs. The internal dose for the others involved in the incident was less.

2. SL-1 Ion Exchange Problem

During the shake-down operation of the SL-1, a stationary low-power Army reactor, difficulty was encountered with the operation of the ion exchange columns in the reactor cooling water system. Also, in-line filters in the cooling water system were being plugged. The Analysis Branch was asked to assist in determining the reason for ion-exchange column failure and for filter plugging in the reactor water system. Analysis of ion exchange resin samples taken from the column showed considerable oil on the resin.

The material plugging the filters was shown to be extremely finely-divided ion-exchange resin. The presence of oil in the water going through the columns was causing attrition of the resin and also improper operation of the resin itself. The oil in the water was traced to over-lubrication of the well-pump supplying make-up water to the reactor. When this situation was corrected both problems disappeared.

3. Xenon-Krypton Leakage at CPP

The Site Survey Branch requested the assistance of the Analysis Branch in devising a method for checking for gas leaks at the Idaho Chemical Processing Plant during Rala operations. Radioactive xenon and krypton were believed to be leaking from the processing system. In cooperation with the Site Survey Branch, carbon traps chilled with liquid nitrogen were designed for sampling the air during operations and are shown in Chapter 8. The collected gases in the carbon traps were brought to the laboratory for analysis. Xenon-133, 135 and Krypton-85 were identified by gamma spectra. The location of the leaks were pin-pointed by this method and steps were initiated to repair them.

4. Activity Induced in Gravel Shielding at SL-1

After several months operation of the SL-1 facility, a sample of the gravel used for biological shielding was submitted by the operating contractor for identification of radioactive isotopes produced by neutron activation. Gamma spectra in conjunction with chemical separations were used to identify the following isotopes: cesium-137 and 134, manganese-54 and 56, scandium-46, sodium-24, chromium-51, protoactinium-233, zinc-65 and iron-59. Other isotopes with negligible activity were not identified.

5. OMRE Coolant Analysis

After a failure of the cladding on a fuel element had occurred in the Organic Moderated Reactor Experiment, analysis of the organic coolant showed that some of the uranium fuel was scattered throughout the coolant. When the refueled reactor was started up following clean-up, the operating contractor requested assistance in determining whether fission products found in the coolant were originating from the uranium left in the coolant from the previous rupture or whether they indicated another fuel cladding failure. By following the radioactive iodine activity on daily sample of coolant with the 256-channel gamma spectrometer over a period of several weeks, the fission product activity was shown to originate from traces of fuel in the coolant. The fuel cladding was intact. The coolant activity was followed at greater intervals throughout the year to verify that no cladding failure had occurred.

6. Activity in ICPP #1 and USGS Wells

For the first time since operations began on the NRTS, radioactivity above background levels has been detected in the underground water supply. Routine monitoring of all wells on the NRTS picked up activity in the Idaho Chemical Processing Plant well #1 at 10^{-6} uc/ml levels early in the summer of 1959. Chemical analyses and gamma spectra showed that the radioactive material was ruthenium-rhodium 106. Shortly after finding this material in the water from the ICPP well, samples from USGS wells used for studying underground water flow in the ICPP area showed the same activity levels of the same isotope. The water from this area has been followed closely and has shown a gradual decrease in radioactivity.

7. Fission Counters

At the request of Argonne National Laboratory, plutonium-239 and uranium-234, 235 and 238 were electroplated on platinum and stainless steel discs for use in fission counters. The depleted electroplating solutions were analyzed for residual plutonium-239 or uranium isotopes to establish the percentage deposition which in all cases was better than 98%. Alpha energy spectra were obtained on several of the plates, and the uniformity of the plated samples was established by alpha-counting several areas of the plated surface through an absorber containing a small hole. Argonne National Laboratory personnel were instructed in electroplating techniques and methods.

8. Referee Beryllium Analyses

Referee beryllium analyses were made on 10 air-dust samples at the request of Reynolds Electrical and Engineering Company, Inc., Las Vegas, Nevada to assist them in evaluating their technique and methods of beryllium analysis.

9. Alpha Energy Spectra

At the request of the AEC Division of Biology and Medicine, Washington, D. C., alpha energy spectra were obtained on uranium and thorium fractions separated from a synthetic sample furnished by the Washington office. Uranium-234, 235, 238, and thorium-230 were identified by alpha energy and thorium-234 by gamma energy.

10. Strontium-90 in Bone

Strontium-90 was determined in approximately 30 big-horn sheep joints submitted by the Las Vegas Branch, Nevada Operations Division, Atomic Energy Commission.

11. Atomic Museum Display

A display showing the capability of the Analysis Branch and the part it plays in control and evaluation of hazards at the NRTS and surrounding environment was designed and assembled for the atomic energy museum set up during the summer months in Idaho Falls to allow the public to view some of the activities in the atomic energy field. A view of the display is shown in Fig. XXXII.

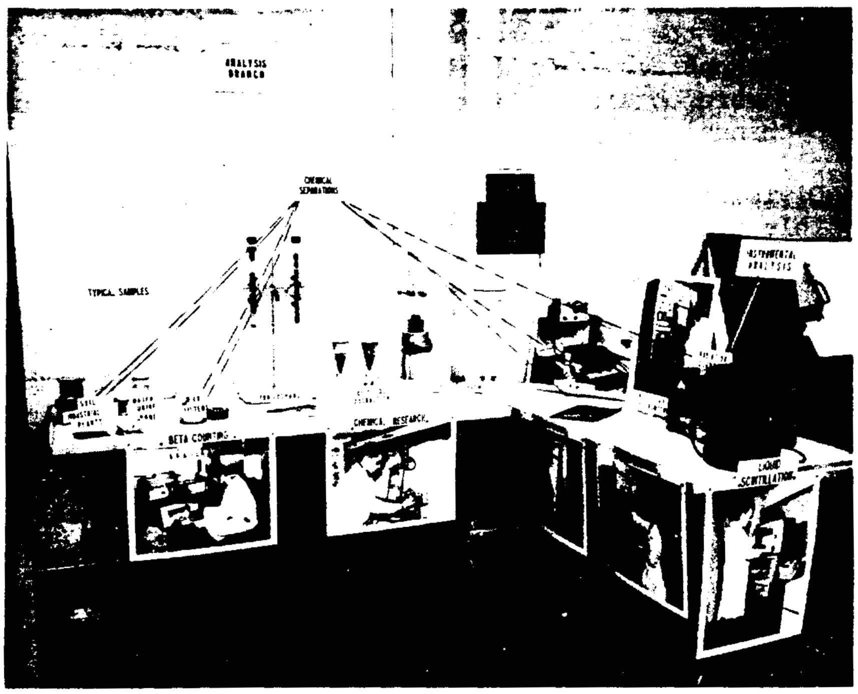


Fig. XXXII. Display of Environmental Samples and Analytical Techniques

12. Training

During the year several short-term training programs for off-site personnel were completed by the Analysis Branch. Eight AEC Radiological Fellowship students from Vanderbilt University were given on-the-job taining in analytical and counting-room techniques. Primary emphasis was placed on understanding and operation of counting instruments and multichannel analyzers in conjunction with gamma and alpha detectors.

Three chemists from Atomics International at Canoga Park, California spent a total of two weeks in the Analysis Branch learning methods of decomposition and radio-chemical analysis of the organic coolant used in the OMRE reactor.

A weeks instruction in the use of the 256-channel analyzer was given to an employee of the U. S. Public Health Service from Las Vegas, Nevada.

D ROUTINE ACTIVITIES

A statistical summary of the routine analyses completed during the year is given in Table 10. The analyses shown represent only those of a recurring nature on the routine health and safety program. In addition to the 24,890 analyses listed in Table 10, 795 gamma-energy analyses of record were obtained with a 256-channel analyzer during the year. In addition to the analyses of record, numerous gamma-energy scans were made of which no records were kept as the data was read directly from the oscilloscope and used in conjunction with chemical separations for identification of isotopes. Over 150 alpha-energy spectra were obtained using a Frisch grid chamber in conjunction with the 256-channel analyzer. Alpha-energy spectra played an important roll in the solution of the problems encountered in the Inspection Division's mill program. Many other types of problems not susceptible to statistical presentation have been completed.

Table 10. Statistical Summary of Analyses

Urine

Gross Beta	8,546
Gross Gamma	2,433
Uranium (Nat)	32
Uranium-233	17
Plutonium-239	18
Radium-226	3
Thorium-230	7
Americium	2
Strontium-91	32
Strontium-90	3
Barium-139	32
Beryllium	41
Lead	79
Cadmium	3
Mercury	4
Total...	11,252

Water

Fluorescein	213
Sodium	797
Gross Alpha	831
Gross Beta	1,657
Gross Gamma	565
Strontium-90	57
Cesium-134, 137	9
Sulphate	3
Plutonium-239	5
Cerium-141, 144	1
Ruthenium-106	2
Beryllium	1
pH	4
Nitrate	7
Ammonia	5
Total...	4,157

Gross Gamma Counting

Carbon Cartridges	1,057
Filters and Fallout plates	331
Milk	251
Vegetation	729
Soil	359
Animal Parts	
Thyroids	824
Other	83
Blood	22
Smears	126
Total...	3,782

Miscellaneous

Beryllium on air dusts and smears	75
Plutonium on air dusts and smears	21
Lead on air dusts and smears	16
Strontium-90 on smears	4
Strontium-90 on soil	54
Strontium-90 in bone	200
Strontium-90 in organic liquids	1
Iron in terphenyl	2
Manganese in Terphenyl	2
Plutonium-239 in soil	11
Plutonium in vegetation	2
Protein-Bound Iodine	4
Smears, Gross Alpha	28
Smears, Gross Beta	133
Vegetation, Gross Beta	80
Vegetation, Uranium	10
Total...	643

Inspection Division Mill Samples

Uranium (Nat) on air dusts	4,493
Uranium on Carbon	1
Thorium-230 in Water	197
Radium-226 in water	329
Uranium in water	45
Total...	5,065

Grand Total... 24,890

E **FUTURE PROGRAMS**

1. Since a large part of the workload of the branch is in the nature of services to contractors at the NRTS and to other branches within the Division of Health and Safety, the variety and scope of future activities will be determined largely by the nature and extent of reactor operations and field testing programs in the coming year. It is expected that routine urinalysis service to contractors will continue to increase as will analytical services in support of the Ecology and Site Survey programs because of increased numbers and complexity of operating reactors.

2. Nuclear Accident Dosimetry (NAD) systems have been placed in operating facilities throughout the site. The NAD systems will be calibrated for neutron and gamma response during the coming year. The plutonium-239, neptunium-237, and uranium-238 foils in the boron 10 shield will be exposed to known neutron fluxes and then counted using the 256-channel analyzer and sodium-iodide detector to determine counting rates of fission product gammas with energies above 1.2 Mev. as a function of time after exposure. Once the detector system has been calibrated, gamma activity induced by fission in the foils during exposure may be counted under the same conditions to obtain the neutron flux which produced fission. Detectors for determining the phosphorus 32 activity induced in the sulfur pellet and the activity induced in the gold and cadmium-covered gold foils by neutron activation will be calibrated in a similar manner. The gamma detectors will be exposed to known gamma fields and calibration curves established for the spectrophotometers used to read them. In conjunction with calibration of the NAD system, sulfur and gold foils in the personnel film badges will be calibrated under similar conditions using the same detector systems.

3. Methods for the determination of carbon-14 and tritium using liquid scintillation counting techniques will be established. Instrumentation is on hand for this purpose. Carbon 14 is of interest to the Health and Safety Division because of the present operation of the OMRE on the site and the probable future operation of other reactors using organic moderators. Tritium analyses will be of major interest when underground water tracing employing tritiated water is undertaken.

4. As an aid in establishing presence or absence of long-lived activity contributed by NRTS operations both on-site and off-site, an attempt will be made to establish rapid methods of determining low-level strontium-90 activity in soil and milk. Present procedures are long, tedious, and subject to error.

5. Full development of the thorium-230 and radium-226 procedures will be pursued during the coming year with a view to publication of the completed work in the open literature. Application of the methods to large sample volumes will be thoroughly checked out to enable determination of low-level activities in mill effluent and surface waters. Application to air-dust samples will be established.

6. Fluorometric Methods of Analysis

During the development of a fluorometric method of anlysis for beryllium using morin, it was found that thorium, zirconium, yttrium, scandium and lanthanum produced fluorescence almost identical to that produced with beryllium. Although none of the reactions are as sensitive as that with beryllium, all are easily competitive with existing chemical procedures for the corresponding element. The development of the fluorometric method for beryllium has been completed so successfully that the same system will be examined with the other elements. Thorium and yttrium particularly appear to give very sensitive reactions. For example, rare earths appeared to give positive fluorescence in the beryllium procedure until the fluorescence was traced to the presence of thorium impurity in the rare earths. An appreciable fluorescence was obtained despite the fact that only 1 mg. of rare earth was taken and rare earth oxide of purity greater than 99.9 per cent was employed.

7. Calibration and Use of Total-Body Counter

Addition of the total-body counter to the line of instrumentation available in the Branch in an operational status has been delayed considerably beyond the expectations of last years report. The scanning gear and crystal mount were delayed for several months because of design and fabrication problems. Later, the entire shield was found to be magnetized, possibly from having stood in the same position in the earths magnetic field for too long a time. Most of the problems seem to have been overcome and calibration is expected to be completed and the instrument placed in use during the coming year.

F TALKS AND PUBLICATIONS

The following talks or papers were presented by Claude W. Sill, Chief, Analysis Branch:

1. IMPROVEMENTS IN THE FLUOROMETRIC DETERMINATION OF SUBMICROGRAM QUANTITIES OF BERYLLIUM by C. W. Sill, C. P. Willis, and J. K. Flygare, Jr. was presented at the Fifth Annual Meeting on Bio Assay and Analytical Chemistry held at Gatlinburg, Tennessee, October 2, 1959.

2. FUNDAMENTALS TO BE CONSIDERED IN DEVELOPMENT OF FLUOROMETRIC METHODS OF ANALYSIS, a talk presented before the Southeast Idaho Section of the American Chemical Society in September, 1959.

3. DETERMINATION OF RADIUM 226 and THORIUM 230 IN MILL EFFLUENTS by E. R. Ebersole, A. Harbertson, J. K. Flygare, Jr., and C. W. Sill was presented at a conference attended by representatives of the U. S. Atomic Energy Commission, the U. S. Public Health Service and other interested parties at the

Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio in December, 1959. A preliminary paper has been prepared and distributed to interested parties describing problems encountered in the determination of radium-226 in mill effluents and a method for their elimination.

J. Kenneth Flygare, Jr. presented a paper on A METHOD FOR THE COLLECTION AND IDENTIFICATION OF XENON AND KRYPTON by J. K. Flygare, Jr., G. Wehmann, A. Harbertson, and C. W. Sill at the Sixth Annual AEC Air Cleaning Seminar held in Idaho Falls, Idaho, July 7 and 8, 1959.

The following papers have been published or are in press:

1. FLUOROMETRIC DETERMINATION OF SUBMICROGRAM QUANTITIES OF BERYLLIUM by C. W. Sill and C. P. Willis, ANALYTICAL CHEMISTRY 31, 598 (1959)

2. IDOINE MONITORING AT THE NATIONAL REACTOR STATION by C. W. Sill and J. K. Flygare, Jr., JOURNAL OF HEALTH PHYSICS, Vol. 2 #3, February 1960.

Chapter 6

INSTRUMENT AND DEVELOPMENT

M. Wilhelmsen, Branch Chief

A SCOPE

The Instrument and Development Branch is primarily a service organization to provide instrumentation for those organizations responsible for the various health and safety programs. Instrumentation is supplied primarily by two methods: First, development of instrumentation for performance of a specific task, which may consist of procurement if commercially available in full or in part, or construction within the Branch. Secondly, the maintenance of existing instrumentation utilized by the various organizations responsible for the health physics program. Portable radiation detection instruments are procured, maintained, and distributed to the various contractors at NRTS and other divisions of AEC, IDO. Portable as well as laboratory instrumentation is procured and maintained for all branches of the Health and Safety Division.

Early in 1959 in cooperation with the Division of Organization and Personnel, the organizational structure of the Branch was changed to form two sections. The Development Section reporting to Mr. DeRay Parker is responsible for the development of new instrumentation (or modification of current instrumentation) used by the Health and Safety Division of IDO and other groups at NRTS, as requested. The Maintenance Section under Mr. Rex Purcell is responsible for the repair and calibration of all radiation instruments supplied to operating contractors and all instrumentation used by the Health and Safety Division and other divisions of AEC, IDO at the NRTS.

3 DEVELOPMENT SECTION SUMMARY OF MAJOR PROGRAMS

1. Telemetry

The telemetering system is being expanded to provide more coverage of off-site radiation monitoring stations and to transmit quantitative data more efficiently. The expanded system is scheduled to be in operation late in 1960. The expanded system will provide 19 primary monitoring stations, each strategically located for the protection of populated off-site areas, or key on-site installations. Each station will consist of a radio receiver and transmitter complex that can be programmed through the control station at Central Facilities. Data from an ionization chamber detector for measuring the field radiation level; a GM detector for measuring radiation levels of particulate materials collected by a continuously moving tape filter and air pump system; and a sodium iodide well crystal scintillation tube detector for measuring radiation levels of gaseous compounds entrapped within a granulated carbon cartridge type filter will be telemetered to CF-646. In addition there will be two weather stations to provide wind direction and velocity at crucial Site areas. Equipment at each station location is to be mounted in a house trailer.

Should radioactive levels increase at the telemetering locations, provision for telephone to radio actuation of an additional 19 secondary high volume air sampling units is included in the system. Data from each primary station and weather station will be transmitted via radio link through a relay station located on East Butte to the control station. Programming will be initiated at the control station and each station will be interrogated sequentially. The complete interrogation time cycle will occupy two minutes. Data reduction and print out may be programmed for specific intervals as well as for the continuous mode.

The whole system is designed to provide an instantaneous data picture of on-site or off-site radiation conditions which in turn may affect operational decisions and health and safety activities.

A contract has been effected with Motorola, Inc. to design and supply the telemetry system. Station housing, detection equipment and some readout distribution equipment is to be provided by the AEC.

2. Automatic Film Reader Testing

Early in 1959 a series of tests were set up and run for the purpose of determining the performance of the Automatic Film Reader. During previous operations, large variances had been observed in the response to trays of film of imputed homogeneity. Statistical tests were needed to ferret out the cause of such implied errors.

The first test was designed to check the reproducibility performance of the film reader. Twenty pieces of film were simultaneously exposed to 250 mrep of uranium beta and then developed. This set of film was run through the automatic film reader once each day for five days. At the 95% confidence level there was no significant difference between runs. But the test did show a large variance between individual films ranging from 190 to 280 mrep.

The second test was similar to the first. Twenty pieces of film were simultaneously exposed to 300 mr of radium gamma and then developed. This set was read once each day for five days. There was no significant difference between runs. The variance between individual films ranged from 270 mr to 310 mr. Previous runs had suggested that perhaps the difference in sequence of exposure of the film produced significant variances. The third test was designed to check this observation. Eighty pieces of film were used. Twenty were exposed to 300 mrep (in all cases) beta only. Twenty were exposed to 300 mr gamma and then to 300 mrep beta. Twenty were exposed to 300 mrep beta and then to 300 mr gamma. Twenty were exposed to 300 mr gamma only. Subsequent reading produced three groups of beta and three groups of gamma. The "F" test for variances was employed to determine the difference between groups. There was no significant difference between the beta groups at the 95% confidence level. However, a significant difference between the gamma groups was indicated.

The fourth test was designed to check the effects of temperature upon film exposure. Eight sets of ten pieces of film each were exposed to various combinations of the following parameters:

a. Room temperature film
b. Refrigerated film
c. First gamma then beta exposure
d. First beta then gamma exposure

When these sets were developed, read and statistically tested, significant differences were quite apparent. Upon observation, however, the differences appeared to be a result of sequence of exposure rather than of temperature effect. A need for further study is indicated to establish whether sequence of exposure does indeed produce variance in film darkening.

Other tests and observations were made in an attempt to localize the cause of those seemingly random but all to frequent excursions of film from calibrated levels. Only one observation seemed to be significant - that fingerprints or smudges impressed upon the film by hand before development contributed very significantly to the error observed in reading.

3. Total Body Counter

Since the inception of the Health and Safety laboratory at the NRTS, there has been an increasing need for means of determining total body activity of individuals.

Late in 1958 a contract was let to provide a completely automatic and versatile control and scanning mechanism, together with a photomultiplier tube and scintillation crystal assembly, for use in our low background vault. It is believed that this is the first time the two functions of total body counting and body scanning have been incorporated into a single unit. This contract ran long past its proposed scheduled delivery and was not installed until the fall of 1959. Thus although the system was mechanically and electrically operational at the close of the year, final testing and calibration were not completed. The total system may conveniently be separated into 5 major components (Fig. XXXIII).

a. 256 Channel Analyzer for isotope determination.
b. Control and recording units
c. Mechanical driven assembly for precise positioning of the detector assemblies.
d. Detector assemblies.
   (1) Large 4" x 8" crystal for total body counting.
   (2) 2" x 2" columinated crystal for scanning.
e. Subject platform on telescoping tracks for easy access and positioning of individual.

When used with the small collinated crystal assembly, the control provides for precise location scanning of the subject. Control voltages are fed to two separate servo-systems to mechanically move the crystal assembly in a prescribed manner over a reclining subject. At the same time voltages are fed to the X and Y inputs or a recorder which moves the pen in an image pattern. The signal from the crystal assembly is fed to a scaler which provides an impulse to drive the point plot mechanism on the XY recorder. The density of the points plotted is a function of detected activity in the body.

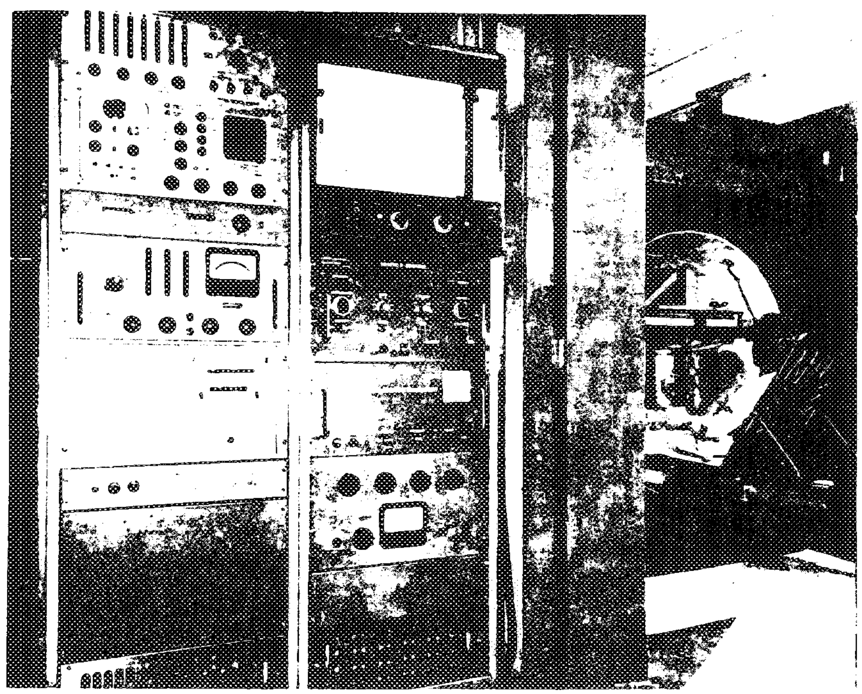


Fig. XXXIII. Total Body Counter and Associated Equipment

When used for total body counting the subject is placed in a half-sitting position as in Fig. XXXIII before the large crystal assembly. The output of the crystal assembly is fed directly to a 256 channel P. H. analyzer. The energy spectrum may then be transferred to the XY recorder and automatically plotted. The large detector assembly consists of a 4" x 8" solid copper canned NaI (Th) Harshaw crystal coupled to 5 three-inch and 1 two-inch PM tube. These outputs are coupled through a transistorized preamp for feeding the outgoing signal.

To maintain as low a background as practical, virtually all materials were tested for activity prior to use in the interior assembly. Samples of the stainless steel welding rod were checked prior to fabrication of the crystal shield. Bases were removed from the PM tubes as an excess of 100 c/m of activity was found to exist in the bases. The interior of the vault was painted with a tygon paint as it was the only type of material found to be free of activity.

To further reduce the background due to backscatter from within, the vault was lined with 3/16" of pure lead and 100 pounds of mercury were added as additional shielding around the large crystal assembly. The addition of the mercury decreased the background count by approximately 300 c/m.

As the total body counter system was nearing completion, magnetic fields were discovered in the iron shielding. These fields caused an energy response shift whenever the scanning mechanism moved the photomultiplier assembly. An attempt was made to de-magnetize the whole vault but was unsuccessful because of the large iron mass involved. However, the magnetic effect was very adequately overcome by use of mu-metal shielding around the photomultiplier assembly.

4. Annular Impactor

The radioactive counting of plutonium dust samples collected by filter paper air sampling systems has to be delayed until the natural radon daughter products have decayed appreciably. This delay emphasizes the need for a selective air sampling device wherein plutonium dust only can be collected and thus may be counted immediately.

An annular impactor was constructed and tested by personnel of the Atomic Energy Research Establishment of Harwell, Berkshire, England. According to the Harwell report*, a collection efficiency of approximately 90% is realized for plutonium dust particles as compared to about a 5% collection efficiency for natural radon decay products.

*A.E.R.E. HP/M 110

Personnel of the Instrument and Development Branch used the Harwell design as a guide in construction of an annular impactor for the Health and Safety Division. The output end of the unit was coned out and fittings were machined to fit a high volume air sampler (Fig. XXXIV) and $3\frac{1}{2}$ inch filter paper. Calibration discs were machined for the intake end.

The unit has been turned over to the Site Survey Branch for testing and evaluation.

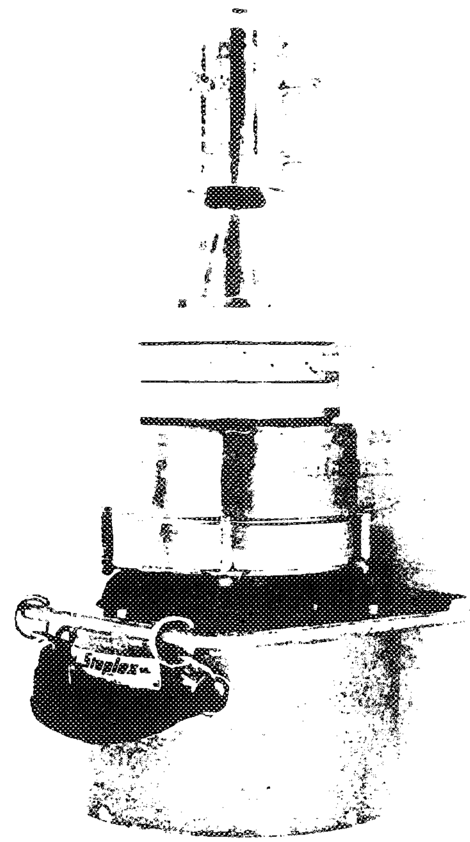


Fig. XXXIV. Annular Impactor with Associated High Volume Air Sampler

5. Aerial Monitoring Instrument

An instrument was constructed on a circuit developed by New York Operations Office, for use in a light aircraft for the purpose of ground monitoring and cloud location and detection (Fig.XXXV). This instrument uses a Sodium Iodide Thallium Activated crystal as the detector. The instrument has upper and lower discriminators to cut out the unwanted low energy background and the high energy cosmic rays for better background control. It has a 4 decade logarithmic scale for wide variation in counting rate. The capability of using printed circuitry and miniature construction techniques was developed by the Branch for this instrument in order to keep the weight and size to a minimum. The instrument is transistorized throughout. An Easterline-Angus recorder is part of the system but leaves much to be desired in portability. A smaller lighter recorder combined with the detector and instrumentation in one package would make a better unit.

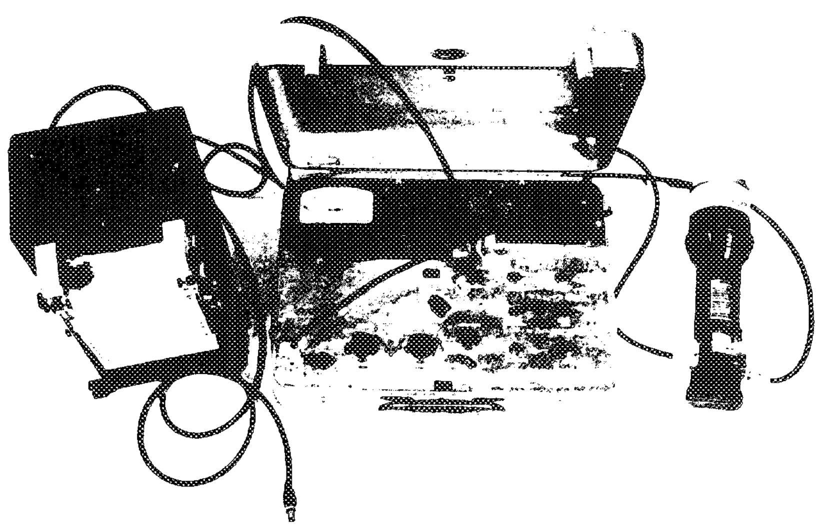


Fig. XXXV. Aerial Monitoring Equipment.

6. Modification of Cary Spectrophotometer Cell Compartment

The accessory device in Fig. XXIII which permits the Cary Model 14 to be utilized in the determination of excitation spectra of fluorescent materials was developed and constructed by personnel of the Instrument and Development Branch, working in cooperation with personnel of the Analysis Branch.

Drawings, pictures and a description of this unit are included in the unpublished paper titled "Determination of Excitation Spectra With a Recording Spectrophotometer" by Claude W. Sill.

C MAINTENANCE SECTION SUMMARY OF MAJOR PROGRAMS

1. Organizations utilizing Instrument and Development Services

The following services are made available to all organizations associated with the NRTS.

Maintenance and repair of portable, field, and laboratory type electronic equipment.

The calibration of instruments, dosimetry film, other radioactive sources by use of electronic and radioactive standards.

A list of these organizations who used one or more of these services during the past year include:

a. Idaho Operations Office

(1) Health and Safety Division
 (a) Instrument and Development Branch
 (b) Analysis Branch
 (c) Ecology Branch
 (d) Site Survey Branch
 (e) Medical Services Branch
 (f) Safety and Fire Protection Branch
 (g) Personnel Metering Branch

(2) Inspection Division

(3) Security Division

b. Governmental Agencies

(1) U. S. Public Health
(2) U. S. Weather Bureau
(3) U. S. Geological Survey
(4) U. S. Navy (NRF)
(5) U. S. Army (SL-1)
(6) Idaho Civil Defense

c. Operating and Construction Contractors at the NRTS

(1) Phillips Petroleum Company
(2) Westinghouse Electric Corporation
(3) General Electric Company
(4) Argonne National Laboratory
(5) Atomics International
(6) Fluor Corporation
(7) Combustion Engineers
(8) Pittsburgh Testing Laboratories
(9) Aero-Jet General Corporation

2. Equipment Accountability

The Maintenance Section is responsible for the accountability of all electronic and laboratory equipment used by the Health and Safety Division. The equipment inventory recorded at the close of the year included a total of 1579 items, or an increase of 257 during the year, 142 being of a portable classification and 115 representing laboratory or fixed monitoring, analysis and testing equipment. The dollar value of the recorded equipment inventory is approximately $690,000 of which 2/3 is portable instrumentation. It should be noted that some items consist of a single instrument or component while others comprise complete and complex instrumentation systems of one or more major components. To facilitate repair and development, two major machine shop items were purchased to replace worn-out equipment.

The increasing number of instruments in use together with additional users, demanded that better methods be found to properly record location, maintenance and calibration data for each item of equipment. To meet this demand, punched cards are being utilized so as to facilitate faster and more accurate means for determining instrument locations and time/cost data as well as complete history of the instrument movement.

Major fixed and laboratory instrumentation systems in service and/or being maintained are listed in Table 11.

Table 11. Major Instrumentation Systems

Scintillation counting systems	9
Proportional alpha counters	6
Automatic Sample counting systems	4
Densitometers	4
X-ray systems	3
Spectrophotometers	3
Single channel analyzers	2
Multi-channel analyzers	2
Automatic film reading system	1
4 pi counting system	1
Frish Grid chamber	1
Low background beta counter	1
Rabbit thyroid counter	1
Uranium analysis system	1
Total body counter	1

Number of portable instrumentation broken down into major types in Table 12.

Table 12. Portable Instrument Inventory

Gieger Counters	186
Cutie Pies	159
Junos	145
Air Sampler, hi-vol.	126
Air Sampler, lo-vol.	119
Radectors	82
Miscellaneous	54
Alpha Counters	51
Dosimeter Chargers	42
Recorders	40
Neutron Counter, slow	32
Neutron Counter, fast	29
Total...	1,065

During the year, some new types of instruments were purchased for use by the contractors in an effort to provide more reliable and accurate equipment. Portable gas proportional alpha counters were procured and an order was placed for new type alpha scintillation counters to be used by emergency monitoring teams and plant personnel. To meet the ever-increasing neutron monitoring problem, specifications were developed by the Branch and a contract let for an improved type BF_3 counter. This unit provides for increased stability and reliability and utilizes transistorized plug in component construction.

3. Instruments Repaired

In addition to maintaining the afore mentioned instrument systems, the following instruments in Table 13 were repaired and/or calibrated during the year:

Table 13. Portable Instrument Repair Workload

Cutie Pies	1,056
Junos	953
Gieger Counters	872
Radectors	259
Air Samplers, hi-vol.	227
Miscellaneous	211
Fast neutron counters	113
BF3, slow neutron counters	93
Count rate meters	90
Portable alpha counters	70
Samson, alpha counter	64
Scalers	55
Portable scintillators	37
Lab Monitors	15
Recorders	6
Total...	4,121

Although the section has no defined responsibility to service instruments other than our own, assistance has been given to construction and testing contractors as well as civil defense units and private organizations carrying on testing programs at the NRTS, when called upon as the workload permits. This number is small and is not reflected in the totals previously listed.

4. Instrument Improvement

In an effort to resolve the increasing problem of space and to facilitate servicing, a major project was undertaken to rack-mount virtually all of the counting room equipment in moveable cabinets, which would enclose a complete system.

Access doors and slide mounted equipment have contributed greatly to the ease of servicing. This approach has also greatly improved the appearance of our laboratory areas.

Each of the well counters in Fig. XXXVI is a complete system with scaler, shield, detector and writing desk contained in one unit which can be easily rolled to another location if desired.

Fig. XXXVI. Unitized Scintillation Well Counters for Gamma Counting

5. Evaluation and Testing

New instruments are procured from time to time for testing and evaluation as to their useability in the various programs and for comparison with those currently in use.

Since the beginning of the air monitoring program at the NRTS, vane type vacuum pumps have been used. These units do not lend themselves to continuous duty without considerable maintenance and service. Tests were run on a smaller and lighter piston type sampler, with encouraging results. An excess of 2,000 continuous hours of unattended operation in a hot and dusty area resulted in virtually no reduction in efficiency; these tests indicate a more satisfactory type of pump and an order is to be placed for a number to supplement the air monitoring program.

Three types of pocket alarms were procured for testing purposes:

a. Minirad, manufactured by Jordan Electronics
b. Fido, manufactured by Controls for Radiation
c. Sparrow, manufactured by Gelman Instrument Company

Each of these units were found to be inadequate for routine use because of their high range and low level audio warning signal which would be inaudable in most plant areas or at a disaster scene. The above units have been evaluated by either Site Survey Branch or contractor personnel, with the same conclusion.

6. Calibration

a. Cs-137

During the past year, study has been given to the possibility of using Cs-137 as a source material for high level gamma calibration in place of Radium. The use of Cesium would accomplish a two-fold purpose - that of eliminating the potential hazard of contamination due to rupture of a radium capsule and also make possible the use of larger gamma fields at an economical cost.

b. Radium Contamination

With the ever present possibility of a radium capsule developing a leak, it is necessary to routinely check each source for possible leakage. The standard method used to check for leakage in the past has been to seal each source capsule in an airtight container with a wad of cotton. After a length of time the cotton is removed and checked for alpha contamination. If considerable contamination is found, it is assumed that the source is leaking. In using this method it was found possible to pick up contamination from nearly all of our radium sources. Since it seemed improbable that all of the sources were leaking, the possibility that the source capsules were externally contaminated was considered. If, after encapsulation of the radium by the manufacturer, a small amount of radium remained on the exterior of the capsule, it would in decaying, give off radon gas which would be picked up by the cotton. This could lead to erroneous decision that the capsule was leaking. With this in mind, it was decided to try to find some method of removing the radium on the exterior of the capsule.

The result of this investigation is, that by means of a chemical bath remove as much as possible of the external contamination on a source capsule and then determine the maximum alpha count given by the source when placed directly on the inverted probe of an alpha detection instrument. In subsequent checks of the source capsule it is assumed that there is no serious leakage as long as the external alpha contamination of the source capsule doesn't change significantly.

D PROPOSED PROJECTS FOR 1960

1. Radiation Data Collecting and Logging System

   Continued effort will be spent in working with Motorola, Inc. in obtaining telemetering equipment and install it at the monitoring stations. Supplementary detection equipment will be procured or fabricated for measurement of radiation levels at the field monitoring stations, and connected to the telemetering equipment for data transmission.

2. The automatic film reader will be redesigned or modified to read 4 fields on each film. Better energy determination will thus be obtained. Improved number reliability will be built into the readout unit.

3. The possibility of procurement of a computer for data handling indicates considerable effort on automation of data collection devices for converting data into a form compatable with a computer system. This may include the film reader, radiation data collecting and logging system, total body and other isotope spectrum analysis, as well as other facets of the counting room.

4. Automation of the calibration wells and film badge calibration equipment is being considered in an effort to eliminate the human error as well as utilize the equipment during periods when personnel cannot be in attendance.

5. Engineering and possible construction on a small animal counter for the Ecology Branch will be done.

Chapter 7

ECOLOGY

Z. M. Fineman, Branch Chief

A SCOPE

1. The reactors and processing plants of the NRTS release, under controlled conditions or by accident, radioactive gases, liquids and particulate to the air, soil, and water of the NRTS and its environs. This results in low level radioactive contamination of the biota of the NRTS and its environs. This contamination if of much greater magnitude could constitute a potential health hazard to man who may ultimately consume plant and animal food products containing radioactive nuclides.

   High level radioactive contamination of the natural environment may affect plant and animal growth and reproduction and eventually result in shifts in number, species composition, and total growth of plant and animal populations. In addition, the NRTS like the adjacent farming and grazing areas shares the common problem of noxious weed and predator animal control.

   To assess the current and yearly level of radioactive contamination of the biota of the NRTS and environs and their effects on plant and animal life and the potential health hazards to man, the Ecology Branch carries on a three phase program:

   a. Biological Monitoring
   b. Ecological Research
   c. Radiobiological Research

   The main objectives of the three phases are as follows:

   (1) Biological Monitoring

      (a) To determine the concentrations and distribution of radioactive contaminants in the soils, plants, and animals of the National Reactor Testing Station and its environs.

      (b) To relate any radioactive contamination in different areas and during different periods to the responsible operation or release.

      (c) To develop methods of estimating the probable environmental contamination from scheduled releases during different meteorological regimes.

      (d) To determine the potential health hazards to man from the radioactive effluent from NRTS operations.

      (e) To develop biological indices for monitoring the environment for all types of radioactive contamination.

2. Ecological Studies

a. To determine the normal trends and changes in plant and animal population.

b. To determine the effects of radioactive contamination on plant and animal populations.

c. To determine the passage of radionuclides through ecological and agricultural food chains.

d. To control predatory animals and noxious weeds.

3. Radiobiological Studies

a. To determine the uptake and release of radioactive isotopes by organs and tissues of animals.

b. To determine the absorption of radioisotopes by the roots and leaves of plants.

c. To determine the effects of internal radioactive contaminants on the growth, development, and reproduction of plants and animals.

B SUMMARY OF MAJOR PROJECTS

1. Biological Monitoring

a. Sampling

The total number of field samples collected are listed in Table 14. Area and operational monitoring were done primarily from the gross gamma activity in sagebrush and soil samples and the Iodine-131 activity in jack rabbit thyroids. Milk and cattle bones were collected to determine whether NRTS operations had resulted in any contamination of food products. Birds, game animals, and small mammals were collected to determine the general level of radioactive contamination in fauna of the NRTS. As in previous years the plants and animals collected were also used to obtain supplementary biological information.

Table 14. Ecological Field Samples Collected and Analyzed During 1959

Type of Sample	Number
Jack rabbits	705
Vegetation	637
Soil	354
Milk	237
Predators (Coyotes Badgers and Bobcats)	70
Small Mammals	57
Sheep and Cattle	48
Antelope, deer*	27
Birds	16
Total...	2,151

*Samples obtained from local hunters or from animals killed by vehicles.

b. General Area Monitoring

(1) Iodine-131: The I-131 activity in jack rabbit thyroids was used as an index of the I-131 contamination of NRTS and its environs. I-131 distribution and levels provides to some extent an index of the general levels and distribution of concommittantly released isotopes. The main sources of I-131 contamination in the NRTS and its environs were the 16 Rala releases from CPP, 4 IET Operations, and operational releases from MTR and ETR. In 1959 the majority of the I-131 came from the 16 Rala releases which were spaced evenly at about 3 week intervals during the year. The I-131 in the jack rabbit thyroids was used as an index of the I-131 contamination in different areas and periods. Since the general wind directions over the Site are oriented northeasterly and southwesterly, most of the sampling stations were on vectors in these two directions from CPP, IET, ETR and MTR. Rabbits were collected mainly on a NE-SW line running 32 miles NE and SW of CPP. Sampling was timed to coincide primarily with the Rala and IET operations. Off-site control rabbits were regularly collected at Taber 20 miles SE of CPP.

The I-131 contamination levels in the NRTS and environs varied with distance from sources and the amount of activity released. The highest I-131 activity level, 4.4×10^4 uuc/g, was observed on March 4 in jack rabbit thyroids collected 3.5 miles NE of CPP. The I-131 activity in jack rabbit thyroids at this location throughout the year are compared in Fig. XXXVII to the activity levels at Taber, 20 miles to the SE, and to the curies of I-131 released by the 16 Rala operations. The curves for thyroid I-131 activities follow the curve for the Rala releases.

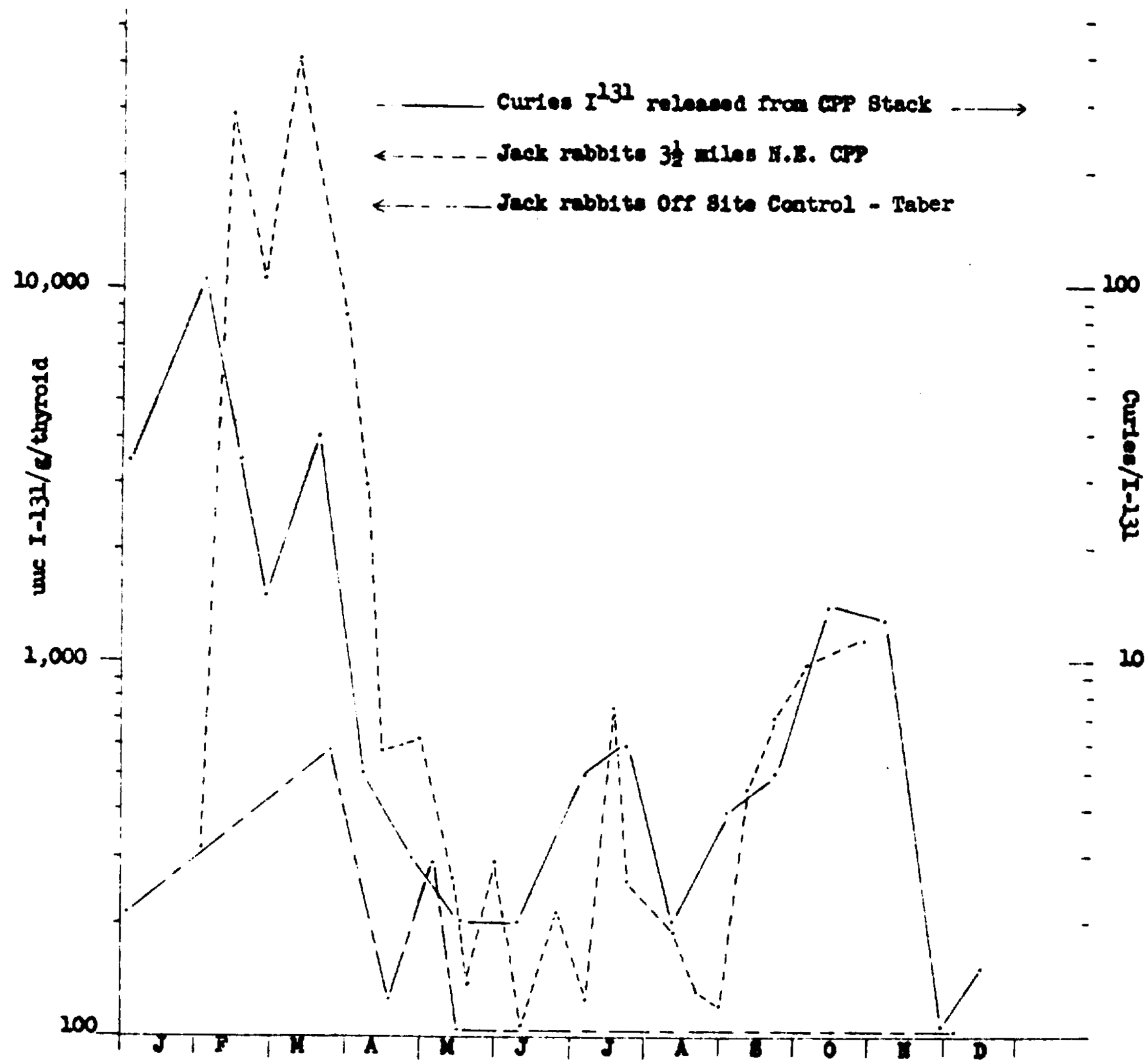


Figure XXXVII. I-131 in Jack Rabbit Thyroids at 2 Locations During 1959 and I-131 Released from CPP Stack.

With the installation of a charcoal filter in off gas system of the CPP in 1958, the I-131 released to the environment from Rala operations was greatly reduced. After surveying the effects of the reduced releases, a quarterly survey of the NRTS and environs for I-131 contamination was initiated. Fig. XXXVIII shows the results of the 1959 winter quarter survey. The I-131 activity in jack rabbit thyroids collected at the north end of the NRTS was primarily from IET operations. The data in Fig. XXXVIII illustrates the differences in I-131 contamination with distance and direction from the CPP and IET stacks.

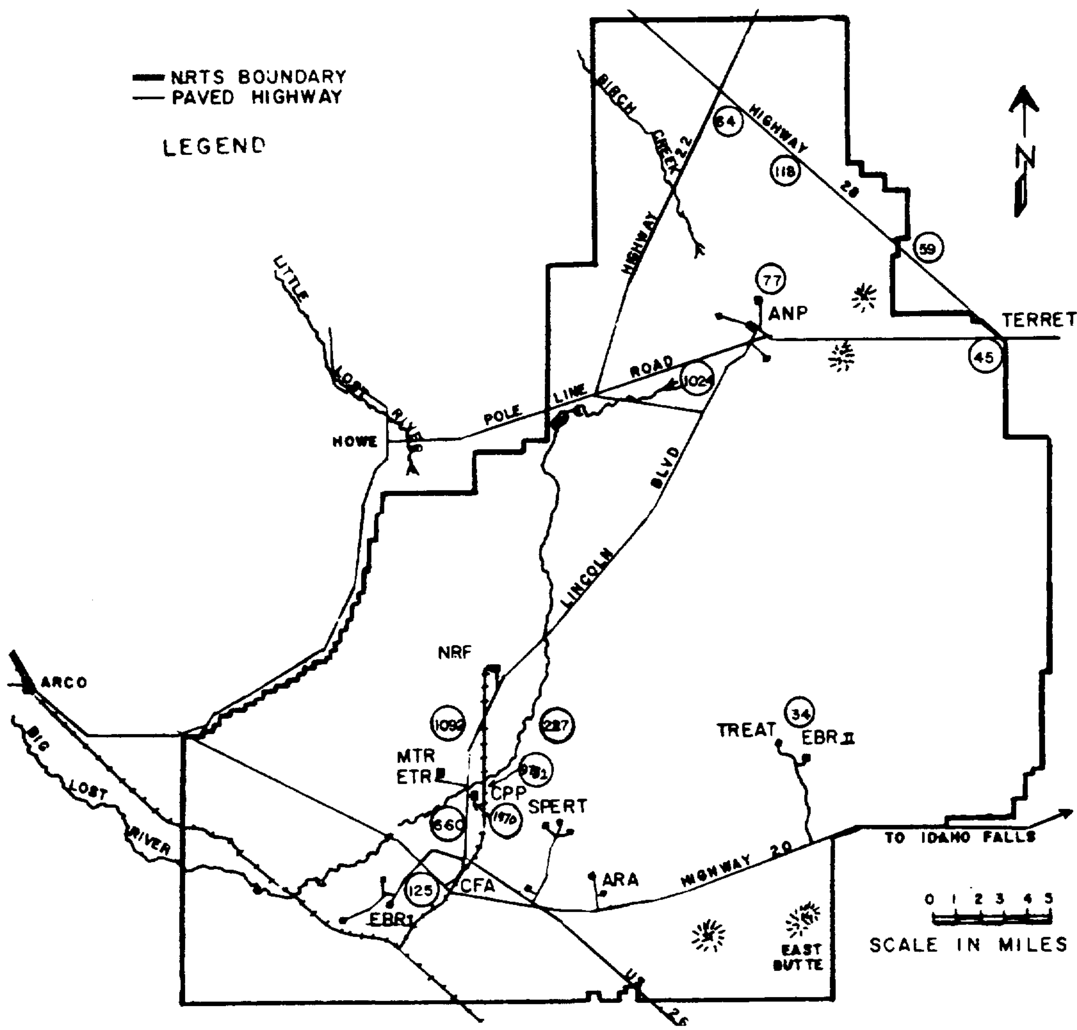


Fig. XXXVIII. 1959 Winter Quarter Survey of the I-131 Activities in uuc/g of Jack Rabbit Thyroid at 13 Locations

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(2) Strontium-90: Starting in August 1956 cattle bones were collected at about monthly intervals from two slaughterhouses located in Shelley and Roberts, Idaho. A portion of the rabbits collected for I-131 monitoring were also used for Sr-90 monitoring. In Table 15, the jack rabbits that were collected on the Site have been divided into three groups: (a) South - around CPP, (b) Central NW of NRF, (c) North around IET. Table 15 contains the means for Sr-90 activity in jack rabbit and cattle bones collected from 1956 to 1959 in different on-site and off-site areas. The Sr-90 in the bones of off-site jack rabbits and cattle increased from 1956 to 1959. The off-site jack rabbits had slightly higher Sr-90 activities than the off-site cattle during this period. During 1956, the Sr-90 activity in the bones of jack rabbits from the South and North areas of the Site were significantly higher than the activity in the jack rabbit bones from the central area. Central area Sr-90 activity in 1956 and 1957 was similar to off-site activity in 1957. In 1958 and 1959, the activity in the South portion of the Site was much higher than in the North portion around IET. The 1959 activity in the North area was higher than the off-site area in 1959. The higher Sr-90 activity in jack rabbit bones from the South portion of the Site in 1958 and 1959 may be attributed to effluent from CPP. No evidence was obtained that would indicate that the increase in Sr-90 activity from 1956 to 1959 in off-site rabbit and cattle bones could be attributed to NRTS operations.

Table 15. Strontium-90 Activity in the Bones of Jack Rabbits and Cattle During the Period August 1956 to December 1959

Means for Sr-90 activity in the bones of indicated animals, from indicated locations, during indicated periods.

Jack Rabbits

Areas

Year	n	South uuc/g/Ca	n	Central ucc/g/Ca	n	North uuc/g/Ca	n	Taber uuc/g/Ca
1956	35	18.71 ± 1.20	45	12.68 ± 0.49	20	16.66 ± 1.08		
1957	108	12.92 ± 0.47	16	11.42 ± 0.71	25	15.85 ± 1.05	43	11.79 ± 0.[illegible]
1958	35	60.34 ± 11.82			43	16.85 ± 0.80	27	16.31 ± 0.[illegible]
1959	41	40.50 ± 7.7	3	12.90 ± 2.17	30	21.0 ± 1.4	17	17.8 ± 1.[illegible]

Cattle

Year	n	Roberts uuc/g/Ca	n	Shelley uuc/g/Ca	n	Mean uuc/g/Ca
1956	7	10.06 ± 3.27	10	10.66 ± 1.94	17	10.41 ± 1.71
1957	14	8.33 ± 1.33	12	12.16 ± 1.83	26	10.10 ± 1.74
1958	17	12.81 ± 1.67	20	11.49 ± 0.73	37	12.10 ± 0.86
1959	17	17.25 ± 2.18	20	16.35 ± 1.35	37	16.76 ± 1.2

Further analysis of the strontium-90 activity in on-site jack rabbit bones is presented in Table 16. In Table 16, the jack rabbits from the areas around CPP and IET have been divided into 6 subgroups on the basis of the direction and distances from CPP and IET, respectively. Rabbit bones from the FECF grid had the highest Sr-90 activity near CPP. NE and SW rabbit bones were significantly higher than CPP - South bones. The Sr-90 activity of the rabbit bones collected within 4 miles of IET was not significantly higher than the activity of the bones collected along the NE perimeter of the Site. It will be noted that in the NE perimeter bones the Sr-90 activity of 20.1 ± 1.0 was not significantly higher than the activity in the off-site control bones from Taber of 17.8 ± 1.7 uuc/g/Ca. From 1957 to 1959 the Sr-90 of Taber jack rabbit bones paralled that of off-site cattle bones. The Sr-90 in the cattle bones is presumably from world wide fallout. Since the Sr-90 activity of the NE perimeter rabbit bones were not significantly greater than Taber bones in 1959, it may be concluded that the Sr-90 activity levels in perimeter jack rabbits is also due to world wide fallout.

Table 16. Strontium-90 Activity in the Bones of Jack Rabbits in 6 Areas of the NRTS During 1959

Plant	Direction from indicated Plant	Distance	Number of Samples	Mean uuc/g of Ca
CPP	FECF grid (South)	0.5 mi.	8	230.4 ± 66.7
	NE	within 1.5 mi.	6	69.5 ± 12.5
	SW	within 1.5 mi.	5	72.2 ± 14.7
	South	over 2.0 miles	30	29.4 ± 3.6
IET	All directions	within 4 mi.	17	21.9 ± 1.6
	NE Perimeter of Site	over 5 mi.	13	20.1 ± 1.0

(3) Quarterly Area Survey: Prior to the fall of 1959, the radioactive contamination of the NRTS and environs was accomplished by pooling the results obtained from monitoring individual releases and operations: Based on the experience of previous years, a quarterly sampling plan was adopted for soil, vegetation, jack rabbit thyroids and bones. A sampling array of 90 stations was established with a greater concentration of stations around CPP and IET than in other on-site and off-site areas, Fig. XXXIX. Many of the off-site stations are at the Site Survey Branch Telemetering Stations. For the winter quarter survey, surface soil and vegetation (sagebrush) were collected at 82 of the 90 stations between November 12 and 28. The gross gamma activities of soil and sagebrush samples from areas adjacent and at a distance from CPP and IET are compared in Table 17. The means of off-site and perimeter soil and sagebrush samples were lower than the means of the samples from the arcs around CPP and IET. The results provide evidence that very little radioactive effluent from NRTS is being deposited in off-site areas. Future quarterly surveys will emphasize the determination of the NRTS contribution to radioactive contamination levels in perimeter and off-site areas.

Table 17. 1959 Winter Quarter Survey of the Gross Gamma Activities of Vegetation (sage brush) and Surface Soil Samples from NRTS and Environs

	Means for gross gamma activity of samples from indicated locations			
	Vegetation		Soil	
Locations	Number of Samples	c/m/g	Number of Samples	$c/m/ft^2$
CPP 0.5 Mile Arc	12	70	12	250
1.0 Mile Arc	12	37	12	190
4.0 Mile Arc	10	24	10	160
IET 1.0 Mile Arc	8	24	8	170
4.0 Mile Arc	8	22	8	180
Perimeter and Off-Site	16	13	16	140

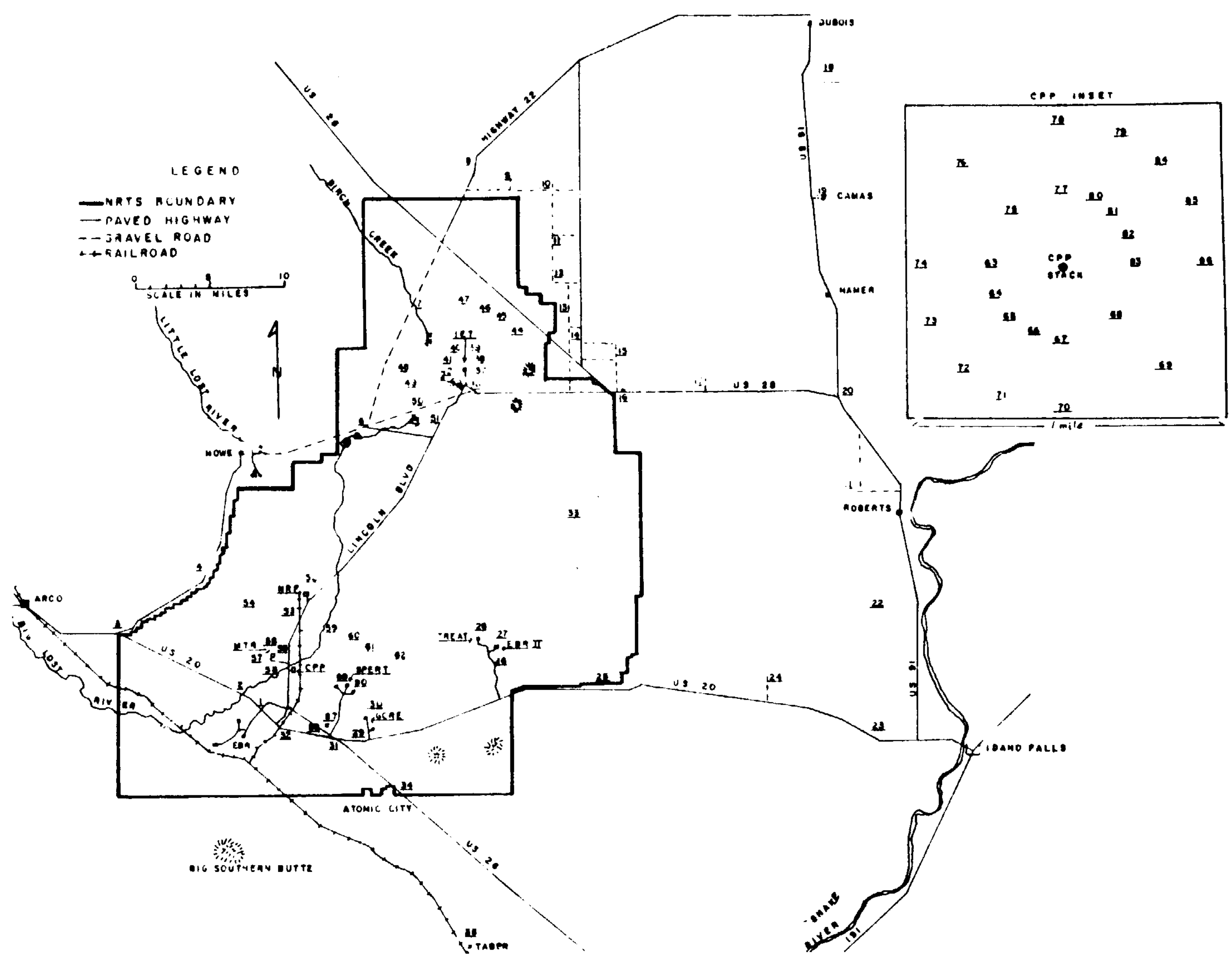

Fig. XXXIX. Sampling Array of 90 Stations for the Quarterly Biological Monitoring Survey of the

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(4) Iodine-131 in milk: The milk monitoring program was confined to farms in the Mud Lake and Monteview areas NE of the Site boundary. Collections of 12 one-quart milk samples were generally made a few days after each Rala release and at the completion of each IET operation. Milk from the individual farm cans was obtained at two creameries at Rexburg and at Ririe: Nineteen collections were made during the year. Each of the two December collections consisted of samples from 24 farms. A total of 237 samples were collected and analyzed during the year for I-131. Fifty farms were sampled during the year. A 50 ml subsample from each quart sample was analyzed. The detection limit for I-131 was 9×10^{-7} uc/ml of milk. I-131 was not detected in any of the 237 milk samples collected during 1959.

c. CPP Criticality Incident of October, 1959.

This incident was monitored by the collection of sagebrush samples on downwind sampling lines 1.0, 2.0, and 4.0 SW of CPP and by the collection of jack rabbits 1 mile SW of CPP. Gamma scans were made of some sagebrush samples and the organs of some jack rabbits. Sr-91 and Ba-139 were detected in some of the sagebrush samples. I-131, I-132, and I-133 were detected in jack rabbit thyroids. Two peaks of gross gamma activity were observed in the sagebrush samples that were collected along the 1.0 mile sampling line, which suggested the passage of two effluent clouds.

d. Fuel Element Cutting Facility Grid

The original contamination of the grid area with fission products from the FECF occurred on the evening of October 29-30, 1958. The original gross gamma activity level of soil and sagebrush are reported in the 1958 Annual Report of the Health and Safety Division, Chapter 6. The permanent 7 x 7 sampling array shown in Fig. 4 was established in November 1959.

The residual gross gamma activity on this grid was followed by 4 collections of surface soil and sagebrush samples in April, May, June, and November 1959. The three spring collections were made primarily to determine if rain would wash the contamination from the sagebrush plants and if wind removed and redeposited soil and plant contamination. Analyses of the data from the first three collections gave no indication of the removal of radioactive contamination from the sagebrush plants by the spring rains. Autoradiographs of leafy sagebrush stems showed a much smaller amount of radioactive contamination on the current year's stems and leaves than on the older stems. Some data were obtained which indicated that the gross activity of the surface soil had been reduced by wind removal and by downward leaching. The residual gross gamma activity in the surface soil in November 1959 is shown in Fig. XL. The pattern of residual radioactive contamination evident in Fig. XL is similar to that obtained by the Site Survey Branch by measuring radiation levels with GM counters.

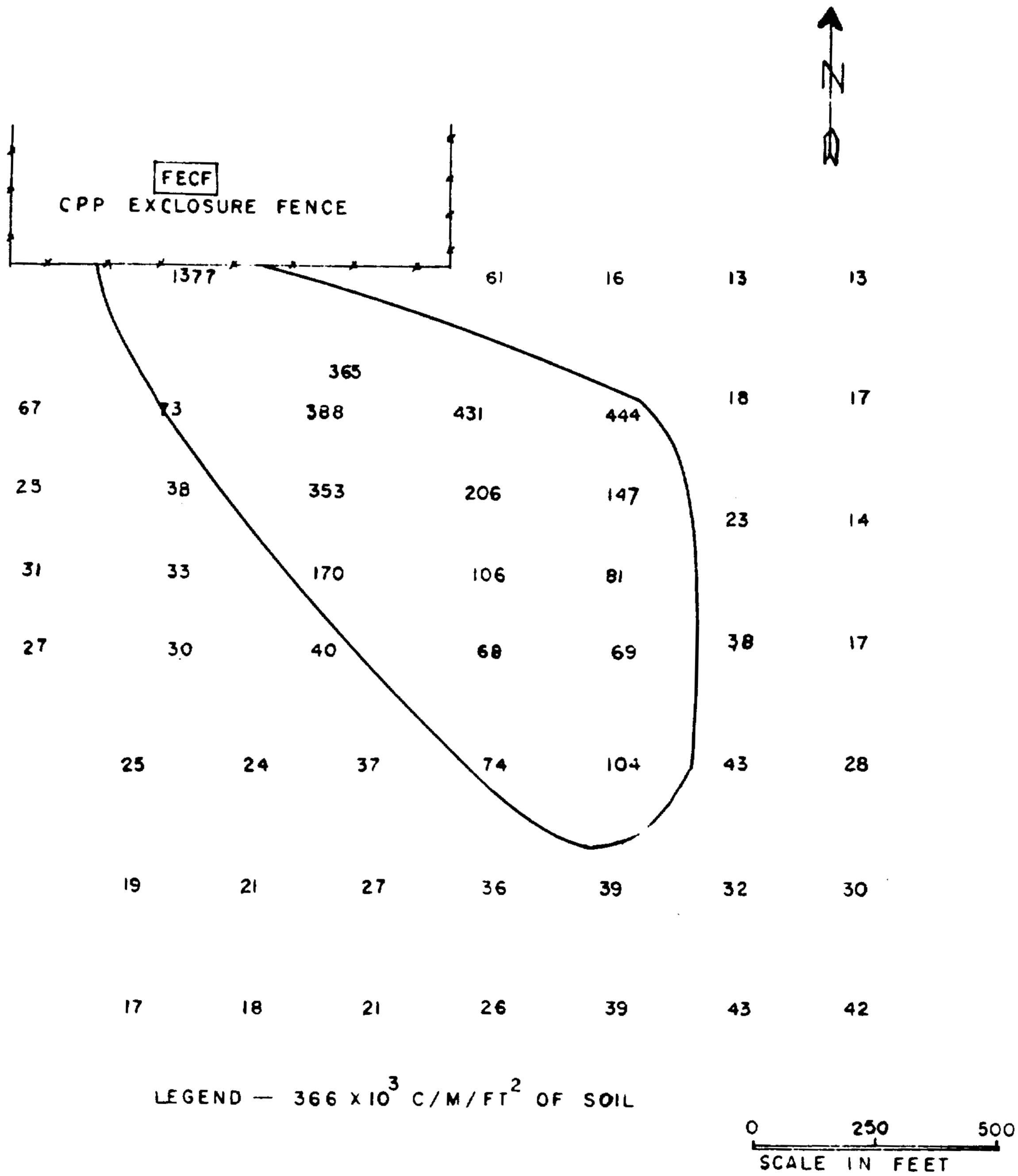

Fig. XL. Residual Gross Gamma Activity x 10^3 c/m/ft^2 in Surface Soil Collected on the F.E.C.F. Grid During November 1959

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e. Fission Product Field Release Test - I:

This test was accomplished on IDO Grid #3 during the summer of 1958. The results of the biological monitoring during the test have been reported in the Health and Safety Division 1958 Annual Report, IDO #12012. In 1959, the residual gross gamma activity in the surface soil along the first 4 sampling arcs was determined from two sets of samples, which were collected on June 25 and July 2. Gamma scans were made of 10 soil samples. The residual contamination pattern obtained in October 1958 was still apparent, but slightly altered by the decay of the isotopes with shorter half-lives. Gamma scans showed that most of the residual gross gamma activity was from Cs-137 and Ce-144.

f. ETR Releases

A number of releases from the ETR were given special monitoring by the collection of jack rabbit thyroids and sagebrush samples before and after the expected release. On June 14, a release of I-131 and I-133 occurred at 1600 hours. From the gross gamma activities of the sagebrush samples collected on sampling lines established 0.5, 1.0, 2.5, and 5.5 miles downwind (NE) from the ETR stack, the deposition pattern shown in Fig. XLI. was drawn.

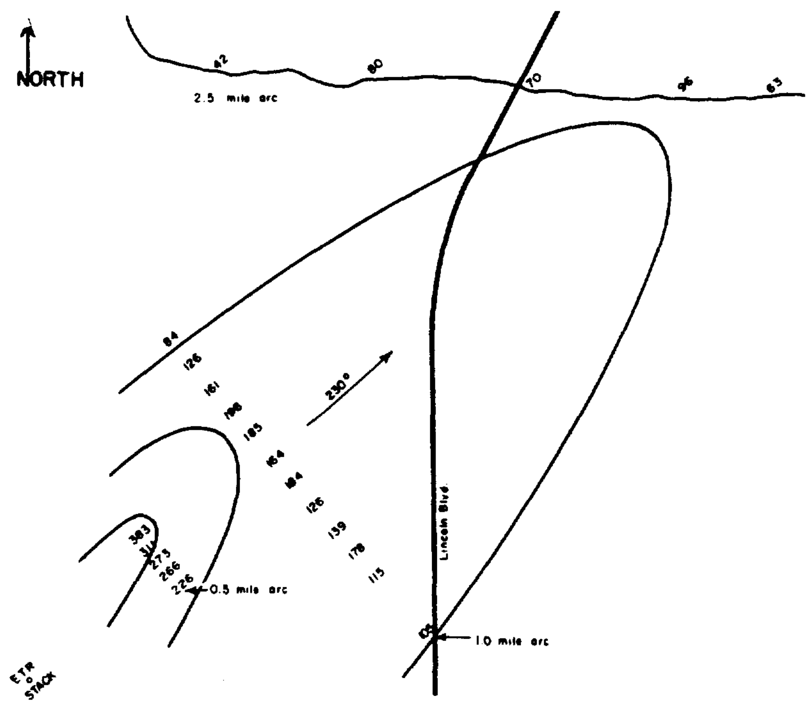

Fig. XLI. Gross Gamma Activities (c/m/g) on Sagebrush From the ETR Release of 6/14/59

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The I-131 and I-133 activities in samples from the 0.5, 1.0, and 2.5 mile arcs were determined by gamma spectrometry. The I-131 activity of a sample from the 0.5 mile arc was 8.5×10^{-5} uc/g of sagebrush. Utilizing the method of French (1958), the I-131 on the vegetation in the jack rabbit diet (100 g/day) was estimated to be 33×10^{-5} uc on June 15. This agreement by a factor of 3 between actual measurements of I-131 on sagebrush and the estimated amount from the I-131 activity in jack rabbit thyroids suggests that the diet of jack rabbits may consist of other vegetation besides sagebrush. The observed and estimated amounts of I-131 deposited on the sagebrush 0.5 mile downwind from ETR were in agreement with amounts calculated from the stack release data and the prevailing meteorological conditions.

2. Ecological Studies

a. Plant studies in contaminated areas

(1) IET and SPERT I areas:
In 1955, 2 series of 5 quadrats, (5 x 5 meters) each, were established NE of IET and SPERT I, in areas most likely to become contaminated from effluent releases. Two control quadrats were established in the SW corner of the Site. All quadrats were re-examined in 1956, 1957, and 1959 for coverage, density, frequency, and species composition. Analyses of the four-years' data revealed no significant differences between the IET, SPERT I, and control quadrats for any of the growth measurements.

(2) TREAT area:
In anticipation of the start of operations at TREAT in the fall of 1959, a line transect of 29 - 50 foot line intercept plots was established NE of TREAT. The plots were laid out at right angles to the transect and were 50 feet apart. Coverage, density, and frequency measurements were made.

b. Animal Studies

(1) Small mammal populations: The seasonal fluctuation in small mammal populations in three areas receiving different levels of radioactive contamination were measured by trap-mark-recapture method on 3 grids each containing 225 traps, 10 meters apart in a 15 x 15 array. Each array was sampled for a 3 day period in June, July, August. An exclusion fence prevented large animals from molesting the traps. The estimated numbers of small mammals in the three areas during June, July, and August are presented in Table 18. Factors affecting the apparent changes in population composition were not readily assessable. Further study on these grids is needed to determine environmental differences other than radiation.

Table 18. Estimated Numbers* of Small Mammals in Three Areas in 1959 Which had Been Subjected to Different Levels of Radioactive Contamination.

	AREAS								
	MTR			IDO GRID #3			CPP		
Animals	June	July	Aug.	June	July	Aug.	June	July	Aug.
Chipmunk	4	8	9	8	7	4	7	12	8
Whitefoot Mouse	9	8	8	3	10	18	7	27	29
Kangaroo Rat	0	1	1	12	7	18	0	0	1
Grasshopper Mouse	1	0	2	2	0	6	0	0	1
Pocket Mouse	20	11	12	20	17	17	21	21	28

*Estimated by Lincoln Index

(2) Jack Rabbit Biology

(a) Anatomical characteristics of the jack rabbit, Lepus californicus: Since the inception in 1956 of the jack rabbit biological monitoring program, over 2,000 rabbits have been collected. Biological data included measurements of the weights of the body, thyroid and adrenal glands. Adrenal weights were included to determine if environmental stresses, including radiation, had any measurable effect on adrenal gland weight. Preliminary statistical analyses were made on these data to determine if there were any differences between sexes and between years for body weight, thyroid weight, and adrenal weight. Seasonal differences in body weight and gland weights were also analyzed. Further data analyses are needed before conclusions can be made and a report published.

(b) Litter size, 1956-1959: During the period, February to June in the years 1956 to 1959, the female jack rabbits taken for biological monitoring were checked for litter size by counting the foeti. The average litter size over the 4 years was 3.5 young per female. The high month was May with an average of 5 young. Comparison of yearly litter sizes showed 1957 to be slightly greater than average, while 1959 was less than average.

(c) Food chain studies: (I-131): A comprehensive collection of animals in an area contaminated with I-131 was made in the spring of 1959. Comparison of I-131 activity in the thyroids of three species of animals collected 3.5 miles NE of CPP were as follows:

		I-131 in muc/g of thyroid tissue	
Species	Number	Mean	Range
Jack Rabbit	11	8.2	2.6 - 18.2
Chipmunk	21	6.5	0.0 - 20.0
Kangaroo Rat	11	3.8	0.0 - 9.5

I-131 activity was not detected in other small mammals and avifauna.

By using the I-131 activity in jack rabbit thyroids as a base line, several species of large mammals endemic to the Snake River Plain were evaluated for I-131 activity. In comparable periods and areas, the I-131 activity of antelope, elk, and deer thyroids were greater than that of the jack rabbit. Antelope exceeded jack rabbits by a factor of two. Elk and deer thyroid I-131 activities exceeded slightly that of antelope. The I-131 activities in the thyroids of carnivores collected throughout the Site were, in general, lower than the activities from either jack rabbit or antelope thyroids.

(d) Pest Control

(1) Predatory animal control: Prior to 1959, the predatory animal control work had been carried out by the local Government trappers of the U. S. Fish and Wildlife Service and consisted of placing 35 poison-baits during the fall and cleaning the remains up the following spring. Also a few aerial flights were carried out for denning and shooting of coyotes. Commencing in the spring of 1959, a student trapper was supplied by the Fish and Wildlife Service, to place poison-cyanide guns (coyote-getters) and spring-steel traps within the confines of the NRTS. During this six weeks period, forty coyotes were removed, eighteen by traps and 22 by coyote-getters. In October 1959, an agreement was made with the Fish and Wildlife Service for the control of coyotes and other predators injurious to livestock. Mr. William Stewart was assigned to this

task and as of December 31, 1959, had placed in operation 40 poison-bait (#1080) stations and 425 coyote-getters and had recovered 68 coyotes killed by the getters. Fig. XLII shows the location of the coyote-getters and poison bait.

During 1959, the Ecology Branch recovered 10 coyotes that had been killed by Security and automobiles.

(2) Halogeton control: Halogeton was first discovered in the late 1940's at the junctions of Highways 20 and 26 and Highways 22 and 28. The first control measures were attempted by U. S. Bureau of Land Mangement using 2-4-D spray in the infected areas.

In 1957 the Ecology Branch initiated a Halogeton control program. A survey of the NRTS was conducted during the spring of 1957 to determine the spread and degree of concentration. Some experimental seeding of crested wheatgrass was carried out in various denuded areas. Thirty acres were seeded in the spring and 160 acres in the fall using a standard grain drill..

Contracts for clean plowing and reseeding to crested wheatgrass were let in the summer of 1957 on the areas having the highest infestation of halogeton. The first contract of 2,420 acres was completed in the fall of 1958. The second contract of 2,608 acres was let in the summer of 1958 and completed in the fall of 1959. The third contract of 1,376 acres was let in the summer of 1959 and completed the same fall.

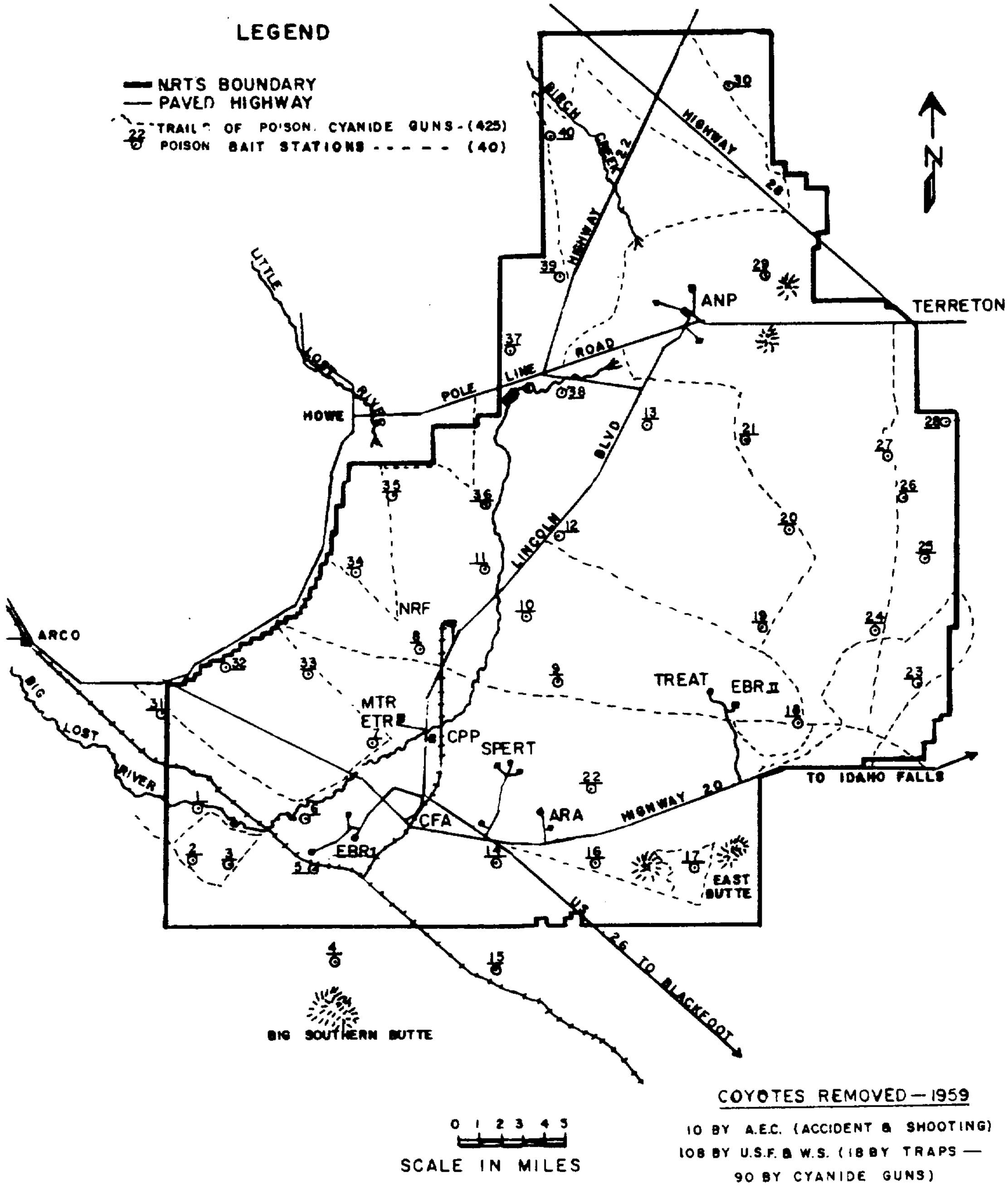

Fig. XLII. Predatory Animal Control on National Reactor Testing Station.

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In the fall of 1959 the Ecology Branch purchased a heavy duty Rangeland Drill. This was used to seed some 1,100 acres of unplowed lands, mainly roadsides, cleared areas and those having low vegetative cover and otherwise subjected to invasion of Halogeton, (Fig. XLIII). During the early summer of 1958 and 1959, a roadside spraying program was carried out. A 2-4-D and water mixture was applied with hand sprayers to the Halogeton plants only, thereby allowing the native vegetation to compete with subsequent re-invasion of Halogeton.

The success of the control program is being determined by plant ecological studies of the sprayed, seeded, and control areas.

3. Radiobiological Studies

a. Animal Studies

(1) I-131 uptake and effective half-life: Native animals in areas adjacent to chemical processing plants and reactors live in intimate contact with a slightly contaminated habitat. Principle among the effluent isotopes which have an environmental existence long enough to measure well but short enough to fluctuate with periodic or incidental releases is I-131. The animals which were particularly amenable to collection and study were: owls, coyotes, jack rabbits, ground squirrels, chipmunks, and kangaroo rats. Jack rabbits had been studied prior to 1959, and are now used as a biological indicator.

General procedures in these studies were as follows: Collection and establishment in the laboratory, determination of background counts of laboratory animals, administration of a spiked pill or contaminated food, and gamma counting to follow uptake and effective half-life of the I-131. Counting was done with live animals in a well type counter or a neck-band type counter, and by killing and removing the localizing organ. usually the thyroid gland, for counting in the well counter.

Due to differences in metabolism and nutritional need, uptake and release rates vary among the different species of animals. Three young owls were given oral doses of 7.36 uc of I-131, took up about 35 per cent in the thyroid gland, and had a four day effective half-life for I-131. Six others were given oral doses 0.71 uc of I-131, took up about 45 per cent in their thyroid, and had a two and one-half day effective half-life for I-131.

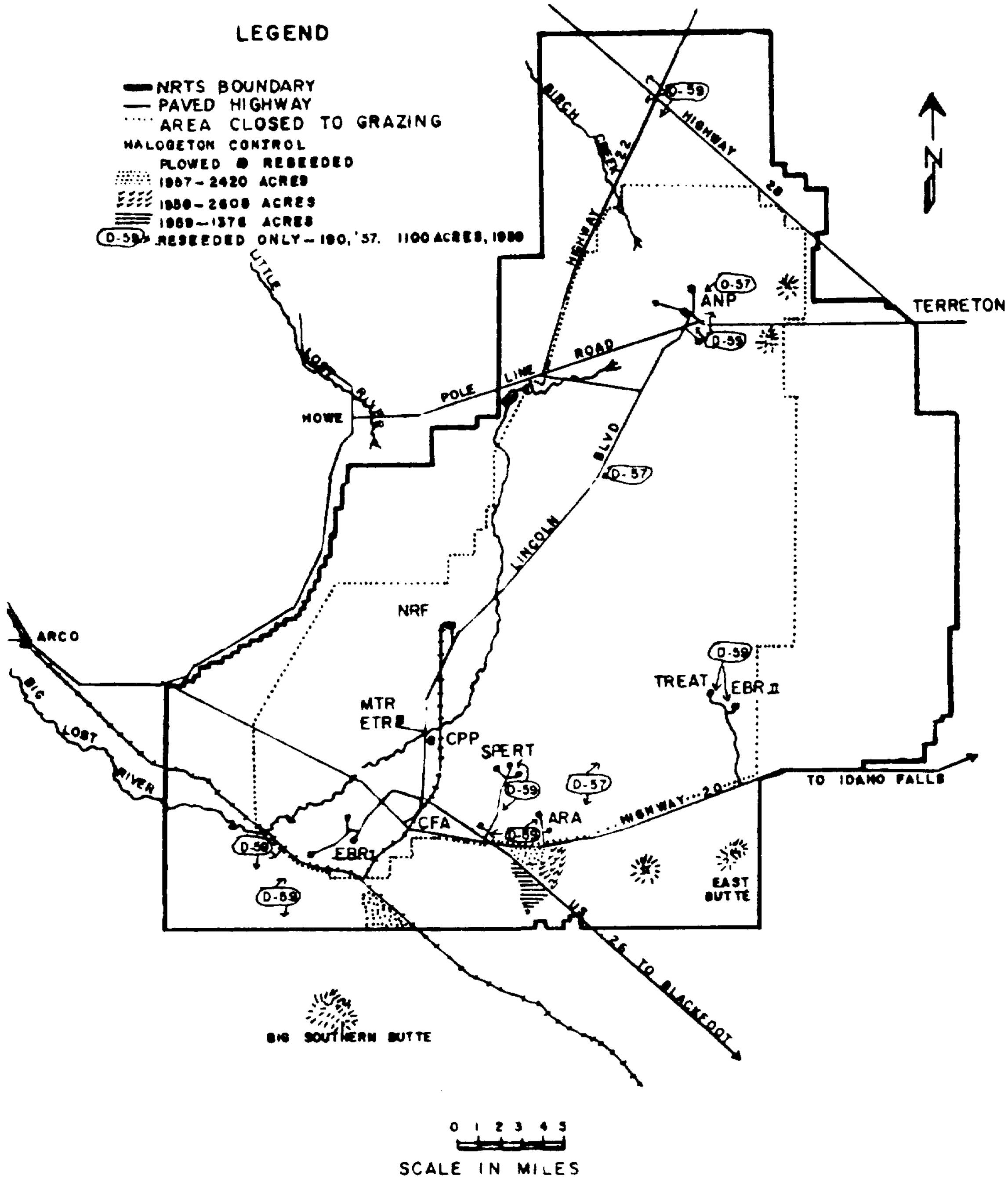

Fig. XLIII. Halogeton Control on National Reactor Testing Station.

Two coyote pups were given oral doses of 8.2 uc I-131. They took up about 75 per cent in their thyroid tissue with an average effective half-life of three days.

Eighteen Townsend's Ground Squirrels were given oral doses of 0.4 uc I-131. They were counted in a whole body gamma counter. Effective half-life of I-131 from the whole body counts was five days. On day one, an excised thyroid gland contained about 80 per cent of the dose.

Sixty kangaroo rats were fed on rolled oats contaminated with 0.1 uc/g of I-131. They ate an average of six grams per day or about 0.6 uc of I-131 on day one. Approximately 80 per cent of the dose was taken up in the thyroid tissue. The effective half-life of the I-131 was seven days.

In April 1959, eleven adult chipmunks were given oral doses of 0.27 uc I-131. They took up about 70 per cent of the I-131, in the thyroid gland, which had an effective half-life of four and one-half days. Subsequently, two chipmunks were given oral doses of 0.4 uc I-131. In these, the effective half-life of I-131 as indicated by daily whole body gamma counts was six and one-half days.

b. Excised Root Studies

This study was designed to develop a method of measuring the biological effects of absorbed isotopes on root growth. The technique developed by Cohn and Merz (Nature, 183: 412, 1959) for growing excised root tips in a culture medium was used. Excised root tips of Black Valentine Bean were grown on the surface of silica sand wetted with culture medium: 1.5 ml of culture medium containing 0.7-1.1 uc of Ce-144 or 0.8-1.3 uc of I-131, was used per small Petri dish. When grown for 3 days in Ce-144, the growth of root tips was 10-15 per cent less than that of the controls. In tests of 6 days duration Ce-144 reduced growth about 25 per cent. 0.8-1.3 uc of I-131 reduced growth 35-50 per cent. Individual root tips absorbed approximately .02 uc of I-131.

c. Sagebrush Sampling Methods

Studies of the variation in the gross gamma of sagebrush samples were continued. In 1959, the differences between the gross gamma activity of samples consisting of leafy stems and floral stems were studied. Samples were collected in August, September, and October in a continuously recontaminated area 0.5-1.0 NE of CPP. In August the gross gamma activity of the leafy samples was 3-4 times greater than the activity of the floral samples. In September, the ratio of the activities was 2:1 and in October the ratio approached unity. The change in the gross gamma activity of the floral samples was associated with the loss of moisture and maturation of the inflorescence. This resulted in an increase in surface area per unit weight of inflorescence.

C FUTURE PROGRAM

1. Biological Monitoring

a. The yearly NRTS contribution to the radioactive contamination of off-site areas will be monitored by the quarterly collection of samples of vegetation, soils, and animals at 90 stations located both on and off-site. Isotopic analyses of soil and vegetation samples will be made. The monitoring program will attempt to follow radioactive contamination in agricultural soils and vegetation.

b. Biological Monitors

The jack rabbit has been used as biological monitor of I-131 and Sr-90 contamination in the NRTS and its environs. The uptake and turnover of strontium in the bones of jack rabbits will be determined by the administering Sr-85, a gamma emitter, to jack rabbits in their native habitat. Values for per cent uptake and turnover will allow for the estimates of strontium activity on the food (vegetation) that the jack rabbit is eating. Uptake and turnover studies for strontium activity will also be undertaken with one small mammal, the white footed mouse, Peromyscus sp. to determine the feasibility of using this genus as a biological indicator of strontium-90 contamination. These mice have a cosmopolitan distribution throughout North America.

c. Redistribution of Residual Contamination:

In heavily contaminated areas, the original radioactive contamination of the surface of plants and soils may be redistribu Surface soil activity may be leached downward to the root zones of plants or be redistributed by the wind. Vegetation contamination may be retained on old wood or seeds and be consumed by animals. The potential health hazards of residual contamination to man and animals will be evaluated by the following of the changing levels of radioactivity in and on plants and soil, and in animal organs and tissues. The contaminated grid areas, FECF and IDO #3, will be utilized for these studies.

2. Ecological Studies

a. Animal Studies

(1) Basic Trends in Populations and Specie Compositions of small mammals: Within the boundaries of NRTS, many different types of vegetation occur. Since animal population densities and composition vary according to the vegetative habitat, estimates of animal populations should be taken for each type. This will be done by established methods of sampling with mammal populations. Population studies will extend into the new land acquisition of 200 square miles to get basic information on animals in that a

(2) Population of large animals: Larger free ranging animals such as the jack rabbit can not be sampled economically by trapping methods. Populations of these animals will be estimated by roadside counts and by line-quadrats. The animal data will be obtained in conjection with other types of field work.

(3) Food habits study: The radioactivity in the organs and tissues of animals generally comes from the radioactivity in and on the food they ingest. It is desirable to enhance the confidence given to the accuracy of these measurements by a food study on jack rabbits and white-footed mice, and if possible, a direct correlating of the isotope concentrations on the food and in the concentrating animal..

(4) Jack rabbit age studies: Studies of the utilization of the chemical components of animal foods, i.e., radioisotopes, show that different rates obtain at different ages of animals. Knowing the age of the animal used as a biological monitor would, in this respect, add to the accuracy of the measurement. Studies of age-indicating organs (eye lenses and trabecular bone) will be made. This is particularly important for evaluating the strontium activity in animals.

b. Radiation Effects in an Ecosystem

(1) Ecology of the FECF grid: Any radioactive effect on animals at levels consistent with those found in the natural environment will be extremely obscure. Since the FECF grid area is contaminated considerably above the general natural background, it presents possibilities of showing some of these effects. The animal populations in this area will be studied systematically for density, composition, variations, and abberrant conditions. Soils, plants, and micro-climate will also be investigated.

c. Plant Studies

(1) Vegetation coverage of the NRTS area varies in species composition and density within species. To better evaluate situations of biological monitoring, a three-type inventory of the NRTS vegetation will be made coincident with the animal studies to show type boundaries, density, and composition. This will also extend to the 200 square miles of new area.

3. Radio-Biological Studies

a. Effects of Radioisotopes on Growth and Reproduction of Native Animals.

(1) Small mammals: This series of studies will be initiated by a laboratory study on one specie of small mammals, the white-footed mouse, Peromyscus sp. Radioisotopes will be administered to a laboratory population of reared mice for several generations.

(2) Jack rabbits: The possible effects of radiation on jack rabbits in their native habitat will be studied by a comparison of jack rabbit populations in uncontaminated and contaminated areas. The jack rabbits collected for the biological monitoring of the NRTS and its environs will be utilized for the study. The following animal characteristics will be evaluated to determine the differences between the two populations: body weight, thyroid weight, adrenal weight, and litter size.

b. Plant Studies

A fraction of the radioactive effluent and fallout that is deposited on the leaves of plants is absorbed and translocated to edible portions of the plant. The fraction not absorbed also constitutes a potential health hazard. It may be eaten by animals; leaves themselves may be the edible portion of the plant (via., spinach and lettuce). The physical and biological factors that affect the retention and absorption of particulate and gaseous effluent by plants will be studied. Work will be accomplished by greenhouse and field plot studies, and by sampling of agricultural fields.

The new plant growth room was released to the Ecology Branch on December 1, 1958. This room has approximately 210 sq. ft. of floor space with 5 mobile benches with an area of 64 sq. ft. This room was especially designed for maintenance of conditions favorable for the growth of experimental plant material. The following features are included in this room.

The room temperature range is from 60 to 100 degrees F. and is maintained at predetermined temperatures by adjustable day and night thermostats which are automatically selected by the photoperiod control. Should the room temperature exceed or drop below preset temperatures an alarm system sounds. The photoperiod is automatically controlled and can be varied from 24 hours to 15 minute intervals.

The light source consists of 20 Power Groove fluorescent lights and 10-100 watt filament lights which produce approximately 1,300 foot candles at the bench level and can be reduced by raising the light bank. (Fig. XLIV).

Fig. XLIV. Plant Growth Room

D TALKS AND PUBLICATIONS

Papers presented:

1. IODINE METABOLISM IN WILD JACK RABBITS, N. R. French, presented at the Oklahoma Conference-Radioisotopes in Agriculture, U.S. Atomic Energy Commission, Oaklahoma State University, Stillwater, Oklahoma, April 2-3, 1959. (TID-7578)

2. BIOLOGICAL STUDIES AT THE NRTS, N. R. French, presented at the Annual Meeting of the Idaho Veterinary Medicine Association, Moscow, Idaho, June 20, 1959.

Chapter 8

SITE SURVEY

Percy Griffiths and George Wehmann

A SCOPE

The Site Survey Branch is responsible for the detection and evaluation of radiation in the physical environment outside areas specifically assigned to contractors at the NRTS. This function is accomplished by means of effluent controls and a waste management program.

The Branch also establishes standards and criteria for radioactive shipments and waste disposal, provides personnel and equipment for emergency radiation monitoring functions at the NRTS and under the Radiological Assistance Plan.

B SUMMARY OF MAJOR PROGRAMS

1. Environmental Monitoring

a. ANP - Initial Engine Test Facility (IET)

During the year the Branch was occupied in monitoring during power tests Nos. 14, 15, 17 and 18 at the Aircraft Nuclear Propulsion Area. Both mobile and fixed monitoring equipment was utilized. No radiation attributed to any of these tests was detected beyond the boundary of the NRTS.

b. Idaho Chemical Processing Plant (ICPP) - Rala

Sixteen Rala runs were made at the ICPP, all of which were monitored by the Branch at points beyond the operational area. Table 19 lists the approximate amounts of activity released to the atmosphere as the result of each Rala operation.

During Rala operations in the latter part of 1958, activity was detected in the field at a time when all off-gas was supposed to have been piped to storage. The activity could be detected with portable survey instruments but could not be collected on either filter paper or activated carbon. Shortly before the activity was detected, multi-curie quantities of radioactive xenon and krypton had been released into the off-gas line. Rare-gas fission products were suspected, apparently from a leak in the Rala off-gas system. To verify this, a sampler capable of collecting the inert gases was developed in cooperation with the Analysis Branch.

Table 19. Curies Released to Atmosphere Due to Rala Operations

Run Numbers	Date of Run	I-131	I-132	Beta Activity minus Iodine
001	February 1-3, 1957	230.	-	114.6
002	February 20-21, 1957	351.3	-	334.7
003	April 5-6, 1957	80.8	-	1.3
004	May 19-20, 1957	42.	-	6.6
005	June 24-25, 1957	158.7	-	6.8
006	September 11, 1957	103.4	-	5.7
007	October 7, 1957	201.7	-	14.8
008	October 21, 1957	234.7	-	25.7
009	January 6, 1958	35.1	-	27.1
010	February 12, 1958	154.6	-	26.6
011	March 13-14, 1958	55.6	-	12.6
012	April 16, 1958	34.9	-	9.2
013	April 30 - May 1, 1958	176.6	626.3	22.4
014	May 28, 1958	111.1	935.	28.7
015	June 2, 1958	205.8	119.	53.0
016*	August 6, 1958	27.7	9.9	14.9
017	August 13, 1958	75.3	18.7	77.6
018	October 1, 1958	70.6	310.6	62.7
019	October 22, 1958	45.6	498.8	30.6
020	October 22 - 23, 1958			
021	November 12, 1958	32.6	120.6	72.3
022	February 4, 1959	104.8	171.8	16.2
023	February 25, 1959	14.4	18.8	16.4
024	March 18, 1959	40.5	60.0	8.0
025	April 8, 1959	4.7	24.8	11.0
026	April 29, 1959	3.4	129.9	27.6
027	May 19, 1959	2.3	14.3	21.2
028	June 10, 1959	2.1	64.9	27.3
029**	July 6 - 7, 1959	9.3	79.5	8.6
030	July 21 - 22, 1959	6.4	183.5	8.5
031	August 11 - 12, 1959	2.1	61.4	18.0
032	September 1 - 2, 1959	4.4	29.8	4.0
033	September 22 - 23, 1959	5.0	37.2	4.6
034	October 13 - 14, 1959	14.0	9,953.6***	30.6
035	November 5 - 6, 1959	12.0	112.2	9.2
036	November 30, December 1, 1959	.4	.3	2.0
037	December 15 - 16, 1959	1.4	27.1	5.9
			10969	219.1

* Carbon Filter beds first utilized

** Start of "two-day" runs

*** Major portion of this release has been attributed to the criticality accident on October 16th.

The sampler, shown in Figure XLV, contained 450 grams of 12 to 30 mesh activated carbon. Six sampling units were placed at strategic locations both in the field and inside the ICPP area during several Rala runs. The average rate of flow of air through the sampler was 1 cfm. Quantities of radioactive xenon and krypton were collected which measured up to 3 R/hr at contact.

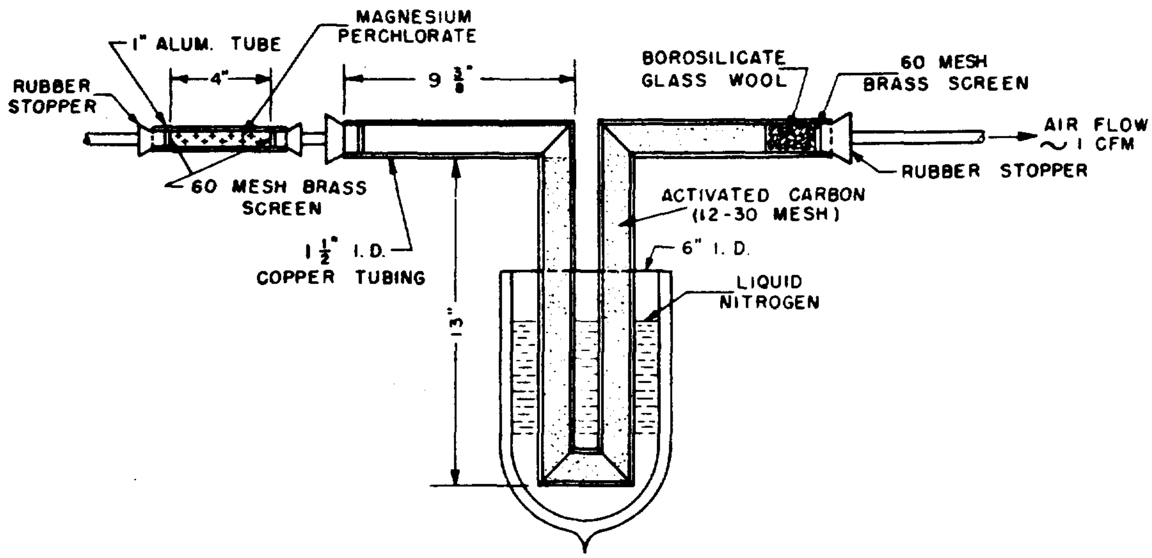

Fig. XLV. Chilled Carbon Sampler

Fig. XLVI shows one of the sampling units.

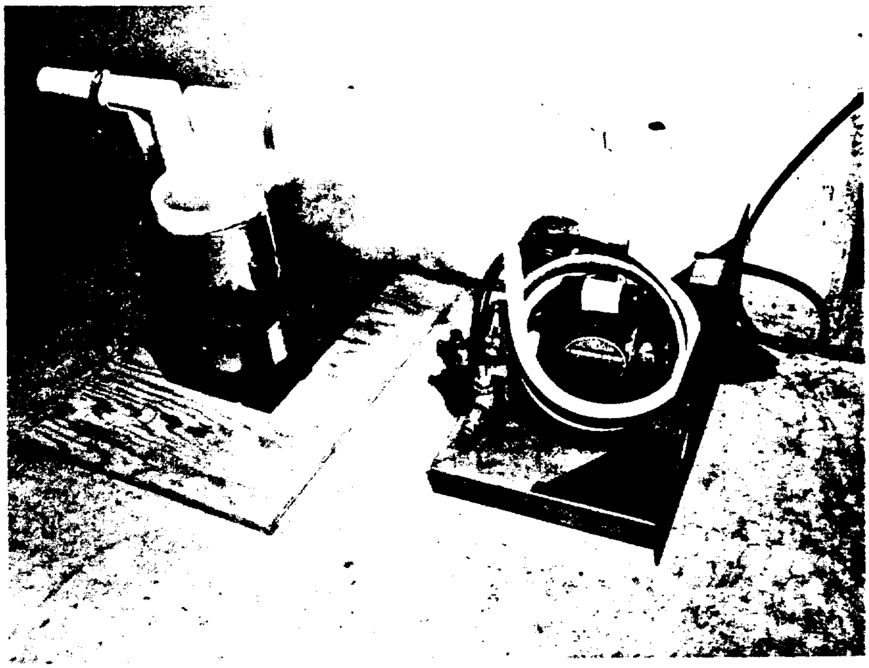

Fig. XLVI. Chilled Carbon Sampler

Two samplers were placed in series, as shown in Fig. XLVII, to determine the collection efficiency which was very nearly 100 per cent and dropped as low as 99 per cent in only one instance.

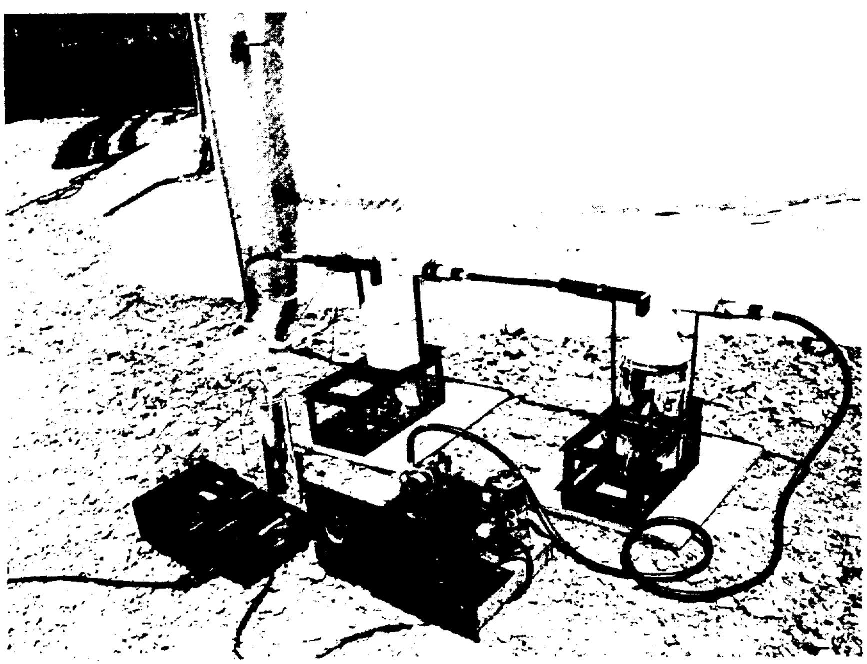

Fig. XLVII. Two Samplers in Series for Efficiency Tests

A complete description of this sampler is found in the paper, A METHOD FOR COLLECTION AND IDENTIFICATION OF RADIOACTIVE XENON AND KRYPTON which was presented at the Sixth Air Cleaning Seminar, July 7-9, 1959 in Idaho Falls, Idaho.

c. ICPP - Fuel Element Cutting Facility (FECF)

On October 30, 1958 a rupture of exhaust filters at the Fuel Element Cutting Facility resulted in the release of approximately 100 C of long half-life particulate activity to the south of ICPP. Periodic radiation surveys of the affected area have been made by the Branch. Two of the surveys are shown in Fig. XLVIII and Fig. XLIX.

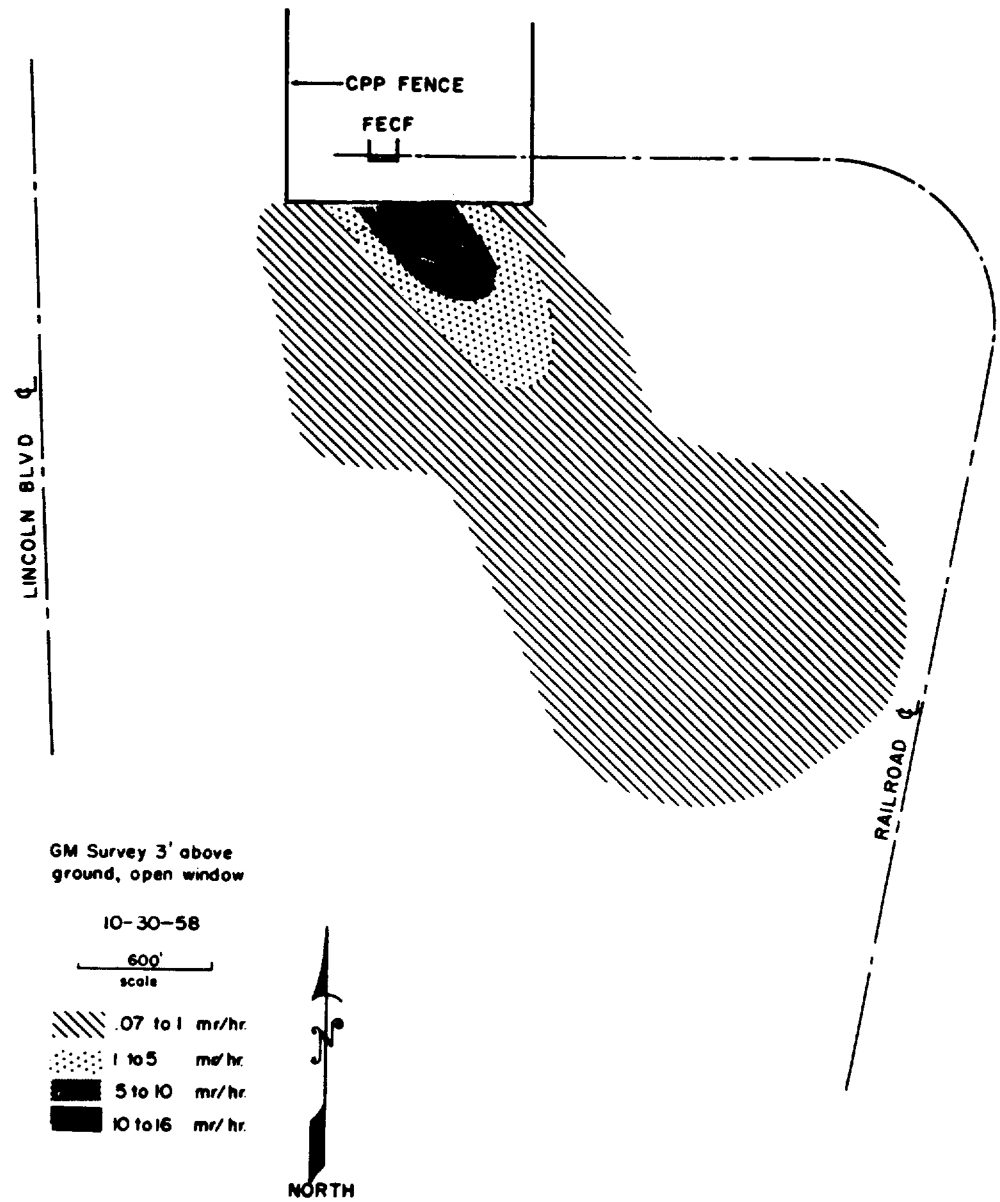

Fig. XLVIII. Initial Survey Following FECF Incident

The follow-up survey figure shows the result of radioactive decay and shift of contamination due to winds. Approximately 19 acres are still contaminated to an extent requiring access restriction.

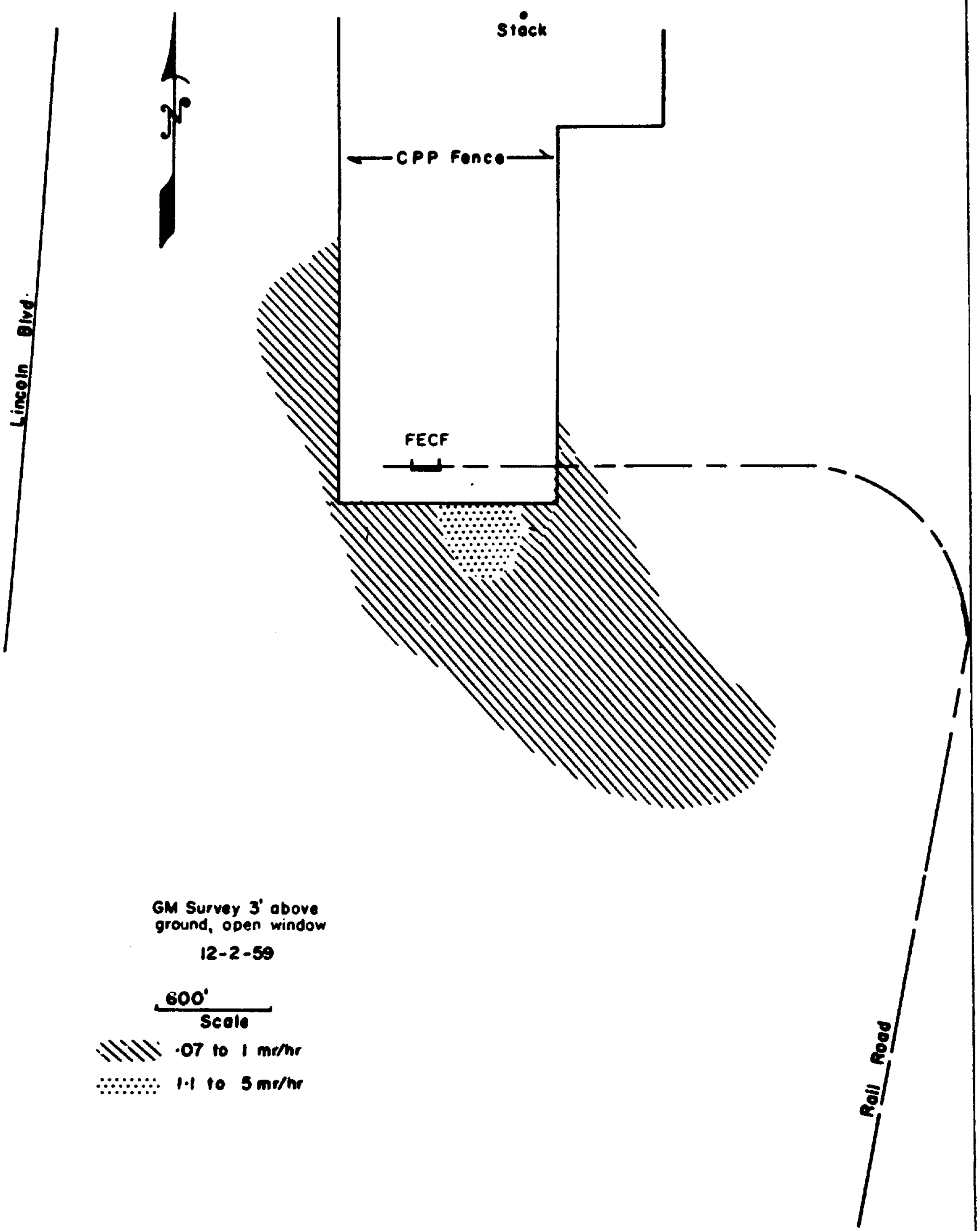

Fig. XLIX. Follow-Up Survey of FECF Incident

d. Radioactive Iodine Monitoring

Continuous air sampling for radioactive iodine was conducted at 8 stations on the NRTS. The average rate of flow of the samplers was 1 cfm. The field cartridge sampler shown in Fig. L contains 12 to 30 mesh activated carbon.

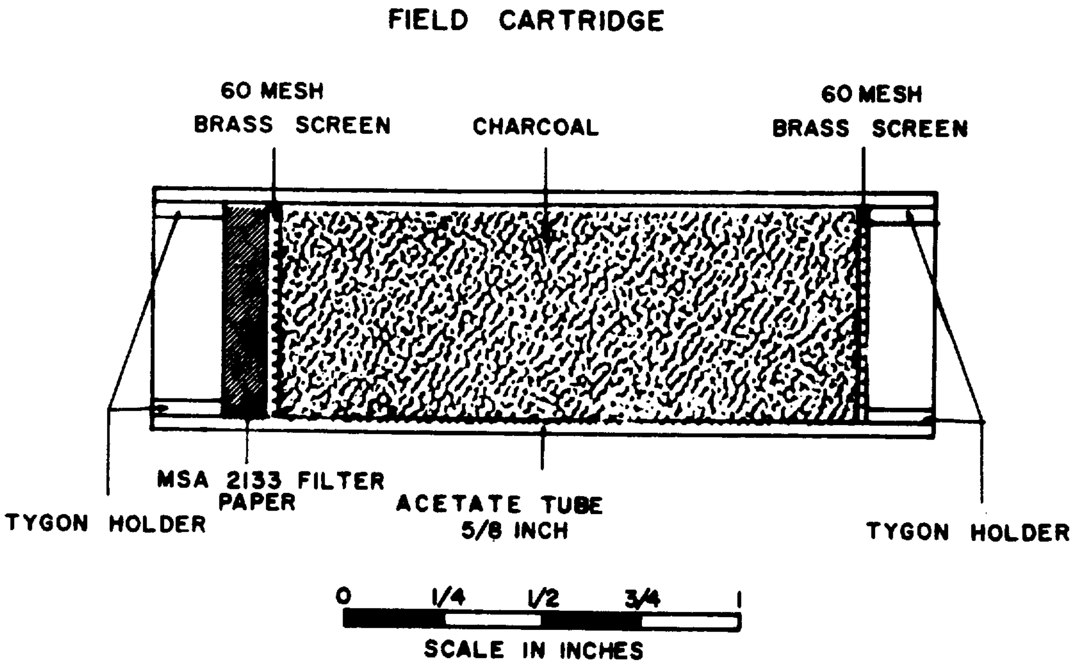

Fig. L. Field Cartridge

The calculated infinity thyroid dose was obtained by counting the activity collected on the carbon and assuming all activity to be due to iodine-131. The station locations and annual dose isopleths are shown in Fig. LI.

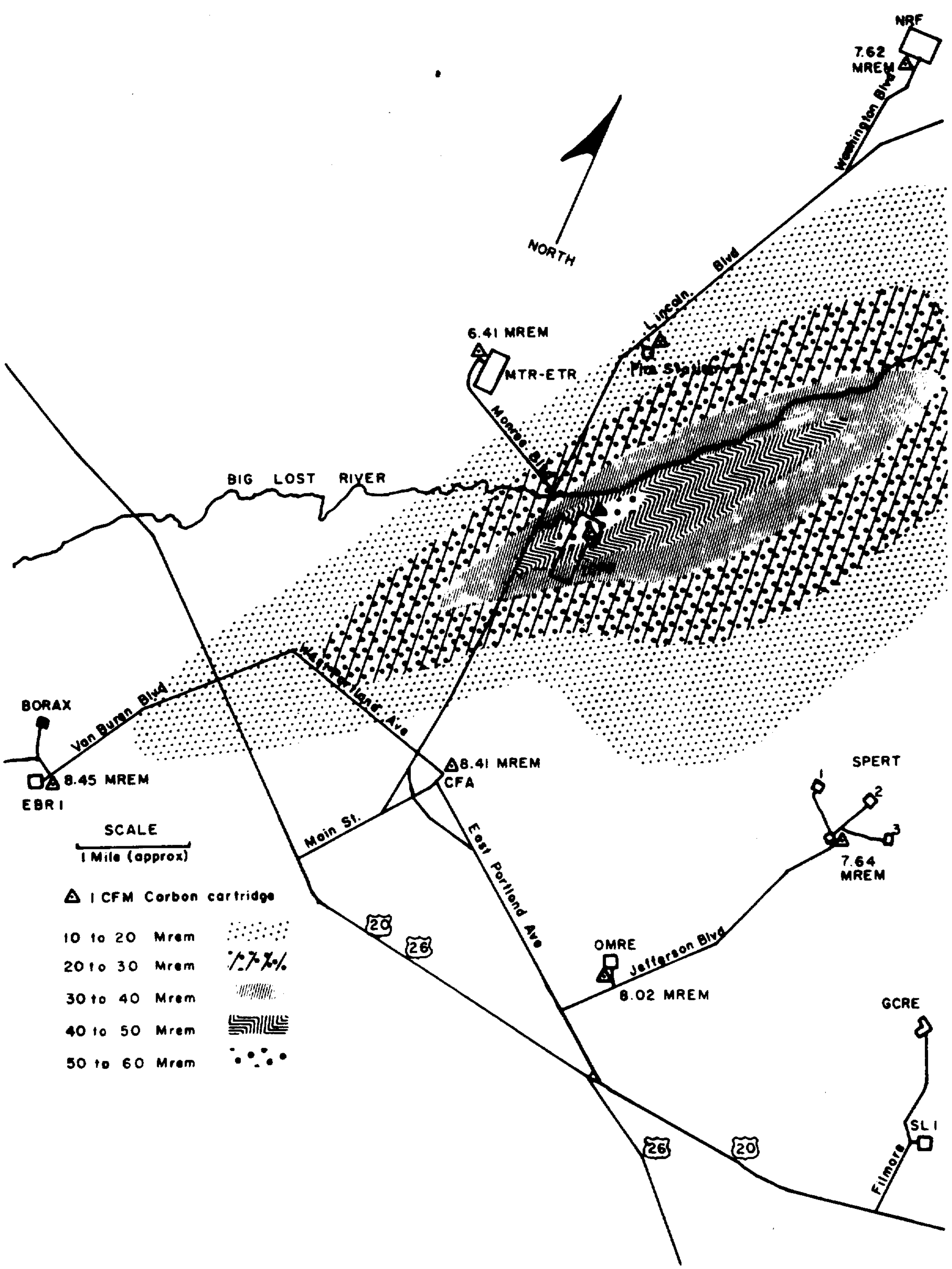

Fig. LI. 1959 Infinity Thyroid Dose from ICPP Operations

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e. Weapons Test Fallout Program

The monitoring program in connection with weapon test fallout was continued during 1959. Samples were collected at a station in Idaho Falls and at Central Facilities Area of the NRTS. The results are summarized in Table 20.

Table 20. Weapons Test Fallout Program

	Air Concentrations ($\mu\mu c/m^3$)					
	Idaho Falls			CFA - NRTS		
	High	Low	Avg.	High	Low	Avg.
January	16	6	11	19	6	13
February	13	4	8	14	7	11
March	13	4	8	26	9	12
April	14	5	9	26	8	13
May	16	6	10	24	9	13
June	16	6	11	35	5	16
July	14	2	7	20	4	12
August	11	2	5	18	4	10
September	8	2	5	23	8	11
October	5	1	3	19	3	8
November	5	1	2	24	1	8
December	10	1	4	28	4	14

The average air concentration (uuc/m^3) at the Idaho Falls station for the period April 1958 to December 1959 is shown in Fig. LII. It should be noted that there has been a gradual reduction in fallout since the discontinuance of weapon tests in the fall of 1958.

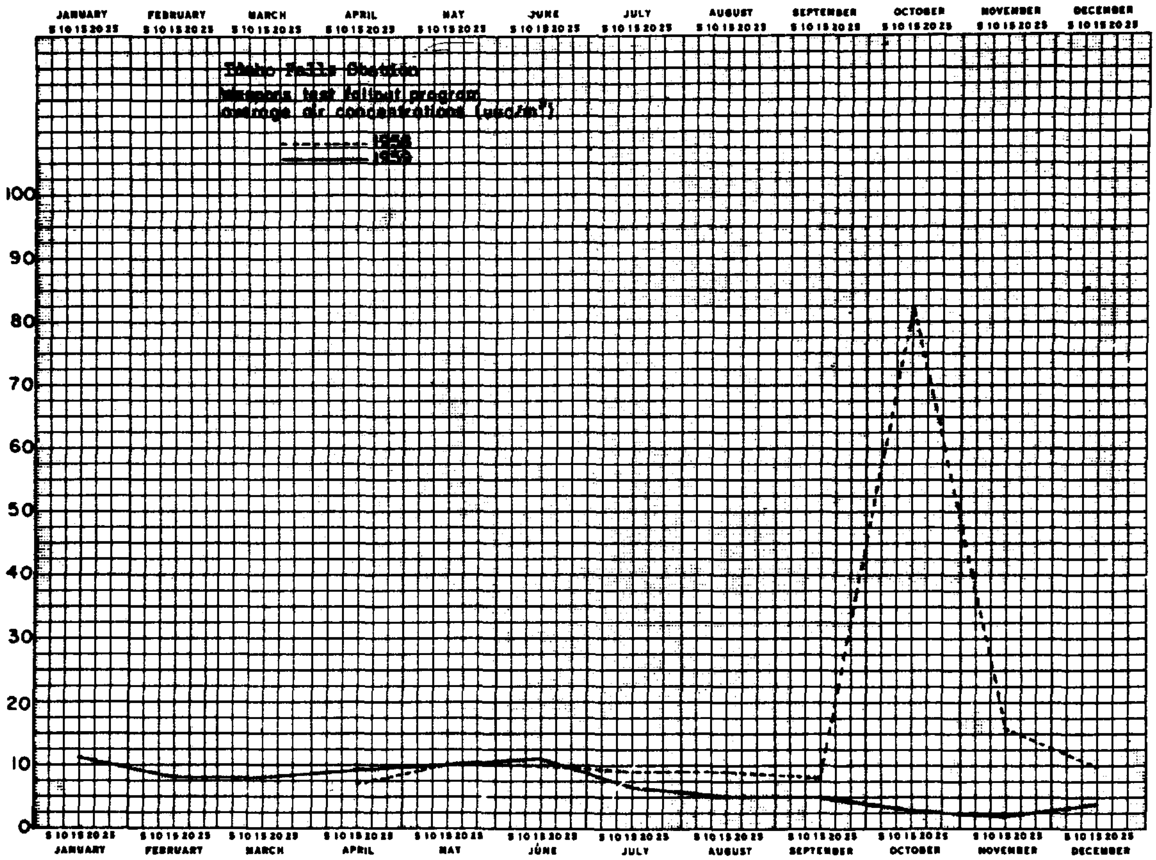

Fig. LII.

f. External Radiation Monitoring Program

Film badges were located at 30 stations throughout the NRTS as a means of area monitoring for external radiation. Fig. LIII shows the average monthly dose in millirem due to gamma radiation. Estimates of external doses downwind of ICPP as the result of the criticality incident of October 16, 1959 were determined by this program.

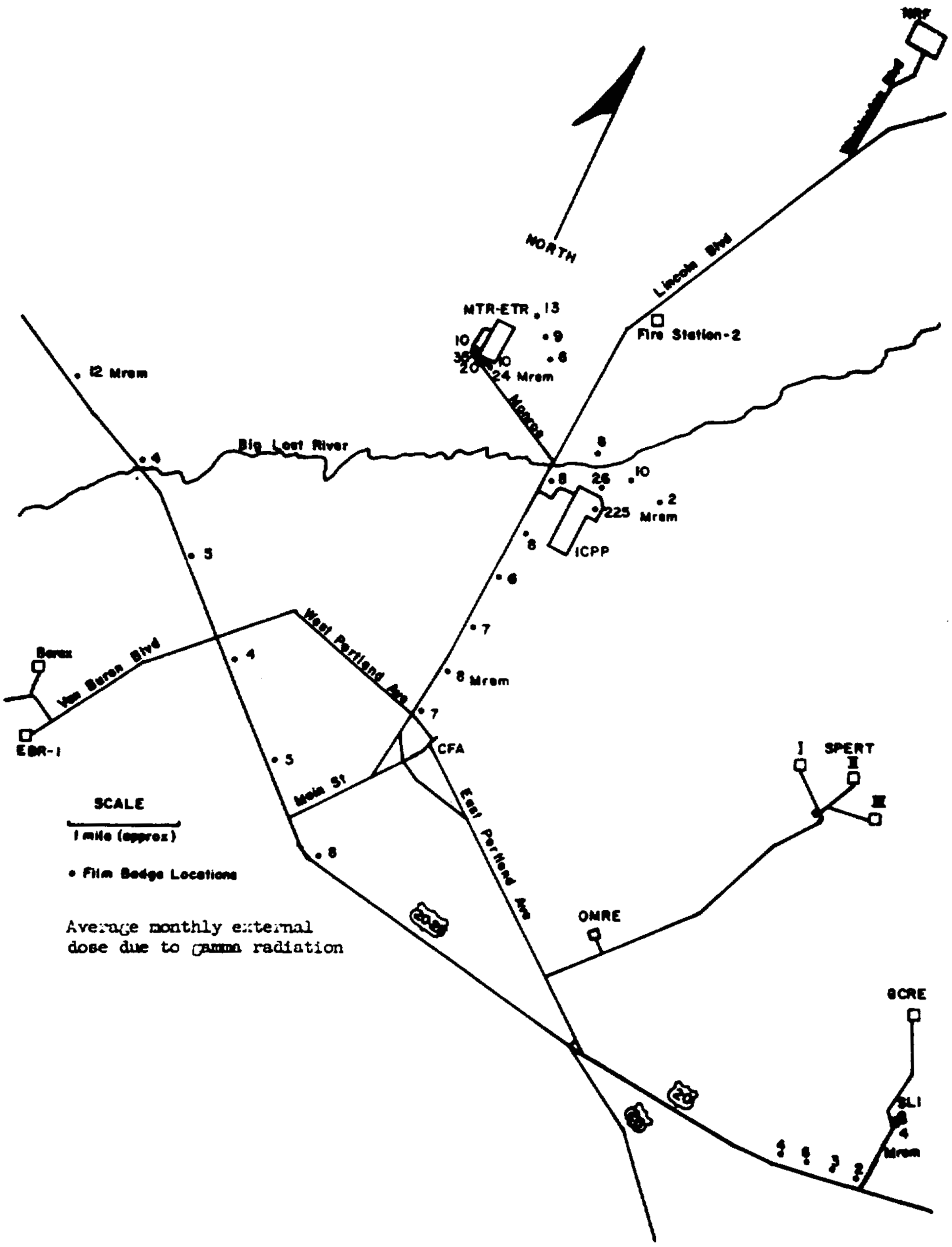

Fig. LIII. NRTS Film Badge Locations and Gamma Radiation Levels

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g. Ground Contamination Survey Program

During the summer of 1959 a survey program was initiated to determine the extent of radioactive material deposited on the ground surrounding three major facilities. Standard GM survey meter readings were made at approximately 3 feet above ground at 500 foot intervals with the probe shield open. The results of these surveys are summarized in Fig. LIV and LV. Special permission was obtained to extend NRTS Test Grid #4 within the ICPP perimeter fence and measure the radiation at those locations.

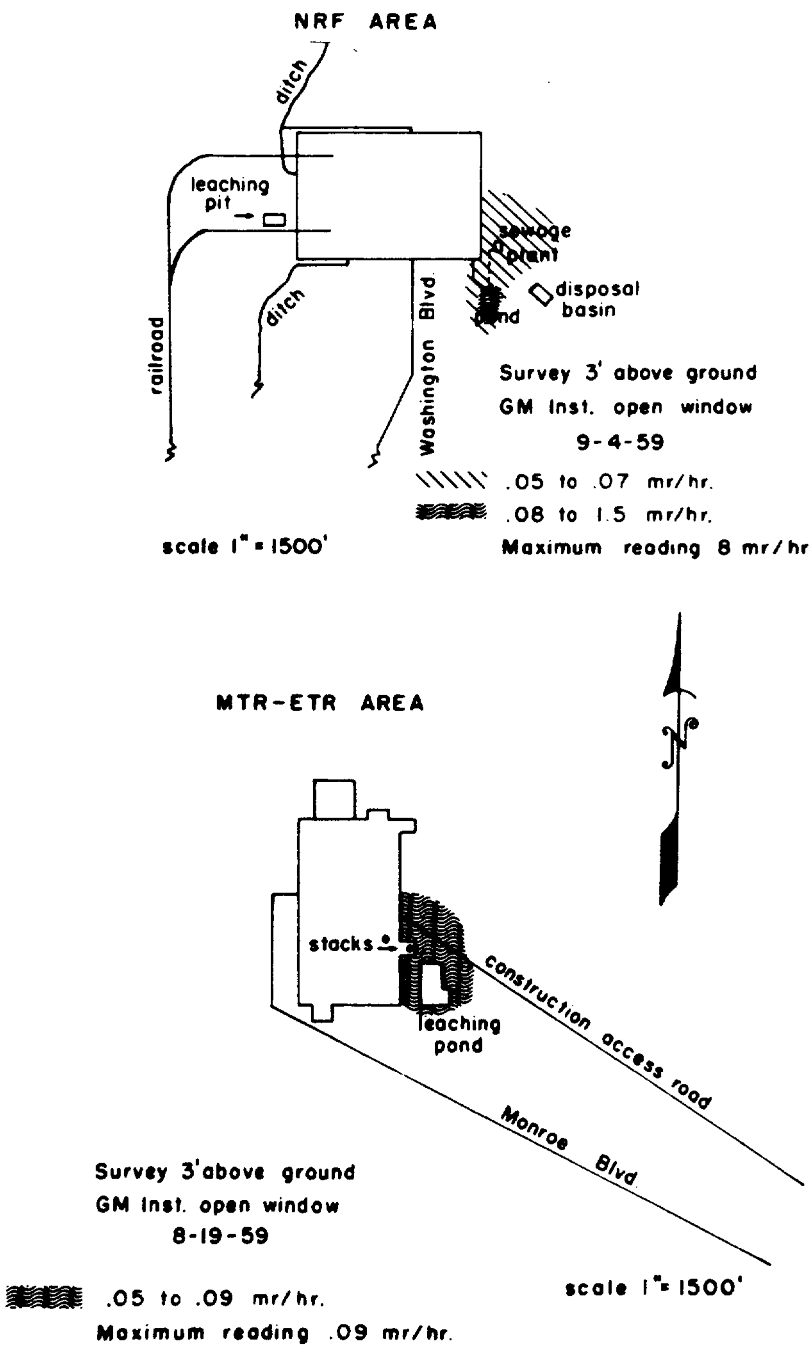

Fig. LIV. Ground Survey of Area Surrounding NRF and MTR-ETR

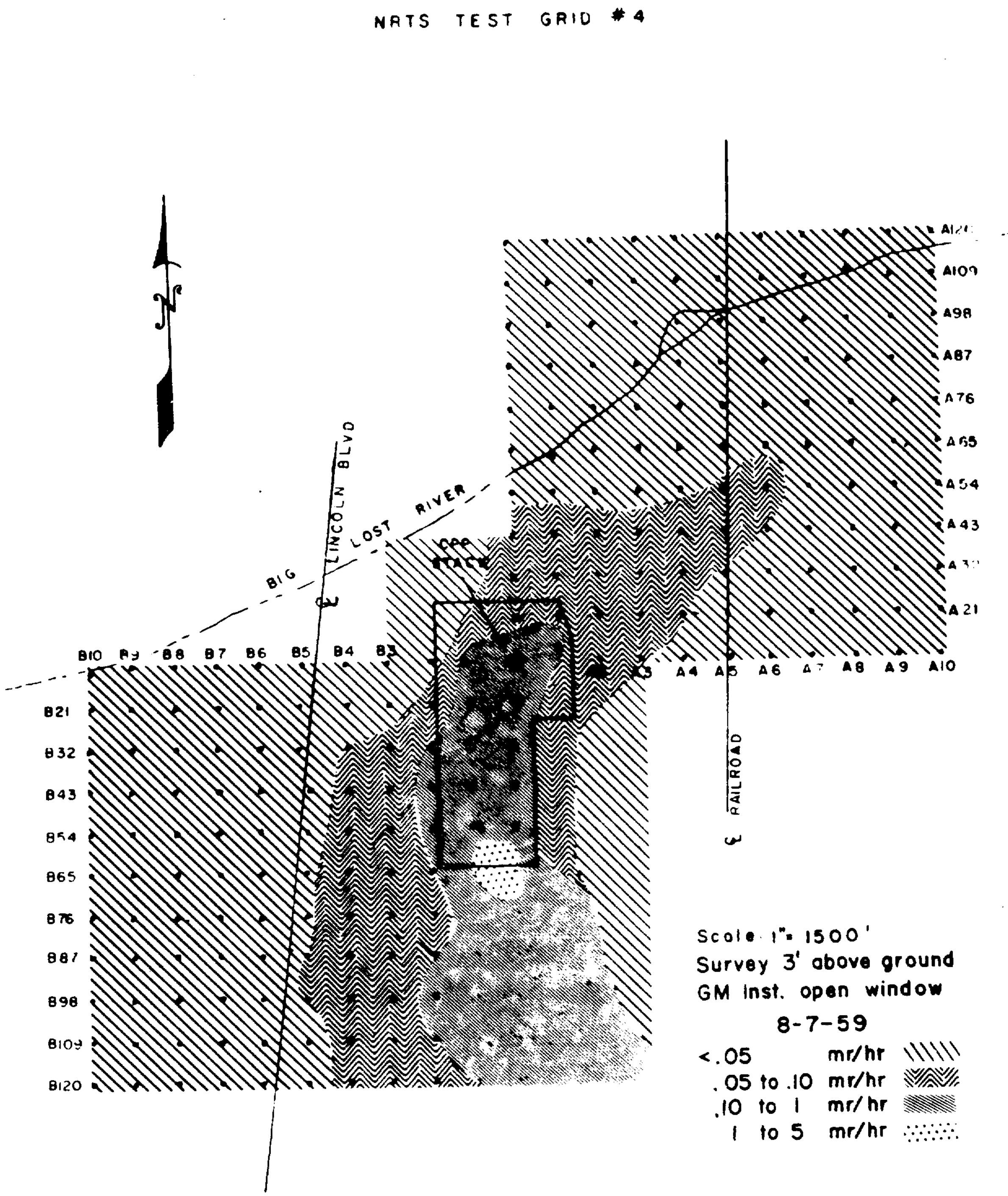

Fig. LV. Ground Survey of ICPP and Surrounding Area

C SPECIAL ACTIVITIES

1. Aerial Radiation Survey of the NRTS and Environs

The Site Survey Branch cooperated with the U. S. Geological Survey during August and September in conducting a survey of the area surrounding the NRTS for the Division of Biology and Medicine. The area surveyed extended approximately 100 miles northward from and east-west line through Pocatello, Idaho and 100 miles westward from a north-south line five miles east of Idaho Falls. The survey was conducted with scintillation detection equipment installed in a DC-3 type aircraft.*

Fig. LVI shows the radiation levels at 500 foot flight elevation expressed in counts per minute. Radioactivity levels range from 300 to 1700 cps. The sediments in the Valley of Birch Creek and the areas included in the vicinity of Mud Lake and the American Falls Reservoir had the lowest radioactivity levels, 300 to 600 cps. Those in the valley of the Little Lost River ranged from 400 to 700 cps; and those in the Valley of the Big Lost River from 400 to 1000 cps.

Radioactivity levels of the lava covered areas ranged from 300 to 400 cps over the lava flows about 15 miles west and southwest of Idaho Falls to 1100 cps over the serrate lava flows north of the Craters of the Moon National Monument.

The rhyolite and trachyte rocks composing the Big Southern Butte and the East Butte showed radioactivity levels between 1400 and 1600 cps.

The highest radioactivity reading (up to 1700 cps) within the survey area, attributable to natural causes, were obtained along a southern flank of the mountains north and northwest of Mud Lake. These readings can generally be correlated with exposures of rhyolitic rocks containing radioactive ores or with streams draining such areas. A few high readings (800 to 1200 cps) were obtained over silicic volcanic rocks along the southern flank of the mountains west of the Craters of the Moon.

This data indicates that there is no accumulation of radioactivity beyond the NRTS as a result of past operations.

The survey is expected to be of value in establishing a baseline for the evaluation of future surveys.

*Davis, F. J., and Reinhardt, P. W., 1957, INSTRUMENTATION IN AIRCRAFT FOR RADIATION MEASUREMENTS; Nuclear Sci. and Eng., Vol. 2, No. 6, P. 713-727.

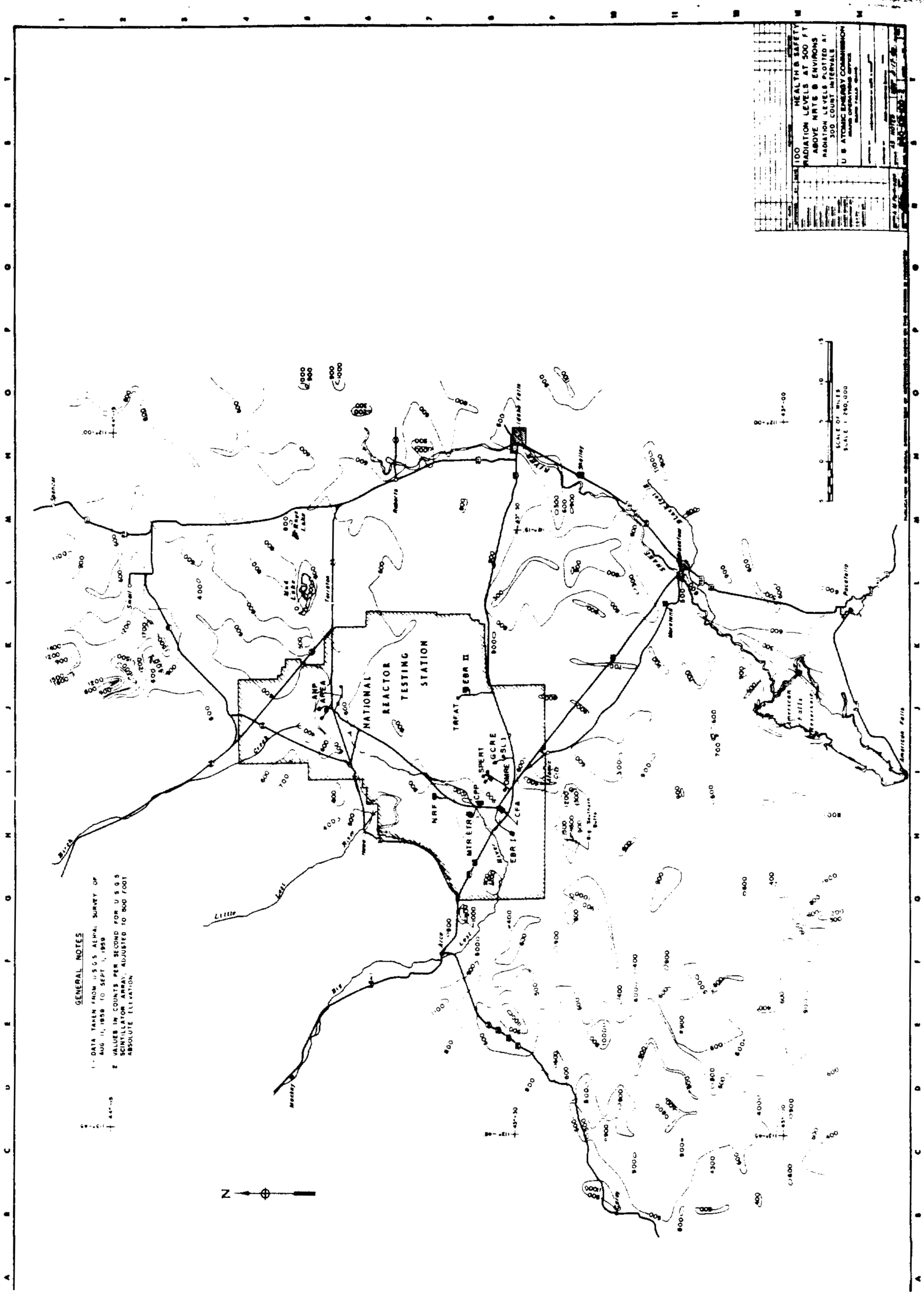

Fig. LVI. Aerial Survey of NRTS and Vicinity

2. Air Cooled Experiments - ETR

During 1959 the Branch monitored three single-pass air cooled experiments at the ETR. Although an elaborate filtering system is provided, there is a discharge of radioactive material to the atmosphere via the 250 foot stack during these experiments. Table 21 summarizes the types and amounts of radioactive material released to the atmosphere as the result of these experiments.

Table 21. Air-Cooled Experiments - ETR - 1959

Experiment Number	Date Completed	Activity Discharged Curies		
		Particulate	Gaseous	Volatiles
5-4	June 14, 1959	27	1,413	445
5-5	August 27, 1959	4	26	1
5-7	December 18, 1959	4	25	1

The Branch had a dual purpose in monitoring these experiments. The primary reason was to determine the degree of dilution from the stack to the point of maximum ground concentration. This monitoring data also served as a useful guide in determining the operating limits of future experiments.

Monitoring results indicate that a maximum dose rate of 0.5 mr/hr was observed approximately one mile downwind near the conclusion of the 5-4 experiment. No significant radiation levels were detected during either the 5-5 or 5-7 experiment. Thus far, it seems that the operating limits for future experiments will be set by in-plant problems and not by the activity discharged to the atmosphere.

3. Radioactivity in ICPP Production Well

Concentrations of gross-beta radioactivity were detected above normal background detection limits (1.5×10^{-7} uc/ml) in samples of well water from the production well #1 at the ICPP during the period April through November. This condition was also noticed in well #2 during the period July through August. (See Fig. LVII). The isotope was identified as ruthenium-106 and the concentration was considerably below the maximum permissible level for continuous consumption (10^{-4} uc/cc) but the source of the contaminant was a matter of concern. The content of sodium, chloride and nitrate ions was normal.

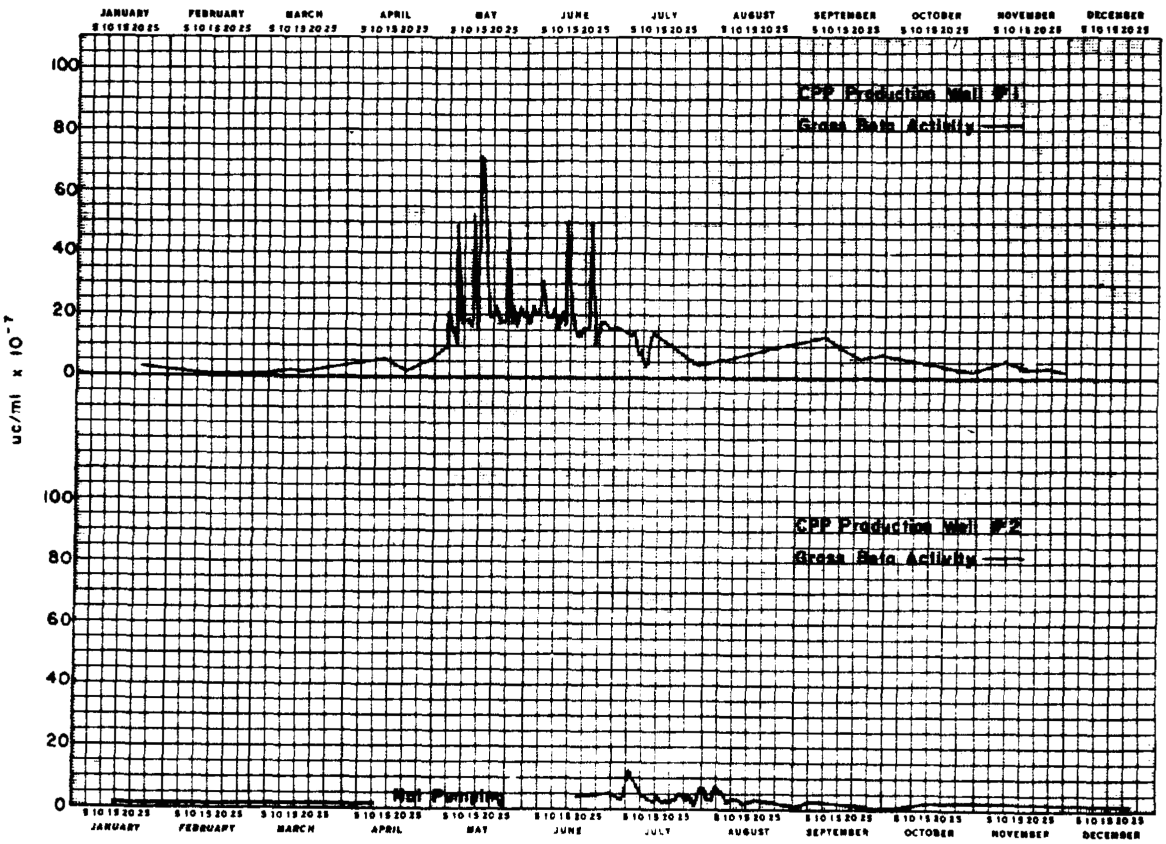

Fig. LVII. Ruthenium-106 Contamination in CPP Production Wells

The low level radioactive waste discharged into the ground water through the disposal well was a logical and first suspected source, although prior to this time it had been assumed that the flow of ground water was in a southwesterly direction, opposite to the direction of the production wells. An analysis of the ground water hydrology resulted in the conclusion that a reversal of the regional water gradient could conceivably occur if pumping occurred at a rate of 1000 gpm. This would result in pumping back of discharged waste. Actually 1,500 gpm was pumped during January and February but this reversal of gradient flow was not substantiated by analysis of data obtained from the chemical and radiological analysis of water samples from the production well or from observation wells south and west of the disposal well.

Another explanation considered was that solutions entering the ground at elevations above the regional ground water table would probably concentrate in a "perched" zone which could slope in any direction. If this occurred and the water moved to the north, it could enter the production wells from above the water table.

Investigation revealed that fire lines and also service lines carrying contaminated solutions to the disposal well had been leaking. "Perched" water tables were also found by drilling two observation wells in the vicinity. These findings supported the latter hypothesis.

4. Criticality Incident - ICPP

At approximately 0250 MST on October 16, 1959, a criticality incident occurred at ICPP. All available Branch personnel and equipment were utilized in evaluating the hazard outside of the plant area and also were made available to the contractor. This included the use of the emergency decontamination trailer until similar facilities within the plant could again be used. Aerial monitoring was used in an attempt to locate any radioactive clouds. Eight special air monitoring stations were also maintained downwind until the situation was restored to normal.

A detailed report of this incident can be found in the publication, IDO-10035.

5. Plutonium Release - ICPP

During the period July 9-11, 1959 approximately 105 millicuries of plutonium were released to the atmosphere at ICPP. The release was the result of burning plutonium contaminated waste solvent. The points of release were believed to be ventilation ports in the furnace box of the waste solvent burner and the exhaust line venturi which is approximately 20 feet above the ground level.

Ground surveys for alpha contamination were conducted in the vicinity of the burner building and extending to beyond the calculated distance of maximum concentration. The only positive results were found 75 feet from the burner building, where approximately 100-300 counts per minute of alpha activity was noted. Three soil samples, each containing approximately 50 grams taken from a 4 square inch area, were collected from this area. Analysis of samples indicated 2700, 3650 and approximately 10,000 d/m per sample. Specifically, 85-88% of the activity in the latter sample was due to plutonium-238 and 12-15% due to plutonium-239.

Continuous air monitoring was maintained in the area when the solvent burner was in operation. Due to the delays in obtaining quantitative results by standard monitoring methods, a special high volume annular impactor (See Chapter 6) was used. Analysis of field samples indicated that maximum permissible concentrations were not exceeded. Special in-plant processing to reduce the amount of plutonium in the solvent and changes in the burning process has reduced the concentration to below detection limits.

D ROUTINE ACTIVITIES

1. Shipments

a. Off-Site Shipments

During 1959, the Branch processed 791 shipments leaving the NRTS, with 125 of these requiring excess curie permits. Table 22 is a summary of outgoing shipments since 1955. All outgoing shipments were checked for compliance with regulations.

Table 22. Summary of NRTS Off-Site Shipments

Year	No. of Shipments
1955	449
1956	649
1957	617
1958	1007
1959	791

b. On-Site Shipments

Table 23 summarizes by facility the 2134 on-site shipments made during 1959, excluding contaminated laundry and radioactive waste for burial.

Table 23. Number of On-Site Shipments-NRTS-1959

Facility	No. of Shipments
MTR	810
CPP	406
OMRE	244
ETR	225
ANP	153
NRF	91
SPERT	79
CFA	73
SL-I	29
EBR-I	21
TREAT	3
TOTAL...	2134

2. Waste Disposal Management

a. Liquid Waste

During 1959, approximately 612 million gallons of water containing an estimated 5,066 curies of radioactive isotopes were discharged to the environment. Table 24 lists the liquid waste discharged to the ground by facility.

Table 24. Liquid Waste Discharged to the Ground at NRTS-1959

Facility	Gallons	Curies
ICPP	335,792,000	59.2
MTR-ETR	230,000,000	4,826.0
NRF	20,042,000	9.4
ANP	16,227,000	18.0
CFA	9,460,000	0.5
SPERT I & III	675,000	152.5
OMRE	8,000	0.2
SL-1	12,000	0.2
ANL	None	--
TOTAL...	612,216,000	5,066.0

Further breakdown of liquid waste discharged to the ground by month and predominate isotope for the ICPP, MTR-ETR, ANP, NRF, and SPERT I and III are found in Tables 25 through 29 respectively.

Table 25. Liquid Waste Discharged to Ground - MTR-ETR - 1959

Month	Gallons (x 10^3)	Curies*	No. of Isotopes Identified	% of total isotopes with half-lives 10 day	10-100 day	100 day	Unidentified
January	13,000	197	3	---	Unknown	---	---
February	13,200	207	3	---	"	---	---
March	8,810	39	4	---	"	---	---
April	14,900	217	4	---	"	---	---
May	15,170	204	4	---	"	---	---
June	18,600	581	4	---	"	---	---
July	13,600	78	16	44%	36%	---	20.
August	18,000	2,020	21	23%	1%	---	75.
September	20,740	160	27	91%	6%	1	2.
October	19,800	193	29	90%	6%	4	---
November	22,300	661	28	53%	9%	---	38.
December	21,520	269	28	30%	2.5%	0.2	67.3
Sub-total	199,640	4,826 1/					
MTR Canal leak 2/	35,360						
TOTAL...	235,000						

1/ Does not include 0.25435 c of alpha emitting isotopes

2/ Estimate involves amount of water escaping through a leak in the MTR canal which became progressively larger during the year. Amount of radioactive contamination could not be monitored, however spot samples of canal water exceed 0.5 curie per day of short-half-life material.

* Beta plus gamma

Table 26. Liquid Waste Discharged to Ground - ICPP - 1959

Month	Gallons (x 10^3)	Radioactivity (curies) I-131	Zr-95	Nb-95	Ru-106	Rh-106	Ce-144	Sr-90	Other	Total
January	47,220	.2		1.1		1.4	12.0	.7	.8	16.2
February	45,397	2.0		.4		.2	4.0	.5	.4	7.5
March	31,353	.3		.3		.6	---	---	.8	2.0
April	27,799	.5		1.6		.2	.5	---	.3	3.1
May	29,360	.2		.4		.8	1.1	---	.2	2.7
June	31,630	.5		.3		.3	1.0	---	.1	2.2
July	27,025	1.2		.2		.3	.9	.2	.4	3.2
August	20,413	.9		.6		.8	.5	---	.4	3.2
September	18,193	.2		.2		.8	.7	.1	.3	2.3
October	14,600	1.4		---		.4	.5	.3	1.1	3.7
November	16,691	3.1		1.8		---	---	.3	.3	5.5
December	26,111	5.2		.5		.3	.4	.4	.8	7.6
TOTAL...	335,792	15.7		7.4		6.1	21.6	2.5	5.9	59.2

Table 27. Liquid Waste Discharged to Ground - SPERT I - III - 1959

Month	Gallons (x 10^3)	Curies	Predominant Isotope
January	314	4.101	Sr-89-90
February	16	19.750	Sr-89-90
March	69	102.100	Sr-89-90
April	24	1.742	Sr-89-90
May	52	28.680	Sr-89-90
June	44	.031	Sr-89-90
July	101	.041	Ce-141-144
August	11	.131	Ce-141-144 - Sr-89
September	8	.013	Ce-141-144 - Sr-89
October	8	.009	Ce-141-144 - Ru-106
November	19	.001	Sr-89
December	9	.001	Zr-95 - Nb-95
TOTAL...	675	156.6	

Table 28. Liquid Waste Discharged to Ground - ANP - 1959

Month	Gallons (x 10^3)	Curies	Predominant Isotopes
January	1,660	.4	Zr-Nb-95
February	1,180	.4	Cs-137
March	1,060	.1	Sr-89-90 - Cs-137
April	1,250	1.3	Zr-Nb-95
May	946	.1	Zr-Nb-95 - Ce-144
June	1,940	0.1	Zr-Nb-95 - Ce-144 - Ru-
July	1,180	0.1	Ce-144 - Ru-103
August	1,430	0.1	Zr-Nb-95 - Ce-144
September	2,160	0.3	Zr-Nb-95 - Ce-144
October	1,171	0.2	Zr-Nb-95
November	1,180	5.7	Zr-Nb-95 - Ce-144 - Sr-
December	1,070	9.6	Na-24
TOTAL...	16,227	18.4	

Table 29. Liquid Waste Discharged to Ground - NRF - 1959

Month	Gallons (x 10^3)	Curies	Predominant Isotope
January	1,016	.531	Cs-134-137 - W-187 - Na-24
February	1,054	.593	" " "
March	1,193	.611	" " "
April	1,791	.364	" " "
May	1,539	.298	" " "
June	2,021	3.366	" " "
July	1,483	1.286	" " "
August	1,566	.575	" " "
September	957	.648	" " "
October	2,670	.758	" " "
November	2,330	.134	" " "
December	1,522	.231	" " "
TOTAL...	19,142	9.395	

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b. Liquid Waste Research

The U. S. Geological Survey staff was supplemented with the assignment of a ground water hydrologist, Mr. Paul Jones. This addition provides a full time technical consultant at the NRTS.

The cooperative program with the USGS continued for the purpose of determining the flow patterns, rate of movement and dilution of discharge liquid waste. Under this program four observation wells were drilled near the ICPP during 1959, bringing the total completed to nineteen. Six hundred and twenty-nine samples were collected from these wells during the year as a part of our observation program. One of these wells, USGS Well #50, was temporarily abandoned after an attempt failed to seal off perched water which was encountered at 87 feet. Well #51 was begun in November and should be completed early in 1960. A monthly summary of contamination levels in monitoring wells near the ICPP are found in Table 30. Fig. LVIII shows isopleths of radioactive contamination in underground water. The concentration isopleths are expressed in microcuries per milliliter and represent the mean gross beta activity of all samples taken in 1959. The detection limit for gross beta radioactivity in liquid is 1.5×10^{-7} uc/ml.

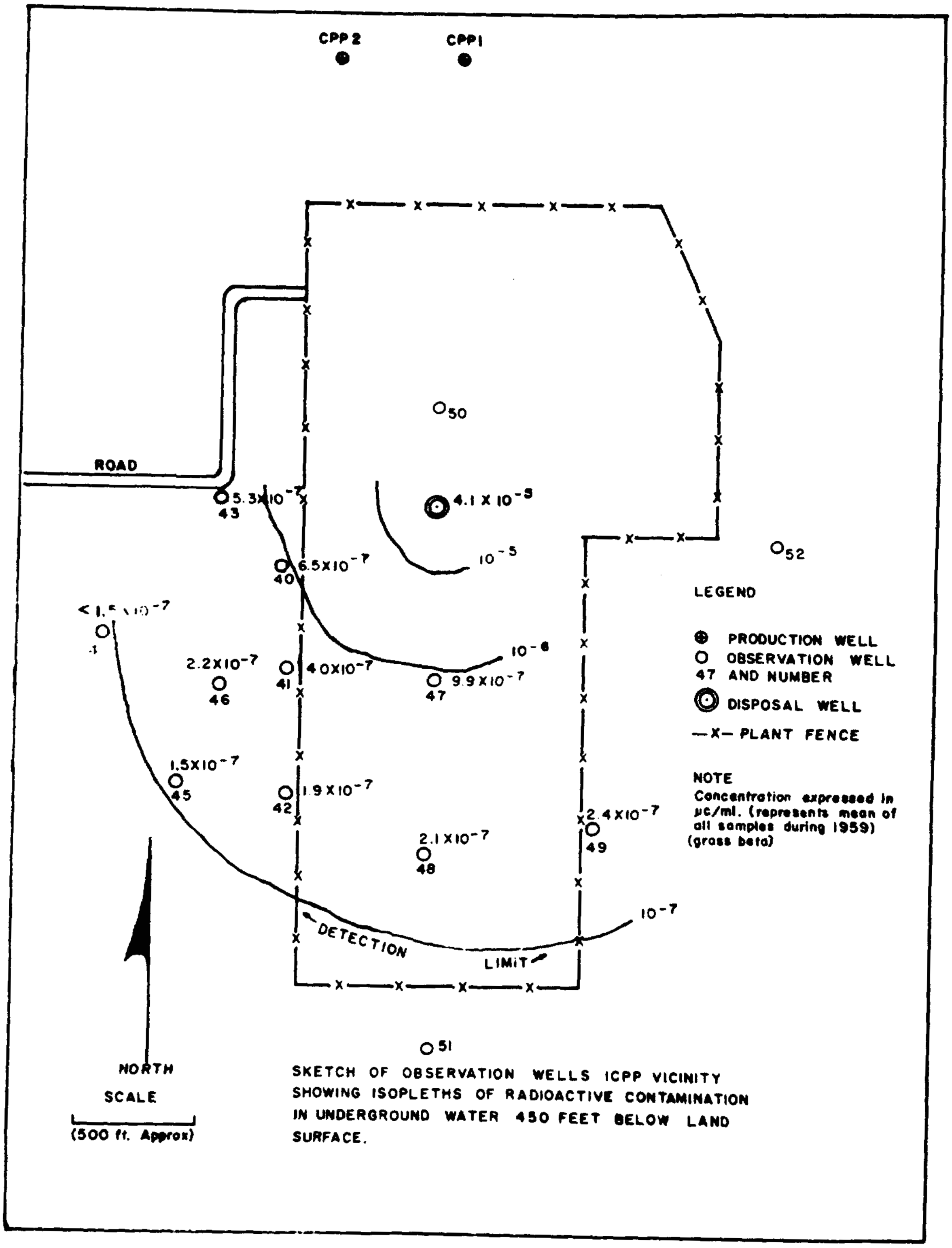

Fig. LVIII.

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Table 30. CONTAMINATION LEVELS IN MONITORING WELLS NEAR ICPP - 1959
[Mean Gross Beta Activity (uc/ml x 10^{-7})]

U.S.G.S. WELL NUMBERS

MONTH	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49**	50***	52***
Jan.	*	*	*	*	*	*	5.6	3.6	1.6	8.4	*	*	*	8.6	*			
Feb.	*	*	*	*	*	*	5.7	4.2	*	5.1	*	*	2.2	10.0	2.2			
March	*	*	*	*	*	*	4.7	3.1	*	2.6	*	*	*	9.9	*			
April	*	*	*	*	*	*	4.9	2.5	1.6	1.9	*	1.6	*	11.9	2.1			
May	*	*	*	*	*	*	8.3	3.0	*	3.5	*	*	*	12.2	1.7			
June	*	*	*	*	*	*	7.0	5.3	*	7.2	*	*	*	9.5	2.2			
July	*	*	*	*	*	*	8.5	6.7	2.1	8.1	*	1.9	1.9	11.0	2.4			
August	*	*	*	*	*	*	5.4	4.3	*	5.2	*	*	3.1	7.3	2.3			
Sept.	*	*	*	*	*	*	7.5	4.4	1.7	5.9	*	*	1.9	10.6	2.4			
Oct.	*	*	*	*	*	*	8.1	4.2	1.7	4.5	*	*	1.8	8.2	2.5	2.0		
Nov.	*	*	*	*	*	*	6.8	3.9	1.9	4.2	*	*	4.1	7.4	2.4	3.6	83.5	74.0
Dec.	*	*	*	*	*	*	6.6	2.9	*	3.8	*	*	3.5	4.7	*	*	30.6	273.8
Yearly Mean							6.6	4.0	1.6	5.0			2.2	9.3	2.1	2.4	57.1	173.9

* Less than the detection limit of 1.5 x 10^{-7} uc/ml.
** Well Number 49 completed October 24, 1959
*** [illegible] Perched Water Zone

Approximately one hundred and sixty-two water samples were obtained from 28 off-site locations shown in Fig. LIX. All samples were analyzed and found to contain less than 1.5×10^{-7} uc/ml, gross beta activity

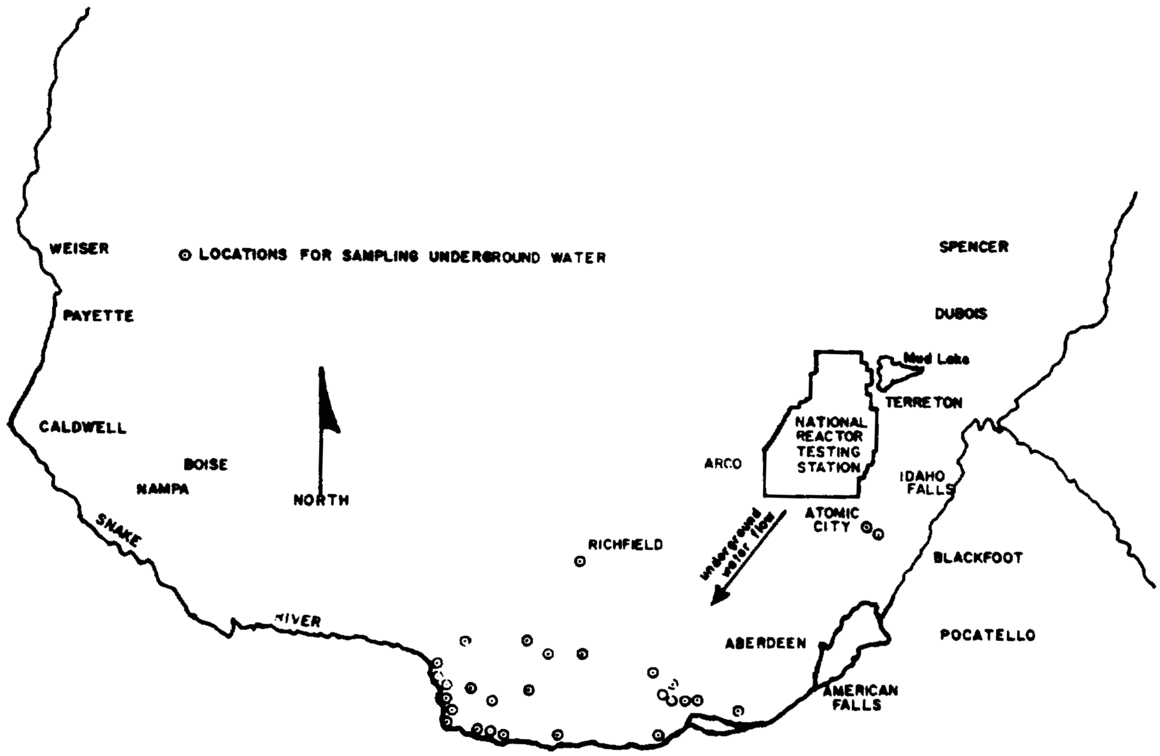

Fig. LIX. Off-Site Underground Water Sampling Stations

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c. Solid Waste

During 1959 a total of 3,582 cubic yards of solid radioactive waste containing approximately 23,130 curies of activity were generated at the NRTS. This waste plus an additional 2,283 cubic yards containing approximately 575 curies from other sources was disposed of in the NRTS Burial Ground. Table 31 contains a breakdown of this waste.

Table 31. Solid Waste Disposal NRTS Burial Ground 1959

Facility	Cubic Yards	Curies (estimate)
ICPP	1,378	1,536
MTR-ETR	931	10,139
NRF	796	7,625
ANP	134	1,915
OMRE	279	104
SPERT	3	negligible
ANL	57	1,810
SL-1	5	negligible
Other	2,283	575
TOTAL...	5,866	23,704

Table 32 shows a summary of solid waste disposed at the NRTS since 1952. The data prior to 1959 have all been estimated and includes a bulking factor. The 1959 values are the actual measured volumes.

Table 32. Summary of Solid Radioactive Waste Disposed at the NRTS Burial Ground

Year	Curies	Volume (Cubic Yards)
1952	70	--
1953	800	2,000
1954	1,500	--
1955	1,500	2,500
1956	10,000	5,000
1957	15,000	6,500
1958	10,000	9,000
1959	23,130	5,865

3. Atmospheric Waste Discharge

Approximately 191,600 curies of gaseous and particulate material were released to the atmosphere during 1959 as the result of routine operations at the NRTS. Table 33 lists the monthly amounts of waste discharged to the atmosphere.

Table 33. Curies of Atmospheric Waste Discharged - NRTS - 1959

Month	MTR-ETR 1/	ICPP 2/	ANP 3/	Others 4/
January	12,076	10	---	---
February	15,759	320	---	---
March	7,466	120	---	---
April	10,489	149	---	6
May	8,942	82	9,300	17
June	8,714	101	900	24
July	8,775	287	2	16
August	8,597	81	---	---
September	17,661	70	1	28
October	16,449	10,010	16	22
November	30,966	137	8	26
December	22,993	37	912	25
Total Curies	168,887	11,404	11,139	164

1/ Predominate isotopes A-41, Kr-89, Xe-137

2/ Predominate isotopes I-132

3/ Predominate isotope Mixed Fission Products, undifferentiated

4/ SPERT, NRF, OMRE, SL-1

Table 34 summarizes the amount of gaseous and particulate waste released to the atmosphere since 1952.

Table 34. Summary of Atmospheric Waste Discharged at NRTS

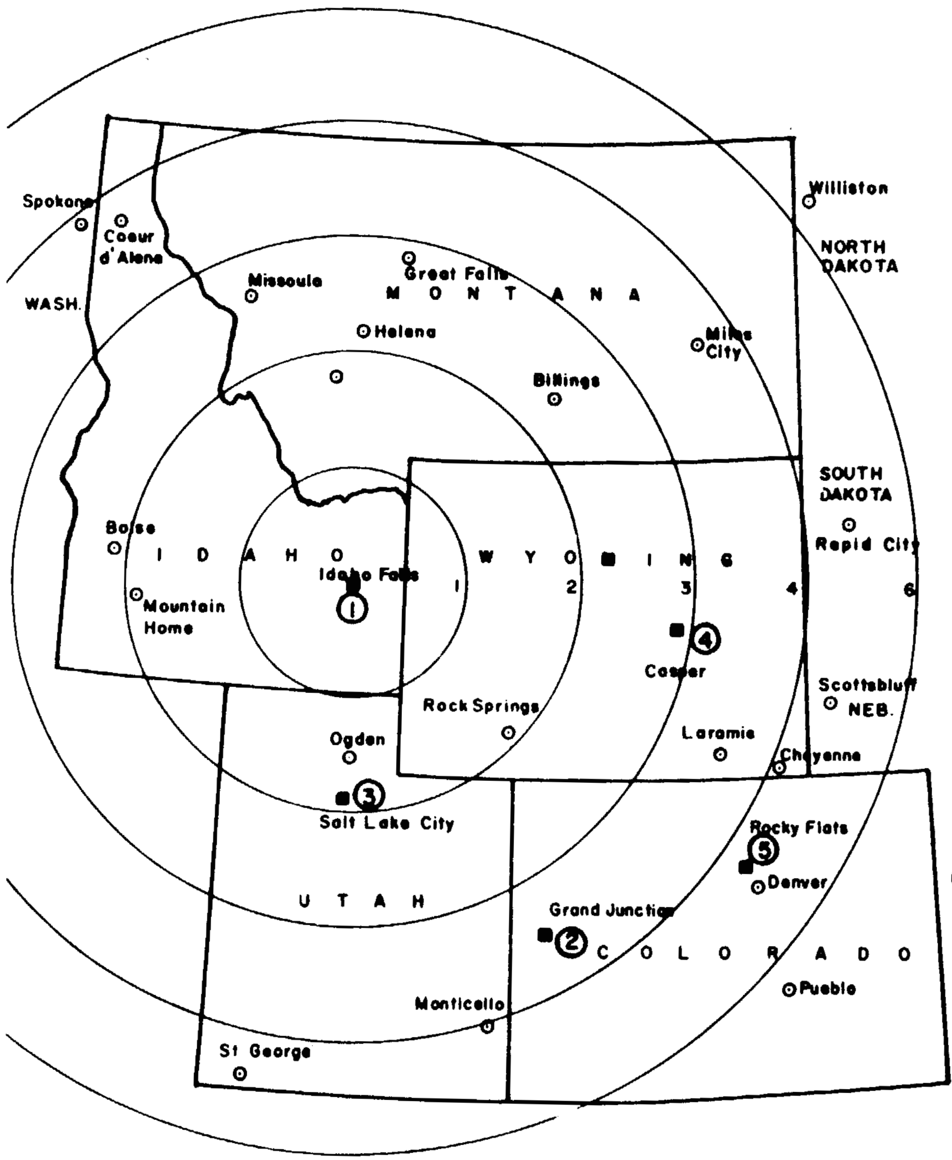
Year	Number of Curies
1952	195,000
1953	370,000
1954	271,000
1955	404,000
1956	213,000
1957	77,000
1958	145,000
1959	191,600

4. Design Review

Approximately sixty sets of design drawings and specifications and project proposals were reviewed by the Branch and comments applied in regard to radiation protection requirements.

5. Radiological Assistance Plan

During 1959, the Idaho Operations Office plan for handling emergencies under the National Radiological Assistance Plan was expanded. Fig. LX shows the five state area and the location of teams within Idaho Operations Office jurisdiction. At the NRTS there are thirty team members, all experts in their particular field.



RADIOLOGICAL ASSISTANCE TEAM LOCATIONS WITHIN IDAHO OPERATIONS OFFICE AREA OF RESPONSIBILITY

(1) IDAHO OPERATIONS OFFICE	P.O.Box 2108 Idaho Falls, Idaho	Jackson 2-6640
(2) GRAND JUNCTION OPERATIONS OFFICE	Grand Junction Colorado	Chapel 3-2110
(3) SALT LAKE CITY BRANCH OFFICE	Salt Lake City Utah	Empire 4-2552 Ext. 246
(4) CASPER BRANCH OFFICE	Casper Wyoming	2-0266
(5) ROCKY FLATS AREA OFFICE	Boulder Colorado	Hillcrest 3-1302

Circles indicate approximate time required to reach various points within region six utilizing chartered aircraft. Approximately one hour has been allowed at Idaho Falls to assemble the emergency team.
* All flights of 3 hr. duration or longer will require refueling in route.

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Fig. LX.

Equipment now includes ten one-man monitoring kits (Fig. LXI). Six of these kits can be used for monitoring alpha, beta, or gamma radiation. The remaining four kits have instruments for monitoring only beta-gamma radiation. Two briefcases, (See Fig. LXII) contain radiological assistance plan, transportation information, radiation handbooks, etc. During 1959 a 28 foot house trailer was converted into a decontamination unit for use in radiological incidents. Fig. LXIII shows a plan view of the trailer which is equipped to decontaminate up to 200 people or to be used for re-entry into a contaminated facility. Two emergency vehicles, each containing equipment for four men, are also available for emergency use. Fig. LXIV shows one of these vehicles. Eleven two-wheel trailers (See Fig. LXV), containing 2.5KVA gasoline powered electric generators are also available.

In 1959, teams were dispatched to assist in two incidents involving radioactive material. On April 17, 1959, a freight train was derailed at Ringling, Montana. There was no serious damage to the radioactive cargo and no radiation problem existed as the result of this accident.

On September 21, 1959, a truck-trailer containing a radioactive shipment was found to be contaminated on arrival at the NRTS. A survey of the truck line docking facilities at Pocatello, Idaho by team members did not disclose any contamination resulting from transfer of the cask at this point. A truck which had conveyed the shipment from Chicago to Pocatello was decontaminated at Boise, Idaho, after surveys revealed several small sections of the floor were contaminated up to 3 mr/hr.

6. In-Service Training

During 1959 approximately 200 man-hours of training was provided to Branch personnel. Branch personnel provided other AEC employees with approximately 120 man-hours of training. Principally, this training consisted of instructing Security Patrolmen in techniques of radiation monitoring.

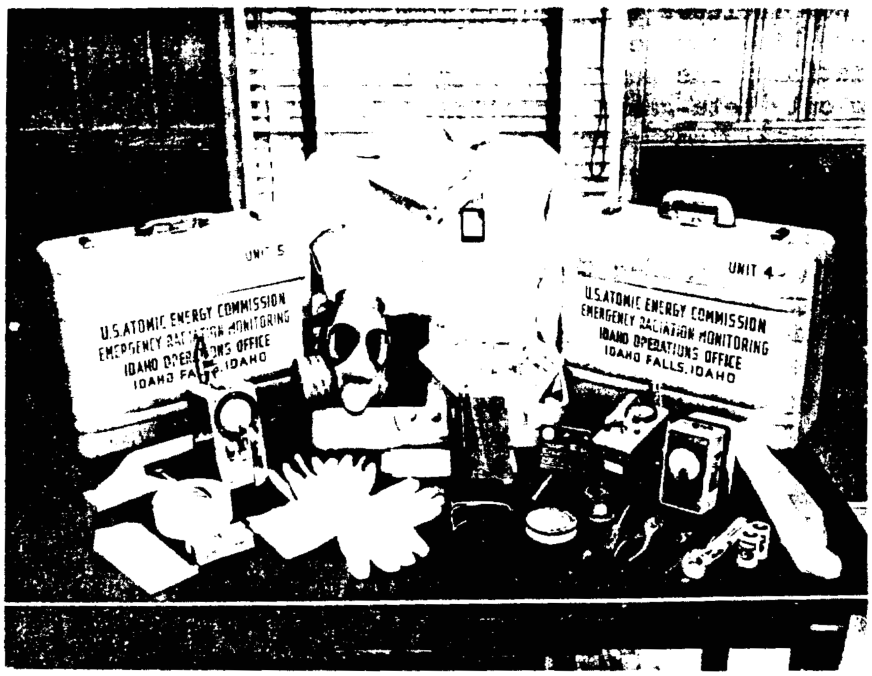

Fig. LXI. Emergency Monitoring Kit

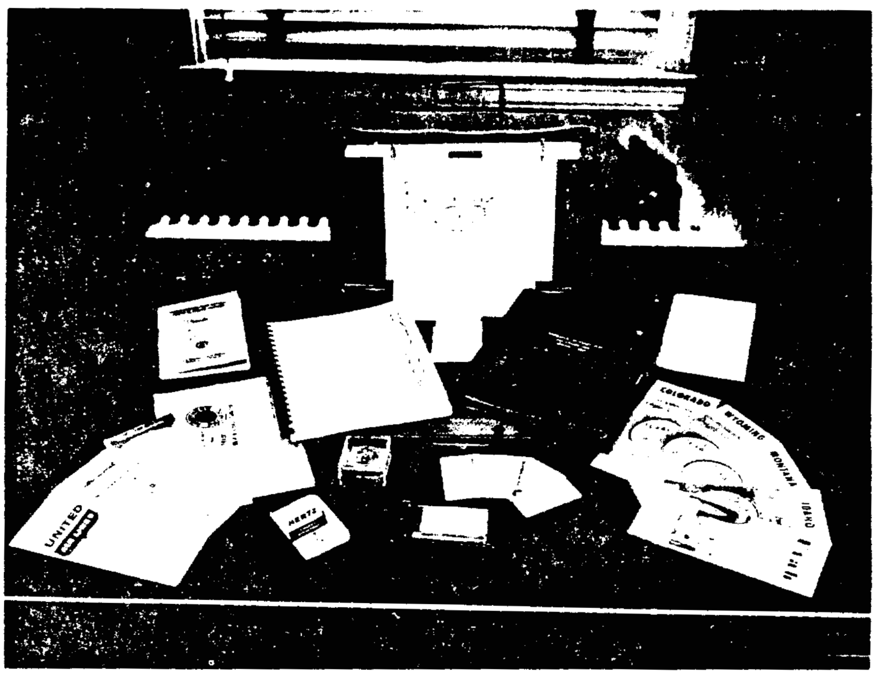

Fig. LXII. Radiological Assistance Plan Briefcase

PLAN VIEW

EMERGENCY DECONTAMINATION TRAILER

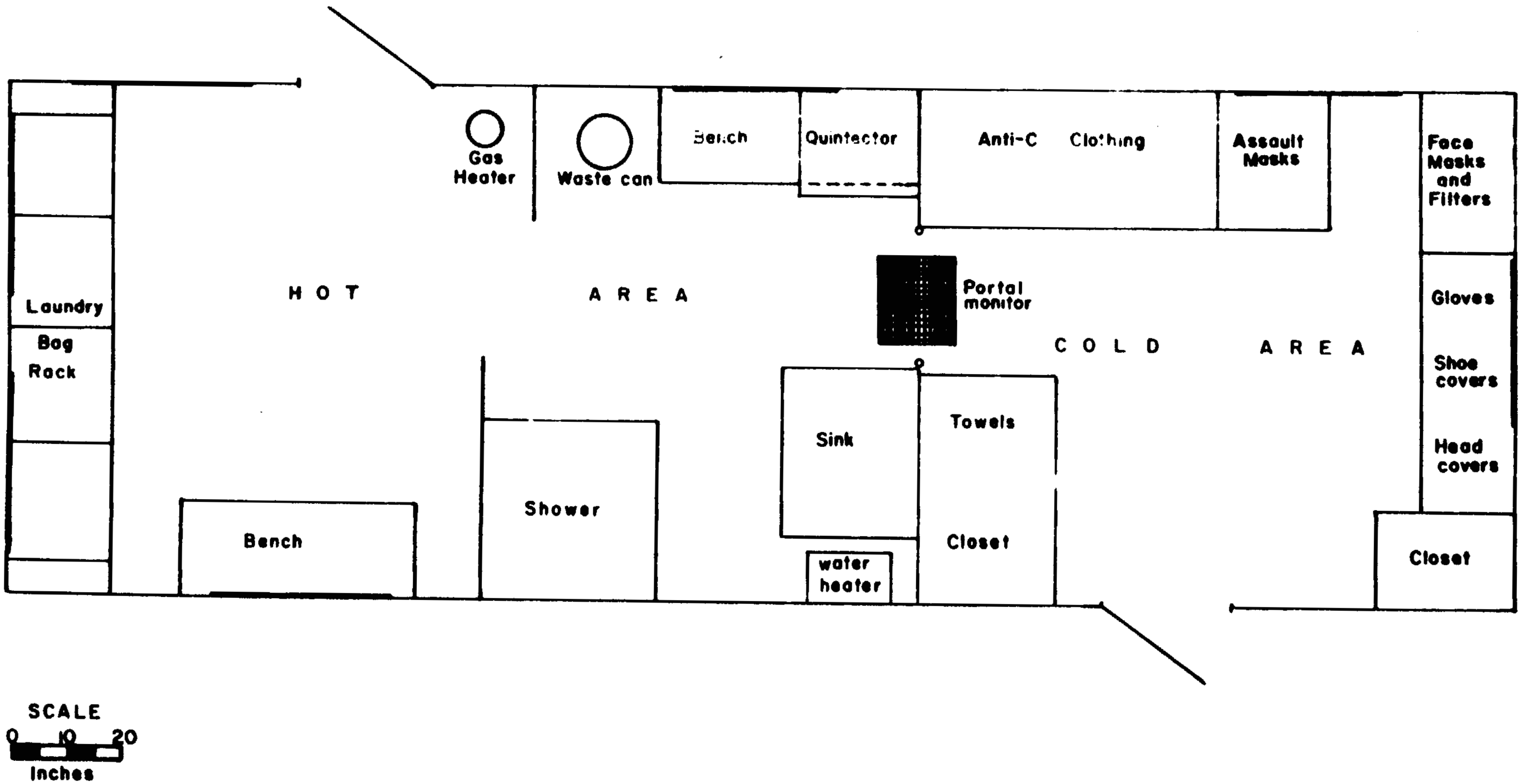

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Fig. LXIV. Emergency Vehicle with Equipment for 4 Men

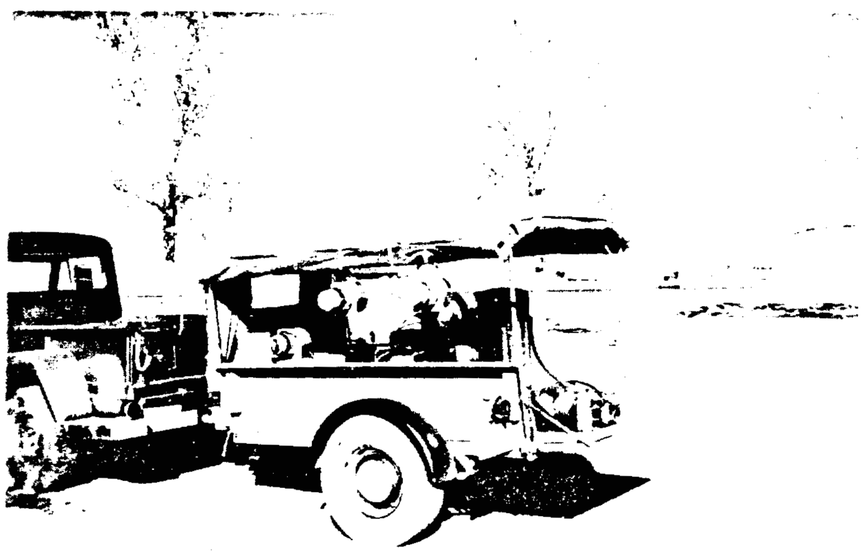

Fig. LXV. Two-Wheel Power Generators with Sampling Equipment

E FUTURE PLANS

1. Environmental Monitoring

Although this phase of the work has become somewhat routine, it is the intent of the Branch to continue to improve methods, obtain better equipment, and to discontinue procedures which fail to justify themselves. As the activities at the NRTS increase, it is expected that unique monitoring problems will arise. Therefore, the Branch will continue to develop and test specially designed air samplers. Special emphasis will be placed upon the utilization of the Division's electronic data processing equipment to record routine environmental monitoring results.

2. Shipments

The Branch will issue in 1960 a revision to the IDO Administrative Manual which will set forth responsibilities and procedures for the handling of radioactive shipments in a clear and concise manner.

3. Waste Management

Data obtained from existing observation wells is not sufficiently complete, specific, extensive, or accurate enough to permit concise interpretation or broad application in regard to the movement of liquid waste discharged to the ground. It has been learned that two or more aquifers with significantly different characteristics are penetrated by these wells. Isolation of these aquifers, using specifically adapted oil well equipment, will be accomplished after which complete hyrological and tracer tests will be performed. This work is planned in cooperation with the U. S. Geological Survey. In addition, it is planned to utilize electrical, thermal, radiometric, seismic and magnetic logging techniques to delineate the stratigraphy of the area.

It is proposed to drill three additional wells in the vicinity of the ICPP. Investigation of the movement of waste disposed into the filtration pit at the MTR-ETR has not been investigated up to this time. A minimum of 4 deep wells are proposed in this vicinity. Eight or ten shallow holes (less than 100 feet) are also proposed for the purpose of studying the movement of the water through the soil mantle and the top strata of underlying basalt.

4. Radiological Assistance Plan

The main effort will be the revision of the manual and increasing the efficiency of team members through training programs. The capability for handling weapons accidents will be expanded in 1960.

5. Inspection

It is the responsibility of the Branch to inspect facilities under IDO jurisdiction to determine that the standards for protection against radiation are in compliance with AEC regulations. Due to lack of personnel, this function has not received sufficient emphasis. However, in 1960 it is expected that a full time position will be established within the Branch to plan and direct this program.

F REPORTS

1. INTERIM REPORT OF LIQUID WASTE DISPOSAL IN THE VICINITY OF THE IDAHO CHEMICAL PROCESSING PLANT, Bruce Schmalz, IDO-12011.

2. PRELIMINARY REPORT OF FISSION PRODUCTS FIELD RELEASE TEST-I, George Wehmann, IDO-12006

Chapter 9

U. S. GEOLOGICAL SURVEY

GROUND WATER BRANCH

M. J. Mundorff, District Geologist

A GENERAL

A Brief reconnaissance of the NRTS area was made by the Water Resources Division in 1948 prior to selection of the Idaho Site for construction of the National Reactor Testing Station. Beginning in 1949 the Ground Water Branch has conducted a continuing program of geologic and hydrologic investigations at the Site for the Atomic Energy Commission.

The initial investigations were designed to answer questions and solve problems relating to the occurrence of ground water and the quantity and quality of the water available beneath the Site. To this end the geology of the area was studied and a geologic map of the Site prepared. A considerable number of test and observation wells were drilled, and data from these, and from advance planning and production wells were used to prepare water table maps and to interpret underground conditions.

Rock samples obtained during drilling of the wells were examined, pumping and other tests performed. Reports covering all of these phases were prepared and released to the Atomic Energy Commission.

The initial investigations have largely been completed, and the earlier questions have been answered. Current investigations are related to research on special problems, to detailed investigations at specific sites, to obtain information to refine preliminary conclusions, and to collection and analysis of data relating to cycles and trends in the water regimen.

B SUMMARY OF PROGRAM

Current investigations are of three general types: (1) Research studies related to underground disposal of waste, (2) Continued collection and analysis of hydrologic data relating to changes or trends in the water regimen and (3) Study of hydrologic conditions at sites selected for new construction.

Research studies to date largely have been concentrated in the vicinity of the Chemical Processing Plant where effluent from the plant discharged into the disposal well is being traced. To date 19 intercept and observation wells have been drilled to define the band of effluent. Water samples collected from the wells have helped define the band of effluent, both vertically and horizontally.

Periodic sampling and analysis for radioactivity, chloride and sodium reveals cycles in the amount of materials reaching the intercept wells and have given approximate rates of travel of the effluent. Water levels are measured in a number of wells, and several continuous recorders show cyclic fluctuations and trends in the water level.

C SPECIAL ACTIVITIES

1. Contamination of Production Well at CPP

After contamination was discovered in the ICPP production well during April of 1959, an analysis of the hydrologic features of the area, that might explain the condition was made at the request of the Health and Safety Division. The analysis suggested two possible explanations. One possibility is as follows:

Under natural (undisturbed) conditions the slope of the water table, in the vicinity of the plant, is southwestward at a very low gradient, probably less than one foot per mile. Pumping the production wells creates a very low inverted cone around the wells, whereas disposing of waste in the disposal well builds a cone around it. Under usual rates of pumping and disposal, the cones are not large enough to cause waste to move from the disposal well to the production well. Under increased pumping and disposal, waste might move into the cone of depression around the pumped well or wells and could eventually be drawn into the production well. Actual contamination of the production well occurred after pumping and disposal rates were again at reduced levels. It is possible that, after the "slug" of contaminated water had traveled for some distance toward the production well, it was near enough to continue towards the well even at the reduced rate of pumping. The hypothetical flow net at rates of pumping of 500 and 1,000 gpm are shown in Fig. LXVI. The other suggested explanation for the contamination is that perched water, which could travel in any direction, might be responsible for the contamination.

2. Vertical Velocity Studies

Differences in chemical content of water samples collected during and after drilling of several intercept wells suggested that water enters these wells at more than one horizon. These data and slight but significant differences and changes in water levels suggested that water from deeper horizons might be under greater head than in the shallower horizons and might enter the well, move up the well bore for some distance, and leave at a higher level. Vertical velocity profiles therefore were made with a deep well current meter in 9 intercept wells. Movement was detected in all but 3 of these, and in all cases appeared to be upward in the well bore.

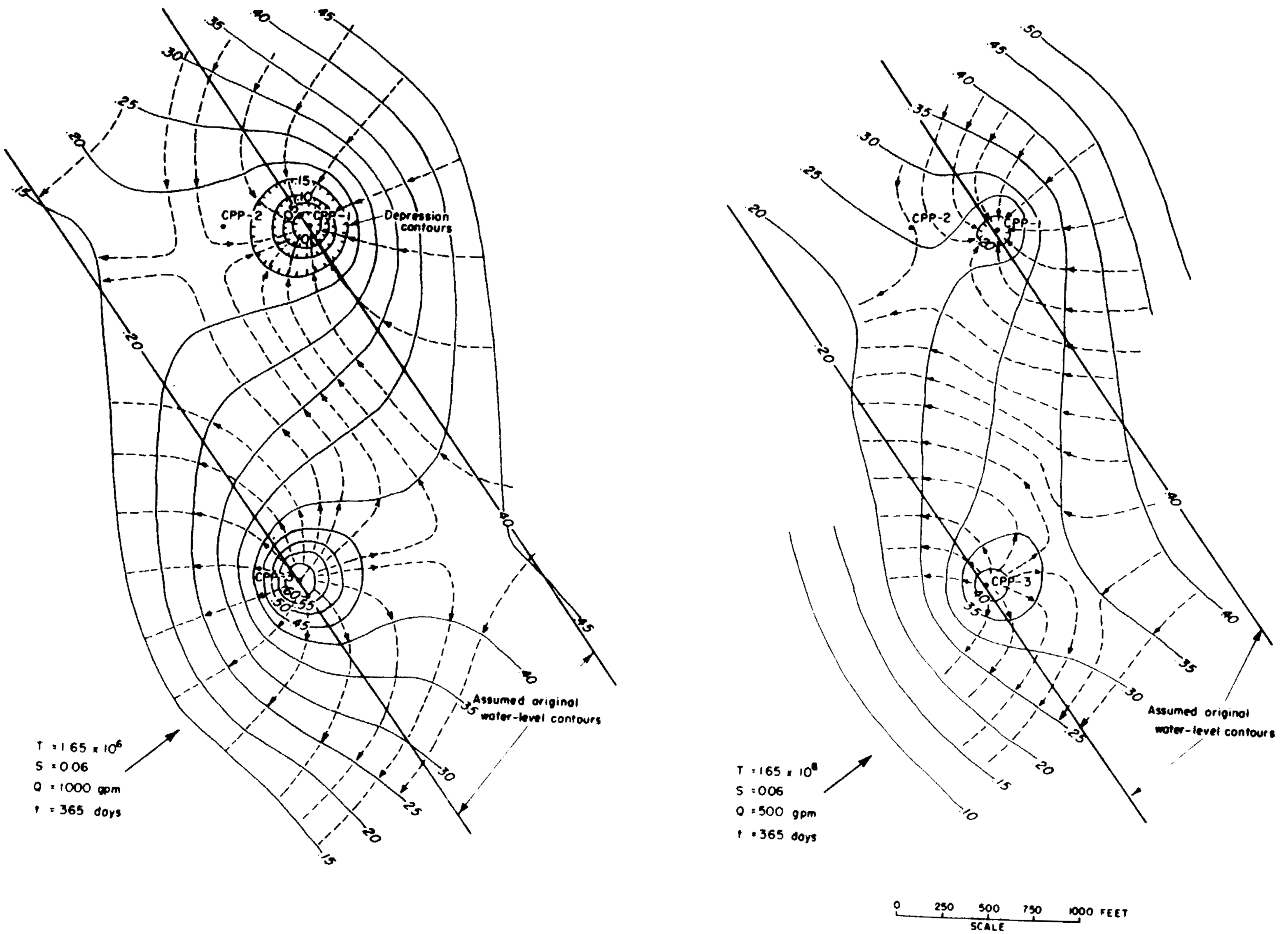

Fig. LXVI. Theoretical Flow Net of Water Table in CPP Area

3. Gamma-Ray Logging of Wells

Gamma-ray logs show the position and thickness of interbeds, the water table and, sometimes, differences in basalt flows. The logs are very useful in correlation of strata from well to well, and are of great value in hydrologic studies.

No gamma-ray logs were made during 1959. However gamma-ray logs of most test and observation wells on the NRTS were made in previous years.

4. Research on Waste Disposal

Beginning in 1959, the research on waste disposal was realigned and intensified by assignment of a research geologist to the project. Mr. Paul Jones was transferred to the NRTS in the latter part of September. The first tasks were to analyze the data already obtained on conditions in the vicinity of the CPP disposal well and to prepare a detailed plan for further studies. The development of this plan was facilitated by obtaining a combination well logger from the Ground Water Branch Hydrologic Laboratory in Denver. Hole diameter, water resistivity, water temperature, spontaneous potential, and formation resistivity profiles were obtained for several intercept wells, and together with the gamma-ray logs previously made, revealed significant features of the underground strata and the liquids contained in them. Fig. LXVII is typical of the logs obtained.

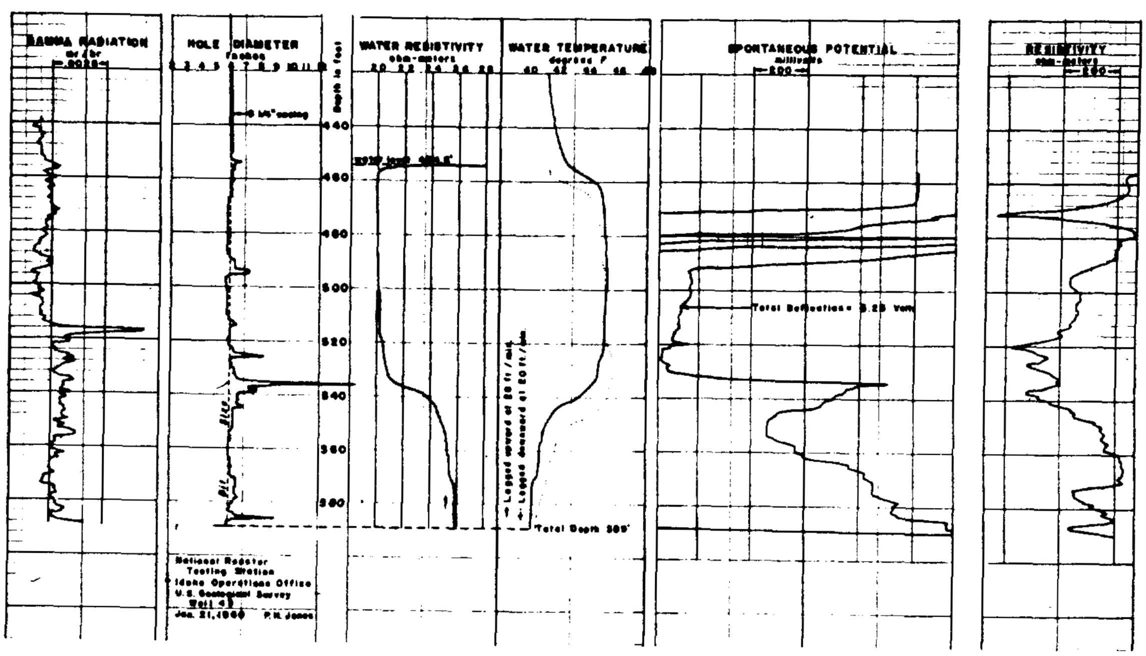

Fig. LXVII. Combination Logs of USGS #43

D ROUTINE ACTIVITIES

Routine activities include collection and analysis of data needed in solving special problems, and hydrologic observations designed to keep current information on the water regimen of the area.

1. Water-level Measurements

Water-level recorders which furnish a continuous record of changes in water level are maintained on 6 wells on or adjacent to the station. Water levels are measured monthly on about 15 additional wells, and quarterly on 35 to 40 more. Once each year, usually in October, a mass measurement is made on all measureable wells on the Site and in the immediate vicinity to detect any changes in the position of the water table.

The position of the water table is influenced by local and distant recharge, and by pumping at various places on the Snake River Plain. Water levels also fluctuate in response to barometric changes, seismic shocks and wind. The Montana earthquake of August 17, 1959 caused a total fluctuation of 4.67 feet in USGS well #4 where the water level was initially at 250 feet below the land surface. (Fig. LXVIII). Water levels in wells in the western part of the Site are related to recharge from Lost, and little Lost River Basins. Fig. LXIX presents the hydrographs

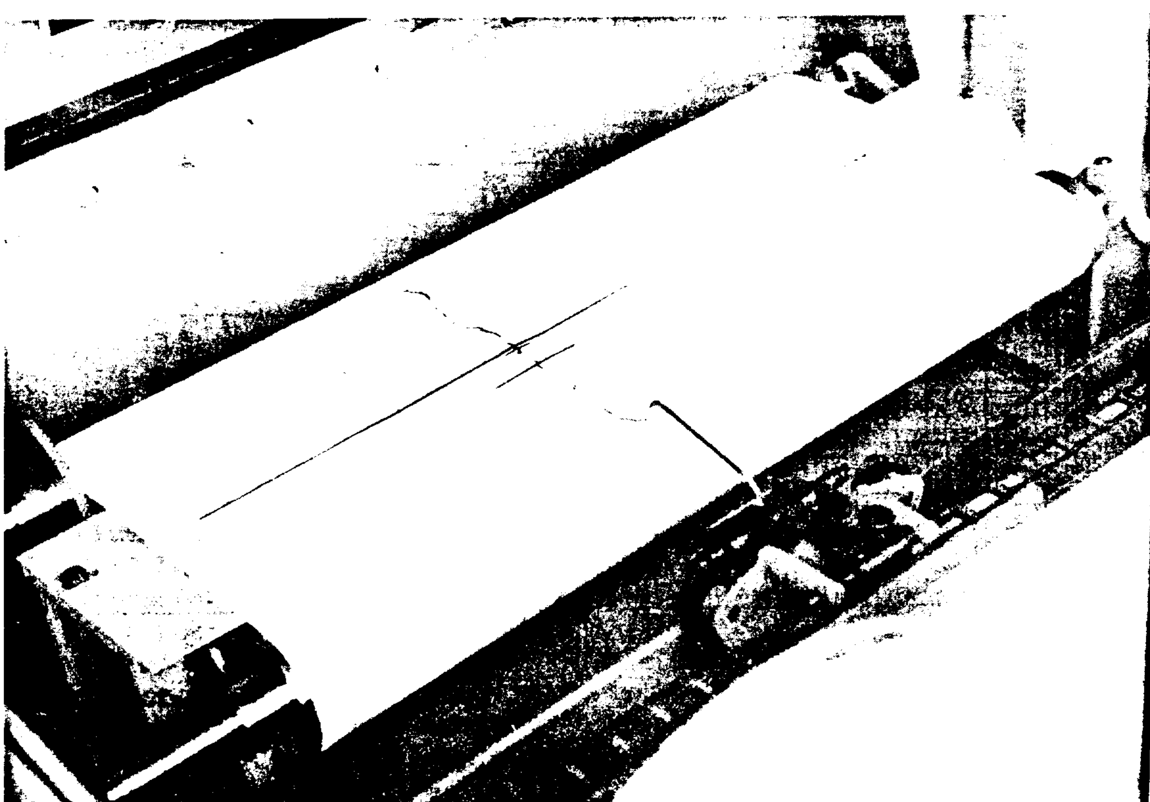

Fig. LXVIII. Automatic Water Level Recorder Showing Influence of Earthquake on August 17, 1959

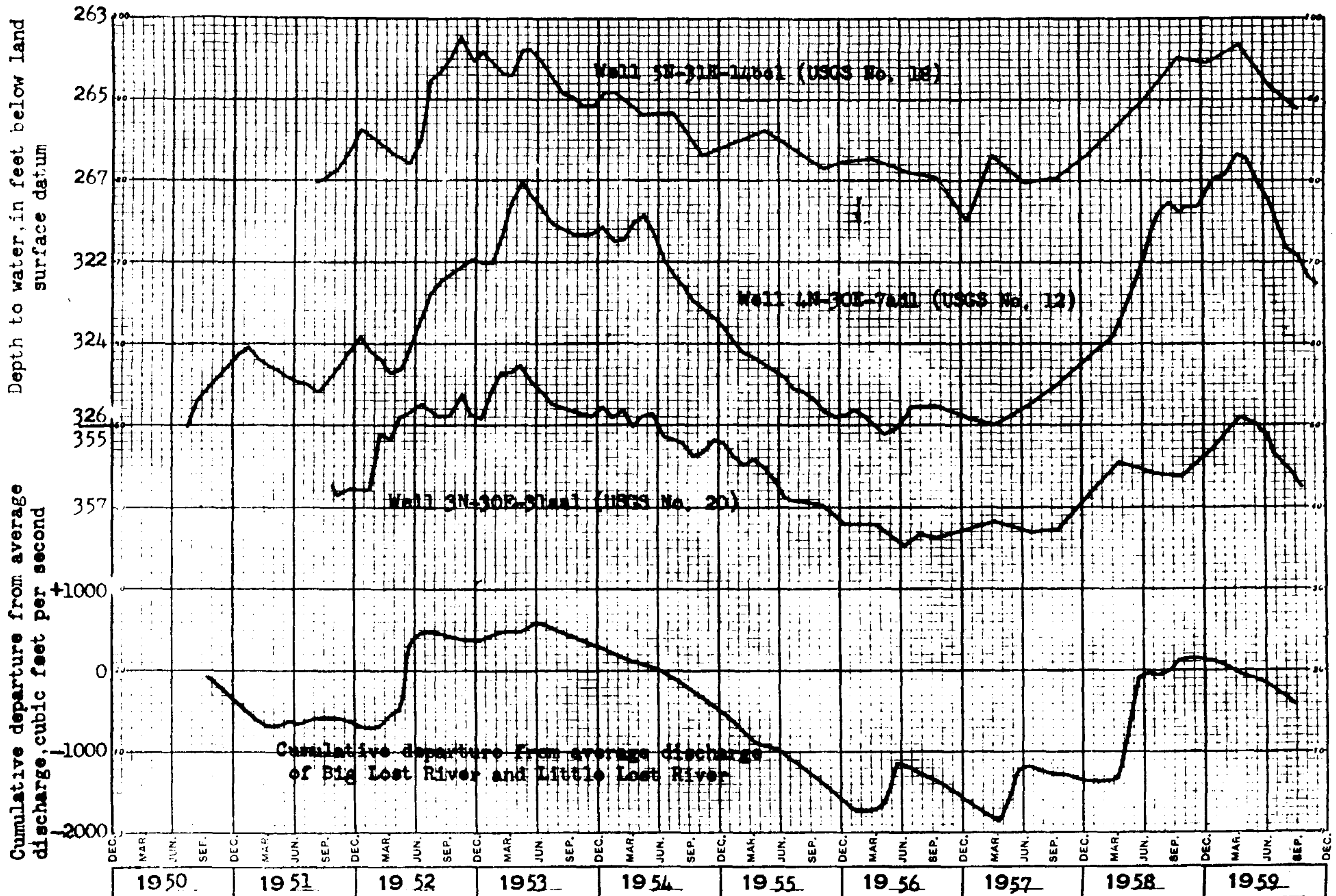

Fig. LXIX. Hydrographs of wells 5N-31E-14bcl (USGS No. 18), 4N-30E-7adl (USGS No. 12), 3N-30E-31aal (USGS No. 20), and cumulative departure from average discharge of Big Lost River and Little Lost River.

of three of these wells and indicates the cumulative departure from average discharge of the Lost Rivers. Water levels in these wells probably also are affected to some extent by cyclic recharge from Birch Creek and Mud Lake basins. Water levels in wells in the south and east part of the Site apparently are influenced by recharge from irrigation of lands adjacent to the Snake River and by large scale pumping in the Taber-Blackfoot area. (See Fig. LXX). Water levels in the north end of the station probably are influenced mostly by recharge from Birch Creek and Mud Lake Basins.

2. Streamflow Measurements

One gaging station is maintained at a site about 3 miles southeast of Arco, about 5 miles west of the NRTS boundary. Records from this station furnish the only information on discharge of Lost River in its lower reaches. Discharge past the station shows fairly close correlation with fluctuations of the water levels in several observation wells.

3. Well Drilling

Under contract drilling, test well 49 was completed at a depth of 656 feet. Drilling of well 50 was discontinued at a depth of 282 feet because of inability to case out the perched water encountered. At the end of the year drilling was continuing in well 51 at a depth of 470 feet, and in well 52 at a depth of 238 feet. Perched water was encountered in well 52. All four wells are in the vicinity of the Chemical Processing Plant and were drilled to further define the band of effluent from the disposal well, and to furnish additional information on the perched water in the vicinity.

4. Collection and Examination of Cuttings

Drilling samples were collected from all test, planning and production wells drilled for the NRTS. These were processed by sorting, cleaning, bagging, and labeling. As time permitted, samples were examined under the microscope and described. One report in the series presenting these data was released in 1959. Lithologic logs of 25 wells are included in that report.

5. Pumping Tests

Pumping tests were made on four wells on the NRTS during 1959 and the data furnished the Idaho Operations Office. A report covering pumping tests from January 1958 through June 1959 has been approved for release.

6. Water Sampling

Intercept Wells. A sample of the first water encountered is taken from each well as it is drilled. As drilling continues samples are collected at frequent intervals to detect any changes in the water. The samples are analyzed for radioactivity and

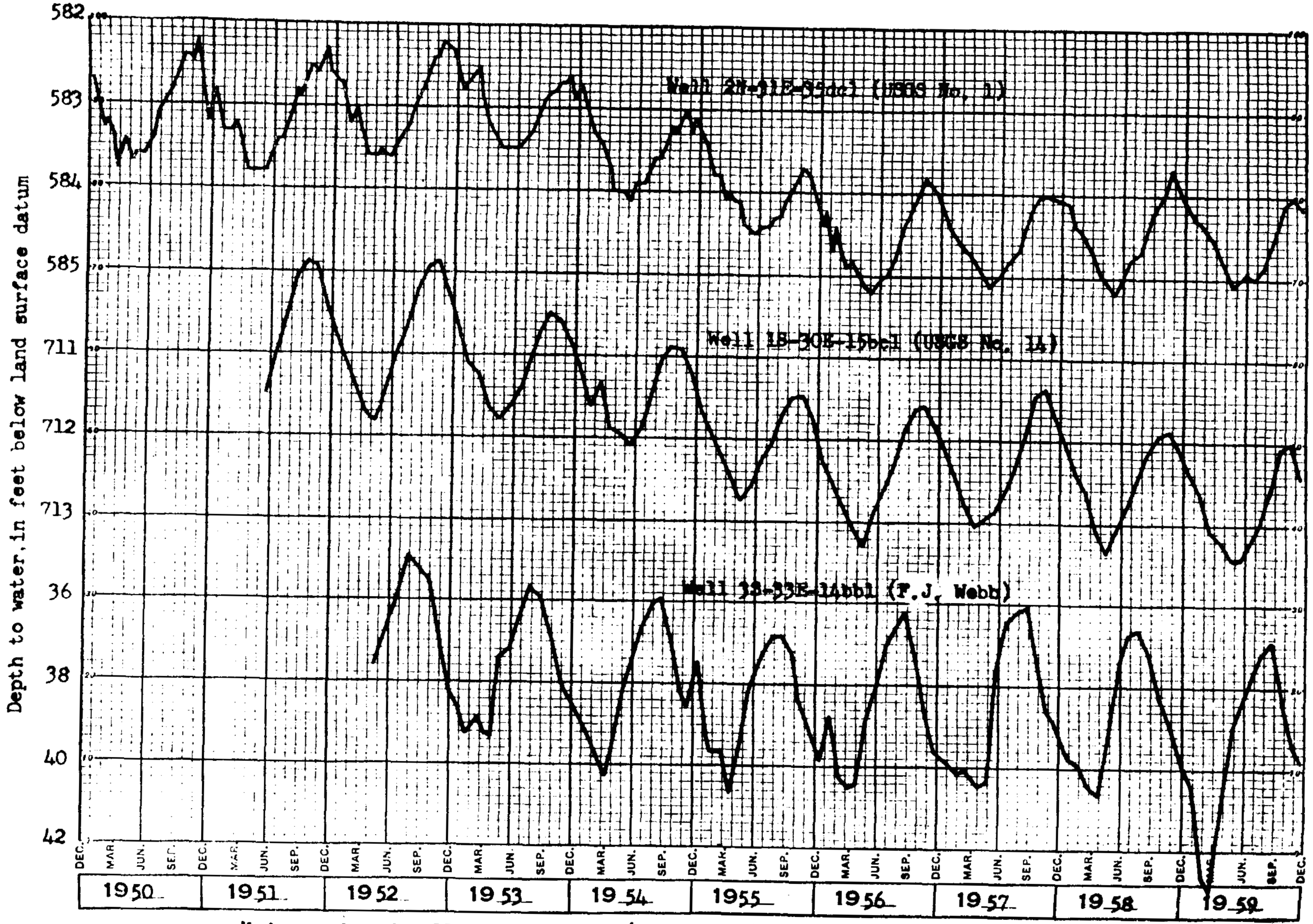

Fig. LXX. Hydrographs of wells 2N-31E-15bcl (USGS No. 1), 1S-30E-15bcl (USGS No. 14), and 3S-33E-14bbl (F.J. Webb).

sodium by the Analysis Branch of the Health and Safety Division, and some of them for chloride content by the U.S.G.S. After the well is completed a one-gallon sample is collected for complete chemical analysis. Samples also are collected at various depths below the water table to reveal vertical changes in the character of the water. Samples are collected periodically after completion of the well to reveal any cycles or trends in the chemical character or radioactivity of the water. The equipment used in collecting these samples, at depths of 450 to 675 feet, is shown in Fig. LXXI.

A one-gallon sample is also collected, after completion, from each advance planning and production well.

Fig. LXXI. Equipment for Sampling of Observation Well

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E <u>FUTURE PLANS</u>

1. Research on Waste Disposal

A detailed and comprehensive study of the hydrologic phases of waste disposal is being planned jointly with the Site Survey Branch. Details of the proposed study are given with the report of that Branch.

2. Data Collection

Hydrologic observations, including water-level measurements, collection and analysis of water samples, collection and examination of well cuttings, aquifer tests and similar observations are needed to define trends and cycles in the hydrologic regimen of the area. There is good reason to believe that withdrawal of ground water from the Snake Plain aquifer will continue to increase, that water levels will decline, and that in some places competition for water will be keen. It is planned to continue the observations necessary to define these trends and to evaluate the factors causing the trends.

F. <u>PUBLICATIONS</u>

Reports submitted to the Health and Safety Division, IDO by the U. S. Geological Survey in 1959.

1. GEOGRAPHY, GEOLOGY AND WATER RESOURCES OF THE NATIONAL REACTOR TESTING STATION, IDAHO, PART 3, HYDROLOGY AND WATER RESOURCES, Document No. IDO-22034-USGS, by R. L. Nace, J. W. Stewart, W. C. Walton and others (1959).

2. INVESTIGATION OF UNDERGROUND WASTE DISPOSAL, CHEMICAL PROCESSING PLANT AREA, NATIONAL REACTOR TESTING STATION, IDAHO, Document No. IDO-22039-USGS, by Alan E. Peckham (1959).

3. GEOGRAPHY, GEOLOGY AND WATER RESOURCES OF THE NATIONAL REACTOR TESTING STATION, IDAHO, PART 2, SUPPLEMENT 3, LOGS OF TEST HOLES AND WELLS IN THE CENTRAL SNAKE RIVER PLAIN, IDAHO, Document No. IDO-22015-USGS, by Alan E. Peckham, J. R. Houston and E. H. Walker.

4. GEOLOGIC AND HYDROLOGIC ASPECTS OF WASTE MANAGEMENT, (No Document Number) by R. L. Nace.

5. GEOGRAPHY, GEOLOGY AND WATER RESOURCES OF THE NATIONAL REACTOR TESTING STATION, IDAHO, PART 3, APPENDIX 2, BASIC HYDROLOGIC DATA, Document No. IDO-22034-USGS, by J. W. Stewart, R. L. Nace, K. H. Fowler, A. E. Peckham, and P. T. Voegeli.

Chapter 10

U. S. WEATHER BUREAU

Norman F. Islitzer, Meteorologist in Charge

A SCOPE

The Weather Bureau, under the auspices of the United States Atomic Energy Commission, maintains an operational and research type weather station at the NRTS. Weather forecasts, required by the Health and Safety Division and the various contractors of the AEC for the safe conduct of reactor experiments, are supplied along with meteorological observations during the course of the experiments. The Weather Bureau also has the responsibility of conducting an extensive observational program in order to provide the necessary climatological statistics for reactor siting and planning purposes.

To increase the understanding of aspects of atmospheric diffusion and transport at the NRTS, that are important to problems encountered in the safe disposal of radioactive material in the atmosphere, an extensive research program is conducted. Studies of diffusion, utilizing radioactive material released from reactor operations and also fluorescent tracers, are carried out. Various turbulence properties of the lower atmosphere are measured for correlation to measured diffusion. Wind forecast studies also are carried out to improve this aspect of the operational program.

B SUMMARY OF MAJOR PROGRAMS

1. Operational

Diffusion forecasts are made in addition to forecasts of certain meteorological elements such as wind speed and direction, temperatures and precipitation. The rate of diffusion of any radioactive material discharged from a reactor stack is known to be correlated to the wind and the vertical temperature gradient. Forecasts of vertical temperature gradient through the day are given as required. Values of Sutton's diffusion coefficients and stability parameter "n" are then included in the forecast. This will permit calculations of anticipated air concentration or radioactive dose for releases of radioactive material. Of particular interest to field monitoring teams are areas of maximum surface concentration from stack releases. These can be estimated fairly well for some weather conditions.

a. TREAT

The last six months have added one new reactor facility that has required forecasts for operational needs, the TRANSIENT REACTOR TEST (TREAT) facility, located in the southeastern portion of the NRTS about one mile northwest of the EBR II site. Should there be a release of fission products with winds from the northwest quadrant, transient testing is suspended in order to avoid possible exposure of contractor and construction personnel in the EBR II area. Daily forecasts of expected winds are given to the TREAT operating personnel to assist their planning.

The Weather Bureau does not maintain a weather station in this area; therefore, winds from the tower at Central Facilities are considered to be representative for the southeastern part of the NRTS. The reasoning behind this assumption is that the forces producing wind shears frequently experienced between the northern and southern ends of the NRTS are not operative between the Central Facilities area and the eastern part of the NRTS. In order to confirm this, the contractor installed a wind station on the roof of the TREAT building some sixty feet above the ground. Comparisons during the warmer months showed essentially no differences in the winds between the two locations. However, with the onset of colder weather which is the season during which pronounced spatial variations of winds usually are experienced over the NRTS, differences in winds were sometimes experienced between the Central Facilities and TREAT locations. Further observations and study are planned to explore this matter further.

b. ANP

Forecasts of diffusion parameters for computations of off-site radiation exposure from an assumed maximum credible accident are included along with wind and precipitation forecasts. The proposed new telemetered and digitalized weather network for the north end of the NRTS has not yet been installed. Consequently forecasts and meteorological control of the IET operations are still monitored from the existing network, which included the 200-foot tower of IET and several outlying Weather Bureau surface stations.

During these operations when detectable amounts of radioactive material are anticipated in the field, trajectories and areas of maximum surface concentration are computed and supplied to the mobile crews of the Health and Safety Division and the U. S. Public Health Service. Fairly good agreement has been found between computed and observed values for d(max), the distance to maximum ground-level air concentrations, for temperature lapse and mild inversion conditions. The computations of d(max) are determined from the temperature lapse rate and the nature of the wind direction trace.

c. MTR-ETR-CPP

A number of experiments and operations in the MTR, ETR, and Chemical Processing Plant, in which significant amounts of radioactive material were released from the 250-foot stacks, were conducted under meteorological control. These included testing of ANP ceramic fuel elements, monthly Rala releases, and several unexpected releases. For the tests in the MTR and ETR, the close-in-hazard diffusion types (fumigating and looping) were closely watched or avoided. As a result the Weather Bureau was required to provide forecasts of times of inversion break-up, sudden wind shifts into an easterly quadrant (easterly winds were sometimes avoided to prevent the possibility of cross-contamination between the ETR and MTR), calm or very light winds with strong temperature lapse, and periods of precipitation. It developed that accurate prognoses of the general weather conditions and resulting winds permitted the application of diffusion climatology to accurate forecasts of the time of fumigation. Forecasts of wind shifts to an easterly quadrant from the prevailing southwest winds were sometimes several hours off in timing but seldom incorrect. During transient weather conditions, differences in winds between the tower at Central Facilities and those experienced in the MTR, ETR, and CPP areas some three miles distant were observed. Consequently, an Aerovane was installed on the top of the 150-foot tower at Grid No. 3, which is about one mile northeast of the MTR-ETR, to cover the operational needs of this area.

2. Climatological

a. Diffusion Climatology

The final in a series of three climatological reports, which summarize the observational results since the Weather Bureau started its program at the NRTS, is being written. This is the Diffusion Climatology of the National Reactor Testing Station. The first two reports, General Climatology of the NRTS and Engineering Climatology of the NRTS, were published in 1959. This third report will present climatological statistics and results of research investigations into atmospheric diffusion and turbulence at the NRTS, that are necessary for computations of radioactive waste disposal into the atmosphere.

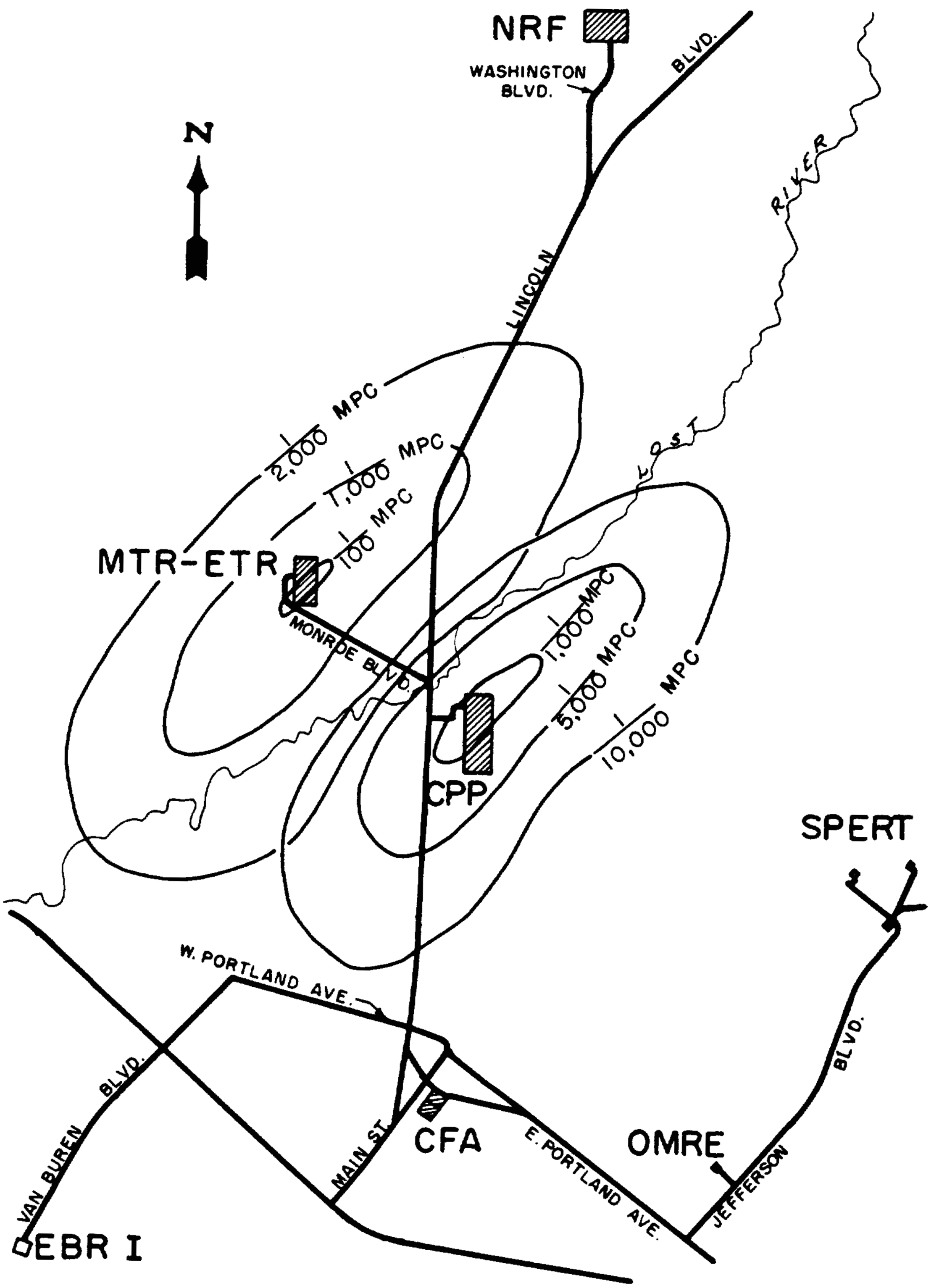
b. Isopleths of Annual Average Air Concentration

To assist in reactor siting problems, mean annual isopleths of relative air concentration were computed for a 75-foot and a 250-foot stack. The computations were based on Sutton's formula, with the assumption that the cloud was averaged over 22½ degree sectors to be compatible with wind rose data. Wind rose and vertical temperature lapse rate data taken at Central Facilities were used in the computation. Isolines of mean annual relative concentrations for both total hours in the day, and also for hours of vertical temperature lapse only, were plotted on overlays to correspond to the scale customarily used for reactor siting maps at the NRTS. By multiplying by the actual release of radioactive material at the NRTS during the year, isolines of air concentration (annual average) can be constructed for long-period steady releases. These overlays will quickly delineate areas of maximum surface-level air-concentration from a reactor site, where virtually continuous release of fission products is anticipated for either day shift operations or continuous operation. One can also quickly evaluate the added relative safety obtained by exclusion areas and separating reactors from one another. Overlays of this type should be more useful than wind roses for such reactor siting problems. Fig. LXXII shows the mean annual air concentrations of the major isotopes released during normal operations at the MTR, ETR and CPP in 1959. The annual concentration isopleths of I-131 assuming constant release of the 1959 total output from IET is presented in Fig. LXXIII. I-131 was assumed to be 1.0% of the year's total discharge. The isopleths are plotted as fractions of MPC for the various isotopes were interpolated from calculated $\frac{\chi}{Q}$ isopleths and plotted as shown.

c. Sub-Surface Temperatures

To assist the engineers in projects that involve burying pipes and conduit below the earth's surface, a study of soil temperatures down to seven feet was initiated about two years ago. Temperature measuring elements were also installed at one foot intervals from two to seven feet below an asphalt highway. Comparisons could be made of sub-surface temperature profiles between the natural terrain and a highway. Of particular interest is the variation of the freezing depth between the two locations. The insulating layer of snow normally experienced in the winter is removed from the road allowing greater sub-surface cooling under the road than under the natural terrain. A slight counteracting effect is the higher reflectivity of solar radiation by the snow blanket compared to a black-top highway. However, incoming solar radiation in the winter is so slight that this effect is not great. The greater thermal conductivity of the road compared to the topsoil will also permit more rapid cooling and heating of the ground under the road.

Fig. LXXIV shows that the freezing level extended to nearly four feet under the road compared to about $2\frac{1}{2}$ feet under the natural terrain during the first winter of the study. This winter was rather mild; consequently, it would be reasonable to expect frost depths to greater than five feet under the highway during normal winters. In the summertime, the sub-surface temperatures under the road are as much as ten degrees higher than comparable layers under the natural terrain. A wider range of temperature is also experienced under the road. The results of this study have been accepted for publication in PUBLIC ROADS MAGAZINE, published by the Bureau Public Roads.



CPP ISOPLETHS-FRACTIONS OF MPC OF I^{131}
MTR-ETR ISOPLETHS-FRACTIONS OF MPC OF A^{41}

Fig. LXXII. Mean Annual Isopleths of Air Concentration of I-131 from ICCP and Inert Gases from the MTR-ETR for Year 1959

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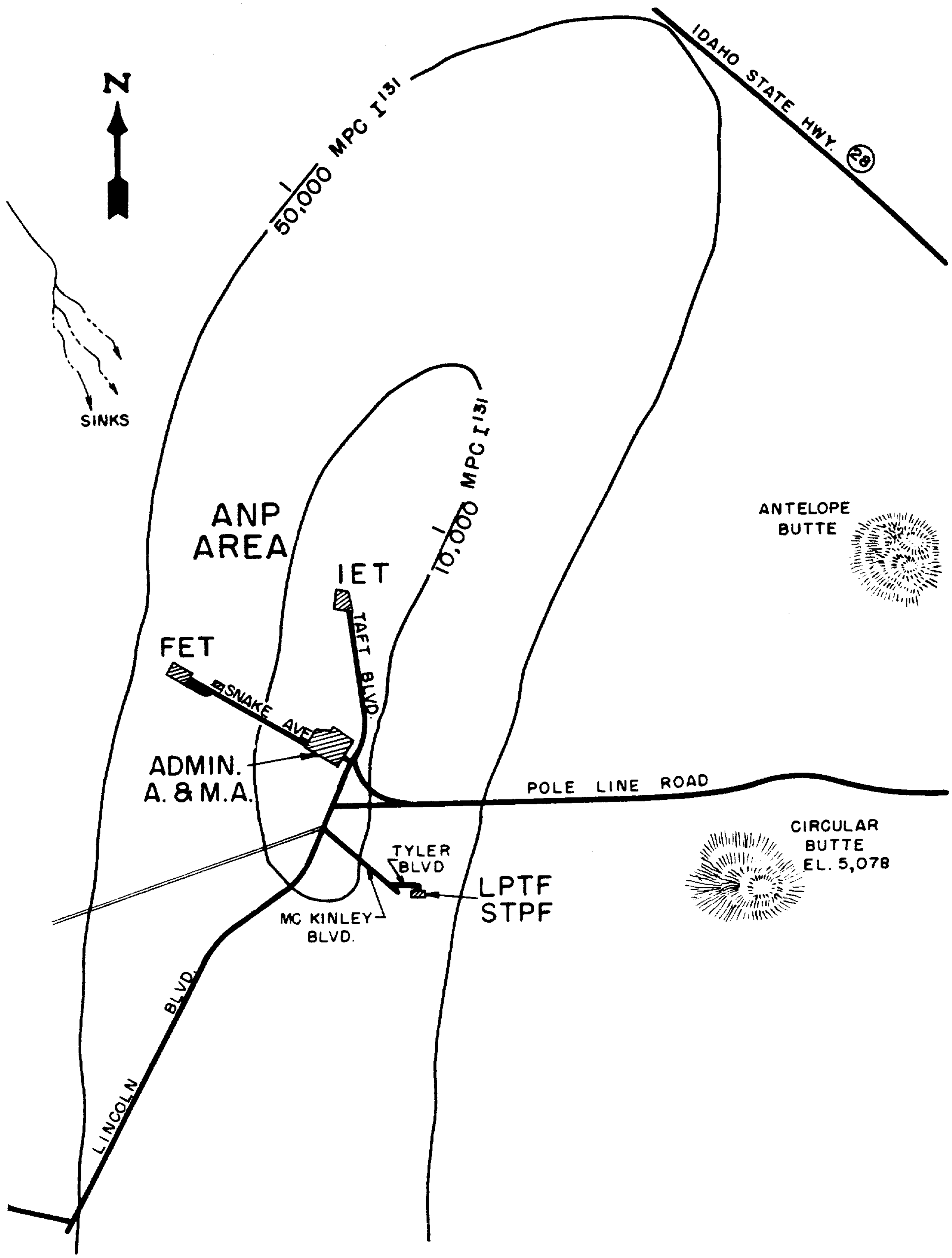

IET ISOPLETHS - FRACTIONS OF MPC OF I[131]

Fig. LXXIII. Mean Annual Isopleth of Air Concentration of I-131 from ~~GPF~~ IET During 1959

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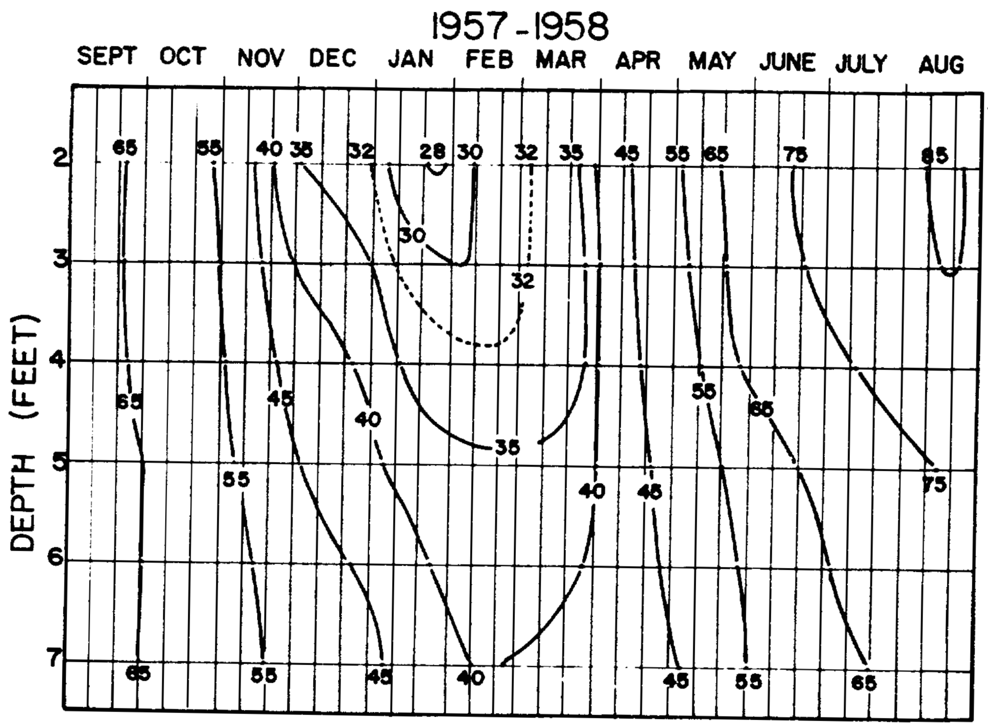
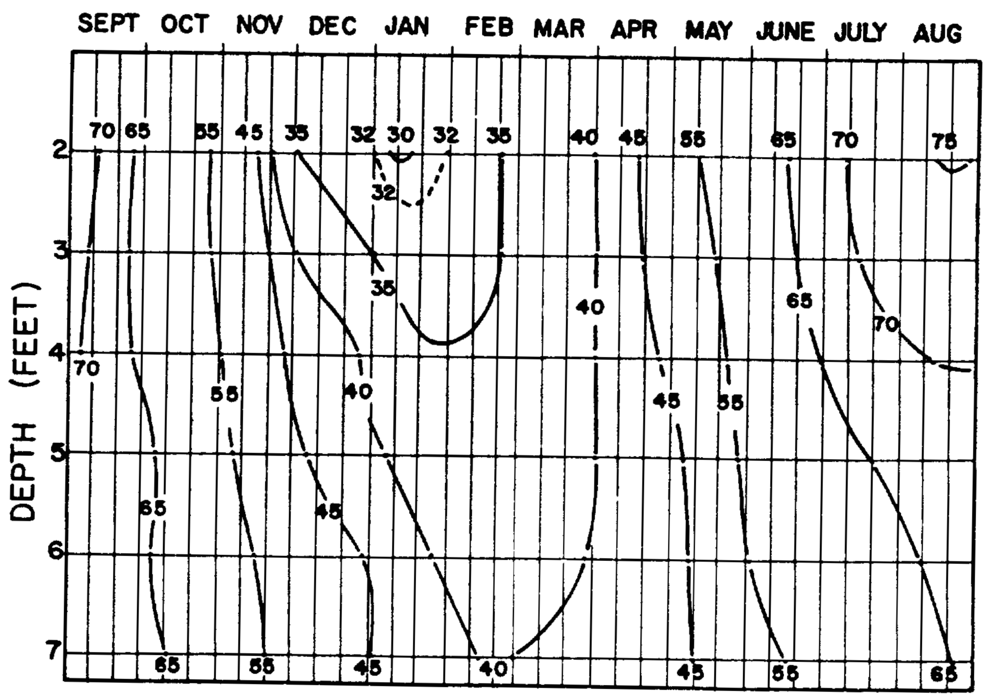


GRAPH "A" TEMPERATURE BENEATH AN ASPHALT ROAD



GRAPH "B" TEMPERATURE BENEATH A SANDY SURFACE

Fig. LXXIV. Sub-Surface Temperature Comparison Between an Asphalt Highway and the Natural Terrain, 1957-1958

3. Research

a. Dispersion Studies With Non-Radioactive Tracers

The dispersion studies conducted in the first half of the year 1959, utilizing uranine dye in solution as a fluorescent tracer, have recently been described by Bowne[1]. The primary objective was to study certain features associated with the diffusion type commonly referred to as looping, such as the maximum surface concentration and the distances from the release point to the maximum surface-level air concentration. The tracer was released from the top of a 150-foot tower for 30 minute periods and was sampled by high-volume air samplers out to two miles. A compressor, delivering 500 cfm of air at 100 psi to a specially designed nozzle, broke the dye and water solution into a fine spray. Several samples collected on Millipore AA filter paper in the field were counted under a microscope showing median particle size between one and two microns, which are within the aerosol range.

One hundred high volume Staplex air samplers were used at various arcs at Grid No. 3. Initially arcs were set up at distances of 300, 400, 600, 1000, 1800, and 3400 meters from the release point. After the eighth test the arc at 3400 meters was discontinued and a new arc at 150 meters was added. The 300, 400, and 600 meter arcs were widened from 40 to 60 degrees at this time. After Test No. 8, arc spacing of samplers was 6° on the 150, 300, 400 meter arcs, 2.7° on the 600 meter arc, 1.7° on the 1000 meter arc and 1.8° on the 1800 meter arc. The odd spacing arose from the fact that the grid was originally set up for a source 100 meters from the first arc rather than 300 meters where the meteorological tower was located.

Meteorological instrumentation included bivanes at two levels on the tower, Beckman and Whitley anemometers at three levels, and temperature instrumentation to measure the vertical temperature lapse rate. From the measurements, the dispersion of the cloud as predicted from meteorological measurements was compared to measured dispersion. Table 35 which was extracted from the report by Bowne, lists some of the more useful results. Of particular interest from this table are: (1) The values of d(max), the distance from the tower to maximum surface level air concentration, (2) Sutton's diffusion parameters, n, C_y, and C_z, and (3) The ratio of predicted to measured maximum ground-level air concentration, $\chi(c)/\chi(m)$.

[1] Measurements of Atmospheric Diffusion From An Elevated Source, July 1959. Norman E. Bowne. Presented to the Sixth Air Cleaning Seminar, Idaho Falls, Idaho.

Run	Q g/sec	d(max) meters	Assumed m	$\chi_{(max)}$ G/m^3	$\bar{u}_{140}$ m/sec	C_z^2 (m^n)	C_y^2 (m^n)	Computed $\chi_{(max)}$ g/m^3	$\chi_{(c)}/\chi_{(m)}$	σ_θ/σ_E
2	0.77	700	0.25	5.0×10^{-6}	5.7	0.025	0.091	1.4×10^{-5}	2.8	M
3	1.39	300	0.20	7.9×10^{-6}	6.5	0.089	0.100	2.2×10^{-5}	2.8	1.1
4	1.00	400	0.20	1.8×10^{-5}	7.0	0.054	0.035	1.5×10^{-5}	0.8	M
5	3.20	530	0.20	2.6×10^{-6}	8.9	0.032	0.083	3.7×10^{-5}	14.2	1.3
6	0.79	650	0.25	4.0×10^{-6}	9.7	0.028	0.238	1.1×10^{-5}	2.8	1.5
7	0.88	600	0.25	4.0×10^{-6}	7.8	0.032	0.190	1.2×10^{-5}	3.0	1.4
8	1.00	560	0.20	2.2×10^{-6}	7.2	0.032	0.289	1.4×10^{-5}	6.4	1.9
9	0.88	470	0.20	2.8×10^{-6}	10.0	0.041	0.092	9.0×10^{-6}	3.2	1.9
10	0.88	940	0.25	2.2×10^{-6}	7.7	0.015	0.250	9.0×10^{-6}	4.1	M
11	0.88	315	0.20	3.4×10^{-6}	6.7	0.082	0.442	1.3×10^{-5}	3.8	2.5
12	1.32	940	0.25	6.7×10^{-6}	8.1	0.015	0.066	1.7×10^{-5}	2.5	1.0
13	0.88	460	0.20	1.2×10^{-6}	11.3	0.041	0.113	7.9×10^{-6}	6.6	1.6
14	0.88	480	0.20	6.1×10^{-6}	9.0	0.035	0.085	1.0×10^{-5}	1.6	1.4
15	0.88	300	0.20	7.4×10^{-6}	6.5	0.089	0.231	1.3×10^{-5}	1.8	1.7
16	0.88	730	0.25	2.6×10^{-6}	10.6	0.023	0.112	7.8×10^{-6}	3.0	1.5
17	0.88	250	0.20	3.0×10^{-6}	6.5	0.110	0.445	1.3×10^{-5}	4.3	2.3

σ_θ Standard deviations of lateral wind direction fluctuation

σ_E Standard deviations of vertical wind direction fluctuation

(M indicates missing)

A number of findings, however, were not readily interpreted. Before publishing these results, it was deemed necessary to extend the experiments along two lines, that is in the vertical direction and for longer sampling periods. All the previous tests were for no more than 30-minute sampling periods and equipment was not available for measurements of diffusion above the ground. It was found that the decrease of centerline concentration with downwind distance was usually much greater than predicted by Sutton's equation. The values for Sutton's stability parameter, n, were usually found to be less than ordinarily assumed for temperature lapse conditions. Before this result can be accepted, the sampling efficiency of the field detectors for the tracer had to be investigated. An even more serious possibility was the effect of fallout or deposition upon the cloud. The direct approach, that is of measuring the air concentration through the plume in at least one vertical plane for continuity checks of the released tracer, was considered preferable to sampling the vegetation for deposited activity.

Frequently a wind direction shear from 10 to 20 degrees existed between the top and bottom anemometer levels of the tower. Theoretical models of diffusion have not taken this into account; however, there undoubtedly could be some effect from shear upon the assumed normal distribution of concentration across the plume. Of some 84 crosswind concentration distributions, only 14 were found to be normal[1]. Only 24 additional cases could be classified as borderline. The distributions of the wind direction fluctuations at the height of the source were considerably more normal. Consequently, only part of the non-normality of the crosswind concentration curves may be attributed to insufficiently long sampling times. Bowne did find a fair statistical relationship between the direction shear and the ratio of computed to measured centerline concentration. However, samples in the vertical direction are needed to properly assess the importance of wind direction shear upon diffusion for the small scales involved in the looping diffusion type.

Four semi-portable 92 foot towers have been installed at the 400-meter arc on Grid No. 3, each six degrees apart. Ten high-volume air samplers are suspended equi-distant from one another on each tower. The initial releases will be from ground level to insure fairly complete sampling through the major part of the cloud for computations of the continuity of the tracer. The amount of tracer passing by one row of towers should be equal to the amount released at the source, if there is no significant fallout or deposition. It is hoped to obtain some 10-15 releases for this purpose in the next six months. The ease with which uranine dye can be dispersed, sampled, and analyzed has made it appear profitable

[1] ibid

to study this material further for its suitability as a tracer in studies of atmospheric diffusion and transport.

The collection efficiency of the samplers used to collect the uranine dye was investigated. A glass fiber type filter, Hurlburt X-934-AH, supported by an MSA 2133 all dust filter is used with the Staplex high-volume air sampler for the diffusion studies. A known amount of uranine dye was mixed dry in a virtually air tight room and the known concentration was sampled for different lengths of time. A measure of the fallout or deposition on the walls and floor was made by a Gelman Sampler, which moves a filter strip through the sampled air stream. The change of air concentration with time will indicate the magnitude of the deposition. Low volume air samplers with Millipore filters and water bubbler type samplers were also checked in this study. The results from the Gelman sampler showed that the cloud concentration decreased about 94 per cent for the ten minute sampling period. The collection efficiency of both the glass fiber type filter and the Millipore low-volume type filter was found to be greater than 50 per cent. The water bubbler samplers, although they showed a high collection efficiency, were not readily evaluated since uranine dye was observed throughout the entire system of these samplers. Although the results indicate that the sampling devices used probably detect most of the tracer in the field, the large fallout in the calibration room prevented computation of precise collection efficiencies.

b. T-Sonde Studies

The T-Sonde program, initiated in April 1959, is providing a body of useful data. The program, which proposes to study ground based nocturnal inversions with modified radiosondes and simplified receiving equipment, was designed primarily to observe the seasonal variation of the height to which the inversions grow. A paper by Dickson and Mansfield[1] describes the system and its operation to obtain the low-level temperature soundings.

[1] THE T-SONDE, A LOW LEVEL AIR TEMPERATURE MEASURING DEVICE, July 1959. By C. R. Dickson and H. R. Mansfield. Submitted to the Sixth Air Cleaning Seminar, July 1959, Idaho Falls, Idaho.

Fig. LXXV shows the components of the T-Sonde and the assembled train.

Fig. LXXV. Components of a T-Sonde

Approximately 100 soundings have been made from which the tabulations of maximum inversion height and the magnitude of the greatest inversion are shown in Table 36.

Table 36. Inversion Heights and Intensities from T-Sonde Measurements.

Month	Range of Inversion Ht. (meters)	Magnitude of greatest inversion °F
April	250-625	22.5
May	625-725	27.5
June - July	300-550	22.5
Aug. - Sept. - Oct.	375-500	22.0
Nov. - Dec.	550-1200	34.0

It is apparent that the nocturnal inversion is well formed in all seasons at the NRTS with maximum heights exceeding the height limitation of tethered blimps, some 3-400 meters. During successive clear nights in winter, the top of the nocturnal surface-based inversion is established above 1000 meters in a polar maritime air mass with the ground uncovered by snow. Similar observations with snow cover for a maritime air mass or for a polar continental air mass are unavailable because of the absence of snow or a polar continental air mass during the first part of winter 1959.

The winter soundings indicate that near adiabatic lapse rates are established during the day only to 5-600 meters as a result of the limited insolation and convection in the layers near the ground. Thus, when the top of the inversion exceeds 600 meters a capping inversion may remain above this height throughout the day. The effect of the elevated inversion upon the vertical profiles of wind direction and speed and its relationship to the resulting surface winds is one of the principal objectives of the sounding program.

c. Atmospheric Transport

Studies of atmospheric motions involving distances of 10-50 miles will be included under the caption of atmospheric transport rather than diffusion or dispersion. The objectives of these studies at the NRTS is to define more clearly the wind patterns and wind shears that are experienced over this region. From the results, it is hoped that information will be obtained to improve wind forecasts and trajectory computations for reactor operational purposes.

Two principal methods of attack are being followed in addition to maintaining a micro-network of wind stations. One is the use of fluorescent tracers and the other is the tracking of constant-level-balloon borne targets by radar. Neither has been successful to date.

Uranine dye in solution was released from the top of the 150-foot tower at Grid No. 3 during a period of steady southwest winds over the entire area. This site is about one mile north of the Chemical Processing Plant in the southern part of the NRTS. The off-site monitoring network of the Health and Safety Division, IDO, some thirty miles to the north, was activated but no traces of the dye could be found. It is quite certain from the observed winds that the trajectory would have intercepted this network of samplers. Therefore, it could only be concluded that insufficient dye was released or it was removed from the air by fallout or deposition on the sagebrush. The results indicated that releases from a more elevated point, to prevent ground deposition, particularly during periods of

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atmospheric stability, might be more successful. Releases from aircraft are suggested, but first it was decided to explore releases from the East Butte (This Butte rises some 1600 feet above the plain in the southeast corner of the NRTS).

Smoke pots were used to obtain some idea of the flow over the East Butte, in order to determine how effectively a tracer might be carried away. For temperature lapse conditions or for wind speeds above 15 mph, the smoke was observed to quickly descend the lee side slope of the Butte. Smoke releases are planned to study the behavior of the winds over the Butte during periods of strong stability and light winds at this height. However, preliminary studies have indicated little reason for believing that the East Butte will be a successful launching point for long range tracer studies. Dispensing material from aircraft may be successful but is expensive.

In order to determine the feasibility of tracking targets by radar, a variety of targets and a small semi-mobile APS-3 radar set were obtained. This set has a nominal 30 kilowatt power rating. A variety of targets including tetroons, which are polyhedrons covered by aluminum foil that can be made to fly at fairly constant levels, and balloons with aluminum dipole reflectors placed on the inside were tried. These targets could only be tracked from two to four miles under the best conditions. It appeared unlikely that purely reflecting type targets would be suitable for low power radar sets.

d. Turbulence Parameters

Within the last six months sufficient equipment has been developed or made available to study various features of atmospheric turbulence, that are needed for computations of atmospheric diffusion. Turbulence parameters such as horizontal and vertical wind gustiness and its variation with height and averaging time, low-level wind profiles for roughness and stress computations, and wind directions fluctuation variances are needed to evaluate dispersion data. The anemometry for the diffusion studies mentioned earlier was not proven to be sufficiently accurate for many of these calculations.

Three bivanes have been developed and have been installed on the 150-foot tower at Grid No. 3. A Beckman and Whitley anemometer is also placed at each bivane level. The 150-foot tower and attached instrumentation are shown in Fig. LXXVI.

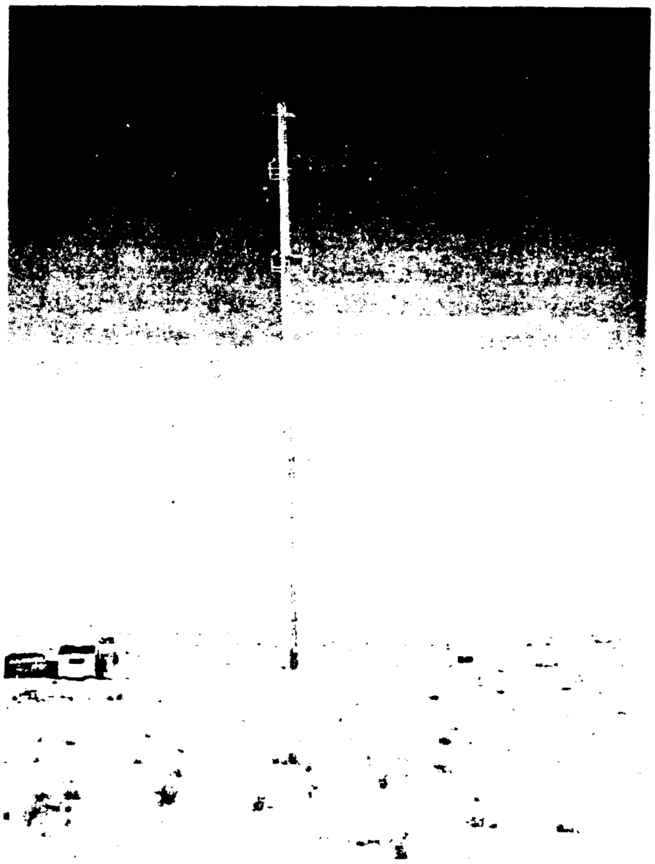


Fig. LXXVI. Meteorological Tower and Instruments with Sampling Grid

The anemometers have been tested in the wind tunnel of the General Electric Company at ANP and found to match fairly accurately. Counters have been placed in parallel with the anemometer recorders to facilitate the adjustment of the measured results for the slight differences in calibration. Considerable care, guided by wind tunnel results, has gone into the selection of suitable recorders for the bivanes. Two considerations are especially important in the selection of the recording system. One is the speed of response of the recorder and the other is the current required to be passed through the potentiometer of the bivane. The latter should be kept to a minimum to reduce arcing across each turn of the potentiometer wire and permit maximum life. From the results of wind tunnel tests and field experience, self-balancing type potentiometer recorders with a one-second full scale deflection were selected. A special input circuit to reduce the current through the bivane to a minimum was substituted for the bridge circuit of the recorder. Preliminary details of the bivane development and testing have been reported by Dickson[1].

The vertical temperature lapse rate will be measured by slow, aspirated, and shielded thermohms. A mobile trailer, to house the various recorders, has been readied and wired. Equipment to convert the various analog inputs from the above described meteorological system into digital form and storage on punched tape has not yet been purchased. The great amount of labor and time involved in reducing the data manually, particularly for spectrum analysis, has made it appear essential to convert to a digital recording system. A program and computer are available for spectrum analysis studies at Washington D. C., once the information is punched on cards or tape.

C SPECIAL ACTIVITIES

1. Seminar Program

In order to keep the entire Weather Bureau Staff informed of the status and results of the various research investigations, a monthly seminar program was initiated. Each meteorologist conducted a seminar in which he presented the highlights and important results of his particular project. The speaker also received beneficial training in presenting scientific research results to a group. From the discussion after each seminar, suggestions and ideas for future work would frequently arise.

2. Visiting Consultant

A consultant, Professor A. K. Blackadar, Department of Meteorology, Pennsylvania State University, joined the Weather Bureau staff for the month of August. From a thorough review of the Site program and needs and by individual discussions with the research meteorologists, many suggestions for future programs and studies were made. Dr. Blackadar also gave a series of lectures dealing with such relevant topics as wind and temperature relationships with height, atmospheric diffusion and turbulence theory, wind shear, and nocturnal thunderstorms.

[1] Wind Tunnel Tests of a Bivane Developed at the National Reactor Testing Station, Idaho Falls, Idaho, 1959, by C. R. Dickson (unpublished manuscript) Weather Bureau, Idaho Falls, Idaho.

D FUTURE PROGRAMS

1. Operational and Service

As the number of reactors and experiments at the NRTS increases, it is anticipated that there will be an increasing demand for reactor operational forecasts and weather surveillance. Best present estimates indicate that demands for Weather Bureau services will be particularly heavy for tests in the MTR-ETR, the IET, the Waste Calcination Plant and the FET in future months. Significant releases of radioactive material are anticipated from some of these experiments requiring close liaison between the contractor, the field monitoring crews of the Health and Safety Division, and the Weather Bureau. Forecasts for the CPP and TREAT facilities as the need requires will be of a more routine nature.

Relocation of the micro-net weather sub-stations from time to time for optimum coverage of reactor operations will be carried out. Elevation of wind instruments above the ground by the semi-portable 92-foot towers, presently in use for diffusion studies, will allow measurement of more meaningful winds to compute trajectories of stack releases. This may be done this year if it is felt that the basic objectives of the present series of diffusion studies are realized.

2. Research

The research program will continue along two main lines: (a) Continued studies of atmospheric diffusion and (b) Collection and study of data describing the three-dimensional wind and temperature field. The latter are needed to improve the understanding of the winds and consequently, their forecasts over the NRTS.

a. Tracer Studies

Fluorescent tracers will be used to continue studies of dispersion of pollutants, which may be released into the atmosphere over the NRTS. The coming year these studies will be extended into the vertical direction by towers. Such three-dimensional tracer studies will be limited to short range, out to two miles. In addition to empirically evaluating various diffusion models for short distances, specifically the looping diffusion type, some fundamental meteorological studies can also be made with the data. The relationship between the three-dimensional dispersion of the tracer, as measured by the variances of the tracer material along the three coordinates, and the turbulence of the atmosphere will be explored as a function of scale and averaging time. Fundamental parameters of turbulence, such as the variance of the wind direction fluctuation, can be obtained from the Weather Bureau bivane. Some ten to fifteen releases are desired to obtain a measure of statistical significance for the results. The scope of the study will depend to some extent upon the degree of digitalization that can be accomplished for the bivane and anemometer systems.

b. Upper Wind and Temperature Studies

About two to three hundred T-Sonde ascents are planned for the coming year. These ascents are usually terminated at 5,000 feet above the surface, and are tracked by double theodolites to obtain winds at all levels. The wintertime studies will be primarily during daylight hours, since the inversion frequently persists at high levels through a major part of the day. During the warmer months of the year, many night-time ascents are contemplated to provide additional detail on the development of the nocturnal inversion. From the seasonal and diurnal variations of the three-dimentional wind and temperature structure, a better insight into the complex relationship between surface winds, topography, and vertical temperature profiles may be obtained. Such understanding is necessary for improvement over present forecast techniques of surface winds at the NRTS.

c. Atmospheric Transport

Atmospheric motions, that are effective in moving radioactive material for larger distances (10-50 miles), may be investigated by radar tracking of constant-level balloon-borne targets. This will depend upon developing a suitable transponder, a transmitter carried by the balloon which is triggered by the radar pulse and detected on the radar scope. Since the present radar set does not have sufficient power for detecting purely reflecting type targets beyond about four miles, a transponder is needed for studies out to distances of any practical value. The Weather Bureau is currently making a feasibility study for development of a transponder.

Tracers are also planned for use in transport studies. These may be either fluorescent tracers or radioactive material released from the stacks at the NRTS. Tracking of radioactive cloud by aircraft is one tool for rapid tracking over difficult terrain for long distances. Animal and vegetation samples, taken by the Ecology Branch, have also been useful for this purpose, since previous studies have shown good agreement between meteorological trajectory computations and observed deposition patterns.

d. Digitalization of NRTS Weather Network

The forthcoming year will see a major stride forward in the automation of the weather measuring system on the NRTS. One system covering the northern part of the NRTS is presently being installed by the General Electric Co. Telemetering from outlying stations and digital readout on electric typewriter and punched tape of winds and temperatures are involved. A similar system will be used to digitalize the weather information currently being measured at Central Facilities and several outlying stations. A high speed punched tape system is also being prepared for storing the information from several bivanes.

E. TALKS AND PUBLICATIONS

1. METEOROLOGICAL PROBLEMS IN THE OPERATION OF REACTORS, presented by Norman F. Islitzer to the Sixth Annual Nuclear Sciences Seminar, Idaho Falls, Idaho, July 1959.

2. MEASUREMENTS OF ATMOSPHERIC DIFFUSION FROM AN ELEVATED SOURCE, presented by Norman E. Bowne to the Sixth Air Cleaning Seminar, Idaho Falls, Idaho, July 1959.

3. SHORT RANGE TRACER STUDIES IN THE ATMOSPHERE, presented by Norman F. Islitzer to the Graduate Student Colloquim, Department of Meteorology, University of Wisconsin, Madison, Wisconsin, December 1959.

4. WORKBOOK IN ATMOSPHERIC DIFFUSION CALCULATION, IDO-12005, G. A. DeMarrais, February 1959.

Chapter 11

U. S. PUBLIC HEALTH SERVICE

R. D. Coleman, Senior Officer

A SCOPE

The U. S. Public Health Service activities at the NRTS operated on two fronts, the Technical Advisor function conducted by the Senior PHS Officer and the Monitoring Evaluation Project, staffed by four professional people with J. J. Sabo as Project Chief. The fourth member of the Monitoring Evaluation Project, a physicist, was added in July.

B SUMMARY OF MAJOR PROGRAMS

1. The monitoring Evaluation Project initiated a study to evaluate the environmental monitoring methods now being used and to correlate different techniques whenever possible. A progress report issued in December 1959 stressed a re-emphasis of techniques and analysis to obtain data in a documented form that is interpretable in terms of a biological hazard such as air concentration, cumulative external exposure, and deposited activity.

   Field use was made of meteorological predictions regarding the point of maximum concentration, d(max). When operating reactors are used as sources their inherently large air volumes and high effective stack heights establish conditions which cannot be duplicated by use of controlled diffusion tests. Significant samples were obtained at d(max) when that point was predicted to be less than three miles from the stack.

   Work on the field testing of materials and methods was conducted in the following areas:

   a. Ultra high volume air sampling was found to be useful in obtaining meaningful samples at concentrations slightly above background for relatively short sampling times. A sampler was devised, utilizing available equipment, to sample at this rate (Fig. LXXVII).

   b. CC-6 filters treated with silver nitrate were used in monitoring reactor effluents because of their affinity for the iodines as well as particulates. Since many of the sources of activity contained iodine in relatively large proportion to the total activity, the method showed merit especially for identification purposes. A 7" x 9" treated filter on a standard High Volume air sampler at 50 cfm supplied good samples even under conditions of varying cloud paths.

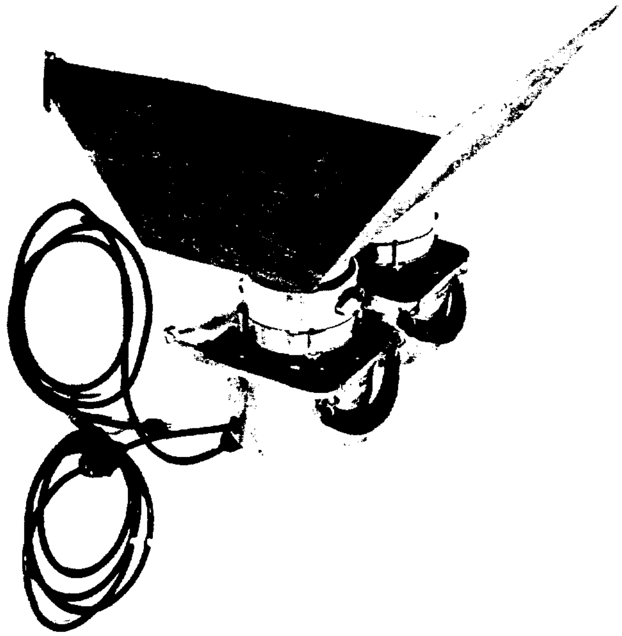


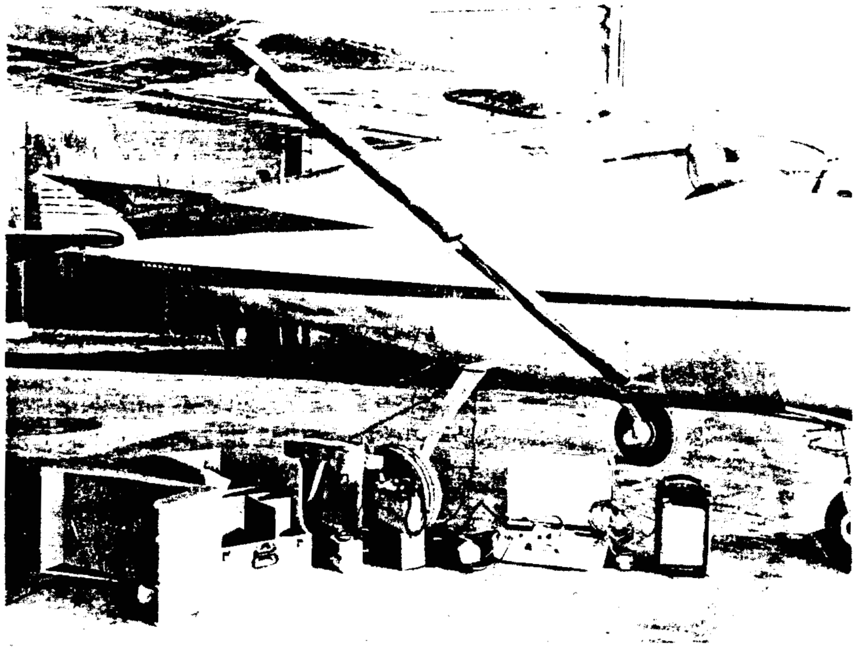
Fig. LXXVII. Ultra High Volume Air Sampler

c. The feasibility of using collimated detectors for positive location of radioactive clouds was evaluated, and field tests were initiated.

2. The Senior Public Health Service Officer prepared a special evaluation of off-site water sampling for the Director of Health and Safety.

The aerial monitoring equipment constructed by the Instrument and Development Branch was placed in operation. Procedures were developed for the application of aerial monitoring to emergency conditions at the NRTS. Radioactive clouds from routine releases were followed in an attempt to obtain data for long range diffusion computations. The accompanying photos show the equipment prior to placement in the aircraft and the equipment setup on the rear seat of a 4 place aircraft (Fig. LXXVIII).

Approximately 32 hours of flight time in light aircraft were utilized in routine, training, and release monitoring and in gathering data for refinements in the use of the equipment. An additional four hours were flown in conjunction with the USGS Aerial Survey of the NRTS.



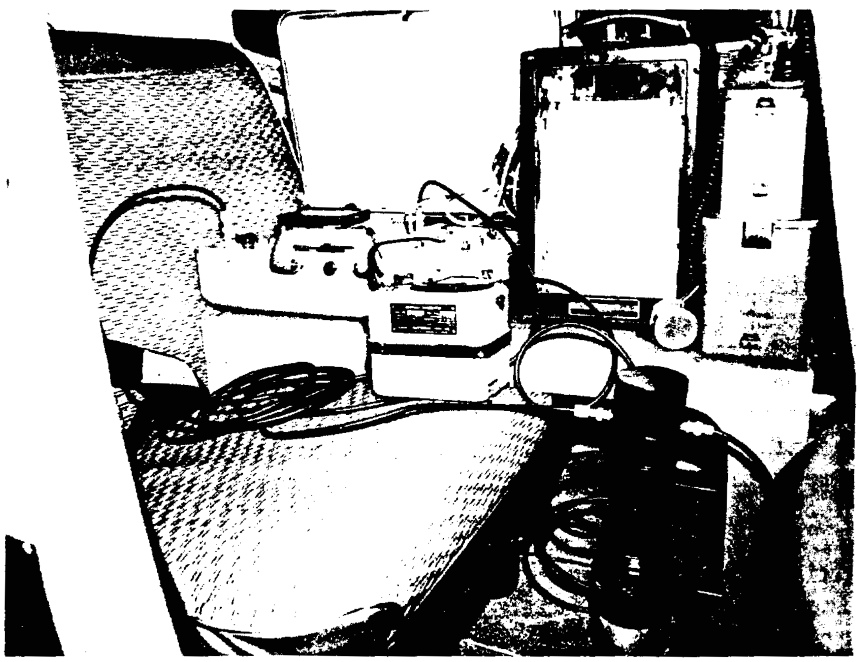


Fig. LXXIX. Aerial Monitoring Equipment

C SPECIAL ACTIVITIES

1. Data were collected to differentiate between fission product and natural background activity on air samples. By establishing the gamma to alpha and beta to alpha ratios for natural activity for sampling times of 2, 4, and 6 hours and decay times of 1/2 to 4 hours a reference is available against which the ratios obtained from unknown samples can be compared without waiting for the decay of the natural components. This technique is useful in correcting for natural activity when the fission products are of short half-life. It can also be applied to screen routine samples for the presence of fission products.

   The use of dosimeter pencils for determining low levels of radiatio over long periods of time was investigated for area monitoring. It was found that the dosimeters must be pre-selected to get statistically reliable results.

   The use of a wind powered air sampler has merit for area monitoring and conceptual studies were initiated. This approach requires a highly advanced technology to remain within the premise of low cost, no auxiliary power, and reasonable sensitivity.

D FUTURE PLANS

The future activities of the Monitoring Evaluation Project will be devoted to:

1. Completion of the study of environmental monitoring methods.
2. Evaluation of the accuracy of meteorological predictions for distances in excess of 3 miles.
3. Specific comparison of the results of treated paper sampling with standard methods now in use at the NRTS.
4. The application of low range dosimeters to area monitoring.
5. Completion of the work on $\frac{\gamma}{\alpha}$ and $\frac{\beta}{\alpha}$ ratios for rapid determinatio of the presence of fission products.
6. The development of a prototype wind powered sampler for actual implementation studies.
7. Initiation of a reference system to quickly determine the specif isotopes which are most probably present in releases from the various operations at the NRTS.
8. The completion and calibration of a collimated detector for clou location purposes.
9. Further investigation of techniques for sampling large air volum

10. Aerial Monitoring activities will be devoted to general familiarization of IDO personnel with equipment and techniques. Training flights will be utilized for the collection of additional data to lend sophistication to aerial monitoring techniques at the NRTS. These flights will also be utilized for determining cloud dimensions at distances greater than three miles in a continuing effort to document the validity of meteorological predictions.

E <u>TALKS AND PUBLICATIONS</u>

1. THE USE OF IODINE AS AN INDICATOR FOR REACTOR MONITORING, by J. J. Sabo, J. E. Martin and R. F. Grossman. Presented at Sixth Air Cleaning Conference, July 1959.

2. AN EVALUATION OF HIGH VOLUME SAMPLING RATES FOR AIR CONTAINING RADIOACTIVE PARTICULATE AT CONCENTRATIONS NEAR NORMAL BACKGROUND, by J. J. Sabo, J. E. Martin, and R. F. Grossman. Presented at Pacific Northwest Section of AIHA, September 1959.

3. AIR MONITORING AT NUCLEAR REACTOR OPERATIONS, presented by J. J. Sabo at the Sanitary Engineering Center, Cincinnati, during the course on Radioactive Air Pollutants, January 1960.

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