DNA 6022F

OPERATION RANGER

Shots ABLE, BAKER, EASY, BAKER-2, FOX 25 JANUARY-6 FEBRUARY 1951

United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

Prepared by the Defense Nuclear Agency as Executive Agency
for the Department of Defense

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: DNA 6022F
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): OPERATION RANGER
SHOTS ABLE, BAKER, EASY, BAKER-2, FOX
25 January - 6 February 1951

5. TYPE OF REPORT & PERIOD COVERED: Final Report

6. PERFORMING ORG. REPORT NUMBER: JRB 2-816-03-423-00

7. AUTHOR(s): Carl Maag, Stephen Rohrer, Robert Shepanek

8. CONTRACT OR GRANT NUMBER(s): DNA 001-79-C-0473

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
JRB Associates
8400 Westpark Drive
McLean, Virginia 22102

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Subtask U99QAXMK506-08

11. CONTROLLING OFFICE NAME AND ADDRESS:
Director
Defense Nuclear Agency
Washington, DC 20305

12. REPORT DATE: 26 February 1982

13. NUMBER OF PAGES: 182

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A Since UNCLASSIFIED

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B350079464 U99QAXMK50608 H2590D. For sale by National Technical Information Service, Springfield, VA 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

RANGER	FOX	Special Weapons Command
ABLE	Nevada Proving Ground	Los Alamos Scientific Laboratory
BAKER	Test Group	
EASY	Scientific Tests Section	Army Participation Group
BAKER-2	Radiological Safety Section	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the activities of DOD personnel, both military and civilian, in Operation RANGER, the first atmospheric nuclear weapons testing series, conducted in Nevada from 25 January to 6 February 1951. The RANGER series consisted of one high-explosive shot and five nuclear shots: ABLE, BAKER, EASY, BAKER-2, and FOX. DOD activities included scientific and diagnostic experiments, DOD air and land support activities, and radiological safety activities. In addition, radiological safety procedures were established and implemented to minimize the radiation exposures of test participants.

18. SUPPLEMENTARY NOTES (Continued)

The Defense Nuclear Agency Action Officer, Lt. Col. H. L. Reese, USAF, under whom this work was done, wishes to acknowledge the research and editing contribution of numerous reviewers in the military services and other organizations in addition to those writers listed in block 7.

Fact Sheet

Defense Nuclear Agency
Public Affairs Office
Washington, D C 20305

Subject: Operation RANGER

Operation RANGER, the first series of atmospheric nuclear weapons tests conducted by the Atomic Energy Commission (AEC) at the Nevada Proving Ground (NPG), consisted of five nuclear detonations, all of which were airdrops. The operation also included one non-nuclear high-explosive test detonated two days before the first nuclear event. Operation RANGER lasted from 25 January through 6 February 1951 and involved approximately 360 Department of Defense (DOD) participants in air support services, scientific experiments, weather support, communications security, and observer activities. The series was intended to provide data for use in determining design criteria for nuclear devices scheduled for detonation at Operation GREENHOUSE, to be conducted at the Pacific Proving Ground from 7 April to 24 May 1951.

Department of Defense Involvement

Since RANGER was only a 13-day operation, the same units and participants performed the same duties throughout the series. The majority of the Department of Defense personnel at Operation RANGER took part in the air support services provided by the Air Support Section of the Test Group. Air Force personnel from the Special Weapons Command (SWC) and Headquarters, Air Force, conducted most of these activities. At each test event, air support activities included the airdrop of the nuclear device, cloud sampling, cloud tracking, aerial surveys of the terrain, and courier service. Air Force personnel also provided meteorological services and communications security and monitored worldwide radioactivity from the RANGER tests for the Atomic Energy Detection System.

Air Force participation at the RANGER shots involved personnel from:

- Headquarters, U.S. Air Force
- Air Research and Development Command
- Air Training Command
- Strategic Air Command
- Air Force Security Service
- Air Weather Service

- Air Force Cambridge Research Laboratory
- 4901st Support Wing (Atomic) (SWC)
- 4925th Special Weapons Group (SWC)
- 374th Reconnaissance Squadron (Very Long Range) Weather
- 1009th Special Weapons Squadron.

The Scientific Tests Section of the Test Group conducted experiments at each nuclear detonation. DOD personnel were involved in eight experiments at each shot except BAKER, where they took part in seven experiments. Of the 12 known DOD participants, six were from the Army Participation Group, an organization representing the Chief, Armed Forces Special Weapons Project. The other six were officers from the Army, Navy, and Air Force. Participants in these scientific experiments placed film badges, fabrics, and other materials and instruments in or around military fortifications constructed in the ground zero area. They retrieved the equipment after the detonation, when radiation levels had decreased and limited access into the shot area was permitted.

The number of observers at RANGER has been documented as 156, but only three of these are believed to have been military personnel.

Summaries of RANGER Nuclear Events

The accompanying table details specific information for each nuclear shot in the RANGER Series, and the accompanying map shows ground zero and the operations area. These five shots were of the same type, were detonated at the same site, and involved similar activities. Shot FOX, the last, was the largest shot and the only event not detonated on schedule. A one-day postponement was caused by an oil leak in the B-50 drop aircraft. Fired 1,435 feet above Frenchman Flat, Shot FOX had a yield of 22 kilotons. The initial radiation survey, conducted about one hour after the detonation, showed a maximum gamma intensity of 15.5 roentgens per hour (R/h) at ground zero and 8.0 R/h about 200 meters from ground zero. At 900 meters, the radiation level decreased to 0.25 R/h.

Safety Standards and Procedures

The Atomic Energy Commission established safety criteria to minimize the exposure of participants to ionizing radiation, while allowing them to accomplish their missions. DOD participants at RANGER were restricted to a gamma exposure limit of 3.0 roentgens per 13-week period. Sampling pilots from the Air Weather Service were authorized to receive up to 3.9 roentgens because the special nature of their mission required them to penetrate the clouds resulting from the shots.

The Test Group was responsible for the radiological safety of all RANGER participants, and its Radiological Safety Section was responsible for implementing the radiological safety procedures. This section consisted of personnel from the AEC, the Los Alamos Scientific Laboratory, and the Army Corps of Engineers. Personnel from Headquarters, Air Force, implemented radiological safety procedures for Air Force participants. The general procedures followed by both groups were similar:

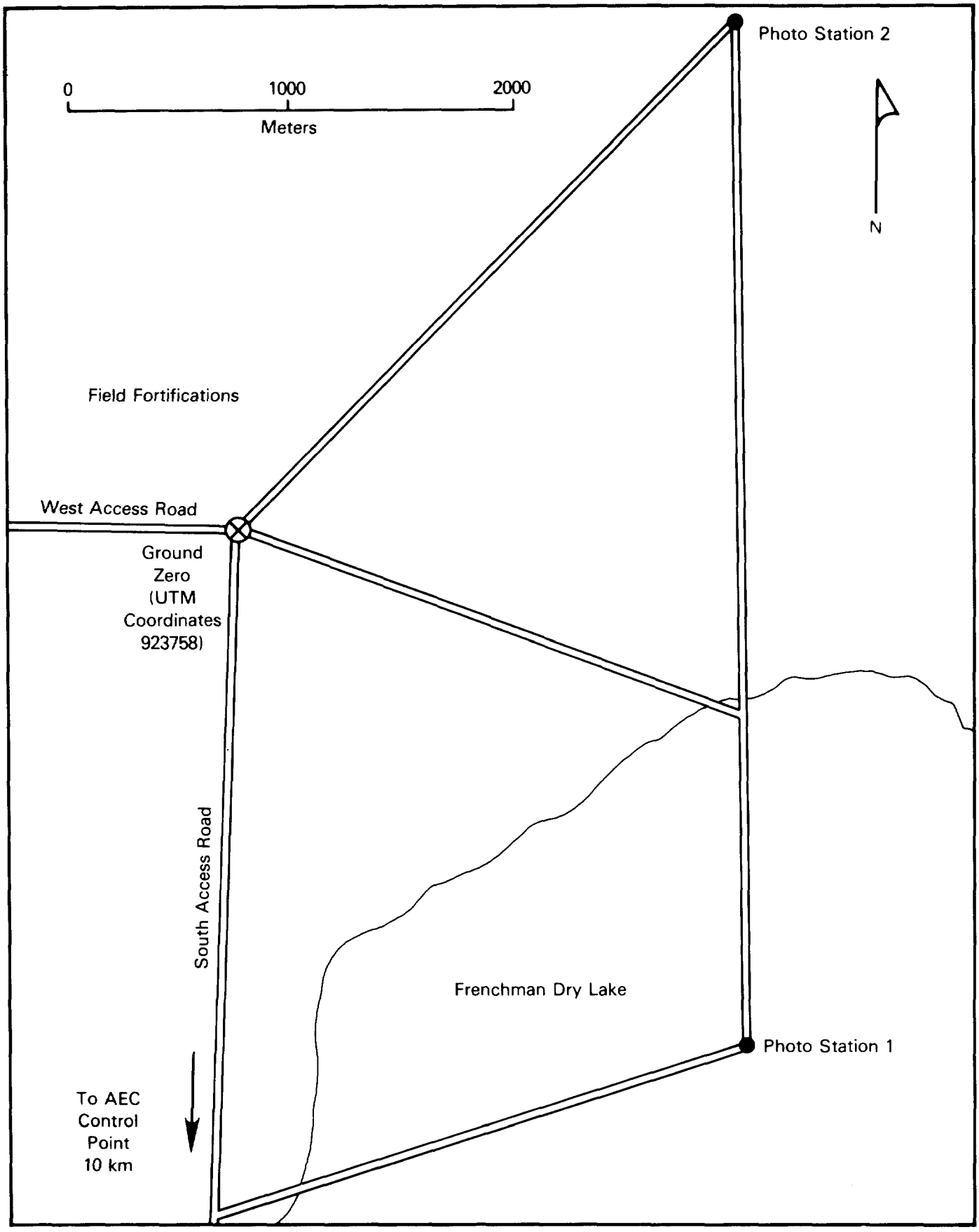
- Personnel dosimetry -- issuing and developing film badges for participants and evaluating gamma radiation exposures recorded on film badges
- Use of protective equipment -- providing clothing, respirators, and other protective equipment
- Monitoring -- performing radiological surveys and controlling access to radiation areas
- Decontamination -- detecting and removing contamination on personnel and equipment.

Radiation Exposures at RANGER

As of February 1982, the military services had identified 262 participants by name for Operation RANGER. Film badge data are available for 63 of these participants, as shown in the table, "Summary of Dosimetry for Operation RANGER." These data indicate that three individuals received exposures greater than the 3.0 roentgen limit.

SUMMARY OF OPERATION RANGER EVENTS (1951)

Shot	ABLE	BAKER	EASY	BAKER-2	FOX
Sponsor	LASL	LASL	LASL	LASL	LASL
Planned Date	27 January	28 January	1 February	2 February	5 February
Actual Date	27 January	28 January	1 February	2 February	6 February
Local Time	0545	0552	0547	0549	0547
NPG Location	Frenchman Flat	Frenchman Flat	Frenchman Flat	Frenchman Flat	Frenchman Flat
Type	Airdrop	Airdrop	Airdrop	Airdrop	Airdrop
Height of Burst (Feet)	1,060	1,080	1,080	1,100	1,435
Yield (Kilotons)	1	8	1	8	22



FRENCHMAN FLAT, NPG, SHOWING GROUND ZERO AND OPERATIONS AREA FOR OPERATION RANGER

SUMMARY OF DOSIMETRY FOR OPERATION RANGER AS OF FEBRUARY 1982

Service	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Gamma Exposure (Roentgens)					Number of Personnel with Zero Gamma Exposure*	Average Gamma Exposure (Roentgens)	Maximum Gamma Exposure (Roentgens)
			<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+			
Army	14	14	1	9	3	1	0	1	0.871	3.4
Navy	3	2	0	0	0	1	1	0	4.265	5.3
Marine Corps	1	1	0	1	0	0	0	0	0.820	0.8
Air Force	202	4	3	1	0	0	0	2	0.062	0.2
Scientific Personnel, Contractors, and Affiliates	42	42	9	27	6	0	0	3	0.618	2.7
TOTAL	262	63	13	38	9	2	1	6	0.758	

* The number of personnel in this column is also represented in the <.1 Gamma Exposure column.

PREFACE

Between 1945 and 1962, the United States Government, through the Manhattan Engineer District and its successor agency, the Atomic Energy Commission (AEC), conducted 235 atmospheric nuclear weapons tests at sites in the United States and in the Atlantic and Pacific Oceans. In all, an estimated 220,000 Department of Defense (DOD) participants, both military and civilian, were present at the tests. Of these, approximately 90,000 were present at the atmospheric nuclear weapons tests conducted at the Nevada Proving Ground* (NPG), northwest of Las Vegas, Nevada.

In 1977, 15 years after the last above-ground nuclear weapons test, the Center for Disease Control+ noted a possible leukemia cluster among a small group of soldiers present at Shot SMOKY, one test of Operation PLUMBBOB, the series of atmospheric nuclear weapons tests conducted in 1957. Since that initial report by the Center for Disease Control, the Veterans Administration has received a number of claims for medical benefits from former military personnel who believe their health may have been affected by their participation in the weapons testing program.

In late 1977, the DOD began a study to provide data to both the Center for Disease Control and the Veterans Administration on potential exposures to ionizing radiation among the military and civilian personnel who participated in the atmospheric tests. The DOD organized an effort to:

- Identify DOD personnel who had taken part in the atmospheric nuclear weapons tests

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*Renamed the Nevada Test Site in 1955.

+The Center for Disease Control is an agency of the U.S. Department of Health and Human Services (formerly the U.S. Department of Health, Education, and Welfare).

- Determine the extent of the participants' exposure to ionizing radiation
- Provide public disclosure of information concerning participation by DOD personnel in the atmospheric nuclear weapons tests.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report is based on the military and technical documents associated with the Operation RANGER atmospheric nuclear weapons tests. Many of the documents pertaining specifically to DOD involvement in Operation RANGER, the first series of atmospheric nuclear weapons tests conducted at the NPG, were found in the Defense Nuclear Agency Technical Library, the Air Force Weapons Laboratory Technical Library, and the Modern Military Branch of the National Archives.

In many cases, the surviving historical documentation of RANGER activities addresses test specifications and technical information rather than personnel data. Moreover, the documents sometimes reveal inconsistencies in facts, such as the number of DOD participants in a certain experiment at a given shot or their locations and assignments at a given time. These discrepancies usually occur between two or more documents but occasionally appear within the same document. Efforts have been made to resolve the inconsistencies wherever possible, or otherwise to bring them to the attention of the reader.

For the experiments discussed in this volume, the only available document describing personnel activities is the six-volume report on Operation RANGER, published by the Los Alamos Scientific Laboratory (LASL). This source, an after-action document, summarizes the experiments performed during the RANGER Series, but does not always supply shot-specific information.

All yield information presented in this volume is taken from the Department of Energy, Announced United States Nuclear Tests, July 1945 through 1979 (NVO-209). Other data on the tests, concerning fallout patterns, meteorological conditions, and cloud dimensions, are taken from DASA 1251-1, Compilation of Local Fallout Data from Test Detonations 1945-1962, Volume 1, except in instances where more specific information is available elsewhere.

ORGANIZATION AND CONTENT OF THIS VOLUME

The following ten chapters discuss DOD participation in Operation RANGER. Chapter 1 provides background information on the operation, including summaries of the five nuclear events in the series and the activities of DOD participants. Chapter 2 details the test organization and responsibilities of the various groups with DOD participants. Chapter 3 describes the RANGER scientific experiments and support activities involving DOD personnel and coordinated by the AEC organization and LASL. Chapter 4 discusses the radiological criteria and procedures in effect during Operation RANGER for each of the DOD groups with significant participation. Chapter 5 presents information on the results of the radiation protection program, including an analysis of film badge readings for DOD personnel. Chapters 6 through 10 address each of the five RANGER shots in turn. Each chapter describes the specific setting and characteristics of the detonation, details DOD personnel activities in the scientific experiments conducted at the shot, and discusses the radiation protection procedures used to minimize exposure to ionizing radiation.

The information in this report is supplemented by the Reference Manual: Background Materials for the CONUS Volumes. The manual summarizes information on radiation physics, radiation health concepts, exposure criteria, and measurement techniques. It also lists acronyms and a glossary of terms used in the DOD reports addressing test events in the continental United States.

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC	Atomic Energy Commission
AEDS	Atomic Energy Detection System
AFB	Air Force Base
AFSWP	Armed Forces Special Weapons Project
AWS	Air Weather Service
CONUS	Continental United States
DMA	Division of Military Application
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Inc.
LASL	Los Alamos Scientific Laboratory
MLC	Military Liaison Committee
NPG	Nevada Proving Ground
psi	Pounds per square inch
R/h	Roentgens per hour
REECo	Reynolds Electrical and Engineering Company
SAC	Strategic Air Command
SFOO	Santa Fe Operations Office
SWC	Special Weapons Command
USAF	United States Air Force
UTM	Universal Transverse Mercator
VLR	Very Long Range

CHAPTER 1

INTRODUCTION

Operation RANGER, the first series of atmospheric nuclear weapons tests conducted within the continental United States, consisted of five nuclear tests. RANGER also included one non-nuclear high-explosive test conducted two days before the first nuclear detonation. The series lasted from 25 January through 6 February 1951 and involved about 360 Department of Defense participants in air and land support activities, scientific experiments, and observer activities. The primary objective of the operation was to provide sufficient data to determine satisfactory design criteria for nuclear devices scheduled to be detonated at Operation GREENHOUSE, conducted at the Pacific Proving Ground from 7 April through 24 May 1951.

This volume summarizes information on organizations, procedures, and activities of DOD personnel at Operation RANGER and provides specific information for each shot. It also shows the relationship of the series to earlier and later atmospheric testing operations in the Atlantic and Pacific Oceans and at the Nevada Proving Ground. This chapter introduces Operation RANGER with a description of the:

- Historical background and establishment of Operation RANGER
- Selection and description of the Nevada Proving Ground
- Five nuclear events
- DOD participation at the test series.

1.1 HISTORICAL BACKGROUND AND THE ESTABLISHMENT OF OPERATION RANGER

Following World War II, the United States launched an extensive nuclear weapons testing program in an effort to expand its nuclear arsenal and to maintain superiority over the Soviet Union. During 1946 and 1948, the United States conducted two testing programs in the Pacific, Operations CROSSROADS and SANDSTONE, respectively. In 1949, the Soviet Union exploded its first nuclear device, well ahead of American expectations (35).*

In November 1950, the Los Alamos Scientific Laboratory discovered that insufficient data were available to determine satisfactory design criteria for nuclear devices to be tested in Operation GREENHOUSE, a series of AEC nuclear tests scheduled for the Pacific Proving Ground from 7 April through 24 May 1951. The LASL scientists believed that variations in the compression of the critical material could affect the yields of the GREENHOUSE devices. To confirm this hypothesis, LASL held conferences on 6 and 11 December 1950 and concluded that a series of small nuclear tests should be conducted to improve the GREENHOUSE design criteria. On 22 December 1950, LASL requested approval for a continental series from the AEC Division of Military Application (DMA). DMA approved the request and asked for Presidential approval to expend the fissionable material required for the series. The White House responded affirmatively on 11 January 1951, formally creating Operation RANGER. The decision to conduct RANGER accelerated the establishment of the Nevada Proving Ground (11; 12).

The same day that Operation RANGER was approved by the President, the AEC distributed its only announcements of the coming tests. Handbills were circulated in the area of the NPG,

*All sources cited in the text are listed alphabetically and numbered in the Reference List at the end of this volume.

stating that from 11 January 1951 the Government would be conducting nuclear tests at the Las Vegas Bombing and Gunnery Range in Nevada. Figure 1-1 shows this handbill.

1.2 SELECTION AND DESCRIPTION OF THE NEVADA PROVING GROUND

Since the detonation of TRINITY at Alamogordo, New Mexico, on 16 July 1945, no nuclear device had been tested in the continental United States (CONUS). The AEC had considered establishing a continental test site in 1948 after SANDSTONE, as a means of reducing construction and logistics costs, but rejected that idea after obtaining the results of an Armed Forces Special Weapons Project (AFSWP) report. This report, "Project Nutmeg," concluded that the physical problems and domestic political concerns were too complicated to warrant the creation of a CONUS test site. It advised continued use of the Pacific Proving Ground but suggested the establishment of a continental test site in an emergency (12).

When the Korean War began in the summer of 1950, however, the AEC doubted that the Pacific Proving Ground could be used for nuclear weapons testing because of the possibility of the Korean War expanding throughout the Far East, thus endangering the Pacific shipping lanes. On 13 July 1950, the AEC Chairman wrote the Chairman of the Military Liaison Committee that the possibility of a national emergency required a joint effort by the AEC and DOD to find a continental test site. The DOD agreed, and the search began for a test site, using the AFSWP "Project Nutmeg" report as an aid in the selection process (12; 26).

The AEC and DOD surveyed six sites within the continental United States before choosing the Frenchman Flat area of the Las

WARNING

January 11, 1951

From this day forward the U. S. Atomic Energy Commission has been authorized to use part of the Las Vegas Bombing and Gunnery Range for test work necessary to the atomic weapons development program.

Test activities will include experimental nuclear detonations for the development of atomic bombs – so-called "A-Bombs" – carried out under controlled conditions.

Tests will be conducted on a routine basis for an indefinite period.

NO PUBLIC ANNOUNCEMENT OF THE TIME OF ANY TEST WILL BE MADE

Unauthorized persons who pass inside the limits of the Las Vegas Bombing and Gunnery Range may be subject to injury from or as a result of the AEC test activities.

Health and safety authorities have determined that no danger from or as a result of AEC test activities may be expected outside the limits of the Las Vegas Bombing and Gunnery Range. All necessary precautions, including radiological surveys and patrolling of the surrounding territory, will be undertaken to insure that safety conditions are maintained.

Full security restrictions of the Atomic Energy Act will apply to the work in this area.

RALPH P. JOHNSON, Project Manager
Las Vegas Project Office
U. S. Atomic Energy Commission

Figure 1-1: AEC HANDBILL ANNOUNCING THE BEGINNING OF THE RANGER TESTS

Vegas Bombing and Gunnery Range.* The Government picked this site because it best suited AEC criteria for favorable meteorological conditions, distance from populated areas, and proximity to operational facilities. When the necessity for RANGER became apparent in November 1950, the AEC met with the Air Force to obtain testing rights in the Las Vegas Bombing and Gunnery Range. On 21 December 1950, the AEC and the Air Force signed an agreement that (12):

- Surrendered to the AEC as a permanent test site the Air Force lease on a rectangular area of the Las Vegas Bombing and Gunnery Range measuring 19 by 48 kilometers+
- Allowed the AEC to use Indian Springs Air Force Base (AFB) facilities to support the test site
- Provided the AEC with operational facilities at Indian Springs and Nellis Air Force Bases for the duration of Operation RANGER.

On 1 January 1951, the AEC Santa Fe Operations Office awarded the Reynolds Electrical and Engineering Company (REECo) a contract to begin construction of facilities at the test site. The construction of the test site was code named Project Mercury. The test site itself was initially named Site Mercury, which in turn evolved into the NPG and later the Nevada Test Site (12).

When RANGER began on 25 January 1951, the AEC had Air Force approval to increase the NPG from 19 by 48 kilometers to 23 by 64 kilometers (12). This enlarged the NPG to 1,472 square kilometers, all of which was located in Nye County, Nevada, 100 kilometers northwest of Las Vegas. Except for its southern boundary, the

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*Later renamed the Nellis Air Force Range.

+Throughout this report, surface distances are given in metric units. The metric conversion factors include: 1 meter = 3.28 feet; 1 meter = 1.09 yards; and 1 kilometer = 0.62 miles.

NPG was completely surrounded by the Las Vegas Bombing and Gunnery Range. Figure 1-2 shows the NPG as it existed in 1951.

The NPG was divided into two geographical areas: Yucca Flat and Frenchman Flat. Yucca Flat, located in the north-central part of the NPG, is a 320-square-kilometer desert valley surrounded by mountains. This area was the location of many nuclear detonations after Operation RANGER. Frenchman Flat, which includes a 15-square-kilometer dry lake, is located in the southeastern part of the NPG. All five RANGER detonations were conducted in this area at the same ground zero. Ground zero was at UTM coordinates 923758,* northwest of Frenchman Lake. Figure 1-3 shows the RANGER test area (12; 34).

The RANGER Control Point, which served as AEC operational headquarters, was 13 kilometers south of ground zero. It was a hastily constructed building that included a control room, administrative office, first-aid station, and shower for personnel decontamination (12; 34).

Two photography stations were located near ground zero. One station was 3.2 kilometers to the southeast on the dry lake. The lake bed also served as the Frenchman Flat landing strip because of its smooth, hard surface. The other station was 3.2 kilometers northeast of ground zero (12; 34).

Extending from ground zero to the west was the West Access Road, north of which lay the field fortifications area, used extensively in scientific experiments. The South Access Road

*Universal Transverse Mercator (UTM) coordinates are used in this report. The first three digits refer to a point on an east-west axis, and the second three digits refer to a point on a north-south axis. The point so designated is the southwest corner of an area 100 meters square.

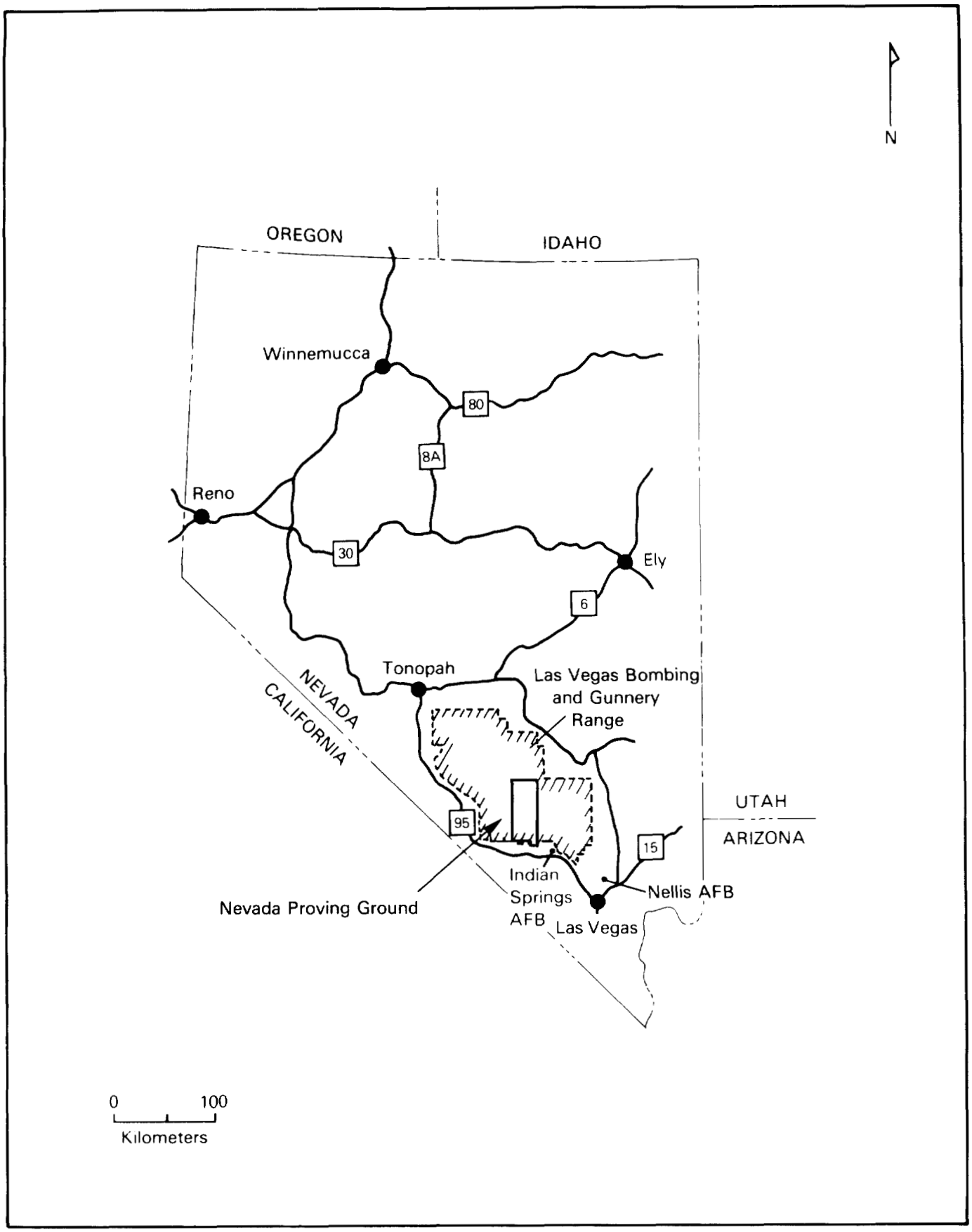

Figure 1-2: LOCATION OF THE NEVADA PROVING GROUND

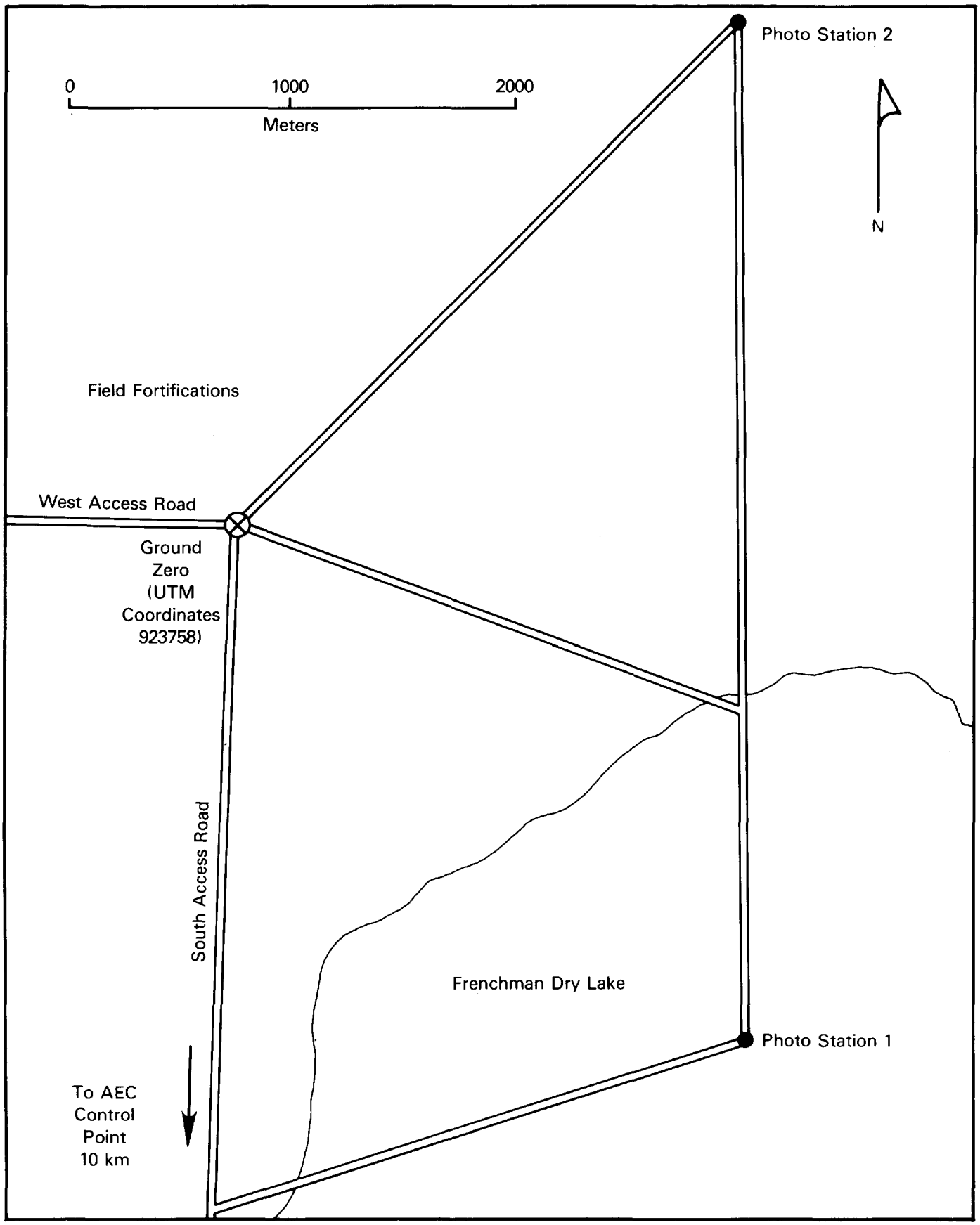

Figure 1-3: FRENCHMAN FLAT, NPG, SHOWING GROUND ZERO AND OPERATIONS AREA FOR OPERATION RANGER

began at ground zero and headed directly south to the AEC Control Point, where it then curved through the mountains toward the southern boundary of the NPG. The AEC generator shack was 3.2 kilometers due south of ground zero on the South Access Road (12; 34).

The main AEC headquarters were at Nellis AFB, located near Las Vegas, 100 kilometers southeast of the NPG. Because facilities at the NPG were limited, the AEC also used Indian Springs AFB, 40 kilometers by road southeast of the NPG, for food services and housing of test personnel, for storing materials and equipment, and for maintaining vehicles.

1.3 SUMMARY OF OPERATION RANGER EVENTS

The five nuclear detonations of Operation RANGER, detailed in table 1-1, included two shots with a yield of one kiloton each (ABLE and EASY), two shots of eight kilotons each (BAKER and BAKER-2), and one shot of 22 kilotons (FOX) (15; 17; 27). These detonations were preceded by a non-nuclear high-explosive detonation, fired on 25 January 1951, to calibrate equipment for the upcoming nuclear tests. The five nuclear devices were detonated during the following 12 days, with the final device fired on 6 February 1951.

The RANGER shots were all airdropped over Frenchman Flat from a height of 19,700 feet* above ground with the exception of Shot FOX, which was airdropped from a height of 29,700 feet above ground (27). Shot FOX was also the only shot not detonated on its planned day. Because of an oil leak in the drop aircraft, FOX was detonated on 6 February instead of 5 February (27).

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*In this report, vertical distances are given in feet. Most altitudes are measured from mean sea level; however, the height of the aircraft that dropped the nuclear device for each shot is measured from the ground.

Table 1-1: SUMMARY OF OPERATION RANGER EVENTS (1951)

Shot	ABLE	BAKER	EASY	BAKER-2	FOX
Sponsor	LASL	LASL	LASL	LASL	LASL
Planned Date	27 January	28 January	1 February	2 February	5 February
Actual Date	27 January	28 January	1 February	2 February	6 February
Local Time	0545	0552	0547	0549	0547
NPG Location	Frenchman Flat	Frenchman Flat	Frenchman Flat	Frenchman Flat	Frenchman Flat
UTM Coordinates	923758	923758	923758	923758	923758
Type	Airdrop	Airdrop	Airdrop	Airdrop	Airdrop
Height of Burst (Feet)	1,060	1,080	1,080	1,100	1,435
Yield (Kilotons)	1	8	1	8	22

1.4 DEPARTMENT OF DEFENSE PARTICIPATION AT OPERATION RANGER

The Test Group, an AEC organization, planned, coordinated, and conducted the RANGER nuclear tests. Consisting of personnel from the AEC, LASL, Sandia Corporation, and DOD, the organization included representatives of the Office of Atomic Energy, the Air Weather Service, and the Special Weapons Command (SWC). Through its Scientific Tests Section, the Test Group conducted eight scientific experiments at the RANGER detonations. The Test Group Radiological Safety Section enforced criteria necessary to protect RANGER participants from the effects of ionizing radiation.

There were no troop exercises at RANGER. DOD personnel at the NPG during the shots participated primarily in the area of test assistance. DOD personnel fielded scientific experiments, and Air Force personnel provided air support for these activities. Ground participants generally placed data collection instruments around the intended ground zero before the scheduled detonation. They returned to recover the equipment after the detonation, when the radiological environment in the shot area would permit access.

The Special Weapons Command, from Kirtland AFB, New Mexico, provided air support to the RANGER manager and to various Test Group experiments. SWC support units included the 4925th Special Weapons Group and the 4901st Support Wing (Atomic), which operated out of Nellis AFB, Indian Springs AFB, and Kirtland AFB (2-4). The Strategic Air Command provided the Special Weapons Command with aircraft and crews for documentary photography, while the Air Weather Service and the Air Force Cambridge Research Laboratory provided Headquarters, USAF, with aircraft and crew.

Film badge data indicate that 22 military and civilian DOD employees participated in the Scientific Tests Section, the

Radiological Safety Section, and observer activities (16; 19; 28; 30). Fifteen of these were Army, four were Navy, and three were Air Force personnel.

The largest military contingent at Operation RANGER came from the Air Force. Between 202 and 335 Air Force personnel participated. The first figure is based on a review of Air Force reports, memoranda, and travel orders. The second figure has been compiled from Air Force documents and from an interview with a senior Air Force officer of the RANGER Air Support Section (14; 22-23; 32; 38).

CHAPTER 2

FUNCTIONS OF THE ADMINISTRATIVE ORGANIZATION DURING OPERATION RANGER

The Atomic Energy Commission was responsible for the activities conducted during Operation RANGER. The AEC organized these activities within a structure that, for the purpose of this report, is called the test organization. The primary functions of the test organization were to schedule and detonate the nuclear devices being tested and to evaluate the results of each detonation.

2.1 THE ATOMIC ENERGY COMMISSION AND THE DEPARTMENT OF DEFENSE

The AEC and the Department of Defense collaborated in the planning and support of Operation RANGER. The AEC, which exercised sole command of Operation RANGER, was responsible for the development of new nuclear weapons technology. The DOD incorporated the weapons into the military defense program and provided air support services that the AEC was not equipped to provide.

Congress established the AEC in 1946 with the passage of the first Atomic Energy Act. In addition to stipulating the purposes of the AEC, which included the exploration of atomic energy as well as nuclear weapons technology, the act provided for the President to appoint five commissioners and a general manager as the chief administrators of the AEC. This Commission was not part of a cabinet-level department, but instead was an independent agency of the executive branch of the Federal Government (1).

The Director of the Division of Military Application, who was by law a member of the Armed Forces, was responsible for

nuclear test operations (1). The Director delegated onsite authority for test preparations to the manager of the AEC Santa Fe Operations Office (SFOO). Later, the manager of SFOO also became the manager* of Operation RANGER (32). Figure 2-1 shows the lines of authority from the President through the AEC to the test organization.

The National Security Act of 1947 established DOD by consolidating the War Department, the Navy Department, and the new Department of the Air Force. The President appointed the Secretary of Defense who, in turn, relied on the Joint Chiefs of Staff to coordinate plans and operations for the armed services (36).

Policy making and planning between the AEC and DOD was the responsibility of the Military Liaison Committee (MLC), which was established by the Atomic Energy Act. The MLC, shown in figure 2-1, provided a forum for DOD consultation with AEC commissioners on the development, manufacture, use, and storage of bombs, the allocation of fissionable material for military research, and the control of information relating to the manufacture or employment of nuclear weapons. On an operational level, the DOD liaison with AEC was the responsibility of the Armed Forces Special Weapons Project. In 1947, AFSWP was organized as the principal agency for nuclear weaponry within the DOD. AFSWP had established its Field Command at Sandia Base, Albuquerque, New Mexico, to conduct DOD weapons effects projects. The AFSWP officer supervising DOD personnel working on weapons testing was under the control of AEC officials. Unlike later test series, a DOD officer did not exercise authority in the field over all DOD personnel within the test organization (1; 36).

AEC support services were obtained directly from the Air Force. The Special Weapons Command and Headquarters, USAF,

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*Officially called the Test Manager in subsequent series.

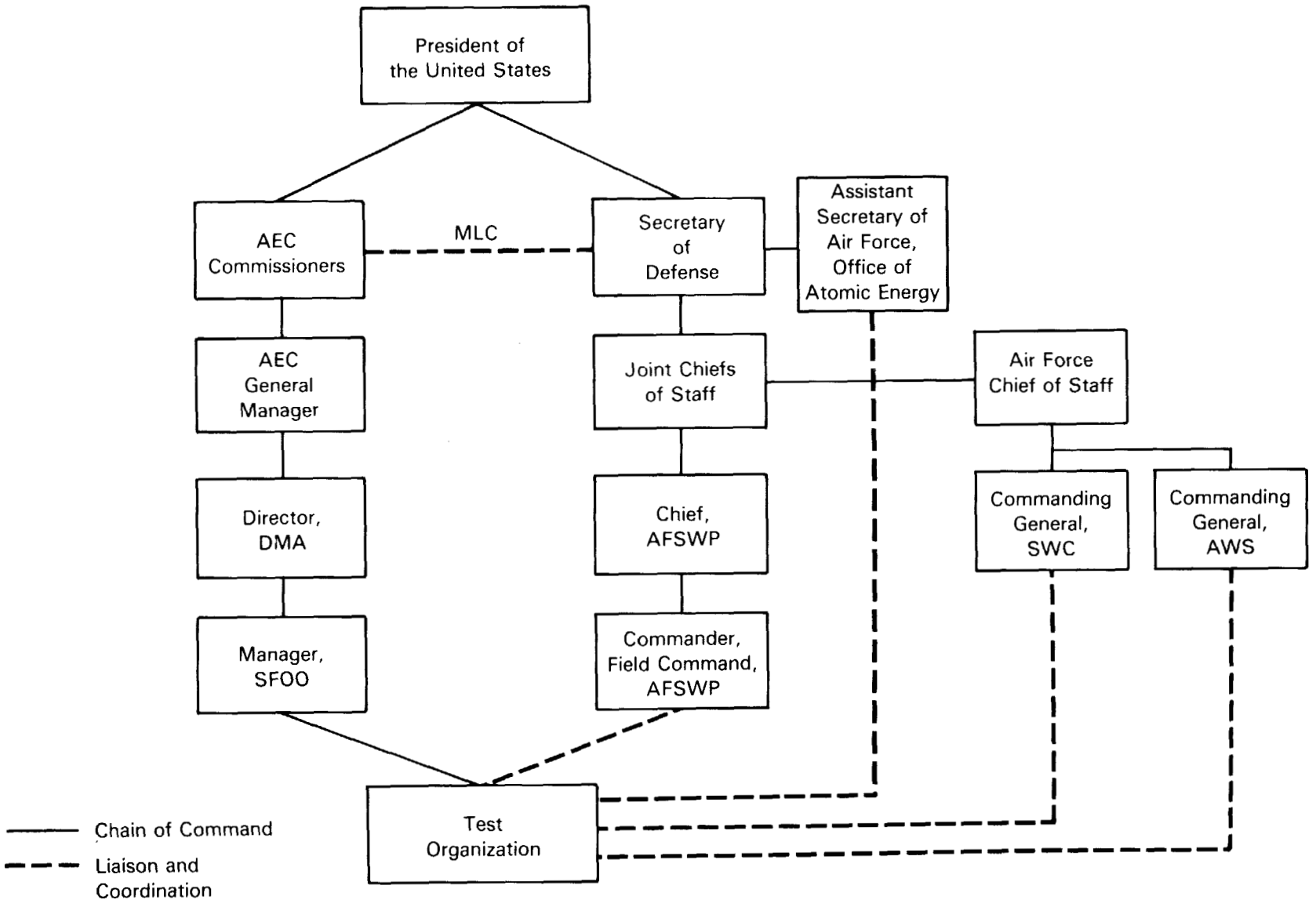

Figure 2-1: RANGER TEST ORGANIZATION STRUCTURE WITHIN THE FEDERAL GOVERNMENT

provided air support for Operation RANGER. The 2059th Weather Wing, a unit of the Air Weather Service, contributed meteorological services. Both the air and weather support personnel were under the authority of the AEC manager of Operation RANGER (29; 32).

2.2 THE MANAGER OF OPERATION RANGER

On 15 January 1951, the General Manager of the AEC appointed the manager of the Santa Fe Operations Office as AEC manager of Operation RANGER. The manager of Operation RANGER was to (32):

- Coordinate and use efficiently the resources of SFOO, the Los Alamos Scientific Laboratory, and the Sandia Corporation for the successful conduct of Operation RANGER
- Negotiate the details of military support for RANGER directly with AFSWP and other DOD agencies and coordinate requirements through the Division of Military Application
- Expend no more fissionable materials than were authorized by the President on 11 January 1951
- Authorize the detonation of the nuclear devices.

A consulting committee of scientists advised the manager of Operation RANGER on data collection and test activities. The manager also used SFOO staff members for Operation RANGER requirements and had the authority to use LASL for special requirements (32).

2.3 THE TEST ORGANIZATION FOR OPERATION RANGER

AEC and DOD officials planned the test organization for Operation RANGER in early January 1951. On 16 January 1951, the day after his appointment, the manager of RANGER established the

Operation RANGER test organization. On 17 January, he appointed chiefs to the test organization's seven divisions (32):

- Executive Office
- Operations Planning Office
- Administrative Services Group
- Security Group
- Test Group
- Public Information Office
- Communications Group.

Figure 2-2 shows the structure of the test organization.

2.3.1 Executive Office

The SFOO Director of Personnel and Organization was appointed Executive Officer. Responsible for operations, the Executive Officer organized staffs for the test organization divisions and coordinated contractor, military, and technical support. He also informed the manager about test activities (32).

2.3.2 Operations Planning Office

The Operations Planning Officer assisted the Executive Officer in coordinating activities of test organization divisions, contractors, and support groups with operations of the armed services and SFOO (32). The Operations Planning Officer was also responsible for the test organization emergency evacuation plan. He accordingly arranged with the Army for the transfer of Company C, 82nd Reconnaissance Battalion, Second Armored Division, from Fort Hood, Texas, to Las Vegas, Nevada. This company, consisting of five officers and 150 enlisted men, had trucks standing by offsite to help evacuate any Nevada or Utah county in case AEC

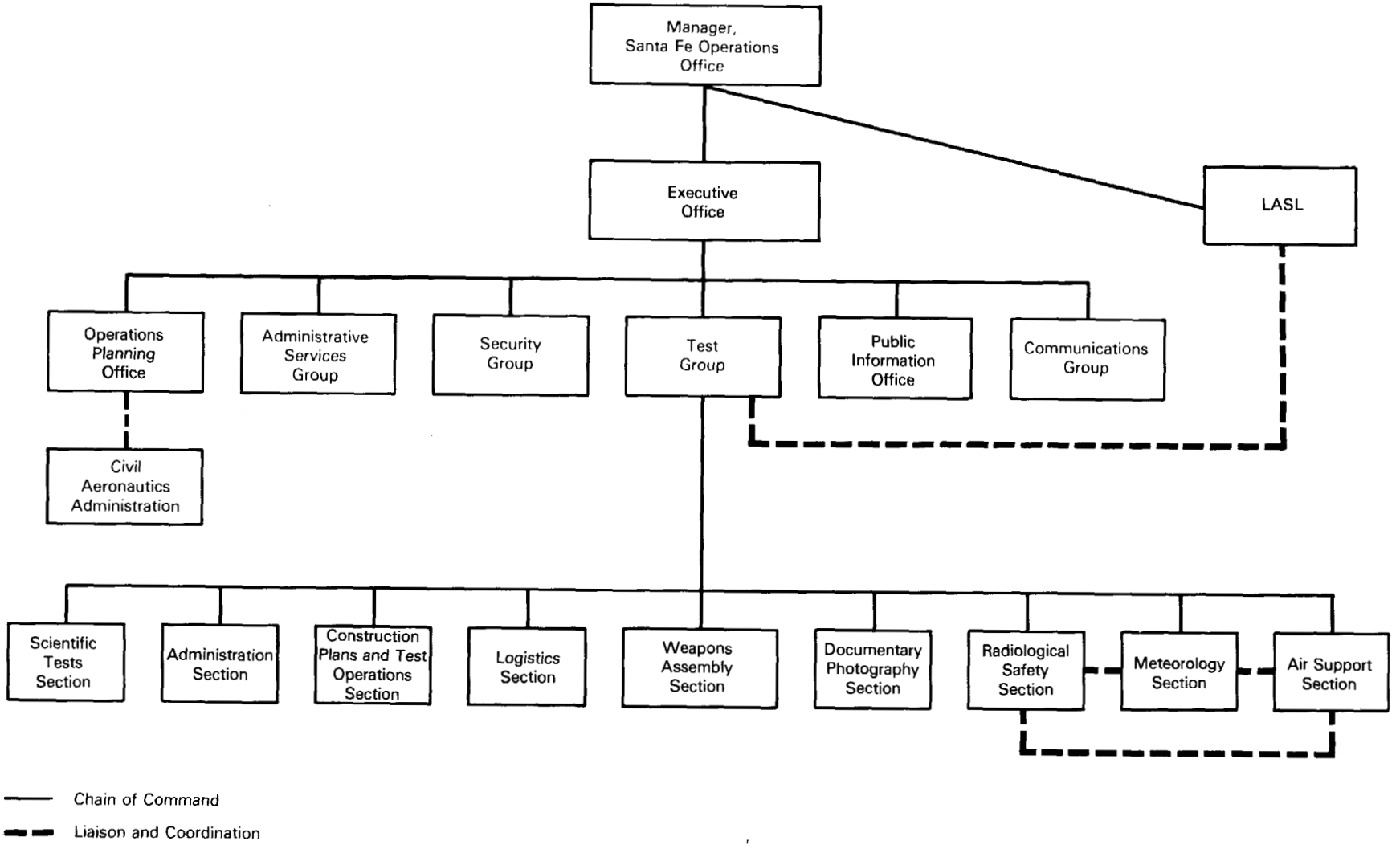

Figure 2-2: RANGER TEST ORGANIZATION

radiological safety teams measured a radiation intensity high enough to endanger public health (32).

The Operations Planning Officer also maintained contact with the Civil Aeronautics Administration, Federal Airways Section in Salt Lake City, Utah. He advised the Civil Aeronautics Administration on rerouting commercial and private aircraft away from radioactive clouds outside the Nevada Proving Ground during detonation periods (32).*

2.3.3 Administrative Services Group

The Administrative Services Group maintained and administered the physical plant for the three primary locations of the test organization: the NPG, Indian Springs AFB, and Nellis AFB. Group personnel provided (32):

- Office services
- Food service and medical facilities
- Motor pools
- Maintenance of buildings, roads, housing, and operational facilities
- Supply services.

The Chief of the Administrative Services Group was responsible for overseeing the physical plant and supervising all contractor personnel working for the test organization (32).

2.3.4 Security Group

The responsibilities of the Security Group included (32):

- Installing and applying physical and personnel security control measures, including visitor control

*The airspace of the NPG was already a restricted area.

- Providing security for classified materials and scientific data in storage and during shipment
- Clearing press and radio releases.

The Security Group also operated the nine test organization security stations, set up roadblocks in conjunction with the Clark and Nye Counties sheriff's offices, and escorted civilian and military observers into the NPG (32).

2.3.5 Test Group

The Chief of the Test Group was a LASL scientist. His principal assistant was the Deputy Test Director. Under their supervision, the Test Group performed the following functions (32):

- Supervised all technical operations
- Prepared all nuclear devices and arranged their delivery to Kirtland AFB
- Ordered the airdrop of a nuclear device when authorized by the manager of Operation RANGER
- Coordinated cloud-tracking and -sampling missions with the Air Force
- Coordinated radiological safety activities
- Collected and interpreted meteorological information
- Advised the manager of Operation RANGER on meteorological and radiological safety information
- Advised the LASL Director on the technical results of each test so he could inform the manager of Operation RANGER of the next nuclear device to be detonated.

To accomplish these activities, the Chief of the Test Group and Deputy Test Director were assisted by the following sections of the Test Group (12; 32):

- Scientific Tests Section
- Administration Section

- Construction Plans and Test Operations Section
- Logistics Section
- Weapons Assembly Section
- Documentary Photography Section
- Radiological Safety Section
- Meteorology Section
- Air Support Section.

The Scientific Tests Section established and coordinated the scientific projects conducted during RANGER. The Technical Deputy headed this section, which consisted primarily of LASL personnel. An Army Participation Group directed by an Army Group Project Officer represented the Chief, AFSWP, in this section (12; 30; 32).

The Administrative Section provided administrative services for the Test Group concerning such matters as personnel, finances, security clearances, and visitor programs (12; 32).

The Construction Plans and Test Operations Section provided planning services to the Test Group for test structures, timing and firing circuits, and communications. The section also acted as a liaison between the SFOO Office of Engineering and Construction and the SFOO Office of Communications, both of which performed construction work for the test organization (12; 32).

The Logistics Section, staffed by LASL personnel, coordinated procurement and maintenance activities of the Test Group. It was headquartered at the Test Group warehouse at Indian Springs AFB (12; 32).

The Weapons Assembly Section operated from Sandia Base, where LASL personnel assembled the nuclear devices and Sandia Corporation employees prepared the devices for delivery (12; 32).

The Documentary Photography Section provided photographic services and was staffed by personnel from the LASL Graphic Arts Division (12; 32).

The Radiological Safety Section, staffed by LASL, SFOO, and DOD personnel, conducted all onsite and offsite radiological safety activities within a radius of 300 kilometers from ground zero (12; 32).

The Meteorology Section was staffed by Air Weather Service personnel. This section was commanded by an officer of the 2059th Air Weather Wing from Tinker AFB, Oklahoma, which supplied 33 of the 56 Air Force participants. Other personnel came from Air Force facilities throughout the country (29). Section headquarters were at the Nellis AFB weather station and housed the Weather Analysis Section. The Weather Analysis Section was administered by the Weather Officer, who was also the senior Air Weather Service official and Chief of the Meteorological Section. The Weather Analysis Section interpreted meteorological data and reported its findings to the Chief of the Test Group and Technical Deputy (29).

Meteorological data were collected by observation stations located at (29):

- Target command post, at the AEC Control Point, NPG
- Nellis AFB
- Indian Springs AFB, Nevada
- Beatty, Nevada
- Tonopah, Nevada
- Caliente, Nevada
- Cedar City, Utah.

Two Air Weather Service personnel, one from LASL and the other from Kirtland AFB, New Mexico, operated the target command post station. The roving observer stations at Caliente and Cedar

City were nominally under the control of the Meteorological Section but were actually administered by the Test Group Radiological Safety Section (29).

The Air Support Section, which included a substantial number of DOD personnel, consisted mostly of personnel from SWC and Headquarters, USAF. The Assistant Deputy Chief of Staff for Operations (Atomic Energy), the Air Force official responsible for nuclear weaponry, went to the NPG to coordinate Air Force activities (33; 36). It is believed he was the de facto chief of the Air Support Section.

SWC was created on 1 December 1949 to provide air support to DOD, AEC, and Government contractors in nuclear testing programs. During RANGER, SWC was responsible for dropping the nuclear devices and providing aerial surveys and courier service. Under the command of an Air Force general, SWC was located at Kirtland AFB, New Mexico. A special AEC representative appointed by the Deputy Test Director maintained AEC liaison with SWC headquarters. This representative was responsible for all activities concerning the arming of the nuclear devices and delivery to SWC personnel at Kirtland AFB (18; 27).

The SWC units at Operation RANGER were the 4925th Special Weapons Group and the 4901st Support Wing (Atomic). The 4925th Special Weapons Group conducted the drop missions and provided direct support to LASL, particularly in the area of aerial radiological safety monitoring. The 4901st Support Wing (Atomic) provided the aircraft and crew for courier operations. The Strategic Air Command (SAC) supplied an aircraft and crew for documentary photography, under the operational control of SWC. Although the SWC air control center was at Nellis AFB, SWC activities were staged from Kirtland AFB, Indian Springs AFB, and the AEC Control Point (3-4).

Air Force personnel were responsible for cloud sampling, cloud tracking, and part of the aerial radiological safety monitoring. They were from the Strategic Air Command, the Air Training Command, and the Air Research and Development Command. The Air Weather Service and the Air Force Cambridge Research Laboratory provided the aircraft and crew for air support. The air control center was located at Nellis AFB, which was also used as a staging base (13; 25).

2.3.6 Public Information Office

The Public Information Officer conducted the press and public relations program for the test organization. This involved primarily the dissemination of news releases on the tests and reports on AEC policies (32).

2.3.7 Communications Group

The Communications Group maintained all communications systems and facilities. The communications center was located in the test organization headquarters at Nellis AFB. The Southern Nevada Telephone Company installed and maintained the telephone equipment, while the Pacific Telephone and Telegraph Company installed and maintained the test organization telex and crypto-teletype systems (32).

2.4 PRINCIPAL RANGER CONTRACTORS

In keeping with the policy set forth by the Atomic Energy Act of 1946, much of Operation RANGER was carried out by Government contractors (1). The Chief, Administrative Services Group, managed contractor personnel at RANGER. In operational matters, however, the contractors were directed by the chief of the appropriate section.

The principal contractors at Operation RANGER were (12; 32):

- The University of California
- Reynolds Electrical and Engineering Company
- Sandia Corporation
- Edgerton, Germeshausen, and Grier, Inc. (EG&G).

The University of California administered and staffed LASL, the main planner and implementor of RANGER. The manager of SFOO supervised the university's activities in its operation of LASL. REECo constructed and maintained the test facilities at the NPG and was under the direct supervision of the Chief, Administrative Services Group (32).

The Test Group employed the services of the Sandia Corporation and EG&G. The Sandia Corporation, a subsidiary of Western Electric, assembled some weapon systems components at Kirtland AFB and conducted some of the RANGER experiments at the NPG. EG&G's primary functions were to install and operate equipment for technical photography, obtain yield data, fabricate timing and firing equipment, and operate nuclear device timing equipment (32).

CHAPTER 3

DEPARTMENT OF DEFENSE PARTICIPATION IN TEST OPERATIONS DURING OPERATION RANGER

Department of Defense participation in Operation RANGER was minimal in comparison to later test series that involved thousands of DOD personnel. There was no Armed Forces Special Weapons Project test group at RANGER, although AFSWP representatives were present during the operation. The DOD role was not expanded until the following series, BUSTER-JANGLE, when the first Exercise Desert Rock military maneuvers were held. DOD participation at RANGER is estimated at 360 individuals, of which approximately 335 were from the Air Force. These Air Force personnel were primarily involved in air support activities associated with some of the scientific experiments.

DOD activities at RANGER may be categorized into four functions:

- Scientific tests
- Air support
- Land support
- Observation.

The Scientific Tests Section consisted primarily of scientists and technicians from the Los Alamos Scientific Laboratory. This section developed and conducted field experiments to gather scientific and weapons development data for the Atomic Energy Commission and the Department of Defense. Air support activities were the responsibility of the Special Weapons Command and Headquarters, USAF. These activities included delivering the nuclear devices, cloud sampling, cloud tracking, and piloting aerial survey aircraft. Land support consisted of weather forecasting and communications security, while observer activities involved witnessing a nuclear detonation (32).

3.1 SCIENTIFIC TESTS SECTION ACTIVITIES

DOD participation in the Scientific Tests Section involved at least 12 individuals. Five officers and one civilian employee worked for the Army Participation Group, an organization representing the Chief, AFSWP, within the Scientific Tests Section. The commanding officer of the Army Participation Group was a lieutenant colonel assigned to the Evans Signal Laboratory. Three Navy officers, two Army officers, and one Air Force officer participated in the Scientific Tests Section experiments not associated with the Army Participation Group (19; 28; 30; 34).

Most non-DOD members of the Scientific Tests Section were from LASL and the AEC Division of Biology and Medicine. The remaining non-DOD personnel came primarily from EG&G and the Sandia Corporation.

The Scientific Tests Section conducted 16 experiments* during RANGER. Eight of these experiments involved DOD participation:

- Radiochemical Results
- Fractionation of Cloud Particles by Shearing Winds
- Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site+

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*RANGER documents differ on the number of experiments conducted during the series. These discrepancies can be attributed to the interlocking and overlapping nature of the experiments. Two RANGER documents entitled "Program Reports" provide the most detailed account of these experiments (19; 30).

+Some RANGER documents, written after the conclusion of the series, refer to the test area as the Nevada Test Site. However, this report refers to the test area by its official name during RANGER, the Nevada Proving Ground.

- Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb
- Thermal Effects Program
- Thermal and Ionizing Radiation Measurements
- Analysis of Fireball Growth at RANGER
- Gamma Radiation Exposure as a Function of Distance (19; 30).

Table 3-1 lists the objectives and participating agencies for these experiments.

DOD participation in the first two experiments, conducted at all RANGER shots, consisted of collecting cloud samples for subsequent laboratory analysis. The Air Support Section supported these missions, discussed in section 3.2. The third experiment, conducted by the Air Weather Service, was an analysis of meteorological data performed after the completion of RANGER. Members of the Meteorological Section, who were also 2059th Air Weather Wing personnel, analyzed weather and cloud-tracking records collected during the RANGER shots. Their analysis showed that the development of clouds resulting from the detonations could be predicted with some certainty based on the weather conditions (30). This postshot analysis was conducted offsite, probably at Tinker AFB, Oklahoma, the home base of the 2059th Air Weather Wing.

Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb was conducted at all RANGER shots by the Army Chemical Center. The objective was to determine the protection afforded by foxholes against gamma radiation emitted by a nuclear airburst (30).

Before the first RANGER detonation, a contractor under the supervision of the Construction Plans and Test Operations Section constructed 14 fortifications. The nearest was at ground zero

Table 3-1: RANGER SCIENTIFIC EXPERIMENTS WITH DOD PARTICIPATION

Experiment	Objective	Shots	Participating Agencies
Radiochemical Results	To analyze radioactive samples taken from clouds resulting from the detonations	All	LASL Headquarters, USAF AWS
Fractionation of Cloud Particles by Shearing Winds	To analyze the effects of winds on the dispersal of clouds resulting from the detonations	All	LASL Headquarters, USAF AWS
Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site	To analyze the effects of weather on the movement of clouds resulting from the detonations	All	AWS
Protection Afforded by Field Fortifications Against Gamma Radiation from an Air-burst Atomic Bomb	To determine the protection afforded by foxholes against gamma radiation at the time of a nuclear device detonation	All	Army Chemical Center
Thermal Effects Program	To obtain data on the thermal hazard of nuclear weapons to military equipment of various materials and finishes	All	Office of the Army Quartermaster General
Thermal and Ionizing Radiation Measurements	To collect data on the biological effects of gamma and thermal radiation from a nuclear detonation	ABLE, EASY, BAKER-2, FOX	Office of the Surgeon General (Army)
Analysis of Fireball Growth at RANGER	To analyze the fireball growth and yield determination recorded by film data	All	LASL
Gamma Radiation Exposure as a Function of Distance	To measure gamma radiation as a function of distance during and immediately following a nuclear detonation	All	Sandia Corporation

and the farthest 1,830 meters from ground zero (30). The fortifications were of three types: two-man foxholes, prone shelters, and a one-man foxhole. The ten two-man foxholes were 1.8 meters long, 0.6 meters wide, and 1.2 meters deep. The three prone shelters were 1.8 meters long, 0.6 meters wide, and 0.6 meters deep. The one-man foxhole was one meter long, 0.6 meters wide, and 1.2 meters deep (30). Because the soil in the fortification area was rocky and loosely packed, it was first decided to revet the foxholes completely with sandbags. However, it became evident that this effort would take too much time, so the foxholes were lined with plywood and the earth immediately surrounding the lining was wetted down and well-tamped. One foxhole 370 meters west of ground zero was revetted with sandbags (30).

The fortifications were not occupied during any of the RANGER shots. Film packets placed in the fortifications before each shot obtained data on the amount of gamma radiation within the positions. Four film badges were bound together in a packet and put into a plywood holder. Each film badge contained two strips of film. The plywood protected the film badges from thermal radiation and minimized the effects of neutron-induced radiation that might have been recorded had metal holders been used (30).

Each prone shelter had ten film packets, while each foxhole had 15. The packets were attached to the sides of the foxholes and to stakes in the bottom. The number of fortifications instrumented with film packets varied from shot to shot, as did the amount of time required to retrieve the packets. The foxhole nearest to ground zero was routinely excluded from instrumentation, since its proximity to the point of detonation would have produced a gamma exposure that exceeded the range of the film badges. One of the two foxholes 1,460 meters from ground zero also had no film packets because it was thought necessary to instrument only one (30). The foxhole 1,830 meters from ground

zero was instrumented only at FOX, the largest of the detonations. Two officers from the Army Chemical Center and one officer from the Army Corps of Engineers placed and retrieved the film packets (28; 30; 34).

The Thermal Effects Program was conducted at all RANGER shots, primarily by the Office of the Quartermaster General (Army). The program objective was to obtain data on the thermal hazard of nuclear weapons to military equipment of various materials and finishes (30). Before each shot, participants placed 48 panels, all supporting over 100 samples of textiles, plastics, and wood, in the shot area. For Shots EASY and BAKER-2, they also displayed four metal plaques, each with more than 100 samples of material. They positioned the panels and plaques in foxholes and on the ground 680 to 4,600 meters west of ground zero. The panels and plaques belonged not only to the Office of the Quartermaster General, but also to the Naval Material Laboratory, Brooklyn, New York; the Naval Radiological Defense Laboratory, San Francisco, California; and the National Bureau of Standards, Washington, D.C. An officer of the Army Quartermaster Corps from Camp Lee, Virginia, placed and retrieved the panels and plaques (28; 30; 34).

Thermal and Ionizing Radiation Measurements was conducted at Shots ABLE, EASY, BAKER-2, and FOX by the Office of the Surgeon General (Army). The objectives were to:

- Collect data on the degree of biological burns produced by nuclear thermal radiation and correlate these data with flashburn experiments
- Determine the intensity and quality of the initial gamma radiation from a nuclear detonation at distances where the combined effects of thermal and ionizing injury could have serious biological consequences
- Determine the time rate of delivery of thermal dosage from the nuclear bomb (30).

One civilian under contract to the Office of the Surgeon General (Army) conducted the first phase of the experiment by placing five plywood panels containing 14 different textile fabrics at distances of 2,740, 2,290, 1,830, 1,460, and 1,280 meters west of ground zero for Shot ABLE. Each fabric panel was displayed with a separate stake panel consisting of plywood backing and a front of heat-sensitive paper and two grades of white paper. The fabric panels were used as test panels, while stake panels were used as thermal radiation detectors. After the detonation, the civilian retrieved all panels (28; 30).

The same participant measured gamma radiation with 25-roentgen and 100-roentgen Victoreen bakelite thimble ion chambers enclosed in aluminum capsules and surrounded by various thicknesses of lead sheets. He placed 21 ion chambers in fox-holes and in the open for Shots EASY, BAKER-2, and FOX and retrieved the chambers after each shot (30).

At ABLE, BAKER-2, and FOX, this civilian used a turntable coated with heat-sensitive paper to determine the time rate of delivery of thermal radiation (30). He placed the turntable in the test area before the shot and retrieved it after the detonation.

Analysis of Fireball Growth was conducted by LASL at all RANGER shots. The objective was to analyze the fireball growth and yield determination by studying film from cameras at photography stations 3.2 kilometers southeast and northeast of ground zero. A special LASL group, consisting of three LASL civilian employees, one Army officer, one Navy officer, and one Air Force officer, retrieved film from the photography stations after each shot and returned the film to Los Alamos for analysis (19; 28).

Gamma Radiation Exposure as a Function of Distance was conducted at all RANGER shots by the Sandia Corporation. Its objective was to measure gamma radiation as a function of distance during and immediately following a nuclear detonation.

Forty-one film badges were placed at 90-meter intervals from ground zero along the West Access Road and the South Access Road. One film badge was positioned at ground zero. To measure neutron-induced activity, film badges were also placed in lead cylinders with ten-centimeter thick walls along the West Access Road 270, 550, 820, 1,100, and 1,370 meters from ground zero. To measure the fraction of initial gamma radiation reaching the film badges, the badges were placed in "mousetrap gadgets" (devices designed to shield the film badges from residual radiation) 460, 910, and 1,830 meters from ground zero along the West Access Road (30).

All film badges were recovered for Shots ABLE, BAKER, EASY, and BAKER-2. At Shot FOX, however, six film badges located within 180 meters of ground zero could not be recovered. At all shots, personnel began recovering film badges within one to two hours after the detonation and finished within five to six hours. Military participants involved in the placement and recovery of the film badges included one Navy officer from Field Command, AFSWP; one Navy officer from LASL; and one officer from the Army Corps of Engineers. Three civilian Sandia Corporation employees also participated in the experiment (28; 30; 34).

Specific details concerning personnel activities during this experiment have not been documented, but one report states that the Navy officer from Field Command, AFSWP, placed and retrieved film badges 370 and 730 meters from ground zero along the West Access Road (34).

3.2 AIR SUPPORT ACTIVITIES

Both the Special Weapons Command and Headquarters, USAF, played a major support role in Operation RANGER. SWC, based at Kirtland AFB, dropped the nuclear devices and directed aerial documentary photography, courier service, and part of the aerial surveying. The SWC activities were staged from four locations: Kirtland AFB, Indian Springs AFB, Nellis AFB, and the AEC Control Point. Headquarters, USAF, conducted cloud sampling, cloud tracking, and aerial survey missions. The Air Force was also involved in sampling activities for the Atomic Energy Detection System (AEDS), which monitored worldwide radioactivity from the RANGER devices (2-4; 13; 25; 32).

The principal SWC unit involved in the series was the 4925th Special Weapons Group. Its purpose was to execute drop missions and to provide direct support, particularly aerial surveying, to the Test Director. To support the 4925th Special Weapons Group, the 4901st Support Wing (Atomic) provided the aircraft and crews for courier service (2-4).

Headquarters, USAF, personnel were aided in their responsibilities by SAC, the Air Training Command, and the Air Research and Development Command. The Air Weather Service and the Air Force Cambridge Research Laboratory, in providing cloud-sampling and cloud-tracking services for Headquarters, USAF, supplied the aircraft and crews for air operations and ground and maintenance personnel for their respective aircraft (13; 25).

The air operations building was at Nellis AFB. Both SWC and Headquarters, USAF, maintained their air control centers there. Although administered separately, the two air control centers were both supervised by the Assistant Deputy Chief of Staff for Operations (Atomic Energy) from Headquarters, USAF (32-33).

According to an Air Force officer who participated at RANGER, 122 Air Force personnel were assigned to SWC activities during RANGER (38). Participants supervised by Headquarters, USAF, minus the offsite AEDS personnel, numbered 124 (38).

DOD participation in air support activities involved the following Air Force organizations (2-4; 13; 21; 25; 32):

- Headquarters, USAF
- Air Research and Development Command
- Air Training Command
- Strategic Air Command
- Air Force Security Service
- Air Weather Service
- Air Force Cambridge Research Laboratory
- 4901st Support Wing (Atomic) (SWC)
- 4925th Special Weapons Group (SWC)
- 374th Reconnaissance Squadron (Very Long Range) Weather
- 1009th Special Weapons Squadron.

Table 3-2 shows DOD participation in air support missions, indicating type of aircraft, unit of origin, and staging base.

3.2.1 Delivery of the Nuclear Devices

The drop aircraft for all five nuclear detonations was a B-50 operating out of Kirtland AFB with a crew of 11 from the 4925th Special Weapons Group and possibly a LASL scientist. After the nuclear device was assembled and transported to Kirtland AFB by representatives of the Sandia Corporation, SWC

Table 3-2: DOD PARTICIPATION IN RANGER AIR SUPPORT MISSIONS

MISSION	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	UNIT OF ORIGIN	STAGING BASE
Airdrop	B-50	1	4925th Special Weapons Group	Kirtland AFB
Photography	B-50	1	SAC	Kirtland AFB
Emergency	C-47	1	4925th Special Weapons Group	Kirtland AFB
Cloud Sampling	B-29	2	374th Recon Squadron (VLR) Weather	Nellis AFB
Cloud Tracking	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB
	B-29	1	374th Recon Squadron (VLR) Weather	McClellan AFB
Aerial Surveying	H-13	1	4925th Special Weapons Group	AEC Control Point
	H-19	1	4925th Special Weapons Group	AEC Control Point
	C-47	1	Air Weather Service	Nellis AFB
	B-17	1	Air Force Cambridge Research Laboratory	Nellis AFB
Courier Service	B-25	3	4901st Support Wing (Atomic)	Indian Springs AFB
Atomic Energy Detection System	B-29	5	Air Weather Service	Barksdale AFB, Robins AFB
	B-29	*	Air Weather Service	Air Force bases in Alaska, Guam, Japan, and Saudi Arabia

*Unknown

ground personnel loaded it, without the nuclear capsule, into the aircraft. LASL personnel delivered the nuclear capsule to SWC about 45 minutes before takeoff (4).

The departure of the B-50 was planned so that the aircraft would be in the vicinity of ground zero about two hours before the drop. The aircraft flew at an altitude of 14,000 feet from Kirtland AFB to Indian Springs AFB. Upon reaching Indian Springs AFB, the B-50 descended to 10,000 feet and proceeded north of ground zero, where the nuclear capsule was inserted. The aircraft then climbed to the bombing height* and made practice runs in a holding pattern. After approval was radioed to the drop aircraft, it began its bomb run and released the device. Its mission completed, the B-50 returned to Kirtland AFB (4).

The drop aircraft was accompanied on its mission by two aircraft from Kirtland AFB, a B-50 and a C-47. A SAC crew of 11 operated the B-50, equipped with photographic equipment. (While SWC had operational control, the Strategic Air Command provided the aircraft, crew, and ground and maintenance support personnel for aerial documentary photography.) The B-50 left Kirtland at approximately the same time as the drop aircraft for all shots except BAKER-2, when the SAC photography aircraft was grounded because of a fuel leak. The B-50 followed the drop aircraft at an altitude of 16,000 feet to the ground zero area. During the practice and bombing runs of the drop aircraft, the photography aircraft remained five to six kilometers behind and 2,000 feet above the drop aircraft to obtain a vantage point from which to photograph the dropping of the device. After completing its mission, the photography aircraft returned to Kirtland AFB. Figure 3-1 shows the flight path of the strike aircraft and the SAC photography aircraft in the vicinity of ground zero (4).

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*Bombing height was 19,700 feet above the ground for all shots except FOX, for which the bombing height was 29,700 feet above ground (12; 27).

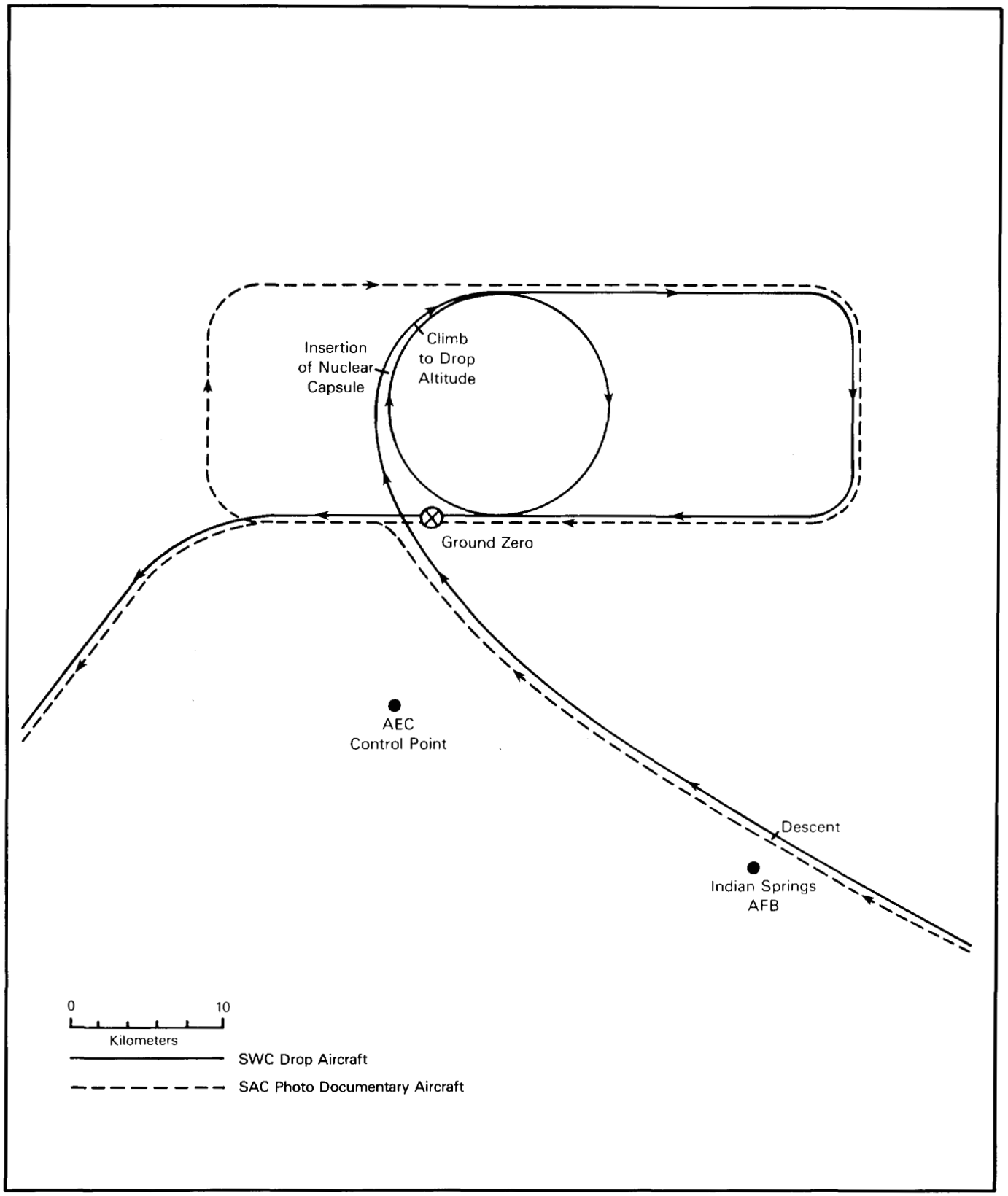

Figure 3-1: FLIGHT PATH OF DROP AIRCRAFT AND SAC DOCUMENTARY AIRCRAFT

Because of AEC concern for safety and security, a C-47 disaster assistance aircraft was available in case of emergency. The C-47 had a disaster team of ten and a crew of four from the 4925th Special Weapons Group. This aircraft left Kirtland AFB and followed the path of the drop aircraft at 12,000 feet to the vicinity of Las Vegas. It then descended to 10,000 feet and flew a holding pattern until the drop aircraft completed its mission over the NPG. The C-47 then returned to Kirtland AFB (4).

3.2.2 Cloud Sampling

An important objective of Operation RANGER was obtaining samples of fission products from nuclear detonations so that the yield and efficiency of the nuclear devices could be determined. The task of collecting samples of particulate and gaseous debris from the clouds formed by the detonations was the responsibility of Headquarters, USAF. The sampling missions gave the Air Force a chance to use manned sampling aircraft for the first time on a routine basis. During the Pacific series before RANGER, LASL collected cloud samples using drone aircraft. Since a drone operation could not be fielded to meet the RANGER test schedule, LASL reluctantly decided not to gather cloud samples for chemical analysis. Headquarters, USAF, however, concluded that manned cloud sampling was safe and feasible after studying the results of sampling experiences at Operation SANDSTONE in 1948 when manned aircraft accidentally penetrated the cloud. When LASL learned that the Air Force was conducting cloud sampling at RANGER, it asked for a share of the sampling filter papers. Headquarters, USAF, agreed (38). These filter papers provided LASL with information to complete two of the Scientific Tests Section experiments discussed in section 3.1: Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds.

To collect samples, two B-29s, each with ten crewmen from the 374th Reconnaissance Squadron (Very Long Range) Weather, operated out of Nellis AFB (13; 21; 25). Each cloud sampler aircraft was equipped with two impact filter paper collectors, approximately 21 centimeters by 25 centimeters. These collectors were mounted in boxes, one on top of the fuselage behind the wing, and the other on the bottom of the fuselage forward of the tail skid (34).

As a safety precaution, the cloud-sampling aircrew was directed to depressurize their aircraft as it entered the nuclear cloud to prevent the intake of contaminated air. After depressurization, the aircrew was directed to breathe 100 percent oxygen and not to eat, drink, or smoke until after they exited from the aircraft. All personnel aboard the aircraft wore oxygen masks and regular flight gear. The radiological safety monitor, who was part of the crew, was in the front of the aircraft and was equipped with two ion chamber instruments, two Geiger-Mueller radiacs, and continuous recording ratemeters connected to the collecting filters (34; 38).

The sampler aircraft left Nellis AFB approximately three hours before shot-time to make and report weather observations in the test area to the Chief of the Test Group. After the detonation, the aircraft followed the cloud until enough time had elapsed to permit diffusion of the fission products which varied with the shot. Next, the aircraft flew through various parts of the cloud collecting samples. The aircraft then returned to Nellis AFB with the samples (13; 25). From Nellis AFB, the Air Force samples went to McClellan AFB to be analyzed by Tracerlab, a Government contractor. LASL's share of the samples was analyzed at Los Alamos (13; 25; 38).

3.2.3 Cloud Tracking

Cloud tracking at RANGER served two purposes: to plot the course of the clouds resulting from the detonations and to help the Civil Aeronautics Administration divert commercial aircraft from the cloud path. A B-29, with a crew of 11 from the 374th Reconnaissance Squadron (VLR) Weather, conducted the cloud tracking during Operation RANGER. The B-29, instrumented with scintillation counter equipment and radiac survey devices, left Nellis AFB about two hours before the detonation to be sure the aircraft was fully operational (38). The tracker aircraft was also equipped with filter paper holders that permitted filter papers to be changed periodically during the missions. These filter papers used for sampling were taken to McClellan AFB for analysis by Tracerlab (38). The aircraft flew in the proximity of the cloud but did not come into contact with the cloud. The crew tracked the cloud visually for four to six hours and then continued the tracking, using instruments (13; 25).

This phase of the tracking mission usually took 12 hours. Thereafter, the initial cloud-tracking aircraft, which by then had almost exhausted its fuel supply, was replaced by another B-29 from McClellan AFB with a crew of 11 from the same squadron. This aircraft tracked the cloud up to the specified 1,000-kilometer limit and then returned to McClellan AFB (13; 25).

3.2.4 Aerial Surveys

Following each nuclear event, several support aircraft made low-altitude radiological surveys of the terrain in and around the Nevada Proving Ground. These surveys helped determine when ground parties could safely enter the test area after the shot and helped assure the safety of personnel in the surrounding areas. Both SWC and Headquarters, USAF, provided aerial surveying support. SWC used two helicopters manned with crews from the 4925th Special Weapons Group. One H-5 helicopter,

stationed at Nellis AFB, was under the control of the Test Group Radiological Safety Section. This aircraft was not used during RANGER (4).

An H-13 helicopter with two crewmen and an H-19 helicopter with three crewmen were directed from the AEC Control Point. Approximately 40 to 50 minutes after the detonation, these two helicopters, with monitors aboard, flew to the ground zero area to survey the area. The monitors measured the intensity of radioactivity at the landing strip at Frenchman Flat and at the various scientific stations located around ground zero. After the area was opened for recovery operations, LASL and contractor personnel were transported by vehicle to the scientific stations, and the two B-25 courier aircraft from Indian Springs AFB landed at the Frenchman Flat airstrip. The H-13 helicopter then conducted aerial surveys for the Radiological Safety Section, while the H-19 helicopter delivered scientific data to the third courier aircraft waiting at Indian Springs AFB (4). The H-13 helicopter also assisted in delivering scientific data to Indian Springs AFB.

Headquarters, USAF, directed an aerial survey of terrain outside the immediate area of ground zero, particularly areas outside the test site boundaries. To accomplish this, the Air Weather Service used a C-47 and a B-17. The Air Weather Service C-47 had a crew of six. The B-17 from the Air Force Cambridge Research Laboratory had nine crewmen (13; 25).

These two aircraft left Nellis AFB at shot-time and proceeded to their assigned areas approximately one hour after the detonation. For the first two shots, the aircraft flew survey patterns planned by the AEC. The aircraft flew down indicated roads at low altitudes and radioed monitoring information to ground surveying teams. Because this method was unproductive, the Air Force developed a grid pattern for the

remaining three shots. A grid was drawn to include a very large area downwind from ground zero. The aircraft then flew at low altitudes, monitoring the terrain and radioing the intensities of radioactivity to the Headquarters, USAF, Control Center at Nellis AFB, using the grid coordinates as a reference. A large map of Nevada, Utah, Arizona, and California, in the Control Center, was marked with grids and covered with acetate so that the radiation readings of the aerial survey aircraft could be posted by location with a grease pencil as they made their reports. The Chief of the Test Group used this display to track the pattern of the fallout. The surveying missions were usually completed within two to four hours, and the aircraft returned to Nellis AFB (13; 25; 38).

3.2.5 Courier Service

The purpose of the SWC courier service was to deliver cloud samples and experimental material from RANGER research projects to laboratory facilities. Three B-25 aircraft, operated by personnel from the 4901st Support Wing (Atomic), transported scientific data, samples, and instrumentation from the test site to Kirtland AFB. There, the data and materials were transferred to a commercial carrier, CARCO, for delivery to LASL. The three courier planes, each with five crewmen from the 4901st Air Support Wing (Atomic), operated from Indian Springs AFB. A LASL courier was also aboard each aircraft (2-4).

After the area immediately surrounding ground zero was opened for reentry, two of the B-25s left Indian Springs AFB for the landing strip at Frenchman Flat. There they picked up scientific samples and instrumentation from LASL personnel and took off for Kirtland AFB. The third B-25 remained at Indian Springs AFB until helicopters had brought the scientific material from the test site. After the cloud-sampling aircraft returned to Nellis AFB, the third B-25 left Indian Springs AFB and flew to

Nellis AFB to pick up the LASL cloud samples. It then flew to Kirtland AFB (2-4).

In case the CARCO aircraft was forced to abort its courier mission, SWC kept a C-45 standing by at Kirtland AFB, so that the delivery of scientific data and samples to LASL would not be interrupted. This standby aircraft was never used (2-4).

3.2.6 Atomic Energy Detection System Activities

To monitor atmospheric radioactivity in the United States and throughout the world, the Air Force maintained a network of ground filter stations and cloud sampler aircraft. The objectives of the AEDS were to (13; 25):

- Provide the Government with an indication of the atmospheric radioactivity over the continental United States
- Detect fallout from possible Soviet nuclear tests.

During Operation RANGER, the AEDS maintained a control center at the Headquarters, USAF, control center at Nellis AFB. Five Air Force officers from the 1009th Special Weapons Squadron probably manned the AEDS control center (28). The AEDS control center coordinated operations with its field units, including ground filter squadrons staffed by elements of the 1009th Special Weapons Squadron at Wright-Patterson AFB, Ohio; Tinker AFB, Oklahoma; Rapid City AFB, South Dakota; and Offutt AFB, Nebraska. The Air Weather Service provided five B-29 sampler aircraft with a crew of 12 each for special vector flights from Barksdale AFB, Louisiana, and Robins AFB, Georgia. Their mission was to analyze the path of the nuclear contamination in areas outside the continental United States. The AEDS also maintained ground filter stations and cloud sampler aircraft in Alaska, Japan, Guam, and Saudi Arabia (13; 25).

AEDS operations for the RANGER devices began soon after each detonation. Ground filter stations operated on a 24-hour basis and changed filter papers every six hours. Filters were then sent to Tracerlab for analysis. At the AEDS control center, personnel of the 1009th Special Weapons Squadron determined the probable location and altitude of the cloud as it drifted away from the Nevada Proving Ground. The 1009th Special Weapons Squadron liaison officers at Barksdale AFB and Robins AFB notified the Air Weather Service of these determinations (13; 25).

The Air Weather Service then dispatched the B-29 samplers to intercept the cloud. Upon return from each mission, the filter papers were sent to the 1009th Special Weapons Squadron Western Field Office at McClellan AFB for further laboratory analysis by Tracerlab (13).

Because of wind conditions at the time of detonation, the clouds from Shots ABLE and BAKER were expected to leave the continental United States and circle the globe. AEDS B-29 sampler aircraft, provided and manned by the Air Weather Service and operating from overseas bases, detected fission products over the Far East (13; 25; 38).

3.3 LAND SUPPORT ACTIVITIES

DOD participation in land support activities at Operation RANGER involved two functions: operations of the Air Weather Service as part of the Test Group Meteorological Section and the operations of Air Force personnel involved in communications security. Although the documentation is not specific on this point, it is believed that the Security Group supervised communications security (22-23).

3.3.1 Air Weather Service

In addition to supplying aircraft and crews for missions, the Air Weather Service also participated in other RANGER activities. The Test Group Meteorology Section, which provided the Chief of the Test Group with weather data necessary for scheduling the detonations, was staffed primarily by members of the 2059th Air Weather Wing from Tinker AFB, Oklahoma. Thirty-three of the 56 Air Weather Service personnel assigned to the Meteorology Section came from the 2059th Air Weather Wing. Twenty members of the Meteorology Section were from Air Force facilities throughout the United States (29):

Facility	Personnel
Lowry AFB, Colorado	2
Edwards AFB, California	6
Andrews AFB, Maryland	3
Castle AFB, California	1
Long Beach AFB, California	1
March AFB, California	1
Davis-Monthan AFB, Arizona	1
Nellis AFB, Nevada	3
Kirtland AFB, New Mexico	1
Air Weather Service Headquarters, Washington, D.C.	1

In addition, two Air Force weather specialists assigned to LASL and one assigned to the Dugway Proving Ground in Utah participated in the Meteorological Section.

Air Weather Service activities were divided between the Nellis AFB Weather Station, headquarters for the Meteorology

Section, and seven field stations. Forty-four of the 56 Air Weather Service personnel were at (29):

Facility	Personnel
Nellis AFB Weather Station	19
Beatty, Nevada, Observation Station	14
Nellis AFB Observation Station	11

The remaining 12 personnel were at the following stations (29):

Facility	Personnel
AEC Control Point Station	2
Observation Station, Tonopah, Nevada	3
Observation Station, Indian Springs AFB	3
Roving Observation Station, Caliente, Nevada	2
Roving Observation Station, Cedar City, Utah	2

The regular Nellis AFB Weather Station staff supported the Meteorology Section by assigning 24 individuals to work on forecasting for RANGER. Also, the 9th Weather Squadron from March AFB, California, supported the Meteorology Section with five participants (29).

The Nellis AFB Weather Station and seven field stations collected the data and made weather forecasts, which were presented to the Chief of the Test Group and Technical Advisor at briefings held daily at 1300 and 2000 hours, and also at 0300 hours on shot-days. The briefings, which took place at Nellis AFB, were very important since the decision to detonate a device on schedule depended on weather conditions (29; 38). With the exception of two participants at the AEC Control Point station, one from LASL, and one from Kirtland AFB, all Air Weather Service personnel involved in Operation RANGER were located offsite (29).

3.3.2 Security Group

Security functions at RANGER were the responsibility of the AEC test organization Security Group. Most security personnel were drawn from LASL and the Sandia Base (32). The only documented DOD participation in security at RANGER involved an estimated 30 Air Force personnel who had been sent to Nellis AFB from Brooks AFB, Texas, and McClellan AFB, California. They were used to ensure the security of the communications system of the test organization, located at Nellis AFB (22-23).

3.4 OBSERVERS

The purpose of inviting observers to the RANGER detonations was to demonstrate the AEC's ability to conduct safe nuclear testing within the continental United States. The AEC invited influential political figures, especially members of Congress, to accompany AEC and high-ranking military officials in witnessing the RANGER detonations. On shot-day, the observers were given an orientation lecture at the AEC Las Vegas office before being driven by bus to the NPG. There they were escorted by Security Group personnel to an observation area, where they witnessed the detonation. The observation area was located approximately 400 meters south of the AEC Control Point (12; 32).

The total number of observers at RANGER was 156 (32). Film badge data, however, have definitely identified only one high-ranking military observer: the brigadier general who was the AEC Director of Military Application (28). A Marine officer assigned to LASL and a Navy officer assigned to the U.S. Public Health Service might also have been observers at RANGER, but there is no proof of this. It is documented, however, that these two men were at RANGER (28).

CHAPTER 4

RADIATION PROTECTION AT OPERATION RANGER

The Atomic Energy Commission initiated radiological safety programs to protect RANGER participants from the ionizing radiation produced by the nuclear detonations. The AEC also developed radiological safety programs to protect the general public residing in surrounding offsite areas. The programs included ground and aerial surveys to determine the extent of radioactive fallout in offsite areas. This chapter discusses these radiological safety procedures and the personnel responsible for and involved with the procedures.

4.1 RADIATION PROTECTION FOR DOD PARTICIPANTS

The Radiological Safety Section was responsible for radiological safety operations during Operation RANGER. The Deputy Test Director, who was assigned by the Chief of the Test Group, administered the section.

The operational responsibilities of the Radiological Safety Section included:

- Providing radiological safety and orientation to personnel at the test site
- Monitoring onsite and offsite areas for radioactive fallout
- Acquiring information concerning the effects of nuclear weapons
- Acquiring knowledge to help determine the feasibility of future nuclear weapons test programs within the continental United States, specifically at the Nevada Proving Ground
- Educating and informing the general public about the nuclear weapons test program.

The Radiological Safety Section worked within exposure guidelines recommended by the AEC. Individual exposures were routinely limited to 3.0 roentgens. Single exposures of up to 3.0 roentgens were permitted, but only when the exposure could not be avoided in performing a necessary duty. The individual receiving this exposure would then be prohibited from any activity that might lead to additional exposure. For those personnel who were scheduled to participate in Operation GREENHOUSE, the exposure limit was 2.0 roentgens (16; 34).

4.1.1 Organization

The Radiological Safety Section included personnel from the AEC, the Army Corps of Engineers, and the Los Alamos Scientific Laboratory. Figure 4-1 shows the organizational structure of this group, and the table below indicates the numbers of participants (16):

PARTICIPANTS IN THE RADIOLOGICAL SAFETY SECTION	
LASL	40
AEC Protective Services	6
AEC Emergency Monitors	17
Army Corps of Engineers	6
TOTAL	69

One of the 40 LASL personnel was the Deputy Test Director. Seven of the group held military rank, but, with the exception of one Air Force enlisted man, their service affiliation is unknown. Headquarters, USAF, and the Air Weather Service provided aircraft and aerial support services for the Radiological Safety Section (16; 28).

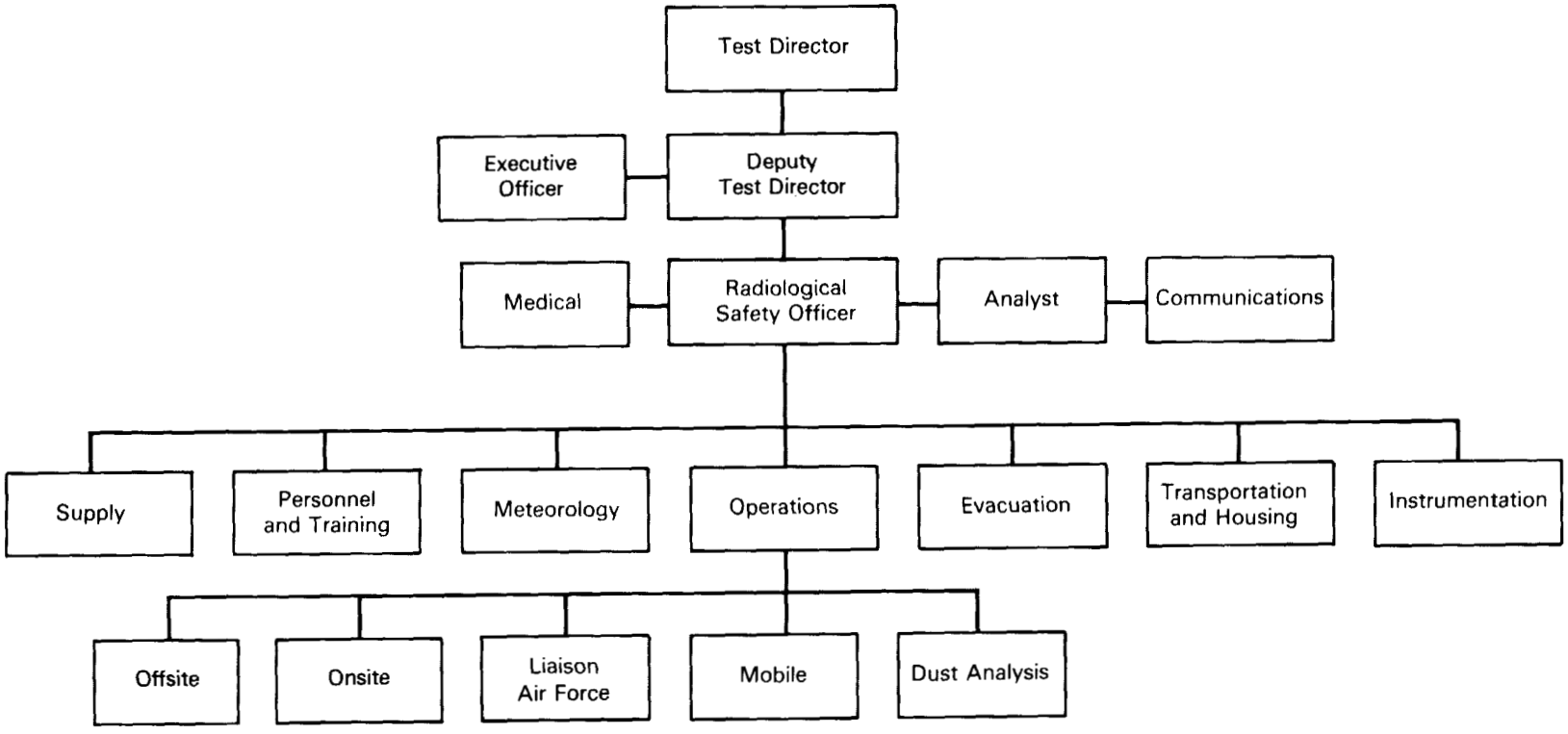

Figure 4-1: RADIOLOGICAL SAFETY SECTION ORGANIZATION

The Radiological Safety Section headquarters at Nellis AFB contained the communication center, storage and maintenance rooms for all monitoring equipment and instruments, a radio repair shop, and office space for the Test Director and his staff. Onsite headquarters for the section was in the Control Point building which housed the onsite monitors and their equipment. Their living quarters were at Indian Springs AFB. Members of the various mobile offsite teams were established in outlying communities. Communications among all groups were by telephone, teletype, and radio. Radio alone proved unreliable because of the distance involved and the irregularities of the terrain (16).

The motor pool at Nellis AFB provided transportation. Eighteen vehicles, including jeeps, sedans, and pickups, were used to transport radiological safety personnel to and from the test area. These vehicles were also used to conduct ground surveys of the test area following a nuclear detonation (16).

4.1.2 Protective Equipment and Personnel Dosimetry

The main responsibility of the Radiological Safety Section was to ensure the radiological safety of RANGER participants by minimizing their exposure to radiation. The section adopted AEC guidelines to control both external and internal exposure.

Radiological safety personnel stationed at the Control Point issued protective clothing, film badges, and other necessary supplies and instruments to personnel entering the test area (16). Each participant was issued a film badge, a pocket dosimeter, coveralls, booties, and gloves. Booties and gloves were sealed to coveralls with masking tape. Respirators were issued to the radiological safety team that made the initial survey. If radiation intensities in the test area were 0.002 roentgens per hour (R/h) or greater, as reported by the initial ground survey, the personnel at the Control Point gave respirators to personnel

entering the area (16). Individuals leaving the test area were required to return this clothing and equipment to radiological safety personnel at the Control Point. The protective clothing and respirators were laundered and cleaned, and the film badges were sent to LASL for processing (34).

Exposure records were maintained for personnel who entered the test area. Personnel leaving the test area turned in pocket dosimeters and film badges to radiological safety personnel at the Control Point. The dosimeter reading for each individual was recorded on his cumulative exposure card. Pocket dosimeter readings were used to monitor an individual's exposure initially, since it took several days for the film badge results to come back from LASL (16). When the film badge data arrived, they were also recorded on the individual's exposure card (37).

Although the report of the Radiological Safety Section (16) indicates that no exposures exceeded the 3.0 roentgen limit at RANGER, film badge records indicate that three individuals received more than 3.0 roentgens. One participant, with an exposure of 3.4 roentgens, was from the Office of the Chief of Engineers. The other two were Navy personnel from AFSWP and Joint Task Force 7. Their exposures were 5.32 and 3.21 roentgens, respectively (14; 28).

Ground personnel removing filter paper samples from sampling aircraft took special precautions to minimize and control exposure to gamma and beta radiation. They used long-handled tongs to remove and transfer the filter paper samples from the aircraft to the carrying case. Each member of the sample removal team wore two film badges, one on his shirt pocket and the other on the cuff at his wrist. He also wore protective clothing, including coveralls, rubber gloves, booties, caps, and a respirator (16).

4.1.3 Onsite and Offsite Monitoring Operations

Weeks before the first detonation, Air Weather Service crews made routine observations of the lower and upper air movements at the test site and surrounding area. Mobile teams of monitors surveyed both onsite and offsite areas to determine background levels of radiation. The monitoring teams used several types of survey meters to measure beta and gamma radiation levels in onsite and offsite areas. Some of the detectors were the T1B Ion Chamber, the Victoreen 263A, and the National Technical Lab MX-5 (16). The monitoring teams also took water samples from Lake Mead as part of this preliminary monitoring procedure (16).

Onsite Monitoring Operations

Monitors conducted ground surveys from several minutes to several hours after each detonation. The initial survey party probably consisted of three or four men with a two-way radio and radiation survey meters, who entered the shot area and took radiation intensity readings at predetermined distances from ground zero. The team radioed this information to the Control Point. Monitors resurveyed the shot area at various times after each detonation (16). Onsite monitoring operations were based at Indian Springs AFB, but the monitoring teams operated from the Control Point, 13 kilometers south of ground zero. Monitoring teams and other personnel entered the test area from this point (16). The Control Point was not in the path of any fallout generated by the detonations. Although Radiological Safety Section personnel did not prepare isointensity maps of the RANGER detonations at the time of the operation, maps based on reconstructed radiation intensity data are available and are included in the shot chapters of this volume (17).

Offsite Monitoring Operations

Monitoring teams also surveyed areas outside the NPG. Five to ten teams, each consisting of three men in a radio-equipped vehicle, surveyed to a distance of 320 kilometers from ground zero (16; 34). They were in radio and telephone contact with radiological safety headquarters at Nellis AFB and with radiological safety personnel at the test site. Before each shot, they determined background radiation levels in the regions where forecasts indicated that the cloud would pass. They continued to monitor these regions for radiation as the cloud passed over their locations (34).

The offsite ground monitoring teams were usually supported by two aircraft, a C-47 from the Air Weather Service and a B-17 from the Air Force Cambridge Research Laboratory. The aircraft, which were airborne at the time of each detonation, surveyed the terrain and tracked the cloud resulting from the detonation as it moved away from ground zero. Information on the cloud path was also radioed to radiological safety headquarters at Nellis AFB and to the radiological safety Control Point at the test site. This information was then used to guide ground monitoring teams to specific areas in the cloud's path (16; 34).

4.1.4 Decontamination

The Radiological Safety Section was responsible for the decontamination of all personnel, vehicles, and helicopters participating in Operation RANGER. The group conducted decontamination operations at a station 30 meters from the Control Point building. Personnel and vehicles leaving the test area were required to report to this station and be checked for radioactive contamination. If gamma readings greater than 0.007 R/h were registered on the surface of vehicles or outer garments of personnel, decontamination procedures were instituted (16).

Personnel

Radiological safety personnel cleaned surface contamination from participants arriving at the decontamination station. They used an industrial vacuum cleaner to remove much of the dust and dirt from the surface of the garments. Test participants then removed respirators and protective clothing, turned in their film badges and pocket dosimeters, and were checked for radioactive contamination. If readings of 0.007 R/h or more were found, the individual was required to remove all clothing and take a shower. After showering, the individual again was monitored. When radiation readings were less than 0.002 R/h on the skin surface, he was issued fresh clothing and released.

During the time between Shots BAKER and EASY, one incident of contamination of SWC personnel was reported. On 30 January, a helicopter with two courier aircraft crewmen landed at Frenchman Flat to inspect the dry lake landing strip. It had snowed earlier, and SWC personnel feared the lake might be too soft for landing operations. The trip proved that the lake was satisfactory for operations. While checking the lake area, however, the two crewmen also "kicked around in some of the damper spots of the lake bed, not knowing at the time that these wet spots were highly radioactive" (2). Upon returning to the Control Point, the men were surveyed and decontaminated after radioactivity was found on the shoes of one of the crewmen (2).

Vehicles

Vehicles were parked in designated areas adjacent to the decontamination station. A team of radiological safety personnel monitored the vehicles for radioactivity and decontaminated them if radiation readings of 0.007 R/h or higher were detected. To clean the vehicles, they used the same type of vacuum cleaner used to decontaminate personnel. They vacuumed all surfaces, including running boards, floorboards, and under-surfaces of fenders. They then resurveyed the vehicles. If the vehicles

were still contaminated, they washed and rinsed them. When radiation intensities were reduced to less than 0.007 R/h, they returned the vehicles to service. For the later RANGER shots, the rented civilian vehicles were given an industrial steam cleaning to ensure removal of all radiation before being returned to civilian use. Decontamination personnel used a portable steam generator and sprayer for the steam-cleaning operation (16; 34).

Aircraft

Decontamination of the aircraft used in cloud sampling, aerial surveys, and cloud tracking was the responsibility of two teams from Headquarters, USAF. Two five-man teams surveyed and decontaminated the aircraft after each mission. Each team member wore a film badge and protective clothing.

After landing at Nellis AFB, the aircraft taxied to a designated area. Decontamination teams surveyed the aircraft to determine the initial level of contamination. They washed and rinsed contaminated aircraft before resurveying them. If radiation levels greater than 0.007 R/h were detected, they again washed the aircraft using a specially formulated detergent. This procedure was repeated until radioactivity on the aircraft had decreased to 0.007 R/h (31; 34).

CHAPTER 5

DOSIMETRY FOR DEPARTMENT OF DEFENSE PERSONNEL AT OPERATION RANGER

This chapter summarizes the data available as of February 1982 on the radiation doses received by Department of Defense personnel during their participation in various military and scientific activities during Operation RANGER. This information is based on research that identified the participants, their unit of assignment, and their doses.

5.1 PARTICIPATION DATA

The identity of participants was determined from several sources:

- The report of the Radiological Safety Officer provided information about the radiological safety personnel and programs at RANGER (16).
- Weapons test reports for AFSWP and other scientific projects often identified personnel, units, and organizations that participated in RANGER.
- After-action reports, security rosters, and vehicle-loading rosters identified some participants.
- Morning reports, unit diaries, and muster rolls identified personnel assigned to participating units, absent from their home units, or in transient status for the purpose of participating in a nuclear weapons test.
- Official travel or reassignment orders provided information on the identity of transient or assigned personnel participating in the nuclear weapons tests.
- Discharge records, maintained by all services, aided in identification.
- A widely publicized national call-in campaign sponsored by the Department of Defense has identified some of the nuclear weapons test participants.

5.2 DOSIMETRY RECORDS

Most of the dosimetry data for Operation RANGER were derived from film badge records (14). As stated in Chapter 4, dosimetry records were maintained by the Radiological Safety Section for each participant at RANGER.

During Operation RANGER, the film badge was the primary device used to measure the radiation dose received by individual participants. The film badge, normally worn at chest level on the outside of clothing, was designed to measure the wearer's exposure to gamma radiation from external sources. The film badge was insensitive, however, to neutron radiation and did not measure the amount of radioactive material, if any, that may have been inhaled or ingested.

Radiological safety personnel issued, received, and interpreted film badges during Operation RANGER. They used manual clerical procedures to record film badge data onto file cards. A dosimetry card was maintained for each participant (5; 37). At the conclusion of the operation, it was the intent of the services to send individual dose records to each participant's home station for inclusion in his records. When the individual left the service, his records were retired to a Federal records repository.

The film badge data summarized in this chapter were obtained from the following sources:

- Historical files of the Reynolds Electrical and Engineering Company, the prime support contractor to the Department of Energy (and previously to the AEC Nevada Operations office). REECo has provided support at the Nevada Test Site since 1952. REECo assumed responsibility for onsite radiological safety after Operation TEAPOT in July 1955, and, consequently, has collected available dosimetry records for nuclear test participants at all nuclear testing operations from 1945 to the present. REECo has on microfilm all available exposure records for individuals working under the Joint Test Organization at Operation RANGER (28).

- Military medical records, maintained at the National Personnel Records Center, St. Louis, Missouri, for troops separated from military service, or at the Veterans Administration, for individuals who have filed for disability compensation or health benefits. Unfortunately, many records were destroyed in a fire at the St. Louis repository in July 1973. That fire destroyed 13 to 17 million Army records for personnel discharged through 31 December 1959, and for members of the Army Air Corps/Air Force discharged through 31 December 1963.

5.3 DOSIMETRY DATA FOR OPERATION RANGER PARTICIPATION

This section presents data on the gamma radiation doses received by DOD participants during RANGER. These doses are presented in tables 5-1 through 5-6, which give the following information by service or units (14):

- The number of personnel identified by name
- The number of personnel identified by both name and film badge
- The average gamma exposure in roentgens
- The distribution of these exposures.

Table 5-1 summarizes all exposures for each service affiliation. In addition to the Army, Navy, Marine Corps, and Air Force designations, the table has data for scientific personnel, contractors, and affiliates. Tables 5-2 through 5-6 provide information about the gamma exposures received by the various participants. In these tables, distributions and averages are given by unit.

Table 5-1: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR OPERATION RANGER PARTICIPANTS BY AFFILIATION

Service	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Army	14	14	0.871	1	9	3	1	0
Navy	3	2	4.265	0	0	0	1	1
Marine Corps	1	1	0.820	0	1	0	0	0
Air Force	202	4	0.062	3	1	0	0	0
Scientific Personnel, Contractors, and Affiliates	42	42	0.618	9	27	6	0	0
TOTAL	262	63	0.758	13	38	9	2	1

Table 5-2: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR ARMY PERSONNEL AND AFFILIATES, OPERATION RANGER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Army Chemical Center	2	2	0.220	0	2	0	0	0
Armed Forces Special Weapons Project	1	1	0.900	0	1	0	0	0
Camp Lee, VA	1	1	0.330	0	1	0	0	0
Corps of Engineers, Fort Belvoir, VA	1	1	1.900	0	0	1	0	0
Evans Signal Laboratory	1	1	0.360	0	1	0	0	0
Los Alamos Scientific Laboratory	2	2	0.400	1	1	0	0	0
Naval Radiological Defense Laboratory	1	1	0.140	0	1	0	0	0
Office Chief of Engineers	4	4	1.740	0	1	2	1	0
Office of the Surgeon General	1	1	0.360	0	1	0	0	0
TOTAL	14	14	0.871	1	9	3	1	0

Table 5-3: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR NAVY PERSONNEL AND AFFILIATES, OPERATION RANGER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Armed Forces Special Weapons Project	1	1	5.320	0	0	0	0	1
Joint Task Force 7	1	1	3.210	0	0	0	1	0
Observers	1	0						
TOTAL	3	2	4.265	0	0	0	1	1

Table 5-4: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR MARINE CORPS PERSONNEL AND AFFILIATES, OPERATION RANGER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
U.S. Navy Administrative Unit, Sandia Base, NM	1	1	0.820	0	1	0	0	0
TOTAL	1	1	0.820	0	1	0	0	0

Table 5-5: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR AIR FORCE PERSONNEL AND AFFILIATES, OPERATION RANGER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
Air Force Cambridge Research Center	1	0						
Air Research and Development Command	1	0						
Air Weather Service	1	0						
Special Weapons Command	5	0						
7th Aviation Squadron	1	0						
9th Weather Squadron	15	0						
55th Reconnaissance Squadron Weather	1	0						
57th Reconnaissance Squadron	1	0						
301st Bombardment Wing	1	0						
330th Bombardment Squadron	1	0						
373rd Reconnaissance Squadron (VLR) Weather	1	0						
374th Reconnaissance Squadron (VLR) Weather	33	0						
513th Reconnaissance Squadron (VLR) Weather	47	0						
550th Aviation Squadron	1	0						
1009th Special Weapons Squadron	5	3	0.076	2	1	0	0	0
1131st Special Activity Squadron	1	0						
2059th Air Weather Wing (DET)	5	0						
2060th Mobile Weather Squadron	29	0						
3171st Electronics Group	1	0						
3595th Pilot Training Wing	15	0						
4901st Support Wing (A)	1	0						
4914th Flight Operations Squadron	4	0						
4925th Special Weapons Group	7	0						
4950th Test Group (N)	1	0						
Unknown *	23	1	0.020	1	0	0	0	0
TOTAL	202	4	0.062	3	1	0	0	0

* Unit information is unavailable.

Table 5-6: DISTRIBUTION OF GAMMA RADIATION EXPOSURES FOR SCIENTIFIC PERSONNEL, CONTRACTORS, AND AFFILIATES, OPERATION RANGER

Units	Personnel Identified by Name	Personnel Identified by Name and by Film Badge	Average Gamma Exposure (Roentgens)	Gamma Exposure (Roentgens)				
				<.1	.1-1.0	1.0-3.0	3.0-5.0	5.0+
DOD Civilians	42	42	0.618	9	27	6	0	0
TOTAL	42	42	0.618	9	27	6	0	0

SHOT ABLE SYNOPSIS

AEC TEST SERIES:	RANGER
DOD EXERCISE:	None
DATE/TIME:	27 January 1951, 0545 hours
YIELD:	1 kiloton
HEIGHT OF BURST:	1,060 feet above ground

Purpose of Test: To test nuclear device designs proposed for Operation GREENHOUSE.

DOD Objective: To collect data on the effects of gamma and thermal radiation from a nuclear detonation.

Weather: At shot-time, the temperature at the surface was -2.0° C, the relative humidity was 73 percent, and the atmospheric pressure was 13.1 psi. The surface winds were nearly calm. Winds were 18 knots from the west at 10,000 feet and 30 knots from the west at 20,000 feet.

Radiation Data: The initial ground survey found that onsite radiation greater than 0.03 R/h was confined to an area 460 meters from ground zero, reaching a maximum intensity of 0.75 R/h near ground zero. Intensities exceeding background radiation were detected 3,200 meters from ground zero.

Participants: Special Weapons Command; Headquarters, USAF; Army Corps of Engineers; Air Weather Service; Office of the Quartermaster General, Army; Office of the Surgeon General, Army; Strategic Air Command; Air Training Command; Air Research and Development Command; Air Force Cambridge Research Laboratory; Santa Fe Operations Office; Los Alamos Scientific Laboratory; Sandia Corporation; EG&G; Atomic Energy Commission.

CHAPTER 6

SHOT ABLE

Shot ABLE, the first nuclear test of Operation RANGER, was detonated on 27 January 1951 at 0545 hours Pacific Standard Time in Frenchman Flat at UTM coordinates 923758. ABLE, a developmental device designed by the Los Alamos Scientific Laboratory, was airdropped from a B-50 aircraft flying 19,700 feet above the ground.* The device, which detonated 1,060 feet above the terrain, had a yield of one kiloton (15; 17).

At shot-time, the temperature at the surface was -2.0 degrees Celsius, and the winds at the surface were nearly calm. At 10,000 feet, winds were 18 knots from the west, and at 20,000 feet, winds were 30 knots from the west. The top of the nuclear cloud reached an altitude of 17,000 feet and moved east from the point of detonation (17).

The Scientific Tests Section, part of the AEC Test Group, fielded eight experiments at Shot ABLE. Twelve DOD participants took part in these experiments. An estimated 246 Air Force personnel engaged in air support. The Radiological Safety Section, part of the AEC Test Group, included the following personnel: one civilian and four officers from the Army Corps of Engineers, two officers from the Army Medical Corps, one Army officer and one Air Force enlisted man from LASL, and one officer whose service branch is unknown. An additional 86 Air Force participants were involved in communications security for the Security Group and in weather support for the Meteorology Section, discussed in chapter 3. Military and civilian officials took part in a program for observers, also discussed in chapter 3 (19; 28; 30).

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*Ground zero at Frenchman Flat was 3,140 feet above mean sea level.

6.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC TESTS SECTION ACTIVITIES AT SHOT ABLE

Department of Defense personnel took part in eight of the 16 experiments fielded by the Scientific Tests Section at Shot ABLE. This section details DOD participation in five of these experiments: Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb, Thermal Effects Program, Thermal and Ionizing Radiation Measurements, Analysis of Fireball Growth at RANGER, and Gamma Radiation Exposure as a Function of Distance. Two of the remaining three experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds, were primarily LASL projects. The cloud-sampling aircraft discussed in section 6.2, Air Support Activities, provided support for these experiments. The final experiment, Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site, was conducted by the Air Weather Service following Operation RANGER to analyze weather data collected for ABLE and the other RANGER shots. Chapter 3 includes information common to all of these experiments.

Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb was conducted by the Army Chemical Center to determine the degree of shielding afforded against gamma radiation emitted by a nuclear airburst. The afternoon before the shot, two participants from the Army Chemical Center and one from the Army Corps of Engineers placed film packets in 11 of 14 fortifications. Figure 6-1 shows which positions were instrumented. These three men also placed four film packets at ground positions 370, 730, 1,100, and 1,460 meters west of ground zero. The same DOD personnel retrieved the film packets, completing recovery by 1100 hours on shot-day (30).

The Thermal Effects Program was conducted by the Office of the Quartermaster General (Army). The objective was to obtain

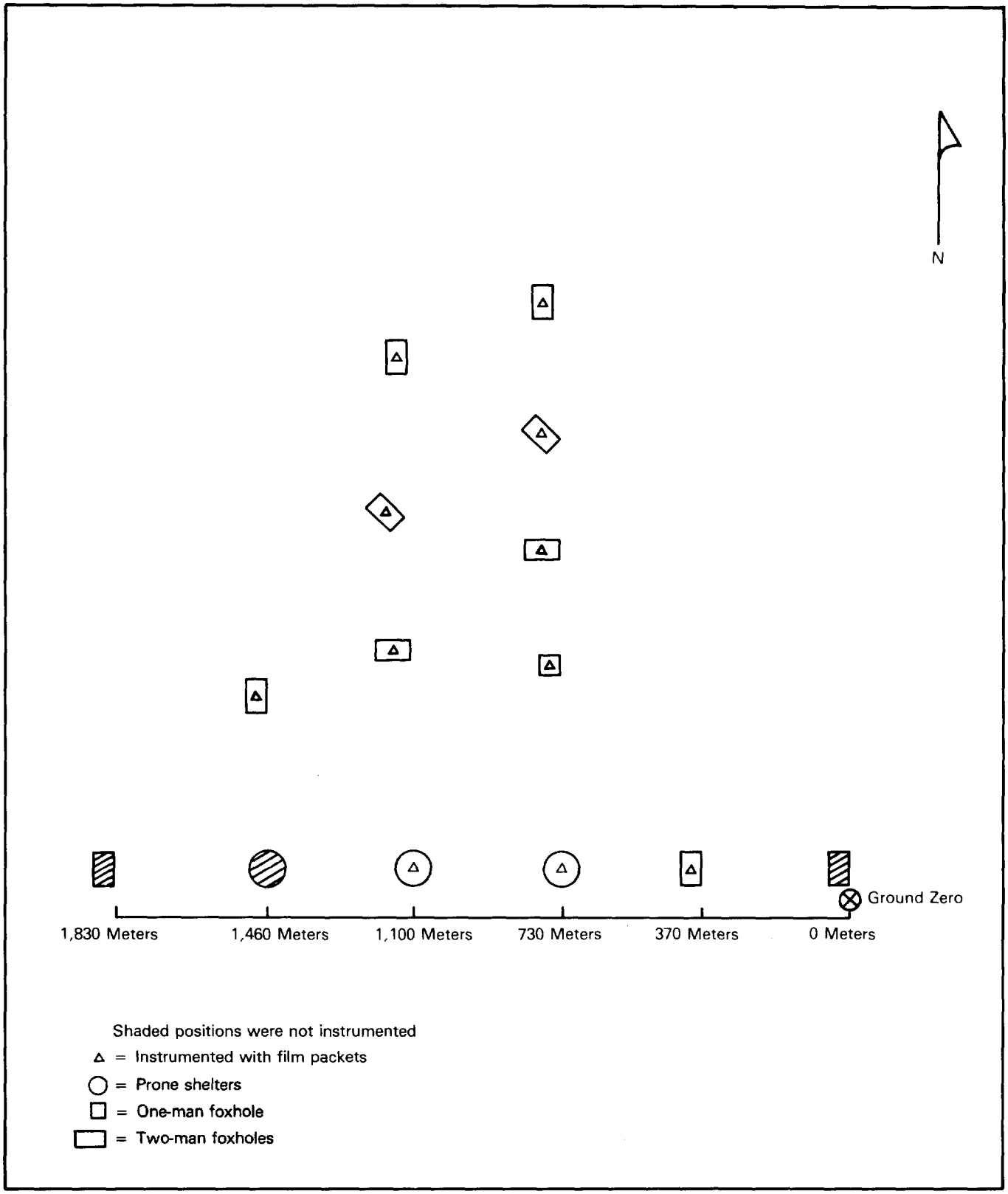

Figure 6-1: FIELD FORTIFICATIONS AT SHOT ABLE

data on the thermal hazard of a nuclear detonation to various materials and finishes (30).

Before the detonation, the experiment's one participant placed test panels belonging to the Office of the Quartermaster General, Naval Material Laboratory, and National Bureau of Standards at the following distances from ground zero:

Distance (meters)	Agencies
730	Quartermaster General
910	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
1,100	Quartermaster General, Naval Material Laboratory
1,460	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
1,830	Quartermaster General
2,290	Quartermaster General

The participant also placed panels in the foxholes constructed for the gamma radiation experiment. He later recovered the panels (30).

The third scientific experiment with DOD field participation was Thermal and Ionizing Radiation Measurements, performed by a civilian under contract to the Office of the Surgeon General (Army). The objectives were to (30):

- Collect data on the degree of biological burns produced by nuclear thermal radiation and correlate these data with flashburn experiments
- Determine the time rate of delivery of thermal radiation from the nuclear detonation.

To obtain information for the first objective, the participant placed five plywood panels containing 14 different

textile fabrics at distances of 2,740, 2,290, 1,830, 1,460, and 1,280 meters west of ground zero. Each fabric test panel was exposed with a thermal radiation detector panel consisting of heat-sensitive paper and two grades of white paper on a plywood backing. The participant retrieved the panels after the shot area was declared safe for reentry (30).

To obtain information for the second objective, the civilian placed a turntable coated with heat-sensitive paper 1,460 meters northwest of ground zero. However, the turntable ran down before the detonation because of faulty timing (30).

The objective of Analysis of Fireball Growth, conducted by LASL, was to analyze the fireball growth and yield determination by studying film from cameras at photography stations 3.2 kilometers southeast and northeast of ground zero. A special LASL group, consisting of three civilian employees and one Army, one Navy, and one Air Force participant, retrieved film from the photography stations after ABLE and returned it to LASL for analysis (19; 28).

Gamma Radiation Exposure as a Function of Distance was conducted by the Sandia Corporation. To measure gamma radiation at different distances during and immediately following a nuclear detonation, 41 film badges were placed at 90-meter intervals from ground zero along the West Access Road and the South Access Road. One film badge was positioned at ground zero. To measure residual neutron-induced activity, film badges were also placed in lead cylinders with 10-centimeter-thick walls along the West Access Road 270, 550, 820, 1,100, and 1,370 meters from ground zero. To measure the fraction of initial gamma radiation reaching the film badges, the badges were placed in "mousetrap gadgets" (devices designed to shield the film badges from residual radiation) 460, 910, and 1,830 meters from ground zero along the West Access Road (30).

Personnel began recovering film badges within one to two hours after the shot and finished within five to six hours. Military personnel assisting in the placement and recovery of the film badges included one Navy participant from Field Command, AFSWP; one Navy participant from LASL; and one participant from the Army Corps of Engineers. Three Sandia Corporation employees also took part in the experiment (28; 30; 34).

Specific details regarding personnel activities during this experiment have not been documented, but one report states that the Navy participant from Field Command, AFSWP, placed and retrieved film badges 370 and 730 meters from ground zero along the West Access Road (34).

6.2 DEPARTMENT OF DEFENSE PARTICIPATION IN AIR SUPPORT SECTION ACTIVITIES AT SHOT ABLE

The Special Weapons Command and Headquarters, USAF, both with air control centers at Nellis AFB, Nevada, directed air support missions at Shot ABLE. SWC directed and conducted the airdrop, the emergency aircraft mission, the courier service, and the helicopter support of the aerial surveys conducted by the Radiological Safety Section. SAC conducted the SWC photography mission. Headquarters, USAF, personnel supervised the cloud sampling, cloud tracking, and, along with SWC, the aerial surveys. They also coordinated activities associated with the Atomic Energy Detection System. The Air Weather Service provided most of the aircraft and crews for air missions supervised by Headquarters, USAF.

SWC support missions involved eight aircraft and an estimated 122 SWC personnel. Of these personnel, 56 were air crew and emergency team members, while the others were ground crew members, radiological safety monitors, air operations control personnel, and administrative staff. Headquarters, USAF,

test and support missions involved 11 aircraft and an estimated 124 Air Force personnel. Of these personnel, an estimated 57 were aircraft crew members, while the others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff (2-3; 4; 13; 25; 38). Table 6-1 identifies the aircraft and the estimated numbers of DOD personnel engaged in air support activities.

6.2.1 Delivery

A B-50 aircraft delivered the ABLE nuclear device. Two other aircraft, a B-50 and a C-47, accompanied the drop aircraft for the purpose of documentary photography and emergency assistance, respectively.

The B-50 drop aircraft, with a crew of 11 from the 4925th Special Weapons Group, left Kirtland AFB at 0115 hours on shot-day and flew at an altitude of 14,000 feet to Indian Springs AFB. Upon reaching the Indian Springs area, the aircraft descended to 10,000 feet and proceeded to the north of ground zero. At 0350 hours, the crew began inserting the nuclear capsule into the device, completing this task at 0434. The aircraft then climbed to its bombing height of 19,700 feet. It completed its first practice run at 0507 and its second practice run at 0520. At 0527, the bomb-bay doors were opened, and at 0534, the B-50 began its bombing run. At exactly 0544:05 hours, the device was released. The B-50 then returned to Kirtland AFB, arriving at 0750 hours (3-4).

The B-50 documentary photography aircraft, with a crew of 11 from SAC, left Kirtland AFB at 0105, ten minutes before the drop aircraft. It accompanied the drop aircraft to the NPG, maintaining an altitude of 16,000 feet. During the practice and bombing runs, the photography aircraft remained five to six kilometers behind and 2,000 feet above the drop aircraft. After

Table 6-1: SUMMARY OF AIR SUPPORT ACTIVITIES, SHOT ABLE

Mission	Type of Aircraft	Number of Aircraft	Unit of Origin	Staging Base	Estimated DOD Personnel
Airdrop	B-50	1	4925th Special Weapons Group	Kirtland AFB	11
Photography	B-50	1	SAC	Kirtland AFB	11
Emergency	C-47	1	4925th Special Weapons Group	Kirtland AFB	14
Cloud Sampling	B-29	2	374th Recon Squadron (VLR) Weather	Nellis AFB	20
Cloud Tracking	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	11
	B-29	1	374th Recon Squadron (VLR) Weather	McClellan AFB	11
Aerial Surveying	H-13	1	4925th Special Weapons Group	AEC Control Point	2
	H-19	1	4925th Special Weapons Group	AEC Control Point	3
	C-47	1	Air Weather Service	Nellis AFB	6
	B-17	1	Cambridge Research Laboratory	Nellis AFB	9
Courier Service	B-25	3	4901st Support Wing (Atomic)	Indian Springs AFB	15
AEDS	B-29	5	Air Weather Service	Barksdale AFB, Robins AFB	60
	B-29	*	Air Weather Service	Air Force bases in Alaska, Guam, Japan, and Saudi Arabia	*

*Unknown

completing its photography assignment, it returned to Kirtland AFB, arriving there at 0745 hours (3-4).

The C-47 emergency aircraft, with a crew of four and a disaster team of ten from the 4925th Special Weapons Squadron, left Kirtland AFB at 0117 hours, two minutes after the drop aircraft. It followed the drop aircraft at an altitude of 12,000 feet to the vicinity of Las Vegas, where it descended to 10,000 feet and flew a holding pattern until the drop aircraft had completed its mission. The C-47 then returned to Kirtland AFB, arriving at 0823 hours (3-4).

6.2.2 Cloud Sampling

Cloud sampling was performed in conjunction with two Scientific Tests Section experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds. To support these experiments, two B-29 cloud samplers, each with a crew of ten from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0245 and 0250 hours, respectively. Each aircraft penetrated the cloud several times. The first aircraft completed its initial cloud penetration two hours after the detonation and continued its sampling runs for about 50 minutes. The second aircraft made passes through the cloud for approximately one hour to obtain its samples (6; 13; 20; 25; 38).

6.2.3 Cloud Tracking

Two B-29 aircraft flew cloud-tracking missions over and beyond the Nevada Proving Ground. One B-29, with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0350 hours to track the cloud and returned to base within 12 hours. A second B-29, also with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, replaced the first B-29, which was starting to run low on fuel. It left from and returned to McClellan AFB (6; 13; 20; 25; 38).

6.2.4 Aerial Surveys

Aerial survey aircraft at Shot ABLE included one SWC helicopter that monitored the area immediately around ground zero and another that performed courier service. In addition, a C-47 and a B-17 aircraft surveyed both onsite and offsite areas. The C-47 left Nellis AFB at 0750 hours with a crew of six from the Air Weather Service. The B-17 left Nellis AFB at 0755, with a crew of nine from the Air Force Cambridge Research Laboratory (6).

The SWC H-19 helicopter, with a crew of three from the 4925th Special Weapons Group, made three postshot trips to the ground zero area to monitor the area and to retrieve scientific data. On its first trip, the helicopter left the AEC Control Point at 0559 and returned at 0618 hours. The H-19 helicopter began its second trip to the ground zero area at 0625 and returned to the Control Point at 0719. Its third trip started at 0800 and was completed at 0812. At 1027, the H-19 left for Indian Springs AFB carrying scientific data for the B-25 courier aircraft; it arrived at 1045 hours. The SWC H-13 helicopter did not fly any aerial survey missions at ABLE, but was instead assigned to deliver scientific data to the courier aircraft at Indian Springs AFB, leaving the Control Point at 1010 and arriving at the base at 1031. The H-13 had a crew of two from the 4925th Special Weapons Group (4).

6.2.5 Courier Service

After the sampling missions had been completed, three B-25 aircraft left Indian Springs AFB on shot-day to deliver cloud samples, instrumentation, and other results from the scientific experiments to Kirtland AFB for later transport to LASL via commercial contract carrier. The couriers aboard these aircraft were LASL civilians, and the aircrews were from the 4901st Air Support Wing (2-4).

The first B-25, with a crew of five and a LASL courier onboard, left Indian Springs AFB for the Frenchman Flat landing strip at 0623. It reached Frenchman Flat at 0640, picked up scientific samples, instrumentation, and data, and left Frenchman Flat at 0659 for Kirtland AFB, arriving at 0905 hours (3-4).

The second B-25, with a crew of five and a LASL courier, left Indian Springs AFB for the Frenchman Flat landing strip at 0652. It reached Frenchman Flat at 0708, picked up scientific samples and materials, and left Frenchman Flat at 0742 for Kirtland AFB, arriving there at 0951 hours (3-4).

The third B-25, with a crew of five and a LASL courier, left Indian Springs AFB for Nellis AFB at 1040 and arrived there at 1102. After receiving cloud samples from Headquarters, USAF, personnel, it left for Kirtland AFB at 1140, arriving at 1331 hours (3-4).

6.3 RADIATION PROTECTION AT SHOT ABLE

The information available for Shot ABLE includes results of onsite and offsite radiological monitoring and decontamination procedures.

Monitoring

The initial ground survey began almost immediately after the shot and was conducted by a team of three, equipped with a two-way radio and alpha, beta, and gamma survey meters. Monitors first encountered gamma radiation intensities exceeding background level at about 3,200 meters west of ground zero. They then took radiation readings at 460-meter intervals and radioed the results to the Control Point. At 460 meters from ground zero, they detected a gamma intensity of 0.03 R/h. From this point, they took radiation readings at 90-meter intervals. Monitors found a maximum gamma intensity of 0.75 R/h near ground

zero about 90 minutes after the shot (16). They did not detect alpha radiation at any location. Figure 6-2 shows a reconstructed isointensity map based on this initial survey (17).

Because there were not enough monitors, subsequent ground surveys in the shot area were unsystematic and uncoordinated. Only a few radiation measurements were taken in the shot area after the initial survey was completed. These measurements indicated that induced radioactivity in the area around ground zero had a half-life of about eight hours (16).

Offsite ground monitoring teams concentrated their efforts in the area east of ground zero, because the Shot ABLE cloud had drifted in that direction. The maximum gamma intensity encountered by any monitoring team was 0.0002 R/h, only slightly greater than the normal background level (16; 34). Two aircraft, a C-47 and a B-17, conducted offsite aerial surveys up to about 320 kilometers from ground zero. Neither aircraft encountered any detectable radiation intensities (16).

Decontamination

Onsite personnel were monitored at the decontamination center about 30 meters from the Control Point. No significant contamination was found on participants, but some of the protective booties they were wearing showed gamma intensities of 0.006 R/h (16).

Vehicles were decontaminated at the same location. Decontamination personnel found that the areas most contaminated were the running boards, floorboards, tires, and mudguards. The highest intensity encountered at any of these locations was 0.03 R/h. In all cases, vacuuming and washing reduced the radioactivity to less than 0.007 R/h (16).

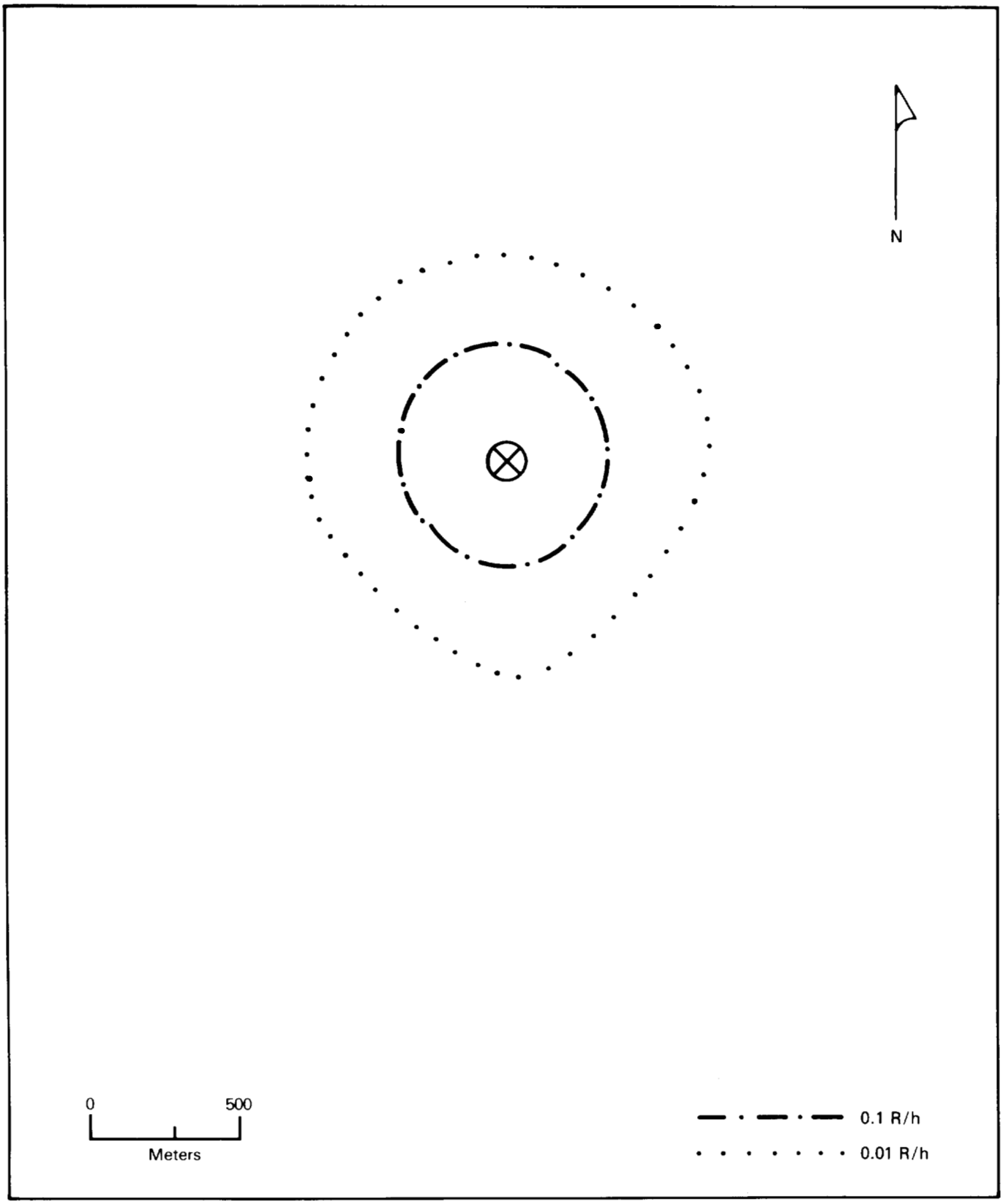

Figure 6-2: RECONSTRUCTED ISOINTENSITY MAP OF ABLE, ONE HOUR AFTER DETONATION

The crews of the two B-29 sampling aircraft were monitored for radiation at Nellis AFB. Decontamination personnel found an average of 0.2 to 0.3 R/h of gamma radiation on some of the crew members. Showering and a change of clothing removed the contamination.

The sampling aircraft were also monitored at Nellis AFB. Decontamination personnel detected average gamma intensities of 0.73 and 0.16 R/h on the aircraft immediately after landing. The first washing reduced these levels to 0.045 and 0.01 R/h, respectively. The final washing further reduced the radioactivity to 0.017 and 0.004 R/h, respectively. The washing effluent was allowed to run off the ramp into the desert sand. Decontamination procedures removed over 95 percent of the radiation on the aircraft (31; 38).

SHOT BAKER SYNOPSIS

AEC TEST SERIES:	RANGER
DOD EXERCISE:	None
DATE/TIME:	28 January 1951, 0552 hours
YIELD:	8 kilotons
HEIGHT OF BURST:	1,080 feet above ground

Purpose of Test: To test nuclear device designs proposed for Operation GREENHOUSE.

DOD Objective: To collect data on the effects of gamma and thermal radiation from a nuclear detonation.

Weather: At shot-time, the temperature at the surface was -2.8° C, the relative humidity was 87 percent, and the atmospheric pressure was 13.04 psi. The winds were six knots from the south-southwest at the surface, 13 knots from the west at 10,000 feet, and 33 knots from the west-northwest at 30,000 feet.

Radiation Data: Soon after the detonation, onsite induced activity greater than 0.3 R/h was confined to an area 460 meters from ground zero; intensities climbed to 16.0 R/h within 90 meters of ground zero. Lighter activity, ranging from 0.0001 R/h to 0.3 R/h, was confined to an area 3,200 to 460 meters from ground zero.

Participants: Special Weapons Command; Headquarters, USAF; Army Corps of Engineers; Air Weather Service; Office of the Quartermaster General, Army; Office of the Surgeon General, Army; Strategic Air Command; Air Training Command; Air Research and Development Command; Air Force Cambridge Research Laboratory; Santa Fe Operations Office; Los Alamos Scientific Laboratory; Sandia Corporation; EG&G; Atomic Energy Commission.

CHAPTER 7

SHOT BAKER

Shot BAKER, the second nuclear test of Operation RANGER, was detonated on 28 January 1951 at 0552 hours Pacific Standard Time in Frenchman Flat at UTM coordinates 923758. BAKER, a developmental device designed by the Los Alamos Scientific Laboratory, was airdropped from a B-50 aircraft flying 19,700 feet above the ground. The device, which detonated 1,080 feet above the terrain, had a yield of eight kilotons (15; 17).

At shot-time, the temperature at the surface was -2.8 degrees Celsius, and the surface winds were from the south-southwest at six knots. Winds were 13 knots from the west at 10,000 feet, 23 knots from the west-northwest at 20,000 feet, and 33 knots from the west-northwest at 30,000 feet. The top of the cloud resulting from Shot BAKER reached an altitude of 35,000 feet and moved southeast from the point of detonation (17).

The Scientific Tests Section fielded seven experiments at Shot BAKER. Eleven DOD participants took part in these experiments. An estimated 236 Air Force personnel engaged in air support for BAKER. The Radiological Safety Section included the following personnel: one civilian and four officers from the Army Corps of Engineers, two officers from the Army Medical Corps, one Army officer and one Air Force enlisted man from LASL, and one officer whose service affiliation is unknown. An additional 86 Air Force participants were involved in communications security for the Security Group and in weather support for the Meteorology Section, discussed in chapter 3. Military and civilian officials took part in a program for observers, also discussed in chapter 3 (19; 28; 30).

7.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC TESTS SECTION ACTIVITIES AT SHOT BAKER

Department of Defense personnel took part in seven of the 15 scientific experiments conducted by the Scientific Tests Section at Shot BAKER. This section details DOD participation in four of these experiments: Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb, Thermal Effects Program, Analysis of Fireball Growth at RANGER, and Gamma Radiation Exposure as a Function of Distance. Two of the remaining three experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds, were primarily LASL projects. The cloud-sampling aircraft discussed in section 7.2, Air Support Activities, provided support for these experiments. The final experiment, Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site, was conducted by the Air Weather Service following Operation RANGER to analyze weather data collected for BAKER and other RANGER shots. Chapter 3 includes information common to all of these experiments.

Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb was conducted to determine the protection afforded against gamma radiation emitted by a nuclear airburst. The afternoon before the shot, two participants from the Army Chemical Center and one from the Army Corps of Engineers placed film packets in 11 of 14 fortifications. In addition, they placed one LASL neutron detector in each of three foxholes. Figure 7-1 shows the instrumented foxholes. The three men also placed four film packets at ground positions 370, 730, 1,100, and 1,460 meters west of ground zero. After the area was opened for recovery, the three personnel began retrieving the film packets. They completed recovery by 0912 hours (30).

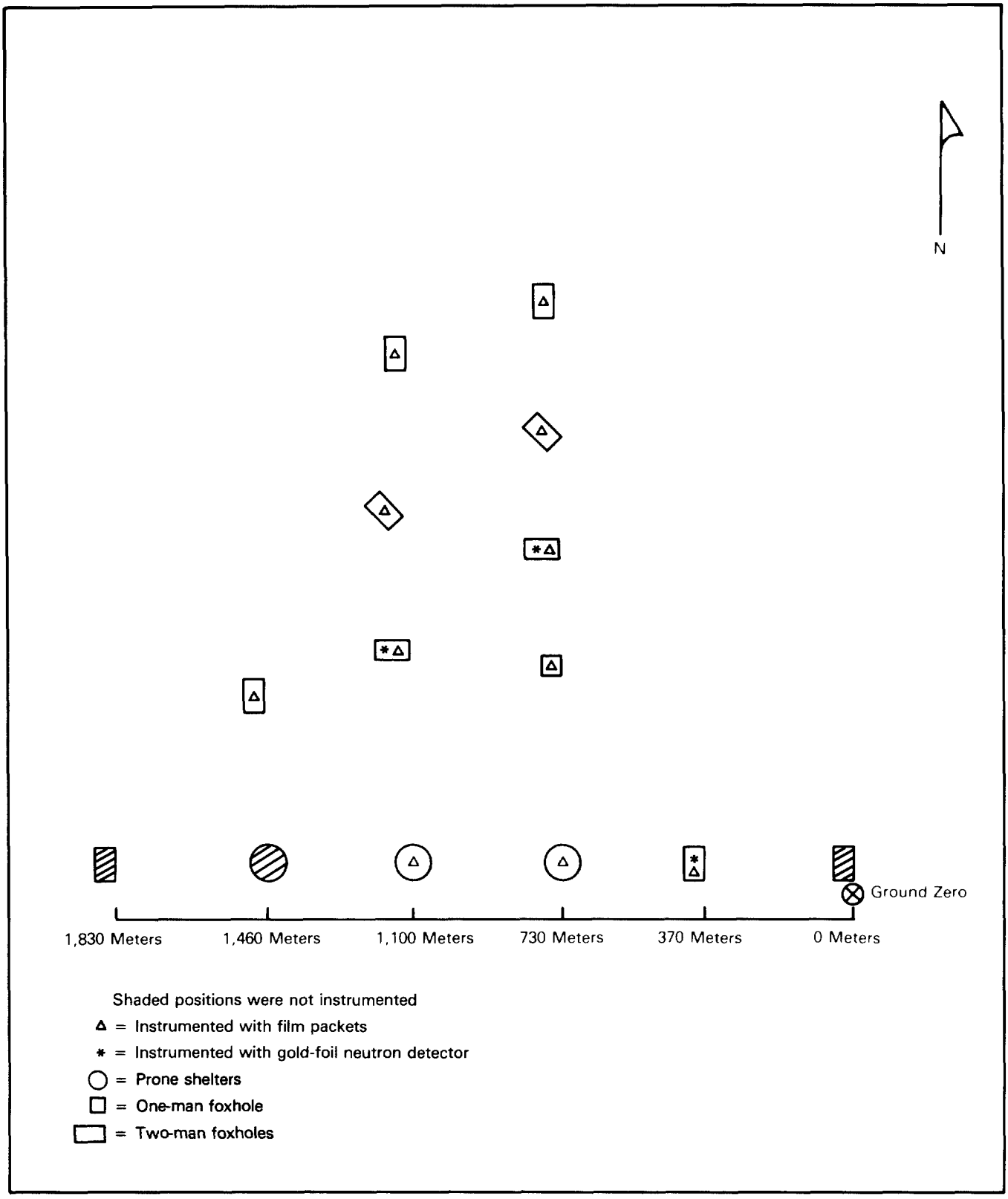

Figure 7-1: FIELD FORTIFICATIONS AT SHOT BAKER

The Thermal Effects Program was conducted by the Office of the Quartermaster General (Army). The objective was to obtain data on the thermal hazard of a nuclear detonation to various materials and finishes (30).

Before the detonation, the experiment's one participant placed test panels belonging to the Office of the Quartermaster General, Naval Material Laboratory, and National Bureau of Standards at the following distances from ground zero:

Distance (meters)	Agencies
1,100	Quartermaster General
1,460	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
1,830	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
2,290	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
2,740	Quartermaster General
3,660	Quartermaster General
4,570	Quartermaster General

The participant retrieved the panels after the area was opened for recovery operations (30).

Analysis of Fireball Growth was conducted by LASL. The objective was to analyze the fireball growth and yield determination by studying film from cameras at photography stations 3.2 kilometers southeast and northeast of ground zero. A special LASL group, consisting of three civilian employees and one Army, one Navy, and one Air Force participant, retrieved film from the photography stations after BAKER and returned it to LASL for analysis (19; 28).

Gamma Radiation Exposure as a Function of Distance was conducted by the Sandia Corporation. To measure gamma radiation at different distances during and immediately following a nuclear detonation, 41 film badges were placed at 90-meter intervals from ground zero along the West Access Road and the South Access Road. One film badge was positioned at ground zero. To measure residual neutron-induced activity, film badges were also placed in lead cylinders with 10-centimeter-thick walls along the West Access Road 270, 550, 820, 1,100, and 1,370 meters from ground zero. To measure the fraction of initial gamma radiation reaching the film badges, the badges were placed in "mousetrap gadgets" (devices designed to shield the film badges from residual radiation) 460, 910, and 1,830 meters from ground zero along the West Access Road (30).

Personnel began recovering film badges within one to two hours after the detonation and finished within five to six hours. Military personnel assisting in the placement and recovery of the film badges included one Navy participant from Field Command, AFSWP; one Navy participant from LASL; and one participant from the Army Corps of Engineers. Three Sandia Corporation employees also took part in the experiment (28; 30; 34).

Specific details regarding personnel activities during this experiment at BAKER have not been documented, but one report states that the Navy participant from Field Command, AFSWP, placed and retrieved film badges 370 and 730 meters from ground zero along the West Access Road (34).

7.2 DEPARTMENT OF DEFENSE PARTICIPATION IN AIR SUPPORT SECTION ACTIVITIES AT SHOT BAKER

The Special Weapons Command and Headquarters, USAF, both with air control centers at Nellis AFB, Nevada, directed air support missions at Shot BAKER. SWC directed and conducted the

airdrop, the emergency aircraft mission, the courier service, and the helicopter support of the aerial surveys conducted by the Radiological Safety Section. SAC conducted the SWC photography mission. Headquarters, USAF, personnel directed the cloud sampling, cloud tracking, and, along with SWC, the aerial surveys. They also coordinated activities associated with the Atomic Energy Detection System. The Air Weather Service provided most of the aircraft and crews for air missions supervised by Headquarters, Air Force.

SWC support missions involved eight aircraft and an estimated 122 SWC personnel. Of these personnel, 56 were aircrew and engineering team members and the others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff. Headquarters, USAF, support missions involved ten aircraft and an estimated 114 Air Force personnel, of whom an estimated 47 were aircrew members, while the others were ground crew members, radiological safety monitors, air operations control personnel, and administrative staff (2-4; 13; 25; 38). Table 7-1 identifies the aircraft and the estimated numbers of DOD personnel engaged in air support activities.

7.2.1 Delivery

A B-50 aircraft delivered the BAKER nuclear device. Two other aircraft, a B-50 and a C-47, accompanied the drop aircraft for the purpose of documentary photography and emergency assistance, respectively.

The B-50 drop aircraft, with a crew of 11 from the 4925th Special Weapons Group, left Kirtland AFB at 0105 hours on shot-day and flew at an altitude of 14,000 feet to Indian Springs AFB. Upon reaching the Indian Springs area, the aircraft descended to 10,000 feet and proceeded to the north of ground zero. At 0342,

Table 7-1: SUMMARY OF AIR SUPPORT ACTIVITIES, SHOT BAKER

Mission	Type of Aircraft	Number of Aircraft	Unit of Origin	Staging Base	Estimated DOD Personnel
Airdrop	B-50	1	4925th Special Weapons Group	Kirtland AFB	11
Photography	B-50	1	SAC	Kirtland AFB	11
Emergency	C-47	1	4925th Special Weapons Group	Kirtland AFB	14
Cloud Sampling	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	10
Cloud Tracking	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	11
	B-29	1	374th Recon Squadron (VLR) Weather	McClellan AFB	11
Aerial Surveying	H-13	1	4925th Special Weapons Group	AEC Control Point	2
	H-19	1	4925th Special Weapons Group	AEC Control Point	3
	C-47	1	Air Weather Service	Nellis AFB	6
	B-17	1	Cambridge Research Laboratory	Nellis AFB	9
Courier Service	B-25	3	4901st Support Wing (Atomic)	Indian Springs AFB	15
AEDS	B-29	5	Air Weather Service	Barksdale AFB, Robins AFB	60
	B-29	*	Air Weather Service	Air Force bases in Alaska, Guam, Japan, and Saudi Arabia	*

*Unknown

the crew began inserting the nuclear capsule into the device, completing this task at 0418. The aircraft then climbed to its bombing height of 19,700 feet. It completed its first practice run at 0447, its second practice run at 0508, and its third run at 0525 hours. At 0530, the bomb-bay doors were opened, and at 0538, the B-50 began its bombing run. At exactly 0552:10 hours, the device was released. The B-50 then returned to Kirtland AFB, arriving at 0751 hours (3-4).

The B-50 documentary photography aircraft, with a crew of 11 from the Strategic Air Command, left Kirtland AFB at 0100, five minutes before the drop aircraft. It accompanied the drop aircraft to the NPG, maintaining an altitude of 16,000 feet. During the practice and bombing runs, the photography aircraft remained five to six kilometers behind and 2,000 feet above the drop aircraft. After completing its photography assignment, it returned to Kirtland AFB, arriving there at 0753 hours (3-4).

The C-47 emergency aircraft, with a crew of four and a disaster team of ten from the 4925th Special Weapons Squadron, left Kirtland AFB at 0107, two minutes after the drop aircraft. It followed the drop aircraft at an altitude of 12,000 feet to the vicinity of Las Vegas, where it descended to 10,000 feet and flew a holding pattern until the drop aircraft had completed its mission. The C-47 then returned to Kirtland AFB, arriving at 0820 hours (3-4).

7.2.2 CLOUD SAMPLING

Cloud sampling was performed in conjunction with two Scientific Tests Section experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds. To support these experiments, one B-29 cloud sampler, with a crew of ten from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0145. The aircraft penetrated the cloud

several times. It completed its first cloud penetration about two hours after the BAKER detonation and finished its sampling runs in approximately 50 minutes (7; 13; 20; 25; 38).

7.2.3 Cloud Tracking

Two B-29 aircraft flew cloud-tracking missions over and beyond the Nevada Proving Ground. One B-29, with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0350 hours to track the cloud and returned to base within 12 hours. A second B-29, also with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, replaced the first B-29, which was starting to run low on fuel. It left from and returned to McClellan AFB (7; 13; 20; 25).

7.2.4 Aerial Surveys

Aerial surveys included monitoring of the area immediately around ground zero by one SWC helicopter. The other SWC aerial-survey helicopter performed only courier service at BAKER. In addition, a C-47 and a B-17 surveyed both onsite and offsite areas. The C-47 left Nellis AFB at 0750 with a crew of six from the Air Weather Service. The B-17 left Nellis AFB at 0755 hours with a crew of nine from the Air Force Cambridge Research Laboratory (7).

The SWC H-19 helicopter, with a crew of three from the 4925th Special Weapons Group, made two postshot trips to the ground zero area to monitor and to retrieve scientific data. Its first trip began at 0618, when the helicopter left the AEC Control Point. It arrived at the ground zero area at 0625 and returned to the Control Point at 0730 hours. The H-19 began its second survey at 0740 and returned to the Control Point at 0820 hours. In addition, the helicopter went to Indian Springs AFB to deliver data to the courier aircraft. It left the Control Point

at 0946 and reached Indian Springs AFB at 1009. The SWC H-13 aerial-survey helicopter delivered scientific data to the courier aircraft at Indian Springs AFB, leaving the Control Point at 0940 and arriving at the base at 0959 hours. The H-13 had a crew of two from the 4925th Special Weapons Group (4).

7.2.5 Courier Service

After the sampling missions had been completed, three B-25 aircraft left Indian Springs AFB on shot-day to deliver cloud samples, instrumentation, and other results from the scientific experiments to Kirtland AFB for subsequent transport to LASL via commercial contract carrier. While the couriers aboard these aircraft were LASL civilians, the aircrews were from the 4901st Air Support Wing (2-4).

The first B-25, with a crew of five and a LASL courier onboard, left Indian Springs AFB for the Frenchman Flat landing strip at 0645. It reached Frenchman Flat at 0706, picked up scientific samples, instrumentation, and data, and left Frenchman Flat at 0709 for Kirtland AFB, arriving at 0919 hours (3-4).

The second B-25, carrying a crew of five and a LASL courier, left Indian Springs AFB for the Frenchman Flat landing strip at 0705. It reached Frenchman Flat at 0721, picked up scientific samples and materials, and left Frenchman Flat at 0803 for Kirtland AFB, arriving there at 1008 hours (3-4).

The third B-25, with a crew of five and a LASL courier onboard, left Indian Springs AFB for Nellis AFB at 1021 and arrived at 1040. After receiving cloud samples from personnel of Headquarters, USAF, it left for Kirtland AFB at 1134, arriving at 1331 hours (3-4).

7.3 RADIATION PROTECTION AT SHOT BAKER

The information available for Shot BAKER includes the results of onsite and offsite radiological monitoring and decontamination procedures.

Monitoring

The initial survey monitoring team entered the test area shortly after the detonation. The team took radiation readings initially at 1,600-meter intervals and radioed the results to the Control Point. About 3,200 meters from ground zero, the team began reporting the readings at 460-meter intervals. After gamma radiation intensities of 0.01 R/h were found 1,350 meters from ground zero, the team began reporting its findings at 90-meter intervals and continued this to ground zero. Readings of 1.0 R/h were encountered about 300 meters from ground zero and a reading of 16.0 R/h was registered near ground zero (16). Figure 7-2 shows a reconstructed isointensity map based on this initial survey.

An aerial survey helicopter with another monitoring team entered the test area about one hour after the detonation. Gamma intensity at the camera station 3.2 kilometers southeast of ground zero was measured at background levels. The helicopter then circled ground zero at a height of 100 feet. The radiation intensity through the floor of the helicopter reached a maximum of 8.0 R/h (30). The helicopter monitoring team next took readings at the generator house, over three kilometers south of ground zero, and found gamma intensities of 0.015 R/h.

Offsite monitoring was conducted by the same survey teams stationed offsite to monitor the previous shot, ABLE. Communications were poor between these teams and the cloud-tracking aircraft that was supposed to direct them to areas over which the Shot BAKER cloud passed. Therefore, the teams did not monitor offsite areas extensively. Through a limited survey, however, they found no gamma intensities exceeding 0.0002 R/h (16; 34).

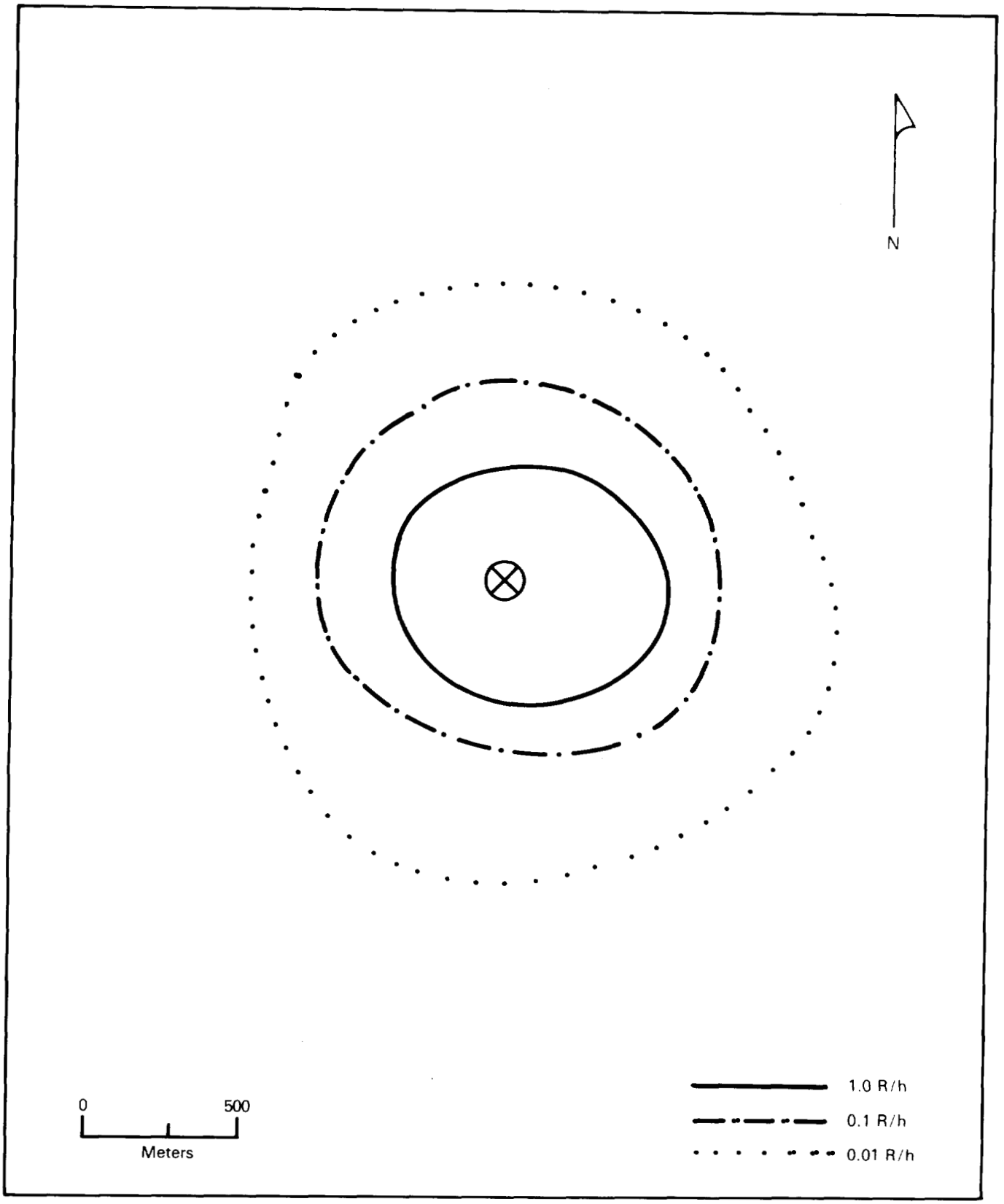

Figure 7-2: RECONSTRUCTED ISOINTENSITY MAP OF BAKER, ONE HOUR AFTER DETONATION

Two aircraft, a C-47 and a B-17, conducted offsite aerial surveys out to about 320 kilometers from ground zero. Neither aircraft encountered radiation intensities above background levels (16).

Decontamination

Onsite personnel were monitored at the decontamination center about 30 meters from the Control Point. Radiological safety teams reported that no radioactive contamination remained on individuals after they had showered and changed into fresh clothing. Working at the same center, the personnel decontaminating vehicles reported gamma intensities of 0.03 R/h at certain locations, particularly on running boards, tires, and mudguards. They found that other contaminated areas on the vehicles had much lower intensities. In all cases, they reduced the radioactivity to below 0.007 R/h by vacuuming and washing the vehicles with detergent and water (16).

The B-29 sampler aircraft was decontaminated at Nellis AFB. The average gamma intensity registered on this aircraft after landing was 0.16 R/h. Decontamination personnel reduced the intensity to 0.02 R/h with two washings, but the radiation was still too high. After they washed the aircraft a third time, the gamma intensity was reduced to an acceptable level of 0.01 R/h. The washing effluent was allowed to run down the ramp into the desert sand. This procedure removed about 93 percent of the radiation on the aircraft (31; 38).

SHOT EASY SYNOPSIS

AEC TEST SERIES:	RANGER
DOD EXERCISE:	None
DATE/TIME:	1 February 1951, 0547 hours
YIELD:	1 kiloton
HEIGHT OF BURST:	1,080 feet above ground

Purpose of Test: To test nuclear device designs proposed for Operation GREENHOUSE.

DOD Objective: To collect data on the effects of gamma and thermal radiation from a nuclear detonation.

Weather: At shot-time, the temperature at the surface was -11.5° C, the relative humidity was 89 percent, and the atmospheric pressure was 13.33 psi. The wind was two knots from the north at the surface and at the height of burst, increasing to ten knots from the north-northeast at 5,000 feet, 26 knots from the north-northwest at 10,000 feet, and 39 knots from the north-northwest at 12,500 feet.

Radiation Data: One hour after the detonation, onsite induced activity greater than 0.01 R/h was confined to an area 500 meters from ground zero. A maximum radiation intensity of 0.55 R/h was detected at ground zero. Radiation readings of 0.005 R/h were measured 900 meters from ground zero.

Participants: Special Weapons Command; Headquarters, USAF; Army Corps of Engineers; Air Weather Service; Office of the Quartermaster General, Army; Office of the Surgeon General, Army; Strategic Air Command; Air Training Command; Air Research and Development Command; Air Force Cambridge Research Laboratory; Santa Fe Operations Office; Los Alamos Scientific Laboratory; Sandia Corporation; EG&G; Atomic Energy Commission.

CHAPTER 8

SHOT EASY

Shot EASY, the third nuclear test of Operation RANGER, was detonated on 1 February 1951 at 0547 hours Pacific Standard Time in Frenchman Flat at UTM coordinates 923758. EASY, a developmental device designed by the Los Alamos Scientific Laboratory, was airdropped from a B-50 aircraft flying at a height of 19,700 feet above ground. The device, which detonated 1,080 feet above the terrain, had a yield of one kiloton (15; 17).

At shot-time, the temperature at the surface was -11.5 degrees Celsius. Winds were two knots from the north at the surface and at the height of burst. They were ten knots from the north-northeast at 5,000 feet, 26 knots from the north-northwest at 10,000 feet, and 39 knots from the north-northwest at 12,500 feet. The top of the Shot EASY cloud reached an altitude of 12,500 feet and moved southeast from the point of detonation. There was no detectable offsite fallout (17).

The Scientific Tests Section fielded eight experiments at Shot EASY. Twelve DOD participants took part in these experiments. An estimated 246 Air Force personnel engaged in air support activities. The Radiological Safety Section, part of the AEC Test Group, included the following personnel: one civilian and four officers from the Army Corps of Engineers, two officers from the Army Medical Corps, one Army officer and one Air Force enlisted man from LASL, and one officer whose service affiliation is unknown. Eighty-six Air Force participants were involved in communications security for the Security Group and in Weather Support for the Meteorology Section, discussed in chapter 3. Military and civilian officals took part in a program for observers, also discussed in chapter 3 (19; 28; 30).

8.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC TESTS SECTION ACTIVITIES AT SHOT EASY

Department of Defense personnel took part in eight of the 16 scientific experiments conducted by the Scientific Tests Section at Shot EASY. This section details DOD participation in five of these experiments: Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb, Thermal Effects Program, Thermal and Ionizing Radiation Measurements, Analysis of Fireball Growth at RANGER, and Gamma Radiation Exposure as a Function of Distance. Two of the remaining three experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds, were primarily LASL projects. The cloud-sampling aircraft discussed in section 8.2, Air Support Activities, provided support for these experiments. The final experiment, Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site, was conducted by the Air Weather Service after the series to analyze weather data collected for EASY and the other RANGER shots. Chapter 3 includes information common to all of these experiments.

Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb was conducted by the Army Chemical Center to determine the degree of shielding afforded against gamma radiation emitted by a nuclear airburst. The afternoon before the shot, two participants from the Army Chemical Center and one from the Army Corps of Engineers placed film packets in 11 of 14 fortifications. They also placed a LASL neutron detector in one of the foxholes and an ion chamber in one of the prone shelters. Figure 8-1 shows the instrumented fortifications. In addition, the three men placed four film packets at ground positions 370, 730, 1,100 and 1,460 meters west of ground zero. After the area was opened for reentry, the three personnel retrieved the film packets, completing recovery operations by 0900 hours on shot-day (30).

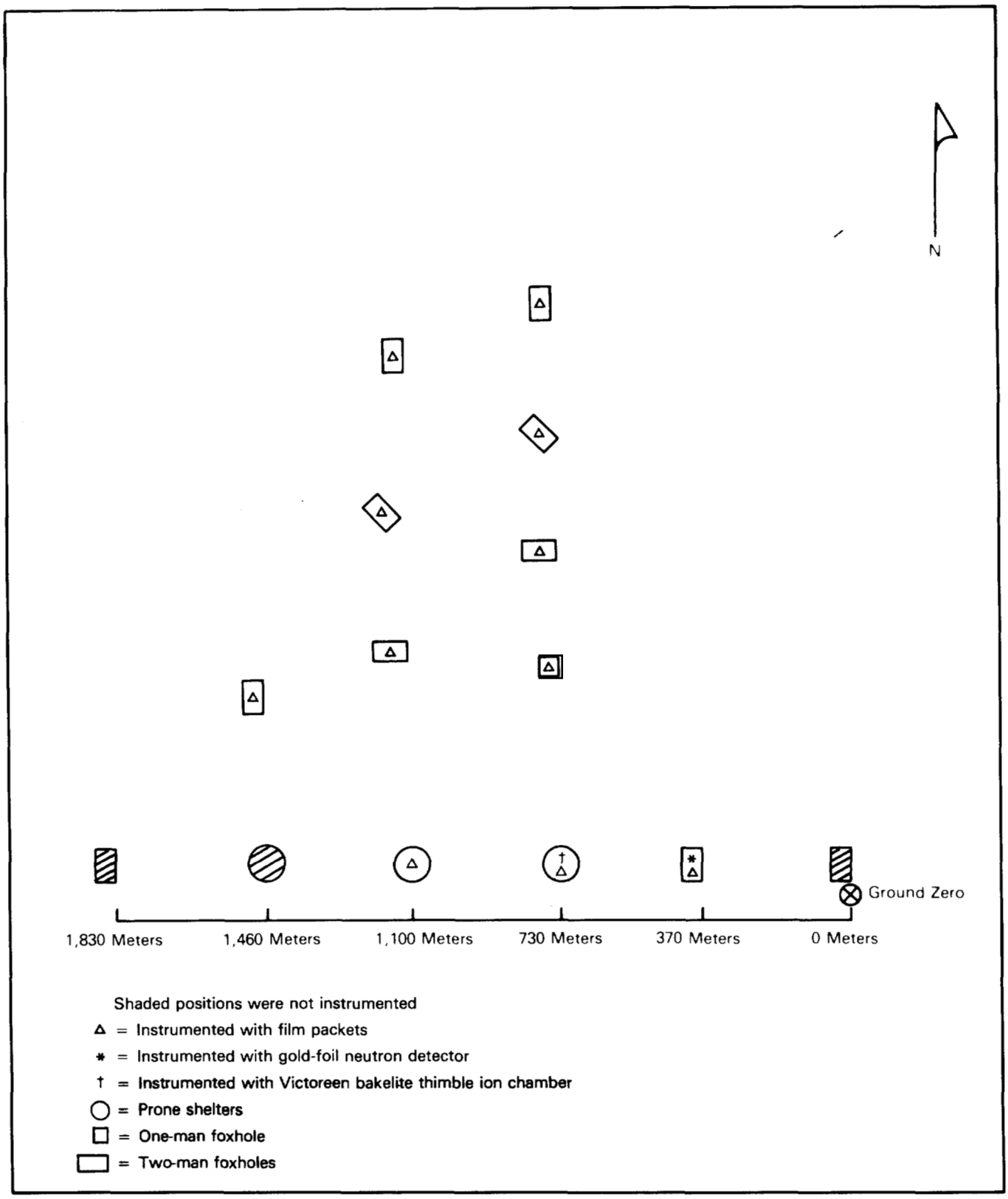

Figure 8-1: FIELD FORTIFICATIONS AT SHOT EASY

The film was then sent for analysis to the Army Chemical Center in Maryland.

The Thermal Effects Program was conducted by the Office of the Quartermaster General (Army). The objective was to obtain data on the thermal hazard of a nuclear detonation to various materials and finishes. Before the detonation, the experiment's one participant placed test panels belonging to the Office of the Quartermaster General and Naval Radiological Defense Laboratory 720 and 1,080 meters from ground zero. He recovered the materials after the area was opened for reentry (30).

Thermal and Ionizing Radiation Measurements was conducted by a civilian under contract to the Office of the Surgeon General (Army). The objective was to determine the intensity and quality of the initial gamma radiation from a nuclear bomb at distances where the combined effects of thermal and ionizing radiation energy may have serious biological consequences. Before the detonation, the participant placed six ion chambers on the ground 1,260 meters from ground zero and a seventh ion chamber in a prone shelter 730 meters from ground zero. He later retrieved the ion chambers (30).

Analysis of Fireball Growth at Shot EASY was conducted by LASL to analyze the fireball growth and yield determination by studying film from cameras at photography stations 3.2 kilometers southeast and northeast of ground zero. A special LASL group, consisting of three civilian employees and one Army, one Navy, and one Air Force participant, retrieved film from the photography stations after Shot EASY and returned it to LASL for analysis (19; 28).

Gamma Radiation Exposure as a Function of Distance was conducted by the Sandia Corporation. To measure gamma radiation at different distances during and immediately following a nuclear

detonation, 41 film badges were placed at 90-meter intervals from ground zero along the West Access Road and the South Access Road. One film badge was positioned at ground zero. To measure neutron-induced activity, film badges were also placed in lead cylinders with ten-centimeter-thick walls along the West Access Road 270, 550, 820, 1,100, and 1,370 meters from ground zero. To measure the fraction of initial gamma radiation reaching the film badges, the badges were placed in "mousetrap gadgets" (devices designed to shield the film badges from residual radiation) 460, 910, and 1,830 meters from ground zero along the West Access Road (30).

Personnel began recovering film badges within one to two hours after the detonation and finished within five to six hours. Military personnel assisting in the placement and recovery of the film badges included one Navy participant from Field Command, AFSWP; one Navy participant from LASL; and one participant from the Army Corps of Engineers. Three Sandia Corporation employees also took part in the experiment (28; 30; 34).

Specific details regarding personnel activities during this experiment have not been documented, but one report states that the Navy participant from Field Command, AFSWP, placed and retrieved film badges 370 and 730 meters from ground zero along the West Access Road (34).

8.2 DEPARTMENT OF DEFENSE PARTICIPATION IN AIR SUPPORT SECTION ACTIVITIES AT SHOT EASY

The Special Weapons Command and Headquarters, USAF, both with air control centers at Nellis AFB, directed air support missions at Shot EASY. SWC directed and conducted the airdrop, the emergency aircraft mission, the courier service, and the helicopter support of the aerial surveys conducted by the Radiological Safety Section. SAC conducted the SWC photography

mission. Headquarters, USAF, personnel supervised the cloud sampling, cloud tracking, and, along with SWC, the aerial surveys. They also coordinated activities associated with the Atomic Energy Detection System. The Air Weather Service provided most of the aircraft and crews for air missions supervised by Headquarters, USAF.

SWC support missions involved eight aircraft and an estimated 122 SWC personnel. Of these individuals, 56 were air crew and emergency team personnel, while the others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff. Headquarters, USAF, support missions involved 11 aircraft and an estimated 124 Air Force personnel. Of these personnel, an estimated 57 were aircraft crew members, while the others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff (2-4; 13; 25; 38). Table 8-1 identifies the aircraft and the estimated numbers of DOD personnel engaged in air support activities.

8.2.1 Delivery

A B-50 aircraft delivered the EASY nuclear device. Two other aircraft, a B-50 and a C-47, accompanied the drop aircraft for the purpose of documentary photography and emergency assistance, respectively.

The B-50 drop aircraft, with a crew of 11 from the 4925th Special Weapons Group, left Kirtland AFB at 0116 hours on shot-day and flew at an altitude of 14,000 feet to Indian Springs AFB. Upon reaching the Indian Springs area, the aircraft descended to 10,000 feet and proceeded to the north of ground zero. At 0357, the crew began inserting the nuclear capsule into the device, completing this task at 0430. The aircraft then climbed to its bombing height of 19,700 feet for two practice runs. At 0515,

Table 8-1: SUMMARY OF AIR SUPPORT ACTIVITIES, SHOT EASY

Mission	Type of Aircraft	Number of Aircraft	Unit of Origin	Staging Base	Estimated DOD Personnel
Airdrop	B-50	1	4925th Special Weapons Group	Kirtland AFB	11
Photography	B-50	1	SAC	Kirtland AFB	11
Emergency	C-47	1	4925th Special Weapons Group	Kirtland AFB	14
Cloud Sampling	B-29	2	374th Recon Squadron (VLR) Weather	Nellis AFB	20
Cloud Tracking	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	11
	B-29	1	374th Recon Squadron (VLR) Weather	McClellan AFB	11
Aerial Surveying	H-13	1	4925th Special Weapons Group	AEC Control Point	2
	H-19	1	4925th Special Weapons Group	AEC Control Point	3
	C-47	1	Air Weather Service	Nellis AFB	6
	B-17	1	Cambridge Research Laboratory	Nellis AFB	9
Courier Service	B-25	3	4901st Support Wing (Atomic)	Indian Springs AFB	15
AEDS	B-29	5	Air Weather Service	Barksdale AFB, Robins AFB	60
	B-29	*	Air Weather Service	Air Force bases in Alaska, Guam, Japan, and Saudi Arabia	*

*Unknown

the B-50 began its bombing run. At exactly 0546:02 hours, the device was released. The B-50 then returned to Kirtland AFB, arriving at 0751 (3-4).

The B-50 documentary photography aircraft, with a crew of 11 from the Strategic Air Command, left Kirtland AFB at 0122, six minutes after the drop aircraft. It accompanied the drop aircraft to the NPG, maintaining an altitude of 16,000 feet. During the practice and bombing runs, the photography aircraft remained five to six kilometers behind and 2,000 feet above the drop aircraft. After completing its photography assignment, it returned to Kirtland AFB, arriving there at 0753 hours (3-4).

The C-47 emergency aircraft, with a crew of four and a disaster team of ten from the 4925th Special Weapons Squadron, left Kirtland AFB at 0120, four minutes after the drop aircraft. It followed the drop aircraft at an altitude of 12,000 feet to the vicinity of Las Vegas, where it descended to 10,000 feet and flew a holding pattern there until the drop aircraft had completed its mission at the NPG. The C-47 then returned to Kirtland AFB, arriving at 0820 hours (3-4).

8.2.2 Cloud Sampling

Cloud sampling was performed in conjunction with two Scientific Tests Section experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds. To support these experiments, two B-29 cloud samplers, each with a crew of ten from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0245 hours. Each aircraft penetrated the cloud several times. The first aircraft completed its cloud penetration about two hours after the detonation, finishing its sampling runs in approximately 50 minutes. The second aircraft made passes through the cloud for approximately one hour to obtain its samples (8; 13; 20; 25; 38).

8.2.3 Cloud Tracking

Two B-29 aircraft flew cloud-tracking missions over and beyond the Nevada Proving Ground. One B-29, with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0245 hours to track the cloud. A second B-29, also with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left from McClellan AFB approximately 12 hours later to replace the first B-29, which was running low on fuel (8; 13; 20; 25).

8.2.4 Aerial Surveys

Aerial survey aircraft included two SWC helicopters that monitored the area immediately around ground zero. In addition, a C-47 and a B-17 surveyed both onsite and offsite areas. The C-47, with a crew of six from the Air Weather Service, left Nellis AFB at 0750 hours. The B-17, with a crew of nine from the Air Force Cambridge Research Laboratory, left Nellis AFB at 0755 (8).

The SWC H-19 helicopter, with a crew of three from the 4925th Special Weapons Group, made two postshot trips to the ground zero area to monitor radiation intensities and to retrieve scientific instrumentation. On its first trip, the helicopter left the AEC Control Point at 0603 and returned at 0625 hours. The helicopter began its second trip to the ground zero area at 0635 and returned to the Control Point at 0724. At 0907, it left for Indian Springs AFB carrying scientific data for the B-25 courier aircraft. It arrived there at 0928 hours (4).

The other SWC helicopter, an H-13 with a crew of two from the 4925th Special Weapons Group, performed one aerial survey. It left the Control Point at 0630, arrived in the ground zero area at 0738, and returned to the Control Point at 0848. It also delivered scientific data to the courier aircraft at Indian

Springs AFB, leaving the Control Point at 0849 and arriving at the base at 0910 hours (4).

8.2.5 Courier Service

After the sampling missions had been completed, three B-25 aircraft left Indian Springs AFB on shot-day to deliver cloud samples, instrumentation, and other results from the scientific experiments to Kirtland AFB for subsequent transport to LASL via a commercial contract carrier. While the couriers aboard these aircraft were LASL civilians, the aircrews were from the 4901st Air Support Wing (2-4).

The first B-25 courier aircraft, with a crew of five and a LASL courier onboard, left Indian Springs AFB for the Frenchman Flat landing strip at 0623. It reached Frenchman Flat at 0639, picked up scientific samples, instrumentation, and data, and left Frenchman Flat at 0655 for Kirtland AFB, arriving at 0910 hours (3-4).

The second B-25, with a crew of five and a LASL courier, left Indian Springs AFB for the Frenchman Flat landing strip at 0635. It reached Frenchman Flat at 0651, picked up scientific samples and materials, and left Frenchman Flat at 0733 for Kirtland AFB, arriving there at 0941 hours (3-4).

The third B-25, carrying a crew of five and a LASL courier, left Indian Springs AFB for Nellis AFB at 1008 and arrived there at 1142. After receiving cloud samples from Headquarters, USAF, personnel, it left for Kirtland AFB at 1215 hours, arriving at 1410 hours (3-4).

8.3 RADIATION PROTECTION AT SHOT EASY

The information available for Shot EASY includes the results of onsite and offsite radiological monitoring and decontamination procedures.

Monitoring

The initial survey monitoring team entered the test area immediately after the detonation. Monitors detected radiation intensities of about 0.005 R/h approximately 900 meters from ground zero. They measured 0.35 R/h 180 meters from ground zero and a maximum of 0.55 R/h at ground zero. Monitors resurveyed the area twice, once about three hours and 30 minutes after the initial survey and again approximately nine hours after the first survey. They took 15 to 20 minutes to complete each survey (16). Figure 8-2 shows a reconstructed isointensity map based on the initial survey (17).

Offsite monitoring was conducted by the same survey teams that monitored the radiation intensities for previous shots. These teams did not conduct extensive offsite surveys because of poor communication links with the surveillance aircraft. However, limited surveys did not detect radiation levels above background levels in offsite areas (16).

Decontamination

Onsite personnel were monitored at the decontamination center about 30 meters from the Control Point. Decontamination personnel reported that no radiation remained on individuals after they had showered and changed into fresh clothing (16).

Vehicles were also decontaminated at the same location. Decontamination personnel found gamma intensities of 0.03 R/h at certain locations on the vehicles, primarily the running boards,

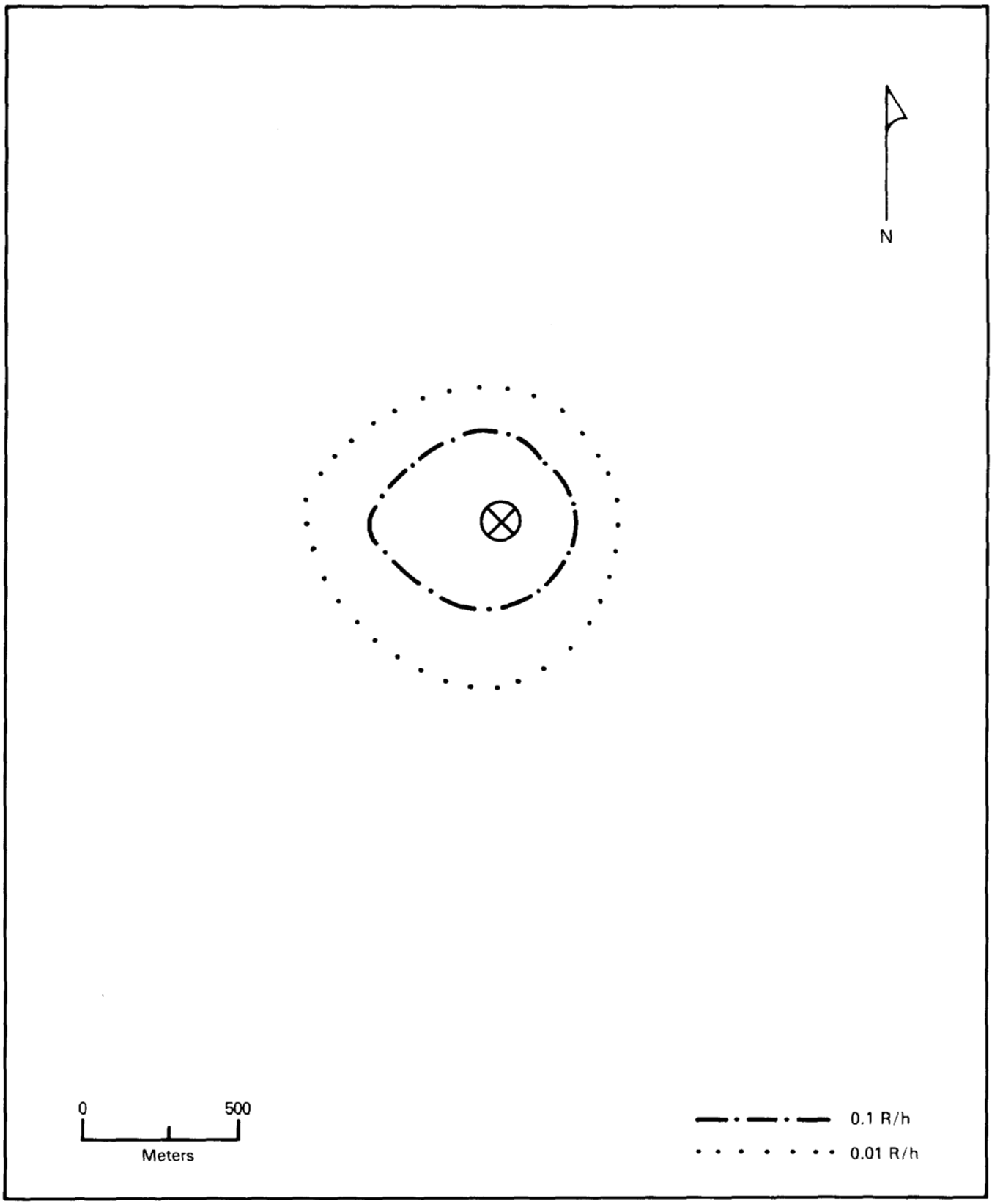

Figure 8-2: RECONSTRUCTED ISOINTENSITY MAP OF EASY, ONE HOUR AFTER DETONATION

floorboards, tires, and mudguards. In all cases, vacuuming and washing reduced the radioactivity to less than 0.007 R/h (16).

The two B-29 sampling aircraft were decontaminated at Nellis AFB. Decontamination personnel detected an average gamma intensity on each aircraft of 0.15 and 0.18 R/h. Repeated washings reduced these levels to 0.01 and 0.02 R/h, respectively. The washing effluent was allowed to run off the ramp into the desert sand. This procedure removed over 90 percent of the radiation on the aircraft (31; 38).

SHOT BAKER-2 SYNOPSIS

AEC TEST SERIES:	RANGER
DOD EXERCISE:	None
DATE/TIME:	2 February 1951, 0549 hours
YIELD:	8 kilotons
HEIGHT OF BURST:	1,100 feet above ground

Purpose of Test: To test nuclear device designs proposed for Operation GREENHOUSE.

DOD Objective: To collect data on the effects of gamma and thermal radiation from a nuclear detonation.

Weather: At shot-time, the temperature at the surface was -9.2° C, the relative humidity was 79 percent, and the atmospheric pressure was 12.8 psi. The surface winds were calm. Winds were 22 knots from the west-southwest at 10,000 feet and 45 knots from the northwest at 20,000 feet.

Radiation Data: About one hour after the detonation, onsite induced activity greater than 0.5 R/h was confined to an area 450 meters from ground zero. Lesser intensities, ranging from 0.5 R/h to 0.0004 R/h, were confined to an area 950 to 3,600 meters from ground zero.

Participants: Special Weapons Command; Headquarters, USAF; Army Corps of Engineers; Air Weather Service; Office of the Quartermaster General, Army; Office of the Surgeon General, Army; Strategic Air Command; Air Training Command; Air Research and Development Command; Air Force Cambridge Research Laboratory; Santa Fe Operations Office; Los Alamos Scientific Laboratory; Sandia Corporation; EG&G; Atomic Energy Commission.

CHAPTER 9

SHOT BAKER-2

Shot BAKER-2, the fourth nuclear test of Operation RANGER, was detonated on 2 February 1951 at 0549 hours Pacific Standard Time in Frenchman Flat at UTM coordinates 923758. BAKER-2, a developmental device designed by the Los Alamos Scientific Laboratory, was airdropped from a B-50 aircraft flying at a height of 19,700 feet above the ground. The device, which detonated 1,100 feet above the terrain, had a yield of eight kilotons (15).

At shot-time, the temperature at the surface was -9.2 degrees Celsius, and the winds at the surface were calm. Winds were 22 knots from the west-southwest at 10,000 feet and 45 knots from the northwest at 20,000 feet. The top of the Shot BAKER-2 cloud reached an altitude of 28,000 feet and moved east-southeast from the point of detonation. Fallout occurred to the southeast (15; 17).

The Scientific Tests Section fielded eight experiments at the shot. Twelve DOD participants took part in these experiments. An estimated 226 Air Force personnel engaged in air support for BAKER-2. The Radiological Safety Section included the following personnel: one civilian and four officers from the Army Corps of Engineers, two officers from the Army Medical Corps, one Army officer and one Air Force enlisted man from LASL, and one officer whose service affiliation is unknown. Another 86 Air Force participants were involved in communications security for the Security Group and in weather support for the Meteorology Section, discussed in chapter 3. Military and civilian officals took part in a program for observers, also discussed in chapter 3 (19; 28; 30).

9.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC TESTS SECTION ACTIVITIES AT SHOT BAKER-2

Department of Defense personnel took part in eight of the 16 scientific experiments conducted by the Scientific Tests Section at Shot BAKER-2. This section details DOD participation in five of these experiments: Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb, Thermal Effects Program, Thermal and Ionizing Radiation Measurements, Analysis of Fireball Growth at RANGER, and Gamma Radiation Exposure as a Function of Distance. Two of the remaining three experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds, were primarily LASL projects. The cloud-sampling aircraft discussed in section 9.2, Air Support Activities, provided support for these experiments. The final experiment, Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site, was conducted by the Air Weather Service after the series to analyze weather data collected for BAKER-2 and the other RANGER shots. Chapter 3 includes information common to all of these experiments.

Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb was conducted by the Army Chemical Center to determine the shielding afforded against gamma radiation emitted by a nuclear airburst. The afternoon before the shot, two participants from the Army Chemical Center and one from the Army Corps of Engineers placed film packets in five fortifications. In addition, they placed ion chambers at three locations. Figure 9-1 indicates the instrumented positions. These personnel retrieved the film packets, completing recovery by 0859 hours (30).

The Thermal Effects Program was conducted by the Office of the Quartermaster General (Army). The objective was to obtain data on the thermal hazard of a nuclear detonation to various materials and finishes (30).

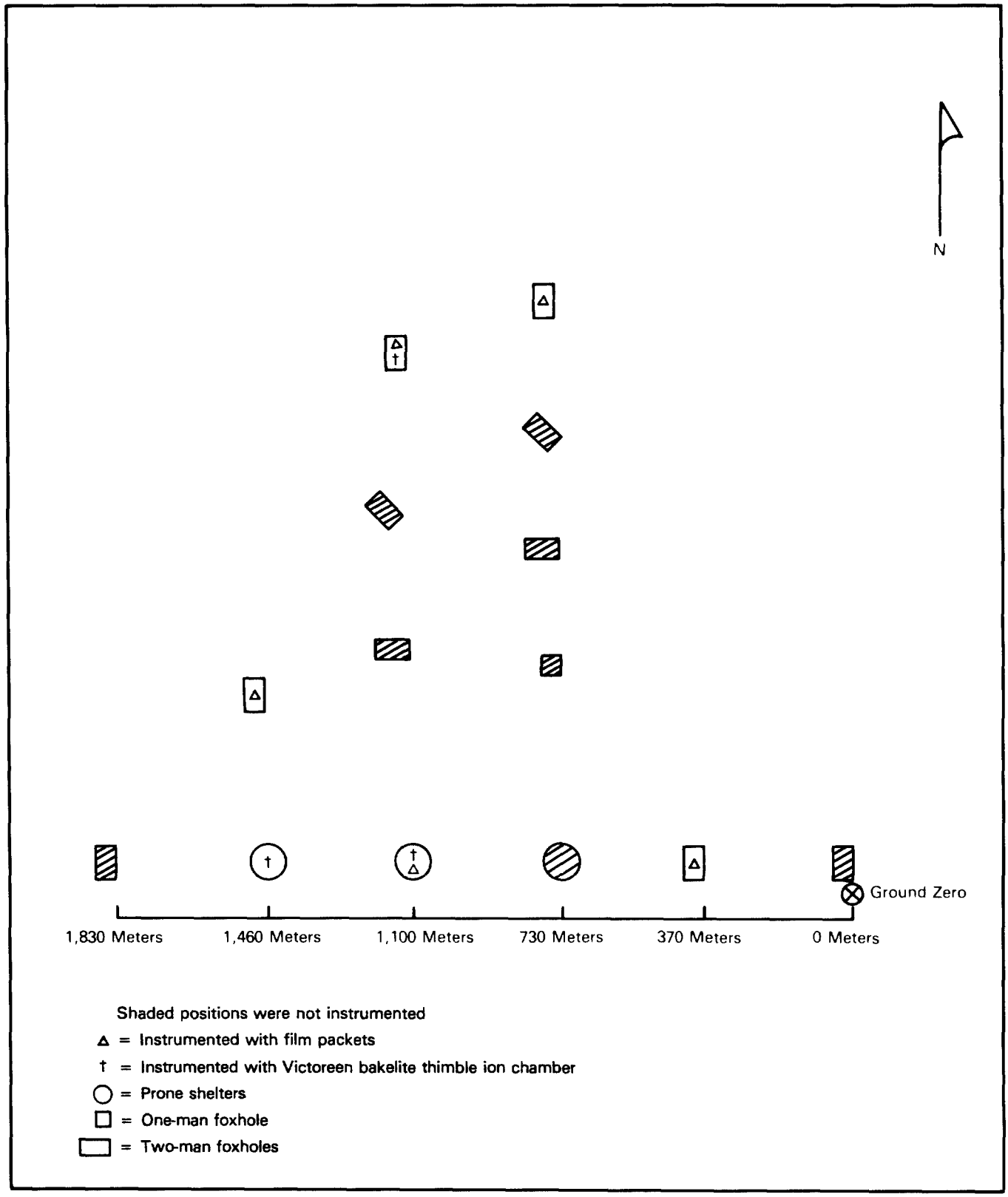

Figure 9-1: FIELD FORTIFICATIONS AT SHOT BAKER-2

Before the detonation, the experiment's one participant placed test materials belonging to the Office of the Quartermaster General, the Naval Material Laboratory, Naval Radiological Defense Laboratory, and the National Bureau of Standards in and near foxholes used in the gamma radiation experiment. The materials were at the following distances from ground zero:

Distance (meters)	Agencies
680	Quartermaster General
1,100	Quartermaster General, Naval Material Laboratory, Naval Radiological Defense Laboratory, National Bureau of Standards
1,830	Quartermaster General, Naval Material Laboratory, Naval Radiological Defense Laboratory, National Bureau of Standards

The participant retrieved the materials after the area was opened for reentry (30).

Thermal and Ionizing Radiation Measurements was conducted by a civilian under contract to the Office of the Surgeon General (Army). The objectives were to (30):

- Determine the intensity and quality of the initial gamma radiation from the nuclear detonation at distances where the combined effects of thermal and ionizing injury could have serious biological consequences
- Determine the time rate of delivery of thermal dosage from the nuclear detonation.

For the first objective, the participant placed ion chambers in one foxhole 1,460 meters northwest of ground zero and in prone shelters 1,100 meters west of ground zero. To gather data for the second objective, he placed a turntable coated with heat-

sensitive paper 1,830 meters northwest of ground zero. Sometime after the detonation, the participant retrieved the ion chambers and the turntable (30).

Analysis of Fireball Growth was conducted by LASL to analyze the fireball growth and yield determination by studying film from cameras at photography stations 3.2 kilometers southeast and northeast of ground zero. A special LASL group, consisting of three civilian employees and one Army, one Navy, and one Air Force participant, retrieved film from the photography stations after BAKER-2 and returned it to LASL for analysis (19; 28).

Gamma Radiation Exposure as a Function of Distance was conducted by the Sandia Corporation. To measure gamma radiation at different distances during and immediately following a nuclear detonation, 41 film badges were placed at 90-meter intervals from ground zero along the West Access Road and the South Access Road. One film badge was positioned at ground zero. To measure neutron-induced activity, film badges were also placed in lead cylinders with ten-centimeter-thick walls along the West Access Road 270, 550, 820, 1,100, and 1,370 meters from ground zero. To measure the fraction of initial gamma radiation reaching the film badges, the badges were placed in "mousetrap gadgets" (devices designed to shield the film badges from residual radiation) 460, 910, and 1,830 meters from ground zero along the West Access Road (30).

Personnel began recovering film badges within one to two hours after the detonation and finished within five to six hours. Military personnel assisting in the placement and recovery of the film badges included one Navy participant from Field Command, AFSWP; one Navy participant from LASL; and one participant from the Army Corps of Engineers. Three Sandia Corporation employees also took part in the experiment (28; 30; 34).

Specific details regarding personnel activities during this experiment have not been documented, but one report states that the Navy participant from Field Command, AFSWP, placed and retrieved film badges 370 and 730 meters from ground zero along the West Access Road (34).

9.2 DEPARTMENT OF DEFENSE PARTICIPATION IN AIR SUPPORT SECTION ACTIVITIES AT SHOT BAKER-2

The Special Weapons Command and Headquarters, USAF, both with air control centers at Nellis AFB, directed air support missions at Shot BAKER-2. SWC directed and conducted the airdrop, the emergency aircraft mission, the courier service, and the helicopter support of the aerial surveys conducted by the Radiological Safety Section. Personnel from Headquarters, USAF, supervised the cloud sampling, cloud tracking, and, along with SWC, the aerial surveys. They also coordinated activities associated with the Atomic Energy Detection System. The Air Weather Service provided most of the aircraft and crews for air missions supervised by Headquarters, USAF.

SWC support missions involved seven aircraft and an estimated 112 SWC personnel. Of these individuals, 45 were aircrew and emergency team personnel, while the others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff. Headquarters, USAF, support missions involved ten aircraft and an estimated 114 Air Force personnel. Of these personnel, an estimated 47 were aircrew members, while the others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff (2-4; 13; 25; 38). Table 9-1 identifies the aircraft and the estimated numbers of DOD personnel engaged in air support activities.

Table 9-1: SUMMARY OF AIR SUPPORT ACTIVITIES, SHOT BAKER-2

Mission	Type of Aircraft	Number of Aircraft	Unit of Origin	Staging Base	Estimated DOD Personnel
Airdrop	B-50	1	4925th Special Weapons Group	Kirtland AFB	11
Emergency	C-47	1	4925th Special Weapons Group	Kirtland AFB	14
Cloud Sampling	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	10
Cloud Tracking	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	11
	B-29	1	374th Recon Squadron (VLR) Weather	McClellan AFB	11
Aerial Surveying	H-13	1	4925th Special Weapons Group	AEC Control Point	2
	H-19	1	4925th Special Weapons Group	AEC Control Point	3
	C-47	1	Air Weather Service	Nellis AFB	6
	B-17	1	Cambridge Research Laboratory	Nellis AFB	9
Courier Service	B-25	3	4901st Support Wing (Atomic)	Indian Springs AFB	15
AEDS	B-29	5	Air Weather Service	Barksdale AFB, Robins AFB	60
	B-29	*	Air Weather Service	Air Force bases in Alaska, Guam, Japan, and Saudi Arabia	*

*Unknown

9.2.1 Delivery

A B-50 aircraft delivered the BAKER-2 nuclear device. A C-47 accompanied the B-50 to provide emergency assistance.

The drop aircraft, with a crew of 11 from the 4925th Special Weapons Group, left Kirtland AFB at 0122 hours on shot-day and flew at an altitude of 14,000 feet to Indian Springs AFB. Upon reaching the Indian Springs area, the aircraft descended to 10,000 feet and proceeded to the north of ground zero area. At 0340, the crew began inserting the nuclear capsule into the device, completing this task at 0408. The aircraft then climbed to its bombing height of 19,700 feet. It completed its first practice run at 0437, its second practice run at 0456, and its third at 0519. At 0524, the crew opened the bomb-bay doors, and at 0532, the B-50 began its bomb run. At exactly 0548:01 hours, the device was released. The B-50 then returned to Kirtland AFB, arriving at 0745 hours (3-4).

The B-50 documentary photography aircraft originally scheduled for the shot did not fly because of fuel leaks. The C-47 emergency aircraft, with a crew of four and a disaster team of ten from the 4925th Special Weapons Squadron, left Kirtland AFB at 0123, one minute after the drop aircraft. It followed the drop aircraft at an altitude of 12,000 feet to the vicinity of Las Vegas, where it descended to 10,000 feet and flew a holding pattern there until the drop aircraft had completed its mission. The C-47 returned to Kirtland AFB at 0831 hours (3-4).

9.2.2 Cloud Sampling

Cloud sampling was performed in conjunction with two Scientific Tests Section experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds. To support

these experiments, one B-29 cloud sampler, with a crew of ten from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0245. The aircraft penetrated the cloud several times. It completed its first cloud penetration two hours after the BAKER-2 detonation and finished its sampling runs in approximately 50 minutes (9; 13; 20; 25; 38).

9.2.3 Cloud Tracking

Two B-29 aircraft flew cloud-tracking missions over and beyond the Nevada Proving Ground. One B-29, with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0350 hours to track the cloud and returned to base within 12 hours. A second B-29, also with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, replaced the first B-29, which was starting to run low on fuel. The second B-29 left from and returned to McClellan AFB (9; 13; 20; 25).

9.2.4 Aerial Surveys

Aerial surveys included two missions flown by SWC helicopters that monitored the area immediately around ground zero. In addition, a C-47 and a B-17 surveyed both onsite and offsite areas. The C-47, with a crew of six from the Air Weather Service, left Nellis AFB at 0750 hours. The B-17, with a crew of nine from the Air Force Cambridge Research Laboratory, left Nellis AFB at 0755 (9).

The SWC H-19 helicopter, with a crew of three from the 4925th Special Weapons Group, made two postshot trips to the ground zero area to monitor the area and to retrieve scientific data. On its first trip, the helicopter left the AEC Control Point at 0610 and returned at 0652. The helicopter began its second trip to the ground zero area at 0801 and returned to the

Control Point at 0824. At 0928, it left the Control Point for Indian Springs AFB carrying scientific data for the B-25 courier aircraft; it arrived at 0940 hours (4; 24).

The other SWC helicopter, an H-13, with a crew of two from the 4925th Special Weapons Group, left the AEC Control Point at 0716 hours for the generator shack 3.2 kilometers due south of ground zero on the South Access Road. The helicopter returned to the Control Point at 0739. At 0840 hours, the H-13 flew back to the generator shack and then returned to the Control Point at 0901. The purpose of both trips was to monitor the retrieval of scientific data (4).

9.2.5 Courier Service

After the sampling missions had been completed, three B-25 aircraft left Indian Springs AFB on shot-day to deliver cloud samples, instrumentation, and other results of the scientific experiments to Kirtland AFB for subsequent transport to LASL via a commercial contract carrier. The couriers aboard these aircraft were LASL civilians, while the aircrews were from the 4901st Air Support Wing (2-4).

The first B-25, with a crew of five and a LASL courier onboard, left Indian Springs AFB for the Frenchman Flat landing strip at 0619 hours. It reached Frenchman Flat at 0630, picked up scientific samples, instrumentation, and data, and left Frenchman Flat at 0646 for Kirtland AFB, arriving at 0856 hours (3-4).

The second B-25, carrying a crew of five and a LASL courier, left Indian Springs AFB for the Frenchman Flat landing strip at 0630 hours. It reached Frenchman Flat at 0645, picked up scientific samples and materials, and left for Kirtland AFB at 1100, arriving at 1258 (3-4).

The third B-25, with a crew of five and a LASL courier, left Indian Springs AFB for Nellis AFB at 0955 hours and arrived there at 1015. After receiving cloud samples from Headquarters, USAF, personnel, it left for Kirtland AFB at 1100, arriving at 1258 hours (3-4).

9.3 RADIATION PROTECTION AT SHOT BAKER-2

The information available for Shot BAKER-2 includes the results of onsite and offsite monitoring and decontamination procedures.

Monitoring

The initial survey monitoring team entered the test area about 45 minutes after the detonation. Monitors first encountered a gamma radiation intensity of 0.0004 R/h about 3,600 meters west of ground zero. At 900 meters from ground zero, the radiation level increased to 0.011 R/h. Monitors detected radiation intensities of 0.5 R/h 450 meters from ground zero. They found a maximum intensity of 16.0 R/h at ground zero about 75 minutes after the detonation (16). Figure 9-2 shows a reconstructed isointensity map based on this initial survey (17).

A second monitoring team surveyed the same area eight hours after completion of the initial survey. The maximum gamma radiation intensity encountered at that time was 7.0 R/h at ground zero. Monitors found intensities of 0.12 R/h and 0.008 R/h at distances of 450 and 900 meters west of ground zero, respectively (16).

Several other surveys of the test area were made the day after the detonation. The maximum radiation intensity encountered during these surveys was 3.7 R/h at ground zero, 33 hours after the detonation. Surveys conducted 50 hours after the detonation measured the highest gamma intensity, 0.42 R/h, at

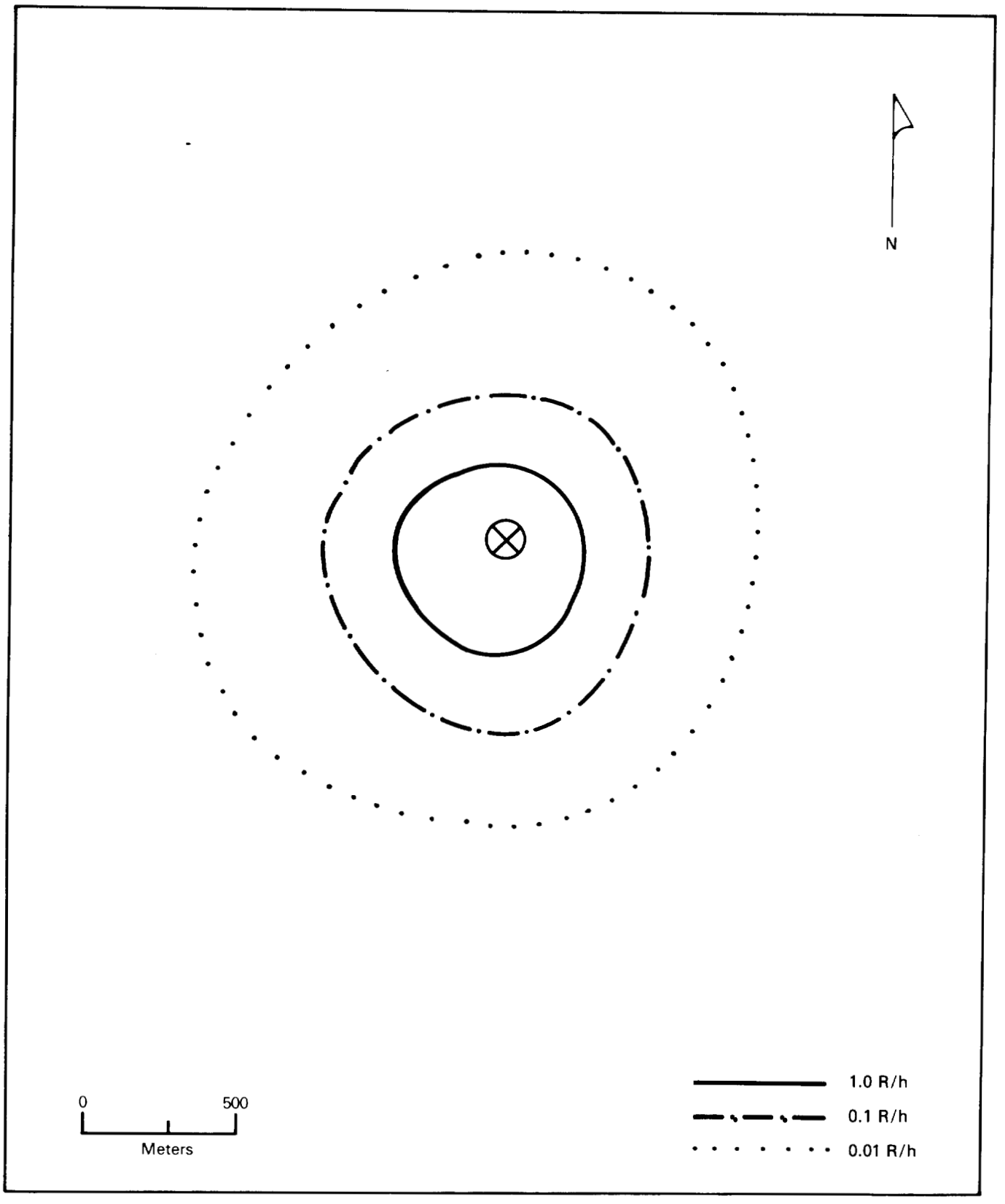

Figure 9-2: RECONSTRUCTED ISOINTENSITY MAP OF BAKER-2, ONE HOUR AFTER DETONATION

ground zero. About 60 hours after the detonation, the radiation intensity at ground zero had decreased to 0.3 R/h (16).

Offsite monitoring was conducted by the same survey teams that monitored the previous RANGER shots. These teams found a maximum gamma radiation intensity of 0.008 R/h at the 9,000-foot level in the Spring Mountains southeast of ground zero. The BAKER-2 cloud had drifted toward these mountains. Monitoring teams in all other areas reported gamma radiation intensities of no greater than 0.0002 R/h (16).

Two aircraft, a C-47 from the Air Weather Service and a B-17 from the Air Force Cambridge Research Laboratory, conducted off-site aerial surveys up to about 320 kilometers from ground zero. These aircraft encountered no gamma radiation levels above the background level (34).

Decontamination

Onsite personnel were monitored at the decontamination center about 30 meters from the Control Point. Decontamination personnel reported that no radioactive contamination remained on individuals after they had showered and changed into fresh clothing.

Vehicles were also decontaminated at the center near the Control Point. Decontamination personnel found that the areas most contaminated were the running boards, floorboards, tires, and mudguards. The highest intensity encountered at any of these places was 0.03 R/h. In all cases, vacuuming and washing reduced the radioactivity to less than 0.007 R/h (16).

The B-29 sampling aircraft was decontaminated at Nellis AFB. The average gamma intensity registered on this aircraft was 0.15 R/h. This was reduced to an acceptable level of 0.01 R/h after

two washings, and the aircraft was released for further service. The washing effluent was allowed to run off the ramp into the desert sand. The decontamination procedure removed about 93 percent of the radiation on the aircraft (31; 38).

SHOT FOX SYNOPSIS

AEC TEST SERIES:	RANGER
DOD EXERCISE:	None
DATE/TIME:	6 February 1951, 0547 hours
YIELD:	22 kilotons
HEIGHT OF BURST:	1,435 feet above ground

Purpose of Test: To test nuclear device designs proposed for Operation GREENHOUSE.

DOD Objective: To collect data on the effects of gamma and thermal radiation from a nuclear detonation.

Weather: At shot time, the temperature at the surface was -2.0° C, the relative humidity was 85 percent, and the atmospheric pressure was 13.2 psi. Surface winds were light and variable one hour and 45 minutes before the shot, the only time for which wind data are available. Winds were 27 knots from the northwest at 10,000 feet and 45 knots from the west-northwest at 30,000 feet.

Radiation Data: One hour after the detonation, onsite induced activity greater than 0.16 R/h was confined to an area 900 meters from ground zero. The maximum radiation intensity, 15.5 R/h, was detected at ground zero. Lower activity, ranging from 0.16 R/h to 0.0003 R/h, was found in an area 900 to 2,300 meters from ground zero.

Participants: Special Weapons Command; Headquarters, USAF; Army Corps of Engineers; Air Weather Service; Office of the Quartermaster General, Army; Office of the Surgeon General, Army; Strategic Air Command; Air Training Command; Air Research and Development Command; Air Force Cambridge Research Laboratory; Santa Fe Operations Office; Los Alamos Scientific Laboratory; Sandia Corporation; EG&G; Atomic Energy Commission.

CHAPTER 10

SHOT FOX

Shot FOX, the fifth and final nuclear test of Operation RANGER, was detonated on 6 February 1951 at 0547 hours Pacific Standard Time in Frenchman Flat at UTM coordinates 923758. A developmental device designed by the Los Alamos Scientific Laboratory, FOX was airdropped from a B-50 aircraft flying 29,700 feet above the ground. The device was detonated 1,435 feet above the terrain. FOX had a yield of 22 kilotons, which made it the largest RANGER shot (15; 17). FOX was the only RANGER device not detonated on its scheduled date, 5 February 1951. The postponement was caused by an oil leak in the drop aircraft (27).

At shot-time, the temperature was -2.0 degrees Celsius at the surface. One hour and 45 minutes before the detonation, the only time for which wind data are available, surface winds were light and variable. Winds were 27 knots from the northwest at 10,000 feet, 48 knots from the west-northwest at 20,000 feet, and 45 knots from the west-northwest at 30,000 feet. The top of the Shot FOX cloud reached an altitude of 43,000 feet and moved southeast from the point of detonation. Light fallout occurred to the southeast (17).

The Scientific Tests Section fielded eight experiments at Shot FOX. Twelve DOD participants took part in these experiments. An estimated 246 Air Force personnel engaged in air support for FOX. The Radiological Safety Section included the following personnel: one civilian and four officers from the Army Corps of Engineers, two officers from the Army Medical Corps, one Army officer and one enlisted man from LASL, and one officer whose service affiliation is unknown. Another 86 Air Force participants were involved in communications security for

the Security Group, discussed in chapter 3. Military and civilian officials took part in a program for observers, also discussed in chapter 3 (19; 28; 30).

10.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC TESTS SECTION ACTIVITIES AT SHOT FOX

Department of Defense personnel took part in eight of the 16 scientific experiments conducted by the Scientific Tests Section at Shot FOX. This section details DOD participation in five of these experiments: Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb, Thermal Effects Program, Thermal and Ionizing Radiation Measurements, Analysis of Fireball Growth at RANGER, and Gamma Radiation Exposure as a Function of Distance. Two of the remaining three experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds, were primarily LASL projects. The cloud-sampling aircraft, discussed in section 10.2, Air Support Activities, provided support for the experiments. The final experiment, Atmospheric Conditions and Their Effects on Atomic Clouds at the Nevada Test Site, was conducted by the Air Weather Service after the series to analyze weather data collected during Operation RANGER. Chapter 3 includes a discussion of this experiment, as well as information common to the other experiments.

Protection Afforded by Field Fortifications against Gamma Radiation from an Air-burst Atomic Bomb was conducted by the Army Chemical Center to determine the shielding afforded by foxholes against gamma radiation emitted by a nuclear airburst. Two days before the shot, two participants from the Army Chemical Center and one from the Army Corps of Engineers placed film packets in five of 14 fortifications. An ion chamber was placed in one foxhole and one prone shelter. Figure 10-1 indicates the instrumented foxholes. Personnel retrieved the film packets, completing recovery by 0922 hours (30).

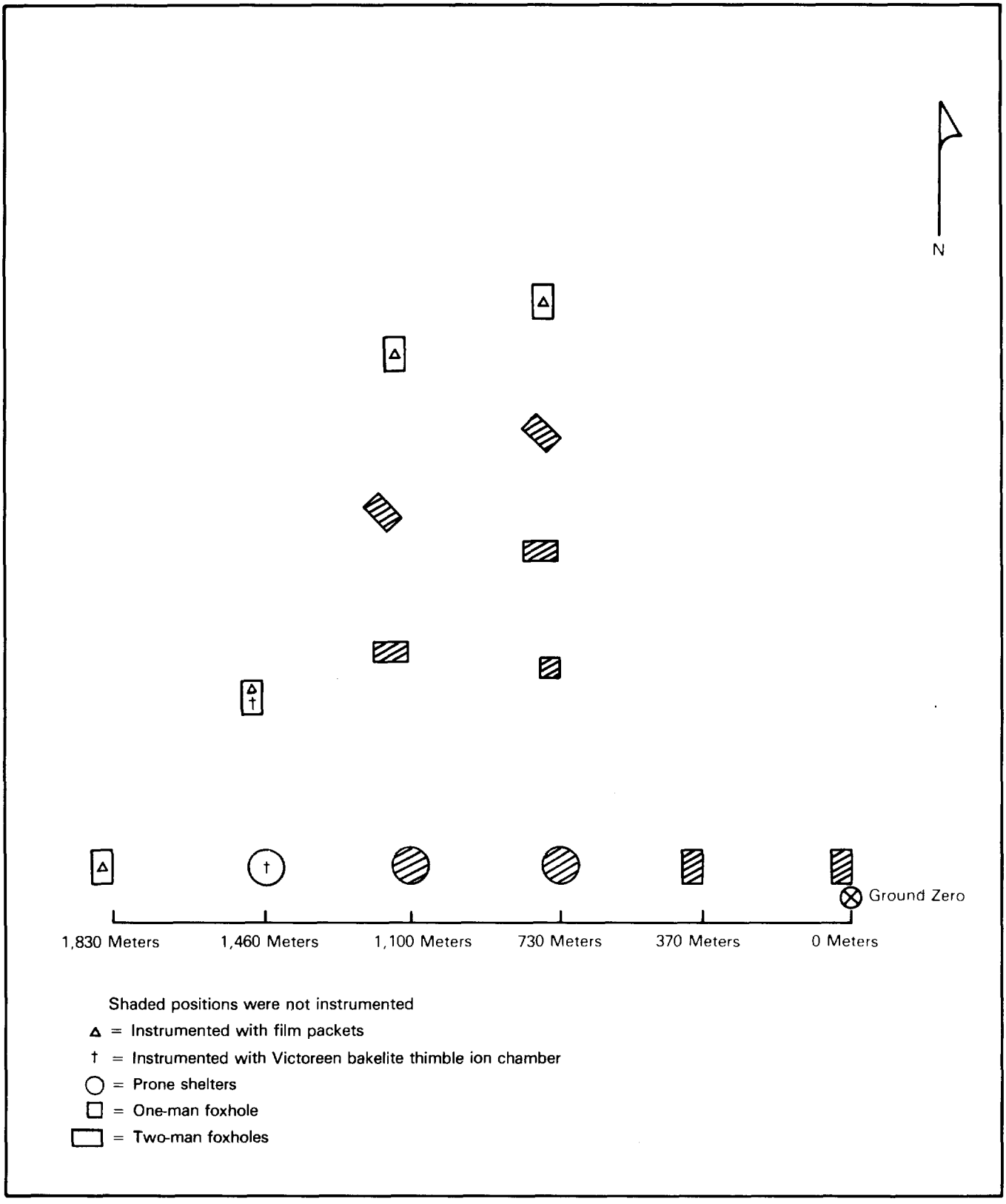

Figure 10-1: FIELD FORTIFICATIONS AT SHOT FOX

The Thermal Effects Program was conducted by one participant from the Office of the Quartermaster General (Army). The objective was to obtain data on the thermal hazard of a nuclear detonation to various materials and finishes. Before the detonation, the participant placed test panels from the Office of the Quartermaster General, Naval Material Laboratory, and National Bureau of Standards at the following distances from ground zero:

Distance (meters)	Agencies
2,100	National Bureau of Standards
2,290	National Bureau of Standards
2,740	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
3,200	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
3,660	Quartermaster General, Naval Material Laboratory, National Bureau of Standards
4,120	Quartermaster General, Naval Material Laboratory
4,570	Quartermaster General

He also placed panels in the foxholes. In addition, he placed one film badge and three washer-shaped devices mounted with heat-sensitive material at three locations 1,100, 1,460, and 1,800 meters from ground zero. He recovered the test materials after the initial radiation survey was completed (30).

Thermal and Ionizing Radiation Measurements was conducted by a civilian under contract to the Office of the Surgeon General (Army). The objectives were to (30):

- Determine the intensity and quality of the initial gamma radiation from the nuclear detonation at distances where the combined

effects of thermal and ionizing energy could have serious biological consequences

- Determine the time rate of delivery of thermal radiation from the nuclear detonation.

For the first objective, the participant placed one ion chamber in each of the two fortifications located 1,460 meters west of ground zero. He also placed five other ion chambers at ground level 2,100 meters west of ground zero. To collect data for the second objective, the participant placed a turntable coated with heat-sensitive paper 2,740 meters northwest of ground zero. He retrieved the ion chambers and the turntable after the completion of the initial radiation survey (30).

Analysis of Fireball Growth was conducted by LASL. The objective was to analyze the fireball growth and yield determination by studying film from cameras at photography stations 3.2 kilometers southeast and northeast of ground zero. A special LASL group, consisting of three civilian employees and one Army, one Navy, and one Air force participant, retrieved film from the photography stations after FOX and returned it to LASL for analysis (19; 28).

Gamma Radiation Exposure as a Function of Distance was conducted by the Sandia Corporation. To measure gamma radiation at different distances during and immediately following a nuclear detonation, 41 film badges were placed at 90-meter intervals from ground zero along the West Access Road and the South Access Road. One film badge was positioned at ground zero. To measure neutron-induced activity, film badges were also placed in lead cylinders with ten-centimeter-thick walls along the West Access Road 270, 550, 820, 1,100, and 1,370 meters from ground zero. To measure the fraction of initial gamma radiation reaching the film badges, the badges were placed in "mousetrap gadgets" (devices designed to shield the film badges from residual radiation) 460, 910, and 1,830 meters from ground zero along the West Access Road (30).

Personnel began recovering film badges one to two hours after the detonation. Except for six film badges located within 180 meters of ground zero that could not be recovered, all badges were recovered within five to six hours. Military personnel assisting in the placement and recovery of the film badges included one Navy participant from Field Command, AFSWP; one Navy participant from LASL; and one participant from the Army Corps of Engineers. Three Sandia Corporation employees also took part in the experiment (28; 30; 34).

Specific details regarding personnel activities during this experiment at Shot FOX have not been documented, but one report states that the Navy participant from Field Command, AFSWP, placed and retrieved film badges 370 and 730 meters from ground zero along the West Access Road (34).

10.2 DEPARTMENT OF DEFENSE PARTICIPATION IN AIR SUPPORT SECTION ACTIVITIES AT SHOT FOX

The Special Weapons Command and Headquarters, USAF, both with air control centers at Nellis AFB, directed air support missions at Shot FOX. SWC directed and conducted the airdrop, the emergency aircraft mission, the courier service, and the helicopter support of the aerial surveys conducted by the Radiological Safety Section. SAC conducted the SWC photography mission. Headquarters, USAF, personnel supervised the cloud sampling, cloud tracking, and, along with SWC, the aerial surveys. They also coordinated activities associated with the Atomic Energy Detection System. The Air Weather Service provided most of the aircraft and crews for air missions supervised by Headquarters, USAF.

SWC support missions involved eight aircraft and an estimated 122 SWC personnel, 56 of whom were aircrew and emergency

team personnel. The others were ground crew personnel, radiological safety monitors, air operations control personnel, and administrative staff. Headquarters, USAF, support missions involved 11 aircraft and an estimated 124 Air Force personnel. Of these personnel, an estimated 57 were aircraft crew members, while the others were ground crew members, radiological safety monitors, air operations control personnel, and administrative staff (2-4; 13; 25; 38). Table 10-1 identifies the aircraft and the estimated numbers of DOD personnel engaged in air support activities.

10.2.1 Delivery

A B-50 aircraft delivered the FOX nuclear device. Two other aircraft, a B-50 and a C-47, accompanied the B-50 for the purpose of documentary photography and emergency aid, respectively.

The B-50 drop aircraft, with a crew of 11 from the 4925th Special Weapons Group, left Kirtland AFB at 0045 hours on shot-day and flew at an altitude of 14,000 feet to Indian Springs AFB. Upon reaching the Indian Springs area, the aircraft descended to 10,000 feet and proceeded to the north of ground zero. At 0319, the crew began inserting the nuclear capsule into the device, completing this task at 0349. The aircraft then climbed to its bombing height of 29,700 feet for two practice runs. At 0437, the B-50 bomb-bay doors were opened, and at 0529 hours, the B-50 began its bombing run. At exactly 0546:17 hours, the device was released, approximately one minute later than scheduled. The B-50 then returned to Kirtland AFB, arriving at 0750 (3-4).

The B-50 documentary photography aircraft, with a crew of 11 from the Strategic Air Command, left Kirtland AFB at 0039, six minutes before the drop aircraft. It accompanied the drop aircraft to the NPG, maintaining an altitude of 16,000 feet.

Table 10-1: SUMMARY OF AIR SUPPORT ACTIVITIES, SHOT FOX

Mission	Type of Aircraft	Number of Aircraft	Unit of Origin	Staging Base	Estimated DOD Personnel
Airdrop	B-50	1	4925th Special Weapons Group	Kirtland AFB	11
Photography	B-50	1	SAC	Kirtland AFB	11
Emergency	C-47	1	4925th Special Weapons Group	Kirtland AFB	14
Cloud Sampling	B-29	2	374th Recon Squadron (VLR) Weather	Nellis AFB	20
Cloud Tracking	B-29	1	374th Recon Squadron (VLR) Weather	Nellis AFB	11
	B-29	1	374th Recon Squadron (VLR) Weather	McClellan AFB	11
Aerial Surveying	H-13	1	4925th Special Weapons Group	AEC Control Point	2
	H-19	1	4925th Special Weapons Group	AEC Control Point	3
	C-47	1	Air Weather Service	Nellis AFB	6
	B-17	1	Cambridge Research Laboratory	Nellis AFB	9
Courier Service	B-25	3	4901st Support Wing (Atomic)	Indian Springs AFB	15
AEDS	B-29	5	Air Weather Service	Barksdale AFB, Robins AFB	60
	B-29	*	Air Weather Service	Air Force bases in Alaska, Guam, Japan, and Saudi Arabia	*

*Unknown

During the practice and bombing runs, the photography aircraft remained five to six kilometers behind and 2,000 feet above the drop aircraft. After completing its photography assignment, it returned to Kirtland AFB, arriving there at 0745 hours (3-4).

The C-47 emergency aircraft, with a crew of four and a disaster team of ten from the 4925th Special Weapons Squadron, left Kirtland AFB at 0046, one minute after the drop aircraft. Its mission was to assist the drop aircraft in case of emergency. It followed the drop aircraft at an altitude of 12,000 feet to the vicinity of Las Vegas, where it descended to 10,000 feet and flew a holding pattern there until the drop aircraft had completed its mission at the NPG. The C-47 then returned to Kirtland AFB, arriving at 0826 hours (3-4).

10.2.2 Cloud Sampling

Cloud sampling was performed in conjunction with two Scientific Tests Section experiments, Radiochemical Results and Fractionation of Cloud Particles by Shearing Winds. To support these experiments, two B-29 cloud samplers, each with a crew of ten from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0245 and 0250 hours, respectively. Each aircraft penetrated the cloud several times. The first aircraft completed its initial cloud penetration two hours after the detonation and finished its sampling runs in approximately 50 minutes. The second aircraft made sampling passes through the cloud for about one hour (10; 13; 20; 25; 38).

10.2.3 Cloud Tracking

Two B-29 aircraft flew cloud-tracking missions over and beyond the Nevada Proving Ground. One B-29, with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left Nellis AFB at 0245 to track the cloud. Approximately 12

hours later, a second B-29, also with a crew of 11 from the 374th Reconnaissance Squadron (Very Long Range) Weather, left McClellan AFB to replace the first B-29, which was starting to run low on fuel (10; 13; 20; 25).

10.2.4 Aerial Surveys

Survey aircraft included two SWC helicopters, an H-19 that monitored the area immediately around ground zero and an H-13 that delivered scientific data to courier aircraft. In addition, a C-47 and a B-17 surveyed both onsite and offsite areas. The C-47, with a crew of six from the Air Weather Service, left Nellis AFB at 0750 hours. The B-17, with a crew of nine from the Air Force Cambridge Research Laboratory, left Nellis AFB at 0755 hours (10).

The SWC H-19 helicopter, with a crew of three from the 4925th Special Weapons Group, made two postshot trips to the ground zero area to monitor the area and to retrieve scientific data. On its first trip to the ground zero area, the helicopter left the Control Point at 0625 and returned at 0725 hours. It began its second trip at 0925 and returned to the Control Point at 0938. At 1031 hours, this helicopter left for Indian Springs AFB carrying scientific data for the B-25 courier aircraft. It arrived there at 1049 hours. The SWC H-13 helicopter delivered scientific data to the courier aircraft at Indian Springs AFB, leaving the Control Point at 0829 hours and arriving at the base at 0845. The H-13 had a crew of two from the 4925th Special Weapons Group (4).

10.2.5 Courier Service

After the sampling missions had been completed, three B-25 aircraft left Indian Springs AFB on shot-day to deliver cloud samples, instrumentation, and other results from the scientific

experiments to Kirtland AFB for subsequent transport to LASL via commercial contract carrier. The couriers aboard these aircraft were LASL civilians, while the aircrews were from the 4901st Air Support Wing (2-4).

The first B-25, with a crew of five and a LASL courier, left Indian Springs AFB for the Frenchman Flat landing strip at 0623 hours. It reached Frenchman Flat at 0647, picked up scientific samples, instrumentation, and data, and left Frenchman Flat at 0729 for Kirtland AFB, arriving at 0940 hours (3-4).

The second B-25, with a crew of five and a LASL courier onboard, remained at Indian Springs AFB. At 0850, it received scientific data from the H-13 helicopter. Five minutes later, at 0855, the B-25 left Indian Springs for Kirtland AFB, arriving at 1044 hours (3-4).

The third B-25, carrying a crew of five and a LASL courier, left Indian Springs AFB for Nellis AFB at 1058 hours and arrived there at 1117. After receiving cloud samples from Headquarters, USAF, personnel, it left at 1201 and arrived at Kirtland AFB at 1359 hours (3-4).

10.3 RADIATION PROTECTION AT SHOT FOX

The information available for Shot FOX includes the results of onsite and offsite radiological monitoring and decontamination procedures.

Monitoring

The initial survey monitoring team entered the test area about 30 minutes after the detonation. Their survey took about 30 minutes to complete. Monitors detected a gamma radiation intensity of 0.0003 R/h about 2,100 meters from ground zero. At 900 meters from ground zero, they measured an intensity of 0.16

R/h. The monitors encountered radiation intensities of 1.1 R/h at 370 meters and 8.0 R/h at 200 meters from ground zero. A maximum intensity of 15.5 R/h was registered near ground zero (16). Figure 10-2 shows a reconstructed isointensity map based on this initial survey (17).

A second monitoring team surveyed the same area seven hours after the initial survey was completed. The maximum gamma intensity they encountered was 5.2 R/h, registered near ground zero. They detected intensities of 2.60 R/h and 0.05 R/h at distances of 300 and 760 meters, respectively, from ground zero (16).

Several other surveys of the shot area were made the day after the detonation. The maximum radiation intensity measured during these surveys was 3.2 R/h, registered near ground zero, 27 hours after the detonation. Surveys conducted about 50 hours after the detonation found a maximum radiation level of 0.32 R/h near ground zero (16).

Offsite monitoring was conducted by the same survey teams stationed offsite to monitor the previous RANGER shots. These teams found the maximum gamma radiation intensity in the area of Charleston Mountain, about 60 kilometers southeast of ground zero. During the morning, the maximum gamma intensity was 0.014 R/h. Two hours later, this reading had decreased to 0.0007 R/h. Monitoring teams in all other offsite areas reported gamma radiation intensities no greater than 0.0002 R/h (16; 34).

Two aircraft, a C-47 and a B-17, conducted offsite aerial surveys out to about 320 kilometers from ground zero. These aircraft detected no gamma radiation levels above background level (16).

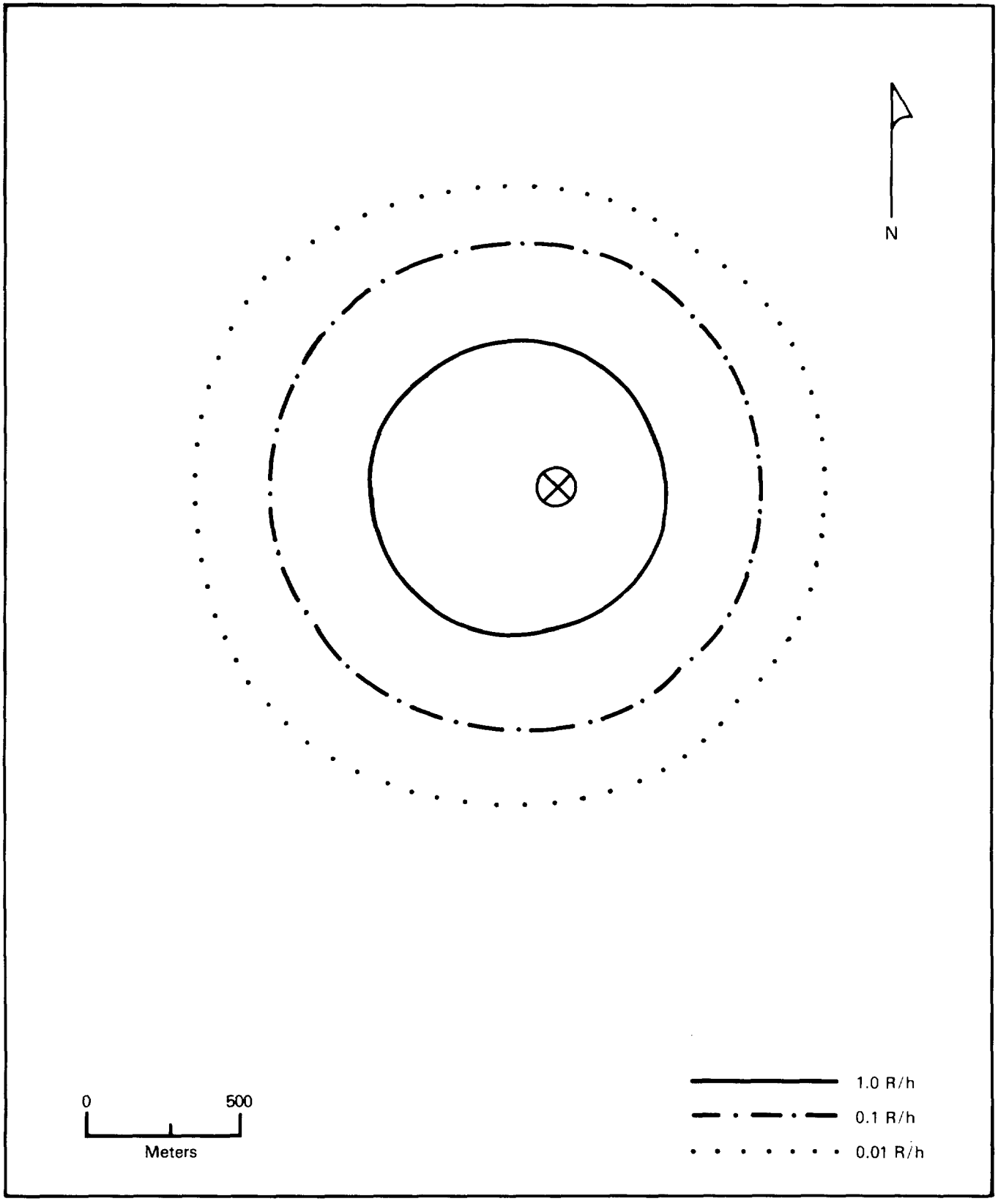

Figure 10-2: RECONSTRUCTED ISOINTENSITY MAP OF FOX, ONE HOUR AFTER DETONATION

Decontamination

Onsite personnel were monitored at the decontamination center about 30 meters from the Control Point. Decontamination personnel reported that no radioactive contamination remained on individuals after they had showered and changed into fresh clothing (34).

Vehicles were also decontaminated at the center near the Control Point. Decontamination personnel found that the areas most contaminated were the running boards, floorboards, tires, and mudguards. The highest intensity encountered at any of these places was 0.03 R/h. In all cases, vacuuming and washing reduced the radioactivity to less than 0.007 R/h (34).

The two B-29 sampling aircraft were decontaminated at Nellis AFB. The average gamma intensity registered on each aircraft, upon landing, was 0.17 R/h and 0.05 R/h. Two washings reduced these levels to 0.01 R/h and 0.007 R/h, respectively. The washing effluent was allowed to run off the ramp into the desert sand. The decontamination procedure removed about 90 percent of the radiation on the aircraft (31; 38).

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Auburn University Library at Mongomery (Reg)
ATTN: Librn

C. W. Post Ctr Long Island University
ATTN: Librn

Bangor Public Library
ATTN: Librn

Bates College Library
ATTN: Librn

Baylor University Library
ATTN: Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

State University College
ATTN: Gov Docs

Akron University
ATTN: Gov Docs

Boston Public Library (Reg)
ATTN: Docs Dept

Bowdoin College
ATTN: Librn

Bowling Green State University
ATTN: Lib Gov Docs Services

Bradley University
ATTN: Librn

Brandeis University Library
ATTN: Docs Section

Brigham Young University
ATTN: Librn

Brigham Young University
ATTN: Docs Collection

Brookhaven National Laboratory
ATTN: Tech Library

OTHER (Continued)

Broward County Library Sys
ATTN: Librn

Brown University
ATTN: Librn

Bucknell University
ATTN: Reference Dept

Buffalo & Erie Co Public Library
ATTN: Librn

State University Library of California at Fresno
ATTN: Library

University Library of California at Los Angeles
ATTN: Pub Affairs Serv U.S. Docs

University of California at San Diego
ATTN: Docs Dept

State College Library of California at Stanislaus
ATTN: Library

California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Librn

California State University at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Librn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Librn

California University Library
ATTN: Gov Docs Dept

California University Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN: Librn

Kearney State College
ATTN: Gov Docs Dept

Cambria County Library Sys
ATTN: Librn

Carleton College Library
ATTN: Librn

OTHER (Continued)

Carnegie Library of Pittsburgh
ATTN: Librn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Librn

Casper College
ATTN: Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Missouri State Univ
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN: Librn

Charleston County Library
ATTN: Librn

Charlotte & Mechlenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Librn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

Chicago University Library
ATTN: Dir of Libraries
ATTN: Docs Processing

Cincinnati University Library
ATTN: Librn

Claremont Colleges Libraries
ATTN: Doc Collection

Clemson University
ATTN: Dir of Libraries

OTHER (Continued)

Cleveland Public Library
ATTN: Docs Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: Docs Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: Docs Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

University of North Carolina at Asheville
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

OTHER (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College So Cpus
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: Docs Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN: Librn

Burlington Library
ATTN: Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: Docs Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN: Librn

East Islip Public Library
ATTN: Librn

OTHER (Continued)

East Orange Public Library
ATTN: U.S. Gov't Depository

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN: Librn

Eastern Kentucky University
ATTN: Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Docs Dept

Fond Du Lac Public Library
ATTN: Librn

Ft Hays State University
Ft Hays Kansas State College
ATTN: Librn

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Geauga Cty Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Grinnell College Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

University of Hawaii at Monoa
ATTN: Dir of Libraries (Reg)

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

University of Idaho
ATTN: Dir of Libraries (Reg)
ATTN: Docs Sec

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

Illinois University at Urbana-Champaign
ATTN: P. Watson Docs Lib

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

Jersey City State College
ATTN: F. A. Irwin Library Periodicals
Doc Sec

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

University of Texas
ATTN: Lyndon B. Johnson School of Public
Affairs Library

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

University of Kentucky
ATTN: Gov Pub Dept
ATTN: Dir of Lib (Reg)

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Lewis University Library
ATTN: Librn

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

Los Angeles Public Library
ATTN: Serials Div U.S. Docs

Louisiana State University
ATTN: Gov Doc Dept
ATTN: Dir of Libraries (Reg)

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Manchester City Library
ATTN: Librn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
ATTN: Librn

Memphis & Shelby County Public Library &
Information Center
ATTN: Librn

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

Miami Dade Community College
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
ATTN: Librn

Murray State University Library
ATTN: Lib

OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN: Librn

Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

University of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

University of New Mexico
ATTN: Dir of Libraries (Reg)

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Control Cultural Ed Ctr

State University of New York at Stony Brook
ATTN: Main Lib Docs Sec

State University of New York Col Memorial Lib
at Cortland
ATTN: Librn

State University of New York
ATTN: Lib Docs Sec

North Texas State University Library
ATTN: Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN: Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State
University
ATTN: Librn

University of North Carolina at Charlotte
ATTN: Atkins Lib Doc Dept

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
ATTN: Docs Librn

University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

OTHER (Continued)

Northeast Missouri State University
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
ATTN: Librn

Northwestern Michigan College
ATTN: Librn

Northwestern State University
ATTN: Librn

Northwestern State University Library
ATTN: Librn

Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN: Librn

Oakland Public Library
ATTN: Librn

Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN: Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN: Docs Dept

Oklahoma City University Library
ATTN: Librn

Oklahoma City University Library
ATTN: Librn

OTHER (Continued)

Oklahoma Department of Libraries
ATTN: U.S. Gov Docs

University of Oklahoma
ATTN: Docs Div

Old Dominion University
ATTN: Doc Dept Univ Lib

Olivet College Library
ATTN: Librn

Omaha Public Library Clark Branch
ATTN: Librn

Onondaga County Public Library
ATTN: Gov Docs Sec

Oregon State Library
ATTN: Librn

University of Oregon
ATTN: Docs Sec

Ouachita Baptist University
ATTN: Librn

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN: Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN: Librn

Portland Public Library
ATTN: Librn

Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN: Librn

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN: Librn

Auburn University
ATTN: Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College Library
ATTN: Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
ATTN: Gov Pubs Ofc

University of Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
ATTN: Librn

OTHER (Continued)

Richland County Public Library
ATTN: Librn

Riverside Public Library
ATTN: Librn

University of Rochester Library
ATTN: Docs Sec

University of Rutgers Camden Library
ATTN: Librn

State University of Rutgers
ATTN: Librn

Rutgers University
ATTN: Dir of Libraries (Reg)

Rutgers University Law Library
ATTN: Fed Docs Dept

Salem College Library
ATTN: Librn

Samford University
ATTN: Librn

San Antonio Public Library
ATTN: Bus Science & Tech Dept

San Diego County Library
ATTN: C. Jones, Acquisitions

San Diego Public Library
ATTN: Librn

San Diego State University Library
ATTN: Gov Pubs Dept

San Francisco Public Library
ATTN: Gov Docs Dept

San Francisco State College
ATTN: Gov Pubs Coll

San Jose State College Library
ATTN: Docs Dept

San Luis Obispo City-County Library
ATTN: Librn

Savannah Public & Effingham Liberty Regional Library
ATTN: Librn

Scottsbluff Public Library
ATTN: Librn

Scranton Public Library
ATTN: Librn

Seattle Public Library
ATTN: Ref Docs Asst

OTHER (Continued)

Selby Public Library
ATTN: Librn

Shawnee Library System
ATTN: Librn

Shreve Memorial Library
ATTN: Librn

Silas Bronson Public Library
ATTN: Librn

Sioux City Public Library
ATTN: Librn

Skidmore College
ATTN: Librn

Slippery Rock State College Library
ATTN: Librn

South Carolina State Library
ATTN: Librn

University of South Carolina
ATTN: Librn

University of South Carolina
ATTN: Gov Docs

South Dakota School of Mines & Technical Library
ATTN: Librn

South Dakota State Library
ATTN: Fed Docs Dept

University of South Dakota
ATTN: Docs Librn

South Florida University Library
ATTN: Librn

Southeast Missouri State University
ATTN: Librn

Southeastern Massachusetts University Library
ATTN: Docs Sec

University of Southern Alabama
ATTN: Librn

Southern California University Library
ATTN: Docs Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Librn

Southern Illinois University
ATTN: Docs Ctr

Southern Methodist University
ATTN: Librn

University of Southern Mississippi
ATTN: Library

OTHER (Continued)

Southern Oregon College
ATTN: Library

Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN: Librn

St Louis Public Library
ATTN: Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN: Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
ATTN: Librn

State University of New York
ATTN: Librn

Stetson University
ATTN: Librn

University of Steubenville
ATTN: Librn

Stockton & San Joaquin Public Library
ATTN: Librn

Stockton State College Library
ATTN: Librn

Albion College
ATTN: Gov Docs Librn

OTHER (Continued)

Superior Public Library
ATTN: Librn

Swarthmore College Library
ATTN: Ref Dept

Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
ATTN: Librn

Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN: Librn

Tennessee Technological University
ATTN: Librn

University of Tennessee
ATTN: Dir of Libraries

College of Idaho
ATTN: Librn

Texas A & M University Library
ATTN: Librn

University of Texas at Arlington
ATTN: Library Docs

University of Texas at San Antonio
ATTN: Library

Texas Christian University
ATTN: Librn

Texas State Library
ATTN: U.S. Docs Sec

Texas Tech University Library
ATTN: Gov Docs Dept

Texas University at Austin
ATTN: Docs Coll

University of Toledo Library
ATTN: Librn

Toledo Public Library
ATTN: Social Science Dept

Torrance Civic Center Library
ATTN: Librn

Traverse City Public Library
ATTN: Librn

Trenton Free Public Library
ATTN: Librn

Trinity College Library
ATTN: Librn

Trinity University Library
ATTN: Docs Coll

OTHER (Continued)

Tufts University Library
ATTN: Docs Dept

University of Tulsa
ATTN: Librn

UCLA Research Library
ATTN: Pub Affairs Svc/U.S. Docs

Uniformed Services University of the Health Sciences
ATTN: LRC Library

University Libraries
ATTN: Dir of Lib

University of Maine at Oreno
ATTN: Librn

University of Northern Iowa
ATTN: Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN: Librn

University of Utah
ATTN: Special Collections

University of Utah
ATTN: Dir of Libraries
ATTN: Dept of Pharmacology

Utica Public Library
ATTN: Librn

Valencia Library
ATTN: Librn

Valparaiso University
ATTN: Librn

Vanderbilt University Library
ATTN: Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Librn

Virginia Military Institute
ATTN: Librn

Virginia Polytechnic Institute Library
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Sec

University of Virginia
ATTN: Pub Docs

Volusia County Public Library
ATTN: Librn

OTHER (Continued)

Washington State Library
ATTN: Docs Sec

Washington State University
ATTN: Lib Docs Sec

Washington University Libraries
ATTN: Dir of Lib

University of Washington
ATTN: Docs Div

Wayne State University Library
ATTN: Librn

Wayne State University Law Library
ATTN: Docs Dept

Weber State College Library
ATTN: Librn

Wesleyan University
ATTN: Docs Librn

West Chester State College
ATTN: Docs Dept

West Covina Library
ATTN: Librn

University of West Florida
ATTN: Librn

West Hills Community College
ATTN: Library

West Texas State University
ATTN: Library

West Virginia College of Grad Studies Library
ATTN: Librn

University of West Virginia
ATTN: Dir of Libraries (Reg)

Westerly Public Library
ATTN: Librn

Western Carolina University
ATTN: Librn

Western Illinois University Library
ATTN: Librn

Western Washington University
ATTN: Librn

Western Wyoming Community College Library
ATTN: Librn

Westmoreland City Community College
ATTN: Learning Resource Ctr

OTHER (Continued)

Whitman College
ATTN: Librn

Wichita State University Library
ATTN: Librn

William & Mary College
ATTN: Docs Dept

Emporia Kansas State College
ATTN: Gov Docs Div

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Willimantic Public Library
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Winthrop College
ATTN: Docs Dept

University of Wisconsin at Whitewater
ATTN: Gov Docs Lib

University of Wisconsin at Milwaukee
ATTN: Lib Docs

University of Wisconsin at Oshkosh
ATTN: Librn

University of Wisconsin at Platteville
ATTN: Doc Unit Lib

University of Wisconsin at Stevens Point
ATTN: Docs Sec

University of Wisconsin
ATTN: Gov Pubs Dept

University of Wisconsin
ATTN: Acquisitions Dept

Worcester Public Library
ATTN: Librn

Wright State University Library
ATTN: Gov Docs Librn

Wyoming State Library
ATTN: Librn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Librn

Yuma City County Library
ATTN: Librn

Simon Schwob Mem Lib, Columbus Col
ATTN: Librn

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