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SHOTS
ABLE TO EASY

The First Five Tests of the BUSTER-JANGLE Series 22 October—5 November 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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BAKER	EASY	Weapons Development Test Unit	Nevada Proving Ground
CHARLIE		Nuclear Tests	

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

This report describes the activities of DOD military and civilian personnel in the first five events of Operation BUSTER-JANGLE, Shots ABLE through EASY, conducted from 22 October through 5 November 1951. DOD personnel participated in the scientific projects conducted by the test units and, at Shot DOG, in Exercise Desert Rock I. Radiological safety criteria and procedures were established and implemented during Operation BUSTER-JANGLE to minimize participants' exposure to radiation.

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PREFACE

Between 1945 and 1962, the U.S. Government, through the Manhattan Engineer District and its successor, 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 participated in 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, a test of Operation PLUMBBOB, the Nevada test series 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, 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 participants in atmospheric nuclear weapons testing. 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. Some of the documents written during Operation BUSTER-JANGLE, however, refer to the area as the NTS.

**The Center for Disease Control is part 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 on Operation BUSTER-JANGLE is based on the military and technical documents associated with these atmospheric nuclear weapons tests. Many of the documents pertaining specifically to DOD participation at Shots ABLE, BAKER, CHARLIE, DOG, and EASY were found in the National Archives, the Defense Nuclear Agency Technical Library, and the Office of Air Force History.

In most cases, the surviving historical documentation of activities conducted at Shots ABLE, BAKER, CHARLIE, DOG, and EASY addresses test specifications and technical information, rather than personnel data. Moreover, the available documents sometimes have inconsistencies in vital facts, such as the number of DOD participants in a certain project at a given shot or their locations and assignments at a given time. When the documents indicate two different personnel numbers, the higher figure was used.

For several of the Desert Rock exercises and test organization projects discussed in this volume, the only source documents available are the Sixth Army Desert Rock operation orders and the Test Director's schedule of events from "Operation Order 1-51." These sources detail the plans developed by DOD and AEC personnel prior to Operation BUSTER-JANGLE. It is not known if all the projects addressed in the planning documents were conducted exactly as planned. Although some of the after-action documents summarize the projects performed during the series, they do not always supply shot-specific information. In the absence of shot-specific after-action reports, projects are

described according to the way they were planned. The references indicate whether the description of activities is based on the schedule of events, operation orders, or after-action reports.

This volume uses the project titles and agency designations listed in "Operation BUSTER, Final Report." Information on dates and yields of the detonations, fallout patterns, meteorological conditions, and nuclear cloud dimensions is taken from General Electric Company-TEMPO's Compilation of Local Fallout Data from Test Detonations 1945-1962, Extracted from DASA 1251, Volume 1, except in instances where more specific information is available elsewhere.

ORGANIZATION AND CONTENT OF BUSTER-JANGLE SERIES REPORTS

This volume details participation by DOD personnel in the first five events of Operation BUSTER-JANGLE. Two other publications address DOD activities during the series:

- Series volume: Operation BUSTER-JANGLE, 1951
- Multi-shot volume: Shots SUGAR and UNCLE, the Final Tests of the BUSTER-JANGLE Series.

The volumes addressing the test events of Operation BUSTER-JANGLE are designed for use with one another. The series volume provides general information, such as a discussion of the historical background, organizational relationships, and radiological safety procedures. In addition, it addresses the overall objectives of the operation, describes the layout of the NPG, and contains a bibliography of all works consulted in the preparation of the three BUSTER-JANGLE reports. The multi-shot volumes combine shot-specific descriptions for the seven BUSTER-JANGLE nuclear events. These volumes contain bibliographies only of the sources referenced in each of the two texts. Descriptions of activities concerning any particular BUSTER-JANGLE shot may be supplemented by the general radiological safety and organizational information contained in the series volume.

Chapter 1 of this volume describes the physical setting and general characteristics of Shots ABLE, BAKER, CHARLIE, DOG, and EASY and briefly introduces the Desert Rock exercises and the scientific activities in which DOD personnel participated. The remaining five chapters of this report address the five shots in turn. Each of these chapters describes the specific setting and characteristics of one detonation and details DOD personnel activities in the scientific projects conducted by the test units. In the chapter dealing with Shot DOG, the training activities associated with Exercise Desert Rock I are also described. The chapters conclude by discussing the radiological 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. This manual summarizes information on radiation physics, radiation health concepts, exposure criteria, and measurement techniques. It also contains a list of acronyms and a glossary of terms used in the reports addressing test events in the continental United States.

TABLE OF CONTENTS

PAGE

PREFACE. 1

LIST OF ILLUSTRATIONS. 7

LIST OF TABLES 7

LIST OF ABBREVIATIONS AND ACRONYMS 9

CHAPTER

1 INTRODUCTION. 10

1.1 Department of Defense Participation in the First Five BUSTER-JANGLE Events. 11
1.2 Test Organization Activities at the First Five BUSTER-JANGLE Events 15
1.3 Exercise Desert Rock I Activities at the First Five BUSTER-JANGLE Events. 16

Shot ABLE Synopsis 18

2 SHOT ABLE 19

2.1 Department of Defense Participation in Scientific and Support Activities at Shot ABLE. 19
2.1.1 Weapons Effects Tests 20
2.1.2 Weapons Development Tests 22
2.1.3 Special Weapons Command Activities. 22

2.2 Radiological Protection at Shot ABLE 23

Shot BAKER Synopsis. 25

3 SHOT BAKER. 26

3.1 Exercise Desert Rock Operations at Shot BAKER. . . 26
3.2 Department of Defense Participation in Scientific and Support Activities at Shot BAKER. . 27

3.2.1 Weapons Effects Tests 27
3.2.2 Weapons Development Tests 36
3.2.3 Special Weapons Command Activities. 36

3.3 Radiological Protection at Shot BAKER. 39

Shot CHARLIE Synopsis. 43

4 SHOT CHARLIE. 44

4.1 Department of Defense Participation in Scientific and Support Activities at Shot CHARLIE 44

TABLE OF CONTENTS (Continued)

CHAPTER	PAGE
4.1.1 Weapons Effects Tests	44
4.1.2 Weapons Development Tests	51
4.1.3 Special Weapons Command Activities	52
4.2 Radiological Protection at Shot CHARLIE	55
Shot DOG Synopsis	59
5 SHOT DOG	60
5.1 Exercise Desert Rock Operations	60
5.1.1 Camp Desert Rock Personnel	62
5.1.2 Observer Activities	66
5.1.3 Troop Maneuver	69
5.1.4 Damage Effects Tests	73
5.2 Department of Defense Participation in Scientific and Support Activities at Shot DOG	74
5.2.1 Weapons Effects Tests	77
5.2.2 Weapons Development Tests	86
5.2.3 Special Weapons Command Activities	86
5.3 Radiological Protection at Shot DOG	89
5.3.1 Desert Rock Radiological Protection Activities	90
5.3.2 Test Organization Radiological Protection Activities	93
Shot EASY Synopsis	97
6 SHOT EASY	98
6.1 Department of Defense Participation in Scientific and Support Activities at Shot EASY	98
6.1.1 Weapons Effects Tests	100
6.1.2 Weapons Development Tests	106
6.1.3 Special Weapons Command Activities	106
6.2 Radiological Protection at Shot EASY	110
REFERENCE LIST	113

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1-1	Nevada Proving Ground Showing Ground Zeros for Operation BUSTER-JANGLE Shots	13
3-1	Isointensity Map for Shot BAKER, 28 October 1951, Calculated for One Hour after Detonation	41
3-2	Survey for Shot BAKER, 28 October 1951, 1820 hours	42
4-1	Isointensity Map for Shot CHARLIE, 30 October 1951, Calculated for One Hour after Detonation	57
4-2	Survey for Shot CHARLIE, 30 October 1951, 1600 Hours	58
5-1	Shot DOG, Detonated at 0730 Hours on 1 November 1951	61
5-2	Display Areas, Parking Area, Battalion Combat Team Objective, and Tactical Defensive Position for Exercise Desert Rock I	67
5-3	Troops at the Observation Point Watching Shot DOG	72
5-4	Isointensity Map for Shot DOG, 2 November 1951, Calculated for One Hour after Detonation	95
5-5	Survey for Shot DOG, 2 November 1951, 0900 hours	96
6-1	Resurvey for Shot EASY, 6 November 1951, 0830 hours	112

LIST OF TABLES

TABLE		PAGE
1-1	Summary of the Five Operation BUSTER Events (1951)	12
2-1	Test Unit Projects, Shot ABLE	20
3-1	Test Unit Projects, Shot BAKER	28
4-1	Test Unit Projects, Shot CHARLIE	45
5-1	Support Units Attached to Camp Desert Rock, Exercise Desert Rock I	63

LIST OF TABLES (Continued)

TABLE		PAGE
5-2	Test Unit Projects, Shot DOG.	75
6-1	Test Unit Projects, Shot EASY	99

LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC	Atomic Energy Commission
AFB	Air Force Base
AFSWP	Armed Forces Special Weapons Project
BCT	Battalion Combat Team
BJY	BUSTER-JANGLE Y
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Inc.
FCDA	Federal Civil Defense Administration
HumRRO	Human Resources Research Office
IBDA	Indirect Bomb Damage Assessment
LASL	Los Alamos Scientific Laboratory
NPG	Nevada Proving Ground
R	Roentgens
R/h	Roentgens per hour
SWC	Special Weapons Command
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Shots ABLE, BAKER, CHARLIE, DOG, and EASY were tests of nuclear devices conducted from 22 October to 5 November 1951 at the Nevada Proving Ground, the continental test site northwest of Las Vegas. The shots were the first five detonations of Operation BUSTER-JANGLE, the atmospheric nuclear weapons test series performed from 22 October to 29 November 1951.

The five nuclear devices were developed and built for the Atomic Energy Commission by the Los Alamos Scientific Laboratory (LASL). As weapons development tests, the detonations were part of the BUSTER phase of Operation BUSTER-JANGLE. The objectives of the BUSTER tests were to evaluate new devices developed by LASL and to obtain data on the basic phenomena associated with these devices (18).*

To fulfill the primary objectives, two test units, the Weapons Effects Test Unit and the Weapons Development Test Unit, conducted scientific experiments at the five shots. The Weapons Effects Test Unit, supervised by the Air Force Special Weapons Command (SWC), fielded projects to evaluate the utility of the five nuclear devices for military application. The Weapons Development Test Unit, composed of scientists from the Los Alamos Scientific Laboratory, from Edgerton, Germeshausen, and Grier, Inc. (EG&G); and from the Sandia Corporation, performed diagnostic tests of the nuclear devices.

The Special Weapons Command, located at Kirtland Air Force Base (AFB) in Albuquerque, New Mexico, supported the BAKER,

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

CHARLIE, DOG, and EASY tests with bomb-drop missions. It also provided cloud-sampling missions and courier flights for all five BUSTER events. SWC conducted cloud tracking and aerial surveys at all BUSTER shots except ABLE.

Table 1-1 summarizes the BUSTER shots, including such information as the UTM* coordinates of the points of detonation and the heights of burst. Figure 1-1 displays a 1951 map of the Nevada Proving Ground, showing the positions of each of the BUSTER-JANGLE tests.

1.1 DEPARTMENT OF DEFENSE PARTICIPATION IN THE FIRST FIVE BUSTER-JANGLE EVENTS

The test organization was established to plan, coordinate, and conduct atmospheric nuclear weapons tests during Operation BUSTER-JANGLE. Consisting of personnel from the Atomic Energy Commission and the Department of Defense, the test organization also included representatives of the Special Weapons Command and various contractors. The numerous scientific and diagnostic projects conducted at the first five BUSTER-JANGLE events were fielded by the two test units and coordinated by the test organization. Other activities were conducted as part of the military training programs associated with Exercise Desert Rock I. These activities, planned and conducted by the armed services, were reviewed and approved by the Test Manager to ensure coordination with the test organization.

Department of Defense personnel present at the Nevada Proving Ground during Operation BUSTER-JANGLE participated in

*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 refer to a point on a north-south axis. The point so designated is the southwest corner of an area 100 meters square.

Table 1-1: SUMMARY OF THE FIVE OPERATION BUSTER EVENTS (1951)

Shot	ABLE	BAKER	CHARLIE	DOG	EASY
Sponsor	LASL	LASL	LASL	LASL	LASL
Planned Date	19 October	23 October	26 October	29 October	1 November
Actual Date	22 October	28 October	30 October	1 November	5 November
Local Time	0600	0720	0700	0730	0830
NPG Location	Area 7	Area 7	Area 7	Area 7	Area 7
UTM Coordinates	868042	870045	870045	871044	867053
Type	Tower	Airdrop	Airdrop	Airdrop	Airdrop
Height of Burst (feet)	100	1,118	1,132	1,417	1,314
Yield (kilotons)	<0.1	3.5	14	21	31

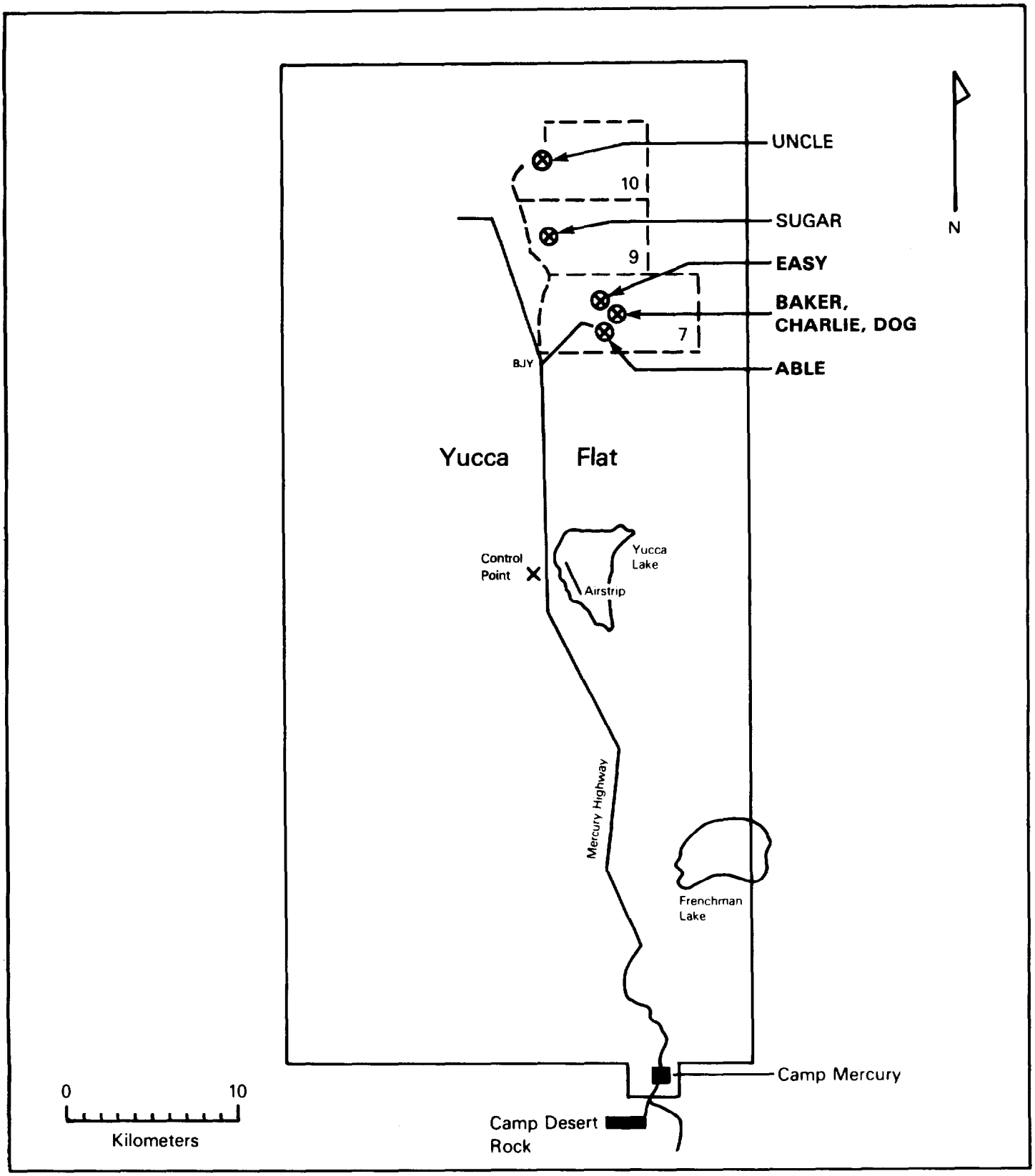

Figure 1-1: NEVADA PROVING GROUND SHOWING GROUND ZEROS FOR OPERATION BUSTER-JANGLE SHOTS

three general types of activities: military training programs, support and staff duties, and test assistance and involvement.

Training activities involving DOD personnel were conducted through the Exercise Desert Rock I programs at Shot DOG. The activities, which involved the greatest number of DOD participants at the shot, included an orientation and indoctrination program, highlighted by the observation of the nuclear burst. Desert Rock activities at DOG also included a troop maneuver and damage effects tests.

In the area of staff and support involvement, some DOD personnel provided support to the test organization. Others were assigned to the Camp Desert Rock support elements. Soldiers of the III Corps Radiological Safety Unit, along with test organization personnel, served as radiological safety monitors for Exercise Desert Rock I participants at Shot DOG. Approximately 2,500 soldiers from various Army units maintained and operated Camp Desert Rock, an installation of the Sixth Army. These soldiers provided essential support, such as food service and housing, as well as transportation, communications, construction, and security services. Some of these Desert Rock support troops worked in the forward areas of the Nevada Proving Ground to construct observer trenches, lay communication lines, provide transportation and traffic control, and assist in the preparations for Desert Rock activities. Many of the Camp Desert Rock personnel observed at least one detonation during Operation BUSTER-JANGLE, and some were called upon to perform support or staff duties in the test areas during the nuclear detonations.

In the area of test assistance and participation, personnel from DOD agencies and all four armed services fielded the military effects projects conducted by the Weapons Effects Test Unit and supported projects performed by the Weapons Development Test Unit. Participants in test unit projects generally placed

data-collection instruments around the intended ground zero during the weeks before the scheduled detonation. They returned to recover the equipment after the detonation, when the Test Manager had determined that the radiological environment in the shot area would permit limited access. During a nuclear detonation, project personnel were generally positioned at designated observer locations or were operating equipment or aircraft. About 300 DOD personnel from units and groups of the test organization participated in or supported field operations at Shots ABLE, BAKER, CHARLIE, DOG, and EASY.

An estimated 500 SWC personnel provided air support to the Test Manager and various test unit projects. During Operation BUSTER-JANGLE, SWC consisted of units of the 4925th Test Group (Atomic) and the 4901st Support Wing (Atomic). The 4925th Test Group operated out of Indian Springs AFB, 30 kilometers* east of Camp Mercury, while the 4901st Support Wing operated out of Kirtland AFB.

1.2 TEST ORGANIZATION ACTIVITIES AT THE FIRST FIVE BUSTER-JANGLE EVENTS

The Weapons Effects Test Unit and the Weapons Development Test Unit conducted scientific and diagnostic projects at Shots ABLE, BAKER, CHARLIE, DOG, and EASY. Department of Defense participants followed radiological protection procedures established by the test organization and SWC. These procedures, described in the BUSTER-JANGLE Series volume, were designed to minimize exposure to ionizing radiation. Except for SWC sampling pilots, participants were to receive no more than 3 roentgens during the entire series. Sampling pilots were authorized to

*Throughout this report, surface distances are given in metric units. The metric conversion factors include: 1 foot = 0.30 meters; 1 yard = 0.91 meters; 1 mile = 1.6 kilometers. Altitudes and other vertical heights are given in feet.

receive up to 3.9 roentgens during the series. To implement these criteria, the test organization Radiological Health and Safety Group controlled access to radiation areas, and project personnel recovering test instruments from these areas were accompanied by radiological safety monitors. The monitors, who measured radiation intensities in the recovery area, recommended that recovery operations cease if intensities were too great or the length of time spent by participants in the areas was too long. To monitor cumulative exposures, most project personnel were issued film badges and pocket dosimeters. These film badges and dosimeters were collected, developed, and evaluated at regular intervals, and any individual whose cumulative exposure exceeded the established limits was barred from further participation in project activities in the forward area. Personnel decontamination procedures were implemented, and emergency evacuation plans were prepared for all test events (29; 31; 37; 46).

Complete decontamination, including showers and changes into clean clothing, was required of cloud-sampling personnel following each project mission, regardless of the exposure received on the flight. Other aircrew members underwent decontamination procedures as necessary. Aircraft were either decontaminated by washing or were isolated until radiation intensities decayed to predetermined levels (17).

1.3 EXERCISE DESERT ROCK I ACTIVITIES AT THE FIRST FIVE BUSTER-JANGLE EVENTS

Exercise Desert Rock I was the first program conducted during a continental nuclear weapons test series to train personnel in the use and effects of nuclear weapons and to test battlefield doctrine and tactics. During the BUSTER shots, Desert Rock activities were performed only at Shot DOG. The

majority of DOD personnel at the event were participants in these activities (26).

The three Desert Rock I programs involved 3,739 DOD personnel (21):

- 2,796 personnel participated in observer activities, which involved watching the nuclear detonation.
- 883 personnel took part in a troop maneuver after they had witnessed the detonation.
- 60 DOD personnel participated in damage effects tests, which were studies of military equipment and field fortifications.

The 2,500 Camp Desert Rock troops provided support, including radiological safety monitoring, for these activities (21; 30).

Radiation protection procedures of Exercise Desert Rock I, like those of the test organization, are detailed in the BUSTER-JANGLE Series volume. Camp Desert Rock personnel and exercise participants were limited to no more than 1 roentgen of exposure during Exercise Desert Rock I. The radiation protection procedures of Exercise Desert Rock I included provisions for:

- Maintaining minimum safe distances from the nuclear detonation
- Controlling access to radiation areas
- Film-badging Desert Rock personnel
- Monitoring individuals working in radiation areas
- Monitoring the cumulative doses of Desert Rock personnel
- Decontaminating personnel and equipment
- Establishing emergency evacuation plans.

These procedures were intended to minimize exposure while still allowing Desert Rock personnel to accomplish their missions (36; 37; 46).

SHOT ABLE SYNOPSIS

AEC TEST SERIES:	BUSTER-JANGLE
DOD EXERCISE:	None
DATE/TIME:	22 October 1951, 0600 hours
YIELD:	Less than 0.1 kiloton
HEIGHT OF BURST:	100 feet (tower shot)

Purpose of Test: (1) Field-test a new device developed by the Los Alamos Scientific Laboratory
(2) Obtain data on the basic phenomena associated with this device.

DOD Objective: To evaluate the utility of the nuclear device for military application.

Weather: At shot-time, the temperature at the surface was 5.8°C, the relative humidity was 22 percent, and the pressure was 874 millibars. The wind was five knots from the northwest at surface level, nine knots from the west-northwest at 5,000 feet, and 17 knots from the west-northwest at 10,000 feet.

Radiation Data: Gamma radiation levels were negligible. Alpha-emitting debris, however, was scattered downwind of ground zero within about a 640-meter radius.

Participants: Los Alamos Scientific Laboratory; Special Weapons Command; Naval Radiological Defense Laboratory; Naval Ordnance Laboratory; Air Weather Service; Headquarters, Air Force; contractors.

CHAPTER 2

SHOT ABLE

Shot ABLE, the first detonation of Operation BUSTER-JANGLE, was fired at 0600 hours Pacific Standard Time on 22 October 1951. The detonation occurred on top of a 100-foot tower in Area 7 of Yucca Flat, at UTM coordinates 868042. The shot was originally scheduled for 19 October 1951 but was postponed because of operational difficulties. Rescheduled for 0600 hours on 22 October 1951, the ABLE device partially misfired. It had a yield of less than 0.1 kiloton. The top of the cloud resulting from the detonation reached an altitude of 8,000 feet* and moved southeast. Onsite gamma radiation intensities were insignificant, but alpha-producing debris was spread downwind of ground zero (16).

2.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT ABLE

Department of Defense personnel took part in scientific experiments conducted by the Weapons Effects Test Unit. The DOD was also involved in a project fielded by the Weapons Development Test Unit. Table 2-1 lists the test unit projects by number and title and identifies the participating agencies.

In addition to test unit participation, the DOD provided support to the test units and the Test Manager. These activities involved about 50 DOD project personnel, 100 SWC air and ground personnel, and perhaps an additional 25 DOD personnel working for various units coordinated by the test organization.

---

*Throughout this report, altitudes are measured from mean sea level, unless otherwise noted. Yucca Flat, where the BUSTER-JANGLE tests were conducted, is approximately 4,000 feet above mean sea level.

Table 2-1: TEST UNIT PROJECTS, SHOT ABLE

Project	Title	Participants
	Weapons Effects Tests	
2.4-1	Basic Thermal Radiation Measurements	Naval Radiological Defense Laboratory
7.3	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force; 4925th Test Group
7.5	Seismic Waves from A-Bombs Detonated over a Land Mass	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
8.2	Air Weather Service Participation in Operation BUSTER	2059th Air Weather Wing; 2060th Mobile Weather Squadron
	Weapons Development Tests	
10.4	Radiochemical Results	Los Alamos Scientific Laboratory

2.1.1 Weapons Effects Tests

The Weapons Effects Test Unit planned to conduct more projects than those listed in table 2-1. However, because ABLE's yield was less than 0.1 kiloton rather than the 0.25 kilotons expected, the AEC aborted many of the planned projects (18).

Project 2.4-1, Basic Thermal Radiation Measurements, was performed by the Naval Radiological Defense Laboratory. The objective was to take thermal measurements at distances from a nuclear detonation where significant thermal damage was expected. Project personnel used thermal detectors and samples to detect and record the thermal pulse. They placed samples of cloth, wood, and paint 500 meters from ground zero. Fifteen hours before the detonation, five project personnel finished checking thermal detectors in the shot area. Three hours after the detonation, three participants, accompanied by a monitor, left the Control Point to recover the samples and the data from the thermal detectors (4; 31).

Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was conducted by Headquarters, Air Force, and the 4925th Test Group (Atomic) in conjunction with cloud-sampling operations. Project personnel analyzed debris obtained during the cloud-sampling missions. These missions are discussed in section 2.1.3 (38).

Project 7.5, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted by the 1009th Special Weapons Squadron, the Naval Ordnance Laboratory, the Acoustics Research Division of the Wright Air Development Center, and the Coast and Geodetic Survey. The objective was to study the propagation of seismic waves by a nuclear detonation. Five project stations were positioned ten to 20 kilometers south of ground zero, and other stations were located offsite. Fifteen hours before the detonation, two project personnel finished installing seismic recorders at the onsite stations. Six hours after the detonation, two participants and a monitor left the Control Point to recover seismic records from these stations (10; 31).

Project 8.2, Air Weather Service Participation in Operation BUSTER, was conducted by the 2059th Air Weather Wing and one of its subordinate units, the 2060th Mobile Weather Squadron, from Tinker AFB, Oklahoma. The objective was to gather and report information before the detonation regarding such weather factors as wind conditions, temperature, and humidity. Weather forecasts included estimates of the anticipated cloud cover, winds at the surface and up to 45,000 feet, and the precipitation projected within a radius of 500 kilometers of the target area. The 90 project participants worked from a weather station at the Control Point and from outlying stations at Tonopah, Warm Springs, Currant, Pioche, and Alamo, Nevada, and at St. George, Utah. Senior weather personnel gave briefings at the Control Point at 0800, 2000, and 2400 hours on the day preceding the detonation and a final summary just before shot-time (23; 31).

2.1.2 Weapons Development Tests

The Weapons Development Test Unit conducted several projects at Shot ABLE. Only one project, however, involved DOD participants: Project 10.4, Radiochemical Results. LASL conducted this project, the objective of which was to determine the particle makeup of the Shot ABLE cloud. The 4925th Test Group (Atomic) conducted cloud sampling for the project (39). This activity is discussed in the next section.

2.1.3 Special Weapons Command Activities

The Special Weapons Command provided personnel to control air activities through the Air Operations Center, which coordinated air traffic over the Nevada Proving Ground. SWC personnel conducted cloud-sampling and sample courier missions for the test units and the Test Manager. Cloud-tracking missions and aerial surveys scheduled for the shot were canceled because of the relatively small yield of the detonation (14).

Cloud Sampling

Two B-29 aircraft were originally scheduled to collect particulate samples of the cloud for Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, and Project 10.4, Radiochemical Results. Because of the relatively small yield of the shot, only one B-29 took part in the sampling. This aircraft, with a crew of ten, flew at altitudes of 5,300 to 7,500 feet, made nine penetrations of the cloud, and spent a total of 39 seconds in the cloud (14).

Upon completion of its mission, the sampler returned to Indian Springs AFB and parked in the aircraft decontamination area. Pilots then shut down the engines. The aircrew disembarked from the aircraft through the nose-wheel door. Personnel from the sample-removing team used long-handled tools to remove

the filter papers from each wing pod and place them in shielded containers. They then loaded the sample containers onto courier aircraft for delivery to laboratories for analysis (13; 14; 38; 39).

Courier Missions

After the sampling missions had been completed, two C-45 aircraft and a B-25 or a C-47 left Indian Springs AFB on shot-day to transport filter papers and equipment to various laboratories, primarily AEC and DOD facilities, for analysis. The 4901st Support Wing (Atomic) conducted these courier missions (31). Each aircraft had a crew of five (13).

2.2 RADIOLOGICAL PROTECTION AT SHOT ABLE

The primary purpose of the radiological protection procedures was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions. The radiological safety information related to Shot ABLE consists of data on onsite and offsite monitoring procedures and decontamination operations coordinated by the test organization.

Monitoring

A helicopter survey of the shot area was conducted soon after the detonation. The helicopter team surveyed Area 7, including the roads leading into the shot area. The radiological safety monitor who accompanied the helicopter survey team remained in Area 7 to control vehicles entering the shot area.

The gamma radiation detected by the helicopter survey was negligible, and isointensity plots of gamma radiation levels in the shot area were not prepared. However, alpha-emitting debris from the misfire of the device was scattered around ground zero.

Within a 100-meter radius of ground zero, alpha activity was 300 to 400 counts per minute, with readings of more than 20,000 counts per minute on some pieces of debris in the shot area. Other alpha contamination was spread within an area about 700 meters east to south of ground zero (16; 37).

Based on data obtained from the initial survey, the Test Manager decided to open the shot area for limited recovery operations about two hours after the detonation. Recovery activities began at about 0800 and were completed by 1200 hours. Each recovery team was accompanied by at least one radiological safety monitor.

Five survey teams, each consisting of two persons, monitored offsite areas. The teams did not detect gamma or alpha radiation in any of these areas (37).

Decontamination

Seven land vehicles and the B-29 cloud sampler were decontaminated during the period that includes Shot ABLE (37).

SHOT BAKER SYNOPSIS

AEC TEST SERIES:	BUSTER-JANGLE
DOD EXERCISE:	None
DATE/TIME:	28 October 1951, 0720
YIELD:	3.5 kilotons
HEIGHT OF BURST:	1,118 feet (airdrop)

Purpose of Test: (1) Evaluate a new weapons design. (2) Document the basic phenomena produced by the nuclear device.

DOD Objective: To evaluate the utility of the nuclear device for military application.

Weather: At shot-time, the temperature was 11.4°C, the relative humidity was 28 percent, and the pressure was 877 millibars. The winds were nine knots from the northwest at surface level, 15 knots from the east-northeast at 10,000 feet, and 43 knots from the east-northeast at 30,000 feet.

Radiation Data: Onsite radiation consisted of neutron-induced activity around ground zero. One hour after the shot, radiation intensities ranged from 6 R/h* to 0.6 R/h in the area 250 to 650 meters from ground zero.

Participants: Los Alamos Scientific Laboratory; Special Weapons Command; Headquarters, Air Force; Naval Material Laboratory; Office of the Quartermaster General; Naval Radiological Defense Laboratory; Naval Medical Research Institute; Air Research and Development Command; Engineer Research and Development Laboratories; Office of the Surgeon General; Signal Corps Engineering Laboratories; Bureau of Ships; Bureau of Aeronautics; Wright Air Development Center; Naval Electronics Laboratory; 1009th Special Weapons Squadron; Air Weather Service; contractors.

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*Roentgens per hour

CHAPTER 3

SHOT BAKER

Shot BAKER, an airdropped nuclear device, was detonated with a yield of 3.5 kilotons at 0720 hours Pacific Standard Time on 28 October 1951. This second nuclear test of Operation BUSTER-JANGLE was originally planned for 23 October but was rescheduled because of adverse weather conditions. A B-50 aircraft dropped the nuclear device, which had been developed by the Los Alamos Scientific Laboratory. The BAKER device was detonated 1,118 feet above Area 7 of Yucca Flat, over UTM coordinates 870045. The top of the Shot BAKER cloud reached an altitude of 31,700 feet and moved southwest. Onsite radiation was in the form of neutron-induced activity around ground zero (16).

3.1 EXERCISE DESERT ROCK OPERATIONS AT SHOT BAKER

According to the AEC operation order for BUSTER-JANGLE, dated 25 August 1951, a rehearsal of the Exercise Desert Rock I troop maneuver and observer program was scheduled for Shot BAKER. In a schedule of events issued in October 1951, the Exercise Director announced that this rehearsal would take place on 21 October, two days before BAKER's scheduled detonation, and a second rehearsal would occur on 27 October, two days before Shot DOG's scheduled detonation on 29 October. According to the AEC operation order, the troops were to move into the forward area the day before each detonation to rehearse their maneuver and were to return to Yucca Lake 45 minutes before each shot. Although neither BAKER nor DOG was detonated on the scheduled day, it is likely that the rehearsals took place as planned since the shot would have been postponed after the rehearsals had begun. The Exercise Desert Rock I final report, however, does not state whether the rehearsals were actually held (21; 31).

3.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT BAKER

Department of Defense personnel took part in scientific experiments conducted at Shot BAKER by the Weapons Effects Test Unit and the Weapons Development Test Unit. Table 3-1 lists these by number and title and identifies the participating organizations.

In addition to test unit participation, the DOD provided support to the test units and the Test Manager. These activities involved about 250 DOD project personnel, 300 SWC air and ground personnel, and perhaps an additional 50 DOD personnel working for various units coordinated by the test organization.

3.2.1 Weapons Effects Tests

In conducting the Weapons Effects Test Unit projects, participants spent several weeks before the detonation placing and calibrating various types of instruments and gauges (18).

Project 2.2, Thermal and Blast Effects on Idealized Forest Fuels, was conducted by the Division of Fire Research of the Forest Service. The objective was to study the effects of a nuclear detonation on forests. Project personnel arranged trays of pine needles, hardwood leaves, and grass at six stations 650 to 3,700 meters from ground zero.

Fifteen hours before the detonation, project personnel finished checking and photographing the specimens in the shot area. At the same time, four persons completed surveying the condition of the natural vegetation of the area. About 11 hours before the detonation, three participants spent two hours setting timers on their cameras at stations 2,130 and 2,740 meters from ground zero. Five participants, accompanied by a monitor, left the Control Point four hours after the detonation to inspect, photograph, and recover the trays of forest specimens (6; 31).

Table 3-1: TEST UNIT PROJECTS, SHOT BAKER

Project	Title	Participants
	Weapons Effects Tests	
2.2	Thermal and Blast Effects on Idealized Forest Fuels	Division of Fire Research, Forest Service
2.3	Effects of Geometry on Flash Thermal Damage	Naval Material Laboratory
2.4a	Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation	Office of the Quartermaster General; Quartermaster Board; Engineer Research and Development Laboratories
2.4b	Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics	Engineer Research and Development Laboratories
2.4-1	Basic Thermal Radiation Measurements	Naval Radiological Defense Laboratory
2.4-2	The Effect of Thermal Radiation on Materials	Naval Material Laboratory
2.6	Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux	Engineer Research and Development Laboratories
3.5	Minefield Clearance	Engineer Research and Development Laboratories
4.1	Radiation Dosimetry	Naval Medical Research Institute
4.2	Thermal Effects on Animals (Dogs)	Medical College of Virginia; Office of the Surgeon General
4.2a	Thermal Effects on Animals (Rats)	Naval Radiological Defense Laboratory
4.3	Flash Blindness	Air Force School of Aviation Medicine
6.1b	Evaluation of Dosimetric Materials	Signal Corps Engineering Laboratories; Bureau of Ships
6.4	Airborne Radiac Evaluation	Bureau of Aeronautics; Wright Air Development Center; Air Research and Development Command
7.1	Transport of Radiation Debris	Headquarters, Air Force; Air Weather Service
7.2	Long-range Light Measurements	4925th Test Group; EG&G
7.3	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force; 4925th Test Group
7.5	Seismic Waves from A-Bombs Detonated over a Land Mass	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
7.6	Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE	Naval Electronics Laboratory; Signal Corps Engineering Laboratories; National Bureau of Standards
8.2	Air Weather Service Participation in Operation BUSTER	2059th Air Weather Wing; 2060th Mobile Weather Squadron
9.1a	FCDA Family Shelter Evaluation	Federal Civil Defense Administration
9.1b	AEC Communal Shelter Evaluation	Los Alamos Scientific Laboratory
	Weapons Development Tests	
10.4	Radiochemical Results	Los Alamos Scientific Laboratory

Project 2.3, Effects of Geometry on Flash Thermal Damage, was conducted by the Naval Material Laboratory. The objective was to determine the effect of a target's size, shape, and thermal properties on the thermal damage resulting from a nuclear detonation. Project personnel placed wooden materials at three stations 610 to 1,520 meters from ground zero. Five project participants finished checking the materials 15 hours before the detonation. Four hours after the detonation, five participants and a monitor left the Control Point to inspect and recover the wooden materials (31; 34).

Project 2.4a, Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation, was conducted by the Office of the Quartermaster General, the Quartermaster Board, and the Engineer Research and Development Laboratories. This project evaluated the protective value of clothing materials exposed to thermal radiation. Fifteen hours before the detonation, five project personnel finished placing and checking clothing materials and thermal detectors 650 to 2,180 meters from ground zero. Four hours after the detonation, five participants, accompanied by a monitor, left the Control Point. They proceeded to the shot area, where they inspected, photographed, and recovered the materials and detectors (12; 31).

Project 2.4b, Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics, was conducted by the Engineer Research and Development Laboratories. Fifteen hours before the detonation, five project participants finished placing and checking specimens at four stations 610 to 2,130 meters from ground zero. Five participants, accompanied by a monitor, left the Control Point four hours after the detonation to inspect, photograph, and recover the specimens (27; 31).

Project 2.4-1, Basic Thermal Radiation Measurements, was performed by the Naval Radiological Defense Laboratory. The

objective was to take thermal measurements at distances from a nuclear detonation where significant thermal damage was expected. Project personnel used thermal detectors to detect and record the thermal pulse. They placed samples of cloth, wood, and paint at distances ranging from 500 to 3,660 meters from ground zero.

Fifteen hours before the detonation, five project participants finished checking thermal detectors in the shot area. Four hours after the detonation, five participants, with a monitor, left the Control Point to inspect and retrieve the samples and the data from the thermal detectors. At 0700 hours the next day, eight project personnel and a monitor left the Control Point to adjust the thermal detectors for use at the next shot, CHARLIE (4; 31).

Project 2.4-2, The Effect of Thermal Radiation on Materials, was conducted by the Naval Material Laboratory. The objective was to study the physical characteristics of thermal radiation and its effects on various materials. Fifteen hours before the detonation, five project personnel finished checking and placing thermal detectors and panels of materials, such as wood, paper, and fabrics, 610 to 1,520 meters from ground zero. Four hours after the detonation, five participants, accompanied by a monitor, left the Control Point to inspect and recover samples and the data from the thermal detectors. Eight participants and a monitor left the Control Point at 0700 hours the next day to adjust thermal detectors for use at Shot DOG (28; 31).

Project 2.6, Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux, was conducted by the Engineer Research and Development Laboratories. The objective was to evaluate the protection afforded by field fortifications against the radiation from a nuclear detonation. Fifteen hours before the detonation, 12 project personnel and a photographer finished placing film badges inside field fortifications 90 to 2,000

meters southwest of ground zero. Nine project participants and two monitors left the Control Point two hours after the detonation to recover the badges (31; 45).

Project 3.5, Minefield Clearance, was conducted by the Engineer Research and Development Laboratories. The objective was to determine the effects of a nuclear airburst on antitank mines placed in an area beginning 400 meters south of ground zero and extending 1,830 meters eastward. Fifteen hours before the detonation, nine project personnel completed placing mines and blast gauges in the shot area. Six hours after the detonation, nine project personnel, a monitor, and a photographer recovered some fuses and placed new fuses in mines 90 to 1,820 meters from ground zero. According to the AEC operations order, at 1300 hours on the next day, nine participants, accompanied by a monitor and a photographer, finished recovering and replacing fuses in the mines for the next test (31; 44).

Project 4.1, Radiation Dosimetry, was conducted by the Naval Medical Research Institute. The objectives were to:

- Measure the ionization produced by gamma radiation at various depths in the ground
- Correlate laboratory measurements with field measurements.

Five project personnel finished placing radiation detectors 610 to 2,290 meters from ground zero 15 hours before the detonation. Three hours after the detonation, five participants and a monitor left the Control Point to recover the detectors (18; 31).

Project 4.2, Thermal Effects on Animals (Dogs), was conducted by the Medical College of Virginia and the Office of the Surgeon General. The primary objective was to determine the biological relationship between burns produced on dogs in the laboratory and those caused by a nuclear detonation. The

secondary objective was to determine the protection afforded against burns by fabrics used by the military.

Six and one-half hours before the detonation, five project personnel began anesthetizing two dogs, clothing them in canvas jackets, and placing them 1,220 meters from ground zero. Personnel left the shot area four hours before the shot. Two hours after the detonation, eight project personnel and a monitor left the Control Point to recover the animals (5; 31).

Project 4.2a, Thermal Effects on Animals (Rats), was conducted by the Naval Radiological Defense Laboratory. The objective was to investigate burn damage to rat skin as a function of the thermal energy delivered from a nuclear detonation. Ten hours before the detonation, five project personnel began placing rats in cages 640 to 3,660 meters from ground zero. This activity took about four hours. Eight project personnel and a monitor left the Control Point two hours after the detonation to recover the animals (31; 35).

Project 4.3, Flash Blindness, was conducted by the Air Force School of Aviation Medicine. The project evaluated the:

- Visual handicap that might be expected if military personnel were exposed to the flash of a nuclear detonation
- Effectiveness of goggles developed to protect the eyes during exposure to a nuclear flash.

Four hours before the detonation, a C-54 aircraft carrying 17 volunteers flew from Kirtland AFB to be about 15 kilometers south of the target at shot-time. Immediately after the detonation, participants who had viewed the flash of the nuclear detonation performed a number of visual tasks. The aircraft then returned to Kirtland AFB (7; 31).

Project 6.1b, Evaluation of Dosimetric Materials, was conducted by the Signal Corps Engineering Laboratories and the Bureau of Ships. The objective was to field-test several personnel dosimeters. Six project participants finished installing dosimeters inside aluminum shelters 830 to 2,100 meters from ground zero approximately 15 hours before the detonation. Three hours after the detonation, five project personnel and a monitor left the Control Point to recover the dosimeters (11; 31).

Project 6.4, Airborne Radiac Evaluation, was conducted by the Bureau of Aeronautics, Wright Air Development Center, and Air Research and Development Command. The objective was to evaluate the ability of airborne radiation detection equipment to detect a radioactive cloud and to indicate its position relative to the monitoring aircraft. Four and one-half hours before the detonation, an Air Force B-17 and a Navy P2V-2 aircraft left Kirtland AFB to be about 30 kilometers southwest of the target at shot-time (31; 43).

Project 7.1, Transport of Radiation Debris, was conducted by Headquarters, Air Force, and the Air Weather Service. The objective was to determine the distribution of airborne debris from a nuclear detonation. The Air Weather Service tracked the debris at various distances from the NPG (1). Cloud tracking is described in section 3.2.3 of this chapter, which discusses Air Force support missions during Shot BAKER.

Project 7.2, Long-range Light Measurements, was conducted by the 4925th Test Group (Atomic) and by EG&G. The objectives were to study light transmission from a nuclear detonation and to obtain data for the design of long-range detection systems. During shot-time, project participants monitored cameras at several offsite stations in Nevada, Arizona, and New Mexico (8).

Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was performed by Headquarters, Air Force, in conjunction with sampling operations conducted by the 4925th Test Group (Atomic). Project personnel made radiochemical analyses of nuclear bomb debris obtained close to the test site (38). Sampling operations are discussed in section 3.2.3 of this chapter.

Project 7.5, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted by the 1009th Special Weapons Squadron, Naval Ordnance Laboratory, Acoustics Research Division of the Wright Air Development Center, and the Coast and Geodetic Survey. The objective was to study the propagation of seismic waves by a nuclear detonation. Five project stations were positioned ten to 20 kilometers south of ground zero, and other stations were located offsite. Thirteen and one-half hours before the detonation, 14 project personnel finished installing seismic recorders at the onsite stations. Fourteen participants left the Control Point three hours after the detonation to recover seismic records from these stations (10; 31).

Project 7.6, Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE, was conducted by the Naval Electronics Laboratory, Signal Corps Engineering Laboratories, and National Bureau of Standards. The objective was to determine the range and reliability of acoustic detection equipment for nuclear detonations of various yields. Project personnel worked at stations in Alaska, California, Florida, Hawaii, Kentucky, New Jersey, Texas, Washington, and Washington, D.C. (32).

Project 8.2, Air Weather Service Participation in Operation BUSTER, was conducted by the 2059th Air Weather Wing and one of its subordinate units, the 2060th Mobile Weather Squadron, from Tinker AFB. The objective was to gather and report information

before the detonation regarding such weather factors as wind conditions, temperature, and humidity. Weather forecasts included estimates of the anticipated cloud cover, winds at the surface and up to 45,000 feet, and the precipitation projected within a radius of 500 kilometers of the shot area.

The 90 project participants worked from a weather station at the Control Point and from outlying stations at Tonopah, Warm Springs, Currant, Pioche, and Alamo, Nevada, and at St. George, Utah. Senior weather personnel gave briefings at the Control Point at 0800, 2000, and 2400 hours on the day preceding the detonation and a final summary just before shot-time (23; 31).

Project 9.1a, FCDA Family Shelter Evaluation, was performed by the Federal Civil Defense Administration. The project evaluated the effects of nuclear blasts on small shelters for family use. Before the shot, project personnel assembled 29 prefabricated shelters made of metal, wood, and brick at ten-meter intervals along an arc 370 meters east of ground zero. Fifteen hours before the detonation, ten project participants finished instrumenting the shelters. Two project participants inspected the shelters six hours after the detonation. At 0700 hours on the day after the detonation, ten participants continued the study of the shelters (15; 31).

Project 9.1b, AEC Communal Shelter Evaluation, was conducted by the Los Alamos Scientific Laboratory. The objective was to determine the effects of nuclear detonations on a prototype shelter constructed of conventional materials and buried under several feet of earth. Fifteen hours before the detonation, ten project personnel finished placing dosimeters inside the shelter, located about 250 meters southeast of ground zero. Six hours after the detonation, two participants inspected the shelter. At 0700 hours on the day after the detonation, ten participants recovered the dosimeters from the shelter (9; 31).

3.2.2 Weapons Development Tests

The Weapons Development Test Unit conducted several projects at Shot BAKER. Only one project, however, involved DOD participants: Project 10.4, Radiochemical Results. Conducted by LASL, this activity was designed to determine the particle makeup of the Shot BAKER cloud. The 4925th Test Group (Atomic) conducted cloud sampling for the project (39). This activity is discussed in the next section.

3.2.3 Special Weapons Command Activities

The Special Weapons Command provided personnel to control air activities through the Air Operations Center, which coordinated air traffic over the Nevada Proving Ground. SWC personnel airdropped the BAKER device. In addition, they conducted cloud-sampling, sample courier, and cloud-tracking missions and aerial surveys for the test units and the Test Manager (17; 20; 41).

The following list indicates the types and numbers of aircraft and the estimated numbers of DOD aircrew personnel involved in SWC missions at Shot BAKER (13; 14):

ACTIVITY	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Airdrop Mission	B-50	1	9
Disaster Mission	C-47	1	14
Sampling			
Sampler	B-29	2	16
Sampler	T-33	1	2
Sample Courier Missions	B-25 or C-47*	1	5
	B-25	1	5
Cloud Tracking	B-29	1	10
Aerial Surveys	C-47	2	10

*It is not known whether a B-25 or C-47 aircraft conducted this mission.

Airdrop and Disaster Missions

The B-50 drop aircraft, with a crew from the 4925th Test Group (Atomic), left Kirtland AFB at 0235 hours, four hours and 45 minutes before shot-time. Climbing to a height of 19,000 feet above Yucca Flat, the aircraft entered a bombing pattern. The B-50, flying a straight and level course, released the BAKER device, which was detonated at 0720 hours. Soon after, the aircraft left the shot area and returned to Kirtland AFB.

The C-47 disaster aircraft, with a crew from the 4901st Support Wing (Atomic) and security, radiological safety, and salvage personnel onboard, left Kirtland AFB at about 0205 hours and orbited southeast of the NPG during the detonation. After the detonation, the aircraft returned to Kirtland AFB (14).

Cloud Sampling

Two B-29s and one T-33 collected particulate samples of the cloud resulting from the detonation for Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, and Project 10.4, Radiochemical Results. The samplers were stationed at Indian Springs AFB. The samplers flew at altitudes of 17,000 to 24,500 feet and made up to seven penetrations of the cloud. The following presents details of their sampling missions:

AIRCRAFT TYPE AND SERIAL NUMBER	TOTAL TIME IN CLOUD (seconds)	PEAK INTENSITY (R/h)	DOSIMETER READING (roentgens)
B-29 (285)	390	30	1.20
B-29 (599)	92	50	1.20
T-33 (951)	NR*	39**	0.48

*NR indicates not reported.
**39 is an estimated reading.

The dosimeter readings given in the preceding list indicate the cumulative exposures recorded by instruments, such as film badges and pocket dosimeters, within the aircraft.

Upon completing their mission, the samplers returned to Indian Springs AFB and parked in the aircraft decontamination area. The procedures upon landing were the same as those described for Shot ABLE, except that the T-33 crew disembarked by stepping onto a removable ladder attached to the side of the aircraft (14; 38; 39).

Courier Missions

After the sampling missions had been completed, several aircraft left Indian Springs AFB on shot-day to transport filter papers and equipment to various laboratories, primarily AEC and DOD facilities, for analysis. The 4901st Support Wing (Atomic) conducted these courier missions (31).

Cloud Tracking

One B-29 from Indian Springs AFB flew a cloud-tracking mission over and beyond the Nevada Proving Ground for the test organization and Project 7.1. The B-29 left Indian Springs AFB at 0515 hours, tracked the cloud at an altitude of 20,000 feet, and returned to base at 1825 hours (14).

Aerial Surveys

After the detonation, two C-47 aircraft, based at Indian Springs AFB, conducted onsite and offsite survey missions to record radiation intensities. They began their surveys at 1100 and completed their missions at 1600 hours. One C-47 flew at heights of 500 to 2,300 feet above the terrain (14). Further details of the two aircraft's flight patterns are not known.

3.3 RADIOLOGICAL PROTECTION AT SHOT BAKER

The primary purpose of the radiological protection procedures was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions. The radiological safety information found concerning Shot BAKER includes data on onsite and offsite monitoring procedures, isointensity maps, and vehicle decontamination operations coordinated by the test organization (29; 37).

Monitoring

The initial ground survey began shortly after the detonation. The party made additional surveys of the shot area within the next 24 hours (37). In addition to the ground survey team, a helicopter team conducted an aerial survey of Area 7, including the roads leading into the shot area. This survey began about 20 minutes after the shot.

On the basis of data obtained from the initial onsite survey, the Test Manager opened the shot area for limited recovery operations about two hours after the detonation. Recovery activities began at about 0920 and were completed for the day by 1500 hours. Each recovery team was accompanied by at least one radiological safety monitor (31; 37).

The two C-47 aerial survey aircraft provided onsite and offsite monitoring. The maximum onsite surface gamma intensity outside the immediate shot area was 0.0006 R/h. In all offsite areas surveyed, aerial survey teams detected maximum surface gamma intensities lower than 0.0002 R/h (31; 37).

Plotting

Ground monitoring teams provided survey data used in plotting isointensity contours. Figure 3-1 shows the isointensity lines around ground zero one hour after the detonation. This map is based on calculations applying the decay curve for neutron-induced activity in Nevada soil to the results of a survey conducted 11 hours after the detonation. Figure 3-2 presents the results of the actual survey done at 1820 hours (16; 37).

Decontamination

Six ground vehicles, two B-29s, and one T-33 aircraft required decontamination. In these cases, radiation levels were reduced to less than 0.002 R/h by repeated washings with detergent and water (17; 29; 37).

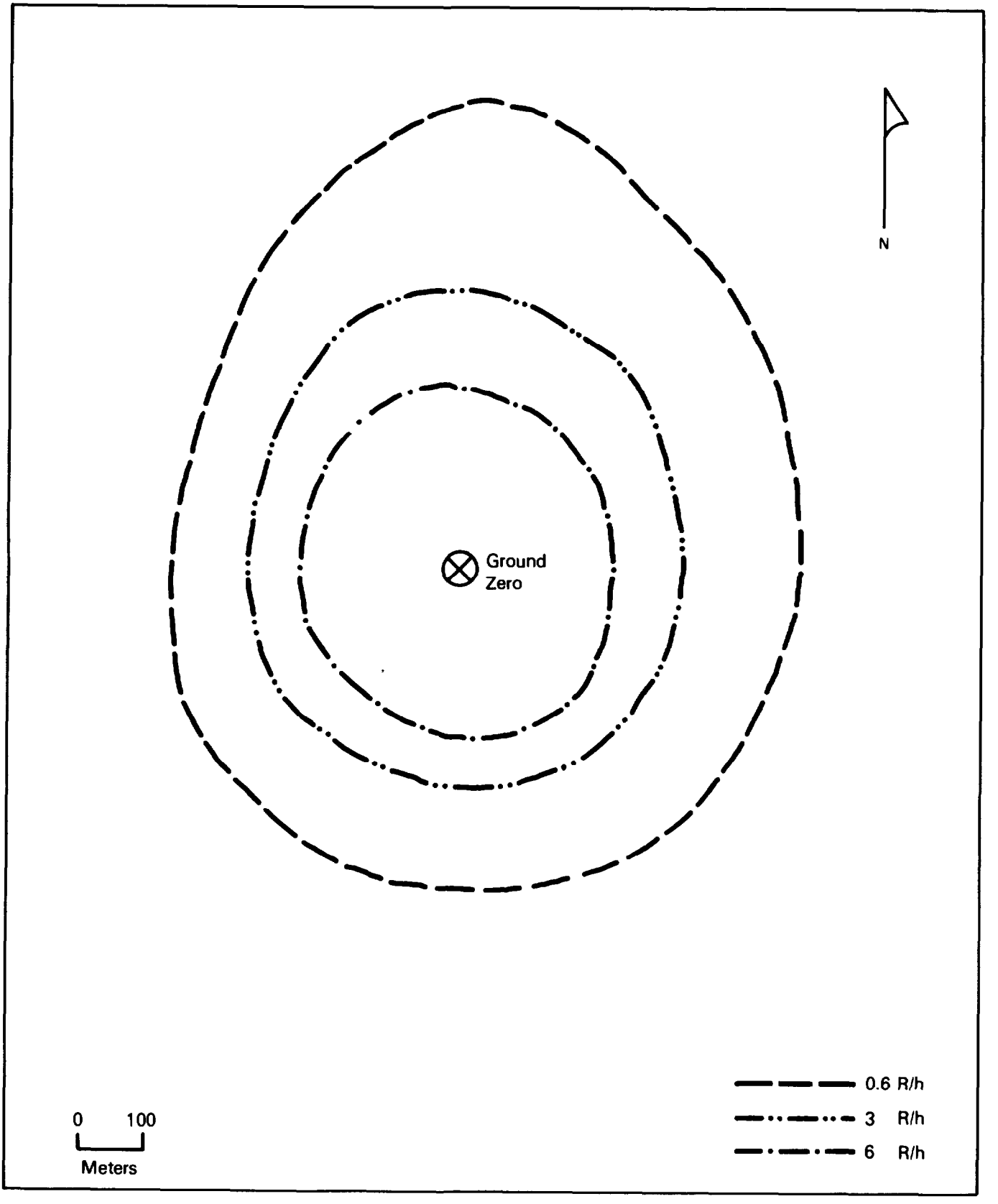

Figure 3-1: ISOINTENSITY MAP FOR SHOT BAKER, 28 OCTOBER 1951, CALCULATED FOR ONE HOUR AFTER DETONATION

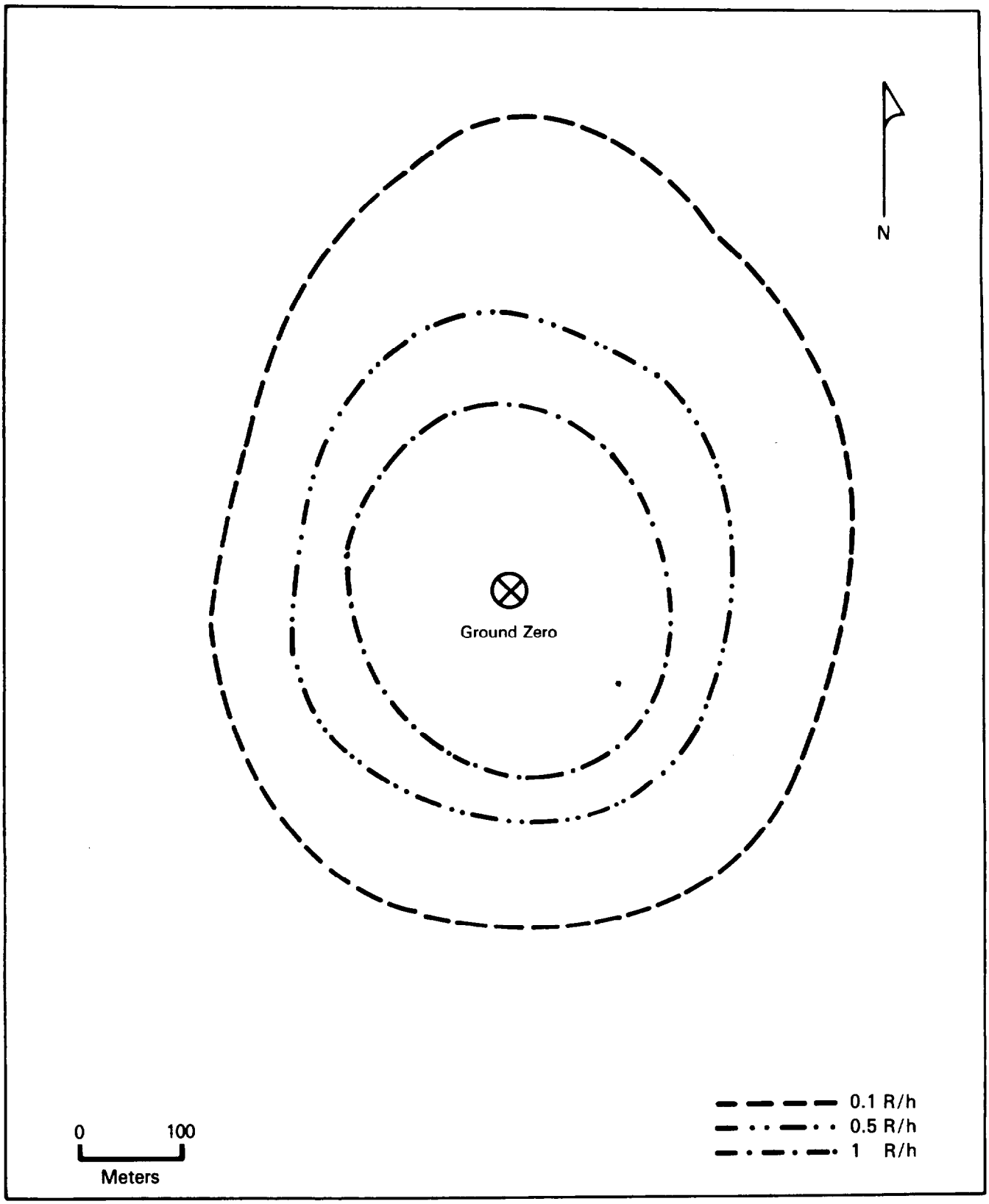

Figure 3-2: SURVEY FOR SHOT BAKER, 28 OCTOBER 1951, 1820 HOURS

SHOT CHARLIE SYNOPSIS

AEC TEST SERIES:	BUSTER-JANGLE
DOD EXERCISE:	None
DATE/TIME:	30 October 1951, 0700 hours
YIELD:	14 kilotons
HEIGHT OF BURST:	1,132 feet (airdrop)

Purpose of Test: (1) Evaluate a new weapon design.
(2) Document basic phenomena produced by the device.

DOD Objective: To evaluate the utility of the nuclear device for military applications.

Weather: At shot-time the temperature was 5.3°C, the relative humidity was 14 percent, and the pressure was 872 millibars. The winds were five knots from the north at surface level, 21 knots from the east-northeast at 20,000 feet, 30 knots from the northwest at 30,000 feet, and 35 knots from the southwest at 40,000 feet.

Radiation Data: Onsite radiation consisted of neutron-induced activity around ground zero. One hour after the shot, radiation intensities ranged from 5 R/h to 0.5 R/h in the area 350 to 580 meters from ground zero.

Participants: Los Alamos Scientific Laboratory; Special Weapons Command; Headquarters, Air Force; Naval Radiological Defense Laboratory; Naval Medical Research Institute; School of Aviation Medicine; Signal Corps Engineering Laboratories; Naval Electronics Laboratory; Air Weather Service; Engineer Research and Development Laboratories; Bureau of Ships; Bureau of Aeronautics; Wright Air Development Center; Air Research and Development Command; Naval Ordnance Laboratory; 1009th Special Weapons Squadron; Air Weather Service; contractors.

CHAPTER 4

SHOT CHARLIE

Shot CHARLIE, an airdropped nuclear device, was detonated with a yield of 14 kilotons at 0700 hours Pacific Standard Time on 30 October 1951. A B-50 aircraft delivered the nuclear device, which had been developed by the Los Alamos Scientific Laboratory. CHARLIE was detonated at a height of 1,132 feet above Area 7, over UTM coordinates 870045. The bottom of the Shot CHARLIE cloud reached an altitude of 27,000 feet, while the top attained an altitude of 41,000 feet. The cloud drifted southwest from the point of detonation. Onsite radiation consisted of neutron-induced activity around ground zero (16).

4.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT CHARLIE

Department of Defense personnel took part in projects conducted at Shot CHARLIE by the Weapons Effects Test Unit and the Weapons Development Test Unit. Table 4-1 lists these projects by number and title and identifies the participating organizations.

In addition to participating directly in test unit projects, DOD personnel provided support to the test units and the Test Manager. These activities involved about 200 DOD project personnel, 300 SWC air and ground personnel, and perhaps an additional 50 DOD personnel working for various units coordinated by the test organization.

4.1.1 Weapons Effects Tests

Project participants spent several weeks before the detonation preparing for the Weapons Effects Test Unit experiments

Table 4-1: TEST UNIT PROJECTS, SHOT CHARLIE

Project	Title	Participants
	Weapons Effects Tests	
2.2	Thermal and Blast Effects on Idealized Forest Fuels	Division of Fire Research, Forest Service
2.4-1	Basic Thermal Radiation Measurements	Naval Radiological Defense Laboratory
2.6	Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux	Engineer Research and Development Laboratories
3.5	Minefield Clearance	Engineer Research and Development Laboratories
4.1	Radiation Dosimetry	Naval Medical Research Institute
4.3	Flash Blindness	Air Force School of Aviation Medicine
6.1b	Evaluation of Dosimetric Materials	Signal Corps Engineering Laboratories; Bureau of Ships
6.4	Airborne Radiac Evaluation	Bureau of Aeronautics; Wright Air Development Center; Air Research and Development Command
6.9	Effects of Atomic Detonations on Radio Propagation	Signal Corps Engineering Laboratories
7.1	Transport of Radiation Debris	Headquarters, Air Force; Air Weather Service
7.2	Long-range Light Measurements	4925th Test Group; EG&G
7.3	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force; 4925th Test Group
7.5	Seismic Waves from A-Bombs Detonated over a Land Mass	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
7.6	Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE	Naval Electronics Laboratory; Signal Corps Engineering Laboratories; National Bureau of Standards
8.2	Air Weather Service Participation in Operation BUSTER	2059th Air Weather Wing; 2060th Mobile Weather Squadron
9.1a	FCDA Family Shelter Evaluation	Federal Civil Defense Administration
9.1b	AEC Communal Shelter Evaluation	Los Alamos Scientific Laboratory
	Weapons Development Tests	
10.4	Radiochemical Results	Los Alamos Scientific Laboratory

listed in table 4-1. During these weeks, they placed and calibrated various types of instruments and gauges (18).

Project 2.2, Thermal and Blast Effects on Idealized Forest Fuels, was conducted by the Division of Fire Research of the Forest Service. The objective was to study the effects of a nuclear detonation on forests. Project personnel arranged and photographed trays of pine needles, hardwood leaves, and grass at six stations 660 to 3,700 meters from ground zero. Fifteen hours before the detonation, four project personnel finished surveying the natural vegetation of the shot area. Eleven hours before the detonation, three participants began setting timers on cameras at stations 2,130 and 2,740 meters from ground zero. This task took about two hours. Shot-day recovery operations were not planned for this activity (6; 31).

Project 2.4-1, Basic Thermal Radiation Measurements, was performed by the Naval Radiological Defense Laboratory. The objective was to take thermal measurements at distances from a nuclear detonation where significant thermal damage was expected. Project personnel used thermal detectors to detect and record the thermal pulse. They placed samples of cloth, wood, and paint at distances of 500 to 3,660 meters from ground zero.

Four project participants finished checking thermal detectors in the shot area 15 hours before the detonation. Four hours after the detonation, six participants, accompanied by a monitor, left the Control Point to inspect and recover the samples and the data from the thermal detectors. At 0700 hours on the day after the detonation, six project personnel and a monitor left the Control Point to adjust the thermal detectors for use at the next shot, DOG (4; 31).

Project 2.6, Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux, was conducted by the Engineer Research and Development Laboratories. The objective was to evaluate the protection afforded by field fortifications against the radiation from a nuclear detonation. Fifteen hours before the detonation, nine project personnel and a photographer finished placing film badges inside field fortifications 90 to 2,000 meters southwest of ground zero and left the shot area. Nine project participants and two monitors left the Control Point two hours after the detonation to recover the badges (31; 45).

Project 3.5, Minefield Clearance, was conducted by the Engineer Research and Development Laboratories. The objective was to determine the effects of a nuclear airburst on antitank mines placed in an area beginning 400 meters south of ground zero and extending 1,830 meters eastward. Fifteen hours before the detonation, nine project personnel completed placing mines and blast gauges in the shot area. Six hours after the detonation, nine project personnel, a monitor, and a photographer recovered some fuses and placed new fuses in mines 90 to 1,820 meters from ground zero. According to the AEC operations order, at 0800 hours on the next day, nine participants, accompanied by a monitor and a photographer, finished recovering and replacing fuses in the mines for the next test (31; 44).

Project 4.1, Radiation Dosimetry, was conducted by the Naval Medical Research Institute. The objectives were to:

- Measure the ionization produced by gamma radiation at various depths in the ground
- Correlate laboratory measurements with field measurements.

Fifteen hours before the detonation, five project personnel finished placing radiation detectors 610 to 2,290 meters from ground zero. Five participants and a monitor left the Control

Point three hours after the detonation to recover the detectors (18; 31).

Project 4.3, Flash Blindness, was conducted by the Air Force School of Aviation Medicine. The objectives were to evaluate the:

- Visual handicap that might be expected if military personnel were exposed to the flash of a nuclear detonation
- Effectiveness of goggles developed to protect the eyes during exposure to a nuclear flash.

Four hours before the detonation, a C-54 aircraft carrying 17 volunteers flew from Kirtland AFB to be about 15 kilometers south of the target at shot-time. Immediately after the detonation, the volunteers who had viewed the flash of the nuclear detonation performed a number of visual tasks. The aircraft then returned to Kirtland AFB (7; 31).

Project 6.1b, Evaluation of Dosimetric Materials, was conducted by the Signal Corps Engineering Laboratories and the Bureau of Ships. The objective was to field-test several personnel dosimeters. Fifteen hours before the detonation, six project participants finished placing dosimeters inside aluminum shelters 1,190 to 2,100 meters from ground zero. Three hours after the detonation, five project personnel and a monitor left the Control Point to recover dosimeters (11; 31).

Project 6.4, Airborne Radiac Evaluation, was conducted by the Bureau of Aeronautics, Wright Air Development Center, and Air Research and Development Command. The objective was to evaluate the ability of airborne radiation detection equipment to detect a radioactive cloud and to indicate its position relative to the monitoring aircraft. Four and one-half hours before the detonation, an Air Force B-17 and a Navy P2V-2 aircraft left

Kirtland AFB to be about 30 kilometers southwest of the target at shot-time (31; 43).

Project 6.9, Effects of Atomic Detonations on Radio Propagation, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the effects of a nuclear detonation on radio communications at various frequencies. Project personnel made measurements at the Nevada Proving Ground and at Alamo and Beatty, Nevada. The onsite station was 2.4 kilometers from the Control Point and about 11 kilometers from ground zero. This station was not manned, and no shot-day recoveries were required (18; 31).

Project 7.1, Transport of Radiation Debris, was conducted by Headquarters, Air Force, and the Air Weather Service. The objective was to determine the distribution of airborne debris from a nuclear detonation. The Air Weather Service tracked the debris at various distances from the Nevada Proving Ground (1). Cloud tracking is described in section 4.1.3 of this chapter, which discusses Air Force support missions during Shot CHARLIE.

Project 7.2, Long-range Light Measurements, was conducted by the 4925th Test Group and by EG&G. The objective was to study light transmission from a nuclear detonation and to obtain data for the design of long-range detection systems. During shot-time, project participants monitored cameras at several offsite stations in Nevada, Arizona, and New Mexico (8).

Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was performed by Headquarters, Air Force, in conjunction with sampling operations conducted by the 4925th Test Group (Atomic). Project personnel made radiochemical analyses of nuclear bomb debris obtained close to the Nevada Proving Ground (38). Sampling operations are discussed in section 4.1.3 of this chapter.

Project 7.5, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted by the 1009th Special Weapons Squadron, the Naval Ordnance Laboratory, the Acoustics Research Division of the Wright Air Development Center, and the Coast and Geodetic Survey. The objective was to study the seismic waves propagated by a nuclear detonation. Five project stations were positioned ten to 20 kilometers south of ground zero, and other stations were located offsite. Thirteen and one half hours before the detonation, 14 project personnel finished installing seismic recorders at the onsite stations. Fourteen participants left the Control Point to recover seismic records from these stations three hours after the detonation (10; 31).

Project 7.6, Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE, was conducted by the Naval Electronics Laboratory, Signal Corps Engineering Laboratories, and National Bureau of Standards. The objective was to determine the range and reliability of acoustic detection equipment for nuclear detonations of various yields. Project personnel worked at stations in Alaska, California, Florida, Hawaii, Kentucky, New Jersey, Texas, Washington, and Washington, D.C. (32).

Project 8.2, Air Weather Service Participation in Operation BUSTER, was conducted by the 2059th Air Weather Wing and its subordinate unit, the 2060th Mobile Weather Squadron, based at Tinker AFB. The objective was to gather and report information before the detonation regarding such weather factors as wind conditions, temperature, and humidity. Forecasts included estimates of winds at the surface and up to 45,000 feet, the anticipated cloud cover, and the precipitation projected within a radius of 500 kilometers of the target area.

The 73 project participants worked from a weather station at the Control Point and from outlying stations at Tonopah, Warm

Springs, Currant, Pioche, and Alamo, Nevada, and at St. George, Utah. Senior weather personnel gave briefings at the Control Point at 0800, 2000, and 2400 hours on the day preceding the detonation and a final summary just before shot-time (23; 31).

Project 9.1a, FCDA Family Shelter Evaluation, was performed by the Federal Civil Defense Administration. The project evaluated the effects of nuclear blasts on small shelters for family use. Before the shot, project personnel assembled 29 prefabricated shelters made of metal, wood, and brick at ten-meter intervals along an arc 370 meters east of ground zero. Ten project participants finished instrumenting the shelters 15 hours before the detonation. At 0700 hours on the day after the shot, ten participants inspected the shelters (15; 31).

Project 9.1b, AEC Communal Shelter Evaluation, was conducted by the Los Alamos Scientific Laboratory. The objective was to determine the effects of a nuclear detonation on a shelter constructed of conventional materials and buried under several feet of earth. Fifteen hours before the detonation, ten project personnel finished placing dosimeters inside the shelter, about 250 meters southeast of ground zero. Ten participants recovered dosimeters from the shelter at 0700 hours on the day after the detonation (9; 31).

4.1.2 Weapons Development Tests

The Weapons Development Test Unit conducted several projects at Shot CHARLIE. Only one project, however, involved DOD participants: Project 10.4, Radiochemical Results. LASL conducted this activity, the objective of which was to determine the particle makeup of the cloud formed by the detonation. The project required cloud sampling, performed by the 4925th Test Group (Atomic) (39). This activity is discussed in the next section.

4.1.3 Special Weapons Command Activities

The Special Weapons Command provided personnel to control air activities through the Air Operations Center, which coordinated air traffic over the Nevada Proving Ground. SWC personnel airdropped the CHARLIE device. In addition, they conducted cloud-sampling, sample courier, and cloud-tracking missions and aerial surveys for the test units and the Test Manager (20).

The following indicates the types and numbers of aircraft and the estimated numbers of DOD aircrew personnel involved in SWC missions at Shot CHARLIE (13; 14):

ACTIVITY	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Airdrop Mission	B-50	1	9
Disaster Mission	C-47	1	14
Sampling			
Sampler	B-29	3	24
Sampler	T-33	2	4
Sample Courier Missions	B-25 or C-47*	1	5
	B-25	1	5
Cloud Tracking	B-29	2	20
Aerial Surveys	C-47	3	15

*It is not known whether a B-25 or C-47 aircraft conducted this mission.

<u>Airdrop and Disaster Missions</u>

The B-50 drop aircraft, with a crew from the 4925th Test Group (Atomic), left Kirtland AFB, New Mexico, at 0215 hours, which was four hours and 45 minutes before shot-time. Climbing to an altitude of 19,000 feet above the ground, the aircraft entered a bombing pattern over Yucca Flat. The B-50, flying a

straight and level course, released the CHARLIE device, which was detonated at 0700 hours. Shortly thereafter, the aircraft left the shot area and returned to Kirtland AFB.

The C-47 disaster aircraft, with a crew from the 4901st Support Wing (Atomic) and security, radiological safety, and salvage personnel, left Kirtland AFB at 0130 hours and orbited southeast of the NPG during the detonation. At about 0705 hours, the aircraft began its return to Kirtland AFB (14).

Cloud Sampling

Three B-29s and two T-33s were scheduled to collect particulate samples of the cloud for Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, and Project 10.4, Radiochemical Results. The B-29s left Indian Springs AFB about one hour before shot-time and orbited near Las Vegas until the detonation. The two T-33s left Indian Springs about 20 minutes after the detonation. The samplers flew at altitudes of 13,000 to 29,000 feet, made up to seven penetrations of the cloud, and traveled as far as 177 kilometers in a northeasterly direction from ground zero. The following listing presents additional information on four of the samplers; the fifth sampler, a T-33, made no contact with the cloud.

AIRCRAFT TYPE AND SERIAL NUMBER	TOTAL TIME IN CLOUD (seconds)	PEAK INTENSITY (R/h)	DOSIMETER READING (roentgens)
B-29 (285)	150	8.0	0.600
B-29 (599)	NR*	0.16	0.025
B-29 (386)	NR	0.80	0.120
T-33 (920)	NR	3.40	0.080

*NR indicates not reported.

The dosimeter readings in the preceding listing indicate the cumulative exposures recorded by instruments, such as film badges and pocket dosimeters, within the aircraft.

Upon completion of their mission, the samplers returned to Indian Springs AFB and parked in the aircraft decontamination area. The procedures upon landing were the same as those described for Shot BAKER (14; 38; 39).

Courier Missions

After the sampling missions had been completed, several aircraft left Indian Springs AFB or the Yucca Flat airstrip on shot-day to transport filter papers and equipment to various laboratories, primarily AEC and DOE facilities, for analysis. The 4901st Support Wing (Atomic) conducted these courier missions (31).

Cloud Tracking

Two B-29s from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Proving Ground for the test organization and Project 7.1. One B-29 left Indian Springs AFB at 0400 hours. It tracked the cloud at altitudes ranging from 20,000 to 24,000 feet, before returning to base at 1300 hours. The other B-29 departed at 0835 hours and tracked the cloud at an altitude of 20,000 feet. About four hours after the detonation, the second B-29 made contact with the cloud, which it tracked for about four and one-half hours. While attempting to circle the cloud, the B-29 encountered debris and became contaminated to the degree that the instruments read offscale. The aircraft was recalled to base and landed at Indian Springs at 1755 hours (14; 17; 41).

Aerial Surveys

After the detonation, three C-47 aircraft, all based at Indian Springs AFB, conducted onsite survey missions to record radiation intensities. One C-47 flew 500 to 3,000 feet above the terrain from 1150 to 1630 hours. Another C-47, flying 500 to 1,000 feet above the terrain, conducted its survey from 1053 to 1553 hours. The last C-47 flew 500 to 2,000 feet above the terrain from 1040 to 1420 hours (14; 17; 41).

4.2 RADIOLOGICAL PROTECTION AT SHOT CHARLIE

The primary purpose of the radiological protection procedures was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions. The radiological safety information related to Shot CHARLIE includes data on onsite and offsite monitoring procedures, isointensity maps, and decontamination operations coordinated by the test organization.

Monitoring

The initial ground survey began shortly after the detonation. The party made additional surveys of the shot area within the next 24 hours (37).

In addition to the ground survey teams, a helicopter team conducted an aerial survey of Area 7, including the roads leading into the shot area. This survey began about one hour after the detonation.

Based on data obtained from the initial onsite survey, the Test Manager decided to open the shot area for limited recovery operations about two hours after the detonation. Recovery activities began at about 0900 and were completed for the day by 1500 hours. At least one radiological safety monitor accompanied each recovery team (31; 37).

The three C-47 terrain survey aircraft provided onsite and offsite monitoring. In all offsite areas surveyed, they detected maximum gamma intensities lower than 0.0008 R/h (31; 37).

Plotting

Ground monitoring teams provided survey data used in plotting isointensity contours. Figure 4-1 shows the isointensity lines around ground zero one hour after the detonation. This map is based on calculations applying the decay curve for neutron-induced activity in Nevada soil to the results of a survey taken nine hours after the shot. Figure 4-2 presents the results of the actual survey conducted at 1600 hours (16; 37).

Decontamination

Eighteen ground vehicles, three B-29 aircraft, and one T-33 aircraft required decontamination. In these cases, radiation levels were reduced to less than 0.002 R/h by repeated washings with detergent and water (17; 29; 37; 41).

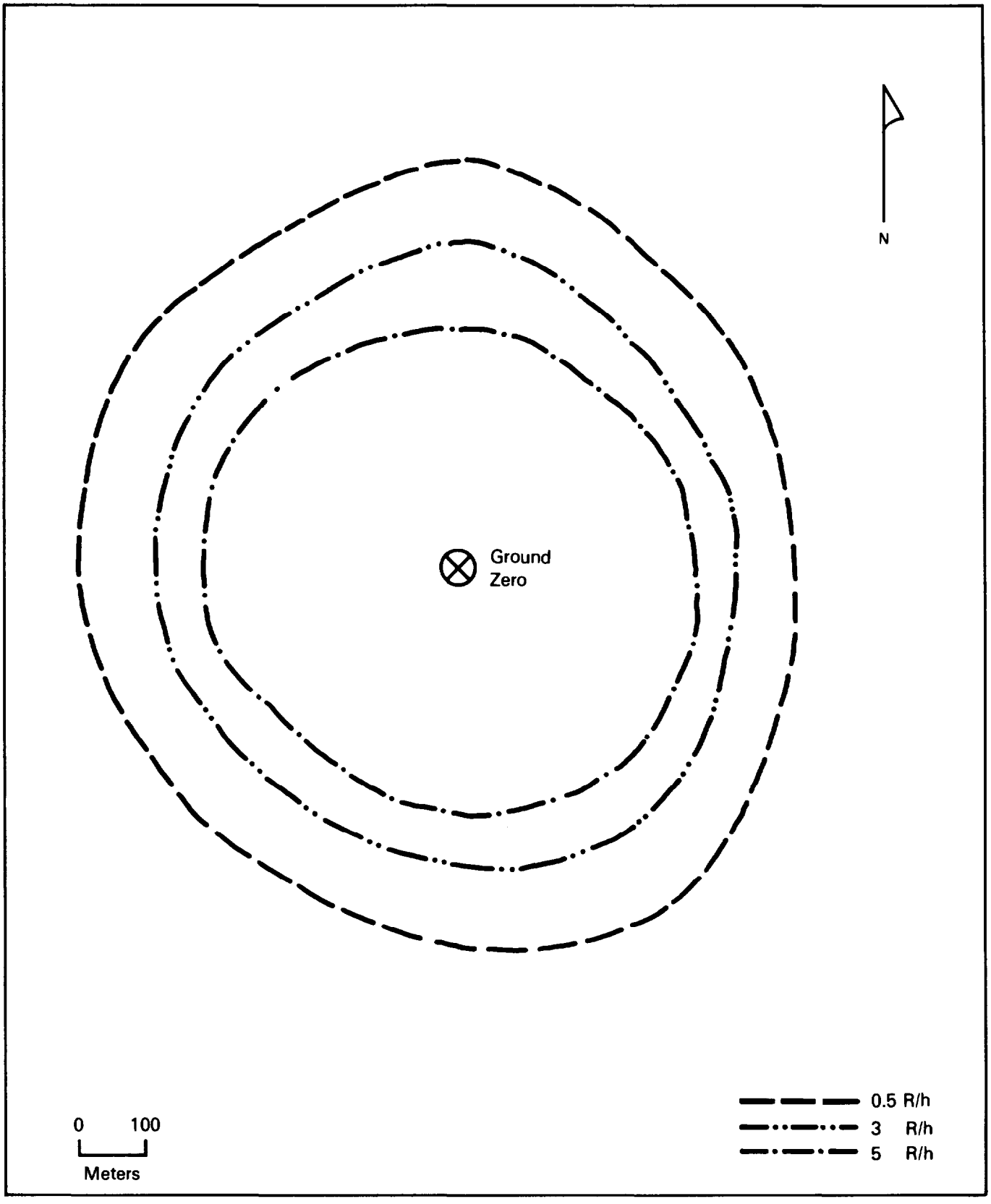

Figure 4-1: ISOINTENSITY MAP FOR SHOT CHARLIE, 31 OCTOBER 1951, CALCULATED FOR ONE HOUR AFTER DETONATION

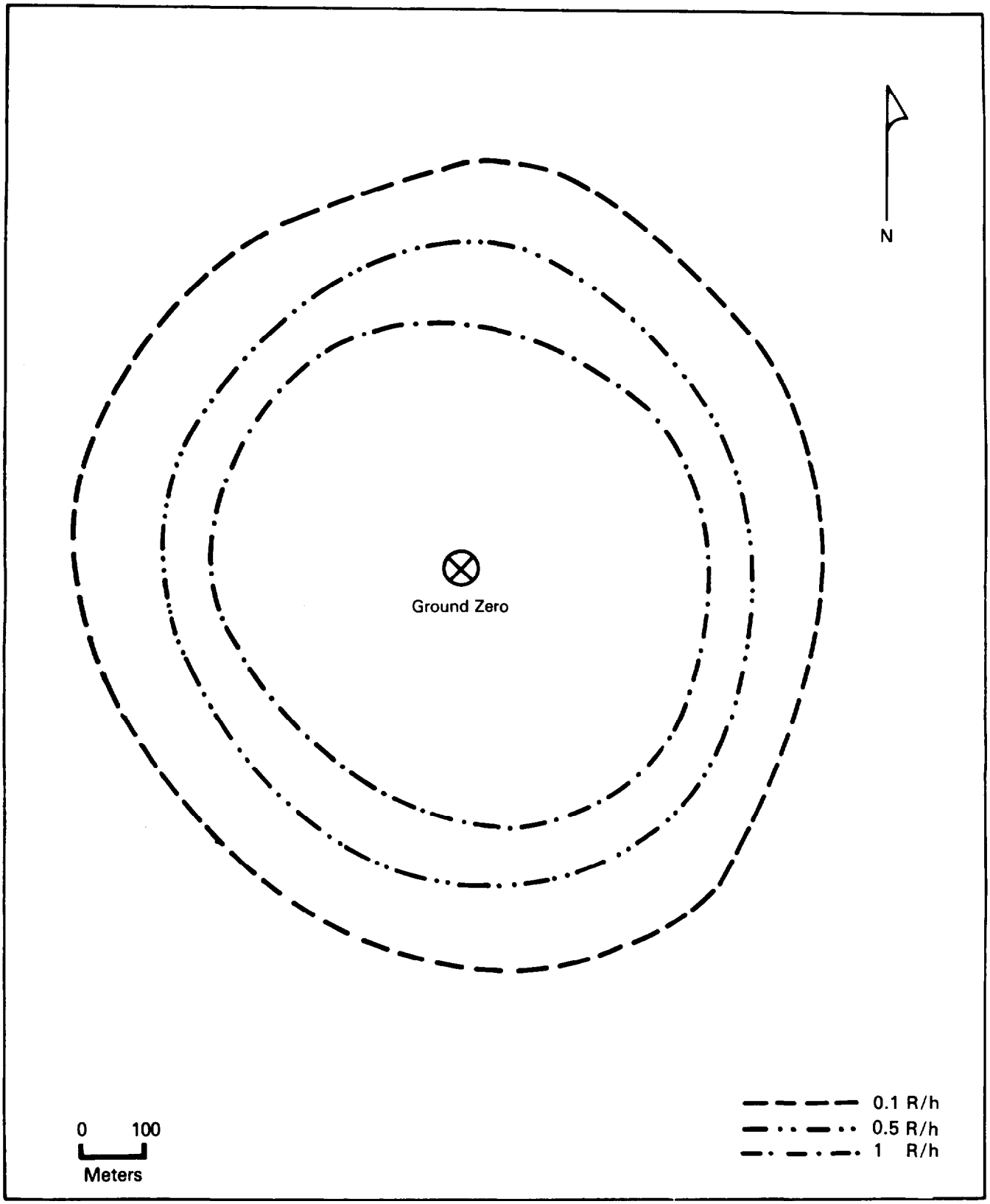

Figure 4-2: SURVEY FOR SHOT CHARLIE, 30 OCTOBER 1951, 1600 HOURS

SHOT DOG SYNOPSIS

AEC TEST SERIES:	BUSTER-JANGLE
DOD EXERCISE:	DESERT ROCK I
DATE/TIME:	1 November 1951, 0730 hours
YIELD:	21 kilotons
HEIGHT OF BURST:	1,417 feet (airdrop)

Purpose of Test: (1) Evaluate a new weapon design
(2) Document basic phenomena produced by the device.

DOD Objectives: To evaluate the utility of the nuclear device for military application, to train a Battalion Combat Team in the tactical use of a nuclear weapon, and to instruct DOD personnel in the effects of a nuclear weapon.

Weather: At shot-time, the temperature was 15.5°C, the relative humidity was 43 percent, and the pressure was 876 millibars. The winds were two knots from the north-northwest at surface level, 32 knots from the northwest at 10,000 feet, 55 knots from the northwest at 20,000 feet, 64 knots from the northwest at 30,000 feet, and 70 knots from the northwest at 40,000 feet.

Radiation Data: Onsite radiation consisted of neutron-induced activity around ground zero. One hour after the shot, radiation intensities ranged from 20 R/h to 2 R/h in the area 290 to 650 meters from ground zero.

Participants: Exercise Desert Rock I troops; Special Weapons Command; Headquarters, Air Force; Bureau of Aeronautics; Air Research and Development Command; Naval Materials Laboratory; Office of the Quartermaster General; Engineer Research and Development Laboratories; Naval Medical Research Institute; Naval Radiological Defense Laboratory; Signal Corps Engineering Laboratories; Bureau of Ships; 1009th Special Weapons Squadron; Naval Ordnance Laboratory; Naval Electronics Laboratory; Lookout Mountain Laboratory; Wright Air Development Center; Office of the Surgeon General; Air Weather Service; Los Alamos Scientific Laboratory; contractors.

CHAPTER 5

SHOT DOG

Shot DOG, an airdropped nuclear device developed by the Los Alamos Scientific Laboratory, was detonated with a yield of 21 kilotons at 0730 hours Pacific Standard Time on 1 November 1951. Figure 5-1 shows the detonation of this fourth nuclear test of Operation BUSTER-JANGLE. The nuclear device was dropped from a B-50 aircraft flying at 235 knots. Shot DOG detonated at a height of 1,417 feet over Area 7, UTM coordinates 871044. The bottom of the Shot DOG cloud reached an altitude of 31,000 feet, while the top attained an altitude of 46,000 feet. The cloud drifted southeast from the point of detonation over southeastern Nevada and northwestern Arizona. Onsite radiation was in the form of neutron-induced activity around ground zero (16).

5.1 EXERCISE DESERT ROCK OPERATIONS

Exercise Desert Rock I operations involved about 3,700 observers and exercise troops at Shot DOG. An additional 2,500 Camp Desert Rock troops, whose activities are discussed in the first part of this section, provided radiological safety, instruction, transportation, communications, and medical services for the exercise in the forward area. Approximately 2,800 personnel from various services took part in the observer activities at Shot DOG. The troop maneuver engaged 883 personnel. Six evaluation teams, each involving an estimated ten participants, took part in tests of military equipment and field fortifications at Shot DOG (2; 21; 26; 30).

Figure 5-1: SHOT DOG, DETONATED AT 0730 HOURS ON 1 NOVEMBER 1951

5.1.1 Camp Desert Rock Personnel

Table 5-1 identifies the service units of Camp Desert Rock troops (21). A minus (-) in a designation indicates that the unit was not fully represented. A plus (+) indicates that the unit was augmented with personnel from other units.

Camp Desert Rock personnel participating in Desert Rock activities at DOG gave administrative, logistical, and operational assistance to the exercise troops. In performing these duties, troops sometimes entered the forward area. Three units particularly involved in shot-day operations were the Control Group, the Radiological Safety Unit, and the Advisory Group.

The Control Group, composed of members of the Camp Desert Rock staff sections, along with military police and signal personnel, accompanied the troops into the forward area. Its duties were to supervise Desert Rock operations and to maintain contact with the Exercise Director.

The Radiological Safety Unit enforced radiological safety criteria and conducted radiation surveys. Its duties included (24; 36):

- Issuing and collecting film badges to be submitted to Signal Corps personnel for processing
- Providing radiological safety monitors to assist AEC monitors
- Conducting radiological surveys after the initial AEC survey
- Accompanying observers, exercise troops, and evaluation teams on their postshot inspections of the equipment displays
- Establishing decontamination stations and procedures.

Table 5-1: SUPPORT UNITS ATTACHED TO CAMP DESERT ROCK, EXERCISE DESERT ROCK I

UNIT	HOME STATION
HEADQUARTERS	
Headquarters and Headquarters Company, III Corps	Camp Roberts, California
Headquarters and Headquarters Battery, III Corps Artillery	Fort Lewis, Washington
ENGINEER	
231st Engineer Combat Battalion	Fort Lewis
359th Engineer Utility Detachment	Camp Cooke, California
90th Engineer Water Supply Company	Fort Lewis
Detachment, 597th Engineer Light Equipment Company	Fort Huachuca, Arizona
Detachment, 705th Engineer Field Maintenance Company	Fort Huachuca
TRANSPORTATION	
4th Transportation Truck Company	Camp Stoneman, California
92nd Transportation Car Company	Camp Roberts
562nd Transportation Staging Area Company	Camp Stoneman
MILITARY POLICE	
Company "A," 505th Military Police Battalion (-)	Camp Roberts
Company "C," 505th Military Police Battalion	Camp Roberts

Table 5-1: SUPPORT UNITS ATTACHED TO CAMP DESERT ROCK, EXERCISE DESERT ROCK I (Continued)

UNIT	HOME STATION
SIGNAL	
Detachment, Headquarters and Headquarters Company, 303rd Signal Service Battalion (+)	Camp Cooke
Detachment, Headquarters and Headquarters Company, Company "B," 314th Signal Service Battalion	Camp Cooke
Detachment, 504th Signal Base Maintenance Company	Sacramento Signal Depot, California
MEDICAL	
Detachment "A," 374th Convalescent Center	Fort Lewis
Detachment "B," 374th Convalescent Center	Fort Lewis
94th Veterinary Food Inspection Detachment	Fort Lewis
ORDNANCE	
393rd Ordnance Battalion	Camp Cooke
161st Ordnance Depot Company (-)	Camp Cooke
3623rd Ordnance Company	Camp Cooke
QUARTERMASTER	
Detachment, Headquarters and Headquarters Company, 53rd Quartermaster Base Depot Company	Utah General Depot
Detachment, 523rd Quartermaster Subsistence Depot Company (-)	Utah General Depot

Table 5-1: SUPPORT UNITS ATTACHED TO CAMP DESERT ROCK, EXERCISE DESERT ROCK I (Continued)

UNIT	HOME STATION
539th Quartermaster Laundry Company	Fort Lewis
621st Quartermaster Service Company	Fort Lewis
ADJUTANT GENERAL	
806th Army Postal Unit	Fort Lewis

The Advisory Group, consisting of three officers from the Armed Forces Special Weapons Project (AFSWP), was assigned to Camp Desert Rock on a temporary basis to provide technical assistance and advice to Desert Rock personnel. Before the shot, the group instructed observers and maneuver troops in nuclear weapons and their effects. After the detonation, these officers briefed the participants as they toured the equipment displays. In addition, they assisted the evaluation teams in assessing data and preparing reports concerning the effects of the detonation on the displays.

Besides the Control Group, the Radiological Safety Unit, and the Advisory Group, several other Desert Rock support elements engaged in activities before shot-day and on the day of the detonation.

Prior to the shot, the 231st Engineer Combat Battalion spent up to five days constructing field fortifications in the display areas. On shot-day, transportation personnel conveyed observers to a location 11 kilometers south of ground zero, where they witnessed the detonation. After the announcement of recovery hour, transportation personnel conveyed observers, exercise troops, and evaluation teams into the shot area (21).

Military police provided traffic control in Camp Desert Rock and at the Nevada Proving Ground during rehearsals and for shot activities. Approximately 160 of thse troops acted as traffic monitors at road junctions and parking areas (21).

Signal Corps personnel established wire and radio communications within the forward area, as well as at Camp Desert Rock. They also processed the film badges worn by participants in Desert Rock activities (21).

The 374th Convalescent Center provided medical support in the forward area and at Camp Desert Rock. During shot-day operations, a medical aid station was established at the observation point, 11 kilometers south of ground zero. Three ambulances remained there until the detonation. After the detonation, two of the ambulances moved forward to Parking Area A at UTM coordinates 845010, shown in figure 5-2 (21).

5.1.2 Observer Activities

Approximately 2,800 personnel from the armed services participated in observer activities at Shot DOG. The participants came from the six continental Army commands; Office, Chief of Army Field Forces; Air Force; Marine Corps; Navy; AFSWP; and various military schools. The largest contingent of observers, 2,300, was from the Army (2; 21; 26).

All observers took part in the same orientation and training activities for the event. In the days immediately preceding the detonation, instructors from the Advisory Group used films and lectures to brief observers on the characteristics of a nuclear detonation and the procedures to follow during a nuclear test. The orientation also involved a rehearsal of shot-day activities, including an inspection of the equipment displays.

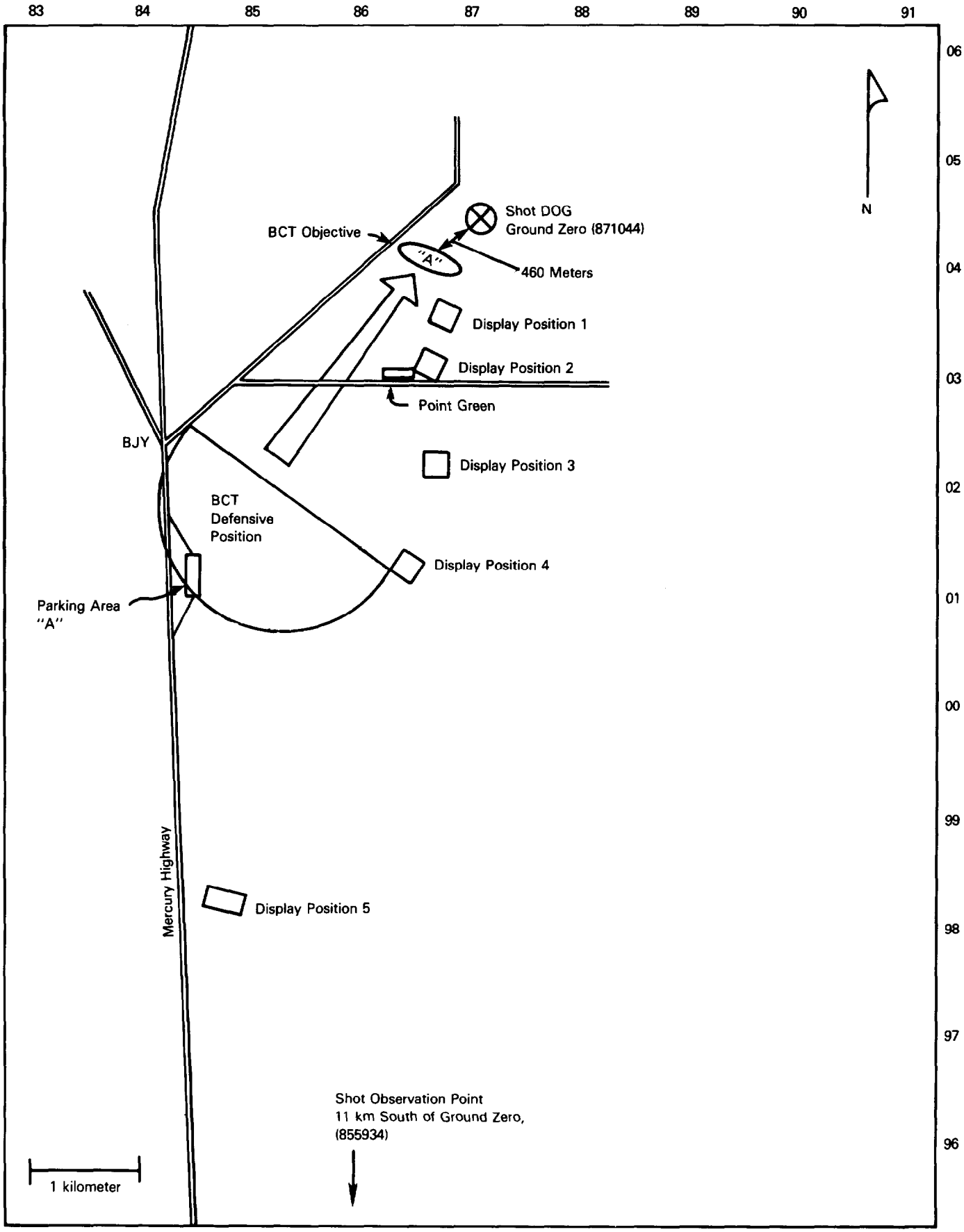

Figure 5-2: DISPLAY AREAS, PARKING AREA, BATTALION COMBAT TEAM OBJECTIVE, AND TACTICAL DEFENSIVE POSITION FOR EXERCISE DESERT ROCK I

At approximately 0530 hours on 1 November, the observers left Camp Desert Rock in a vehicle convoy for a location 11 kilometers south of ground zero, where they would witness the detonation. They arrived at the observation point, indicated in figure 5-2, at about 0615 hours. Advisory Group instructors then conducted a brief preshot orientation. Shortly before the shot, the instructors directed the observers to sit on the ground with their backs toward ground zero. After the initial flash of light from the detonation, which occurred at 0730 hours, the instructors directed observers to turn and view the fireball and resulting cloud.

After the detonation, test organization monitors made helicopter and ground surveys of the display positions. One radiological safety monitor at each of the display positions surveyed the ground and test items before the exercise and observer troops arrived at these positions.

At about 0800 hours, after the forward area was cleared for recovery operations, the observers and Advisory Group, accompanied by radiation monitors, began traveling in a vehicle convoy toward the equipment displays, shown in figure 5-2. They first reached display position 5, 6.4 kilometers south-southwest of ground zero. After leaving the vehicles, the observers then walked through the display with the instructors, who explained the effects of the detonation on the equipment, fortifications, and animals.

The observers and instructors, with the radiation monitors, then proceeded in the vehicles to a parking area designated Point Green, approximately 1,500 meters south-southwest of ground zero, as shown in figure 5-2. Leaving the vehicles, they walked to display position 2, located 1,350 meters south-southwest of ground zero. They then divided into three groups, each of which spent about 15 minutes inspecting the equipment, fortifications,

and animals. Their instructions were to limit their advance to 1,300 meters from ground zero and thus not to proceed north of display position 2. Records indicate that some observers went closer to the site of detonation. Information is not available, however, on their specific movements in the forward area. Data on their exposures, which were only slightly higher than those of other Desert Rock participants, are presented in section 5.3 of this chapter, on radiological protection at DOG.

The observers then proceeded to display positions 3 and 4, located approximately 2,300 meters south-southwest of ground zero. After a briefing at this location, they walked through the combat team defensive position, shown in figure 5-2. They then went to Parking Area A, where they gave their film badges to Chemical Section personnel and entered the trucks for the return to Camp Desert Rock.

One cameraman attached to Camp Desert Rock photographed observer activities for the public information office. The Nellis AFB Photography Laboratory in Nevada processed these photographs (21).

5.1.3 Troop Maneuver

The Army developed the troop maneuver according to the following scenario. An aggressor with overwhelming forces invaded the western United States and pushed friendly forces into retreat. The aggressor then established a line of strong defensive positions that resisted breakthrough by friendly forces using conventional weapons. To gain the offensive and penetrate enemy lines, friendly forces counterattacked with Shot DOG. After the detonation, they advanced to capture the enemy objective.

The maneuver at Shot DOG involved 883 troops from four units (21):

- 1st Battalion, 188th Airborne Infantry Regiment, 11th Airborne Division, Camp Campbell, Kentucky
- 3rd Medical Platoon, 188th Airborne Medical Company, Camp Campbell
- Platoon, Company A, 127th Engineer Battalion, Camp Campbell
- Battery C, 546th Field Artillery Battalion, Fort Lewis, Washington.

Participating troops were organized for the maneuver into a Battalion Combat Team (BCT).

Troops began arriving at Camp Desert Rock on 12 October. From 16 to 19 October, they developed the defensive position, an area 2,300 meters wide and 1,400 meters deep located southwest of ground zero. Figure 5-2 shows the location of the defensive position. Troops did not witness the detonation from this position, which included foxholes, observation posts, and military equipment. The defensive position was to be used to determine the effects of a nuclear detonation on standard field fortifications.

On 16 and 17 October, radiological safety monitors from the Chemical Section trained some BCT personnel as monitors. On 20 October, instructors from the Advisory Group presented an orientation lecture to the troops. Participants rehearsed shot-day activities on 20, 21, and 27 October. As indicated in chapter 3, there is some evidence that troops may have also rehearsed the Shot DOG maneuver at Shot BAKER, on 28 October.

On 31 October, the BCT moved in a convoy of 46 vehicles to the tactical defensive position and placed film badges and individual equipment in locations where troops could be positioned during a nuclear attack. By 1600 hours, most of the

team had left the forward area and begun the return to Camp Desert Rock. By 0230 hours on shot-day, three officers and ten enlisted men who remained to guard the defensive position had also left the area.

Between 0445 and 0500 hours on shot-day, troops received film badges from Chemical Section personnel and boarded trucks for movement to the observation point, 11 kilometers south of ground zero. After reaching the observation point, which they shared with the observers, they received a briefing from the instructors. At shot-time, participants were seated and facing south, away from ground zero. After the detonation, they were directed by instructors to turn and view the fireball and cloud. Figure 5-3 shows troops at the observation point watching the shot.

Within an hour after the detonation, radiological safety monitors from the Chemical Section surveyed the forward area, including the defensive position prepared by the BCT. The monitors determined that the 1 R/h area was 320 meters from ground zero. After receiving the monitors' report, the troops proceeded by truck to Parking Area A, where they were briefed by instructors.

The troops then walked through the defensive position, where they retrieved the film badges and equipment positioned during the previous day. At about 1100 hours, they began their attack. They moved in 15 columns, each accompanied by three BCT radiological safety monitors and preceded by an AFSWP monitor. During their march toward Objective "A," the troops viewed the effects of the nuclear detonation on animals and equipment at some of the display positions. By approximately 1200 hours, they had reached their objective, which was 460 meters southwest of ground zero at its closest point. Each column then turned to the right and proceeded south to display position 1, which was

Figure 5-3: TROOPS AT THE OBSERVATION POINT WATCHING SHOT DOG

900 meters south of ground zero. After inspecting the equipment, they went to position 2, about 1,350 meters south of ground zero. They toured the display and then proceeded to Point Green, where they gave their film badges to Chemical Section personnel. They then boarded trucks, which traveled in a convoy to display position 5, over six kilometers from ground zero. After inspecting display position 5, BCT troops returned to Camp Desert Rock. There is no indication that the troops visited display positions 3 and 4.

The maneuver at Shot DOG also involved an experiment conducted by the Human Resources Research Office (HumRRO), a civilian agency under contract to the Department of the Army. HumRRO investigators studied the psychological reactions of the troops. Investigators were particularly interested in observing troop behavior during the maneuver and measuring the changes in troop attitudes about nuclear weapons before and after participation in the activities. In addition, HumRRO assessed factors governing the amount of information on nuclear testing communicated to home station troops by participants after they returned to their bases. To gain data, HumRRO personnel accompanied one of the attacking columns to the tactical objective (3; 21).

5.1.4 Damage Effects Tests

Six evaluation teams studied the effects of the DOG detonation on military equipment and field fortifications. One team came from each of the following Camp Desert Rock sections: Chemical, Signal, Engineer, Medical, Ordnance, and Quartermaster. Each team was responsible for constructing equipment displays at the five display areas shown in figure 5-2, for recovering test equipment after the detonation, and for preparing a report of its findings.

From one to five days before the detonation, the teams constructed their displays, with the assistance of the 231st

Engineer Combat Battalion. In addition, they instrumented the field fortifications with film badges to indicate the radiation exposure that personnel could have received had they been in those positions during the detonation (21; 48).

On shot-day after the announcement of recovery hour, the teams proceeded to the display areas to evaluate the damage. A radiological monitor accompanied each team to prevent personnel from entering any area with a radiological intensity exceeding 1 R/h. On 3 November, the teams reentered the forward area to retrieve test equipment. The 231st Engineer Combat Battalion, which had constructed the fortifications, recovered materials and equipment used in the fortifications. Recovery personnel were restricted to areas with a radiological intensity of not more than 0.5 R/h.

In preparing their reports, the teams received technical information from the Advisory Group. The LASL Graphic Arts Group provided them with photographs of the weapons effects tests for the reports (21).

5.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT DOG

Department of Defense personnel took part in several scientific projects conducted at Shot DOG by the Weapons Effects Test Unit. They also participated in one project fielded by the Weapons Development Test Unit. Table 5-2 lists the test unit projects by number and title and identifies the participating agencies.

In addition to test unit participation, the DOD provided support to the test units and the Test Manager. These activities involved about 300 DOD project personnel, 300 SWC air and ground personnel, and perhaps an additional 75 DOD personnel working for various units coordinated by the test organization.

Table 5-2: TEST UNIT PROJECTS, SHOT DOG

Project	Title	Participants
	Weapons Effects Tests	
2.2	Thermal and Blast Effects on Idealized Forest Fuels	Division of Fire Research, Forest Service
2.3	Effects of Geometry on Flash Thermal Damage	Naval Material Laboratory
2.4a	Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation	Office of the Quartermaster General; Quartermaster Board; Engineer Research and Development Laboratories
2.4b	Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics	Engineer Research and Development Laboratories
2.4-1	Basic Thermal Radiation Measurements	Naval Radiological Defense Laboratory
2.4-2	The Effect of Thermal Radiation on Materials	Naval Material Laboratory
2.6	Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux	Engineer Research and Development Laboratories
3.5	Minefield Clearance	Engineer Research and Development Laboratories
3.8	Effects of an Atomic Detonation on Aircraft Structures on the Ground	Wright Air Development Center
4.1	Radiation Dosimetry	Naval Medical Research Institute
4.2	Thermal Effects on Animals (Dogs)	Medical College of Virginia; Office of the Surgeon General
4.2a	Thermal Effects on Animals (Rats)	Naval Radiological Defense Laboratory
4.3	Flash Blindness	Air Force School of Aviation Medicine
6.1b	Evaluation of Dosimetric Materials	Signal Corps Engineering Laboratories; Bureau of Ships
6.4	Airborne Radiac Evaluation	Bureau of Aeronautics; Wright Air Development Center; Air Research and Development Command
6.5	Operational Tests of Techniques for Accomplishing IBDA	Wright Air Development Center
6.9	Effects of Atomic Detonations on Radio Propagation	Signal Corps Engineering Laboratories

Table 5-2: TEST UNIT PROJECTS, SHOT DOG (CONTINUED)

Project	Title	Participants
	Weapons Effects Tests (Continued)	
7.1	Transport of Radiation Debris	Headquarters, Air Force; Air Weather Service
7.2	Long-range Light Measurements	4925th Test Group; EG&G
7.3	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	Headquarters Air Force; 4925th Test Group
7.5	Seismic Waves from A-Bombs Detonated over a Land Mass	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
7.6	Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE	Naval Electronics Laboratory; Signal Corps Engineer Laboratory; Naticnal Bureau of Standards
8.2	Air Weather Service Participation in Operation BUSTER	2059th Air Weather Wing; 2060th Mobile Weather Squadron
8.4	Technical Photography for IBDA Project	Lookout Mountain Laboratory
9.1a	FCDA Family Shelter Evaluation	Federal Civil Defense Administration
9.1b	AEC Communal Shelter Evaluation	Los Alamos Scientific Laboratory
	Weapons Development Tests	
10.4	Radiochemical Results	Los Alamos Scientific Laboratory

5.2.1 Weapons Effects Tests

Project personnel spent several weeks before the detonation preparing for the Weapons Effects Test Unit projects. During these weeks, they placed and calibrated various types of instruments and gauges (18).

Project 2.2, Thermal and Blast Effects on Idealized Forest Fuels, was conducted by the Division of Fire Research of the Forest Service. The objective was to study the effects of a nuclear detonation on forests. Project personnel arranged trays of pine needles, hardwood leaves, and grass at six stations 630 to 3,670 meters from ground zero.

Project personnel finished checking and photographing the specimen trays in the shot area 15 hours before the detonation. At the same time, four participants completed a survey of natural vegetation in the area. Eleven hours before the detonation, three personnel began setting timers on cameras at stations 2,130 and 2,740 meters from ground zero, a task that took about two hours.

Four hours after the detonation, five participants, accompanied by a monitor, left the Control Point to inspect and photograph the trays of forest materials. At 0700 hours on the day after the detonation, ten participants began recovering trays from the area (6; 31).

Project 2.3, Effects of Geometry on Flash Thermal Damage, was conducted by the Naval Material Laboratory. The objective was to determine the effect of a target's size, shape, and thermal properties on the thermal damage resulting from a nuclear detonation. Project personnel placed wooden materials at three stations ranging 1,220 to 1,830 meters from ground zero. Fifteen hours before the detonation, five project participants finished checking the materials in the shot area. Five participants,

accompanied by a monitor, left the Control Point four hours after the detonation to inspect and recover the materials. Three participants began removing experimental equipment from the area at 0700 hours on the day following the detonation (31; 34).

Project 2.4a, Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation, was conducted by the Office of the Quartermaster General, the Quartermaster Board, and the Engineer Research and Development Laboratories. This project evaluated the protective value of clothing materials exposed to thermal radiation. Fifteen hours before the detonation, five project personnel finished checking and placing clothing materials and thermal detectors 1,240 to 2,150 meters from ground zero. Four hours after the detonation, five participants and a monitor left the Control Point to inspect, photograph, and retrieve the materials (12; 31).

Project 2.4b, Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics, was conducted by the Engineer Research and Development Laboratories. About 15 hours before the detonation, five project personnel finished checking and placing painted materials, plastics, and fabrics at five positions 610 to 3,660 meters from ground zero. Five participants, accompanied by a monitor, left the Control Point four hours after the detonation to inspect, photograph, and recover the specimens (27; 31).

Project 2.4-1, Basic Thermal Radiation Measurements, was performed by the Naval Radiological Defense Laboratory. The objective was to take thermal measurements at distances from a nuclear detonation where significant thermal damage was expected. Project personnel used thermal detectors to detect and record the thermal pulse. They placed samples of cloth, wood, and paint at distances of 500 to 3,660 meters from ground zero.

Fifteen hours before the detonation, five project participants finished checking thermal detectors in the shot area. Accompanied by a monitor, five project personnel left the Control Point four hours after the detonation to inspect and recover the samples and the data from the thermal detectors. Six project personnel and a monitor left the Control Point at 0700 hours on the day after the detonation to adjust the thermal detectors for use at the next shot (4; 31).

Project 2.4-2, The Effect of Thermal Radiation on Materials, was conducted by the Naval Material Laboratory. The objective was to study the physical characteristics of thermal radiation and its effects on various materials. Fifteen hours before the detonation, five project personnel finished checking thermal detectors and wood, paper, and fabric samples 1,220 to 2,130 meters from ground zero. Four hours after the detonation, five project participants and a monitor left the Control Point to inspect and recover samples and the data from the thermal detectors (28; 31).

Project 2.6, Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux, was conducted by the Engineer Research and Development Laboratories. The objective was to evaluate the protection afforded by field fortifications against the radiation from a nuclear detonation. Approximately 15 hours before the detonation, 12 project personnel and a photographer finished placing film badges inside field fortifications 90 to 2,000 meters southwest of ground zero. Two hours after the detonation, 12 project participants and two monitors left the Control Point to recover the film badges (31; 45).

Project 3.5, Minefield Clearance, was conducted by the Engineer Research and Development Laboratories. The objective was to determine the effects of a nuclear airburst on antitank mines placed in an area beginning 400 meters south of ground zero

and extending 1,830 meters eastward. Fifteen hours before the detonation, nine project personnel finished placing mines and blast gauges in the shot area. Six hours after the detonation, nine project personnel, a monitor, and a photographer recovered some fuses and placed new fuses in mines 90 to 1,820 meters from ground zero. According to the AEC operations order, nine participants, accompanied by a monitor and a photographer, completed recovery of fuses at 0800 hours on the next day (30; 43).

Project 3.8, Effects of an Atomic Detonation on Aircraft Structures on the Ground, was conducted by the Wright Air Development Center. The objective was to determine the structural damage to parked aircraft from the thermal and blast energy of a nuclear detonation. Project personnel tested one B-17 and one F-47 aircraft, which were instrumented with oscillograph recorders. They placed the B-17 1,920 meters south and the F-47 1,300 meters northeast of ground zero (33).

Project 4.1, Radiation Dosimetry, was conducted by the Naval Medical Research Institute. The objectives were to:

- Measure the ionization produced by gamma radiation at various depths in the ground
- Correlate laboratory measurements with field measurements.

Fifteen hours before the detonation, five project personnel finished placing radiation detectors 610 to 2,280 meters from ground zero. Five participants and a monitor left the Control Point three hours after the detonation to recover the detectors (18; 31).

Project 4.2, Thermal Effects on Animals (Dogs), was conducted by the Medical College of Virginia and the Office of the Surgeon General. The primary objective was to determine the

biological relationship between burns produced on dogs in the laboratory and burns caused by a nuclear detonation. The secondary objective was to determine the protection afforded against burns by fabrics used by the military.

Four and one-half hours before the detonation, eight project personnel began anesthetizing six dogs, clothing them in canvas jackets, and placing them in the shot area, 2,130 and 2,740 meters from ground zero. They left the shot area within two and one-half hours. Seven project personnel and a monitor left the Control Point 90 minutes after the detonation to recover the animals (5; 31).

Project 4.2a, Thermal Effects on Animals (Rats), was conducted by the Naval Radiological Defense Laboratory. The objective was to investigate burn damage to rat skin as a function of the thermal energy delivered from a nuclear detonation. Ten hours before the detonation, four project personnel began placing rats in cages positioned 640 to 3,660 meters from ground zero. This activity took about four hours. Six project personnel and a monitor left the Control Point two hours after the shot to recover the animals (31; 35).

Project 4.3, Flash Blindness, was conducted by the Air Force School of Aviation Medicine. The project evaluated the:

- Visual handicap that might be expected if military personnel were exposed to the flash of a nuclear detonation
- Effectiveness of goggles developed to protect the eyes during exposure to a nuclear flash.

A C-54 aircraft carrying an estimated 17 volunteers flew from Kirtland AFB four hours before the detonation to be about 15 kilometers south of the target at shot-time. Immediately after the detonation, participants who had viewed the flash of the

nuclear detonation performed a number of visual tasks. The aircraft then returned to Kirtland AFB (7; 31).

Project 6.1b, Evaluation of Dosimetric Materials, was conducted by the Signal Corps Engineering Laboratories and the Bureau of Ships. The objective was to field-test several personnel dosimeters. Fifteen hours before the detonation, six project participants finished installing dosimeters inside aluminum shelters 1,280 to 2,270 meters from ground zero. Three hours after the detonation, five project personnel and a monitor left the Control Point to recover the dosimeters (11; 31).

Project 6.4, Airborne Radiac Evaluation, was conducted by the Bureau of Aeronautics, Wright Air Development Center, and Air Research and Development Command. The objective was to evaluate the ability of airborne radiation detection equipment to detect a radioactive cloud and to indicate its position relative to the monitoring aircraft. An Air Force B-17 and a Navy P2V-2 aircraft left Kirtland AFB four and one-half hours before the detonation to be about 30 kilometers southwest of the target at shot-time (31; 43).

Project 6.5, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment, was conducted by the Wright Air Development Center. The objective was to test, under operational conditions, radar and photographic equipment as a means of determining ground zero, height-of-burst, and yield of a nuclear detonation. Four and one-half hours before the detonation, one B-29 and two B-50 aircraft, instrumented with radar equipment and cameras, left Kirtland AFB to be in position to accompany the strike aircraft on its bombing run. One B-50 was 2,000 feet above and 60 meters behind the strike aircraft; the other B-50 was 2,000 feet above and 11 kilometers behind the strike aircraft. The B-29 was 1,000 feet below the strike aircraft at a point eight kilometers due south of ground zero at

shot-time. Following the detonation, project participants in the B-29 and the B-50s took photographs and recorded data (22; 31).

Project 6.9, Effects of Atomic Detonations on Radio Propagation, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the effects of a nuclear detonation on radio communications at various frequencies. Project personnel made measurements at the Nevada Proving Ground and at Alamo and Beatty, Nevada. The onsite station was 2.4 kilometers from the Control Point and about 11 kilometers from ground zero. This station was not manned, and no shot-day recoveries were required (40).

Project 7.1, Transport of Radiation Debris, was conducted by Headquarters, Air Force, and the Air Weather Service. The objective was to determine the distribution of airborne debris from a nuclear detonation. The Air Weather Service tracked the debris at various distances from the Nevada Proving Ground (1). Cloud tracking is described in section 5.2.3 of this chapter, which discusses Air Force support missions during Shot DOG.

Project 7.2, Long-range Light Measurements, was conducted by the 4925th Test Group (Atomic) and by EG&G. The objective was to study light transmission from a nuclear detonation and to obtain data for the design of long-range detection systems. During shot-time, project participants monitored cameras at several offsite stations in Nevada, Arizona, and New Mexico (8).

Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was performed by Headquarters, Air Force, in conjunction with sampling operations conducted by the 4925th Test Group (Atomic). Project personnel made radiochemical analyses of nuclear bomb debris obtained close to the Nevada Proving Ground (38). Sampling operations are discussed in section 5.2.3 of this chapter.

Project 7.5, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted by the 1009th Special Weapons Squadron, Naval Ordnance Laboratory, Acoustics Research Division of the Wright Air Development Center, and the Coast and Geodetic Survey. The objective was to study the seismic waves propagated by a nuclear blast. Five stations were positioned ten to 20 kilometers south of ground zero, and other stations were located offsite. Thirteen and one-half hours before the detonation, 14 project personnel finished installing seismic recorders at the onsite stations. Fourteen participants left the Control Point three hours after the detonation to recover seismic records from these stations (10; 31).

Project 7.6, Airborne Low-frequency Sound from the Atomic Explosions during Operation BUSTER and JANGLE, was conducted by the Naval Electronics Laboratory, Signal Corps Engineering Laboratories, and National Bureau of Standards. The objective was to determine the range and reliability of acoustic detection equipment for nuclear detonations of various yields. Project personnel worked at stations in Alaska, California, Florida, Hawaii, Kentucky, New Jersey, Texas, Washington, and Washington, D.C. (32).

Project 8.2, Air Weather Service Participation in Operation BUSTER, was conducted by the 2059th Air Weather Wing and one of its subordinate units, the 2060th Mobile Weather Squadron, from Tinker AFB. The objective was to gather and report information before each detonation regarding such weather factors as wind conditions, temperature, and humidity. Weather forecasts included estimates of the anticipated cloud cover, winds at the surface and up to 45,000 feet, and the precipitation projected within a radius of 500 kilometers of the target area.

The 73 project participants worked from a weather station at the Control Point and from outlying stations at Tonopah, Warm

Springs, Currant, Pioche, and Alamo, Nevada, and at St. George, Utah. Senior weather personnel gave briefings at the Control Point at 0800, 2000, and 2400 hours on the day preceding the detonation and a final summary just before shot-time (23; 31).

Project 8.4, Technical Photography for IBDA Project, was conducted by the Air Force Lookout Mountain Laboratory. The purpose was to provide technical and documentary photography for Project 6.5, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment. Two B-50 aircraft accompanied the bomb delivery aircraft throughout the drop operation. One was 2,000 feet above and 60 meters behind the bomb delivery aircraft, while the other was 2,000 feet above and 11 kilometers behind the delivery aircraft. The 4925th Test Group (Atomic) probably operated the B-50s. A B-29 was positioned eight kilometers due south of ground zero at the time of the detonation. Personnel from the Armament Test Division of Eglin AFB, Florida, operated the B-29. All three aircraft staged out of Kirtland AFB (20; 22).

Project 9.1a, FCDA Family Shelter Evaluation, was performed by the Federal Civil Defense Administration. The project evaluated the effects of a nuclear detonation on small shelters for family use. Before the first shot of the series, project personnel assembled 29 prefabricated shelters made of metal, wood, and brick at ten-meter intervals along an arc 370 meters east of ground zero. Fifteen hours before the detonation, ten project participants finished instrumenting the shelters. Ten participants inspected the shelters at 0700 hours on the next day (15; 31).

Project 9.1b, AEC Communal Shelter Evaluation, was conducted by the Los Alamos Scientific Laboratory. The objective was to determine the effects of a nuclear detonation on a shelter constructed of conventional materials and buried under several

feet of earth. Fifteen hours before the detonation, ten project personnel finished placing dosimeters inside the shelter, located about 250 meters southeast of ground zero, and left the area. Ten participants recovered the dosimeters from the shelter at about 0700 hours the next day (9; 31).

5.2.2 Weapons Development Tests

The Weapons Development Test Unit conducted several projects at Shot DOG. The only project with DOD participants was Project 10.4, Radiochemical Results. This experiment, conducted by LASL, was to determine the particle makeup of the cloud resulting from the detonation (39). The project required cloud sampling, conducted by the 4925th Test Group (Atomic), and is discussed in the next section.

5.2.3 Special Weapons Command Activities

The Special Weapons Command provided personnel to control air activities through the Air Operations Center, which coordinated air traffic over the Nevada Proving Ground. SWC personnel airdropped the DOG device. In addition, they conducted cloud-sampling, sample courier, and cloud-tracking missions and aerial surveys for the test units and the Test Manager (20).

The following information indicates the types and numbers of aircraft and the estimated numbers of DOD aircrew personnel involved in SWC missions at Shot DOG (13; 14):

ACTIVITY	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Airdrop Mission	B-50	1	9
Disaster Mission	C-47	1	14
Sampling			
Sampler	B-29	2	16
Sampler	T-33	2	4
Sample Courier Mission	B-25	2	10
	C-45	1	5
	C-47	1	5
Cloud Tracking	B-29	2	20
Aerial Surveys	C-47	3	15

Airdrop and Disaster Missions

The B-50 drop aircraft, with a crew from the 4925th Test Group (Atomic), left Kirtland AFB at 0215 hours, five hours and 15 minutes before shot-time. Climbing to a height of 19,000 feet above the target area, the aircraft began a bombing pattern over Yucca Flat. The B-50, flying a straight and level course, released the DOG device, which detonated at 0730 hours. Soon after, the aircraft left the shot area and returned to Kirtland AFB.

The C-47 disaster aircraft, with a crew from the 4901st Support Wing (Atomic) and security, radiological safety, and salvage personnel onboard, flew from Kirtland AFB. It orbited southeast of the NPG until after the detonation, when it returned to Kirtland AFB (14).

Cloud Sampling

Two B-29s and two T-33s collected particulate samples of the Shot DOG cloud for Project 7.3, Radiochemical, Chemical, and

Physical Analysis of Atomic Bomb Debris, and Project 10.4, Radiochemical Results. The B-29s left Indian Springs AFB about one hour before the shot and orbited near Las Vegas until the detonation. The two T-33s left Indian Springs about 20 minutes after the detonation. The samplers flew at altitudes of 27,000 to 41,000 feet, made up to nine penetrations of the cloud, and traveled up to 230 kilometers in a southeasterly direction from ground zero. The following gives further details of their sampling mission (14; 17; 41):

AIRCRAFT TYPE AND SERIAL NUMBER	TOTAL TIME IN CLOUD (seconds)	PEAK INTENSITY (R/h)	DOSIMETER READING (roentgens)
B-29 (285)	680	16	0.65
B-29 (599)	NR*	20	0.95
T-33 (920)	NR	22	1.00
T-33 (950)	325	15	0.85

*NR indicates not reported.

The dosimeter readings in the preceding listing indicate the cumulative exposures recorded by instruments, such as film badges and pocket dosimeters, within the aircraft.

Upon completion of their mission, the samplers returned to Indian Springs AFB and parked in the aircraft decontamination area. The procedures upon landing were the same as those described for Shot BAKER (14; 38; 39).

Courier Missions

After the sampling missions had been completed, two B-25s, one C-45, and one C-47 aircraft left Indian Springs AFB on shot-day to transport filter papers and equipment to various

laboratories, primarily AEC and DOD facilities, for analysis. The 4901st Support Wing (Atomic) conducted these courier missions (31).

Cloud Tracking

After the detonation, two B-29s from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Proving Ground for the test organization and Project 7.1, Transport of Radiation Debris. One B-29 took off at 0530 hours, tracked the cloud at altitudes ranging from 17,000 to 20,000 feet, and returned to base at 1800 hours. The other B-29 departed at 1000 hours, tracked the cloud (primarily at an altitude of 20,000 feet), and landed at Indian Springs at 1730 hours (14).

Aerial Surveys

After the detonation, three C-47 aircraft, all based at Indian Springs AFB, conducted onsite survey missions to record radiation intensities. One C-47 flew 500 to 1,000 feet above the ground from 1100 to 1340 hours. Another C-47, flying 600 to 800 feet above the terrain, surveyed the area from 1103 to 1422 hours. The last C-47 flew at 350 to 1,200 feet above the ground from 1107 to 1407 hours (14).

5.3 RADIOLOGICAL PROTECTION AT SHOT DOG

The primary purpose of the radiological protection procedures developed for members of Exercise Desert Rock, the test units, and SWC for Operation BUSTER-JANGLE was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions. The radiological safety information that has been found includes aggregate film badge data for Exercise Desert Rock I participants and film badge readings for some of the test organization personnel at Shot DOG.

5.3.1 Desert Rock Radiological Protection Activities

For the maneuver conducted by members of the 11th Airborne Division and the observers, the Army planned and supplied personnel for radiation protection activities. AFSWP personnel assisted the Army in these activities (24; 36).

Dosimetry

The Radiological Safety Unit issued film badges to maneuver troops, observers, and Desert Rock personnel entering the area forward of the Control Point at Yucca Pass. Section personnel distributed badges to maneuver troops and observers on 31 October, the day before the detonation. After the maneuver, section personnel collected badges in the forward area before troops and observers boarded trucks for the return to camp. There was no central point for issuing badges to Desert Rock personnel. While some badges were distributed the day before the shot, others were issued in the forward area on shot-day. Section personnel collected the film badges after participants returned to camp. The following table from the Exercise Desert Rock I Final Report shows the number of badges worn and the radiation levels indicated (21):

Maneuver Troops

Badges worn:	883
Badges reported:	863
Percentage reported:	97.7%
Maximum reading:	0.20 roentgens (R)
Minimum reading:	0.02 R
Average reading:	0.059 R

Observers

Badges worn:	2,796
Badges reported:	2,714
Percentage reported:	97.2%
Maximum reading:	0.32 R
Minimum reading:	less than 0.02 R
Average reading:	0.031 R (includes only those readings of at least 0.02 R, which accounted for 87.2% of the observers' readings)

Desert Rock Personnel

Badges worn:	1,587
Badges reported:	1,523
Percentage reported:	96.6%
Maximum reading:	0.225 R
Minimum reading:	less than 0.02 R
Average reading:	Not computed because Desert Rock personnel had diverse responsibilities.

A Signal Corps mobile laboratory processed the film badges (21).

Monitoring

On 16 October 1951, three officers and 12 enlisted radiological safety monitors reported to Camp Desert Rock from the Chemical Corps School, Fort McClellan, Alabama. In the days preceding the detonation, these personnel trained 45 monitors from the 1st Battalion, 188th Airborne Infantry Regiment, and 15 monitors from the service units attached to Camp Desert Rock and participating in the exercise.

On shot-day, after the detonation, test organization monitors first surveyed the shot area from a helicopter. Then the newly trained monitors surveyed the shot area to evaluate the residual radiation and to determine safe routes of advance for the troops. Participants in the Desert Rock activities were not to enter areas with radiation intensities exceeding 1 R/h. Monitors operating from 1/4-ton trucks then conducted two ground surveys. Within an hour after the detonation, the survey parties took the following readings (21):

DISTANCE FROM GROUND ZERO (meters)	ONE HOUR AFTER DETONATION	THREE HOURS AFTER DETONATION
1,350 (display area 2)	0.01 R/h	NR*
900 (display area 1)	0.03 R/h	0.02 R/h
675	0.14 R/h	0.09 R/h
450	0.80 R/h	0.39 R/h
320	1.00 R/h	NR
225	NR	1.00 R/h

*NR indicates not reported.

After the initial readings were taken, the monitors accompanied troops on their maneuver in the forward area and surveyed the area repeatedly. One monitor from the service sections attached to Camp Desert Rock monitored the ground and all items at the display areas (21).

Decontamination

On 15 October 1951, an officer proficient in decontamination procedures reported to Camp Desert Rock from the Chemical Section, Headquarters Sixth Army. The officer trained eight individuals in personnel and equipment monitoring and in decontamination procedures. These eight individuals then established and operated a decontamination station near the exercise location. Immediately after the exercise, the decontamination personnel monitored at the station all participants who had gone closer to ground zero than display area 2, 1,350 meters from ground zero. They found that none of these participants had a reading exceeding the limit of 0.02 R/h (21).

5.3.2 Test Organization Radiological Protection Activities

The Radiological Health and Safety Group, consisting of personnel from LASL, from the armed services, and from various other civilian groups, developed and conducted radiation protection activities at Shot DOG.

Dosimetry

Two Air Force personnel from the 4925th Test Group received cumulative gamma exposures over 3.9 roentgens. These personnel were involved with cloud-sampling activities and may have been pilots or crew members of the sampling aircraft. They had gamma exposures of 4 and 4.4 roentgens (47).

Monitoring

Radiological safety teams began the initial ground survey shortly after the detonation (37). This survey preceded the surveys done by Desert Rock monitors.

In addition to the ground survey teams, a team in one helicopter conducted an aerial survey of the shot area. This survey began about 20 minutes after the detonation. Approximately 40 minutes later, a second helicopter with one radiological safety monitor aboard made another survey of the shot area, including all roads leading into Area 7.

After the teams completed the initial ground and aerial surveys, the Test Manager opened the shot area for limited recovery operations. Recovery parties, each of which was accompanied by a radiological safety monitor, began their operations at about 0930 and completed their work by 1330 hours.

The three C-47 aerial survey aircraft provided offsite monitoring. The gamma intensities measured by the aerial survey teams in offsite areas were all lower than 0.0003 R/h (31; 37).

Plotting

Ground monitoring teams provided survey data used in plotting isointensity contours. Figure 5-4 shows the isointensity lines around ground zero one hour after the detonation. This map is based on calculations applying the decay curve for neutron-induced activity in Nevada soil to the results of a survey taken 25 and one-half hours after the shot. Figure 5-5 presents the results of that survey (16; 37).

Decontamination

Five ground vehicles and four aircraft, two B-29s and two T-33s, required decontamination. In these cases, radiation levels were reduced to less than 0.002 R/h by repeated washings with detergent and water (17; 29; 37; 41).

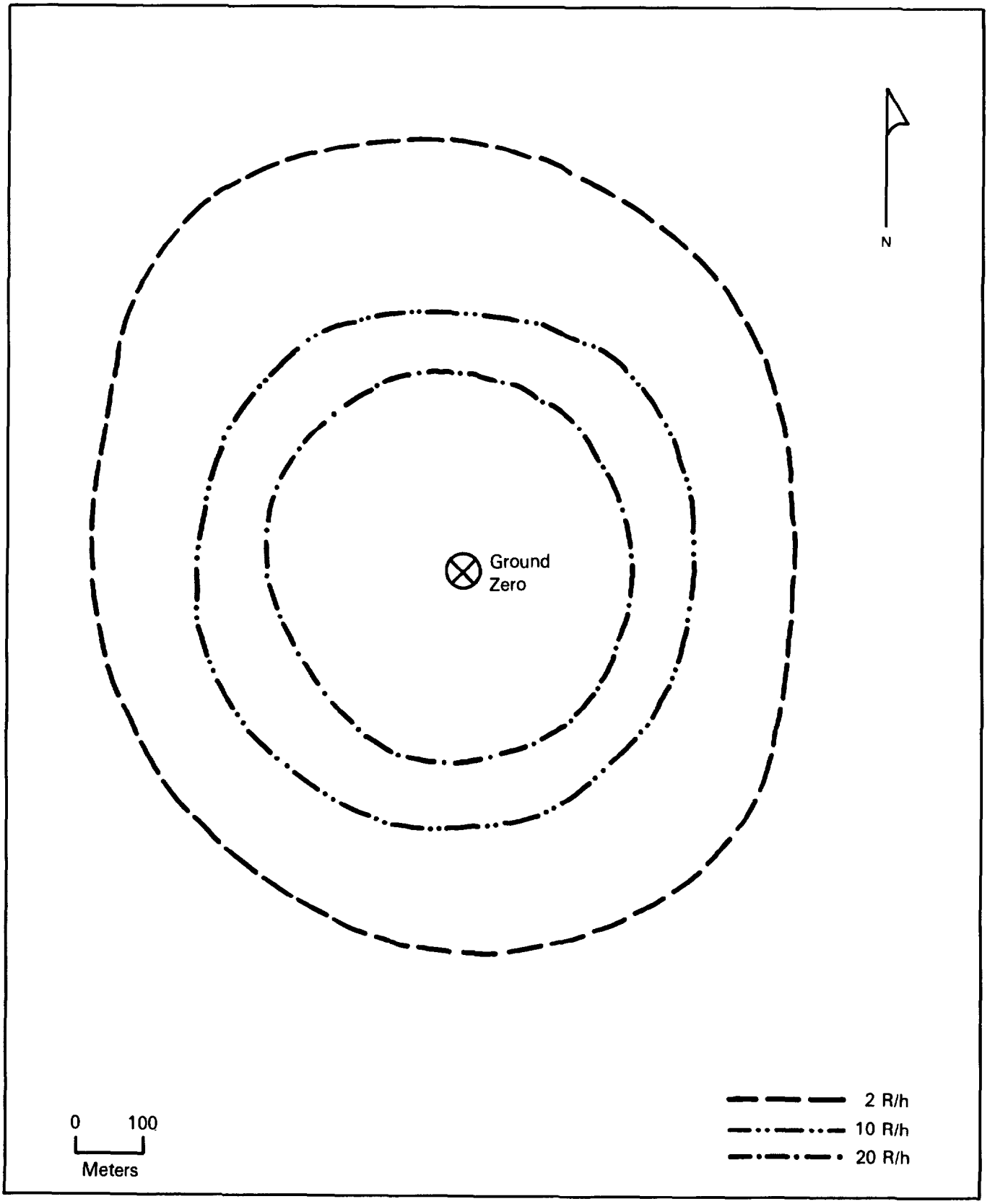

Figure 5-4: ISOINTENSITY MAP FOR SHOT DOG, 2 NOVEMBER 1951, CALCULATED FOR ONE HOUR AFTER DETONATION

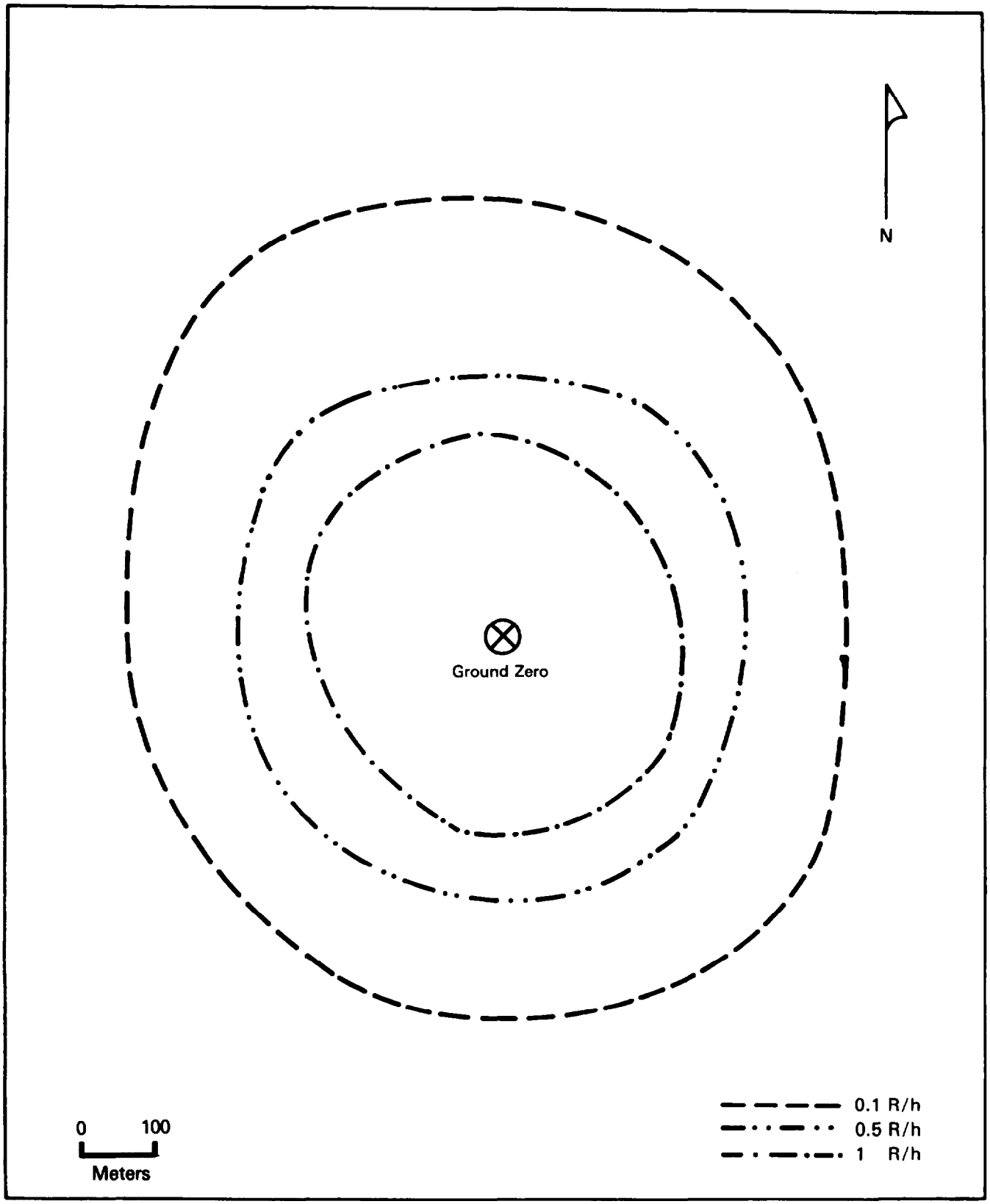

Figure 5-5: SURVEY FOR SHOT DOG, 2 NOVEMBER 1951, 0900 HOURS

SHOT EASY SYNOPSIS

AEC TEST SERIES:	BUSTER-JANGLE
DOD EXERCISE:	None
DATE/TIME:	5 November 1951, 0830 hours
YIELD:	31 kilotons
HEIGHT OF BURST:	1,314 feet (airdrop)

Purpose of Test: (1) Evaluate a new weapon design
(2) Document basic phenomena produced by the device.

DOD Objective: To evaluate the utility of the nuclear device for military application.

Weather: At shot-time the temperature was 11.3°C, the relative humidity was 17 percent, and the pressure was 878 millibars. The winds were 13 knots from the north-northeast at the surface, 19 knots from the northwest at 20,000 feet, 27 knots from the north at 30,000 feet, and 45 knots from the north-northwest at 40,000 feet.

Radiation Data: Onsite radiation consisted of neutron-induced activity around ground zero. Twenty-four hours after the shot, radiation intensities ranged from 1 R/h to 0.1 R/h in the area 440 to 810 meters from ground zero.

Participants: Los Alamos Scientific Laboratory; Special Weapons Command; Headquarters, Air Force; Naval Radiological Defense Laboratory; Engineer Research and Development Laboratories; Bureau of Aeronautics; Air Research and Development Command; Signal Corps Engineering Laboratories; 1009th Special Weapons Squadron; Naval Electronics Laboratory; Air Weather Service; Wright Air Development Center; Lookout Mountain Laboratory; contractors.

CHAPTER 6

SHOT EASY

Shot EASY, the last airdropped nuclear device of Operation BUSTER-JANGLE, was detonated with a yield of 31 kilotons at 0830 hours Pacific Standard Time on 5 November 1951. Developed by the Los Alamos Scientific Laboratory, the nuclear device was dropped from a B-45 aircraft. Shot EASY detonated 1,314 feet above Area 7, UTM coordinates 867053. The bottom of the Shot EASY cloud reached an altitude of 35,000 feet, while the top attained an altitude of 50,000 feet. The cloud drifted south-southeast from the point of detonation. Onsite radiation consisted of neutron-induced activity around ground zero (16).

6.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT EASY

Department of Defense personnel took part in scientific projects conducted by the Weapons Effects Test Unit, discussed in the first part of this section. They also participated in one study conducted by the Weapons Development Test Unit. Table 6-1 lists the test unit projects by number and title and identifies the participating organizations.

In addition to test unit participation, the DOD provided support to the test units and the Test Manager. The activities discussed in this section involved about 200 DOD project personnel, 300 SWC air and ground personnel, and perhaps an additional 50 DOD personnel working for various units coordinated by the test organization.

Table 6-1: TEST UNIT PROJECTS, SHOT EASY

Project	Title	Participants
	Weapons Effects Tests	
2.2	Thermal and Blast Effects on Idealized Forest Fuels	Division of Fire Research, Forest Service
2.4-1	Basic Thermal Radiation Measurements	Naval Radiological Defense Laboratory
3.5	Minefield Clearance	Engineer Research and Development Laboratories
3.8	Effects of an Atomic Detonation on Aircraft Structures on the Ground	Wright Air Development Center
3.9	Effects on Selected Water Supply Equipment	Engineer Research and Development Laboratories
4.1	Radiation Dosimetry	Naval Medical Research Institute
6.4	Airborne Radiac Evaluation	Bureau of Aeronautics; Wright Air Development Center; Air Research and Development Command
6.5	Operational Tests of Techniques for Accomplishing IBDA	Wright Air Development Center
6.9	Effects of Atomic Detonations on Radio Propagation	Signal Corps Engineering Laboratories
7.1	Transport of Radiation Debris	Headquarters Air Force; Air Weather Service
7.2	Long-range Light Measurements	4925th Test Group; EG&G
7.3	Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force; 4925th Test Group
7.5	Seismic Waves from A-Bombs Detonated over a Land Mass	1009th Special Weapons Squadron; Naval Ordnance Laboratory; Wright Air Development Center; Coast and Geodetic Survey
7.6	Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE	Naval Electronics Laboratory; Signal Corps Engineering Laboratories; National Bureau of Standards
8.2	Air Weather Service Participation in Operation BUSTER	2059th Air Weather Wing; 2060th Mobile Weather Squadron
8.4	Technical Photography for IBDA Project	Lookout Mountain Laboraory
9.1b	AEC Communal Shelter Evaluation	Los Alamos Scientific Laboratory
	Weapons Development Tests	
10.4	Radiochemical Results	Los Alamos Scientific Laboratory

6.1.1 Weapons Effects Tests

As table 6-1 indicates, the Weapons Effects Test Unit conducted a number of projects at Shot EASY. Project participants spent several weeks before the detonation positioning and checking various types of instruments and gauges (18).

Project 2.2, Thermal and Blast Effects on Idealized Forest Fuels, was conducted by the Division of Fire Research of the Forest Service. The objective was to study the effects of a nuclear detonation on forests. Project personnel arranged and photographed trays of pine needles, hardwood leaves, and grass at six stations 1,420 to 4,400 meters from ground zero. Fifteen hours before the detonation, four project participants finished surveying the natural vegetation of the shot area. Four participants, accompanied by a monitor, left the Control Point six hours after the detonation to inspect, photograph, and recover the trays of forest materials (6; 31).

Project 2.4-1, Basic Thermal Radiation Measurements, was performed by the Naval Radiological Defense Laboratory. The objective was to take thermal measurements at distances from a nuclear detonation where significant thermal damage was expected. Project personnel used thermal detectors to detect and record the thermal pulse. They placed samples of cloth, wood, and paint at distances ranging from 500 to 3,660 meters from ground zero. Six project participants finished checking thermal instruments in the shot area 15 hours before the detonation. Four hours after the detonation, five participants, accompanied by a monitor, left the Control Point to recover the samples and the data from the thermal detectors (4; 31).

Project 3.5, Minefield Clearance, was conducted by the Engineer Research and Development Laboratories. The objective

was to determine the effects of a nuclear airburst on antitank mines placed in an area beginning about 900 meters southeast of ground zero and extending 1,830 meters eastward. Fifteen hours before the detonation, nine project personnel finished placing the mines and blast gauges in the shot area. Six hours after the detonation, nine project personnel, a monitor, and a photographer began recovering fuses and placing new fuses in mines 90 to 1,820 meters from ground zero. According to the AEC operations order, at 0800 hours on the next day, nine participants, accompanied by a monitor and a photographer, completed recovering fuses and placing new fuses in the mines (31; 44).

Project 3.8, Effects of an Atomic Detonation on Aircraft Structures on the Ground, was conducted by the Wright Air Development Center. The objective was to determine the structural damage to parked aircraft from the thermal and blast energy of a nuclear detonation. Project personnel tested one B-17 and one F-47 aircraft, which were instrumented with oscillograph recorders. They placed the B-17 1,780 meters southeast and the F-47 820 meters east of ground zero. Project participants recovered the instruments after the detonation (33).

Project 3.9, Effects on Selected Water Supply Equipment, was performed by the Engineer Research and Development Laboratories. The project determined the:

- Blast and thermal damage to 3,000-gallon tanks filled with water
- Radioactivity of water in the tanks
- Amount of induced radioactivity in canned samples of sea water in various dilutions and in bottles of assorted fresh water.

Fifteen hours before the detonation, six project participants completed filling the water tanks positioned 460 to 3,930 meters southwest of ground zero. Three hours after the detonation, six

participants, a monitor, and a photographer inspected and photographed the tanks (25; 31).

Project 4.1, Radiation Dosimetry, was conducted by the Naval Medical Research Institute. The objectives were to:

- Measure the ionization produced by gamma radiation at various depths in the ground
- Correlate laboratory measurements with field measurements.

Fifteen hours before the detonation, five project personnel finished placing radiation detectors 610 to 2,290 meters from ground zero. Three hours after the detonation, five participants and a monitor left the Control Point to recover the detectors (18; 31).

Project 6.4, Airborne Radiac Evaluation, was conducted by the Bureau of Aeronautics, Wright Air Development Center, and Air Research and Development Command. The objective was to evaluate the ability of airborne radiation detection equipment to detect a radioactive cloud and to indicate its position relative to the monitoring aircraft. Four and one-half hours before the detonation, an Air Force B-17 and a Navy P2V-2 aircraft left Kirtland AFB to be about 30 kilometers southwest of the target at shot-time (31; 43).

Project 6.5, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment, was conducted by the Wright Air Development Center. The objective was to test, under operational conditions, radar and photographic equipment as a means of determining ground zero, height-of-burst, and yield of a nuclear detonation. With measurements gathered by strike aircraft, it would then be possible to assess the effect of the nuclear detonation on enemy installations.

Four and one-half hours before the detonation, one B-29 and two B-50 aircraft, instrumented with radar equipment and cameras, left Kirtland AFB to be in position to accompany the strike aircraft on its bombing run. One B-50 was 2,000 feet above and 60 meters behind the strike aircraft; the other was 2,000 feet above and 11 kilometers behind the strike aircraft. The B-29 was 1,000 feet below the strike aircraft at a point eight kilometers due south of ground zero at shot-time. Following the detonation, project participants in the B-29 and the B-50s took photographs and recorded data (22; 31).

Project 6.9, Effects of Atomic Detonations on Radio Propagation, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the effects of a nuclear detonation on radio communications at various frequencies. Project personnel made measurements at the Nevada Proving Ground and at Alamo and Beatty, Nevada. The onsite station was 2.4 kilometers from the Control Point and about 11 kilometers from ground zero. This station was not manned, and no shot-day recoveries were required (18; 31).

Project 7.1, Transport of Radiation Debris, was conducted by Headquarters, Air Force, and the Air Weather Service. The objective was to determine the distribution of airborne debris from a nuclear detonation. The Air Weather Service tracked the debris at various distances from the Nevada Proving Ground. In addition, project personnel conducted surface sampling at 50 offsite stations (1). Cloud tracking is described in section 6.1.3 of this chapter, which discusses Air Force support missions during Shot EASY.

Project 7.2, Long-range Light Measurements, was conducted by the 4925th Test Group (Atomic) and by EG&G. The objective was to study light transmission from a nuclear detonation and to obtain data for the design of long-range detection systems. During

shot-time, project participants monitored cameras at several offsite stations in Nevada, Arizona, and New Mexico (8).

Project 7.3, Radiochemical, Chemical, and Physical Analysis of Atomic Bomb Debris, was performed by Headquarters, Air Force, in conjunction with sampling operations conducted by the 4925th Test Group (Atomic). Project personnel made radiochemical analyses of nuclear bomb debris obtained near the Nevada Proving Ground. Sampling operations are discussed in section 6.1.3 (38).

Project 7.5, Seismic Waves from A-Bombs Detonated over a Land Mass, was conducted by the 1009th Special Weapons Squadron, the Naval Ordnance Laboratory, the Acoustics Research Division of the Wright Air Development Center, and the Coast and Geodetic Survey. The objective was to study the propagation of seismic waves by a nuclear detonation. Five project stations were positioned ten to 20 kilometers south of ground zero, and other stations were located offsite.

Thirteen and one-half hours before the detonation, 14 project personnel finished installing seismic recorders at the onsite stations. Fourteen participants left the Control Point three hours after the detonation to recover seismic records from these stations (10; 31).

Project 7.6, Airborne Low-frequency Sound from the Atomic Explosions during Operations BUSTER and JANGLE, was conducted by the Naval Electronics Laboratory, Signal Corps Engineering Laboratories, and National Bureau of Standards. The objective was to determine the range and reliability of acoustic detection equipment for nuclear explosions of various yields. Project personnel worked at stations in Alaska, California, Florida, Hawaii, Kentucky, New Jersey, Texas, Washington, and Washington, D.C. (32).

Project 8.2, Air Weather Service Participation in Operation BUSTER, was conducted by the 2059th Air Weather Wing and one of its subordinate units, the 2060th Mobile Weather Squadron, from Tinker AFB. The objective was to gather and report information before the detonation regarding such weather factors as wind conditions, temperature, and humidity. Weather forecasts included estimates of the anticipated cloud cover, winds at the surface and up to 45,000 feet, and the precipitation projected within a radius of 500 kilometers of the shot area.

The 73 project participants worked from a weather station at the Control Point and from outlying stations at Tonopah, Warm Springs, Currant, Pioche, and Alamo, Nevada, and at St. George, Utah. Senior weather personnel gave briefings at the Control Point at 0800, 2000, and 2400 hours on the day preceding the detonation and a final summary just before shot-time (23; 31).

Project 8.4, Technical Photography for IBDA Project, was conducted by the Air Force Lookout Mountain Laboratory. The purpose was to provide technical and documentary photography for Project 6.5, Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment. Two B-50 aircraft, probably operated by the 4925th Test Group (Atomic), accompanied the bomb delivery aircraft throughout the drop operation. One was 2,000 feet above and 60 meters behind the bomb delivery aircraft, while the other was 2,000 feet above and 11 kilometers behind. A B-29 was positioned eight kilometers due south of ground zero at the time of detonation. The B-29 was manned by personnel from the Armament Test Division of Eglin AFB, Florida. All three aircraft staged out of Kirtland AFB (20; 22).

Project 9.1b, AEC Communal Shelter Evaluation, was conducted by the Los Alamos Scientific Laboratory. The objective was to determine the effects of a nuclear detonation on a shelter constructed of conventional materials and buried under about three

feet of earth. Fifteen hours before the detonation, ten project personnel finished placing dosimeters inside the shelter, located about 250 meters southeast of ground zero. At 0700 hours on the next day, ten participants began recovering the dosimeters from the shelter (9; 31).

6.1.2 Weapons Development Tests

The Weapons Development Test Unit conducted several projects at Shot EASY. Only one project, however, involved DOD participants: Project 10.4, Radiochemical Results. LASL conducted this activity, the objective of which was to determine the particle makeup of the cloud resulting from Shot EASY. The project required cloud sampling, conducted by the 4925th Test Group (Atomic) (39). This activity is discussed in the next section.

6.1.3 Special Weapons Command Activities

The Special Weapons Command provided personnel to control air activities through the Air Operations Center, which coordinated air traffic over the Nevada Proving Ground. SWC personnel airdropped the EASY device. In addition, they conducted cloud-sampling, sample courier, and cloud-tracking missions and aerial surveys for the test units and the Test Manager (20).

The following listing indicates the types and numbers of aircraft and the estimated numbers of DOD aircrew personnel involved in SWC missions at Shot EASY (13; 14):

ACTIVITY	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Airdrop Mission	B-45	1	4
Disaster Mission	C-47	1	14
Sampling			
Sampler	B-29	2	16
Sampler	T-33	3	6
Sample Courier	B-25 or C-47*	1	5
Mission	B-25	1	5
Cloud Tracking	B-29	3	30
Aerial Surveys	C-47	3	15

*It is not known whether a B-25 or C-47 aircraft conducted this mission.

Airdrop and Disaster Missions

The B-45 drop aircraft, with a crew from the 4925th Test Group (Atomic) and security, radiological safety, and salvage personnel onboard, left Kirtland AFB at 0600 hours, two hours and 30 minutes before shot-time. Climbing to 24,000 feet above the target area, the aircraft began a bombing pattern over Yucca Flat. The B-45, flying a straight and level course, released the EASY device, which detonated at 0830 hours. Soon after, the aircraft left the shot area and returned to Kirtland AFB.

The C-47 disaster aircraft, also with a crew from the 4901st Support Wing (Atomic), left Kirtland AFB at 0315 and orbited southeast of the NPG during the detonation. At 0835 hours, the aircraft began its return to Kirtland AFB (14).

Cloud Sampling

Two B-29s and three T-33s collected particulate samples of the cloud for Project 7.3, Radiochemical, Chemical, and Physical

Analysis of Atomic Bomb Debris, and Project 10.4, Radiochemical Results. The B-29s left Indian Springs AFB about one hour before the shot and orbited near Las Vegas until the detonation. The T-33s left Indian Springs about 20 minutes after the detonation. The samplers flew at altitudes of 30,000 to 40,000 feet, made up to four penetrations of the cloud, and traveled up to 177 kilometers in a southeasterly direction from ground zero. The following listing gives further details of the sampling mission (14; 17; 41):

AIRCRAFT TYPE AND SERIAL NUMBER	TOTAL TIME IN CLOUD (seconds)	PEAK INTENSITY (R/H)	DOSIMETER READING (roentgens)
B-29 (285)	300	1.2	0.03
B-29 (386)	300	40	0.50
T-33 (920)	NR*	32	1.40
T-33 (950)	270	40	0.68
T-33 (951)	60	20	0.88

*NR indicates not reported.

The dosimeter readings noted above indicate the cumulative exposures recorded by instruments, such as film badges and pocket dosimeters, within the aircraft.

Both B-29s experienced difficulties in their flights. One developed engine trouble and could not fly above 31,500 feet. It could not, therefore, obtain good samples of the cloud. The radiological monitor aboard the second B-29 misread the instruments after the aircraft made a sampling pass through the cloud. He reported a reading of 4.5 R/h, rather than the correct reading of 0.45 R/h, to the Control Point. Because the error was not discovered until later, the Control Point instructed the B-29 to return immediately to Indian Springs AFB.

Upon completion of their mission, the samplers returned to Indian Springs AFB and parked in the aircraft decontamination area. The procedures upon landing were the same as those described for Shot BAKER (14; 38; 39).

Courier Missions

After the sampling missions had been completed, several aircraft left Indian Springs AFB on shot-day to transport filter papers and equipment to various laboratories, primarly AEC and DOD facilities, for analysis. The 4901st Support Wing (Atomic) conducted these courier missions (31).

Cloud Tracking

After the detonation, three B-29s from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Proving Ground for the test organization and Project 7.1, Transport of Radiation Debris. One B-29 took off at 0530 hours, tracked the cloud at altitudes ranging from 18,000 to 25,000 feet, and returned to base at 1530 hours. The second B-29 left the base at 0945 hours, tracked the cloud at an altitude of 20,000 feet, and returned at 1835 hours. The third B-29 took off at 1145 hours, tracked the cloud at an altitude of 20,000 feet, and landed at Indian Springs at 1920 hours (14).

Aerial Surveys

After the detonation, three C-47 aircraft, all based at Indian Springs AFB, conducted onsite survey missions to record radiation intensities. One C-47 flew 500 to 1,100 feet above the terrain from 1130 to 1543 hours. Another C-47, flying 600 to 800 feet above the terrain, surveyed the area from 1112 to 1551 hours. The last C-47 flew 500 to 2,800 feet above the terrain from 1157 to 1617 hours (14).

6.2 RADIOLOGICAL PROTECTION AT SHOT EASY

The primary purpose of the radiological protection procedures was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions. The radiological safety information found concerning Shot EASY includes data on onsite and offsite monitoring procedures, isointensity maps, decontamination operations coordinated by the test organization, and film badge readings for some of the test organization personnel at Shot EASY.

Dosimetry

Film badge records indicate that one individual from the 3200th Target Drone Squadron had a total gamma exposure of 3.1 roentgens after his participation at Shot EASY (47). His activities are not known.

Monitoring

The initial ground survey began shortly after the detonation. The teams made additional surveys of the shot area during the next several days (31; 37).

In addition to the ground survey teams, a helicopter team conducted an aerial survey of Area 7, including the roads leading into the shot area. This survey began about 20 minutes after the detonation.

Based on data obtained from the initial onsite surveys, the Test Manager decided to open the shot area for limited recovery operations about two hours after the detonation. Recovery activities began at about 1030 and were completed by 1400 hours. Each recovery team was accompanied by at least one radiological safety monitor.

The three C-47 aerial survey aircraft provided additional offsite monitoring. The aerial survey teams encountered gamma intensities of no more than 0.0017 R/h in all areas surveyed (31; 37).

Plotting

Ground monitoring teams provided survey data used in plotting isointensity contours. Figure 6-1 presents an isointensity plot showing the results of a survey conducted 24 hours after the detonation (37).

Decontamination

Thirty-seven ground vehicles and five aircraft required decontamination. In these cases, radiation levels were reduced to less than 0.002 R/h by repeated washings of the aircraft with detergent and water (17; 29; 37).

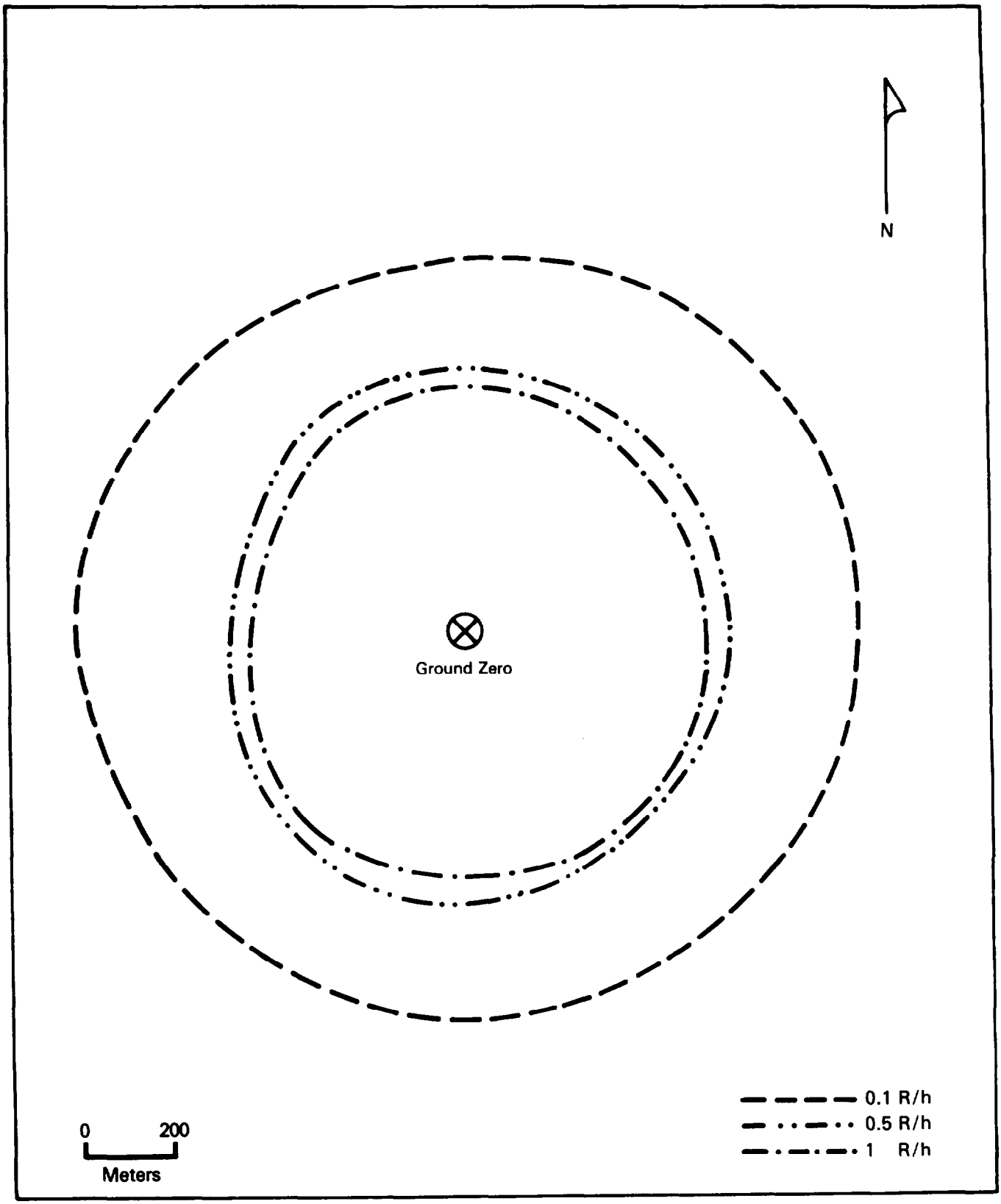

Figure 6-1: SURVEY FOR SHOT EASY, 6 NOVEMBER 1951, 0830 HOURS

REFERENCE LIST

The following list of references represents only those documents consulted in the ABLE through EASY volume. When a DASA-WT or DNA-WT document is followed by an EX, the latest version has been cited. The bibliography of documents consulted during the preparation of all three BUSTER-JANGLE reports is contained in the Operation BUSTER-JANGLE volume.

AVAILABILITY INFORMATION

An availability statement has been included at the end of the reference citation for those readers who wish to read or obtain copies of source documents. Availability statements were correct at the time the bibliography was prepared. It is anticipated that many of the documents marked unavailable may become available during the declassification review process. The Coordination and Information Center (CIC) and the National Technical Information Service (NTIS) will be provided future DNA-WT documents bearing an EX after the report number.

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OPERATION BUSTER-JANGLE
SHOTS ABLE THROUGH EASY REFERENCE LIST

1. Allen, P. W.; et al. Transport of Radioactive Debris from Operation BUSTER and JANGLE, Project 7.1. Headquarters, Air Force. Washington, D. C.: DNA. WT-308-EX. October 1979. 187 Pages. (A09) AD/B951 736.*

2. Atomic Energy Commission, Director of Military Applications. [Correspondence File, Subject: Troop Participation in Atomic Exercises, July - November 1951.] Washington, D. C. 1951. 9 Pages.**

3. Bordes, P. A.; Finan, J. L.; Hochstim, J. R.; et al. Desert Rock I: A Psychological Study of Troop Reactions to an Atomic Explosion. George Washington Univ., Human Resources Research Office. Washington, D. C.: HumRRO. TR-1. 1953. 152 Pages. (A08) AD 006 092.*

4. Broido, A.; et al. Basic Thermal Radiation Measurements, BUSTER Project 2.4-1. Naval Radiological Defense Laboratory. Washington, D. C.: AFSWP. WT-409. June 1952. 100 Pages.***

5. Brooks, J. W.; et al. Thermal Effects on Animals (Dogs), BUSTER Project 4.2. Medical College of Virginia and Office of the Surgeon General. Washington, D. C.: AFSWP. WT-362. June 1952. 81 Pages.***

6. Brown, A. A.; et al. "Thermal and Blast Effects on Idealized Forest Fuels, BUSTER Project 2.2." Forest Service. Washington, D. C.: AFSWP. WT-309. April 1952. 51 Pages. (A04).*

7. Byrnes, V. A. "Flash Blindness, BUSTER Project 4.3." School of Aviation Medicine. Washington, D. C.: AFSWP. WT-341. March 1952. 22 Pages.***

8. Colson, E. A.; Grier, H. E. "Long-Range Light Measurements, BUSTER Project 7.2." Edgerton, Germeshausen and Grier. Washington, D. C.: AFSWP. WT-379. January 1952. 65 Pages.***

*Available from NTIS; order number appears before the asterisk.

**Available at CIC.

***Not available, see Availability Information page.

****Requests subject to Privacy Act restrictions.

9. Corsbie, R. L. AEC Communal Shelter Evaluation, BUSTER Project 9.1b. Atomic Energy Commission. Washington, D. C.: AFSWP. WT-360. March 1952. 83 Pages. (A05) PB 163 429.*

10. Crocker, J. A. Seismic Waves from A-Bombs Detonated over a Land Mass, BUSTER Project 7.5, JANGLE Project 7.2. Headquarters, Air Force. Washington, D. C.: AFSWP. WT-321. March 1952. 123 Pages. (A06).*

11. Cryden, J.; Gibson, F. P. "Evaluation of Dosimetric Materials, BUSTER Project 6.1b." Signal Corps Engineering Laboratories and Navy, Bureau of Ships. Washington, D. C.: AFSWP. WT-317. March 1952. 42 Pages. (A03) AD/A077 496.*

12. Davis, J. M.; Parthum, A. H. Protective Value and Ignition Hazards of Textile Materials Exposed to Thermal Radiation, BUSTER Project 2.4a. Office of the Quartermaster General. Washington, D. C.: AFSWP. WT-312. June 1952. 96 Pages. (A05) AD/A995 133.*

13. Fackler, P. H. Interview with Col. Paul H. Fackler, USAF (Ret.), Subject: CONUS Tests. McLean, VA. April 22, 1981.***

14. Fackler, P. H., Lt. Col., USAF. Technical Air Operations. Air Force Special Weapons Command. Kirtland AFB, NM.: SWC. WT-422. January 1952. 87 Pages.***

15. Flynn, A. P. "FCDA Family Shelter Evaluation, BUSTER Project 9.1a." Federal Civil Defense Administration. Washington, D. C.: AFSWP. WT-359. March 1952.***

16. General Electric Company--TEMPO. Compilation of Local Fallout Data from Test Detonations 1945-1962. Vol. 1: "Continental US Tests." Washington, D. C.: Defense Nuclear Agency. DNA 1251-1(EX.). 1979. 612 Pages. (A99) AD/A079 309.*

17. Gerster, Max. The Special Weapons Center and Atomic Testing. Air Force Special Weapons Center. Kirtland AFB, NM.: AFSWC. K242.04. January 1957. 305 Pages.***

*Available from NTIS; order number appears before the asterisk.

**Available at CIC.

***Not available, see Availability Information page.

****Requests subject to Privacy Act restrictions.

18. Gilbert, H. K.; Wilson, R. Q. "Operation BUSTER, Final Report." Armed Forces Special Weapons Project. Washington, D. C.: AFSWP. WT-412. July 1952. 33 Pages.***

19. Harlan, W. E. "Aerial Survey of Distant Contaminated Terrain, JANGLE Project 2.1C-1." (In: Operation JANGLE, Gamma Radiation Measurements, WT-370, 339 pages.) Headquarters, Air Force. Washington, D. C.: AFSWP. WT-330. June 1952. 27 Pages. (A15) AD/A078 575.*

20. Hatlem, J. C., Lt. Col., USAF. Special Weapons Command Participation in Operation BUSTER-JANGLE. Air Force, Special Weapons Command. Kirtland AFB, NM.: SWC. 1951. 139 Pages.***

21. Headquarters, III Corps. Exercise Desert Rock I. Sixth U. S. Army. Fort MacArthur, CA.: HQS III Corps. 26 June 1952. 125 Pages. (A06) AD/A078 556.*

22. James, F. E. "Operational Tests of Techniques for Accomplishing Indirect Bomb Damage Assessment, BUSTER Project 6.5, JANGLE Project 6.4." Wright Air Development Center. Washington, D. C.: AFSWP. WT-344. March 1952. 56 Pages. (A04) AD/A995 164.*

23. Karstens, E. H. Air Weather Service Participation in Operation BUSTER, BUSTER Project 8.2. Air Weather Service. Washington, D. C.: AFSWP. WT-342. December 1951. 263 Pages. (A12) AD/995 159.*

24. Kean, W. B., MGEN., USA; Tyler, C. L., Manager, SFOO. Memo of Agreement: Agreement Reached between General Kean and C. L. Tyler at a Conference Held at Camp Desert Rock, Nevada, 16 October 1951. III US Corps and AEC. [Camp Desert Rock, NV.: HQS., Camp Desert Rock.] 16 October 1951. 2 Pages.**

25. Lindsten, D. C.; Hansen, C. E. "Effects on Selected Water Supply Equipment, BUSTER Project 3.9." Engineer Research and Development Laboratories. Washington, D. C.: AFSWP. WT-314. April 1952. 36 Pages. (A03) AD 482 983.*

*Available from NTIS; order number appears before the asterisk.

**Available at CIC.

***Not available, see Availability Information page.

****Requests subject to Privacy Act restrictions.

26. Military Liaison Committee. Memorandum for the Chairman, Atomic Energy Committee, Subject: Attendance of Military Personnel at Atomic Weapons Tests. Washington, D. C. MLC 31.4. 16 July 1951. 2 Pages.**

27. Miller, H. Thermal Radiation Effects on Paints, Plastics, and Coated Fabrics, BUSTER Project 2.4b. Engineer Research and Development Laboratories. Washington, D. C.: AFSWP. WT-407. July 1952. 118 Pages.***

28. Monahan, T. I. The Effect of Thermal Radiation on Materials, BUSTER Project 2.4-2. New York Naval Shipyard. Washington, D. C.: AFSWP. WT-311. 1951. 110 Pages. (A06) AD 483 460.*

29. Nadler, M. R., Capt., USAF. "Report of Radiological Safety, Indian Springs AFB, Nevada, Project BUSTER/JANGLE." Air Force, Special Weapons Command. Kirtland AFB, NM: SWC. 5 December 1951. 52 Pages.***

30. Office, Chief of Army Field Forces. [Ltr., OCAFF, ATTNG-43, 12 May 1953, Subject: Troop Participation, Exercise Desert Rock VI, to: CMDT CTGSC. wo/incl.] U. S. Army, OCAFF. Fort Monroe, VA. ATTNG-43 354(C). 12 May 1953. 5 Pages.**

31. Office of the Test Director, J-Division. Operation Order No. 1-51 (BUSTER-JANGLE). Los Alamos, NM.: LASL. J-8000. August 1951. 223 Pages.**

32. Olmsted, G. B. Detection of Airborne Low-Frequency Sound from the Atomic Explosions of Operations BUSTER and JANGLE, BUSTER Project 7.6, JANGLE Project 7.3. Headquarters, Air Force. Washington, D. C.: AFSWP. WT-322. March 1952. 147 Pages. (A07) AD/A995 156.*

33. Peters, R. E. Effects of an Atomic Detonation on Aircraft Structures on the Ground, BUSTER Project 3.8. Wright Air Development Center. Washington, D. C.: AFSWP. WT-384. January 1952. 101 Pages.***

34. Robertson, A. F. "Effects of Geometry on Flash Thermal Damage, BUSTER Project 2.3." National Bureau of Standards. Washington, D. C.: AFSWP. WT-310. March 1952. 33 Pages. (A03).*

*Available from NTIS; order number appears before the asterisk.

**Available at CIC.

***Not available, see Availability Information page.

****Requests subject to Privacy Act restrictions.

35. Sheline, G. E.; et al. "Thermal Effects on Animals (Rats), BUSTER Project 4.2a." Naval Radiological Defense Laboratory. Washington, D. C.: AFSWP. WT-316. February 1952. 53 Pages. (A04) AD/A995 134.*

36. Shipman, Thomas, M.D., Rad Safe and Health Director. Memorandum for J. C. Clark, Subject: Policy and Procedure for Rad Safe Organization in Conjunction with Operation Desert Rock. AEC, Rad Safe and Health Unit. Las Vegas, NV. October 4, 1951. 2 Pages.**

37. Shipman, Thomas, M.D. "Radiological Safety, Operation BUSTER-JANGLE." Los Alamos Scientific Laboratory. Los Alamos, NM.: LASL. WT-425-EX. October 1979. 64 Pages. (A04) AD/B951 743.*

38. Singlevich, W.; Douthett, E. M. "Radiochemical, Chemical and Physical Analysis of Atomic Bomb Debris, BUSTER Project 7.3, JANGLE Project 7.1." Headquarters, Air Force. Washington, D. C.: AFSWP. WT-320-EX. January 1979. 23 Pages. (A02) AD/A995 009.*

39. Spence, R. W.; Knight, J. D. "Radiochemical Results, BUSTER-JANGLE Project 10.4." Los Alamos Scientific Laboratory. Washington, D. C.: AFSWP. WT-413. February 1952. 42 Pages.***

40. Stanford, L. H. "Effects of Atomic Detonations on Radio Propagation, BUSTER Project 6.9." Signal Corps Engineering Laboratories. Washington, D. C.: AFSWP. WT-319. February 1952. 71 Pages. (A04).*

41. Taylor, L. B. History of the Air Force Atomic Cloud Sampling. Vol. 1: "Narrative"; Vol. 2: "Appendix." Air Force Special Weapons Center. Kirtland AFB, NM.: AFSWC. 61-142-1. January 1963. 330 Pages.***

42. Terry, J. H.; Robertson, G. D. "Aerial Survey of Local Contaminated Terrain, JANGLE Project 2.1c-2." (In: Operation JANGLE, Gamma Radiation Measurements, WT-370, 339 pages.) Navy, Bureau of Aeronautics, and Wright Air Development Center. Washington, D. C.: AFSWP. WT-351. 1951. 59 Pages. (A15) AD/A078 575.*

*Available from NTIS; order number appears before the asterisk.

**Available at CIC.

***Not available, see Availability Information page.

****Requests subject to Privacy Act restrictions.

43. Terry, J. H.; Robertson, G. D. "Airborne Radiac Evaluation, BUSTER Project 6.4." Bureau of Aeronautics. Washington, D. C.: AFSWP. WT-318. May 1952. 32 Pages. (A03) AD/A077 497.*

44. Thurston, R. D.; Bardeen, T. Minefield Clearance, BUSTER Project 3.5. Engineer Research and Development Laboratories. Washington, D. C.: AFSWP. WT-313. March 1952. 101 Pages. (A06) AD 374 623.*

45. Walsh, T. G. The Protective Effects of Field Fortifications against Neutron and Gamma Ray Flux, BUSTER Project 2.6. Engineer Research and Development Laboratories. Washington, D. C.: AFSWP. WT-383. May 1952. 77 Pages. (A05) AD 370 259.*

46. Warren, Shields, M. D., Director, Div. of Biology and Medicine. Memorandum for Carroll Tyler, Manager SFOO, Subject: Permissible Levels of Radiation Exposure for Test Personnel. AEC. Washington, D. C. October 11, 1951. 2 Pages.**

47. Reynolds Electrical and Engineering Company, Inc. Exposure Data Master File--BUSTER-JANGLE. Mercury, NV. REECo. Report 838-00. February 1981. Computer Printout.****

48. [Headquarters, Camp Desert Rock.] Report of Test Exercises Desert Rock II and III. [Sixth Army.] Camp Desert Rock, NV.: HQS. Camp Desert Rock. 15 December 1951. 274 Pages. (A12) AD/B951 583.*

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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

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
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Memphis & Shelby County Public Library & Information Center
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Memphis State University
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Mercer University
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Mesa County Public Library
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Miami Dade Community College
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University of Miami Library
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Miami Public Library
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University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
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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
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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

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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
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University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

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Northeast Missouri State University
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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
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Northwestern University Library
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Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
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Oakland Community College
ATTN: Librn

Oakland Public Library
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Oberlin College Library
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Ocean County College
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Ohio State Library
ATTN: Librn

Ohio State University
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Ohio University Library
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Oklahoma City University Library
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Oklahoma City University Library
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OTHER (Continued)

Oklahoma Department of Libraries
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University of Oklahoma
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Old Dominion University
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Omaha Public Library Clark Branch
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Onondaga County Public Library
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Oregon State Library
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University of Oregon
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Ouachita Baptist University
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Pan American University Library
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Passaic Public Library
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Queens College
ATTN: Docs Dept

Pennsylvania State Library
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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
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Association of Portland Library
ATTN: Librn

Portland Public Library
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Portland State University Library
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Pratt Institute Library
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Louisiana Tech University
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Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
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Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
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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
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University of Rhode Island
ATTN: Dir of Libraries

Rice University
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OTHER (Continued)

Richland County Public Library
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Riverside Public Library
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University of Rochester Library
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University of Rutgers Camden Library
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State University of Rutgers
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Rutgers University
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Rutgers University Law Library
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Salem College Library
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Samford University
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San Antonio Public Library
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San Diego County Library
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San Diego Public Library
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San Diego State University Library
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San Francisco Public Library
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San Francisco State College
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San Luis Obispo City-County Library
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Savannah Public & Effingham Liberty Regional Library
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Scottsbluff Public Library
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Scranton Public Library
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Seattle Public Library
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OTHER (Continued)

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Shreve Memorial Library
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Silas Bronson Public Library
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Sioux City Public Library
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Slippery Rock State College Library
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South Carolina State Library
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University of South Carolina
ATTN: Librn

University of South Carolina
ATTN: Gov Docs

South Dakota School of Mines & Technical Library
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South Dakota State Library
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University of South Dakota
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South Florida University Library
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Southeast Missouri State University
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Southeastern Massachusetts University Library
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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
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OTHER (Continued)

Southern Oregon College
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Southern University in New Orleans Library
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Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
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Southwestern University
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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
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St Paul Public Library
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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
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Stetson University
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University of Steubenville
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Stockton & San Joaquin Public Library
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Stockton State College Library
ATTN: Librn

OTHER (Continued)

Superior Public Library
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Swarthmore College Library
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Syracuse University Library
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Tacoma Public Library
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Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN: Librn

Tennessee Technological University
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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
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Traverse City Public Library
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Trenton Free Public Library
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Trinity College Library
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Trinity University Library
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Tufts University Library
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University of Tulsa
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UCLA Research Library
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Uniformed Services University of the Health Sciences
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University Libraries
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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

University of Richmond
ATTN: Library

Valencia Library
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
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Washington State University
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Washington University Libraries
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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

William College Library
ATTN: Librn

Willimantic Public Library
ATTN: Librn

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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