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DNA 6017F

SHOTS
ANNIE TO RAY
The First Five Tests of the UPSHOT-KNOTHOLE Series 17 MARCH - 11 APRIL 1953

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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UPSHOT-KNOTHOLE		Ionizing Radiation
ANNIE	NANCY	Exercise Desert Rock V
RUTH	DIXIE	Nevada Proving Ground
RAY	AFSWC	Radiological Safety
AFSWP		Military Effects Group

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

This report describes the activities of DOD personnel, both civilian and military, in Shots ANNIE, NANCY, RUTH, DIXIE, and RAY, the first five tests of the UPSHOT-KNOTHOLE atmospheric nuclear weapons test series. These tests were conducted from 17 March to 11 April 1953 and involved participants from Exercise Desert Rock V, AFSWP, AFSWC, AEC nuclear weapons design laboratories, and the Civil Effects Group. This volume also describes the radiological safety activities at each of these shots.

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PREFACE

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

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

In late 1977, the Department of Defense (DOD) began a study which provided data to both the Center for Disease Control and the Veterans Administration on potential exposures to ionizing

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*Renamed the Nevada Test Site in 1955.

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

radiation among the military and civilian personnel who participated in the atmospheric nuclear weapons tests. DOD organized an effort to:

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

This report, which concerns the first five tests of Operation UPSHOT-KNOTHOLE, Shots ANNIE, NANCY, RUTH, DIXIE, and RAY, is based on the military and technical documents associated with the atmospheric nuclear weapons test events.

METHODS AND SOURCES USED TO PREPARE THIS DOCUMENT

Many of the documents pertaining specifically to DOD involvement during the first five shots of Operation UPSHOT-KNOTHOLE were found in the Defense Nuclear Agency Technical Library, the National Federal Archives Record Center, the Department of Energy Nevada Operations Office, the Los Alamos National Laboratory,* and the Modern Military Branch of the National Archives.

In most cases, the surviving historical documentation of activities conducted at Shots ANNIE, NANCY, RUTH, DIXIE, and RAY addresses test specifications and technical information, rather than the personnel data critical to the study undertaken by the Department of Defense. The available historical documentation sometimes has inconsistencies in vital facts. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader.

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*Formerly Los Alamos Scientific Laboratory (LASL)

To facilitate the use of references, this report uses weapons test report titles for each project. All yield information presented in this report is taken from the Department of Energy, Announced United States Nuclear Tests, July 1945 through 1979 (NVO-209). Other data on the tests, concerning fallout patterns, meteorological conditions, and cloud dimensions, are taken from DNA 1251-1, Compilation of Local Fallout Data from Test Detonations 1945-1962, volume 1, except in instances where more specific information is available elsewhere.

For several of the Exercise Desert Rock and test organization projects discussed in this volume, the only documents available that give participation information are the Sixth Army Desert Rock operation orders and the Test Director's Schedule of Events from "Operation Order 1-53." These sources detail the plans developed by DOD and AEC personnel before Operation UPSHOT-KNOTHOLE. Although some of the after-action documents, such as the weapons test reports for AFSWP, summarize the projects performed during Operation UPSHOT-KNOTHOLE, 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.

ORGANIZATION OF OPERATION UPSHOT-KNOTHOLE REPORTS

This volume details participation by DOD personnel in the first five events of the Operation UPSHOT-KNOTHOLE atmospheric nuclear weapons testing series conducted at the NPG. Four other publications address DOD activities during the operation:

- Series volume: Operation UPSHOT-KNOTHOLE, Atmospheric Nuclear Weapons Tests, 1953
- Shot volume: Shot BADGER
- Shot volume: Shot SIMON

- Shot volume: Shots ENCORE to CLIMAX, the Final UPSHOT-KNOTHOLE Tests.

The volumes addressing the test events of Operation UPSHOT-KNOTHOLE have been designed to complement one another. The series volume describes those dimensions of Operation UPSHOT-KNOTHOLE that transcend specific events, such as historical background, organizational relationships, and radiological safety procedures. In addition, it discusses the overall objectives of the operation, describes the geographic layout of the NPG, and contains a bibliography of works consulted in the preparation of all five Operation UPSHOT-KNOTHOLE reports. The shot volumes, on the other hand, contain none of this general information on Operation UPSHOT-KNOTHOLE.

The single-shot volumes describe DOD participation in Shots BADGER and SIMON, and the multi-shot volumes combine shot-specific descriptions for the other nuclear events in Operation UPSHOT-KNOTHOLE. Descriptions of activities concerning any particular shot in Operation UPSHOT-KNOTHOLE, whether the shot is addressed in a single-shot volume or in a multi-shot volume, may be supplemented by the general organizational and radiological safety information contained in the UPSHOT-KNOTHOLE volume.

Chapter 1 of this volume describes the physical setting and general characteristics of the early UPSHOT-KNOTHOLE test events and briefly introduces the Desert Rock maneuvers and those JTO diagnostic and scientific activities in which DOD personnel participated. The remaining five chapters of this report address each of the early UPSHOT-KNOTHOLE tests in turn. Each of these chapters describes the specific setting and characteristics of one detonation, details DOD personnel activities in the scientific, diagnostic, and technical projects sponsored by JTO and Exercise Desert Rock V, and describes the steps taken to minimize exposures to ionizing radiation. Details of the overall radiation protection program at Operation UPSHOT-KNOTHOLE are provided in the series volume.

The information in this report is supplemented by the Reference Manual: Background Materials for the CONUS Volumes. This report summarizes basic radiation physics, radiological health concepts, exposure criteria, and measurement techniques, as well as listing acronyms and terms used in the DOD reports for test events in the continental United States.

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC	Atomic Energy Commission
AFB	Air Force Base
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
BCT	Battalion Combat Team
BJY	BUSTER-JANGLE "Y"
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Incorporated
FCDA	Federal Civil Defense Administration
HumRRO	Human Resources Research Office
IBDA	Indirect Bomb Damage Assessment
JTO	Joint Test Organization
LASL	Los Alamos Scientific Laboratory
NPG	Nevada Proving Ground
REECo	Reynolds Electrical and Engineering Company
R/h	Roentgen per hour
SAC	Strategic Air Command
TAC	Tactical Air Command
UCRL	University of California Radiation Laboratory
USAF	United States Air Force
UTM	Universal Transverse Mercator
2d MCPAEB	2d Marine Corps Provisional Atomic Exercise Brigade

CHAPTER 1

INTRODUCTION

Shots ANNIE, NANCY, RUTH, DIXIE, and RAY were tests of nuclear devices conducted from 17 March through 11 April 1953 at the Nevada Proving Ground. They were the first five detonations of Operation UPSHOT-KNOTHOLE, a series of atmospheric nuclear weapons tests performed from 17 March through 4 June 1953.

Table 1-1 presents a summary of Shots ANNIE through RAY, including dates of detonation, the UTM* coordinates of the points of detonation, the modes of delivery, the heights of burst, and the explosive yields. Figure 1-1 displays a map of the NPG in 1953, with the positions of each of the UPSHOT-KNOTHOLE tests (23).+

The nuclear devices for Shots ANNIE through RAY were developed for the Atomic Energy Commission by either the Los Alamos Scientific Laboratory (LASL) or the University of California Radiation Laboratory (UCRL), two AEC nuclear weapons development laboratories. The primary objective of the tests was to evaluate the design of the devices by using the blast, thermal, and radiation phenomena produced by developmental weapons designs for diagnostic experiments.

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*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.

+All sources cited in the text are listed alphabetically and numbered in the Reference List, appended to this volume. The number given in the text is the number of the source document in the Reference List.

Table 1-1: SUMMARY OF THE FIRST FIVE OPERATION UPSHOT-KNOTHOLE EVENTS (1953)

Shot	ANNIE	NANCY	RUTH	DIXIE	RAY
Sponsor	LASL	LASL	UCRL	LASL	UCRL
Planned Date	17 March	24 March	31 March	6 April	18 April
Actual Date	17 March	24 March	31 March	6 April	11 April
Local Time	0520	0510	0500	0730	0445
NPG Location	Area 3	Area 4	Area 7	Area 7	Area 4
UTM Coordinates	871004	797056	868042	871045	806060
Type	Tower	Tower	Tower	Airdrop	Tower
Height of Burst (Feet)*	300	300	300	6020	100
Yield (Kiloton)	16	24	0.2	11	0.2

*Altitudes are measured from mean sea level, while heights are measured from the ground. All vertical distances are given in feet.

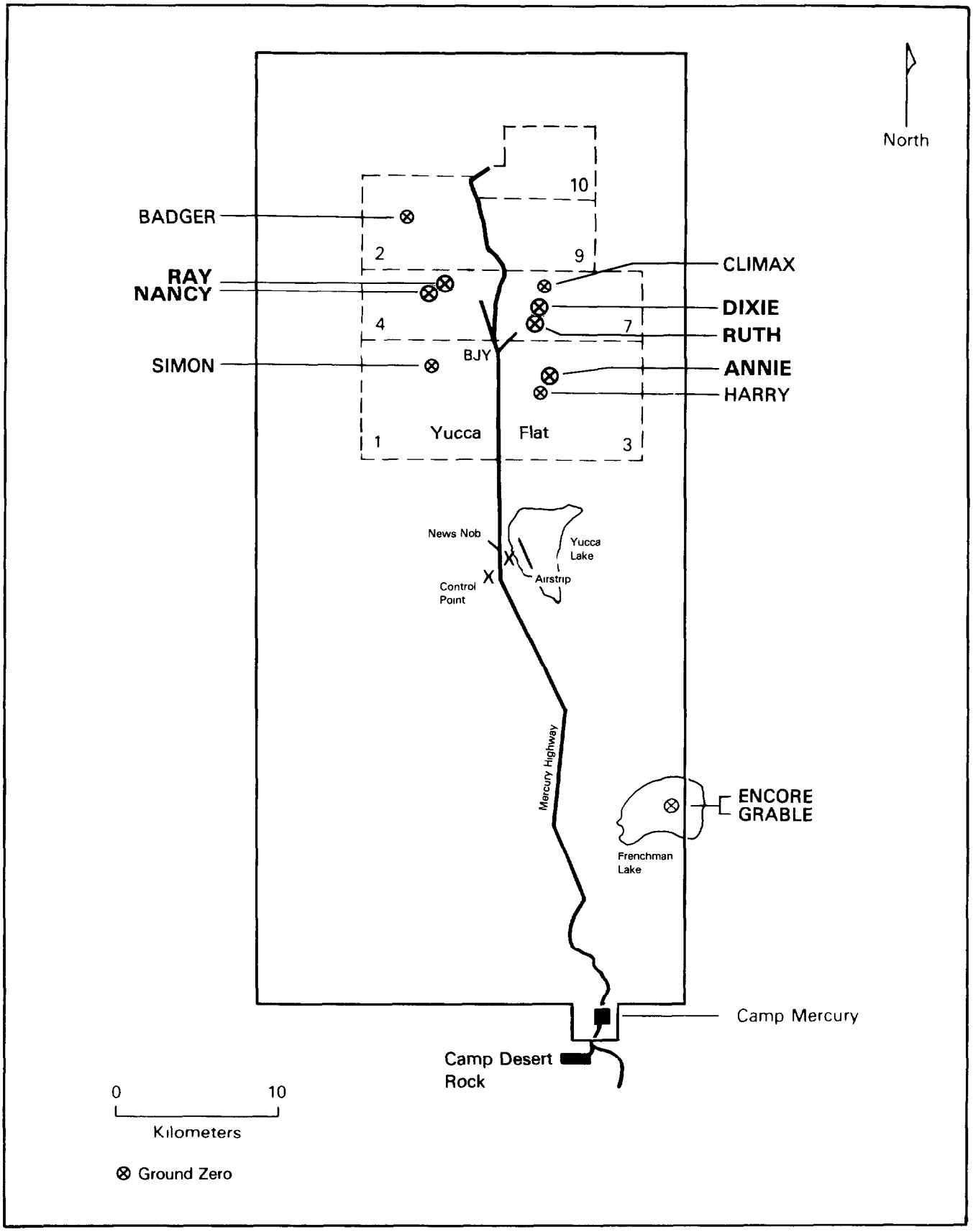

Figure 1-1: NEVADA PROVING GROUND SHOWING GROUND ZEROS FOR OPERATION UPSHOT-KNOTHOLE

1.1 DEPARTMENT OF DEFENSE PARTICIPATION AT THE FIRST FIVE UPSHOT-KNOTHOLE EVENTS

Department of Defense personnel took part in three types of activity at the first five UPSHOT-KNOTHOLE events: scientific experiments, military technical and training projects, and support services. The Weapons Development Group, the Military Effects Group, and the Civil Effects Group conducted the scientific experiments. The military technical and training projects, known as Exercise Desert Rock V, were conducted by various armed services personnel on temporary assignment from stations throughout the country. Camp Desert Rock troops, elements of the Joint Test Organization (JTO), and personnel from the Air Force Special Weapons Center (AFSWC) provided support services (7; 23-25; 34; 45).

The Weapons Development Group was composed of scientists from the Sandia Corporation, LASL, and UCRL. This test group performed experiments to measure the characteristics of each detonation. Other scientific projects were conducted by the Military Effects Group, sponsored by the Armed Forces Special Weapons Project (AFSWP), which evaluated the five nuclear devices for military applications. The Federal Civil Defense Administration (FCDA) Civil Effects Group also conducted scientific projects to assess the effects of nuclear detonations on civilian structures, products, and food supplies, as well as to evaluate emergency preparedness plans.

Participants in test group projects were scientists and technicians with a knowledge of radiation effects. They generally remained at Camp Mercury and conducted experiments during several shots of the series. Personnel fielded data-collection instruments around ground zero in the days and weeks preceding each scheduled detonation. Much of the work required

for these projects was completed before the first detonation of the series by AEC construction contractors. Such pre-series work included building and modifying structures and trenches that would be tested for blast pressure effects, placing instrumentation in the ground, and establishing recording shelters.

Once the basic project instrumentation was set up, project personnel spent minimal time in the shot areas. They returned to recover equipment or data after the detonation, usually after recovery hour, when the Test Director had determined that the radiological environment in the area of the experiments would permit limited access. Certain time-sensitive projects required personnel to enter an area very soon after a shot. Other projects required that individuals remain at stations within areas closed to all other personnel during a detonation. Safety precautions were taken in these situations. Personnel were required to wear protective clothing, survey the areas they entered, and have reliable vehicles and communication equipment.

In addition to the test group projects, the armed services took advantage of the conditions and phenomena produced by the nuclear weapons tests to conduct military training activities. These Exercise Desert Rock V activities were used to evaluate military tactics and equipment and to train selected personnel in the special tasks associated with tactical nuclear warfare (64). The majority of the DOD personnel involved in Shots ANNIE, NANCY, DIXIE, and RAY were participants in Exercise Desert Rock V. During these events, an estimated 4,600 DOD personnel took part in five Exercise Desert Rock activities: an orientation and indoctrination program, damage effects tests, a volunteer officer observer program, troop maneuver programs, and operational helicopter test programs. These Desert Rock programs accounted for the largest number of DOD participants during these four events. There were no Desert Rock activities at Shot RUTH (45).

Approximately 2,000 soldiers from various Army units maintained and operated Camp Desert Rock, an installation of the Sixth U.S. Army. These personnel administered Exercise Desert Rock V activities and performed various services. Support troops worked in the forward areas of the NPG to construct observer trenches, lay communication lines, provide transportation and security, and assist in other preparations for Desert Rock activities. Soldiers of the 50th Chemical Service Platoon served as radiological safety monitors for Exercise Desert Rock participants during the nuclear tests (45).

The Air Force Special Weapons Center provided air support to the Test Manager, the Test Director, and various test group projects. Based at Kirtland Air Force Base (AFB) in Albuquerque, New Mexico, AFSWC personnel performed cloud-sampling missions for test group projects, as well as air-drop missions, aerial surveys, cloud-tracking missions, and courier services (23-24; 39).

During the first five UPSHOT-KNOTHOLE events, as at all shots in the operation, the Joint Test Organization coordinated all activities. Comprising personnel from the AEC, DOD, and FCDA, the JTO was administered by the Test Manager, assisted by a Test Director. The UPSHOT-KNOTHOLE Series volume contains a detailed description of their duties, as well as the functions of the Joint Test Organization (23).

1.2 RADIATION PROTECTION PROCEDURES DURING THE FIRST FIVE UPSHOT-KNOTHOLE EVENTS

In carrying out their tasks, DOD participants followed the radiation protection procedures established to minimize exposure to ionizing radiation while still allowing participants to accomplish their missions.

The AEC Division of Biology and Medicine established exposure limits for JTO participants, including test group and AFSWP personnel. Test group participants were to receive no more than 3.9 roentgens of radiation exposure per 13-week period, or for the test series. To help implement this criterion, radiological safety personnel controlled access to contaminated areas and accompanied project personnel recovering test instruments from radiation areas. The monitors, who continuously monitored the radiation intensity in the recovery area, kept the participants informed of the radiological environment. The 9778th Radiological Safety Support Unit issued film badges for project personnel to wear at all times in the test area. These film badges were collected, developed, and evaluated regularly, and any individual whose accumulated dose exceeded the established limits was barred from further participation in project activities in the forward area. Although evacuation was not required during UPSHOT-KNOTHOLE, emergency evacuation procedures were prepared for all test events (26).

The radiation protection procedures authorized for AFSWC by the Test Manager included the same exposure limit of 3.9 roentgens of gamma radiation for air and ground crews as that established for the test group personnel. Complete decontamination, including showers and exchanges of clothing in the event of clothing contamination, was required of all air crew members following each project mission. Aircraft were either decontaminated by washing or were isolated until radiation intensities decayed to predetermined levels (26).

Radiation protection procedures for Exercise Desert Rock V participants, like those of the test groups and AFSWC, were designed to minimize potential exposure to ionizing radiation. Camp Desert Rock personnel and exercise participants were limited to no more than 6.0 roentgens of whole-body gamma radiation during any six-month period (45).

SHOT ANNIE SYNOPSIS

AEC TEST SERIES:	UPSHOT-KNOTHOLE
DOD EXERCISE:	Desert Rock V
DATE/TIME:	17 March 1953, 0520 hours
YIELD:	16 kilotons
HEIGHT OF BURST:	300 feet (tower shot)

AEC Objective: To evaluate the nuclear yield, blast, thermal, and radiological phenomena produced by this experimental device.

DOD Objectives: To evaluate military equipment, tactics, and doctrine; to evaluate the military applications of the device; and to train troops in the tactical use of nuclear weapons.

Weather: At shot-time, the winds at surface level were light and variable. At all levels above 10,000 feet, the wind was out of the west: 25 knots at 10,000 feet, 54 knots at 20,000 feet, 68 knots at 30,000 feet, and 89 knots at 40,000 feet. The temperature was 2.7°C, the relative humidity was 43 percent, and the pressure was 876 millibars.

Radiation Data: Onsite fallout occurred mostly east and slightly southeast of ground zero. In other directions, intensities greater than 0.01 R/h* were confined within about 1.5 kilometers of ground zero. Intensities greater than 1.0 R/h were detected about 0.5 kilometer from ground zero.

Participants: Exercise Desert Rock V participants, Armed Forces Special Weapons Project, Air Force Special Weapons Center, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, contractors.

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*roentgens per hour

CHAPTER 2

SHOT ANNIE

Shot ANNIE, the first nuclear test of Operation UPSHOT-KNOTHOLE, was detonated on 17 March 1953, at 0520 hours Pacific Standard Time in Yucca Flat,* Area 3 of the Nevada Proving Ground, at UTM coordinates 871004. ANNIE, a developmental device from the Los Alamos Scientific Laboratory, was detonated on a 300-foot tower and had a yield of 16 kilotons.

The top of the cloud created by the detonation climbed to an altitude of 41,000 feet. The winds, which were all from the west, rapidly carried the cloud eastward. The fallout pattern extended into southwestern Utah, where it was confined to a narrow band (38).

The Military Effects Group, the Weapons Development Group, and the Civil Effects Group fielded projects involving DOD participants. The Air Force Special Weapons Center provided operational control of all aircraft and air support, including aerial surveys and cloud-sampling, cloud-tracking, and courier missions. Participants in Exercise Desert Rock V conducted four programs at the ANNIE event:

- 505 DOD personnel observed the shot as part of the orientation and indoctrination program
- 1,181 Camp Desert Rock personnel took part in the tactical troop maneuver program
- About ten Marines participated in operational helicopter tests
- Two evaluation teams surveyed vehicle and equipment damage after the shot.

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*Yucca Flat is 4,000 feet above mean sea level.

In addition, Camp Desert Rock and JTO staff and support personnel participated in operation support and control (40; 44-45).

The AEC designated ANNIE an "open shot." This was the second time in the CONUS tests that members of the news media were permitted onsite to observe a shot. In addition to the hundreds of reporters who viewed the shot from News Nob, 12 kilometers* from ground zero, 20 reporters were selected to accompany the troops viewing the shot from trenches 3.2 kilometers from the point of detonation (35).

Because civil defense had a large part in the justification, planning, and conduct of "open" shots, the Civil Effects Group played an active role in Shot ANNIE. As part of the Civil Effects Group program, the Director of FCDA and his assistant were present in the forward trenches, 3.2 kilometers from the detonation (45).

2.1 EXERCISE DESERT ROCK V OPERATIONS AT SHOT ANNIE

Almost 1,700 Camp Desert Rock personnel participated in Desert Rock V programs. Approximately 70 percent of these personnel, or 1,181 individuals, participated in a tactical maneuver. Unlike the maneuver troops at other UPSHOT-KNOTHOLE events, the troops at Shot ANNIE were from Camp Desert Rock. Personnel from Army Field Forces Human Research Office Unit No. 2 of the Human Resources Research Office (HumRRO) were present at Shot ANNIE to investigate the psychological reactions of the troops to the detonation. These research personnel were to be present at all shots attended by provisional Battalion Combat Teams (BCTs). At ANNIE, it is likely that the HumRRO personnel

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

restricted their activities to observing troops before and after the shot. Other Camp Desert Rock support personnel provided radiological safety, transportation, communications, and control functions for the exercises in the forward area. A total of 505 troops from various services participated in the orientation and indoctrination program, which consisted of instruction on nuclear weapons, observation of the detonation, and a postshot tour of the display areas. Approximately ten Marines from the Helicopter Atomic Test Unit, 2d Marine Corps Provisional Atomic Exercise Brigade, participated in operational helicopter tests. Table 2-1 lists the number of DOD participants in each Desert Rock program at Shot ANNIE, the nature of the activity, and the service of the units involved (45; 83).

Table 2-1: EXERCISE DESERT ROCK V ACTIVITIES AT SHOT ANNIE

Program	Participating Service	Estimated DOD Personnel
Troop Orientation and Indoctrination (Observers)	Army Navy Air Force Marine Corps	303 152 41 9
Tactical Troop Maneuver	Army (Camp Desert Rock Troops)	1,181
Operational Helicopter Tests	Marine Corps	10
Damage Effects Evaluation	Army	*

* Unknown

2.1.1 Camp Desert Rock Personnel

The Camp Desert Rock support troops participating in Desert Rock V programs at ANNIE provided logistical, operational, and administrative support to the exercise troops. In performing

these duties, support troops sometimes entered the forward area. The Control Group accompanied troops into the shot area to ensure that all personnel remained together and followed instructions. This group comprised officers and enlisted men from the Operations Section (G-3) and included a medical officer, the Radiological Safety Section, the Instructor Group, and elements of the Aviation Section (45-46).

The Radiological Safety Section, supported by the 50th Chemical Service Platoon, enforced radiological safety procedures and conducted radiological surveys. After ANNIE was detonated, two radiological safety teams surveyed the shot area. Each team consisted of a radiological monitor and a driver from the 50th Chemical Service Platoon and one radio operator.

A radiological safety team, consisting of a driver from the 50th Chemical Service Platoon, a radio operator from the 505th Signal Service Group , and a monitor from the Radiological Safety Section, accompanied each of the Battalion Combat Teams into the forward area. Another radiological safety team operated on the ground zero flank of the attack line. Members of the combat teams, who accompanied their battalions into the shot area, provided additional radiological monitoring.

The Instructor Group consisted of four Army officers, an Air Force officer, a Navy officer, and an Army medical officer from the Armed Forces Special Weapons Project. After the detonation on shot-day, the instructors advised observers and later the maneuver units during their tours of the display area to view the damage caused by the burst (45).

Several other Desert Rock support elements engaged in activities at ANNIE. Before the shot, the 412th Engineer Construction Battalion spent seven to ten days preparing the equipment display area. The 26th Transportation Battalion (-)* used approximately

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*Some subordinate units were not present.

110 vehicles to carry military personnel to and from the forward area. At shot-time, these vehicles were parked about 15 kilometers south of ground zero (45).

The 505th Signal Service Group (Composite Company) established wire and radio communications within the forward area, as well as at Camp Desert Rock. It was planned that 505th Signal personnel would operate the two mobile public address systems in the display area after the shot to assist the Instructor Group in its presentations. In addition, members of this unit entered the forward area on shot-day as part of the radiological safety teams. The 505th Signal contributed one man to each of the radiological safety teams (47).

The 371st Evacuation Hospital (-) provided medical support in the forward area and at Camp Desert Rock. Plans for ANNIE specified that the surgeon was to accompany the Control Group to the forward area and remain at the forward Command Post throughout the maneuvers. Because ANNIE was an open shot, involving many newsmen and civil defense personnel, and because Camp Desert Rock personnel formed the two participating BCTs, medical support involved more personnel than at other shots. Four company aidmen were assigned to each BCT and two were assigned to the observer group. Each march unit was assigned an ambulance for use in evacuation. Two more ambulances were equipped as aid stations; one was assigned to the Control Group and one to the news and civil defense personnel. A medical officer was present at each of the aid stations. The aid station for the Control Group, originally established at the parking area, was moved forward to the vicinity of the control trench immediately after the shot. The aid station for the civilians was at News Nob throughout the exercise (45; 47).

A helicopter for litter evacuation also was available at the helicopter strip. Radio and telephone communication was available for its dispatch (45; 47).

2.1.2 Troop Orientation and Indoctrination

Service observers were assigned to Camp Desert Rock to participate in the orientation and indoctrination program. As shown in table 2-1, a total of 505 troops from the Army, Navy, Marine Corps, and Air Force arrived at Camp Desert Rock on 13 March to prepare for participation in the shot (23).

Although the observers in the orientation and indoctrination program were from different services, they took part in this program as a group. The observers were scheduled to witness Shot ANNIE from trenches 3,200 meters from ground zero. The Camp Desert Rock Instructor Group conducted preshot classroom instruction, covering such subjects as basic atomic theory, characteristics of nuclear weapons, radiological protection measures, tactical use of nuclear weapons, and the plan for shot-day operations. The rehearsal of shot-day activities on 14 March consisted of visiting the trenches, practicing procedures for the detonation, and viewing the preshot condition of equipment placed in the display area. This wedge-shaped area extended south from ground zero, as illustrated in figure 2-1 (51).

On shot-day, 17 March, the observers arrived at the trench area by 0400 hours, one hour and 20 minutes before the shot. The Camp Desert Rock vehicles used to transport the observers were parked eight kilometers south of ground zero. From 0420 to 0510 hours, the observers were again briefed on the nature of nuclear detonations and safety procedures. Ten minutes before the shot, the observers were instructed to enter the trenches. Two minutes before the detonation, the observers crouched in the trenches. Personnel in the vehicle park were also ordered to crouch at this time. ANNIE was detonated on schedule at 0520 hours. After the shock wave passed, the observers were allowed to rise to view the fireball (45).

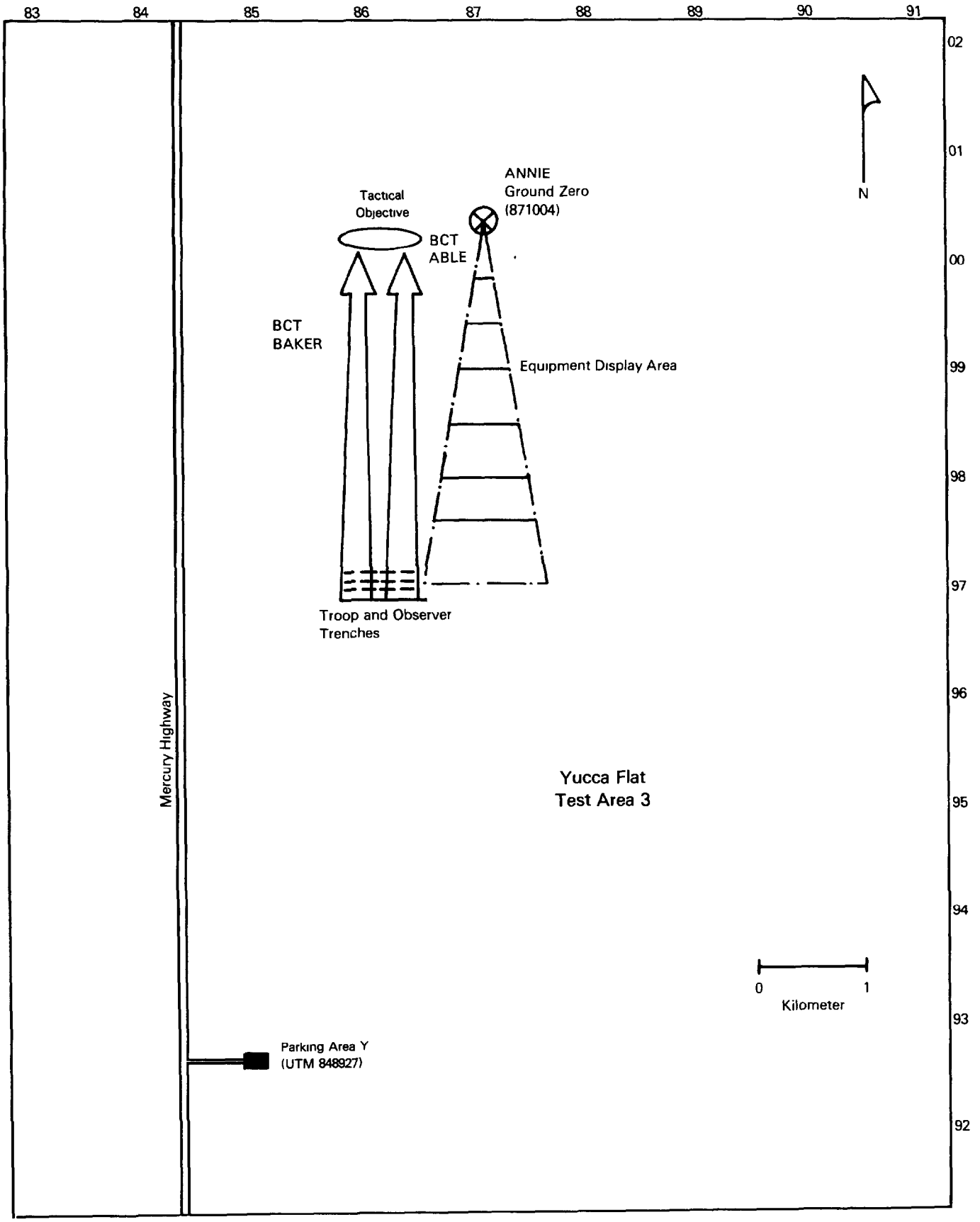


Figure 2-1: SHOT ANNIE TROOP MANEUVER, OBSERVER TRENCHES, DISPLAY AREA

At about 0540 hours, 20 minutes after the detonation, the observers left the trenches to begin their tour through the display area. The Control Group from Camp Desert Rock and members of the Camp Desert Rock Instructor Group conducted the tour and explained the effects of the detonation upon equipment and field fortifications. Radiological safety monitors preceded the observer group in order to locate the 2.5 R/h radiation intensity line. This line, located about 640 meters from ground zero on the left of the display and about 460 meters from ground zero on the right, was the limit of the observers' advance. The observers boarded trucks at 910 meters from ground zero for the return trip to Camp Desert Rock at 0800 hours. All units arrived at the camp by 1040 hours (39; 45; 47).

2.1.3 Tactical Troop Maneuvers

During the ANNIE event, 1,181 men from Camp Desert Rock conducted a tactical maneuver as part of Exercise Desert Rock V. The participating units included the 412th Engineer Construction Battalion, transportation units, and other support units assigned to Camp Desert Rock for Operation UPSHOT-KNOTHOLE. These Army units were divided into two BCTs for the tactical exercise.

The purpose of the tactical exercise was to provide military personnel with instruction and training in the battlefield use of nuclear weapons. The operation also gave the Army a chance to test its tactical doctrine and battlefield procedures for the use of nuclear weapons (16; 45; 47; 71).

The tactical maneuver at Shot ANNIE consisted of four phases:

- Preshot orientation
- Observation of the shot
- Tactical maneuver
- Postshot tour of the display area.

The troops rehearsed shot-day activities in the ANNIE shot area on 14 March. The troops listened to a simulated countdown of the ANNIE detonation from their protective trenches. They then practiced the attack phase of their operations, as shown in figure 2-2, advancing approximately 900 meters from the trenches. The troops then viewed the preshot condition of military equipment and fortifications, which had been placed in the display area to demonstrate the detonation effects.

At about 0145 hours on shot-day, the participants began mustering and boarding the vehicles for the trip from Camp Desert Rock. The convoy was divided into four march units. The Camp Desert Rock Control Group was followed by BCTs ABLE and BAKER and the observer group. BCT ABLE left Camp Desert Rock at approximately 0210 hours, and BCT BAKER departed ten minutes later.

The first trucks transporting BCT ABLE arrived at the same trenches used by the observers, UTM coordinates 865969, at 0335 hours. BCT BAKER personnel arrived at 0345 hours. The drivers then moved the vehicles to a parking area eight kilometers south of ground zero (47). From 0420 to 0510 hours, the troops were briefed on the nature of nuclear detonations and safety procedures. Figure 2-3 shows troops awaiting the countdown for Shot ANNIE. Ten minutes before detonation, the troops were instructed to enter the trenches. Two minutes before the shot, the troops were instructed to crouch in the trenches. Personnel in the vehicle park were also ordered to crouch at this time. ANNIE was detonated on schedule at 0520 hours (45).

The tactical maneuver at Shot ANNIE was designed to reach an objective near UTM coordinates 862004, located about one kilometer west of the ANNIE ground zero (UTM coordinates 871004). As shown in figure 2-1, the path of the two BCTs' attack extended three kilometers northward from the trenches. Both BCTs had the same general objective, to be reached through parallel routes of

Figure 2-2: REHEARSAL OF TROOP MANEUVER FOR SHOT ANNIE, 14 MARCH 1953

Figure 2-3: TROOPS AWAITING COUNTDOWN FOR SHOT ANNIE

attack. ABLE's course, due east of BAKER's route, was closer to the ANNIE ground zero (47).

At 0535 hours, when the BCTs began their attack, the air was still dust-filled from the blast. Moving north from the trenches, the troops covered a distance of three kilometers before reaching their objective at 0700 hours. During the operation, a radiological safety monitor preceded each BCT. At one point, dust in the area caused the monitor to lose sight of the attacking force for about ten minutes (45).

Once they reached their objective, the troops returned to the display area and viewed the postshot condition of materiel, as was standard procedure for maneuver operations. The Instructor Group led the troops up to the 2.5 R/h line. Both BCTs departed for Camp Desert Rock by 0800 hours, after spending about four hours in the shot area (45).

2.1.4 Operational Helicopter Tests

Marine Corps personnel from the Helicopter Atomic Test Unit, 2d Marine Corps Provisional Atomic Exercise Brigade, conducted operational helicopter tests at ANNIE. These tests were designed to investigate factors that might affect the use of helicopter assaults after a battlefield nuclear detonation, but overpressure was the only effect studied at Shot ANNIE (44).

Three Marine HRS helicopters and approximately ten Marines were involved in these tests at Shot ANNIE. The helicopters were parked on the reverse slope of a hill, 17 kilometers from ground zero at the time of the detonation. Although not tied down, they suffered no noticeable effects. About 45 minutes after the shot, the helicopters proceeded to the rear of the trench area. At that point, the Marines boarded the helicopters, which transported them to a location two kilometers south of ground zero

within the display area. The airlifted Marines presumably rejoined their respective units in the display area. As time did not permit the Helicopter Atomic Test Unit to submit an operations plan, the exact paths of the helicopters are unknown (43-45).

2.1.5 Damage Effects Evaluation

Before the ANNIE detonation, Desert Rock personnel established a display area extending south from ground zero for a distance of 3,200 meters (see figure 2-1). The display was designed primarily to add realism to the orientation of troops, who reviewed the display before and after the shot. The 412th Engineer Construction Battalion constructed barbed wire obstacles at 90-meter intervals out to approximately 460 meters. Thereafter, at 460-meter intervals, they constructed trenches, bunkers, and foxholes. The 3623rd Ordnance Company placed equipment in the display, beginning with a landing vehicle at ground zero. Other items included tents, machine guns, flame throwers, mortars, trucks, rifles and carbines, an artillery aiming circle, howitzers, and communications equipment. After the shot, an engineer team and an ordnance team returned to the display area to assess the damage to the fortifications and equipment (45).

In conjunction with the damage effects evaluation, Desert Rock personnel conducted shielding experiments using the display as the location for dosimetry instruments. A chemical team, probably part of the 50th Chemical Service Platoon, placed film badges on stakes in the open and in the trenches, foxholes, and bunkers. After the shot, the chemical team retrieved the badges to process them and record their readings (45).

2.2 DEPARTMENT OF DEFENSE PARTICIPATION IN JOINT TEST ORGANIZATION OPERATIONS AT SHOT ANNIE

Department of Defense personnel took part in projects sponsored by the Military Effects Group, the Weapons Development Group, and the Civil Effects Group (2). Table 2-2 lists the test group projects by number and title and identifies the participating groups (33).

In the days and weeks before the shot, project personnel and construction contractors constructed a blast line, modified underground shelters used in earlier test series, and placed radar equipment, cameras, instruments, and other experiments around ground zero. Gauges that measured weapons effects characteristics were connected to cables that transmitted the measurements to recording equipment located in the underground shelters.

From several days up to three hours before the ANNIE detonation, personnel were entering the test area to place experiments, calibrate instruments, and turn on generators. Personnel for several projects traveled to stations that they would man during the shot and checked communications with the Control Point. The Aircraft Participation Unit positioned 23 aircraft that conducted missions for five projects and one aircraft that performed a photography mission for the Air Force Lookout Mountain Laboratory. Within minutes after the detonation, eight AFSWC aircraft began a cloud-sampling mission for two projects. Later, a C-47 conducted an offsite aerial survey, and two B-29s and one B-25 conducted cloud-tracking missions for the Test Manager. Thirty minutes after the detonation, an initial radiological safety party began surveying the test area to determine the radiological environment. An L-20 aircraft assisted ground personnel by taking radiation measurements above the ground. They completed the survey 90 minutes after the shot, and the Test Director declared that recovery activities could begin at 0715 hours, almost two hours after the detonation.

Table 2-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT ANNIE

Project	Title	Participants
	Military Effects Group	
1.1a/1 2	Air Blast Measurements	Naval Ordnance Laboratory
1.1c-1	Air Shock Pressure-time versus Distance for a Tower Shot	Sandia Corporation
1 4	Free-field Measurements of Earth Stress, Strain, and Ground Motion	Sandia Corporation
4 5	Ocular Effects of Thermal Radiation from Atomic Detonation	Air Force School of Aviation Medicine
5.1	Atomic Weapon Effects on AD Type Aircraft in Flight	Navy Bureau of Aeronautics
6 2	Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques	Wright Air Development Center, Vitro Corporation
6.3	Interim IBDA Capabilities of Strategic Air Command	Strategic Air Command
6.7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	Signal Corps Engineering Laboratories
6.8	Evaluation of Military Radiac Equipment	Signal Corps Engineering Laboratories; Bureau of Ships
6.8a	Initial Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
6.9	Evaluation of Naval Airborne Radiac Equipment	Navy Bureau of Aeronautics
6 10	Evaluation of Rapid Aerial Radiological Survey Techniques	Signal Corps Engineering Laboratories
6.12	Determination of Height of Burst and Ground Zero	Signal Corps Engineering Laboratories; Army Field Forces Board #1
7.1	Electromagnetic Effects from Nuclear Explosions	Headquarters, Air Force *
7.3	Detection of Airborne Low Frequency Sound from Nuclear Explosions	Headquarters, Air Force *
7 4	Seismic Measurements	Headquarters, Air Force
7.5	Calibration and Analysis of Close-in A-Bomb Debris	Headquarters, Air Force; AFSWC
8.1b	Additional Data on the Vulnerability of Parked Aircraft to Atomic Bombs	Wright Air Development Center

* Other participating agencies are listed in the text

Table 2-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT ANNIE (Continued)

Project	Title	Participants
	Military Effects Group (Continued)	
8.2	Measurement of Thermal Radiation with a Vacuuum Microphone	Air Force Cambridge Research Center
9.1	Technical Photography	EG&G; Signal Corps Pictorial Center; Air Force Lookout Mountain Laboratory
	Weapons Development Group	
13.1	Radiochemistry Sampling	AFSWC
18.1	Total Thermal and Air Attenuation	Naval Research Laboratory
18.2	Power versus Time	Naval Research Laboratory
18.3	Spectroscopy	Naval Research Laboratory
18 4	Light Absorption	Naval Research Laboratory
18 6	Surface-brightness Investigations	Naval Research Laboratory
	Civil Effects Group	
23.1	Biological Effectiveness of Ionizing Radiation within Shelters	Naval Radiological Defense Laboratory; Naval Medical Research Institute
23.2	Bacteriological Studies on Animals Exposed to Neutron Radiation	Naval Radiological Defense Laboratory
23 3	Long-term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters	Naval Radiological Defense Laboratory
23.17	Neutron Flux Measurements in AEC Group Shelters and Lead Hemispheres	Naval Radiological Defense Laboratory

Project personnel received access permits at the Control Point and then were briefed by radiological safety personnel on the radiation areas. This sequence caused some problems; one recovery party entered the test area before it had been briefed. A decision was made to brief personnel before giving them access permits at future detonations. Personnel retrieved experiments and returned to the Control Point or Camp Mercury after being monitored and decontaminated (26; 33).

2.2.1 Military Effects Group Projects

The Military Effects Group of AFSWP Field Command performed the projects shown in table 2-2 (32; 36). The following descriptions discuss the activities of participants before, during, and after the detonation. In many cases, the source documents do not indicate exactly what the participants did. Most of the projects were not time-sensitive, so personnel did not need to enter the radiation areas until after recovery hour was announced at 0715 hours.

Project 1.1a/1.2, Air Blast Measurements, was fielded to measure blast pressures from the nuclear detonation in free air. The day before the shot, project personnel placed 13 rocket launchers southwest of ground zero. Personnel placed the launchers at 120-meter intervals along a line between 910 and 2,370 meters from ground zero. Project 9.1 personnel set up cameras about five kilometers northeast of ground zero. Immediately before the shot, the smoke rockets were ignited from the Control Point. High-speed cameras equipped with a timing apparatus photographed the smoke trails through the fireball, recording broken and hooked patterns in the trails to indicate motion in the air produced by the shock front. Personnel returned later to remove the cameras (62).

Projects 1.1c-1 and 1.4 were conducted by the Sandia Corporation to measure air blast pressures and earth stress, strain, and acceleration during a detonation. Although each project had a separate objective, similar instrumentation and recording equipment were required. The Reynolds Electrical and Engineering Company (REECo) constructed instrument mounts, modified instrument shelters used in previous series, placed cables and underground instruments, and installed some of the gauges. The gauges were placed underground and above ground along a blast line that extended north-northwest of the ANNIE ground zero. Underground cables connected to the gauges ran to underground recording stations located at intervals along the blast line. Personnel calibrated gauges and turned on recording equipment before the shot and reentered after recovery hour to collect data and recalibrate the above-ground gauges (73).

Project 1.1c-1, Air Shock Pressure-time versus Distance for a Tower Shot, was conducted to record pressure-time histories for use in predicting these parameters at Shot SIMON. Before the detonation, personnel placed 26 gauges along the ground and 12 gauges on towers about ten feet high along the blast line from 210 to 2,380 meters north-northwest of ground zero. Personnel calibrated the gauges in the field before and after the detonation. After the shot, personnel retrieved recorded data from shelters located along the blast line (76).

Project 1.4, Free-field Measurements of Earth Stress, Strain, and Ground Motion, was conducted to test instruments for measuring forces generated by a nuclear detonation and transmitted through the earth. Before the shot, personnel placed earth stress and strain gauges in the ground at a location 440 meters from ground zero. The gauges were connected to a cable that ran to an amplifier in an underground recording shelter. Personnel retrieved records after recovery hour (67; 73).

Project 4.5, Ocular Effects of Thermal Radiation from Atomic Detonation, was conducted to determine to what degree the flash of a nuclear detonation impairs night vision. This project consisted of two parts. In the first part, 12 officers from Nellis AFB watched the nuclear detonation from a darkened trailer located approximately 12 kilometers from ground zero. The subjects viewed the flash through experimental filters that blocked out a large portion of the visible and infrared portion of the spectrum. Afterwards, they remained in the trailer for about an hour to perform visual tasks.

In the second part of the project, rabbits were used as test subjects to determine the distance at which retinal burns would occur. Two five-man parties placed 100 rabbits at 11 stations located three to 19 kilometers from ground zero about 12 hours before the shot. At recovery hour, two parties, each consisting of six men, recovered the rabbits (8a-8b; 18).

Project 5.1, Atomic Weapon Effects on AD Type Aircraft in Flight, was designed to obtain test data that verified or redefined the safe operational limits of the AD-2 aircraft. In addition, the blast and thermal effects of nuclear weapons on the aircraft were studied. Five aircraft participated: one AD-2 aircraft, two F8F aircraft, and two AD-4 aircraft. The AD-2 aircraft was configured to be a drone, but because this was the first drone test of the series, a safety pilot manned the aircraft. One F8F aircraft controlled the drone, and the second was a backup. The two AD-4 aircraft accompanied the AD-2 over the test site.

The five aircraft took off from Indian Springs AFB at about 0414 hours and entered the test site air space six minutes later. They flew over the area for about one hour before shot-time at an altitude of 17,200 feet. At shot-time, the aircraft were approximately 13,000 feet above the burst. They returned to Indian Springs AFB by 0559 hours.

In related ground activities, project personnel were at station 5.1b, located at UTM coordinates 861877, to guide the AD-2 pilot to the correct position during the detonation. Four hours before the detonation, four personnel left station 5.1b by vehicle to light flare pots as marker beacons at UTM coordinates 787140. This activity took about one hour. Station 5.1a was located at UTM coordinates 874804, but no activities at this station have been documented (8a-8b; 33-34; 72).

Project 6.2, Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques, was performed to confirm that a radar return could be obtained from a nuclear explosion to determine ground zero. Three B-29 aircraft with IBDA equipment took off from Kirtland AFB at 0045 hours on shot-day, entering the test area at approximately 0340 hours. They orbited eight kilometers south, 11 kilometers east, and eight kilometers north of ground zero, respectively. The aircraft left the area around 0540 hours and landed at Kirtland AFB at about 0740 hours (34).

This project was also scheduled to use a ground radar transmitter and receivers to investigate whether the fireball significantly changed the direction of a radar beam. Two men were scheduled to man a station at UTM coordinates 830880 beginning two hours and 30 minutes before the shot. Two men were also to man each of the two stations located at UTM coordinates 875880 and 870880, beginning three hours and 30 minutes before the shot. Personnel were to remain at all three stations until one hour after the shot. Except for one man who was to retrieve film, personnel then were to return to Camp Mercury. Although the radar transmitter and 15 receivers had been placed in the area before the ANNIE detonation, this part of the project was not completed due to equipment failure (8a-8b; 46; 61).

In other related ground activities, two Project 6.2 personnel were to drive to UTM coordinates 860160, at the north

end of Yucca Flat, in two vehicles to set up an equipment station at 0045 hours on shot-day. They were to stay there for 45 minutes before returning to the Control Point. Two hours after recovery hour, two men in one vehicle were to go to this equipment station and spend five hours moving the station to a location 10.5 kilometers north of the NANCY shot-tower, if radiation levels permitted (8a-8b).

Project 6.3, Interim IBDA Capabilities of Strategic Air Command (SAC), was a corollary to Project 6.2. This project evaluated the latest IBDA systems, which were installed in SAC aircraft flying simulated strike and support missions. These aircraft recorded data essential for determining the three IBDA parameters: yield, burst height, and ground zero.

The 9th Bombardment Wing (Medium), based at Travis AFB, California, sent 13 B-29 aircraft to participate. The bombers reached the area at 0308 hours flying at 25,000 feet. The aircraft flew in formation over the test area for 90 minutes to simulate strike and support activities and then returned to Travis AFB. A total of 132 personnel were in the B-29s (33-34; 56).

Project 6.7, Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations, detected and measured electromagnetic signals emitted before and during a nuclear detonation. At 1920 hours the evening before shot-day, three personnel were to travel in two vehicles to an equipment station at UTM coordinates 830900, 11 kilometers from ground zero. They were to remain there until two hours after the shot. Thirty minutes after recovery hour was announced, personnel were to leave the station to deliver film to the Control Point for processing (8a-8b; 27; 32).

Projects 6.8, Evaluation of Military Radiac Equipment, and 6.8a, Initial Gamma Exposure versus Distance, were fielded by the Signal Corps Engineering Laboratories and the Bureau of Ships, assisted by Air Force students and Navy personnel. Project 6.8 was designed to test newly developed dosimeters and radiac instruments in initial and residual radiation fields produced by a nuclear detonation. Project 6.8a provided reliable National Bureau of Standards film dosimeters as a basis for the evaluation of the dosimeters tested by Project 6.8.

Project personnel placed experimental dosimeters and National Bureau of Standards film badges at 18 stations located 1,190 to 2,740 meters west-northwest of ground zero. These portable stations were fitted with aluminum thermal and blast shields. Two or three hours after the detonation, two parties of four men each, including monitors, traveled by vehicle to recover the film and dosimeters. The estimated time of their mission was three hours. Afterward, the experimental dosimeters were compared to the film exposed in National Bureau of Standards film holders (8a-8b; 54; 59).

Four hours after recovery hour, two parties, each consisting of five men and one monitor, traveled to an area approximately three kilometers from ground zero. They performed a radiological safety survey using experimental radiac instruments. The crews recorded data and observed and recorded any instrument malfunctions (8a-8b; 54).

Project 6.9, Evaluation of Naval Airborne Radiac Equipment, evaluated aerial ground survey equipment, automatic recording dosimeters, and droppable telemetering equipment. The equipment was tested to determine its accuracy at high altitudes compared to its accuracy at ground level. The equipment was being tested for possible use by special carrier-based aircraft to warn assault troops if they were entering a radiation area.

A P2V aircraft from Kirtland AFB, equipped with test instruments and carrying a crew of three, circled approximately 19 kilometers southwest of the shot area at an altitude of 12,000 feet from one hour before the shot until one hour after the shot. The radiac equipment had been turned on before shot-time to allow for a one-hour warm-up period before the aircraft entered the shot area.

About one hour after the shot, the Aircraft Participation Unit cleared the P2V to begin runs in a cloverleaf pattern over the radiation area. The patterns were flown at an initial height of some 6,000 feet above the terrain, with subsequent patterns flown at heights decreasing by 500 feet each run, the lowest height being 1,000 feet. The P2V dropped gamma dosimeters with telemeters into the area and monitored them. After recovery hour, three project personnel accompanied by a monitor traveled by vehicle to photograph the P2V as it dropped the telemetering units. The aircraft was in the air a total of three hours and 30 minutes and landed at Indian Springs AFB at 0806 hours. The P2V took off from Indian Springs AFB at 1241 hours on the afternoon of shot-day to conduct the same tests. It flew cloverleaf patterns over the area for 35 minutes and landed at Indian Springs AFB at 1355. The next morning, the P2V left from Indian Springs to repeat the tests, but landed seven minutes later due to engine failure (33-34; 81).

Project 6.10, Evaluation of Rapid Aerial Radiological Survey Techniques, was fielded to improve the radiological aerial survey procedures used during Operations BUSTER-JANGLE and TUMBLER-SNAPPER. In addition, the effect of the aircraft on radiac instrument readings taken inside the aircraft was studied. Film badges were placed at various locations opposite one another on the interior and exterior of the aircraft used in the project.

A C-45 aircraft took off from Indian Springs AFB at 0705 hours on shot-day and reached the area at 0724 hours. It circled at a distance of eight kilometers from ground zero and at a height of about 500 feet. The crew selected a landmark at or near ground zero as a reference point and then flew a cloverleaf pattern centered over the reference point at three different altitudes. The first leg of the cloverleaf pattern passed over the point in the direction of maximum fallout. Airspeed, direction, and altitude were kept constant on each leg of the pattern. Monitors in the aircraft obtained data by using a mechanical recording system and by writing intensity readings on a data sheet every five seconds. The C-45 was in the area for about one hour and landed at Indian Springs AFB by 0831 hours (34; 68).

Project 6.12, Determination of Height of Burst and Ground Zero, was fielded to evaluate methods available to a field army for locating ground zero and determining height of burst. Three methods were tested: sound ranging, seismic, and flash ranging. Sound-ranging microphone arrays and meteorological stations were established to the south, southwest, and southeast of Camp Desert Rock, a distance of about 50 to 60 kilometers from ground zero. Flash-ranging cameras and seismic geophones used for seismic height of burst determination were located in the southeast corner of Yucca Lake about 13 kilometers from ground zero. Three hours before the shot, ten men in four vehicles were scheduled to turn on the generators to power the equipment at two flash-ranging and seismic stations. They then went to station 6.12b, located between the two stations, and remained there through shot-time (8a-8b; 82).

Project 7.1, Electromagnetic Effects from Nuclear Explosions, was conducted to obtain information on the electromagnetic radiation produced by nuclear detonations. Personnel from the National Bureau of Standards, the Air Force Security Service, the

Air Force Cambridge Research Center, and the Air Weather Service manned one station at Yucca Lake, UTM coordinates 861877, and 11 stations offsite. Five hours before the shot, 17 personnel traveled by jeep and truck to the onsite station. They remained there until two hours after the shot (65).

Project 7.3, Detection of Airborne Low Frequency Sound from Nuclear Explosions, was designed to compare low frequency sound produced by nuclear detonations at various remote field stations. These stations were located across the United States and around the world. Signal Corps Engineering Laboratories personnel operated stations in Alaska, Hawaii, Greenland, Japan, and Germany. Personnel from the Navy Electronics Laboratory, the Signal Corps Engineering Laboratories, and the National Bureau of Standards operated the nine stations in the continental United States (66).

Project 7.4, Seismic Measurements, was to record the seismic waves produced by the shot for comparison with those produced by shots of other series and by other shots of Operation UPSHOT-KNOTHOLE. Seismic stations were manned in Arizona, Montana, South Dakota, Oklahoma, Alabama, Alaska, and Wyoming. Another station was onsite, at UTM coordinates 843094, about ten kilometers from ground zero. It was not manned at shot-time. Two project personnel and a radiological safety monitor traveled to the seismic station one hour after recovery hour to turn off equipment and recover records. Personnel remained at the station for about one hour (8a-8b; 28; 77).

Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris, was performed to analyze samples of the Shot ANNIE cloud to evaluate various parameters of the nuclear device. An F-84G aircraft took gaseous and particulate samples of the cloud. Because the cloud sampling was performed by AFSWC personnel, it is discussed in section 2.2.4 (77).

Project 8.1b, Additional Data on the Vulnerability of Parked Aircraft to Atomic Bombs, was fielded to determine the thermal and blast effects of nuclear detonations on parked aircraft. A B-29 was situated approximately 2,350 meters from ground zero. The day before the shot, it was instrumented for peak temperature readings. Personnel recovered data and inspected the damage after the detonation (36-37).

Project 8.2, Measurement of Thermal Radiation with a Vacuum Microphone, evaluated a device used to measure the thermal radiation produced by a nuclear detonation. Before the shot, project personnel traveled to a van located about 11 kilometers southwest of ground zero and remained there through the test (14).

Project 9.1, Technical Photography, filmed technical aspects of various Military Effects Group projects. Personnel from Edgerton, Germeshausen, and Grier, Inc. (EG&G), with assistance from 23 officers and enlisted men from the Army Signal Corps Pictorial Center and five enlisted men from the Air Force, performed this project.

Personnel used four remote-control cameras in trailers to photograph the fireball. In addition, photographers placed a camera about five kilometers northeast of ground zero to take high-speed motion pictures of smoke rocket trails for Project 1.1a/1.2. After all camera stations were installed for a shot, a complete dry run was held. Cameras were then covered with plastic bags to protect them from dust. Before the shot, personnel removed the plastic bags and loaded the cameras with film. The same project personnel who installed the film recovered it on shot-day after the declaration of recovery hour. EG&G processed the film in either Las Vegas or Los Angeles (40).

In addition to the Project 9.1 photography, documentary photographs were taken by personnel from the Air Force Lookout Mountain Laboratory. A C-47 aircraft left Indian Springs AFB at about 0420 hours to photograph the ANNIE detonation. The C-47 entered the ANNIE shot area at about 0440 hours and was in position at shot-time. The photography crew photographed the cloud and left the area by 0535 hours. The aircraft landed at Indian Springs AFB at about 0548 hours (34).

2.2.2 Weapons Development Group Projects

The Weapons Development Group performed 21 projects at Shot ANNIE, only six of which involved DOD personnel. Table 2-2 lists the Weapons Development Group projects that had DOD participants.

Project 13.1, Radiochemistry Sampling, was performed by sampling pilots from the AFSWC 4926th Test Squadron (Sampling) for LASL. This project is discussed under AFSWC participation in section 2.2.4.

Project 18.1, Total Thermal and Air Attenuation, Project 18.2, Power Versus Time, Project 18.4, Light Absorption, and Project 18.6, Surface-brightness Investigations, were conducted at ANNIE by the Naval Research Laboratory. No detailed information is available.

Project 18.3, Spectroscopy, was conducted to obtain information on spectral characteristics of light emitted from nuclear detonations. This was accomplished by using spectrometers, which recorded the wavelength of light with time. The spectrometers used in this experiment were housed in Building 400, located near the Control Point at Yucca Pass. Project personnel manned Building 400 on shot-day, operating the instruments manually. At Shot ANNIE, the distance between ground zero and Building 400 was about 13 kilometers. Three other spectrometers were located

about two kilometers from ground zero in Station 413, a reinforced semitrailer, which served as a mobile instrument station. The spectrometers in Station 413 were not used at ANNIE (19; 29).

2.2.3 Civil Effects Group Projects

The Civil Effects Group conducted 29 projects at Shot ANNIE. Only four projects involved DOD participants. The Naval Radiological Defense Laboratory conducted these projects; in general, the same personnel participated in all four projects. No information is available for Project 23.3, Long-term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters.

Project 23.1, Biological Effectiveness of Ionizing Radiation within Shelters, used dogs and mice as test subjects to measure directly the biological hazard from radiation within two earth-protected AEC communal shelters located 460 meters from ground zero. Personnel transported the animals to the shelters eight hours before the shot. Recovery operations were to begin one hour after recovery hour. Six project participants and three monitors were scheduled to spend 45 minutes recovering the animals (8a-8b; 15).

Project 23.2, Bacteriological Studies on Animals Exposed to Neutron Radiation, collected data on the role played by post-irradiation infection in deaths caused by radiation exposure. Project participants placed 153 animals, mostly mice and dogs, in the same shelters used for Project 23.1. The animals were retrieved from one to two hours after recovery hour, in conjunction with Project 23.1 recovery operations (85).

Project 23.17, Neutron Flux Measurements in AEC Group Shelters and Lead Hemispheres, investigated neutron radiation inside and outside lead hemispheres and shelters and measured the

neutron dose received by animals in those shelters. Project personnel placed hemispheres containing gold and sulfur neutron detectors at distances of 220 to 1,580 meters from the shot-tower. They also placed animals in the same shelters used for Projects 23.1 and 23.2. Thirty minutes after recovery hour, two parties of four personnel and three monitors each were to travel to the shelters and spend 30 minutes working there. One hour after recovery hour, another party of three persons and one monitor were to spend 15 minutes picking up the neutron detectors (21a; 86).

2.2.4 Air Force Special Weapons Center Activities

AFSWC exercised operational control of all air activities through its Air Operations Center, which coordinated military flights over the NPG. In addition, AFSWC conducted cloud sampling, sample courier missions, cloud tracking, and aerial surveys for the Test Manager and test groups.

Cloud sampling, which was conducted for LASL Project 13.1, Radiochemistry Sampling, and AFSWP Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris, enabled AEC and DOD scientists to obtain and analyze samples of the Shot ANNIE cloud. AFSWC sample couriers transported the samples to the AEC and DOD laboratories. Cloud tracking not only allowed the Test Manager to plot the course of the cloud, but also helped the Civil Aeronautics Administration to divert commercial aircraft from the cloud path. Aerial surveys of the terrain enabled the Test Manager to monitor areas exposed to fallout more quickly than he could with ground surveys.

With the exception of the B-29 cloud-tracking aircraft, which staged out of Kirtland AFB, AFSWC aircraft originated at Indian Springs AFB. The types and numbers of aircraft and esti-

mated numbers of AFSWC aircrew personnel involved at Shot ANNIE follow (34).

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Sampling			
Sampler	F-84G	7	7
Sampler Control	B-50	1	9
Sample Courier Missions	B-25	2	8
	C-47	2	6
Cloud Tracking	B-29	2	20
	B-25	1	5
Aerial Surveys	L-20	1	3
	C-47	1	5

Cloud Sampling

In conjunction with Projects 13.1 and 7.5, seven F-84G aircraft performed cloud sampling and one B-50 served as the sampler control aircraft. One of the F-84G samplers acted as "snooper" before sampling began. The operation was routine for the most part, although a tire of one sampler aircraft blew out upon landing at Indian Springs AFB. No damage to the aircraft resulted.

During the mission, the F-84G aircraft collected samples at altitudes from 25,000 to 40,000 feet. The B-50 sampler control aircraft and the snooper F-84G aircraft surveyed the cloud before the actual sampling sorties began. The snooper landed and then took off about 55 minutes later to collect samples. The B-50 remained in the air throughout the sampling missions. The first sampler began cloud penetration one hour after the detonation, and the last began two hours and 28 minutes after the shot. The peak intensity encountered by the samplers was 9.0 R/h. Each

F-84G had only a pilot, while the B-50 had a crew of nine. The following listing summarizes the sampling missions. Aircraft are listed according to the sequence in which they flew the sampling missions (34).

AIRCRAFT (F-84G)	NUMBER OF PENETRATIONS	TOTAL TIME IN CLOUD (seconds)	TOTAL TIME IN CLOUD AREA (minutes)
Tiger Blue 3	2	120	49
Tiger White 3	2	180	47
Tiger White 2	1	35	31
Tiger Blue 1	1	70	39
Tiger Blue 2	1	4	39
Tiger Red 1	1	70	41
Tiger Red 2	2	142	70

After the sampling missions were completed, all aircraft returned to Indian Springs AFB and parked in designated areas. Engines were shut down, and the canopies remained closed until the samples were removed from the aircraft. The pilots remained on full oxygen while they waited. The 4926th Test Squadron sample-removing team used long-handled tools to remove the samples from each aircraft and place them in shielded containers. They then loaded the sample containers onto courier aircraft for delivery to laboratories for analysis.

After the samples from each aircraft were removed and stored, the pilots shut down their oxygen, opened the canopies, and stepped onto platforms held by a forklift so they would not touch the exterior of the aircraft. The pilots were then taken in pickup trucks to the decontamination station where they were monitored and decontaminated as necessary (80).

Sample Courier Missions

Following the ANNIE event, four AFSWC aircraft transported samples and experiments for test group projects, including Projects 7.5 and 13.1, to agencies and laboratories throughout the United States. Two B-25s and two C-47 aircraft were used. The B-25s were flown by crews of four; each C-47 had three crew members.

Cloud Tracking

Three cloud-trackers participated in Shot ANNIE: two Air Weather Service B-29s, each with a crew of ten from Kirtland AFB, and a B-25 with a crew of five from Indian Springs AFB. The B-25, which began its mission 15 minutes after the detonation, was instructed to track the cloud at 12,000 feet. Although the pilot's instructions were to track the leading edge of the cloud as measured by radiation survey meters onboard, he followed the cloud visually instead. Consequently, no data were obtained from this air mission (26).

The two B-29s were to track the cloud at 18,000 and 22,000 feet, respectively. They left Kirtland AFB on time. However, after arriving at their designated orbit point, they received no further directions until 0830 hours. Consequently, no early data were collected at these levels (26; 34).

At 0830 hours, the Radiological Safety Control Officer requested that the two aircraft check contamination along airways surrounding the test site from 14,000 to 18,000 feet and from 18,000 to 22,000 feet. During the next three hours, the B-29 aircraft determined that these airways were clear and then returned to Kirtland AFB (26).

Aerial Surveys

Aerial surveys at Shot ANNIE consisted of both onsite and offsite missions. An L-20 aircraft conducted the onsite surveys; a C-47 flew the offsite surveys.

The L-20, probably with a crew of three, conducted two onsite surveys. During one sortie of about 40 minutes, which began about 30 minutes after the detonation, the crew measured fallout intensities within a radius of about three kilometers of ground zero. On another sortie, which took about one hour and 45 minutes and began about three hours after shot-time, the L-20 crew surveyed Area 4, then traveled to the north of Yucca Flat, down the east side of Frenchman Flat, and back to Indian Springs AFB on a route east of the NPG.

The same L-20 that performed the onsite terrain survey also conducted a radiological survey within 32 kilometers of ground zero. Because of the mountainous terrain, communications were unsatisfactory throughout the flight. Data from this survey were not available until the end of the flight.

The C-47 conducted two offsite survey sorties, each about four hours in length, in an area extending 320 kilometers from ground zero. During one of the sorties, the C-47 had trouble with communications (26; 34).

2.3 RADIATION PROTECTION AT SHOT ANNIE

For Operation UPSHOT-KNOTHOLE, Exercise Desert Rock V, the test groups, and AFSWC developed radiation protection procedures to keep individual exposure to ionizing radiation to a minimum while still allowing participants to accomplish their missions. Information on radiological safety procedures at Shot ANNIE includes descriptions of some Desert Rock radiation protection activities, JTO film badge data, data on radiological safety

equipment, survey results and records, isointensity plots, and decontamination records.

2.3.1 Desert Rock Radiation Protection Activities

Information concerning Desert Rock radiation protection activities has been obtained from the annex for ANNIE of the Exercise Desert Rock V Final Report (45-46) and from the operations order for the shot (47). A general discussion of radiological safety procedures for Desert Rock participants appears in chapter 5 of the Operation UPSHOT-KNOTHOLE volume.

At ANNIE, the two BCTs and the observer group witnessed the detonation from trenches located 3,200 meters from ground zero. As soon as the blast wave passed, the monitoring parties began their survey of the test area. Two teams surveyed the display area and identified and marked the 2.5 R/h line, which was about 640 meters from ground zero on the left of the display and about 460 meters from ground zero on the right of the display. The teams also identified and marked the 5.0 R/h line, which was about 90 meters beyond the 2.5 R/h line. The 2.5 R/h line was the forward limit for all individuals on foot. Members of the Instructor Group advised observers and the BCTs during a tour of the display up to the 2.5 R/h line (45).

Desert Rock participants in the forward area were required to wear film badges. In addition, for Desert Rock shielding studies, film badges were positioned at various ranges from ground zero to record the immediate radiation exposures that personnel either in the open or in trenches would have received at these locations. Film badge readings above ground and in trenches indicate that the radiation exposure on a film badge 3,200 meters from ground zero was 0.3 roentgen. This exposure was similar to what a soldier in the open would have received at this location. The film badges placed within a trench 3,200 meters from ground zero indicated a negligible exposure (45; 49).

2.3.2 Joint Test Organization Radiation Protection Activities

Information available on JTO radiation protection activities at Shot ANNIE includes data on dosimetry, logistics, monitoring, plotting and briefing, and decontamination.

Dosimetry

During the period 16 March to 22 March 1953, which covers the 17 March detonation of Shot ANNIE, the Dosimetry and Records Section issued about 1,500 film badges. Eleven JTO personnel at ANNIE received gamma exposures greater than 2.0 roentgens. Of these 11, ten were involved in recovery activities and one was the Radiological Safety Control Officer, who took a reading at ground zero three days after the detonation. The highest exposure reported for this period was 3.38 roentgens (26).

Logistics and Supply

For the period covering Shot ANNIE, 16 March to 22 March, the Supply Section issued the following items (26):

- 951 coveralls
- 1,058 pairs of high-density goggles
- 190 respirators
- 834 protective caps
- 824 pairs of cotton gloves
- 1,958 shoe covers.

Monitoring

The initial ground survey party consisted of four two-man teams. The party began its survey at 0550 hours and completed its readings at 0650 hours. The isointensity plot resulting from the initial survey is shown in figure 2-4. The teams made additional surveys through 7 April. Figure 2-5 presents maps drawn from the resurveys.

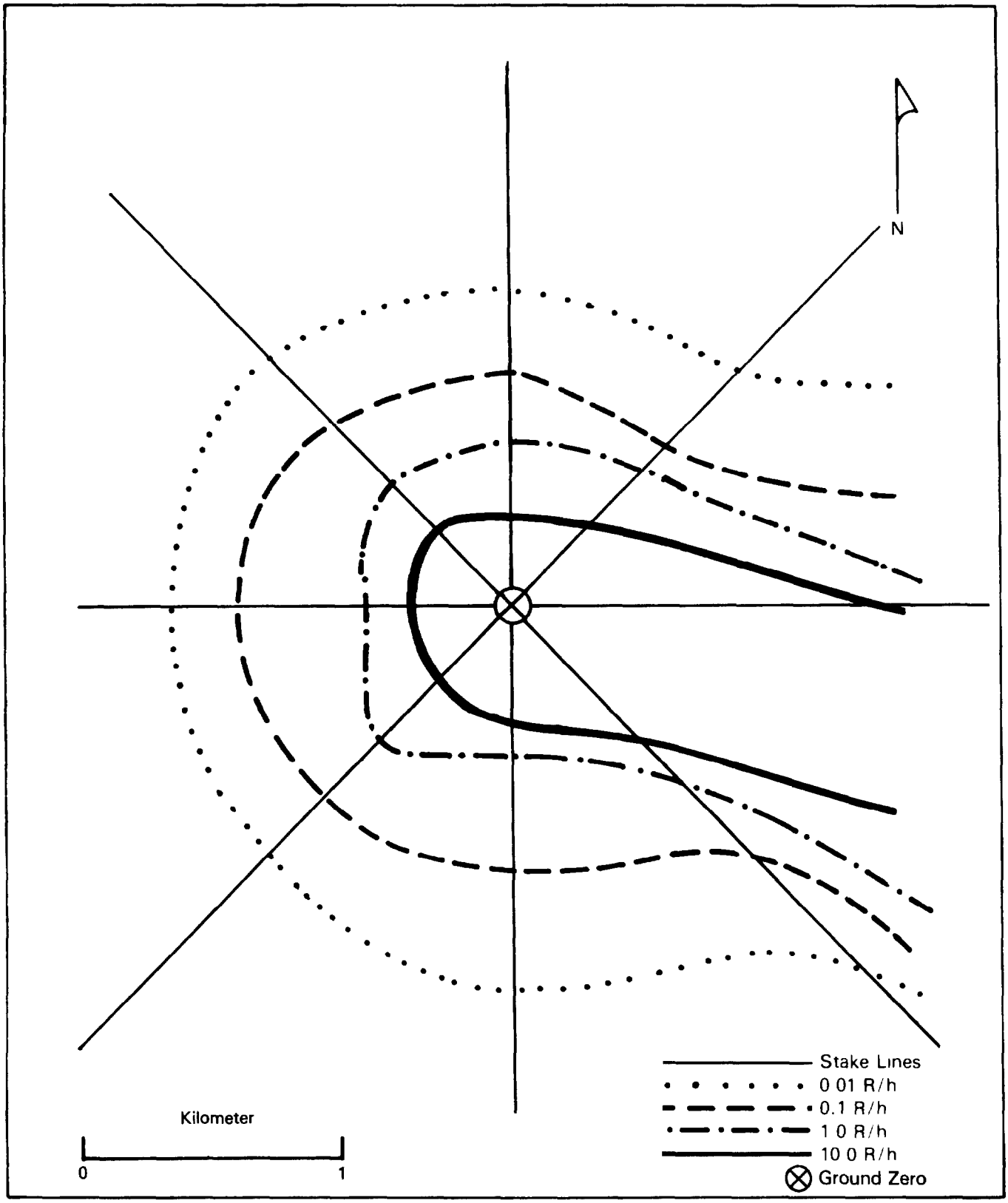
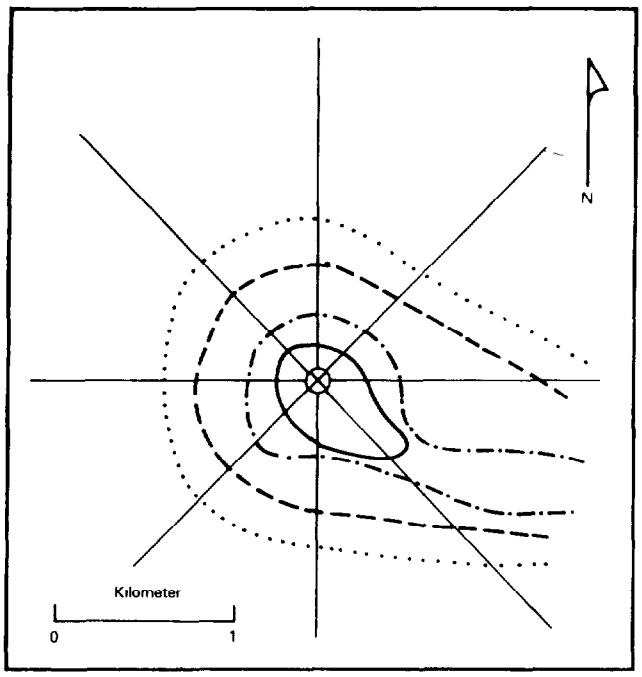
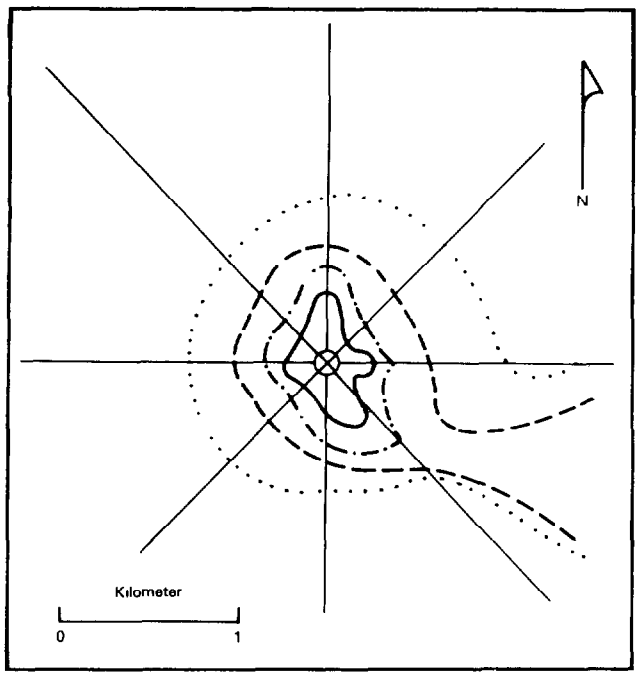


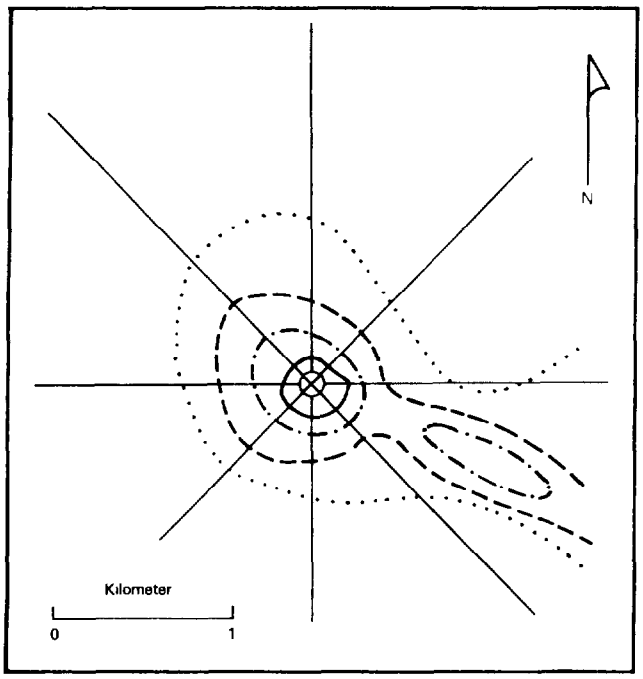
Figure 2-4: INITIAL SURVEY FOR SHOT ANNIE, 17 MARCH 1953, 0550 TO 0650 HOURS



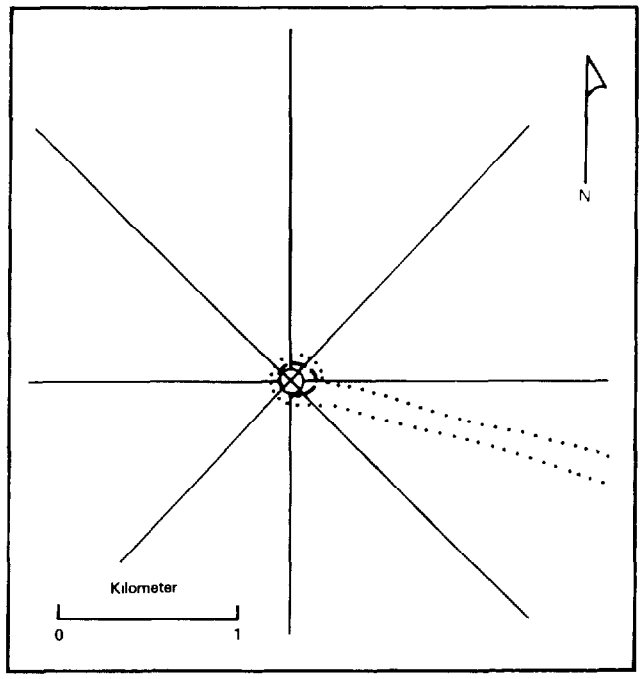
18 March 1953, 0600 to 1100 Hours



19 March 1953, Completed 0630 Hours



20 March 1953, Completed 0630 Hours



7 April 1953

Stake Lines
0.01 R/h
0.1 R/h
1.0 R/h
10. R/h
Ground Zero

Figure 2-5: SUBSEQUENT SURVEYS FOR SHOT ANNIE

One L-20 performed the onsite aerial survey. The highest intensity, converted to a ground reading, was 0.18 R/h. In addition, the same L-20 surveyed up to 32 kilometers from ground zero, and a C-47 surveyed up to 320 kilometers offsite. The maximum intensity encountered on this extended survey, converted to a ground reading, was 0.08 R/h (26).

Four DOD personnel were involved in offsite surveying to the east of the Nevada Proving Ground, in areas around St. George, Utah. The offsite monitors detected a maximum of 0.6 R/h along the fallout path. In the town of St. George, the maximum gamma intensity encountered inside a building was 0.004 R/h, while the maximum reading outside was 0.026 R/h. The film badge worn by the monitor surveying in this area showed an exposure of 0.14 roentgens (26).

The Plotting and Briefing Section cleared 113 parties for entry into the test area during the period of 16 March to 22 March. On shot-day, parties received area access permits before the announcement of recovery hour although they had not been briefed or cleared for entrance into test area. Because this practice led to some loss of control, it was decided that for all future operations, access permits would be issued only in conjunction with the briefings (26).

Decontamination

During the period of Shot ANNIE, the Vehicle and Equipment Decontamination Section decontaminated 50 vehicles and placed two vehicles in the "hot" park to allow decay of the radiation level (26).

SHOT NANCY SYNOPSIS

AEC TEST SERIES:	UPSHOT-KNOTHOLE
DOD EXERCISE:	Desert Rock V
DATE/TIME:	24 March 1953, 0510 hours
YIELD:	24 kilotons
HEIGHT OF BURST:	300 feet (tower shot)

AEC Objective: To evaluate the nuclear yield, blast, thermal, and radiological phenomena produced by this experimental device.

DOD Objective: To evaluate military equipment, tactics, and doctrine; to measure effects characteristics and evaluate the military applications of the device; and to indoctrinate troops in the tactical uses of a nuclear weapon.

Weather: At shot-time, the weather was clear, with light surface winds at two knots from the northwest. Winds were south-southeast at 12 knots at 10,000 feet. Above 10,000 feet, the winds were from the southwest at 20 knots at 20,000 feet and 32 knots at 30,000 and 40,000 feet. The temperature was 10°C, the relative humidity was 39 percent, and the pressure was 870 millibars.

Radiation Data: Fallout occurred west and northwest of ground zero, heavily contaminating Area 2 to the north of ground zero. The initial radiological survey teams found that radiation intensities exceeded 10.0 R/h in that direction; from northeast clockwise through southwest, intensities greater than 0.1 R/h were confined to within about 1.5 kilometers from ground zero.

Participants: Exercise Desert Rock V participants, Armed Forces Special Weapons Project, Air Force Special Weapons Center, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, contractors.

CHAPTER 3

SHOT NANCY

NANCY, the second shot of Operation UPSHOT-KNOTHOLE, was detonated on 24 March 1953 at 0510 hours in Area 4 of Yucca Flat, UTM coordinates 797056. NANCY was a developmental device of the Los Alamos Scientific Laboratory, detonated on a 300-foot tower, with a yield of 24 kilotons. The top of the cloud resulting from the detonation eventually climbed to 41,500 feet and moved northeast from the shot area.

Fallout within 30 kilometers of ground zero was greater than expected because high altitude winds were lighter than forecast. The lower altitude winds caused an actual fallout pattern west of the predicted path. NANCY heavily contaminated Area 2 to the north, which eventually led to the decision to postpone the firing date for BADGER. The south and east portions of the target area were readily accessible, but the northwest and north portions could not be monitored by radiological survey teams on shot-day because most of that area was contaminated at a level greater than 10.0 R/h. Offsite fallout occurred near Lincoln Mine, Nevada (38).

At Shot NANCY, 2,861 military personnel participated in Desert Rock exercises, the third largest contingent of DOD personnel active during Operation UPSHOT-KNOTHOLE. These Desert Rock exercises included five programs:

- Orientation and indoctrination (observers)
- Volunteer officer observers
- Tactical troop maneuver
- Operational helicopter test
- Damage effects evaluation.

The largest Desert Rock activity was the tactical troop maneuver, which involved 2,349 DOD participants. Personnel from Army Field Forces Human Research Unit No. 2 from HumRRO were present at Shot NANCY to investigate the psychological reactions of these troops to the detonation. These research personnel were to be present for all shots attended by provisional Battalion Combat Teams. The HumRRO unit administered a questionnaire to the troops before and after the shot since the BCTs at NANCY represented a substantial study population (45; 83). An additional 490 DOD personnel observed the shot as part of the troop orientation and indoctrination program. Also observing the shot were nine participants in the volunteer officer observer program. In addition, approximately 13 members of the Marine Corps Helicopter Atomic Test Unit, 2d Marine Corps Provisional Atomic Exercise Brigade, conducted operational helicopter tests at Shot NANCY (45).

DOD personnel participated in 18 weapons effects projects as part of the Military Effects Group. In addition, the Weapons Development Group conducted 21 experiments and the Civil Effects Group conducted five. DOD personnel were active in five of the Weapons Development Group projects and one of the Civil Effects Group projects. The Air Force Special Weapons Center provided air support to some test group projects and to the Test Manager. Missions included cloud sampling, courier missions, cloud tracking, and aerial surveys.

3.1 EXERCISE DESERT ROCK V OPERATIONS AT SHOT NANCY

The purpose of Desert Rock V exercises conducted at Shot NANCY was to indoctrinate troops in the methods of tactical nuclear weapons employment and in the effects of the nuclear weapons themselves and to test equipment for its use on the nuclear battlefield. Table 3-1 lists the number and service of DOD personnel participating in each Desert Rock activity.

Table 3-1: EXERCISE DESERT ROCK V ACTIVITIES AT SHOT NANCY

Program	Participating Service	Estimated DOD Personnel
Troop Orientation and Indoctrination (Observers)	Army Navy Air Force Marine Corps	308 86 79 17
Volunteer Officer Observers	Army Navy Air Force	4 4 1
Tactical Troop Maneuvers	Army	2,349
Operational Helicopter Tests	Marine Corps	9
Damage Effects Evaluation	Army	*

* Unknown

3.1.1 Camp Desert Rock Personnel

The support troops participating in Desert Rock V programs at NANCY provided logistical, operational, and administrative support to the exercise troops. In performing these duties, support troops sometimes entered the forward area. The Control Group accompanied troops into the shot area to ensure that all personnel remained together and followed instructions. This group consisted of officers and enlisted men from the Operations Section (G-3) and included the Radiological Safety Section, the Instructor Group, and elements of the Aviation Section (45).

The Radiological Safety Section, supported by the 50th Chemical Service Platoon, enforced radiological safety criteria and conducted radiological surveys. After NANCY was detonated, two radiological safety teams surveyed the shot area. Each team consisted of a radiological safety monitor, a driver from the 50th Chemical Service Platoon, and a radio operator.

A radiological safetv team, also consisting of a radiological safety monitor and a driver from the 50th Chemical Service Platoon and a radio operator from the 505th Signal Service Group, accompanied each of the BCTs into the forward area. Another radiological safety team operated on the ground zero flank. Members of the BCTs, who accompanied their respective battalions into the shot area, provided additional radiological monitoring (45).

The Instructor Group consisted of four Army officers, who were assisted by an Air Force officer, a Navy officer, and an Army medical officer from the Armed Forces Special Weapons Project. After the detonation, the instructors advised observers and later the maneuver units during their tours of the display area to view the effects of the burst (45).

Several other Desert Rock support elements also engaged in activities at NANCY. Before the shot, personnel from the 412th Engineer Construction Battalion spent an estimated seven to ten days preparing the damage effects display area. The 26th Transportation Battalion transported military personnel to and from the forward area. At shot-time, their vehicles were parked about 14 kilometers from ground zero (45).

The 505th Signal Service Group (Composite Company) established wire and radio communications within the forward area, as well as at Camp Desert Rock. It was planned that these personnel would operate the two mobile public address systems in the display area to assist the Instructor Group in its postshot presentations. In addition, the 505th Signal Service Group contributed one radio operator to each of the radiological safety teams that entered the forward area on shot-day (45; 48).

The 371st Evacuation Hospital provided medical support for NANCY in the forward area and at Camp Desert Rock, including

ambulances, a mobile aid station, and two company aid men for the observers. A helicopter was also provided in the event that an evacuation was necessary. The helicopter and the aid station were moved to the vicinity of the control trench immediately after the shot (45).

3.1.2 Troop Orientation and Indoctrination

Military personnel were assigned to Camp Desert Rock for a few days as observers, as indicated in table 3-1. These observers took part in the orientation and indoctrination activities as a single group. Before the shot, the observers spent one day rehearsing shot-day activities and another day in classroom instruction. Rehearsal of shot-day activities, on 22 March, included visiting the trench area, practicing procedures for the detonation, and viewing the preshot condition of items placed in the damage effects display area. The display area was a wedge-shaped sector extending south-southwest of ground zero, as shown in figure 3-1. Later, the observers toured the ANNIE display area to view the damage to equipment from that detonation (45; 48; 51).

By 0340 hours on shot-day, 24 March, the observers arrived at the trench area, located 3,660 meters south-southwest of ground zero. The vehicles that had transported the observers were then driven to the parking area 14 kilometers from ground zero. From 0410 to 0500 hours, the observers were briefed again on the nature of nuclear detonations and safety procedures. Ten minutes before NANCY was detonated, the observers were instructed to enter the trenches, and two minutes before the blast, they were told to crouch. NANCY was detonated on schedule at 0510 hours. When the shock wave had passed, the observers were allowed to rise to view the fireball.

At 0531 hours, about 20 minutes after the detonation, the observers left the trenches to begin their display area tour,

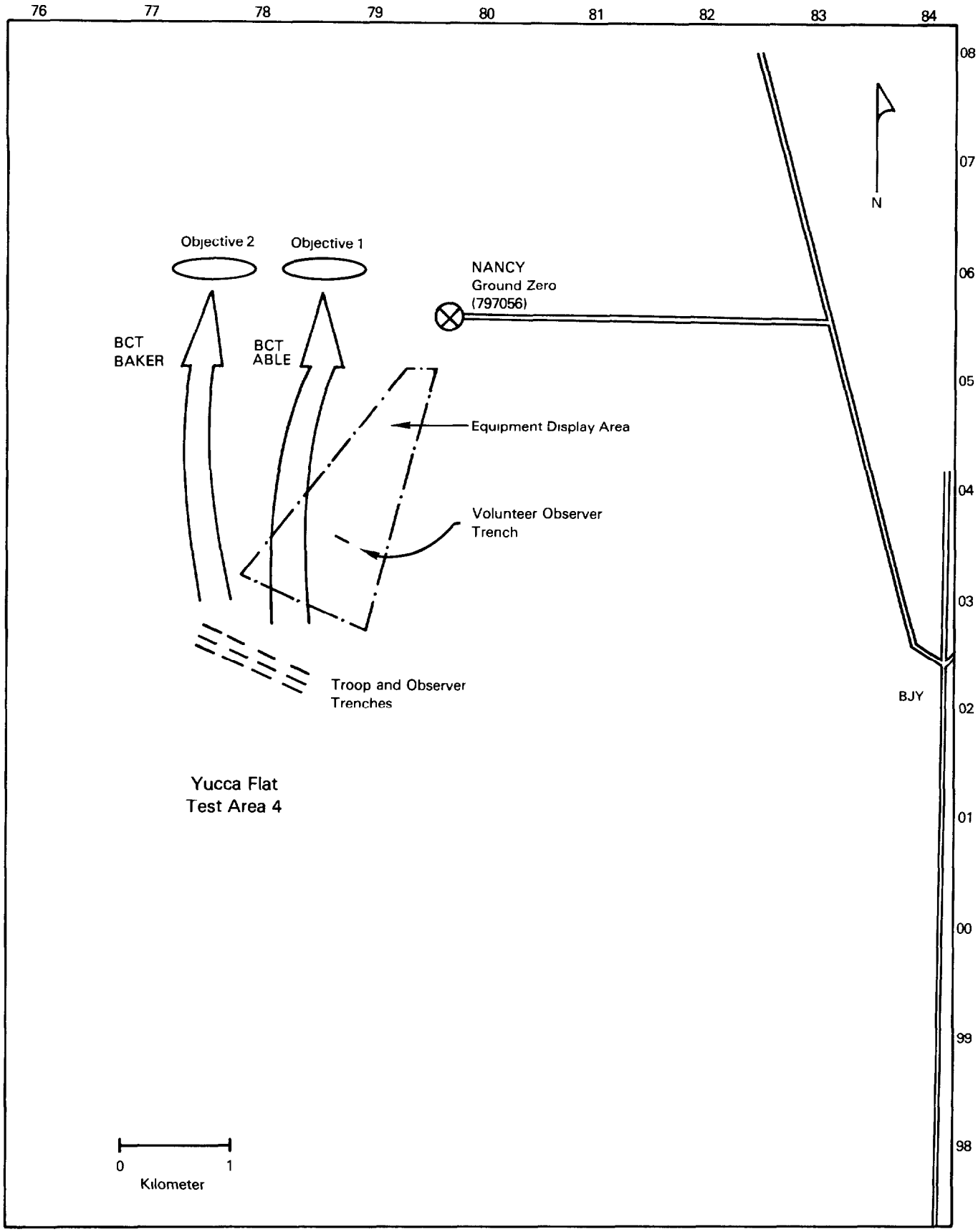


Figure 3-1: SHOT NANCY TROOP MANEUVER, OBSERVER TRENCHES, DISPLAY AREA

which was conducted by the Instructor Group. These instructors explained the effects of the detonation on the equipment, field fortifications, and sheep placed in the display area.

The observer group was preceded by radiological safety monitors from Camp Desert Rock, who established the location of the 2.5 R/h radiation intensity line. This line, located 780 meters from ground zero on the east boundary of the display area and 1,140 meters on the west boundary of the display area, was the forward limit of the observers' advance. The observers inspected some of the display items 910 meters from ground zero. After returning to the trench area, the observers boarded trucks for the return to the camp. All units arrived at Camp Desert Rock by 1032 hours (23; 45).

3.1.3 Volunteer Officer Observers

Nine officers participated in the volunteer officer observer program at Shot NANCY. The program was designed to evaluate the ability of trained staff officers to estimate and calculate minimum safe distances for observing a nuclear detonation from a trench. The volunteers were from the Army, Navy, and Air Force and were specially trained in the effects of nuclear detonations. The officers chose to position themselves in a 1.2-meter-wide trench 2,300 meters south-southwest of ground zero, on the basis of calculations that indicated they would receive no more than five roentgens of prompt whole-body exposure, eight pounds per square inch maximum overpressure, and one calorie per square centimeter of thermal radiation. To assist in their calculations, they used the TM 23-200 Capabilities of Atomic Weapons, dated October 1952. These officers were the first participants in this program, which was a new feature of the Desert Rock exercises in 1953 (31).

The volunteer officer observers arrived at the main trench area for Shot NANCY, 3,660 meters from ground zero, by 0340 hours on shot-day. They had traveled from Camp Desert Rock by truck along with the other shot participants. The volunteer officer observers were then taken to their trench 1,370 meters north of the main trench area. At the time of the detonation, they were positioned in a heavily revetted and sandbagged six-foot-deep trench.

Volunteers noted that the light from the detonation produced a white flash, changing to orange and then brown. A rolling motion of the ground followed by a "distinct bump" knocked the observers forward in the trench but did not knock anyone down. When they stood up, they were able to see the fireball for only a few seconds. Dust obscured everything for about one minute, and then the observers were able to see the cloud. The nine officers decided to evacuate their trenches after a shift in the wind caused a portion of the cloud stem to approach their position and after they observed a reading of 0.09 R/h on their radiac instruments. After walking 460 meters toward the main trench area, the volunteers were met by a vehicle. At this point, they observed a reading of 0.02 R/h. After returning to the main trenches, the volunteer officer observers were interviewed by HumRRO investigators (45).

3.1.4 Tactical Troop Maneuvers

Army service personnel began arriving at Camp Desert Rock on 20 March 1953 to form two specially composed BCTs and to participate in the tactical troop maneuver planned for Shot NANCY. The two BCTs, ABLE and BAKER, had a total planned strength of 2,400. The BCTs actually totaled 2,349 servicemen drawn from the Second, Third, Fifth, and Sixth Armies. The following table illustrates the distribution of the participants from the Second, Third, and Sixth Army areas. The home stations for these troops, shown by their BCT assignments at Shot NANCY, were:

HOME STATIONS OF TROOPS PARTICIPATING
IN SHOT NANCY MANEUVERS

Battalion Combat Team ABLE	Battalion Combat Team BAKER
Second Army Area	Third Army Area
Fort Meade, MD	Fort Benning, GA
Fort Monroe, VA	Fort McPherson, GA
Camp Pickett, VA	Fort McClellan, AL
Aberdeen Proving Ground, MD	Camp Rucker, AL
Military District of Washington	Camp Campbell, KY
Fort Myer, VA	Fort Bragg, NC
	Fort Jackson, SC
	Sixth Army Area
	Camp Roberts, CA
	Fort Ord, CA
	Presidio of San Francisco, CA

The press release that supplied the above information did not include home stations for Fifth Army personnel (45; 52; 55).

BCTs ABLE and BAKER represented a type of unit under development by the Armed Forces at that time. These units were designed to increase the flexibility and independence of small units performing military missions. Flexibility and independent action were the characteristics considered crucial for success under the conditions anticipated on a nuclear battlefield (45).

The purpose of the troop maneuver at Shot NANCY was to provide a realistic training exercise to familiarize the BCTs

with the effects of nuclear weapons. The armed services also wanted to determine whether troops acquainted with the characteristics of nuclear weapons would be able to operate in a nuclear combat environment. A hypothetical situation was developed around Shot NANCY, with maneuvers involving enemy forces entrenched in strongly protected defensive positions. To prepare for an offensive breakthrough against these positions, a barrage of nuclear weapons was to be used. The actual test detonation of Shot NANCY represented one shot of this barrage, and the attack by the two BCTs represented one element of the maneuver (48).

Following a standard schedule of activities for exercise troops assigned to Camp Desert Rock, the two BCTs began classroom orientation on 21 March. On the following day, they took part in a full dress rehearsal at the actual test site in Area 4 and conducted a short simulation of the attack, advancing 1,400 meters beyond the trench area. The troops were then taken on a preshot tour of the damage effects display area, located between the trenches and the NANCY ground zero. Here they viewed the equipment and field fortifications placed at various distances from ground zero to illustrate the preshot condition and layout of the display items.

At approximately 0045 hours on shot-day, personnel began departing from Camp Desert Rock. The personnel (Control Group, maneuver units, and observers) were divided into six march units, four of which were the combat teams. The first element of BCT BAKER left Camp Desert Rock at approximately 0100 hours, with the second element following shortly thereafter. BCT ABLE's units were enroute to the test area at 0110 and 0115 hours. All participating troop units had arrived at the trenches in the vicinity of UTM coordinates 780024 by about 0330 hours. The participants were in their designated trench areas by 0410 hours (48). The vehicles that transported them were moved to a truck park about 14 kilometers from ground zero.

While awaiting the detonation, military personnel listened to a preshot briefing delivered over the public address system from 0410 to 0500 hours. At 0500 hours, ten minutes before the shot, troops were ordered into the trenches, where they crouched for the final countdown. At the detonation, the troops experienced a small ground shock. After the shock wave passed, they observed the fireball, which was soon obscured by dust in the trench area. Soon after the blast, the wind direction shifted, causing radiation to blow over the trenches.

At 0533 hours, the BCTs left their trenches and began to advance toward their objectives to the north. Several radiological survey teams preceded the advancing units. One team from the 50th Chemical Service Platoon was positioned about 140 meters east and slightly ahead of the right flank of BCT ABLE, and each BCT was preceded by its own monitors (45; 48).

A considerable amount of fallout occurred in the area west of ground zero. This was noted in a draw that lay between the attacking troops and their objectives. As BCT ABLE encountered radiation levels approaching 2.0 R/h, the unit began to "sideslip to the west." Neither unit was able to advance closer than 460 to 640 meters to its objective before being halted by monitors. At that point, the radiation intensity was 14.0 R/h for one of the BCTs, considerably above the pre-established limit of 2.5 R/h. Apparently, the monitors assigned to the BCTs had not kept their commanders informed of the radiation environment (45).

The BCT commanders experienced some difficulty in withdrawing their men from the radiation area; however, "little time was spent in the area" (45). After the troops were withdrawn from the area, the maneuver was terminated and the troops began their march to the diplay area to observe the effects of the shot. While in the display area, troops approached to within 640 meters of ground zero at 0640 hours (45; 50).

After touring the display area, the troops returned to the trench area, where they boarded vehicles for the return trip to Camp Desert Rock. At about 0800 hours, the units began the return trip, and all had returned to Camp Desert Rock by 1032 hours.

3.1.5 Operational Helicopter Tests

At Shot NANCY, Marine Corps personnel from the Helicopter Atomic Test Unit, 2d Marine Corps Provisional Atomic Exercise Brigade, conducted operational helicopter tests to investigate factors that might affect the use of helicopter assaults after a battlefield nuclear detonation. At Shot NANCY, the factors studied included overpressure, ground and airborne radiation levels, and flash blindness (44).

Four Marine helicopters and nine personnel took part in the test. A pilot and a co-pilot operated each helicopter. In addition, at least one monitor was present, probably in helicopter A, which was scheduled to land upwind of the detonation so that the monitor could disembark to take ground radiation readings and determine the feasibility of troop entry at that time. At shot-time, helicopters A, B, and C were positioned about 18 kilometers from the NANCY ground zero and near the Yucca Lake Airstrip. Because this was the first time airborne helicopters were to be subjected to a nuclear detonation, an extra 3.7 kilometers of distance from ground zero was added for safety. To allow internal pressure equalization, windows, doors, and access holes to the tail cone were left open until after the passage of the shock wave. Helicopter D was parked to face the blast about 15 kilometers southeast of ground zero, near UTM coordinates 840880. Figure 3-2 displays the positions of all four helicopters at the time of detonation and routes taken afterwards (44).

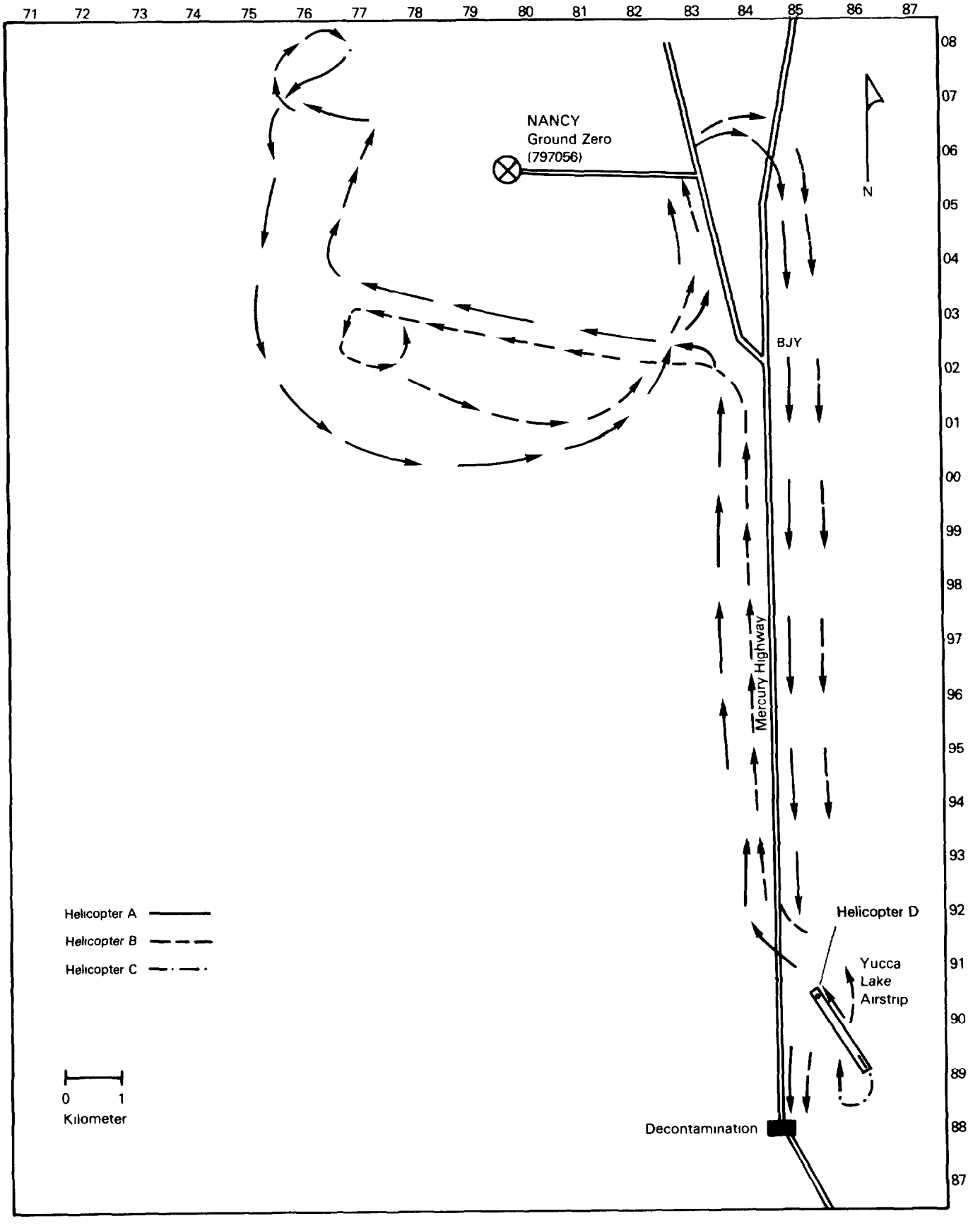


Figure 3-2: OPERATIONAL HELICOPTER TESTS AT SHOT NANCY

One minute before the detonation, helicopters A, B, and C brought their rotors to liftoff speed, while some crew members put on high-density goggles to shield their eyes from the flash of Shot NANCY. Crew members without goggles were instructed to look away from the shot. One, however, accidentally looked at the detonation. He experienced almost total loss of vision for 60 to 90 seconds, before regaining his normal vision (44).

At the time of detonation, helicopter A was facing the blast, helicopter B was port-side to the blast, and helicopter C was facing away from the blast. Ten seconds after the detonation, helicopters A, B, and C became airborne to experience the shock wave, and all three headed in the direction they were facing when parked. Helicopter A proceeded directly toward ground zero to attempt a landing for a radiological check of the vicinity west of the detonation. Helicopter B, which circled nearby, was to keep helicopter A within sight as a safety precaution and to render any assistance necessary. Helicopter A attempted to land near ground zero several times, approaching the area from different directions. The thick dust and radiation intensities prevented any landing, however. During this time, helicopter C had flown directly south to the decontamination station at UTM coordinates 840880 near Yucca Lake. There, it was checked and cleared by Camp Desert Rock radiological safety personnel. Helicopters A and B soon joined helicopter C at the decontamination station. After their radiological clearance, all helicopters proceeded to Camp Desert Rock (44).

Planning and after-action documents indicate that helicopter D did not become airborne during the detonation and did not approach ground zero. However, reports do indicate that helicopter D joined the other three helicopters for decontamination before proceeding to Camp Desert Rock (44-45).

3.1.6 Damage Effects Evaluation

Before the detonation, Desert Rock personnel established a display area southwest of ground zero (see figure 3-1). The display was designed to familiarize troops with the effects of a nuclear detonation and add realism to their orientation. The 412th Engineer Construction Battalion constructed a bunker and a fence at 365 meters; trenches, bunkers, and a foxhole at 550 meters; and trenches, bunkers, and foxholes at 460-meter intervals to a distance of 2,740 meters from ground zero (48).

The 3623rd Ordnance Company placed equipment in the display, beginning with a tank mounted with a 75mm gun at ground zero. Other items in the display included tanks, machine guns, rifles and carbines, mortars, trucks, howitzers, and an aiming circle. After the shot, an engineer team and an ordnance team returned to the display area to assess the damage to fortifications and equipment (45).

In conjunction with the damage effects evaluation, Desert Rock personnel also conducted medical and shielding experiments, using the display area as the location for placing test animals and dosimetry instruments.

For the medical evaluation, which was the responsibility of the veterinary officer, personnel placed 43 sheep at various distances from ground zero on the day before Shot NANCY. Two sheep were placed in bunkers at 90-meter intervals from 90 to 360 meters from ground zero. Beginning at 460 meters and continuing at 460-meter intervals out to 2,740 meters, one sheep was placed in the open, two in trenches, and two in bunkers (45).

On shot-day, the veterinary officer and two enlisted men accompanied the Control Group into the forward area. Immediately

after the shot, they moved by truck to the display area to evaluate the sheep. Those sheep that were still alive were moved to the animal pens in Frenchman Flat (45).

For the shielding evaluation, a chemical team placed film badges on stakes in the open and in trenches, foxholes, and bunkers. After the shot, the chemical team retrieved the badges to process them and record their readings (45).

3.2 DEPARTMENT OF DEFENSE PARTICIPATION IN JOINT TEST ORGANIZATION OPERATIONS AT SHOT NANCY

In addition to the Desert Rock activities described in the previous section, DOD personnel performed a variety of tasks that required them to enter the forward area before, during, and after the shot. DOD personnel participated in projects sponsored by the Military Effects Group, the Weapons Development Group, and the Civil Effects Group. In addition, AFSWC supported the test groups and the Test Manager. Table 3-2 lists the test group projects by numbers and titles and identifies the participating organizations.

3.2.1 Military Effects Group Projects

The Military Effects Group of AFSWP Field Command performed 18 projects at Shot NANCY. These projects were intended to evaluate military effects for specific applications against a variety of military targets (32-33).

In the days and weeks before NANCY, project and construction personnel placed radar units, recording equipment, and measurement instruments in the areas around ground zero. From several days until about three hours before the shot, personnel calibrated instruments, checked equipment, turned on generators, and

Table 3-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT NANCY

Project	Title	Participants
	Military Effects Group	
2 2a	Gamma Radiation Spectrum of Residual Contamination	Signal Corps Engineering Laboratories
4 5	Ocular Effects of Thermal Radiation from Atomic Detonation	Air Force School of Aviation Medicine
5.1	Atomic Weapon Effects on AD Type Aircraft in Flight	Navy Bureau of Aeronautics
6.2	Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques	Wright Air Development Center; Vitro Corporation
6.3	Interim IBDA Capabilities of Strategic Air Command	Strategic Air Command
6 7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	Signal Corps Engineering Laboratories
6 8	Evaluation of Military Radiac Equipment	Signal Corps Engineering Laboratories, Bureau of Ships
6.8a	Initial Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
6.9	Evaluation of Airborne Radiac Equipment	Navy Bureau of Aeronautics
6.10	Evaluation of Rapid Aerial Radiological Survey Techniques	Signal Corps Engineering Laboratories
6 12	Determination of Height of Burst and Ground Zero	Signal Corps Engineering Laboratories; Army Field Forces Board #1
7.1	Electromagnetic Effects from Nuclear Explosions	Headquarters, Air Force *
7 3	Detection of Airborne Low Frequency Sound from Nuclear Explosions	Headquarters, Air Force *
7.4	Seismic Measurements	Headquarters, Air Force
7 5	Calibration and Analysis of Close-in A-Bomb Debris	Headquarters, Air Force; AFSWC
8 2	Measurement of Thermal Radiation with a Vacuum Microphone	Air Force Cambridge Research Center
8.5	Thermal Radiation Protection Afforded Test Animals by Fabric Assemblies	Quartermaster Research and Development Laboratories; Walter Reed Army Medical Center
9.1	Technical Photography	EG&G; Signal Corps Pictorial Center; Air Force Lookout Mountain Laboratory

* Other participating agencies are listed in the text.

Table 3-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT NANCY (Continued)

Project	Title	Participants
	Weapons Development Group	
13 1	Radiochemistry Sampling	AFSWC
18 1	Total Thermal and Air Attenuation	Naval Research Laboratory
18 2	Power versus Time	Naval Research Laboratory
18 3	Spectroscopy	Naval Research Laboratory
18 6	Surface-brightness Investigations	Naval Research Laboratory
	Civil Effects Group	
27 1	Distribution and Characteristics of Fallout at Distances Greater than Ten Miles	School of Medicine, UCLA, Navy

placed animals in the areas. Several projects required that personnel man stations in the area that was closed to other personnel. The closest manned station was about eight kilometers from ground zero. Aircraft orbited outside the shot area, waiting for clearance from the Air Participation Unit to conduct their missions. Other project personnel remained at the Control Point during the detonation. The initial radiological monitoring team entered the area and radioed information to the Control Point, where radiation isointensity maps were drawn. After the Test Director declared recovery hour at 0710 hours, two hours after the shot, the recovery personnel entered the area through designated checkpoints to retrieve experiments.

Project 2.2a, Gamma Radiation Spectrum of Residual Contamination, studied the residual gamma radiation resulting from both tower and air shots. At Shot NANCY, the project was conducted primarily to familiarize personnel with instruments and techniques and to allow for modifications of experimental designs for use in shots later in the series.

About three hours after the shot, three project personnel and two monitors took measurements with radiac meters at locations 1,100 and 910 meters from ground zero, where the radiation intensities were 0.085 R/h and 0.228 R/h, respectively. Personnel also made radiac measurements the next day at the same two locations, where the radiation intensity had decreased to 0.01 R/h and 0.02 R/h (13).

Project 4.5, Ocular Effects of Thermal Radiation from Atomic Detonation, determined to what degree the flash of a nuclear detonation impairs night vision. In the first part of this project, 12 officers from Nellis AFB witnessed the detonation from a darkened trailer located about 18 kilometers from ground zero. They viewed the detonation through experimental filters that blocked out much of the visible and infrared portion of the spectrum. Afterwards, they remained in the trailer for about an hour to perform visual tasks. In the second part of this project, rabbits were used to determine the distance at which retinal burns would occur. Ten project personnel positioned 130 rabbits at 12 locations ranging from five to 23 kilometers from ground zero before the detonation. Twenty minutes after the shot, 12 men recovered the animals, approaching as close as five kilometers to ground zero (9; 18).

Project 5.1, Atomic Weapon Effects on AD Type Aircraft in Flight, was designed to study the blast and thermal effects of nuclear weapons on AD type aircraft in flight. Activities included both ground and air operations. Five hours before the detonation, four project personnel traveled in two vehicles to UTM coordinates 787140 to light flare pots which were used as marker beacons for the aircraft. After lighting the flares, personnel returned to the radar control station at UTM coordinates 861877. They remained there through shot-time to control the drone aircraft before and after the detonation and direct the F8F control aircraft during the detonation (9).

Five aircraft were involved in air operations: one AD-2, two F8Fs, and two AD-4s. The AD-2 aircraft was a drone positioned tail-on to the blast by one of the F8F control aircraft, using instructions provided by ground control radar. The other F8F provided backup support. The two AD-4 aircraft were armed escorts that were to shoot down the drone in case the F8F lost control of it. The four manned aircraft took off from Indian Springs AFB at 0325 hours and reached the test area by 0410 hours. They remained in the area for 30 minutes and returned to base by 0535 hours (34; 72).

Project 6.2, Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques, was performed to confirm indications that the radar return from a nuclear explosion could be used to determine ground zero, height of burst, and yield. This project also used ground-based radar transmitters to investigate whether the fireball refracted a radar beam.

Three B-29 aircraft, carrying IBDA equipment, took off from Kirtland AFB at about 0025 hours on shot-day. Ninety minutes later, one B-29 aborted the mission due to an oil leak in one of its engines. The other two aircraft arrived at the test area at about 0250 hours. One B-29 orbited eight kilometers south of ground zero, and the other orbited 11 kilometers east of ground zero. Both aircraft left the area at about 0530 hours and landed at Kirtland AFB by 0755 hours.

To investigate whether the fireball significantly refracted a radar beam, a radar transmitter was aimed past ground zero at a line of 16 receivers. An additional manned radar set was positioned west of the Control Point. Generally, the manned receiver stations were at least 11 kilometers from ground zero, and the transmitter was at least nine kilometers from ground zero.

At 2200 hours on the night before the detonation, project personnel traveled to three sites. Two men traveled to the

remote transmitter station about ten kilometers north-northwest of ground zero (UTM coordinates 754150) to turn on generators. Three participants traveled to a receiver station (UTM coordinates 874906) at Yucca Lake. A third group of two men traveled to another receiver station (UTM coordinates 880908) at Yucca Lake. About five hours before the detonation, the first group traveled to the radar station near the Control Point to man the main radar set. They remained there through shot-time. The remaining two groups stayed at the receiver stations through shot-time. Three men were scheduled to travel to the remote transmitter station to turn off generators three hours after recovery hour. However, this probably was done at a later time, since the transmitter was located in the radiation area north-northwest of ground zero (9; 34; 53; 61).

Project 6.3, Interim IBDA Capabilities of Strategic Air Command, was a corollary to Project 6.2. This project evaluated the latest IBDA systems, which were installed in SAC aircraft flying simulated strike and support missions. These aircraft recorded data essential for determining the three IBDA parameters: yield, burst height, and ground zero.

Twelve B-36 aircraft of the 19th Air Division from Carswell AFB, Texas, reached the test area at 0436 hours at an altitude of 30,000 feet. The aircraft flew in formation over the test site for about one hour. A total of 204 aircrew members were involved (34; 56).

Project 6.7, Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations, measured electromagnetic signals emitted before and during a nuclear detonation. Two or three hours before the shot, personnel traveled to an equipment station about two kilometers north of the Control Point to turn on generators. They returned after recovery hour to turn off power and retrieve film (9; 27).

Projects 6.8, Evaluation of Military Radiac Equipment, and 6.8a, Initial Gamma Exposure versus Distance, were fielded by the Signal Corps Engineering Laboratories and the Bureau of Ships, assisted by Air Force and Navy personnel. Project 6.8 was designed to test experimental dosimeters and radiac instruments in the initial and residual radiation fields produced by a nuclear detonation. Project 6.8a provided reliable National Bureau of Standards film dosimeters as a basis for the evaluation of other dosimeters tested by Project 6.8.

Personnel placed experimental and standard dosimeters at 16 stations located 1,280 to 2,650 meters from ground zero. These portable stations were fitted with aluminum thermal and blast shields. Two or three hours after recovery hour, two seven-man parties, including monitors, traveled in vehicles to recover dosimeters. The estimated time of the mission was three hours (9; 54; 59).

Three hours after recovery hour, two parties of six men each performed a radiological survey to evaluate and test radiation survey equipment. The crew, consisting of Air Force and Navy personnel, recorded data and checked instrument malfunctions (9; 34; 54; 59).

Project 6.9, Evaluation of Airborne Radiac Equipment, was designed to evaluate aerial ground survey equipment, automatic recording dosimeters, and gamma telemetering equipment dropped by aircraft. Equipment was evaluated to determine its accuracy at high altitudes compared to its accuracy at ground level. The equipment was designed for use by special carrier-based aircraft to warn assault troops if they were entering radiation areas.

A P2V aircraft with a crew of three and equipped with instruments took off from Kirtland AFB at 0055 on the morning of shot-day. It entered the test area at 0320 and circled

approximately 20 kilometers southwest of ground zero at an altitude of about 12,000 feet until about one hour after the detonation. The radiac equipment was turned on before shot-time to allow a one-hour warm-up period before the aircraft entered the shot area.

About one hour after the shot, the Aircraft Participation Unit cleared the aircraft to begin runs over the radiation area. The aircraft flew cloverleaf patterns at an initial height of some 6,000 feet above the terrain. It flew subsequent patterns at lower heights, decreasing by 500 feet each run until it was at its lowest height, 1,000 feet. The aircraft landed at Indian Springs AFB at 0629 hours. Identical missions were conducted in the evening of shot-day and on the day after. Gamma dosimeters with telemetering units were dropped from the aircraft the morning after the shot. The aircraft then returned to Kirtland AFB (4; 9; 34; 81).

Project 6.10, Evaluation of Rapid Aerial Radiological Survey Techniques, was designed to improve the procedures for radiological aerial surveys used during Operations BUSTER-JANGLE and TUMBLER-SNAPPER. In addition, the effect of the aircraft on radiac instrument readings taken inside the aircraft was studied. Film badges were placed at various locations opposite one another on the interior and exterior of the aircraft used in the project.

A C-45 aircraft took off from Indian Springs AFB at 0716 hours on shot-day and reached the test area at 0720 hours. It entered the radiation area flying at about 500 feet and circled ground zero at a distance of one kilometer. The crew selected a landmark at or near ground zero as a reference point and then flew a cloverleaf pattern centered over the reference point at three different altitudes. The first leg passed over the point in the direction of maximum fallout. Airspeed, direction, and altitude were kept constant on each leg of the pattern. Monitors

in the C-45 obtained data by using a mechanical recording system and by writing intensity readings on a data sheet every five seconds. The aircraft was in the area for about one hour and landed at Indian Springs AFB at 0859 hours (9; 34; 68).

Project 6.12, Determination of Height of Burst and Ground Zero, evaluated various equipment and techniques for locating ground zero and determining height of burst. Three methods were tested: sound ranging, seismic, and flash ranging. Sound-ranging microphones were located south, southwest, and southeast of Camp Desert Rock, at about 55 to 60 kilometers from ground zero. Flash-ranging cameras and seismic geophones were located in the southeast corner of Yucca Lake about 15 kilometers from ground zero. One of the stations was manned during the detonation.

Three hours before the detonation, ten men in three vehicles were scheduled to turn on equipment in seven of the stations. They were then to go to a central station where they would operate equipment through shot-time (9; 82).

Project 7.1, Electromagnetic Effects from Nuclear Explosions, was conducted to obtain information on the electromagnetic radiation produced by nuclear detonations. Project personnel were from the National Bureau of Standards, the Air Force Security Service, the Air Force Cambridge Research Center, and the Air Weather Service. They manned an onsite station just south of Yucca Flat, about 22 kilometers from ground zero, and several locations offsite. Four hours before the shot, 18 personnel traveled to the onsite location and remained there through the detonation (65).

Project 7.3, Detection of Airborne Low Frequency Sound from Nuclear Explosions, was designed to compare low frequency sounds produced by nuclear detonations at various remote field stations.

These stations were located across the United States and around the world. Personnel from the Naval Electronics Laboratory, the Signal Corps Engineering Laboratories, and the National Bureau of Standards manned these stations (36; 66).

Project 7.4, Seismic Measurements, was conducted to record the seismic waves produced by the shot for comparison with those produced by shots of other series and with other shots of Operation UPSHOT-KNOTHOLE. Seismic stations were manned in Arizona, Montana, South Dakota, Oklahoma, Alabama, Alaska, and Wyoming. One unmanned station was onsite, about six kilometers from ground zero at UTM coordinates 843094. Two project personnel and a radiological safety monitor drove in one vehicle to the onsite station to turn off the equipment and recover the records two hours after recovery hour (9; 28).

Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris, was conducted to analyze samples of the Shot NANCY cloud to evaluate various parameters of the nuclear device. A B-29 aircraft manned by a crew of six took gaseous and particulate samples of the cloud. This project required cloud sampling, as did Weapons Development Group Project 13.1, Radiochemistry Sampling. Because the cloud sampling was conducted by AFSWC, it is discussed in section 3.2.4 (77).

Project 8.2, Measurement of Thermal Radiation with a Vacuum Microphone, was conducted to evaluate a device used to measure the thermal radiation produced by a nuclear detonation. Personnel placed sensing equipment two to three kilometers from the shot-tower. Signals generated in the microphones by the pressure of the radiant energy were amplified electronically, fed to an oscilloscope, and recorded on magnetic tape. The equipment was contained in two vans located 16 kilometers from ground zero and within view of the detonation. Personnel also placed a microphone station about three kilometers from ground zero. Before

the detonation, personnel traveled to the equipment vans and remained there until two hours after the shot (14).

Project 8.5, Thermal Radiation Protection Afforded Test Animals by Fabric Assemblies, was fielded to evaluate the skin burn protection afforded by service and experimental clothing. Animals wrapped in fabrics of standard or experimental armed services uniforms were exposed to the thermal pulse and ensuing blast wave.

Personnel conducted a small-scale trial run using eight pigs at Shot NANCY. This test demonstrated that the equipment and procedures planned for the main tests, at Shots ENCORE and GRABLE, were generally satisfactory. Seven hours before the shot, six project personnel placed anesthetized pigs with various types of clothing at eight locations from 880 to 1,700 meters from ground zero. At recovery hour, ten men and three monitors recovered the test animals. Recovery operations were scheduled to take one hour (9; 63).

Project 9.1, Technical Photography, provided both still and motion picture photography of various Military Effects Group projects. This included photographing the construction sequence, as well as the postshot test results. EG&G personnel, with assistance from 23 officers and enlisted men from the Army Signal Corps Pictorial Center and five enlisted men from the Air Force, performed this project.

Project participants placed cameras near the rabbits in Project 4.5 and near the pigs in Project 8.5. Although they did not photograph the fireball, Project 9.1 personnel did place a 17-foot camera tower 260 meters from ground zero to determine the stability of the tower at that location. Technical photographs were taken by remote control (4; 40).

In addition to Project 9.1 photography, documentary photographs were taken by ten personnel from the Air Force Lookout Mountain Laboratory. They occupied five camera stations during th shot. The station locations and number of personnel were as follows:

UTM COORDINATES	NUMBER OF PERSONNEL
894982	2
900928	2
830900	2
780958	2
843878 (Control Point)	2

All personnel were to be at their camera stations about two hours before the shot and remain in the area photographing the burst and the subsequent cloud formation. Following the shot, the photographers dismantled their equipment and returned to Camp Mercury with the film.

In addition to the ten Air Force personnel on the ground, Lookout Mountain Laboratory personnel photographed the detonation from a C-47 aircraft. The C-47 left Indian Springs AFB at 0410 hours and arrived over the test area at 0425 hours. The crew photographed the burst and resulting cloud and left the area for its return to Indian Springs AFB by 0540 hours. The aircraft landed at 0550 hours (9; 34).

3.2.2 Weapons Development Group Projects

The Weapons Development Group performed 21 projects at Shot NANCY. Of these, only five involved DOD personnel. Table 3-2 lists the Weapons Development Group projects that had DOD participants.

Project 13.1, Radiochemistry Sampling, was performed by sampling pilots from the AFSWC 4926th Test Squadron (Sampling) and is discussed under AFSWC participation in section 3.2.4.

Project 18.1, Total Thermal and Air Attenuation, Project 18.2, Power versus Time, and Project 18.6, Surface-brightness Investigations, were conducted by the Naval Research Laboratory. Documentation concerning project participation is not available.

The objective of Project 18.3, Spectroscopy, also conducted by the Naval Research Laboratory, was to obtain information on spectral characteristics of light emitted from nuclear detonations. Spectrometers were used to record on film the wavelength of light as it varied with time.

Two spectrometers were housed in Building 400, near the Control Point at Yucca Pass. On shot-day, the building was manned by project personnel who operated the instruments. At Shot NANCY, the distance between ground zero and Building 400 was about 18 kilometers. Three other spectrometers were located in Station 413, a reinforced semitrailer, which served as a mobile instrument station. Station 413 was located about three kilometers southeast of the Shot NANCY ground zero at UTM coordinates 823037. The day before the test, ten personnel occupied Station 413 until three hours before the shot. Project personnel loaded film into the spectrometers and set the instruments for remote-control operation. They then secured the trailer and left the area until after the shot. Five men and a monitor from the 9778th Radiological Safety Support Unit entered the test area about 15 minutes after recovery hour to retrieve film and recorder charts from Station 413 for processing and analysis. The estimated working time in this area was 15 minutes (19; 29).

3.2.3 Civil Effects Group Projects

The Civil Effects Group conducted five projects at Shot NANCY. One project involved DOD personnel, as listed in table 3-2.

Project 27.1, Distribution and Characteristics of Fallout at Distances Greater than Ten Miles, involved detailed studies of fallout to determine the possible associated hazards. Thirty-one Navy personnel participated in a mobile field group. Project personnel established numerous collection stations in the area of the predicted fallout pattern.

Because the fallout pattern depended on weather conditions, the field group remained at previously assigned rendezvous points until after the final weather briefing the night before the shot. After they received the fallout pattern prediction, the personnel established 17 stations in an array covering about 30 degrees on each side of the estimated midline of the fallout at shot-time. About four hours were allowed for the mobile field group to establish stations and return safely to the rendezvous points. The closest stations were established six, eight, and 13 kilometers northeast of ground zero. Other stations were located as far as about 70 kilometers from ground zero. Although the stations had been placed in the predicted fallout path, a wind shift moved the fallout away from the stations. To gather the necessary data, the field group left their rendezvous points and began monitoring in the area of actual fallout 12 hours after the detonation (69).

Due to the lack of radio communications, 13 project participants were exposed to radiation. The maximum dosimeter readings were 0.6 to 0.7 roentgens. The men had set up their mobile station 64 kilometers due north of ground zero. As soon as their

instruments registered the presence of fallout, they reestablished the station on the north shore of Groom Lake. However, because of insufficient radio contact, the project participants were unable to plan a route that would have lessened their radiation exposure. It is not known whether any DOD personnel were among the men exposed (22a; 69).

3.2.4 Air Force Special Weapons Center Activities

AFSWC support to the Test Manager, the Test Director, and test groups consisted of operational control of aircraft, cloud sampling, sample courier missions, cloud tracking, and aerial terrain surveys. With the exception of the B-50 cloud-tracking aircraft, which was staged out of Kirtland AFB, AFSWC aircraft originated at Indian Springs AFB. The following listing indicates the types and numbers of aircraft and estimated numbers of AFSWC aircrew personnel involved in air missions at Shot NANCY (34).

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampling			
Sampler	F-84G	9	9
Sampler	B-29	1	9
Sampler Control	B-50	1	9
Sample Courier Missions	B-25	2	6
	C-47	1	5
Cloud Tracking	B-29	2	20
	B-25	1	5
Aerial Surveys	H-5	1	2
	L-20	1	3
	C-47	1	4

Cloud Sampling

Ten aircraft collected particulate and gaseous samples of the Shot NANCY cloud. Nine of these aircraft collected samples for Project 13.1. These were F-84G samplers, code-named Tiger, flown by pilots of the 4926th Test Squadron. The tenth aircraft was a B-29 sampler that collected gaseous samples for AFSWP Project 7.5. A B-50 sampler control aircraft with a crew of nine and one of the F-84G samplers acting as a "snooper" surveyed the cloud before the actual sampling sorties. Nine minutes after the detonation, the F-84G reported the top and base height of the cloud and returned to Indian Springs. It left for a sampling mission about 75 minutes later, at 0700 hours. The B-50 took off from Indian Springs at 0455 and remained in the air throughout the sampling missions, landing at 1211 hours (34).

The first cloud penetration occurred two hours and 50 minutes after the detonation. The highest gamma intensity measured during the sampling missions was 10.0 R/h. The following listing details the activities of each sampler aircraft. Aircraft are listed according to the sequence in which they flew the sampling mission (34).

AIRCRAFT	NUMBER OF PENETRATIONS	TOTAL TIME IN CLOUD (seconds)	TOTAL TIME IN CLOUD AREA (minutes)
Tiger Red 1*	4	112	140
Tiger Red 2	4	450	91
Tiger Red 3	5	532	82
Tiger Red 4	3	219	126
Tiger White 1	3	185	118
Tiger White 2	4	235	123
Tiger White 3	7	-	148
Tiger Blue 1	5	-	145
Tiger Blue 2	2	30	132
Catnip B-29	0	0	260

*Also acted as "snooper"

After the sampling missions were completed, all aircraft returned to Indian Springs AFB and parked in designated areas. Engines were shut down, and the canopies remained closed and sealed until the samples were removed from the aircraft. The pilots remained on full oxygen while they waited. The 4926th sample-removing team and radiological safety monitors used long-handled tools to remove the filter papers from each aircraft and place them in shielded containers. Members of the sample-removing team loaded the sample containers onto courier aircraft for delivery to laboratories for analysis (34).

After the samples from each aircraft were removed and stored, the pilot shut down his oxygen and opened his canopy. The pilots in F-84G aircraft stepped onto a platform held by a forklift so they would not touch the exterior of the aircraft. The B-29 sampler crew left the airplane from the rear side door. The crews were then taken in a pickup truck to the decontamination station, where they were monitored and decontaminated as necessary (80).

Sample Courier Missions

After Shot NANCY, three AFSWC aircraft transported samples for AFSWP Project 7.5, LASL Project 13.1, and other test group projects to laboratories throughout the United States for analysis. Two B-25s and one C-47 aircraft flew these missions (34).

Cloud Tracking

After the NANCY detonation, two B-29s with nine or ten crewmen each from Kirtland AFB and a B-25 with five crewmen from Indian Springs AFB flew cloud-tracking missions. The purpose of these missions was to determine the direction of the cloud and to assist the Test Manager in keeping the airways clear of any aircraft other than test aircraft that might encounter the cloud.

One B-29 tracked the cloud for almost six hours, the other B-29 for about five hours, and the B-25 for about three hours and 20 minutes.

The B-29s tracked the cloud at 22,000 and 18,000 feet, respectively, and the B-25 flew at 12,000 feet. Maximum radiation intensities encountered were 1.5 R/h for the B-29 at 22,000 feet, 8.0 R/h for the B-29 at 18,000 feet, and 1.8 R/h for the B-25. On completion of this mission, the three aircraft returned to their staging bases (26; 34).

Aerial Surveys

As directed by the Test Manager and the Test Director, one H-5 helicopter, one L-20, and one C-47 flew radiological safety and aerial surveys after the shot to record radiation intensities.

The H-5 helicopter began the initial onsite radiological safety survey about one hour and 40 minutes after the detonation. It flew for about one hour and 45 minutes at heights ranging from 50 to 500 feet (26).

The L-20 and C-47 began extended aerial surveys at 0640 and 0730 hours, respectively. Both aircraft flew about 500 feet above the ground, taking radiation intensity readings. The L-20 surveyed primarily onsite for 90 minutes, while the C-47 surveyed offsite for about four hours and 30 minutes (26; 34).

3.3 RADIATION PROTECTION AT SHOT NANCY

Exercise Desert Rock V, the test groups, and AFSWC each developed radiation protection procedures for the entire UPSHOT-KNOTHOLE Series. The procedures were designed to keep individual exposures to ionizing radiation to a minimum, while still

allowing participants to accomplish their activities. Some of the procedures described in chapter 5 of the UPSHOT-KNOTHOLE Series volume resulted in the production of records or activity logs that enabled these organizations to evaluate the effectiveness of their radiation protection programs. Records indicating the procedures performed at Shot NANCY are available for some of the activities in which test group and Exercise Desert Rock members participated.

3.3.1 Desert Rock Radiation Protection Activities

Information concerning radiation protection activities has been obtained primarily from the Exercise Desert Rock V Final Report (45). In addition, the report of the Deputy Test Director lists the range of exposures for the nine volunteer officer observers (23).

When they returned to the trench area and before they boarded vehicles for the return to Camp Desert Rock, all ground troops underwent field decontamination. The standard decontamination procedures, which consisted of sweeping off clothing and subsequent monitoring, reduced contamination levels below established limits, and no individuals required additional decontamination.

For NANCY, each individual was issued a film badge, and some were issued pocket dosimeters. Members of the 505th Signal Service Group processed these film badges. Two members of the 50th Chemical Service Platoon were assigned to help process the badges (45).

Battalion Combat Teams

Two BCTs witnessed the detonation from trenches 3,660 meters from ground zero. Soon after the blast, the wind direction

changed, causing part of the cloud stem to pass over the troops in the trenches. A monitor in one of the trenches noted a peak radiation intensity at that time of 0.018 R/h (45).

As described in section 3.1.4, the BCTs, preceded by Desert Rock radiological safety monitors, began to advance toward their objective shortly after the detonation. BCT ABLE changed its direction of march when intensities of 2.0 R/h were reached. It was not until BCT monitors noted gamma intensities of 40 R/h that the troops of one BCT, probably BAKER, were halted and withdrawn from an area of 14 R/h. After the maneuver, the BCTs toured the portions of the display area where the intensity was less than 2.5 R/h. They then returned to the trench area and boarded trucks that took them to Camp Desert Rock. The highest exposure reading from the pocket dosimeters was 3.0 roentgens. The estimated average radiation exposure for the troops was 2.5 roentgens. These pocket dosimeter readings are somewhat at odds with the limited film badge data available for BCT BAKER. The film badge readings cluster around 0.9, 1.3, and 2.2 roentgens, with a high reading of 2.8 roentgens. These data suggest that only the lead company of BCT BAKER was reflected in the pocket dosimeter average (45; 50; 84).

Orientation and Indoctrination

After witnessing the detonation, observers left the trenches to tour the display area. Twenty-one minutes after the shot, members of the Instructor Group led the observers on this tour. As mentioned above, the forward limit for all individuals on foot in the display area was 2.5 R/h. The observers were also able to view part of the 910-meter display area (45). The mean reconstructed dose for the observers is 0.35 roentgen (39).

Volunteer Officer Observers

A volunteer observer group, consisting of four Army officers, four Navy officers, and an Air Force officer, viewed the detonation from a six-foot-deep trench 2,300 meters from ground zero. The officers had all received training in nuclear weapons effects. Based upon this knowledge and using the Army publication TM-23-200, Capabilities of Atomic Weapons, they calculated the distance from which they could safely view the detonation.

When the volunteer officer observers read their meters after the detonation, they noted a radiation intensity of 1.0 to 2.0 R/h on the floor of the trench and 4.5 R/h at shoulder height in the entrance to the trench. Film badges, placed on the floor of the trench and recovered within an hour after the shot, recorded a total exposure of 0.4 roentgen. Individual film badge readings were between 0.3 and 0.545 roentgen. However, research of film badge data indicates that one of the volunteer officer observers received 0.787 roentgen (30; 45).

The wind that developed at shot-time caused part of the NANCY cloud stem to move toward the volunteers' trench. As the cloud stem approached their trench, the volunteers noted readings on their survey meters of 0.09 roentgen and decided to evacuate the trench to the rear. By the time the volunteers had gone 460 meters, a vehicle sent from the control trench picked them up. At this location, radiac meters registered an intensity of 0.02 R/h. Reconstructed doses of the volunteer observers indicate a mean exposure of 0.64 roentgen (23; 39; 45).

Operational Helicopter Test

As described in section 3.1.5, four HRS Marine Corps helicopters participated in this test. Marine Corps safety regulations for this project specified that the helicopters were not to

operate either in the cloud or in areas with radiation intensities greater than 10.0 R/h. One of the aircraft flew toward ground zero after the blast wave passed. The helicopter was to land as close as possible to ground zero to take radiation readings. Excessive dust and radiation intensities in excess of 10.0 R/h prevented the crew from landing, however. One other helicopter approached within four kilometers of ground zero. These two aircraft, and the other two that did not approach ground zero, were monitored for radioactivity at the decontamination station (43-45).

3.3.2 Joint Test Organization Radiation Protection Activities

Records describing the radiation protection activities performed by JTO personnel were obtained from the Radiological Safety Operations Report (26). Logistical data on film badges and protective equipment issued, survey records and isointensity plots, and decontamination records are available. In addition, Form 102R exposure records describe the activities surrounding some cases of overexposure.

Dosimetry

Between 23 and 29 March 1953, the Dosimetry and Records Section processed about 1,880 film badges. The average exposure for personnel of the Monitoring Section, through 29 March, was 0.65 roentgen. Also during this period, three monitors received more than 3.0 roentgens of exposure, and 18 received more than 1.0 roentgen. In addition, two individuals from Project 6.8 exceeded the 3.9 roentgen limit (26).

Two personnel who may have been involved with Project 6.8 had total exposures exceeding 3.9 roentgens as a result of their activities at Shot NANCY. An individual from Wright Patterson AFB had a total exposure of 6.4 roentgens by 24 March, while one person from Lowry AFB had an exposure of 8.7 roentgens (1b).

During the time of Shot NANCY, two initial survey monitors from the Radiological Safety Support Unit, Fort McClellan, Alabama, had accumulated exposures of 16.1 and 16.8 roentgens. These exposures occurred because the monitors did not turn on their survey meter until they had reached their initial planned survey point, where they found that the intensity was greater than 50 R/h. The following description of the incident is given on their Forms 102R: The exposures occurred while they were "making initial survey of shot area. Crew entered area with AN/PDR-T1B turned off. When instrument was turned on, it went off scale....Left the area immediately" (1a-1b).

One of the DOD monitors working offsite at Lincoln Mine had a film badge reading of 1.22 roentgens for the period beginning one hour before the shot and ending 29 hours after the shot. This individual was indoors about half of that time. The highest film badge reading, 1.825 roentgens, was for a U.S. Public Health Service monitor who was outdoors during the period of fallout (26).

Logistics and Supply

For the period covering Shot NANCY, the Supply Section issued the following items:

- 97 pairs of booties
- 118 caps
- 131 coveralls
- 122 pairs of gloves
- 296 protective goggles
- 113 respirators.

In addition, the Instrument Repair and Supply Section issued 139 radiation survey instruments (26).

Monitoring

Monitors began the initial ground survey 35 minutes after the detonation and completed it by 0830 hours. Poor radio reception in the area prevented one monitoring team from reporting any reading by radio. The south and east portions of the target area were readily accessible, but the north and northwest portions could not be surveyed because most of that area had radiation intensities greater than 10.0 R/h (26).

One H-5 helicopter performed the initial onsite aerial survey. The highest radiation intensity measured was 20.0 R/h, 500 feet above ground zero. In addition, one L-20 and one C-47 performed aerial surveys up to 320 kilometers offsite. The highest intensities, converted to ground readings, were 0.4 R/h and 0.004 R/h, respectively. The day after the detonation, the C-47 resurveyed the area around the NPG and found no readings above background level (26).

Two hours after the shot, the Test Director declared recovery hour. Before this time, the Test Director allowed four teams into the area to recover data, including one non-DOD team to proceed forward of the 10.0 R/h line (26).

An officer of the Monitoring Section checked all access roads leading to radiation areas and posted signs within those areas, thus reducing the requirement for multiple checkpoints.

Based on winds at shot-time, the fallout was expected to occur near to and north of Lincoln Mine. In fact, the maximum fallout activity measured offsite was in the immediate vicinity of Lincoln Mine. In addition to the mobile ground monitors, a two-man monitoring station was established at Lincoln Mine the day before the shot. The cloud from NANCY passed directly over Lincoln Mine about one hour after the detonation. A peak gamma

intensity of 0.58 R/h from fallout was measured at this location about two hours after the detonation. By ten hours after the shot, the radiation levels had decreased to 0.045 R/h (26).

Plotting and Briefing

Figure 3-3 shows the isointensity plot resulting from the initial survey. The test area was resurveyed on 25, 26, 27, 28, and 30 March and on 1, 4, and 7 April 1953. Figure 3-4 shows the survey results for 25, 26, 27 March and 7 April (26).

In addition to its other activities, the Plotting and Briefing Section cleared 93 parties (353 individuals) for entry into the test area during the period 23 to 29 March 1953. Individuals were required to go first to the plotting and briefing room and then to the operations office for final clearance. This procedure reduced the time required to process a party.

Decontamination

During the period of Shot NANCY, 52 vehicles were decontaminated and one was placed in the "hot" park. On the nights of 25 and 26 March, monitors surveyed all motor pools and found three contaminated vehicles parked in the AEC motor pool at the Control Point. These vehicles were decontaminated on 26 March. Following this incident, the vehicle checkpoint located on Mercury Highway was moved north of the access road to the Control Point (26).

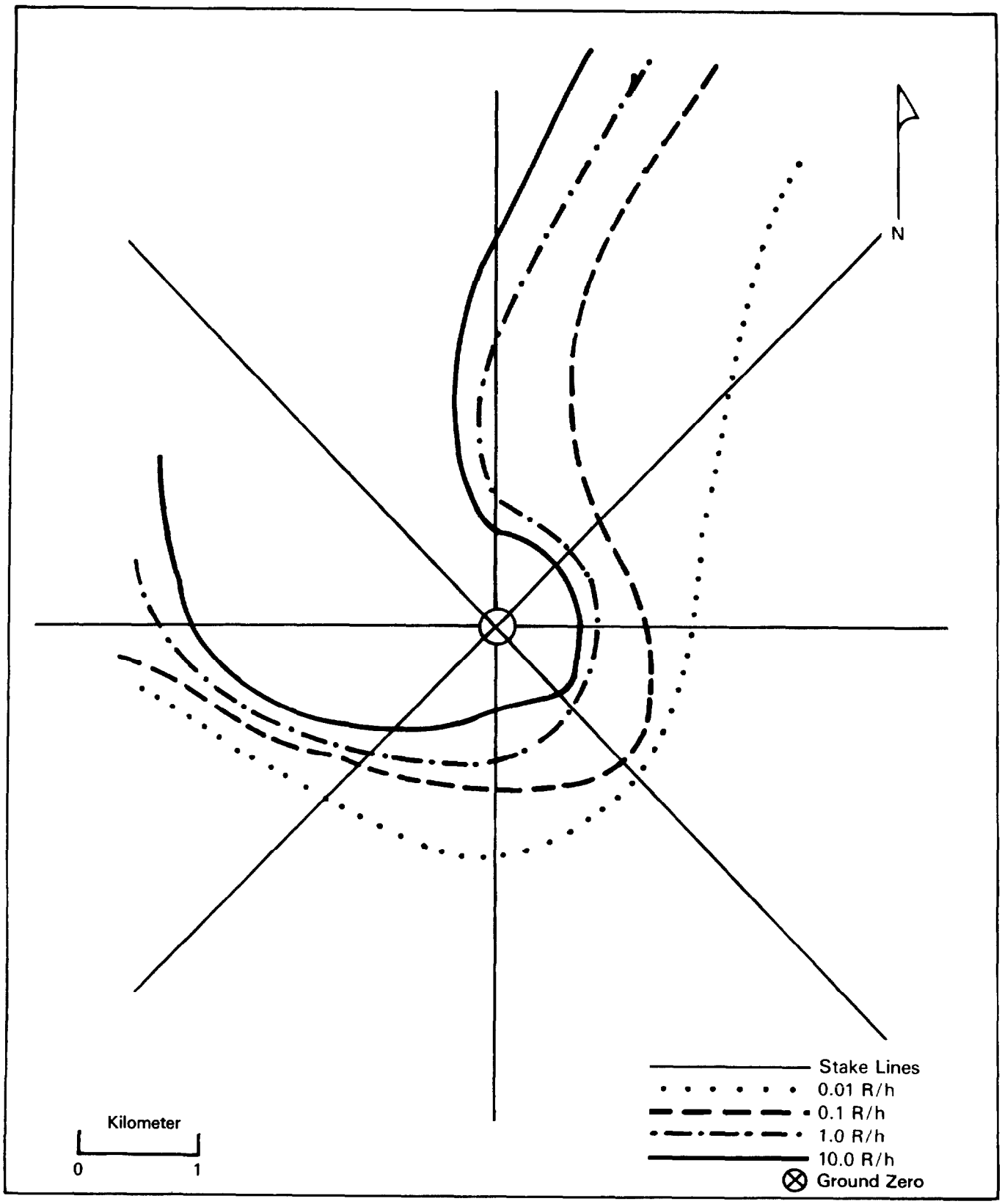
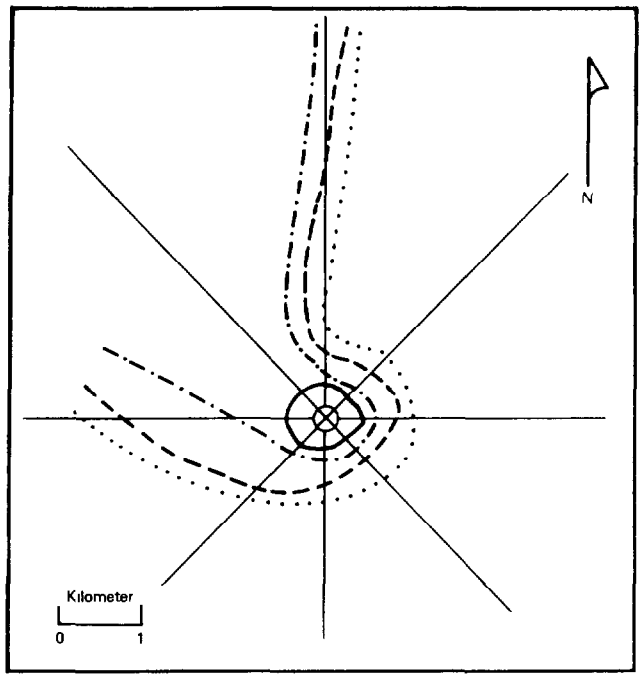
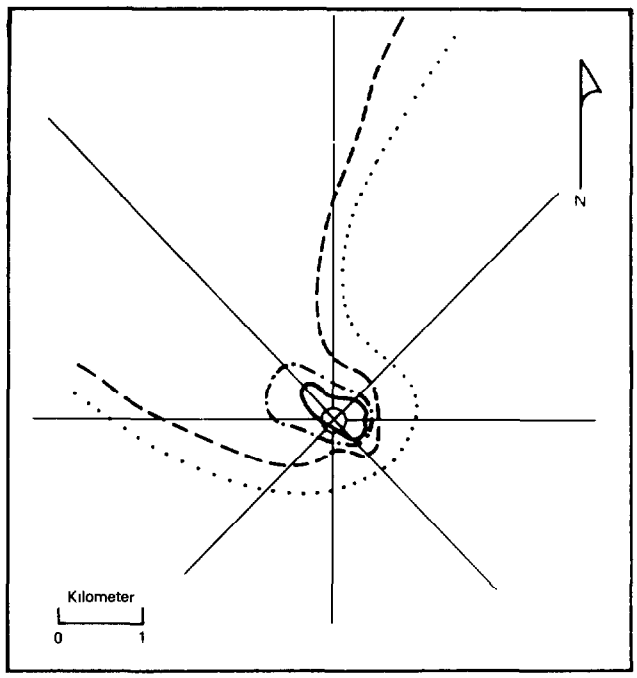


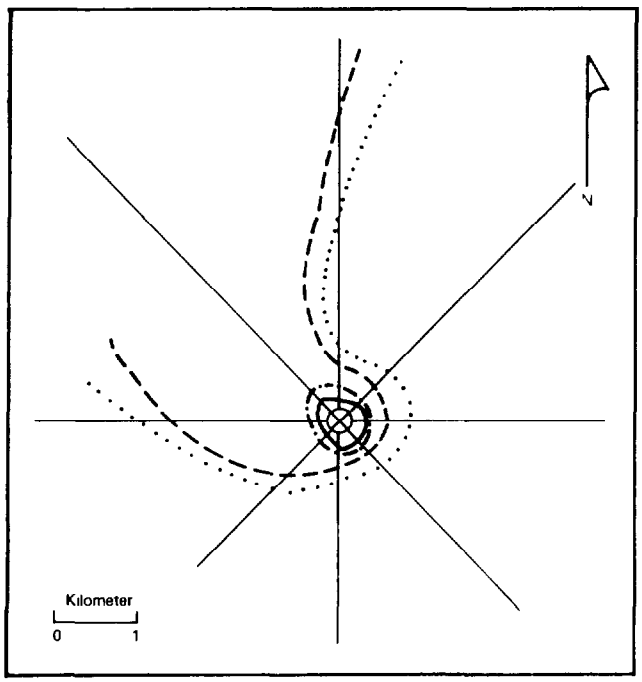
Figure 3-3: INITIAL SURVEY FOR SHOT NANCY, 24 MARCH 1953, 0545 TO 0830 HOURS



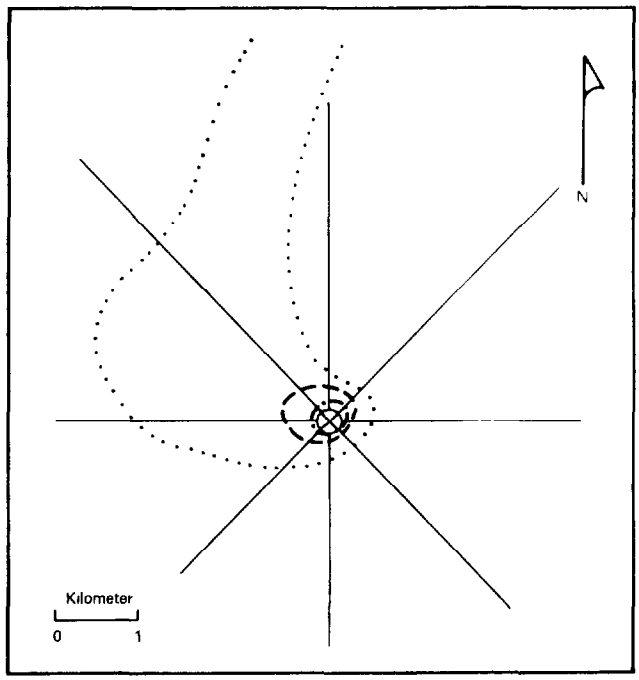
25 March 1953, Completed 0730 Hours



26 March 1953, Completed 0630 Hours



27 March 1953, Completed 0830 Hours



7 April 1953, Completed 1200 Hours

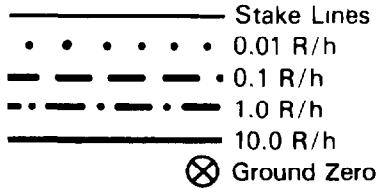


Figure 3-4: SUBSEQUENT SURVEYS FOR SHOT NANCY

SHOT RUTH SYNOPSIS

AEC TEST SERIES:	UPSHOT-KNOTHOLE
DOD EXERCISE:	None
DATE/TIME:	31 March 1953, 0500 hours
YIELD:	0.2 kiloton
HEIGHT OF BURST:	300 feet (tower shot)

AEC Objective: To evaluate the nuclear yield, blast, thermal, and radiological phenomena produced by this experimental device.

DOD Objective: To measure the effects of the detonation and evaluate the military applications of the device.

Weather: At shot-time, the surface wind was from the north at four knots. The winds at 10,000 feet were from the northwest at 18 knots. The temperature was 4.4°C, the relative humidity was 48 percent, and the pressure was 873 millibars.

Radiation Data: The nuclear yield was lower than expected and onsite fallout was minimal; intensities exceeding 0.1 and 0.01 R/h were found as far as four kilometers from ground zero in a narrow band to the south.

Participants: Armed Forces Special Weapons Project, Air Force Special Weapons Center, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, University of California Radiation Laboratory, contractors.

CHAPTER 4

SHOT RUTH

Shot RUTH, one of the smaller detonations of Operation UPSHOT-KNOTHOLE, was conducted as scheduled on 31 March 1953 at 0500 hours, Pacific Standard Time. The device, developed by the University of California Radiation Laboratory, was detonated from a 300-foot tower in Area 7 of Yucca Flat, UTM coordinates 868042. It produced a yield of 0.2 kiloton, which was much less than expected. The top of the cloud resulting from the detonation reached an altitude of 13,600 feet, and the cloud moved southeast from the shot area.

The temperature at shot-time was 4.4 degrees Celsius, and the surface winds were from the north at four knots. The winds at 10,000 feet were from the northwest at 18 knots. Because of the unexpectedly small yield, onsite fallout was minimal, marked only by a small pattern south of ground zero (38).

Before the shot, the Bureau of Aeronautics grounded the four helicopters that were to be used for the Marine Corps Operational Helicopter Tests. No other Exercise Desert Rock V activities were planned because of the small yield expected. The Military Effects Group, the Weapons Development Group, and the Civil Effects Group fielded projects with DOD participation. In addition, the Air Force Special Weapons Center provided aircraft operational control and air support to one Military Effects Group project, one Weapons Development Group project, and the Test Manager.

4.1 DEPARTMENT OF DEFENSE PARTICIPATION IN JOINT TEST ORGANIZATION OPERATIONS AT SHOT RUTH

Department of Defense participation at Shot RUTH was primarily in the areas of experiment preparation and data recovery for the three test groups. These activities required DOD personnel to enter the forward area before, during, and after the shot. DOD personnel conducted the 16 projects sponsored by the Military Effects Group. Other projects involving DOD participation were five of the 22 projects conducted by the Weapons Development Group and five of the ten Civil Effects Group projects. Table 4-1 lists the test group projects by number and title.

4.1.1 Military Effects Group Projects

At Shot RUTH, the Military Effects Group of AFSWP Field Command performed the projects listed in table 4-1. The Test Director allowed recovery operations to begin at 0615 hours.

Project 1.1b, Air Pressure and Ground Shock Measurements, was fielded to obtain data on blast phenomena. Personnel placed air pressure gauges at 11 locations from 330 meters to 3,700 meters southeast of ground zero before the shot. This was the blast line for Shot DIXIE. A station, probably located along this blast line, was instrumented with equipment to record gauge data. Two hours after recovery hour, an estimated four men with one radiological safety monitor traveled to the station to recover instrument records (6; 10a-10b; 78).

Project 2.2a, Gamma Radiation Spectrum of Residual Contamination, was fielded to characterize the gamma radiation resulting from the detonation. At Shot RUTH, the main goal of the project was to familiarize personnel with instruments and techniques and to test the design of the experiment for later shots in the series. Data were obtained using two types of

Table 4-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT RUTH

Project	Title	Participants
	Military Effects Group	
1 1b	Air Pressure and Ground Shock Measurements	Stanford Research Institute
2.2a	Gamma Radiation Spectrum of Residual Contamination	Signal Corps Engineering Laboratories
6 2	Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques	Wright Air Development Center, Vitro Corporation
6 7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	Signal Corps Engineering Laboratories
6.8a	Initial Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
6.9	Evaluation of Naval Airborne Radiac Equipment	Navy Bureau of Aeronautics
6.12	Determination of Height of Burst and Ground Zero	Signal Corps Engineering Laboratories, Army Field Forces Board #1
7.1	Electromagnetic Effects from Nuclear Explosions	Headquarters, Air Force*
7 3	Detection of Airborne Low Frequency Sound from Nuclear Explosions	Headquarters, Air Force*
7.4	Seismic Measurements	Headquarters, Air Force
7.5	Calibration and Analysis of Close-in A-Bomb Debris	Headquarters, Air Force; AFSWC
8.1a	Effects of Thermal and Blast Forces from Nuclear Detonations on Basic Aircraft Structures and Components	Wright Air Development Center, Division of Research, University of Dayton
8.1b	Additional Data on the Vulnerability of Parked Aircraft to Atomic Bombs	Wright Air Development Center
8.2	Measurement of Thermal Radiation with a Vacuum Microphone	Air Force Cambridge Research Center
8 10	Physical Characteristics of Thermal Radiation from an Atomic Bomb Detonation	Naval Radiological Defense Laboratory
9 1	Technical Photography	EG&G, Signal Corps Pictorial Center; Air Force Lookout Mountain Laboratory

*Other participating agencies are listed in the text.

Table 4-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT RUTH (CONTINUED)

Project	Title	Participants
	Weapons Development Test Group	
13.1	Radiochemistry Sampling	AFSWC
18.1	Total Thermal and Air Attenuation	Naval Research Laboratory
18.2	Power versus Time	Naval Research Laboratory
18 3	Spectroscopy	Naval Research Laboratory
18.6	Surface-brightness Investigations	Naval Research Laboratory
	Civil Effects Test Group	
23.1	Biological Effectiveness of Ionizing Radiation within Shelters	Naval Radiological Defense Laboratory; Naval Medical Research Institute
23.2	Bacteriological Studies on Animals Exposed to Neutron Radiation	Naval Radiological Defense Laboratory
23.3	Long-term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters	Naval Radiological Defense Laboratory
23 17	Neutron Flux Measurements in AEC Group Shelters and Lead Hemispheres	Naval Radiological Defense Laboratory
27 1	Distribution and Characteristics of Fallout at Distances Greater than Ten Miles	School of Medicine, UCLA; Navy

instrumentation. Personnel took measurements one hour and two days after the detonation. On shot-day, radiation measurements were 0.187 R/h to 0.312 R/h at points 90 and 270 meters from ground zero, respectively. Two days later, the radiation intensity was 0.204 R/h at 30 meters from ground zero (10a-10b; 13).

Project 6.2, Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques, was conducted to confirm indications that a radar return from a nuclear explosion could be used to determine ground zero, height of burst, and yield. This project used aircraft, a ground-based radar transmitter, and several receivers to investigate whether the fireball significantly changed the direction of a radar beam.

Two B-29 and one B-50 aircraft carrying IBDA equipment took off from Kirtland AFB by 0035 hours on shot-day, entering the test area at about 0300 hours. One aircraft was in a holding pattern south of ground zero, another in a pattern east of ground zero, and the third in a pattern north of ground zero. The aircraft left the area soon after the shot and landed at Kirtland AFB around 0700 hours (6; 34; 53; 61).

Several hours before the detonation, six participants traveled to ground stations. Two participants traveled by vehicle to a receiver station on the east side of Yucca Lake, and two traveled to a second receiver station on Yucca Lake. These two-man teams remained at the stations through the shot. The other two-man team traveled to a mobile radar transmitter unit at UTM coordinates 845206. Four hours and 30 minutes before the shot, these two men left the mobile radar unit for the Control Point. One hour later, two personnel in two vehicles traveled to a radar station located west of the Control Point, UTM coordinates 830880, and stayed through the detonation. Concurrently, the two men arrived at the Control Point from the mobile radar unit. Three hours after recovery hour, the two men left the

Control Point and returned to the mobile radar unit to turn off power generators (6; 34; 53; 61).

Project 6.7, Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations, measured amplitude, duration, and polarization of the pulse of the electromagnetic radiation. Two or three hours before the shot, personnel traveled to an equipment station located between 15 and 20 kilometers from ground zero to turn on generators. They returned after the shot to turn off equipment and retrieve film (10a-10b; 27).

Project 6.8a, Initial Gamma Exposure versus Distance, documented initial gamma radiation exposure data for the RUTH device. Before the shot, National Bureau of Standards film dosimeters were placed at 18 stations located 370 to 2,010 meters from ground zero. These stations were fitted with aluminum thermal and blast shields. Two hours after recovery hour, three parties of five men each, plus monitors, traveled by vehicle to recover the film and dosimeters. The estimated time of the recovery mission was three hours (10a-10b; 59).

Project 6.9, Evaluation of Naval Airborne Radiac Equipment, was designed to evaluate aerial ground survey equipment and automatic recording dosimeters. The equipment was evaluated to determine its accuracy at high altitudes compared to its accuracy at ground level.

A P2V aircraft equipped with test equipment took off from Kirtland AFB three to four hours before shot-time. At shot-time, the aircraft was orbiting approximately 19 kilometers southwest of the shot area at an altitude of about 12,000 feet. The radiac equipment was turned on before shot-time to allow a one-hour warm-up period before the aircraft entered the shot area.

About one hour after the shot, the Aircraft Participation Unit cleared the aircraft to begin runs in a cloverleaf pattern over the radiation area. The patterns were flown at an initial height of some 6,000 feet above the terrain, with subsequent patterns flown at heights decreasing by 500 feet each run. The lowest pattern was at 1,500 feet. The P2V was over the area for about one hour and landed at Indian Springs AFB at 0705 (34; 81).

Project 6.12, Determination of Height of Burst and Ground Zero, evaluated various methods available to a field army for locating ground zero and determining height of burst. Sound-ranging stations were located in the area around Camp Desert Rock, a distance of 50 to 60 kilometers from ground zero. Flash-ranging cameras and seismic geophones were located in the south-east corner of Yucca Lake about 14 kilometers from ground zero.

At 1930 hours on the day before the detonation, three men in one vehicle were scheduled to go to one of the camera and geophone stations on Yucca Lake and man the station through shot-time. Three hours before the detonation, ten men in three vehicles were scheduled to travel to a second station on Yucca Lake and remain there through shot-time (10a-10b; 82).

Project 7.1, Electromagnetic Effects from Nuclear Explosions, was conducted to obtain information on the electromagnetic radiation produced by nuclear detonations. The project was conducted by Headquarters, Air Force, with assistance from the National Bureau of Standards, the Air Force Security Service, the Air Force Cambridge Research Center, and the Air Weather Service.

Personnel manned 13 stations across the United States. Two onsite stations were also used during Shot RUTH. One station 20 kilometers from ground zero was manned by 18 men who remained there through shot-time. The other station, more than 40

kilometers from ground zero, was unmanned during the detonation (10a-10b; 65).

Project 7.3, Detection of Airborne Low Frequency Sound from Nuclear Explosions, compared low-frequency sounds produced by nuclear detonations at various field stations located across the United States and around the world. Personnel from the Signal Corps Engineering Laboratories manned stations in Alaska, Hawaii, Greenland, Japan, and Germany. The Naval Electronics Laboratory, the Signal Corps Engineering Laboratories, and the National Bureau of Standards manned nine stations throughout the continental United States (66).

Project 7.4, Seismic Measurements, was conducted to record the seismic waves produced by the shot for comparison with these produced by shots of other series and with other shots of Operation UPSHOT-KNOTHOLE. Seismic stations were manned in Arizona, Montana, South Dakota, Oklahoma, Alabama, Alaska, and Wyoming. The one onsite station, at UTM coordinates 843094, was not manned at shot-time. Two project personnel and a radiological safety monitor in one vehicle drove to the onsite seismic station and spent one to two hours turning off equipment and recovering records two hours after recovery hour (10a-10b; 28).

Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris, analyzed samples of the Shot RUTH cloud to evaluate various parameters of the nuclear device. Two B-29 aircraft, each with six crew members, took gaseous and particulate samples of the cloud. Because AFSWC conducted the cloud sampling, the project is discussed more fully in section 4.1.4, which describes AFSWC activities (77).

Project 8.1a, Effects of Thermal and Blast Forces from Nuclear Detonations on Basic Aircraft Structures and Components, was developed to increase knowledge of the capabilities of

weapons delivery aircraft. Project personnel instrumented a blast shield from an aircraft and placed it approximately 800 meters from ground zero. They returned about one hour after recovery hour to inspect the damage and collect data (75).

Project 8.1b, Additional Data on the Vulnerability of Parked Aircraft to Atomic Bombs, was fielded to determine the thermal and blast effects of nuclear detonations on parked aircraft. Project personnel placed instrumentation on a B-29 aircraft located 2,350 meters from ground zero before the shot. One hour after recovery hour, seven men and one monitor inspected the damage and recovered data. These were the same personnel who inspected damage to the blast shield for Project 8.1a. Estimated time of the recovery mission was three hours (10a-10b; 37).

Project 8.2, Measurement of Thermal Radiation with a Vacuum Microphone, was fielded to evaluate a device used to measure the thermal radiation produced by a nuclear detonation. Personnel placed sensing equipment at two locations, approximately two and 15 kilometers from ground zero. The 15-kilometer site was also the location of equipment vans, which were manned during the detonation. Signals generated in the microphones by the pressure of the radiant energy were amplified electronically, fed to oscilloscopes located in the vans, and recorded on magnetic tape (6; 14).

Preshot project activities began three days before the shot, when personnel checked the sensing elements for electrical operation. The next day, personnel calibrated the sensing elements and checked other procedures to ensure that the equipment was in working order. One day before the detonation, they repeated these steps. Four hours before the shot, six project personnel traveled to the equipment vans and remained there through the test. Five hours after the shot, personnel retrieved equipment from the close-in station (10a-10b; 14).

Project 8.10, Physical Characteristics of Thermal Radiation from an Atomic Bomb Detonation, was designed to obtain data on the basic thermal radiation characteristics of nuclear devices. The night before the shot, three personnel instrumented two ground stations, consisting of seven-meter towers and instrument shelters. These two stations were 850 and 1,590 meters from ground zero. Three hours after the detonation, three participants and one radiation safety monitor recovered the data. The estimated time of the recovery mission was 90 minutes (6; 10a-10b; 41).

Project 9.1, Technical Photography, provided both still and motion picture photography of the technical aspects of Military Effects Group projects. EG&G personnel conducted Project 9.1, along with 23 officers and enlisted men from the Army Signal Corps Pictorial Center and five enlisted men from the Air Force.

The cameras that had been installed to photograph smoke rocket trails for Shot DIXIE, the next shot of the series, were instrumented and loaded to take motion pictures of the RUTH detonation. These cameras were mounted on top of steel photo-towers approximately four kilometers from the RUTH ground zero. Personnel covered the cameras with plastic bags before the shot to keep dust from damaging them. A dry run was held before the shot. Then the plastic bags were removed and all cameras were loaded with film. After the shot, the film was recovered by the same project personnel who installed it. Participants recovered the film on shot-day, following the Test Director's declaration of recovery hour. EG&G processed the film in Las Vegas or Los Angeles (40).

In addition to Project 9.1 photography, Air Force Lookout Mountain Laboratory personnel occupied five camera stations to

photograph the detonation for historical purposes. The camera stations were located as follows (10a-10b):

STATION	LOCATION (UTM)	PERSONNEL
1	894982	2
2	829900	2
3	781958	2
4	786002	2
5*	843878	2

Project personnel probably remained at their stations through shot-time in order to photograph the burst.

Lookout Mountain personnel also used a C-47 aircraft for documentary photography. The C-47 left Indian Springs AFB at about 0400 hours. At shot-time, the aircraft was in a holding pattern 16 kilometers south of ground zero at an altitude of 10,000 feet. Personnel onboard photographed the blast and resulting cloud formation until about 0505 hours, when the C-47 left the area to return to Indian Springs AFB. It landed at Indian Springs at about 0515 hours (10a-10b; 34).

4.1.2 Weapons Development Group Projects

The Weapons Development Group performed 22 projects at Shot RUTH, five of which involved DOD personnel. Table 4-1 lists the Weapons Development Group projects in which DOD personnel participated.

Project 13.1, Radiochemistry Sampling, was performed by sampling pilots from the AFSWC 4926th Test Squadron (Sampling) and is discussed under AFSWC participation in section 4.1.4.

*Station 5 was at the Control Point.

Project 18.1, Total Thermal and Air Attenuation, Project 18.2, Power versus Time, and Project 18.6, Surface-brightness Investigations, were conducted by the Naval Research Laboratory. No further information is available concerning these projects.

Project 18.3, Spectroscopy, was also conducted by the Naval Research Laboratory. The objective was to obtain information on spectral characteristics of light emitted from nuclear detonations. Spectrometers were used to record on film the wavelength of light as it varied with time.

Two spectrometers were in Building 400, located near the Control Point at Yucca Pass. On shot-day, project personnel operated the instruments in Building 400 manually. At Shot RUTH, the distance between ground zero and Building 400 was about 17 kilometers.

Three other spectrometers were located in Station 413, a reinforced semitrailer which served as a mobile instrument station. The trailer, was located about three kilometers from ground zero. On the night before the test, 11 men occupied Station 413 until about four hours before shot-time. The participants entered Station 413 to load film into the spectrometers and set the instruments for remote control operation. They then secured the trailer and left the area until after the shot. Five personnel plus a radiation safety monitor went to the station after recovery hour to recover film and recorder charts for processing and analysis. They spent about 15 minutes working in this area (10a-10b; 19; 29).

4.1.3 Civil Effects Group Projects

The Civil Effects Group performed ten separate projects at Shot RUTH. Five projects involved DOD participants, as shown in table 4-1. The same Naval Radiological Defense Laboratory

personnel usually conducted all of the Program 23 projects. Detailed information is not available on Project 23.3, Long-term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters.

Project 23.1, Biological Effectiveness of Ionizing Radiation within Shelters, involved the direct biological measurements of the total radiation hazard within earth-protected communal shelters built by the AEC. Mice were used as test subjects. Project participants transported the animals to the shelters, which were 90 meters from ground zero, eight hours before the detonation and retrieved the animals one hour after recovery hour was announced. Radiation intensities were 0.1 R/h outside the shelter and 0.05 R/h inside the shelter (15; 22b).

Project 23.2, Bacteriological Studies on Animals Exposed to Neutron Radiation, collected data on the role played by post-irradiation infection in deaths caused by radiation exposure. Project participants placed 153 animals, mostly mice and dogs, in the same shelters used for Project 23.1. Recovery operations probably began one hour after recovery hour (85).

Project 23.17, Neutron Flux Measurements in AEC Group Shelters and Lead Hemispheres, investigated neutron radiation inside and outside lead hemispheres and shelters and measured the neutron dose received by animals in those structures. At Shot RUTH, the only project activities involved placing animals in the shelters used by Projects 23.1 and 23.2 and retrieving them after recovery hour (86).

Project 27.1, Distribution and Characteristics of Fallout at Distances Greater than Ten Miles, involved detailed studies to determine the hazards from fallout. The field group for this project included about 32 Navy enlisted men. They were responsible for placing and collecting samples and reporting field observations.

The operational plan called for setting up stations consisting of various experiments along roads and trails selected on the basis of predicted fallout patterns. Because the primary objective was to study fallout at distances 16 kilometers or more from ground zero, four stations were placed directly in the path of the cloud on arcs from 16 to 130 kilometers from ground zero.

To maximize the data to be collected, the field group remained at previously assigned rendezvous points until after the final weather briefing. The Air Weather Service predicted the fallout pattern one day before the shot. The prediction was then relayed to the field group via telephone or radio. The field group established stations in a pattern covering approximately 30 degrees on each side of the estimated midline of the fallout at shot-time. About four hours were allowed for the field group to establish stations and return safely to the rendezvous points. About 12 hours after the detonation, the teams collected samples. The group continued to work at the stations until one day after the shot when they dismantled the stations and returned to Camp Mercury (69).

4.1.4 Air Force Special Weapons Center Activities

AFSWC support to the Test Manager and test groups during Shot RUTH consisted of aircraft control, cloud sampling, sample courier missions, cloud tracking, and aerial surveys. With the exception of the B-29 cloud-tracking aircraft that flew from Kirtland AFB, AFSWC aircraft originated at Indian Springs AFB. The types and numbers of aircraft and estimated numbers of AFSWC aircrew involved in air missions at Shot RUTH follow (34).

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Sampling			
Sampler	F-84G	9	9
Sampler	B-29	2	12
Sampler Control	B-50	1	9
Snooper	F-84G	1	1
Sample Courier Missions	B-25	2	10
	C-47	1	3
Cloud Tracking	B-29	2	20
	B-25	1	5
Aerial Surveying	H-5	1	2
	C-47	1	4
	L-20	2	6

Cloud Sampling

At Shot RUTH, 11 aircraft collected particulate and gaseous samples. Nine of the eleven aircraft were F-84G samplers, code-named tiger, flown by pilots of the 4926th Test Squadron for LASL Project 13.1. The other two aircraft were B-29 samplers that collected samples for AFSWP Project 7.5. A B-50 sampler control aircraft with a crew of nine and an F-84G aircraft, called a "snooper," surveyed the cloud before the actual sampling sorties began. After conducting the "snooper" mission, the F-84G took off at 0733 hours to conduct a sampling mission, but landed 13 minutes later because of a malfunction in one of the tiptank sampling devices. The first cloud penetration occurred 35 minutes after the shot. The following listing details the activities of each sampler aircraft. Aircraft are listed according to the sequence in which they flew the sampling mission (34).

AIRCRAFT	NUMBER OF PENETRATIONS	TOTAL TIME IN CLOUD (seconds)	TOTAL TIME IN CLOUD AREA (minutes)
Tiger Red 2	4	106	46
Tiger Red 3	1	_	88
Tiger Red 4	1	-	50
Tiger White 1	3	171	72
Tiger White 3	2	-	25
Tiger White 4	1	-	62
Tiger Blue 2	1	-	55
Tiger Blue 3	3	-	73
Tiger Blue 4	1	-	80
Catnip (B-29)	_	-	135
Catnip (B-29)	-	-	132

After the sampling missions were completed, the aircraft landed at Indian Springs AFB and parked in designated areas. Engines were shut down, and the canopies remained closed and sealed until the samples were removed from the aircraft. The pilots remained on full oxygen while they waited. The 4926th sample-removing team and radiological safety monitors used long-handled tools to remove the filter papers from each aircraft and place them in shielded containers. Members of the sample-removing team then loaded the sample containers onto courier aircraft for delivery to AEC and DOD laboratories for analysis.

After the samples from each aircraft were removed and stored, the pilot shut down his oxygen and opened his canopy. The pilots in F-84G aircraft stepped onto a platform held by a

forklift, so they would not touch the exterior of the aircraft. The B-29 pilots exited through the rear side door. The pilots were then taken in a pickup truck to the decontamination station, where they were monitored and decontaminated as necessary (80).

Sample Courier Missions

After Shot RUTH, two B-25 and one C-47 aircraft flew courier missions for AFSWP Project 7.5, LASL Project 13.1, and other test group projects (33).

Cloud Tracking

Immediately after the detonation, two B-29s with crews of ten each and one B-25 with a crew of five left from Indian Springs AFB and flew cloud-tracking missions over and beyond the NPG. The purpose of these missions was to determine the direction of the cloud and to assist the Test Manager in keeping the airways clear of any private or commercial aircraft that might encounter contaminated clouds. The two B-29s, which had been assigned to track the cloud near an altitude of 20,000 feet, returned to the base after tracking the cloud for only 34 minutes, because the cloud reached a maximum height of only 14,300 feet. The B-25 spent four hours tracking the cloud at 12,000 feet, encountering a maximum intensity of 0.1 R/h. On completion of the mission, the aircraft returned to the staging base (34).

Aerial Surveys

As directed by the Test Manager and the Test Director, an H-5 helicopter, a C-47 aircraft, and two L-20 aircraft flew radiological safety and aerial surveys following the RUTH detonation to record radiation intensities.

The initial onsite aerial survey, using the H-5 helicopter, continued for 80 minutes after the detonation at heights ranging

from five to 50 feet above the ground. The C-47 surveyed as far as 320 kilometers offsite at heights ranging from 500 to 800 feet. The two L-20 aircraft conducted missions for 128 minutes and 54 minutes, respectively (26).

4.2 RADIATION PROTECTION AT SHOT RUTH

For Operation UPSHOT-KNOTHOLE, the test groups and AFSWC developed radiation protection procedures to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their activities. For Shot RUTH, logistical data on radiological safety equipment, survey results and records, isointensity plots, and decontamination records are available.

Dosimetry

During the period of 30 March to 5 April 1953, which covers the 31 March detonation of Shot RUTH, the Dosimetry and Records Section of the JTO processed approximately 1,200 film badges (26). No information is available concerning radiation exposures received by participants at Shot RUTH.

Logistics and Supply

For the period covering Shot RUTH, the Supply Section issued the following items:

- 80 respirators
- 95 protective caps
- 105 pairs of gloves
- 131 pairs of shoe covers
- 153 coveralls.

In addition, the Supply Section issued 55 radiation survey instruments (26).

Monitoring

The initial ground survey party began its survey 22 minutes after the detonation and completed the assignment at 0711 hours. Resurveys were conducted on the afternoon of shot-day and on 1, 2, and 3 April 1953. Monitors also conducted a general survey of Yucca Flat on 2 April. Communication during the initial survey was poor. Although personnel in the Plotting and Briefing room could hear the survey teams, transmissions to the survey teams were mostly inaudible. On subsequent days, communications ranged from satisfactory to poor.

One H-5 helicopter performed the initial onsite aerial survey for 80 minutes following the detonation. The highest radiation intensity, 1.0 R/h at a height of ten feet above the ground, was measured near ground zero. In addition, two L-20s and a C-47 performed aerial surveys up to 320 kilometers offsite. These aircraft found negligible amounts of radiation (26).

Plotting and Briefing

Figure 4-1 presents the plot resulting from the initial ground survey, and figure 4-2 shows the results of the resurveys on 31 March and 1, 2, and 3 April.

In addition to its other activities, the Plotting and Briefing Section briefed 297 personnel in 73 parties for entry into the test area during the period 30 March to 5 April (26).

Decontamination

During the period of Shot RUTH, the Vehicle and Equipment Decontamination Section decontaminated 152 vehicles (26).

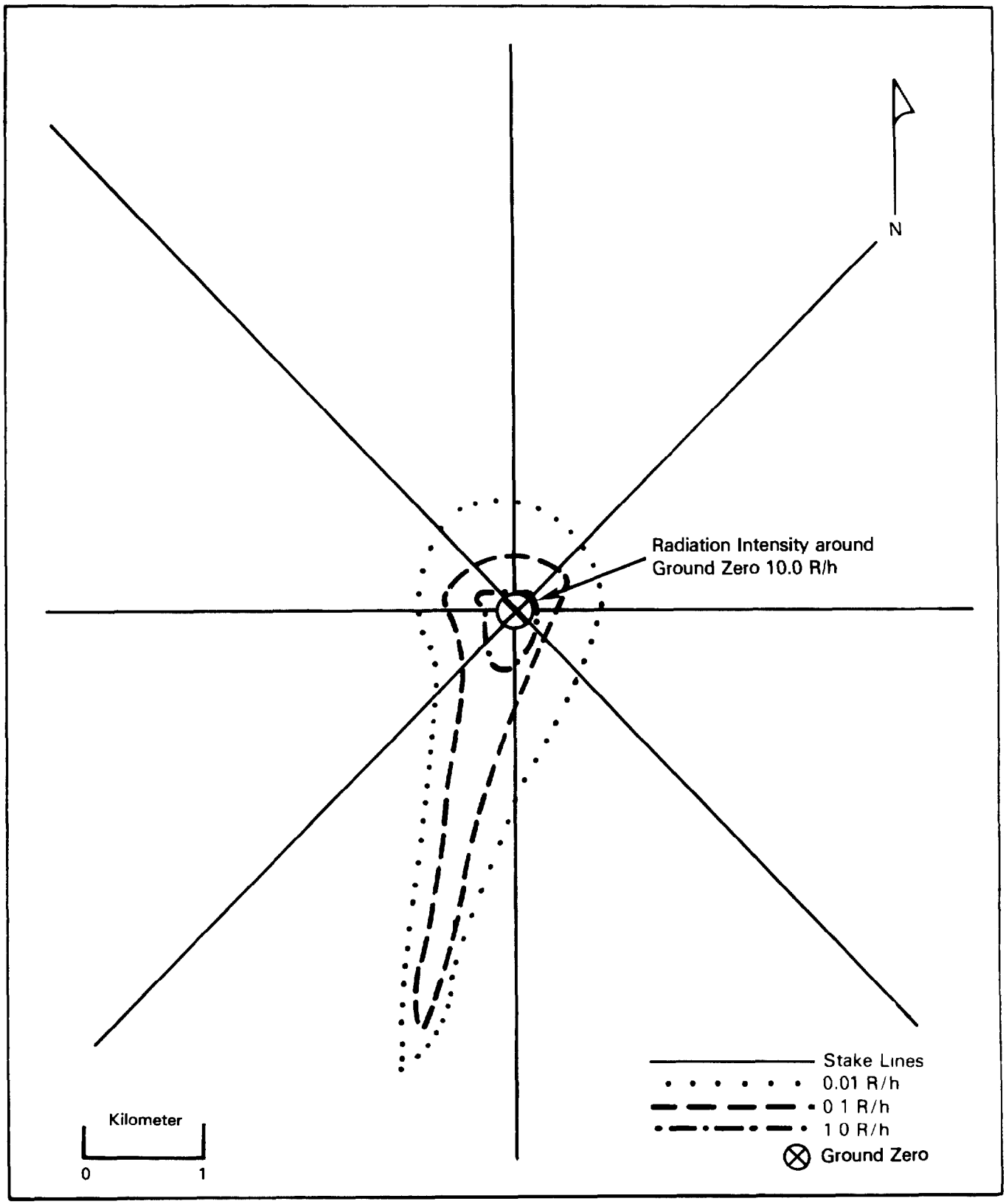
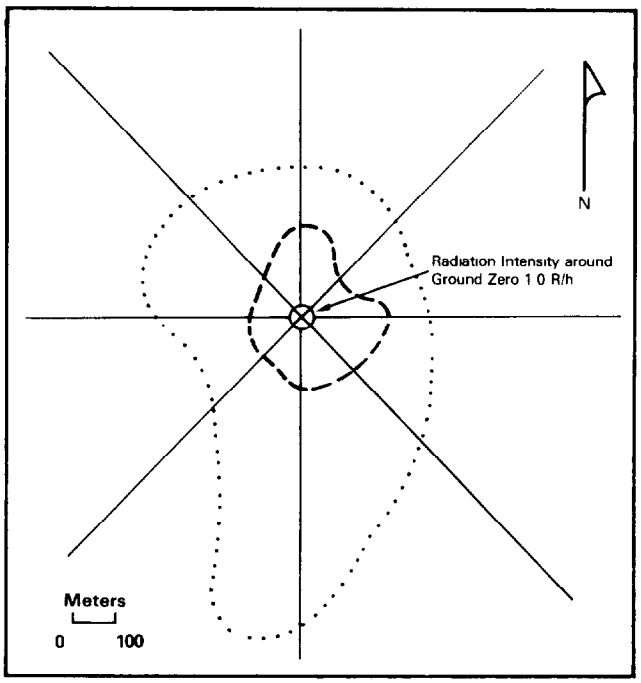
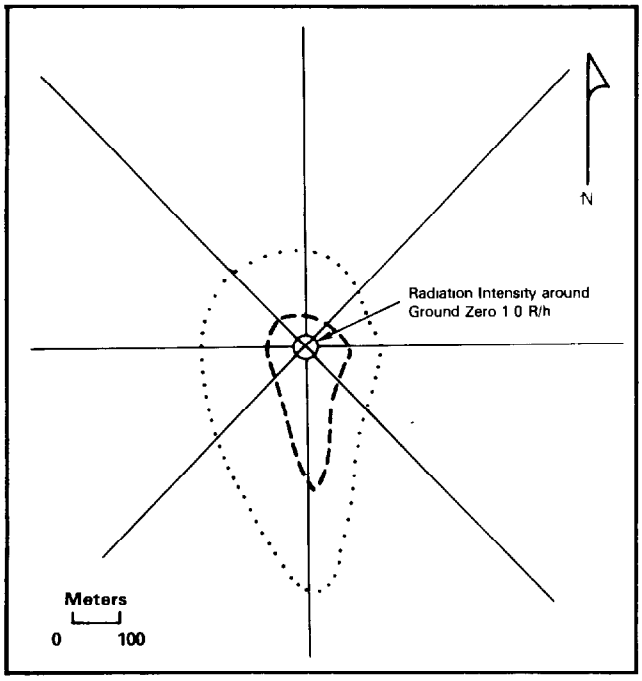


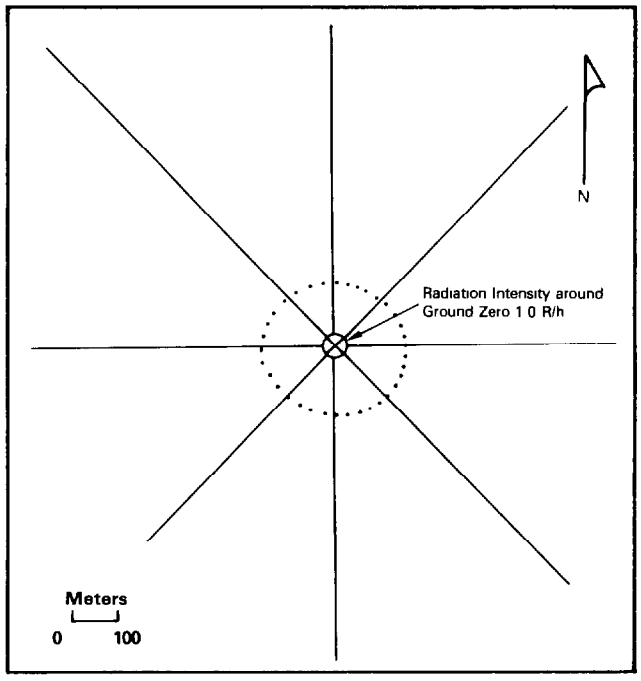
Figure 4-1: INITIAL SURVEY FOR SHOT RUTH, 31 MARCH 1953, 0522 TO 0711 HOURS



1 April 1953, Completed 0600 Hours



2 April 1953, Completed 0700 Hours



3 April 1953, Completed 0600 Hours

Stake Lines
0.01 R/h
0.1 R/h
1.0 R/h
Ground Zero

Figure 4-2: SUBSEQUENT SURVEYS FOR SHOT RUTH

SHOT DIXIE SYNOPSIS

AEC TEST SERIES:	UPSHOT-KNOTHOLE
DOD EXERCISE:	Desert Rock V
DATE/TIME:	6 April 1953, 0730 hours
YIELD:	11 kilotons
HEIGHT OF BURST:	6,020 feet (airdrop)

AEC Objective: To evaluate the nuclear yield, blast, thermal, and radiological phenomena produced by this experimental device.

DOD Objective: To evaluate military equipment, tactics, and doctrine; to measure effects characteristics and evaluate the military applications of the device; and to indoctrinate DOD personnel in the tactical uses of nuclear weapons.

Weather: At shot-time, surface winds were from the north-northeast at seven knots. At 10,000 feet, winds were from the west at 28 knots. At all altitudes above 10,000 feet, the winds were from the west-northwest: 72 knots at 20,000 feet, 92 knots at 30,000 feet, and 122 knots at 40,000 feet. The surface temperature was 15.5°C, the relative humidity was 25 percent, and the pressure was 861 millibars.

Radiation Data: Very little ground contamination occurred because the burst was so high. Radiation intensities around ground zero were 0.0015 R/h about one hour after the shot.

Participants: Exercise Desert Rock V participants, Armed Forces Special Weapons Project, Air Force Special Weapons Center, Los Alamos Scientific Laboratory, Federal Civil Defense Administration, contractors.

CHAPTER 5

SHOT DIXIE

Shot DIXIE was the first of three airdrops performed at Operation UPSHOT-KNOTHOLE. This shot took place on 6 April 1953 at 0730 hours Pacific Standard Time. The device, dropped from a B-50 aircraft flying at an altitude of 33,190 feet, was detonated 6,020 feet above Area 7 of Yucca Flat,* at UTM coordinates 871045. The shot was one of the more spectacular bursts in the series and had a yield of 11 kilotons.

The top of the cloud resulting from Shot DIXIE reached an altitude of 43,000 feet, and the cloud moved to the south. Winds were so great at the higher altitudes that the cloud was reported past the 320-kilometer zone three hours after detonation. There was very little ground contamination--at one hour after detonation, the radiation intensity was 0.0015 R/h at ground zero. Localized fallout was absent because the height of burst prevented soil particles from being swept into the cloud. No offsite fallout was detected, except at St. George, Utah, where a light, brief rain shower contained some weapon debris (26; 38).

The Military Effects Group, the Weapons Development Group, and the Civil Effects Group fielded 28 projects with DOD participation. The two Exercise Desert Rock V activities conducted at Shot DIXIE involved 135 DOD personnel who witnessed the shot as part of an orientation and indoctrination program and 11 Marine Corps personnel who conducted operational helicopter tests. The Air Force Special Weapons Center airdropped the DIXIE device,

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*Yucca Flat is approximately 4,000 feet above mean sea level.

provided aircraft operational control, and provided air support to one Military Effects Group project, one Weapons Development Group project, and to the Test Manager.

5.1 EXERCISE DESERT ROCK V OPERATIONS AT SHOT DIXIE

Only two Desert Rock projects were performed at Shot DIXIE. Table 5-1 lists Desert Rock V activities at DIXIE and the number and units of the personnel involved.

Table 5-1: EXERCISE DESERT ROCK V ACTIVITIES AT SHOT DIXIE

Program	Participating Service	Estimated DOD Personnel
Troop Orientation and Indoctrination (Observers)	Marine Corps Army (Camp Desert Rock Troops)	75 60
Operational Helicopter Tests	Marine Corps	11

5.1.1 Orientation and Indoctrination

The standard orientation and indoctrination program of Exercise Desert Rock V was not used at Shot DIXIE. There was no classroom instruction, and no display area was prepared for the detonation. However, 75 Marine Corps officers and enlisted personnel from Camp Pendleton, California, an advance party of the 2d Marine Corps Provisional Atomic Exercise Brigade (2d MCPAEB) witnessed the event. These personnel were joined by 60 observers from Camp Desert Rock. The entire group witnessed the detonation from News Nob, 16 kilometers from the DIXIE ground zero.

The observer group arrived at News Nob, UTM coordinates 848888, at 0630 hours on shot-day. From 0645 to 0715 hours, a member of the Camp Desert Rock Instructor Group conducted a pre-shot orientation covering the nature of the device to be detonated and its mode of delivery.

Shot DIXIE detonated on schedule at 0730 hours. Although the observers were 16 kilometers from the burst, they felt the blast wave and thermal effects. The radiac instruments at News Nob did not record any radiation. Because of the height of the detonation, dust conditions were negligible. The observer group left News Nob at 0800 hours and arrived at Camp Desert Rock at 0845 hours (45).

5.1.2 Operational Helicopter Tests

Marine Corps personnel from the Helicopter Atomic Test Unit, 2d Marine Corps Provisional Atomic Exercise Brigade, conducted operational tests with four Marine HRS helicopters at Shot DIXIE. A pilot and co-pilot operated each helicopter. Monitors were aboard three helicopters. These tests were designed to investigate factors that might affect the use of helicopter assaults after a battlefield nuclear detonation. At Shot DIXIE, the results included findings on overpressure and ground and airborne radiation intensities (44).

At the time of the detonation, helicopters A, B, C, and D were located at the extreme south of Yucca Lake, 18 kilometers from ground zero, at UTM coordinates 878865. The helicopters were on the ground, port-side to the shot. About 30 seconds after the shot, all four helicopters hovered about ten feet above the ground and turned toward the shot to experience the shock wave. All helicopters then proceeded toward ground zero. Helicopter A was to approach ground zero and land at an upwind

position, where radiation intensity did not exceed 0.05 R/h. There it was intended that a radiological monitor would disembark to determine the feasibility of troop entry at this point. The monitor was not to approach ground zero closer than the 10.0 R/h intensity line. Since no landing points were indicated for Shot DIXIE and since the yield was low, it is unlikely that the aircraft landed or that the monitors took readings (44).

While helicopter A was to proceed as close to ground zero as possible, helicopter B was to hover no closer than 1,600 meters from ground zero and near UTM coordinates 868031 to maintain visual contact with helicopter A and render any assistance necessary.

Helicopters C and D also proceeded to within 1,600 meters of ground zero with the intention of landing approximately 1,600 meters north of the DIXIE ground zero. The after-action reports on this operation do not specify whether either of these helicopters actually landed there. After about 25 minutes, all helicopters were to return to the Yucca Lake Airstrip and land at UTM coordinates 854891 for radiological decontamination and clearance. Figure 5-1 shows the flight patterns of the helicopters (44).

5.2 DEPARTMENT OF DEFENSE PARTICIPATION IN JOINT TEST ORGANIZATION OPERATIONS AT SHOT DIXIE

In addition to Desert Rock activities, DOD personnel performed a variety of tasks that required them to enter the forward area before, during, and after the shot. The Military Effects Group sponsored 20 projects at Shot DIXIE. DOD personnel also participated in five of the 15 projects conducted by the Weapons Development Group and six of ten projects performed by the Civil Effects Group. The Air Force Special Weapons Center supported several test group projects and the Test Manager.

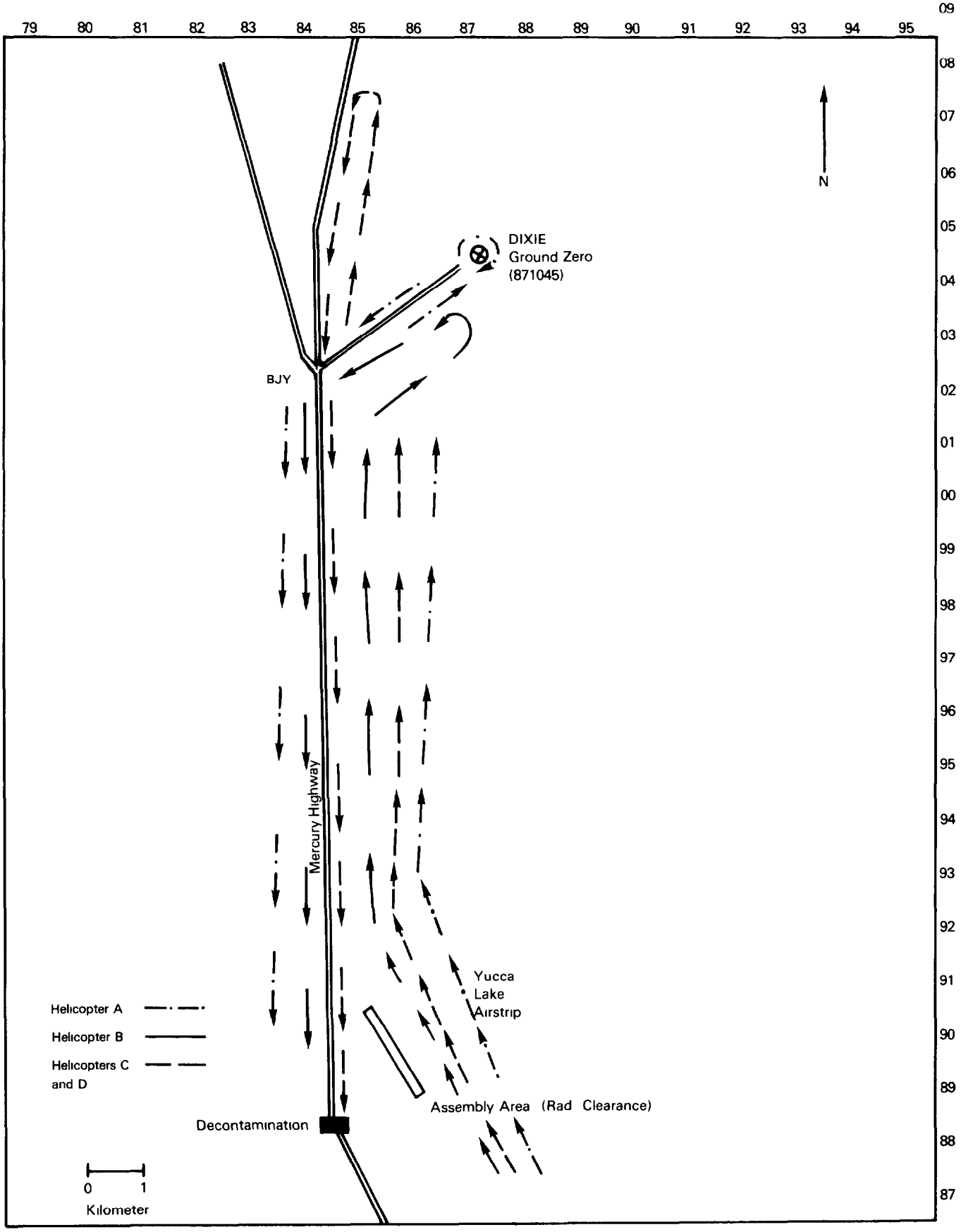

Figure 5-1: OPERATIONAL HELICOPTER TESTS AT SHOT DIXIE

These AFSWC support activities included aircraft operational control, airdrop of the nuclear device, cloud sampling, cloud tracking, and courier missions. Table 5-2 lists the test group projects by number and title and identifies the fielding organizations.

5.2.1 Military Effects Group Projects

At Shot DIXIE, the Military Effects Group of AFSWP Field Command performed the projects shown in table 5-2. The Test Director declared recovery hour at 0812 hours, 42 minutes after the detonation.

Project 1.1a/1.2, Air Blast Measurements, was fielded to detect overpressures in free air. Smoke rocket photography was used to obtain measurements. Personnel placed 15 rockets in a line located about 910 meters northwest of ground zero. A camera station was situated about five kilometers southwest of ground zero. Immediately before the shot, the smoke rockets were ignited from a switch at the Control Point. The camera was timed to begin photographing when the rocket trails ignited. Two of the rockets did not fire. At recovery hour, two men and a monitor traveled to the rocket line and removed the rocket hazards. Personnel retrieved film at the camera station (11a-11b; 17; 62).

Project 1.1b, Air Pressure and Ground Shock Measurements, was fielded to obtain additional data on blast phenomena. Before the shot, personnel placed 24 air pressure gauges in the field at locations 185 to 4,030 meters west and south of ground zero. The gauges were connected to cables that went to a shelter about 1,800 meters from ground zero where recording instruments were placed. Two hours after recovery hour, four men and a radiological safety monitor traveled to the recording shelter to recover the records. Estimated time for the mission was 30 minutes (11a-11b; 62).

Table 5-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT DIXIE

Project	Title	Participants
	Military Effects Group	
1.1a/1 2	Air Blast Measurements	Naval Ordnance Laboratory
1 1b	Air Pressure and Ground Shock Measurements	Stanford Research Institute
1 3	Free-air Atomic Blast Pressure Measurements	Air Force Cambridge Research Center
2 1	Radioactive Particle Studies inside an Aircraft	Chemical and Radiological Laboratories
4.1	The Radiation Hazard to Personnel within an Atomic Cloud	Air Force Cambridge Research Center, Air Force School of Aviation Medicine*
5.2	Atomic Weapon Effects on B-50 Type Aircraft in Flight	Wright Air Development Center
6 2	Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques	Wright Air Development Center; Vitro Corporation
6 3	Interim IBDA Capabilities of Strategic Air Command	Strategic Air Command
6 7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	Signal Corps Engineering Laboratories
6 8	Evaluation of Military Radiac Equipment	Signal Corps Engineering Laboratories; Bureau of Ships
6 11	Indoctrination of Tactical Air Command Air Crews in the Delivery and Effects of Atomic Weapons	Tactical Air Command, Air Research and Development Command
6 12	Determination of Height of Burst and Ground Zero	Signal Corps Engineering Laboratories, Army Field Forces Board #1
7 1	Electromagnetic Effects from Nuclear Explosions	Headquarters, Air Force*
7.3	Detection of Airborne Low Frequency Sound from Nuclear Explosions	Headquarters, Air Force*
7 4	Seismic Measurements	Headquarters, Air Force
7 5	Calibration and Analysis of Close-in A-Bomb Debris	Headquarters, Air Force, AFSWC
8 2	Measurement of Thermal Radiation with a Vacuum Microphone	Air Force Cambridge Research Center
8 10	Physical Characteristics of Thermal Radiation from an Atomic Bomb Detonation	Naval Radiological Defense Laboratory

* Other participating agencies are listed in the text.

Table 5-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT DIXIE (Continued)

Project	Title	Participants
	Military Effects Group (Continued)	
8 11b	Ignition and Persistent Fires Resulting from Atomic Explosions—Exterior Kindling Fuels	Forest Service, Division of Fire Research
9 1	Technical Photography	EG&G, Signal Corps Pictorial Center; Air Force Lookout Mountain Laboratory
	Weapons Development Group	
13.1	Radiochemistry Sampling	AFSWC
18 1	Total Thermal and Air Attenuation	Naval Research Laboratory
18.2	Power versus Time	Naval Research Laboratory
18 3	Spectroscopy	Naval Research Laboratory
18 6	Surface-brightness Investigations	Naval Research Laboratory
	Civil Effects Group	
23 1	Biological Effectiveness of Ionizing Radiation within Shelters	Naval Radiological Defense Laboratory, Naval Medical Research Institute
23 2	Bacteriological Studies on Animals Exposed to Neutron Radiation	Naval Radiological Defense Laboratory
23.3	Long-term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters	Naval Radiological Defense Laboratory
23.17	Neutron Flux Measurements in AEC Group Shelters and Lead Hemispheres	Naval Radiological Defense Laboratory
27 1	Distribution and Characteristics of Fallout at Distances Greater than Ten Miles	School of Medicine, UCLA; Navy
29 1	Comparison and Evaluation of Dosimetry Methods Applicable to Gamma Radiation	Atomic Energy Project, UCLA*

* Other participating agencies are listed in the text

Project 1.3, Free-air Atomic Blast Pressure Measurements, was designed to obtain data on the peak overpressure of the free-air shock wave before the arrival of the reflected ground wave. Two B-29 aircraft, flying in close formation, made four practice runs between 40 and 12 minutes before the detonation. Two minutes before the DIXIE detonation, the two aircraft, flying upwind at 20,000 feet at a speed of 175 knots, began to drop 14 parachute-borne canisters. The canisters contained pressure altimeters, differential pressure transducers, and a radio transmitter unit. The final canister was dropped 20 seconds before the detonation.

Ground project activities began about four hours before shot-time. Fourteen project personnel went to a station east of Yucca Lake more than 2,700 meters from ground zero, and another group of 14 went to a second station about 1,600 meters north of the Control Point to record data transmitted from the canisters. They remained at these stations through shot-time. Concurrently, two men traveled to a radar beacon station 2,740 meters south of ground zero to check instruments and turn on the power. They left the station about two hours and 30 minutes before the detonation. Personnel retrieved the canisters several days after the shot (11a-11b; 42).

Project 2.1, Radioactive Particle Studies inside an Aircraft, was to evaluate the inhalation hazard to aircraft crews flying through the clouds formed by detonations. Two QF-80 drone aircraft were instrumented for Project 4.1, as described in the next paragraph. Project 2.1 personnel installed additional instruments in the drones to measure the inhalation of radioactive particulates (20).

Project 4.1, Radiation Hazard to Personnel within a Nuclear Cloud, was conducted to evaluate the radiation hazards to aircrews in a modern military aircraft flying through the cloud

resulting from a detonation. Two QF-80 drone aircraft were used for both this project and Project 2.1 to measure both internal and external radiation hazards. Personnel from the 3205th Drone Group from Eglin AFB, Florida, provided, maintained, and operated the drones.

Animals were placed onboard each drone aircraft to be flown through the cloud. In addition, personnel placed temperature and pressure gauges and radiation instruments inside and outside the aircraft. Each drone also carried wing-tip chambers with filter papers to collect particulate samples of the cloud. The aircraft passed through the cloud once. The highest drone aircraft passed through the bottom of the cloud at 30,000 feet, four and one-half minutes after shot-time. The ratemeter showed a maximum radiation dose rate of 2.1 roentgens per second and an integrated dose of 11.3 roentgens. The lowest drone, flying at 28,000 feet, missed the cloud, but penetrated the radiation field under the cloud. After the pass, the drones were landed at the Yucca Flat Airstrip. The samples and animals were taken to the Los Alamos Scientific Laboratory, where autopsies were performed on the animals.

In addition, a B-50 and a B-47 aircraft each dropped five instrumented canisters. The AFSWC 4925th Test Group provided the aircraft and crews. The B-50 flew at 35,000 feet and dropped the canisters at 150-meter intervals beginning about one minute after the shot. It remained in the air after the canister drop to act as the sample control aircraft during the cloud-sampling mission for Projects 7.5 and 13.1. The B-47, flying at 45,000 feet, released the canisters at 200-meter intervals beginning about eight minutes after the detonation. The canisters contained telemetering equipment. As they dropped through the cloud, a telemetering station located seven kilometers from ground zero recorded their radiation data. Four project participants manned

the station through shot-time. The canisters were recovered the day after the shot (34; 58; 82).

Project 5.2, Atomic Weapon Effects on B-50 Type Aircraft in Flight, was designed to determine the minimum safe altitude for dropping nuclear weapons from medium bombardment aircraft. Three B-50 aircraft operated by Wright Air Development Center and SAC aircrews were instrumented for pressure and thermal radiation. One B-50 withdrew an hour after takeoff due to engine failure. A flight pattern was established so that the B-50s were in formation with the bomb-drop aircraft. The two aircraft, one with a crew of nine and the other with eight, flew at 30,000 feet, 3,000 feet behind and 3,000 feet below the drop aircraft. The slant range to the burst for the closest aircraft was 5,940 meters (3; 34; 60).

Project 6.2, Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques, was conducted to confirm indications that a radar return from a nuclear explosion could determine ground zero, height of burst, and yield. A B-29 aircraft took off from Kirtland AFB at 0400 hours on shot-day, entering the test area at about 0704 hours. It orbited eight kilometers south of ground zero. The aircraft left the area at 0838 hours and landed at Kirtland AFB at 1046 hours. In addition to the air operation, a ground operation was conducted with a radar set connected to an oscilloscope and camera used to record the returns. Two hours before the shot, four project personnel in two vehicles were scheduled to go to a radar station 800 meters west of the Control Point and remain there through the detonation (11a-11b; 33-34; 53; 61).

Project 6.3, Interim IBDA Capabilities of Strategic Air Command, was a corollary to Project 6.2. This project evaluated the latest IBDA systems, which were installed in SAC aircraft

flying simulated strike and support missions. These aircraft recorded data essential for determining the three IBDA parameters: yield, burst height, and ground zero.

Eleven or 12 B-47 aircraft of the 6th Air Division from McDill AFB, Florida, reached the test area at 0655 hours at an altitude of 37,000 feet. The aircraft flew in formation over the test site for approximately 50 minutes. Thirty-three aircrew personnel participated (3; 11a-11b; 33-34; 56).

Project 6.7, Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations, was designed to detect and measure amplitude, duration, and polarization of the pulse of the electromagnetic radiation emitted from a nuclear detonation and to record any electromagnetic signals that might be emitted in the instant before the nuclear detonation.

Before the shot, three project participants in two vehicles drove to two stations, about three kilometers south of ground zero, to turn on equipment. They then traveled to a station about two kilometers north of the Control Point, where they remained through shot-time. One hour after recovery hour, these men, accompanied by a monitor, proceeded to the two stations to turn off equipment and pick up the data. Estimated time in the area was about two hours (11a-11b; 27).

Project 6.8, Evaluation of Military Radiac Equipment, was fielded by the Signal Corps Engineering Laboratories, assisted by Air Force and Navy personnel. This project was designed to test dosimeters and radiac instruments in initial and residual radiation fields produced by a nuclear detonation. Personnel placed dosimeters at 12 to 14 stations located 460 meters to 2,740 meters from ground zero. These portable stations were fitted with aluminum thermal and blast shields.

Two hours after recovery hour, one party of six men accompanied by a monitor traveled by vehicle to recover the dosimeters. Estimated time of the mission was three hours. Due to low levels of residual radiation, other activities planned for Project 6.8 were canceled (11a-11b; 54).

Project 6.11, Indoctrination of Tactical Air Command Air Crews in the Delivery and Effects of Atomic Weapons, was fielded by the Air Research and Development Command and the Tactical Air Command (TAC). The project was designed to provide realistic operational training for TAC aircrews in the effects of blast, thermal, and nuclear radiation that might be encountered in the delivery of nuclear weapons. The project also provided data on the temperature of aircraft skin while in flight.

Seven TAC T-33 aircraft, each with a crew of two, were fitted with test gear at Indian Springs AFB. After take-off, the seven aircraft joined the B-50 drop aircraft about 40 minutes before the shot. The T-33s accompanied the aircraft through three dry runs and the actual drop mission at 33,192 feet. The seven aircraft were in groups of four and three, from right to left respectively, flying a stepped-down modified pattern away from the B-50.

At bomb release plus 10 seconds, the right flank of aircraft rolled into a 90-degree bank, extended dive brakes, applied 100 percent power, and began a 2.5 g* diving turn to the right. At bomb release plus 13 seconds, the left flank performed a similar maneuver falling into the trail of the right flank. They pulled out at 22,000 feet on a heading of about 120 degrees. At shot-time, all aircraft were in a 20-degree climb outward from the point of detonation. Approximately 10 seconds after the shot, dive brakes were retracted, normal fighter formation was

*Force equal to 2.5 times normal gravity.

resumed, and the aircraft proceeded directly to George AFB, California, for decontamination and debriefing (33-34; 70).

Project 6.12, Determination of Height of Burst and Ground Zero, evaluated various equipment and techniques for locating ground zero and determining height of burst. Sound-ranging stations were located in the area around Camp Desert Rock, 50 to 60 kilometers from ground zero. The system consisted of three separate microphone arrays several kilometers apart along a line perpendicular to the line from the center of the array to the burst point. Flash-ranging cameras and seismic geophones were operated at stations in the southeast corner of Yucca Lake approximately 13 to 16 kilometers from ground zero. The night before the shot, three men in one vehicle went to the control station, which was located centrally to the other stations, and remained there through the detonation. Three hours before the shot, ten men in three vehicles turned on equipment at the other stations and returned to the central station where they remained through shot-time (11a-11b; 82).

Project 7.1, Electromagnetic Effects from Nuclear Explosions, was designed to obtain additional information on the electromagnetic radiation produced by nuclear detonations. This project continued similar investigations conducted at Operations BUSTER-JANGLE and TUMBLER-SNAPPER. Personnel from the National Bureau of Standards, the Air Force Security Service, the Air Force Cambridge Research Center, and the Air Weather Service manned one station onsite and several stations in the United States and in Bermuda. The manned onsite station was just south of Yucca Flat, about 20 kilometers from ground zero. Sixteen project personnel traveled there about four hours before the shot and remained through shot-time (65).

Project 7.3, Detection of Airborne Low Frequency Sound from Nuclear Explosions, was designed to compare low frequency sounds

produced by nuclear detonations at various remote field stations. These stations were located across the United States and around the world. The Signal Corps Engineering Laboratories operated stations in Alaska, Hawaii, Greenland, Japan, and Germany. The Naval Electronics Laboratory, the Signal Corps Engineering Laboratories, and the National Bureau of Standards operated nine stations in the continental United States (66).

Project 7.4, Seismic Measurements, was conducted to record the seismic waves produced by the shot for comparison with those produced by shots of other series and by other shots of Operation UPSHOT-KNOTHOLE. Ten seismic stations were manned in Arizona, Montana, South Dakota, Oklahoma, Alabama, Alaska, and Wyoming. The one onsite station, at UTM coordinates 843094, was not manned during the shot. Two project personnel and a radiological safety monitor in one vehicle proceeded to this station to turn off the equipment and recover the records about two hours after recovery hour (11a-11b; 28).

Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris, was designed to analyze samples of the Shot DIXIE cloud to evaluate various parameters of the nuclear device. A B-29 with a crew of seven took gaseous and particulate samples of the cloud. Because AFSWC conducted the cloud sampling, it is discussed more fully in the AFSWC section, 5.2.4 (77).

Project 8.2, Measurement of Thermal Radiation with a Vacuum Microphone, evaluated a device used to measure the thermal radiation produced by a nuclear detonation. Personnel placed sensing equipment three and 15 kilometers from the detonation location. Signals generated in the microphones by the pressure of the radiant energy were amplified electronically, fed to an oscilloscope, and recorded on magnetic tape. The equipment was contained in two vans manned and located about 15 kilometers from ground zero near the more distant microphone station.

Preshot project activities began three days before the detonation when personnel checked the sensing elements. The next day, project personnel calibrated the sensing elements and checked to ensure that all the equipment was working. One day before the detonation, they repeated these steps. Four hours before the shot, six project personnel traveled to the equipment vans and remained there through the test. After the detonation, personnel retrieved equipment from the close-in station (11a-11b; 14).

Project 8.10, Physical Characteristics of Thermal Radiation from an Atomic Bomb Detonation, was designed to supply additional data on the basic thermal radiation characteristics of nuclear devices. In order to obtain the necessary field data for checking theoretical approaches to the problem of calculating scattered radiation, ground stations were instrumented so that certain physical characteristics of the thermal radiation could be closely monitored.

Where low thermal flux was anticipated, the instruments were placed about three meters above ground level. Before shot-time, three project personnel instrumented two stations consisting of 17-meter towers and instrument shelters. These two stations were 2,070 and 2,620 meters south of the DIXIE ground zero. One hour after recovery hour, three personnel plus a radiation safety monitor recovered the data. The estimated time of the recovery mission was one hour.

In addition to the instruments at the ground stations, two Strategic Air Command B-50 aircraft and one B-50 that operated for Project 5.2 were instrumented to obtain thermal measurements for this project. The aircraft flew in formation with the drop aircraft at 30,000 feet (33-34; 41).

Project 8.11b, Ignition and Persistent Fires Resulting from Atomic Explosions--Exterior Kindling Fuels, studied exterior

kindling fuels found in urban areas. Before the shot, project participants placed newspaper bundles, rags, and mops at locations 1,500 to 3,000 meters from ground zero. One hour after recovery hour, three men and a radiological safety monitor inspected the damage (3; 11a-11b; 74).

Project 9.1, Technical Photography, provided both still and motion picture photography of the shock front at Shot DIXIE. EG&G personnel, 23 officers and enlisted men from the Army Signal Corps Pictorial Center, and five Air Force enlisted men performed this project.

The shock front was photographed by cameras mounted in two photography trailers at an unknown distance from ground zero. After the shot, project personnel recovered the film. EG&G processed the film in Las Vegas or Los Angeles (40).

In addition to Project 9.1 technical photography, a documentary photography mission was performed by personnel from the Air Force Lookout Mountain Laboratory. Ten personnel established five camera stations at the following locations (11a-11b):

Station	Location (UTM)	Number of Personnel	Distance from Ground Zero (kilometers)
1	900928	2	12
2	830910	2	14
3	829900	2	15
4	781958	2	13
5*	843878	2	17

They remained in the area to photograph the burst and resulting cloud.

*Station 5 was at the Control Point.

Lookout Mountain Laboratory personnel also took documentary photographs from a C-47 aircraft. The aircraft left Indian Springs AFB at 0630 hours and established a holding pattern 16 kilometers south of ground zero at 10,000 feet. Personnel photographed the DIXIE burst, and the C-47 left the area at 0733 hours. It landed at Indian Springs AFB at 0746 hours (34; 40).

5.2.2 Weapons Development Group Projects

The Weapons Development Group performed 15 projects at Shot DIXIE, only five of which involved DOD personnel. Table 5-2 lists DOD participation in the Weapons Development Group.

Project 13.1, Radiochemistry Sampling, was performed by sampling pilots from the AFSWC 4926th Test Squadron (Sampling) and is discussed under AFSWC participation in section 5.2.4.

Projects 18.1, Total Thermal and Air Attenuation, 18.2, Power versus Time, and 18.6, Surface-brightness Investigations, were performed for the Weapons Development Group by the Naval Research Laboratory of Washington, D.C. No further information is available concerning these projects.

Project 18.3, Spectroscopy, was conducted by the Naval Research Laboratory to obtain information on spectral characteristics of light emitted from nuclear detonations. Spectrometers were used to record on film the changes in the wavelength of light with time. Two spectrometers used in this experiment were in Building 400, located near the Control Point at Yucca Pass. Project personnel manned Building 400 on shot-day to operate the instruments. At Shot DIXIE, the distance between ground zero and Building 400 was about 17.4 kilometers.

Three other spectrometers were located in Station 413, a reinforced semitrailer, which served as a mobile instrument station. On the day of the test, 11 people occupied Station 413, 3,000 meters from ground zero, until four hours before shot-time. Project personnel loaded film into the spectrometers and set the instruments for remote-control operation. They then secured the trailer and left the area until after the test. Four men plus a radiological safety monitor entered the DIXIE test area after recovery hour was declared to recover film and recorder charts from Station 413 for processing and analysis. The estimated working time in this area was about 15 minutes (19; 29).

5.2.3 Civil Effects Group Projects

The six Civil Effects Group projects listed in table 5-2 involved DOD participants. The same Naval Radiological Defense Laboratory personnel usually conducted all of the Program 23 projects. No information is available on Project 23.3, Long-term Studies on Dogs Exposed to Primarily Neutron Irradiation in Shelters.

Project 23.1, Biological Effectiveness of Ionizing Radiation within Shelters, involved the direct biological measurements of the total radiation hazard within earth-protected AEC communal shelters, using mice as test subjects. Project participants transported the animals to the shelters eight hours before the shot. One hour after recovery hour, they retrieved the animals from the AEC shelters located at a slant range of 2,570 meters from the burst point (15; 21b).

Project 23.2, Bacteriological Studies on Animals Exposed to Neutron Radiation, collected data on the role played by post-irradiation infection in deaths caused by radiation exposure. Project participants placed 153 animals, mostly mice and dogs, in the same shelters used for Project 23.1. Recovery operations are

not documented, but probably took place one hour after recovery hour (85).

Project 23.17, Neutron Flux Measurements in AEC Group Shelters and Lead Hemispheres, investigated neutron radiation inside and outside lead hemispheres and shelters and measured the neutron dose received by animals in those shelters. At Shot DIXIE, the only activities involved placing animals in the shelters used in Project 23.1 and retrieving them after recovery hour (86).

Project 27.1, Distribution and Characteristics of Fallout at Distances Greater than Ten Miles, involved detailed studies of the physical phenomena of fallout in order to provide information for use in evaluating possible hazards from fallout.

The field group for this project, consisting of about 32 Navy enlisted men, was responsible for placing equipment, collecting samples, monitoring, and reporting field observations. The operational plan called for setting up 42 air-sampling stations consisting of various experiments along roads and trails selected on the basis of predicted fallout patterns. To maximize the data to be collected, the field group remained at previously assigned rendezvous points until after the Air Weather Service predicted the fallout pattern, one day before the shot. These predictions were relayed to the field group via telephone or radio. Approximately four hours were allowed for the field group to establish stations and return to the rendezvous points.

Sixteen stations were located at ten-kilometer intervals starting northeast of Las Vegas on Route 91. Thirteen stations were located at ten-kilometer intervals starting northeast of Kingman, Arizona, on Route 66. The remaining 13 stations were at 16-kilometer intervals starting at Quartz, Arizona, on Highway 60 to Highway 71 through Congress Junction on Highway 89 through

Prescott, Arizona. The teams were to collect the samples three days after the shot. Actual fallout from DIXIE was very limited, but it is not known how this affected project plans (21b; 69).

Project 29.1, Comparison and Evaluation of Dosimetry Methods Applicable to Gamma Radiation, was conducted by the Atomic Energy Project, University of California at Los Angeles. Evans Signal Laboratory, part of the Signal Corps Engineering Laboratories, fielded the experiment with assistance from the Naval Radiological Defense Laboratory, the Federal Civil Defense Administration, the Naval Medical Research Laboratory, and the Army Chemical Corps. The project compared and evaluated the accuracy and practicality of chemical and film methods for measuring initial and residual gamma radiation. At DIXIE, 26 project participants placed 105 dosimeters in the shot area to measure residual gamma radiation. Thirty of the dosimeters were exposed in the test stations belonging to AFSWP Project 6.8. The other 75 dosimeters were placed at slant ranges of 1,830 to 2,590 meters from the burst point (21b; 79).

5.2.4 Air Force Special Weapons Center Activities

AFSWC support to the test groups and Test Manager during Shot DIXIE consisted of operational control of all aircraft, airdropping the device, cloud sampling, sample courier missions, cloud tracking, and aerial surveys. DIXIE was the first airdrop of Operation UPSHOT-KNOTHOLE. Nine F-84G aircraft and one B-29 aircraft flew cloud-sampling missions in support of LASL Project 13.1, Radiochemistry Sampling, and AFSWP Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris. The B-47 and B-50 that dropped canisters for Project 4.1 were also AFSWC aircraft. The B-50 also acted as sample control aircraft. Canister drop activities are described under Project 4.1 (34).

With the exception of the B-50 delivery aircraft, which flew from Kirtland AFB, AFSWC aircraft originated at Indian Springs AFB. The types and numbers of aircraft and estimated numbers of AFSWC aircrew personnel involved in air missions at Shot DIXIE are shown in the following listing (34).

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Delivery	B-50	1	11
Sampling			
Sampler	F-84G	9	9
Sampler	B-29	1	9
Sampler Control*	B-50	1	9
Sample Courier	C-47	4	12
Missions	B-25	1	5
	TBM	1	3
Cloud Tracking	B-29	2	20
	B-25	1	5
Aerial Surveys	H-5	1	2
	C-47	1	4
	L-20	2	6
Canister Drop	B-47	1	3

*Also participated in Project 4.1

Cloud Sampling

Ten aircraft collected particulate and gaseous samples of the Shot DIXIE cloud. Nine of the ten aircraft were F-84G samplers, code-named Tiger, flown by pilots of the 4926th Test Squadron for Project 13.1. The other aircraft was a B-29 that collected samples for AFSWP Project 7.5. A B-50 sampler control aircraft, with a crew of nine including a scientific advisor from LASL, and one of the F-84G sampler aircraft, which acted as a "snooper," surveyed the DIXIE cloud before the actual sampling

sorties began. The snooper landed after determining cloud height and then left again to conduct a sampling mission. The first cloud penetration occurred one hour and 15 minutes after the shot. The listing that follows summarizes sampling aircraft activities. Aircraft are listed in the sequence in which they conducted the sampling (34).

AIRCRAFT	NUMBER OF PENETRATIONS	TOTAL TIME IN CLOUD (seconds)	TOTAL TIME IN CLOUD AREA (minutes)
Tiger Red 1	1	35	71
Tiger Red 2	1	130	40
Tiger Red 3	2	144	59
Tiger Red 4	2	120	80
Tiger White 1	1	12	22
Tiger White 4	2	2	30
Tiger Blue 2	2	180	100
Tiger Blue 3	-	-	63
Tiger Blue 4	2	10	109
Catnip (B-29)	-	-	135

The peak intensity encountered ranged from 0.15 to 10.0 R/h. Sampling was very difficult at Shot DIXIE. The cloud rose to a height of 43,000 feet and forced the F-84G samplers to perform at altitudes approaching the aircraft's limits (34).

After the sampling mission was completed, the aircraft landed at Indian Springs AFB and parked in designated areas. Engines were shut down, and the canopies remained closed and sealed until the samples were removed from the aircraft. The

pilots remained on full oxygen while they waited. The 4926th sample-removal team and radiological safety monitors used long-handled tools to take samples from each aircraft and place them in shielded containers. Members of the sample-removal team then loaded the sample containers on courier aircraft for delivery to AEC and DOD laboratories for analysis.

After the samples from each aircraft were removed and stored, the pilot shut down his oxygen and opened his canopy. The pilots in F-84G aircraft stepped onto a platform held by a forklift, so they would not touch the exterior of the aircraft. The B-29 crew exited through the rear side door. The crews were taken in a pickup truck to the decontamination station, where they were monitored and decontaminated as necessary (80).

Sample Courier Missions

Following Shot DIXIE, six AFSWC aircraft flew courier missions for test group projects, including Projects 7.5 and 13.1. Four C-47s, one B-25, and one TBM aircraft were used. AFSWC personnel piloted all of the aircraft (33).

Cloud Tracking

After the detonation, two Air Weather Service B-29s, each with a crew of ten, and one B-25 with a crew of five left from Indian Springs AFB on cloud-tracking missions over and beyond the NPG. The purpose of these missions was to determine the direction of the Shot DIXIE cloud and to assist the Test Manager in keeping the airways clear of any private or commercial aircraft that might encounter the cloud.

One B-29 aircraft tracked the cloud for 65 minutes; the other B-29 followed the cloud for 115 minutes. The B-25 flew for 96 minutes in the cloud area. The cloud-tracking aircraft found no radiation at the assigned altitudes of 22,000, 18,000 and

12,000 feet, respectively. On completion of this mission, the three aircraft returned to their respective staging bases (26; 34).

Aerial Surveys

As directed by the Test Manager and the Test Director, an AFSWC H-5 helicopter, a C-47, and two AFSWC L-20 aircraft flew radiological safety and aerial surveys of the terrain following the DIXIE detonation.

The H-5 helicopter began the initial onsite radiological safety survey 15 minutes after the detonation and finished it 25 minutes later. The C-47 and L-20 aircraft flew extensive radiological survey missions. The L-20 missions lasted 178 minutes and 54 minutes respectively. The C-47 aircraft conducted an offsite survey for 105 minutes. This mission was curtailed because there was little fallout and radiation readings were low (26; 34).

5.3 RADIATION PROTECTION AT SHOT DIXIE

For Operation UPSHOT-KNOTHOLE, Exercise Desert Rock V, the test groups, and AFSWC developed radiation protection procedures to keep individual exposure to ionizing radiation to a minimum while still allowing participants to accomplish their missions. Some of the procedures described in chapter 5 of the Operation UPSHOT-KNOTHOLE volume resulted in the production of records that enabled these organizations to evaluate the effectiveness of their radiation protection programs. Information from these records is presented below.

5.3.1 Desert Rock Radiation Protection Activities

Radiation protection activities were limited at DIXIE, since there was no troop maneuver and no equipment display area. A group of observers viewed the blast from News Nob, 16 kilometers from ground zero. Radiation survey meters located at News Nob showed no radiation above background levels following the detonation (45).

5.3.2 Joint Test Organization Radiation Protection Activities

Records of the JTO radiation protection activities were obtained from the radiological safety report of operations. The information in that report includes data on film badges and safety equipment issued, survey records, isointensity plots, and decontamination records (26).

Dosimetry

During the period of 5 April to 9 April 1953, which covers the 6 April detonation of Shot DIXIE, the Dosimetry and Records Section of the JTO processed 1,100 film badges. No information is available concerning exposures received by DOD participants at DIXIE, but gamma intensities were so low when surveyed that no recovery personnel would have received a dose measurable on a film badge (26).

Logistics and Supply

From 5 April to 9 April, the Supply Section issued the following items:

- 51 respirators
- 73 protective caps
- 83 coveralls
- 113 pairs of gloves
- 132 pairs of shoe covers
- 268 pairs of goggles.

In addition, the Supply Section issued 41 radiation survey instruments (26).

Monitoring

The initial survey team completed its readings at 0900 hours. The team, consisting of eight men, detected only low levels of radioactivity. The highest gamma intensity encountered at the DIXIE ground zero was 0.0015 R/h. Because the onsite helicopter survey was completed by 0810 hours, the Test Director announced the test area opened for recovery operations at 0812 hours, before the ground survey was completed. One day after the shot, monitors conducted a general survey of Yucca Flat to determine and map areas of radiation from previous detonations. The only residual radiation found in Area 7 was from Shot RUTH, which had been detonated one week earlier (26).

Five of the 18 offsite monitors were DOD personnel. The offsite monitors detected no ground-level radiation from DIXIE.

Plotting and Briefing

Figure 5-2 shows the isointensity plot resulting from the initial survey. The test area was not resurveyed since the initial survey team had found only low levels of radiation.

In addition to its other activities, the Plotting and Briefing Section briefed 60 parties, totaling 179 personnel, for entry into the test area during the period of 5 April to 9 April (26).

Decontamination

During the period of Shot DIXIE, the Vehicle and Equipment Decontamination Section decontaminated six vehicles, apparently from operations in areas with residual radiation areas (26).

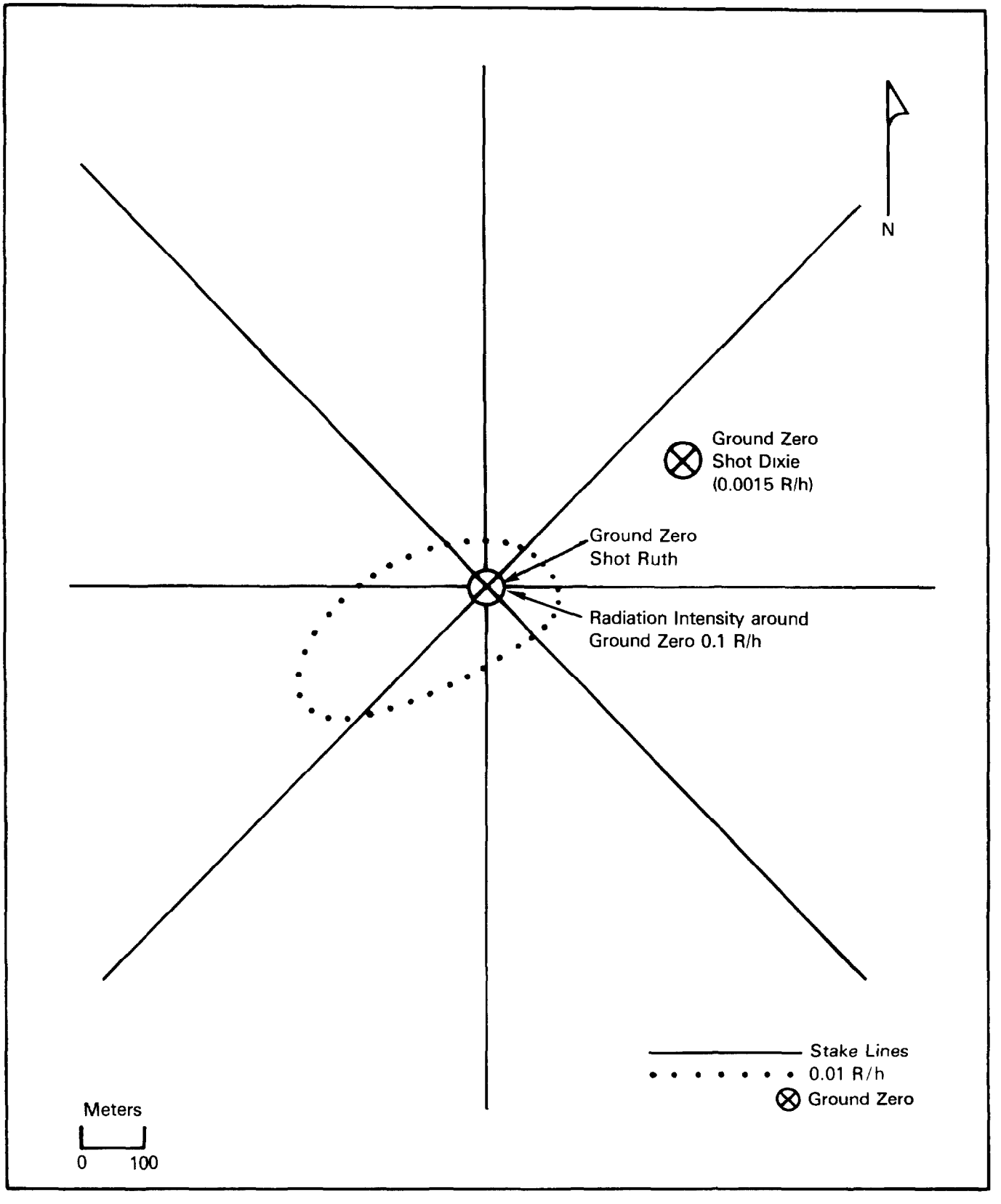

Figure 5-2: INITIAL SURVEY FOR SHOT DIXIE, 6 APRIL 1953, 0805 TO 0900 HOURS

SHOT RAY SYNOPSIS

AEC TEST SERIES:	UPSHOT-KNOTHOLE
DOD EXERCISE:	Desert Rock V
DATE/TIME:	11 April 1953, 0445 hours
YIELD:	0.2 kiloton
HEIGHT OF BURST:	100 feet (tower shot)

AEC Objective: To evaluate the nuclear yield, blast, thermal, and radiological phenomena produced by this device.

DOD Objective: To evaluate military equipment, tactics, and doctrine; to measure effects characteristics and evaluate the military applications of the device; and to orientate military personnel in the tactical uses of nuclear weapons.

Weather: At shot-time, surface winds were from the northeast at five knots. Winds were from the north at 15 knots at 5,000 feet and 31 knots at 10,000 feet. The temperature was -0.3°C, the relative humidity was 43 percent, and the pressure was 869 millibars.

Radiation Data: Radiation intensities of 10.0 R/h from the RAY detonation were detected south of ground zero during the initial survey about one hour after the shot. From Shot NANCY, which had been detonated on 24 March about one kilometer from the RAY ground zero, residual radiation intensities in excess of 0.01 R/h extended northward.

Participants: Exercise Desert Rock V participants, Armed Forces Special Weapons Project, Air Force Special Weapons Center, University of California Radiation Laboratory, Federal Civil Defense Administration, contractors.

CHAPTER 6

SHOT RAY

Shot RAY, the final shot treated in this volume and the fifth of Operation UPSHOT-KNOTHOLE, was detonated on 11 April 1953 at 0445 hours Pacific Standard Time. The detonation occurred on the date originally scheduled for Shot BADGER and its Marine Corps exercise. Because the area to be used for Shot BADGER, Area 2, had been contaminated by the NANCY detonation on 24 March, preparations for BADGER were delayed. To maintain the UPSHOT-KNOTHOLE schedule, the shot days for RAY and BADGER were switched. The RAY detonation took place in Area 4 of Yucca Flat, at UTM coordinates 806060, on a 100-foot tower. Sponsored by the University of California Radiation Laboratory, RAY was one of the smallest detonations of the series, with a yield of 0.2 kiloton.

The top of the cloud resulting from Shot RAY attained an altitude of 12,800 feet, and the cloud moved south from ground zero. The predicted wind direction posed the possibility that fallout might occur at the Control Point. The actual fallout came close but passed to the west. The fallout pattern was a narrow band extending offsite south into the California desert. Moderate offsite fallout was detected by ground survey teams along the following roads:

- U.S. Highway 95, west of Mercury
- A desert road about 30 kilometers south of Mercury
- Nevada Highway 52 between Pahrump, Nevada, and Shoshone, California
- The road east of Tecopa, California (38).

The Military Effects Group, the Weapons Development Group, and the Civil Effects Group conducted 17 scientific, diagnostic, and technical projects with DOD participation. Exercise Desert Rock V activities were not extensive at Shot RAY. DOD personnel participated in only two Desert Rock V programs. As part of the Exercise Desert Rock V orientation and indoctrination program, 63 DOD personnel witnessed the shot. Another 11 Marine Corps personnel conducted operational helicopter tests. The Air Force Special Weapons Center provided aircraft operational control and air support to two test group projects and to the Test Manager. AFSWC missions included aerial surveys and cloud-sampling, cloud-tracking, and courier missions.

6.1 EXERCISE DESERT ROCK V OPERATIONS AT SHOT RAY

As noted above, only two Desert Rock activities were performed at this shot: the orientation and indoctrination program and the Marine Corps operational helicopter tests. Table 6-1 displays Desert Rock V activities and the numbers and units of personnel involved at Shot RAY:

Table 6-1: EXERCISE DESERT ROCK V ACTIVITIES AT SHOT RAY

Program	Participating Service	Estimated DOD Personnel
Troop Orientation and Indoctrination (Observers)	Army (Camp Desert Rock Troops)	33
	Marine Corps	25
	Air Force	4
	Navy	1
Operational Helicopter Tests	Marine Corps	8

6.1.1 Orientation and Indoctrination

The standard orientation and indoctrination program of Exercise Desert Rock V was not used at Shot RAY. There was no classroom instruction, and no display area was prepared for the detonation. However, 63 DOD observers witnessed the shot. These observers included 33 Army Corps personnel, 25 Marine Corps officers from the 2d Marine Corps Provisional Atomic Exercise Brigade, four Air Force personnel, and one Navy participant (45).

The observers witnessed the RAY detonation from News Nob, UTM coordinates 848888, approximately 18 kilometers from ground zero. The observers arrived at News Nob at 0412 hours on shot-day. No shelter was required because of the distance from ground zero and the small size of the detonation. However, personnel were required to face away from the shot-tower immediately before the detonation. The observers heard the blast but did not feel the shock wave. The observers returned to Camp Desert Rock by 0540 hours. No measurable radiation was noted at the observation point, and no assistance from radiological safety personnel was required at any time during the operation (45).

6.1.2 Operational Helicopter Tests

At Shot RAY, Marine Corps personnel from the Helicopter Atomic Test Unit, 2d MCPAEB, conducted operational tests with four Marine HRS helicopters. These tests were designed to investigate a number of factors that might affect the use of helicopter assaults under the conditions following a battlefield nuclear detonation. The factors studied at Shot RAY included flash blindness, overpressure, and ground and airborne radioactivity.

Although four HRS helicopters were scheduled for this operation, only three (A, C, and D) were used. Helicopter C was to follow the operating plan for helicopter B after passage of

the shock wave. Each helicopter was to be operated by a pilot and copilot. A monitor was probably also aboard helicopters A and C since helicopter A was scheduled to land about 1.6 kilometers upwind of ground zero so that ground readings could be taken. Helicopter C was to provide assistance as necessary (44).

The helicopters left Yucca Lake airstrip and proceeded to positions south-southeast of ground zero. Helicopter A proceeded to an orbiting point at UTM coordinates 856982, about 14 kilometers from ground zero. Helicopters C and D assumed their positions near UTM coordinates 846016, about 5,940 meters from ground zero. Figure 6-1 illustrates the helicopter movements.

About one minute before the shot, helicopter A proceeded at a height of 400 feet on a course designed to place it 8.5 kilometers from the shot, port-side of the blast, at the time of detonation. At about the same time, helicopters C and D were about six kilometers from ground zero hovering about ten feet off the ground, facing the blast. At the time of detonation, helicopter A was about nine kilometers from ground zero, while helicopters C and D maintained their preshot positions.

Immediately after the shot, helicopter A turned and proceeded toward ground zero. With the arrival of the shock wave, helicopter C left its position to accompany helicopter A, and helicopter D returned to the Yucca Lake airstrip.

In the meantime, helicopter A continued toward ground zero, and helicopter C maintained visual contact as a safety precaution. Helicopter A landed about 1.6 kilometers east of ground zero, where a radiological safety monitor disembarked to record early radiation levels. About 35 minutes after the shot, the monitor was scheduled to reboard helicopter A. Helicopters A

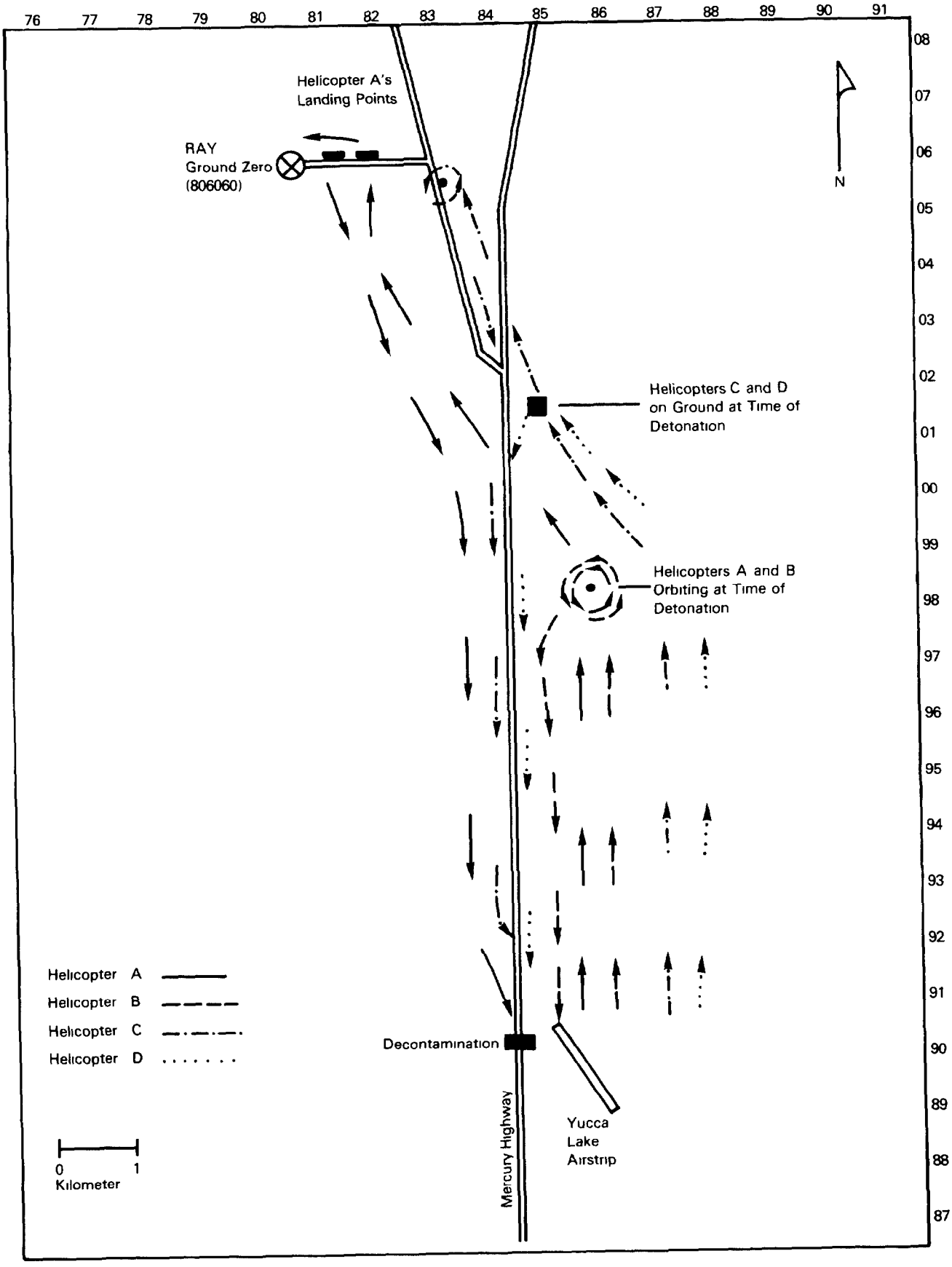

Figure 6-1: OPERATIONAL HELICOPTER TESTS AT SHOT RAY

and C returned to Yucca Lake airstrip for radiological safety clearance. All helicopters then returned to Camp Desert Rock (44).

6.2 DEPARTMENT OF DEFENSE PARTICIPATION IN JOINT TEST ORGANIZATION OPERATIONS AT SHOT RAY

The Military Effects Group sponsored 11 projects during Shot RAY. DOD personnel also took part in five of the projects conducted by the Weapons Development Group and in one of two projects performed by the Civil Effects Group. Table 6-2 lists the test group projects by number and title and identifies the fielding organizations. In addition, AFSWC personnel provided support to test groups and to the Test Manager.

6.2.1 Military Effects Group Projects

At Shot RAY, the Military Effects Group of AFSWP Field Command performed the projects shown in table 6-2. The Test Director allowed recovery operations to begin at 0624 hours.

Project 6.2, Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques, was performed to confirm indications that a radar return from a nuclear explosion could be used to determine ground zero, height of burst, and yield. At 2200 hours the night before the shot, two project personnel traveled to a receiver station located in the northeast corner of Yucca Lake, and three men in one vehicle traveled to a second receiver station at the north end of Yucca Lake. These men manned the two stations through shot-time. Another group of three in two vehicles traveled to a mobile radar transmitter located about 5.5 kilometers northwest of the Control Point in order to start the generator and prepare the station for operations. Soon after midnight, these personnel went to the Control Point and then traveled to a radar station about 800 meters west of the Control

Table 6-2: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT RAY

Project	Title	Participants
	Military Effects Group	
6.2	Indirect Bomb Damage Assessment (IBDA) Phenomena and Techniques	Wright Air Development Center, Vitro Corporation
6.7	Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations	Signal Corps Engineering Laboratories
6.8a	Initial Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
6.12	Determination of Height of Burst and Ground Zero	Signal Corps Engineering Laboratories; Army Field Forces Board #1
7 1	Electromagnetic Effects from Nuclear Explosions	Headquarters, Air Force*
7.3	Detection of Airborne Low Frequency Sound from Nuclear Explosions	Headquarters, Air Force*
7 4	Seismic Measurements	Headquarters, Air Force
7.5	Calibration and Analysis of Close-in A-Bomb Debris	Headquarters, Air Force, AFSWC
8 1a	Effects of Thermal and Blast Forces from Nuclear Detonations on Basic Aircraft Structures and Components	Wright Air Development Center; Division of Research, University of Dayton
8 2	Measurement of Thermal Radiation with a Vacuum Microphone	Air Force Cambridge Research Center
9 1	Technical Photography	EG&G, Signal Corps Pictorial Center; Air Force Lookout Mountain Laboratory
	Weapons Development Group	
13 1	Radiochemistry Sampling	AFSWC
18.1	Total Thermal and Air Attenuation	Naval Research Laboratory
18.2	Power versus Time	Naval Research Laboratory
18.3	Spectroscopy	Naval Research Laboratory
18 6	Surface-brightness Investigations	Naval Research Laboratory
	Civil Effects Group	
29.1	Comparison and Evaluation of Dosimetry Methods Applicable to Gamma Radiation	Atomic Energy Project, UCLA*

*Other participating agencies are listed in the text

Point, where they remained during the test. Three hours after recovery hour, one project participant and a monitor traveled to a transmitter station nine kilometers north of ground zero to turn off the generator (12a-12b; 33; 53).

Project 6.7, Measurements and Analysis of Electromagnetic Radiation from Nuclear Detonations, detected and measured amplitude, duration, and polarization of the pulse of the electromagnetic radiation emitted from a nuclear detonation and any electromagnetic signals that might be emitted in the instant before a detonation. Personnel traveled to the instrument stations two or three hours before shot-time to turn on generators and allow the equipment to warm up. They left before shot-time. One hour after recovery hour was announced, three participants, accompanied by a monitor, traveled to stations about three kilometers south of ground zero to turn off equipment and to pick up data. Estimated time in the area was one hour (12a-12b; 27).

Project 6.8a, Initial Gamma Exposure versus Distance, fielded by the Signal Corps Engineering Laboratories, was designed to document initial gamma radiation exposure from the RAY device. Personnel placed dosimeters at 13 stations located 180 to 1,080 meters from ground zero. These portable stations were fitted with aluminum thermal and blast shields. Two hours after recovery hour, one party of six men accompanied by a monitor traveled by vehicle to recover film and dosimeters. The estimated time of the mission was three hours (12a-12b; 59).

Project 6.12, Determination of Height of Burst and Ground Zero, was to evaluate various equipment and techniques for locating ground zero and determining the height of burst. Sound-ranging stations were located around Camp Desert Rock from 55 to 60 kilometers from ground zero. The system was composed of three

separate microphone arrays several kilometers apart along a line perpendicular to the line from the center of the array to the shot-tower. Flash-ranging cameras and seismic geophones were operated at stations in the southeast corner of Yucca Lake. Three hours before the shot, 13 men in four vehicles turned on equipment at seven stations. After completing their mission, they returned to a central station in Yucca Lake, where they remained through shot-time (12a-12b; 82).

Project 7.1, Electromagnetic Effects from Nuclear Explosions, was conducted at all UPSHOT-KNOTHOLE events to obtain additional information on the electromagnetic radiation produced by nuclear detonations. This project was a continuation of similar investigations conducted at both Operations BUSTER-JANGLE and TUMBLER-SNAPPER. Personnel from the National Bureau of Standards, the Air Force Security Service, the Air Force Cambridge Research Center, and the Air Weather Service manned monitoring stations onsite and offsite.

Two onsite locations were used for Shot RAY. Station A was just south of Yucca Flat about 20 kilometers from ground zero. It was manned by 16 men who remained there through shot-time. Station B was more than 50 kilometers from ground zero. It is not known if personnel remained at Station B through shot-time (12a-12b; 65).

Project 7.3, Detection of Airborne Low Frequency Sound from Nuclear Explosions, was designed to compare low frequency sounds produced by nuclear detonations at various field stations. These stations were located across the United States and around the world. Personnel from the Signal Corps Engineering Laboratories manned stations in Alaska, Hawaii, Greenland, Japan, and Germany. The Naval Electronics Laboratory, the Signal Corps Engineering Laboratories, and the National Bureau of Standards manned nine stations in the continental United States (66).

Project 7.4, Seismic Measurements, was to record the seismic waves produced by the shot for comparison with those produced by shots of other series and with other shots of Operation UPSHOT-KNOTHOLE. Manned seismic stations were located in Arizona, Montana, South Dakota, Oklahoma, Alabama, Alaska, and Wyoming. The one onsite seismic station, at UTM coordinates 843094, was not manned at shot-time. Two project personnel and a radiological safety monitor drove in one vehicle to the onsite seismic station two hours after recovery hour to turn off equipment and recover records. Personnel remained at the station for one hour (12a-12b; 28).

Project 7.5, Calibration and Analysis of Close-in A-Bomb Debris, was designed to analyze samples of the Shot RAY cloud to evaluate various parameters of the nuclear device. Two B-29 aircraft took gaseous and particulate samples of the cloud. This project was similar to Project 13.1, Radiochemistry Sampling, and is discussed more fully in the AFSWC section, 6.2.4 (77).

Project 8.1a, Effects of Thermal and Blast Forces from Nuclear Detonations on Basic Aircraft Structures and Components, was to obtain data on the reaction of aircraft components to the thermal and blast effects of nuclear detonations. Project personnel placed basic B-36 aircraft structures and components 170, 240, and 330 meters from ground zero before the shot. The components and structures were instrumented to determine the maximum temperatures reached. Several hours after recovery hour, four project personnel accompanied by a monitor inspected the components. The estimated time of the mission was one hour (5; 12a-12b; 75).

Project 8.2, Measurement of Thermal Radiation with a Vacuum Microphone, evaluated a device used to measure the thermal radiation produced by a nuclear detonation. Personnel placed sensing equipment three and 16 kilometers from the point of detonation.

Signals generated in the microphones by the pressure of the radiant energy were amplified electronically, fed to an oscilloscope, and recorded on magnetic tape. The recording equipment was contained in two manned vans located north of the Control Point near the farthest microphone station 16 kilometers from ground zero.

Three days before the shot, personnel checked the sensing elements for electrical operation. The next day, they calibrated the sensing elements and checked to ensure that the equipment was working. On the day before the shot, personnel repeated these checks. Four hours before the shot, six project personnel traveled to the equipment vans and remained there through shot-time. Personnel retrieved the equipment from the close-in station sometime after recovery hour (12a-12b; 14).

Project 9.1, Technical Photography, provided both still and motion picture photography of the technical aspects of Military Effects Group projects. EG&G personnel, 23 officers and enlisted men from the Army Signal Corps Pictorial Center, and five enlisted men from the Air Force performed this project.

There is no documentation indicating that Project 9.1 photography was conducted at Shot RAY. However, personnel may have photographed the fireball during the detonation. This would have been done by remote control with cameras on steel phototowers. In the standard procedure for this photography mission, camera stations were installed, and a complete dry run was held. Before the shot, personnel removed the plastic bags covering the cameras to keep out dust and loaded the cameras with film. The same project personnel who installed the film recovered it on shot-day after recovery hour was announced. EG&G processed all film in Las Vegas or Los Angeles (40).

In addition to the technical film support provided by Project 9.1 personnel, the Air Force Lookout Mountain Laboratory was

scheduled to take documentary photographs of the RAY burst and subsequent cloud development. Ten personnel from the Lookout Mountain Laboratory were to occupy five camera stations about two hours before shot-time to photograph the RAY burst. The station locations are listed below (12a-12b):

Station	Location (UTM)	Number of Personnel	Distance from Ground Zero (kilometers)
1	894982	2	13
2	844962	2	11
3	800992	2	7
4	781958	2	10
5*	843878	2	18

These personnel probably remained at their stations through shot-time to photograph the burst (12b).

6.2.2 Weapons Development Group Projects

The Weapons Development Group performed 19 projects at Shot RAY. Of these projects, only five involved DOD personnel, as shown in table 6-2.

Project 13.1, Radiochemistry Sampling, was performed by sampling pilots from the AFSWC 4926th Test Squadron (Sampling) for the Los Alamos Scientific Laboratory, a member of the Weapons Development Group. This project is discussed in the AFSWC participation section, 6.2.4.

Project 18.1, Total Thermal and Air Attenuation, Project 18.2, Power versus Time, and Project 18.6, Surface-brightness Investigations, were conducted at the shot by the Naval Research Laboratory. No other information is available concerning these projects.

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*Station 5 was at the Control Point.

Project 18.3, Spectroscopy, was also conducted by the Naval Research Laboratory. The objective was to obtain information on spectral characteristics of light emitted from nuclear detonations. Spectrometers were used to record on film the wavelength of light with time.

Two spectrometers were in Building 400, located near the Control Point at Yucca Pass, about 19 kilometers from the RAY ground zero. On shot-day, project personnel operated the instruments in this building manually. Three other spectrometers were located in Station 413, a reinforced semitrailer, which served as a mobile instrument station. This trailer, located about 3.2 kilometers from ground zero, was designed to withstand blast pressures. On the day before the test, 12 individuals occupied Station 413 until four hours before shot-time. Project personnel loaded film into the spectrometers and set the instruments for remote-control operation. They then secured the trailer and left the area until after the shot. Four men and a radiological safety monitor went to Station 413 about 15 minutes after recovery hour to recover film and recorder charts for processing and analysis. They worked at the station about 15 minutes (19; 29).

6.2.3 Civil Effects Group Projects

The Civil Effects Group conducted one project at RAY that involved DOD participants. Project 29.1, Comparison and Evaluation of Dosimetry Methods Applicable to Gamma Radiation, was conducted by the Atomic Energy Project of the University of California at Los Angeles. Other agencies, including the Evans Signal Laboratory (part of the Signal Corps Engineering Laboratories), supplied gauges. The project evaluated the accuracy and practicality of chemical versus film and other methods of gamma dosimetry for measuring initial and residual radiation.

For initial radiation measurements, project personnel placed dosimeters in the field the night before the shot. Fifteen minutes after recovery hour, three project members and a monitor spent one hour recovering dosimeters 90 to 365 meters from ground zero.

In addition, 26 personnel from the Evans Signal Laboratory participated as survey teams to check the performance of various radiation instruments in newly contaminated areas with gamma radiation intensity as high as 10.0 R/h. These personnel retrieved the film on the day following the detonation (79).

6.2.4 Air Force Special Weapons Center Activities

AFSWC support at Shot RAY consisted of operational control of all aircraft, cloud sampling, sample courier missions, and aerial surveys. No cloud-tracking missions were conducted at Shot RAY due to the small yield of the nuclear device (34).

The types and numbers of aircraft and estimated numbers of AFSWC aircrew personnel involved in air missions at Shot RAY follow. These aircraft originated at Indian Springs AFB (34).

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	ESTIMATED NUMBER OF PERSONNEL
Sampling			
Sampler	F-84G	8	8
Sampler	B-29	2	18
Sampler Control	B-50	1	9
Sample Courier Missions	C-47	1	3
	B-25	3	15
Radiological Safety and Aerial Surveying	H-5	1	2
	L-20	1	2
	C-47	1	3

Cloud Sampling

Eleven aircraft collected particulate and gaseous samples from the Shot RAY cloud. Nine were F-84G samplers, code-named Tiger, flown by pilots of the 4926th Test Squadron for LASL Project 13.1. The other two aircraft were B-29 samplers collecting samples for AFSWP Project 7.5. A B-50 sampler control aircraft, manned by a crew of nine including a scientific advisor from LASL, and one of the sampler F-84Gs acting as a "snooper" surveyed the cloud before the actual sampling sorties. The F-84G flew near the cloud immediately after the detonation to determine cloud height and then remained in the air to collect samples. The first cloud penetration occurred 45 minutes after the detonation. A peak intensity of 40 R/h was detected. The following listing summarizes the sampling aircraft activities (34):

AIRCRAFT	NUMBER OF PENETRATIONS	TOTAL TIME IN CLOUD (seconds)	TOTAL TIME IN CLOUD AREA (minutes)
Tiger Red 2	4	115	50
Tiger Red 4	6	33	77
Tiger White 1	_	_	_
Tiger White 2*	2	90	35
Tiger White 3	4	-	77
Tiger White 4	4	-	68
Tiger Blue 1	3	20	26
Tiger Blue 2	3	-	25
Tiger Blue 4	2	-	13
Catnip (B-29)	_	109	
Catnip (B-29)	-	-	112

*Also acted as "snooper"

After completing the sampling missions, all aircraft returned to Indian Springs AFB and parked in designated areas. Engines were shut down, and the canopies remained closed and sealed until the samples were removed from the aircraft. The pilots remained on full oxygen while they waited. The 4926th sample-removal team and radiological safety monitors used long-handled tools to remove the samples from each aircraft and place them in shielded containers. The sample-removal team then loaded the sample containers onto courier aircraft for delivery to AEC and DOD laboratories for analysis.

After the samples from each aircraft were removed and stored, the pilot shut down his oxygen and opened his canopy. The pilots in F-84G aircraft stepped onto a platform held by a forklift so they would not touch the exterior of the aircraft. The B-29 crews exited through the rear side door. The crews were transported in a pickup truck to the decontamination station, where they were monitored and decontaminated as necessary (80).

Sample Courier Missions

After Shot RAY, one C-47 and three B-25 AFSWC aircraft flew courier missions for Projects 7.5, 13.1, and other test group projects to take experiments and samples to laboratories for further study (33).

Aerial Surveys

As directed by the Test Manager and the Test Director, one H-5 helicopter, one L-20 aircraft, and one C-47 aircraft flew aerial surveys following the RAY detonation to record radiation intensities. The H-5 helicopter began the initial aerial survey 15 minutes after the detonation and continued for 86 minutes at heights ranging from ten to 100 feet. The L-20 flew onsite for one hour, detecting fallout in a narrow strip west of the Control Point. The C-47 surveyed as far as 320 kilometers offsite at heights ranging from 500 to 800 feet (26; 34).

6.3 RADIATION PROTECTION AT SHOT RAY

For Operation UPSHOT-KNOTHOLE, Exercise Desert Rock V, the test groups, and AFSWC developed radiation protection procedures to keep individual exposure to ionizing radiation to a minimum while still allowing participants to accomplish their missions. Some of these procedures, described in chapter 5 of the Operation UPSHOT-KNOTHOLE volume, resulted in the production of records that enabled these organizations to evaluate the effectiveness of their radiation protection programs. Information from these records is presented below.

6.3.1 Desert Rock Radiation Protection Activities

Because there was no troop maneuver and no equipment display for this shot, little assistance from radiological safety personnel was required. The observers viewed the blast from News Nob, 16 kilometers from the detonation. Radiation survey meters located at the observation point did not record radiation intensities above background levels (45).

Operational Helicopter Test

Three HRS helicopters participated in this test. Immediately after the shock wave passed, one of the helicopters proceeded toward the shot area and then landed about 150 meters east of ground zero. A monitor then disembarked and recorded radiation levels at several locations, from 1,000 to 275 meters from ground zero. The monitor took readings in the area for about ten minutes. The highest radiation intensity recorded was 10.0 R/h, 510 meters from ground zero. According to the operations order for RAY, the monitor was not to proceed into areas where the residual radiation intensity was greater than 10.0 R/h. All recorded intensities except one were less than 10.0 R/h. The monitor and all personnel aboard the aircraft wore anticontamination clothing (26; 45-46).

6.3.2 Joint Test Organization Radiation Protection Activities

Records of the JTO radiation protection activities were obtained from the radiological safety report of operations. The information in that report includes data on film badges and safety equipment issued, survey records, isointensity plots, and decontamination records (26).

Dosimetry

During the period of 10 April to 16 April 1953, which covers the 11 April detonation of Shot RAY, the Dosimetry and Records Section of JTO processed 1,100 film badges. The final exposure report of the Radiological Safety Support Unit indicates that one individual, a radiological safety monitor from Fort McClellan, had a total exposure of 4.6 roentgens by 14 April, three days after the RAY detonation (1b).

Logistics and Supply

For the period covering Shot RAY, the Supply Section issued the following items:

- 53 respirators
- 181 protective caps
- 166 pairs of cotton gloves
- 215 pairs of coveralls
- 209 pairs of goggles
- 516 pairs of shoe covers.

In addition, the Supply Section issued 143 radiation survey instruments (26).

Monitoring

The initial ground survey party completed its readings at 0630 hours. The party, probably consisting of four teams of two men each, had been delayed by communications problems. Monitors also conducted resurveys on 12 and 13 April. In addition, they

surveyed Yucca Flat on 14 April, providing further data concerning the radiological conditions resulting from the first five UPSHOT-KNOTHOLE events.

One H-5 helicopter performed an initial aerial survey. Within 30 minutes after the shot, the helicopter had established the general pattern of the onsite fallout. The maximum intensity encountered was 25 R/h, five feet above the ground (24).

One L-20 aircraft conducted an onsite aerial survey, and a C-47 conducted an offsite survey up to 320 kilometers offsite. The maximum intensity that either aircraft encountered at heights greater than 100 feet was 0.05 R/h (26; 34).

Three of the 15 offsite monitors were DOD personnel. These monitors detected maximum radiation intensities of 0.028 R/h in an area south of the Nevada Proving Ground and west of Mercury (26).

Plotting and Briefing

Figure 6-2 presents the isointensity plot resulting from the initial survey, and figure 6-3 shows the plots drawn after the resurveys of 12 and 13 April. Shot NANCY contributed the radiation field from its ground zero area northward.

In addition to plotting the survey maps, the Plotting and Briefing Section briefed 118 parties, involving a total of 521 personnel, for entry into the test area during the period of 10 April to 16 April (26).

Decontamination

During the period of Shot RAY, the Vehicle and Equipment Decontamination Section decontaminated 66 vehicles (26).

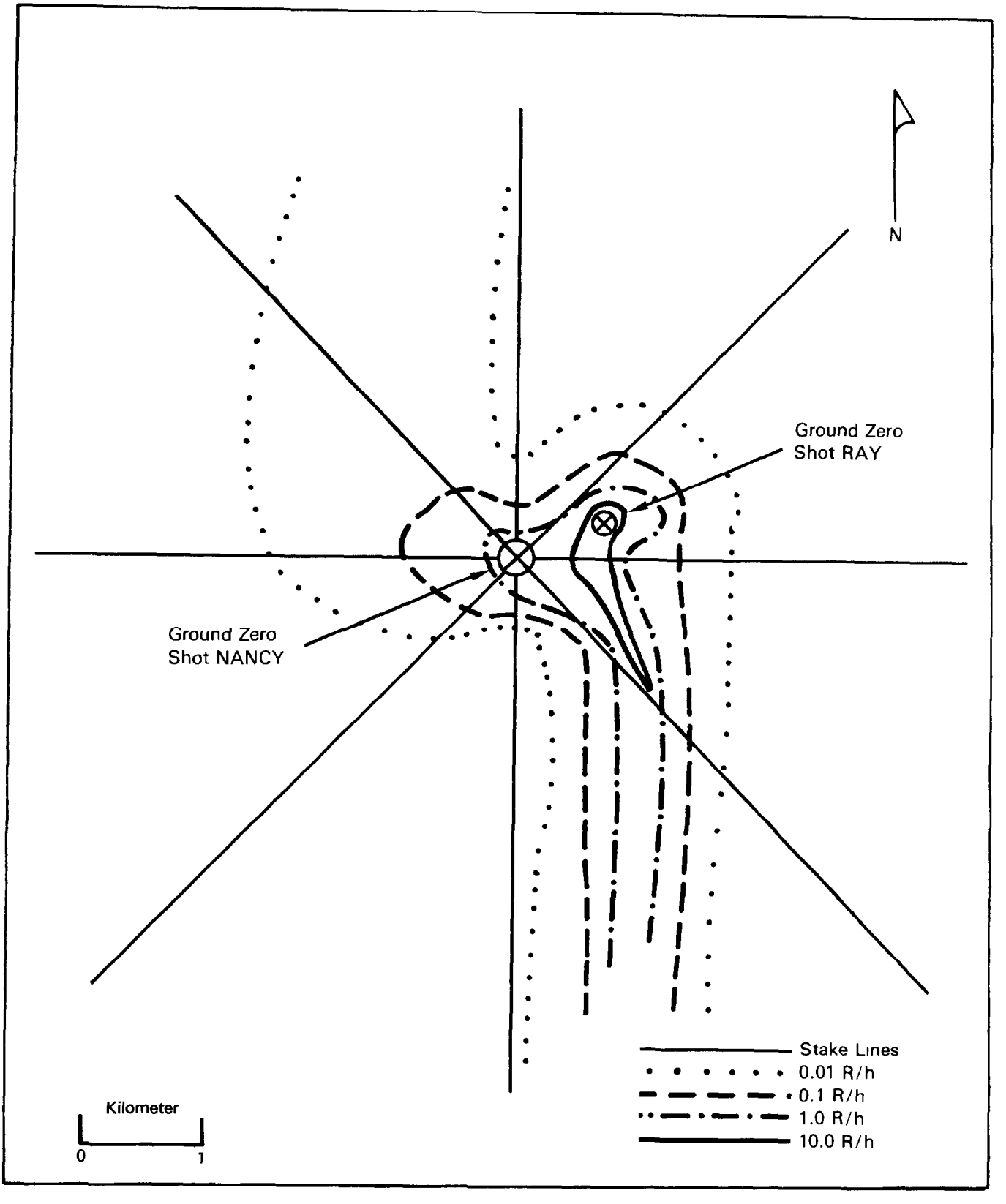
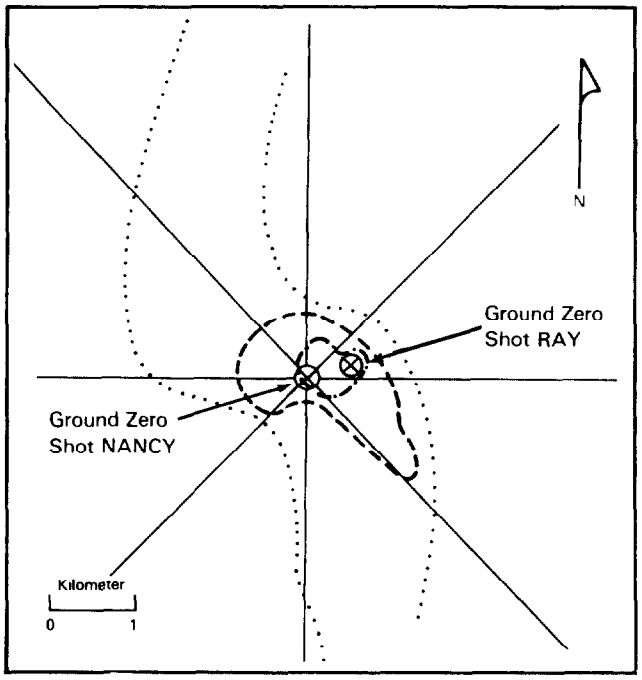
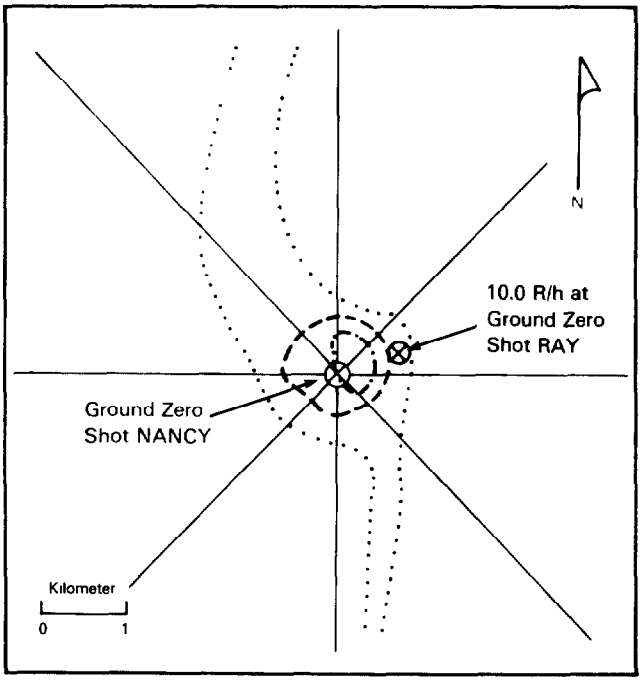


Figure 6-2: INITIAL SURVEY FOR SHOT RAY, 11 APRIL 1953, 0515 TO 0630 HOURS



12 April 1953, Completed 0700 Hours



13 April 1953, Completed 0700 Hours

Stake Lines
0.01 R/h
0.1 R/h
1.0 R/h

Figure 6-3: SUBSEQUENT SURVEYS FOR SHOT RAY

SHOTS ANNIE THROUGH RAY REFERENCE LIST

The following list of references represents only those documents cited in the ANNIE through RAY volume. When a DNA-WT document is followed by an EX, the latest version has been cited. A complete list of documents reviewed during the preparation of the Operation UPSHOT-KNOTHOLE volumes is contained in the UPSHOT-KNOTHOLE Series volume bibliography.

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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Additional ordering information or assistance may be obtained by writing to the NTIS, Attention: Customer Service, or by calling (703) 487-4660.

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Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

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

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

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

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

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

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

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

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

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

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Lewis University Library
ATTN: Librn

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

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

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

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Manchester City Library
ATTN: Librn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN. Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
ATTN: Librn

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

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

Miami Dade Community College
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
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Michigan State University Library
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Murray State University Library
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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
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State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN: Librn

Minneapolis Public Library
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University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

University of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

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

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Control Cultural Ed Ctr

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

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

State University of New York
ATTN: Lib Docs Sec

North Texas State University Library
ATTN: Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN. Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
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Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State
University
ATTN: Librn

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

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
ATTN: Docs Librn

University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

OTHER (Continued)

Northeast Missouri State University
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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
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Northwestern State University
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Northwestern State University Library
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Northwestern University Library
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Norwalk Public Library
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Northeastern Illinois University
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University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN: Librn

Oakland Public Library
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Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

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)

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University of Oklahoma
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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
ATTN: Docs Sec

Ouachita Baptist University
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Pan American University Library
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Passaic Public Library
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Queens College
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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
ATTN: Librn

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
ATTN: Librn

Princeton University Library
ATTN: Docs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN: Doc & Maps Room

Purdue University Library
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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
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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
ATTN: Dir of Libraries

Louisiana College
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OTHER (Continued)

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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
ATTN: Fed Docs Dept

Salem College Library
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Samford University
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San Antonio Public Library
ATTN: Bus Science & Tech Dept

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 Jose State College 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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Shawnee Library System
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Shreve Memorial Library
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Sioux City Public Library
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Slippery Rock State College Library
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University of South Carolina
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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
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Southern California University Library
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Southern Connecticut State College
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Southern Illinois University
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Southern Illinois University
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Southern Methodist University
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University of Southern Mississippi
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OTHER (Continued)

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Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
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Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN. Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN: Librn

St Lawrence University
ATTN Librn

St Louis Public Library
ATTN: Librn

St Paul Public Library
ATTN: Librn

Stanford University Library
ATTN Gov Docs Dept

State Historical Soc Library
ATTN: Docs Serials Sec

State Library of Massachusetts
ATTN: Librn

State University of New York
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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
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Albion College
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OTHER (Continued)

Superior Public Library
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Swarthmore College Library
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Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
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Hillsborough County Public Library at Tampa
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Temple University
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Tennessee Technological University
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University of Tennessee
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College of Idaho
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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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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
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ATTN: Dept of Pharmacology

Utica Public Library
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Valencia Library
ATTN: Librn

Valparaiso University
ATTN: Librn

Vanderbilt University Library
ATTN: Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Librn

Virginia Military Institute
ATTN: Librn

Virginia Polytechnic Institute Library
ATTN: Docs Dept

Virginia State Library
ATTN: Serials Sec

University of Virginia
ATTN: Pub Docs

Volusia County Public Library
ATTN: Librn

OTHER (Continued)

Washington State Library
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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

Williams & 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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