DNA 6008F

SHOTS
BOLTZMANN TO WILSON
The First Four Tests of the PLUMBBOB Series
28 MAY - 18 JUNE 1957

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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BOLTZMANN	AFSWC	Nevada Test Site
FRANKLIN	AFSWP	Nuclear Tests
LASSEN	Ionizing Radiation	
WILSON	Exercise Desert Rock	
PLUMBBOB	Nevada Test Organization	

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

This report describes the activities of DOD personnel, both military and civilian, in Shots BOLTZMANN to WILSON, the first four nuclear tests in the PLUMBBOB Series, which were conducted from 28 May to 18 June 1957. The tests involved participants from Exercise Desert Rock VII and VIII, AFSWP, AFSWC, and various AEC test groups. This volume also describes the radiological Safety criteria and procedures in effect at Shots BOLTZMANN to WILSON.

18. SUPPLEMENTARY NOTES (Continued)

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

PREFACE

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

In 1977, 15 years after the last above-ground weapons test, the Center for Disease Control+ noted a possible leukemia cluster among a group of soldiers present at Shot SMOKY, one nuclear test of Operation PLUMBBOB. 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 adverselv affected bv participation in the atmospheric nuclear weapons tests and consequent exposure to low levels of ionizing radiation.

In late 1977, the Department of Defense began a study to provide data to both the Center for Disease Control and Veterans Administration on potential exposures to ionizing radiation among

*Formerly called the Nevada Proving Ground, the name of the test range was changed to the Nevada Test Site in 1955.

+Part of the U.S. Department of Health and Human Services, formerlv the U.S. Department of Health, Education, and Welfare.

the atmospheric testing veterans. The Department of Defense responded by organizing an effort to:

- Identifv Department of Defense personnel who had taken part in the atmospheric nuclear weapons tests
- Provide public disclosure of information concerning participation bv DOD personnel in the atmospheric nuclear weapons tests.

This report on the first four PLUMBBOB shots, BOLTZMANN, FRANKLIN, LASSEN, and WILSON, is based on the historical record of military and technical documents associated with each of the nuclear weapons test events. These reports provide a public record of the activities and associated potential for radiation exposure of DOD personnel, for use in ongoing public health research and policy analysis.

Many of the documents pertaining specificallv to DOD involvement during the first four PLUMBBOB shots were found in the Defense Nuclear 4gencv Technical Librarv, the National Federal Archives Record Center, the Department of Energy Nevada Operations Office, and the Los Alamos National Laboratorv.* In certain cases, the surviving historical documentation addresses test specifications and technical information, rather than personnel data critical to the study undertaken bv the Department of Defense. Moreover, these documents sometimes have revealed inconsistencies in vital facts, such as the number of DOD participants in a certain project at a given shot or their locations and assignments at a given time. These inconsistencies in data usuallv occur between two or more documents but occasionallv appear within the same document. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader. In addition to these inconsistencies in information, the documents describing test organization projects do not alwavs distinguish between projects that were only planned and those that were actually conducted.

*Formerlv the Los 41amos Scientific Laboratory (LASL)

This report discusses only those projects verified by documentation as having been conducted,

For several of the Exercise Desert Rock and test organization projects discussed in this volume, the onlv documents available are the Sixth Army Desert Rock operation orders, the annexes to the Test Director's "Operation Plan CTDN-22," and Air Force air mission summarv reports. These sources detail the plans developed by DOD and AEC personnel prior to Operation PLUMBBOB; they do not necessarily describe operations as they were actuallv conducted at the NTS. Although some of the after-action documents summarize the projects performed during the operation, they do not alwavs supplv shot-specific information. In the absence of shot-specific after-action reports, projects are described according to the way they were planned. Because accomplishment of PLUMBBOB objectives required detailed planning and adherence to operations orders, plans and operations orders should provide a reasonably accurate account of personnel activities. The references indicate whether the description of activities is based on the annexes, operation orders, air mission summary reports, or after-action reports.

CONTENTS OF PLUMBBOB REPORTS

This volume details participation by DOD personnel in the first four Operation PLUMBBOB events. Seven other publications address DOD activities during the operation:

- Series volume: PLUMBBOB Series, 1957
- Shot volume: Shot PRISCILLA, a Test of the PLUMBBOB Series
- Shot volume: Shot HOOD, a Test of the PLUMBBOB Series
- Multi-shot volume: Shots DIABLO to FRANKLIN PRIME, the Mid-series PLUMBBOB Tests

- Shot volume: Shot SMOKY, a Test of the PLUMBBOB Series
- Shot volume: Shot GALTLEO, a Test of the PLUMBBOB Series
- Multi-shot volume: Shots WHEELER to MORGAN, the Final PLUMBBOB Tests.

These volumes have been designed for use with one another. The series volume provides information common to the PLUMBBOB shots, such as historical background, organizational relationships, and radiation-safetv procedures. In addition, that volume contains a bibliographv of works consulted in the preparation of all Operation PLUMBBOB reports.

The single-shot volumes describe DOD participation in Shots PRISCILLA, HOOD, SMOKY, and GALILEO. These volumes have been bound separatelv because the shots included substantial numbers of Desert Rock participants. Each multi-shot volume combines shot-specific descriptions for several nuclear events. The shot and multi-shot volumes list the sources referenced in each text. Descriptions of activities concerning anv particular PLUMBBOB shot, whether the event is addressed in a single- or in a multi-shot volume, mav be supplemented bv the general organizational and radiological safetv information in the PLUMBBOB Series volume.

The information in these reports is supplemented bv the Reference Manual: Background Materials for the CONUS Volumes. This report summarizes information on the phvsical processes and characteristics of a nuclear detonation, radiation phvsics, radiation health concepts, exposure criteria, and measurement techniques. It also lists acronvms and a glossarv of terms used in the DOD reports addressing test events in the continental U.S.

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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
BJY	Buster-Jangle "Y"
CBR	Chemical, Biological, Radiological
CETG	Civil Effects Test Group
DOD	Department of Defense
EG and G	Edgerton, Germeshausen, and Grier
FCDA	Federal Civil Defense Administration
LASL	Los Alamos Scientific Laboratory
NTO	Nevada Test Organization
NTS	Nevada Test Site
REECo	Reynolds Electrical and Engineering Company
R/h	Roentgen per hour
UCRL	University of California Radiation Laboratory
USAF	United States Air Force
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Shots BOLTZMANN, FRANKLIN, LASSEN, and WILSON were tests of nuclear devices conducted between 28 May and 18 June 1957 at the Nevada Test Site, the AEC continental nuclear test site northwest of Las Vegas. These shots were the first four nuclear test events of Operation PLUMBBOB, a series of 24 nuclear weapons tests and six safety experiments performed between 24 April and 7 October 1957 (10).*

The nuclear devices for the four shots were sponsored, designed, and built by AEC laboratories. The Los Alamos Scientific Laboratory (LASL) was responsible for the BOLTZMANN and FRANKLIN devices, while the University of California Radiation Laboratory (UCRL) was responsible for the LASSEN and WILSON devices. The primary objective of these nuclear tests was to evaluate the nuclear yield and the blast, thermal, and radiation phenomena produced by the devices. To fulfill this objective, LASL and UCRL test groups conducted scientific experiments to measure the physical characteristics of the detonations. The Armed Forces Special Weapons Project (AFSWP) Field Command Weapons Effects Test Group conducted effects projects to evaluate the utility of the devices for military applications and to investigate additional requirements for future nuclear weapons development (24; 48).

The Federal Civil Defense Administration (FCDA) Civil Effects Test Group conducted projects to assess the effects of nuclear detonations on civilian structures, products, and food

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

supplies and to evaluate Civil Defense emergency preparedness plans (17).

A number of other activities related to the conditions and phenomena produced by a nuclear detonation were also conducted at these four events. The DOD conducted operational training projects to indoctrinate personnel in the effects of nuclear detonations and to test equipment. The armed services also fielded projects to evaluate military equipment and tactics and to indoctrinate troops in weapons effects as part of Exercise Desert Rock VII and VIII, the Army technical testing and training program at Operation PLUMBBOB (24; 35).

Table l-l presents a summary of the first four PLUMBBOB tests (25). The table provides such information as the dates of shots, the UTM coordinates* of the points of detonation, the heights of burst,+ and the explosive yields. Figure l-l displays a map of the Nevada Test Site in 1957, indicating the location of each PLUMBBOB test and highlighting the shots discussed in this volume.

1.1 DEPARTMENT OF DEFENSE PARTICIPATION IN NEVADA TEST ORGANIZATION ACTIVITIES AT THE FIRST FOUR PLUMBBOB EVENTS

The Nevada Test Organization (NTO) was established for planning, coordinating, and conducting atmospheric nuclear weapons tests during Operation PLUMBBOB. All activities were under the control of an AEC-appointed Test Manager assisted by

*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.

+Vertical distances are given in feet. Altitudes are measured from mean sea level, while heights are measured from the ground surface. Yucca Flat, the area of the NTS where these four events were tested, is about 4,000 feet above mean sea level.

Table I-I: SUMMARY OF THE FIRST FOUR PLUMBBOB SHOTS

Shot	BOLTZMANN	FRANKLIN	LASSEN	WILSON
Sponsor	LASL	LASL	UCRL	UCRL
Planned Date	05/15/57	05/15/57	06/02/57	06/08/57
Actual Date	05/28/57	06/02/57	06/05/57	06/18/57
Local Time	0455	0455	0445	0445
NTS Location	Area 7	Area 3	Area 9	Area 9
UTM Coordinates	867056	870004	852100	852100
Type	Tower	Tower	Balloon	Balloon
Height of Burst (Feet)	500	300	500	500
Actual Yield (Kilotons)	12	0140	0 0005	10

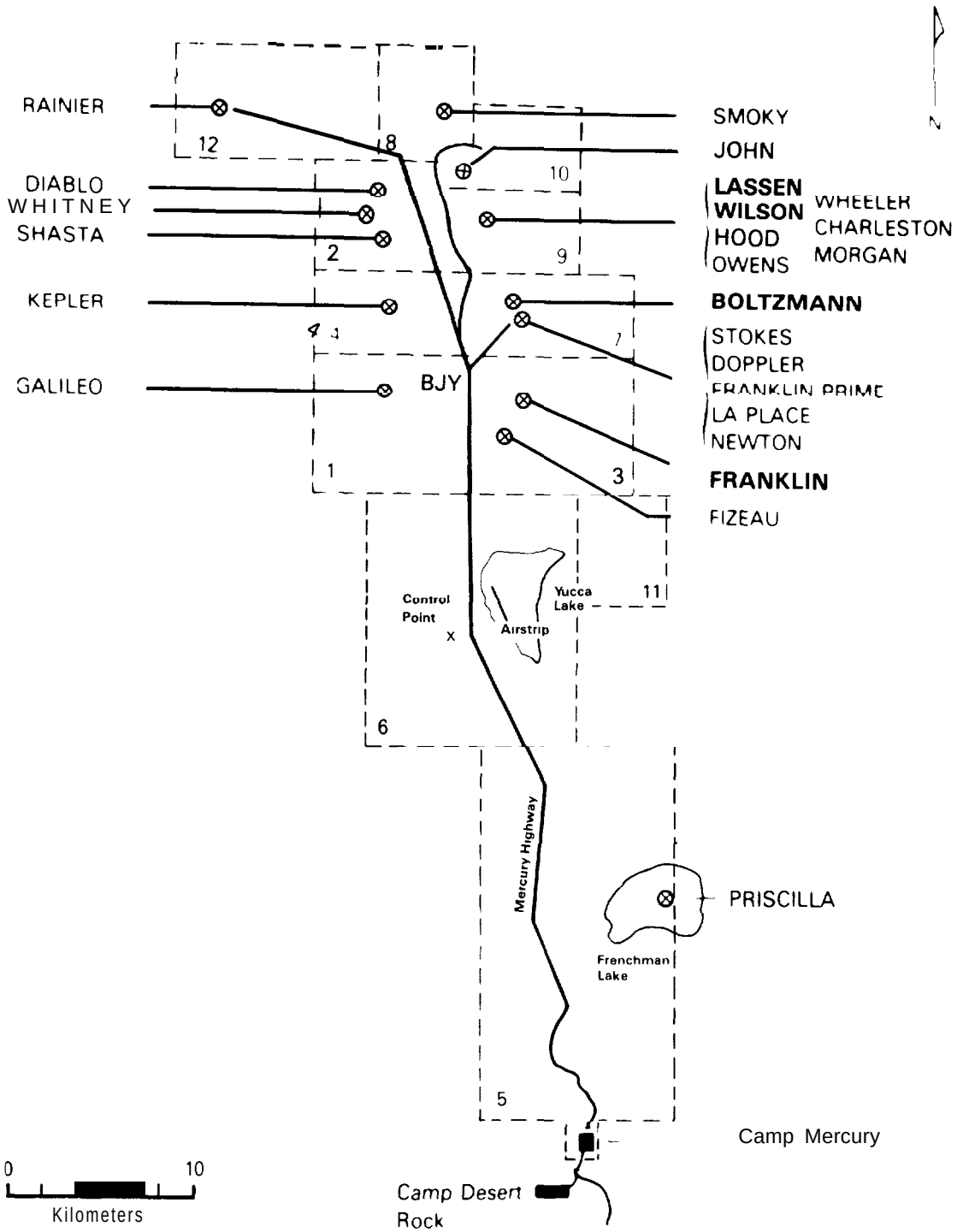


Figure I-I: LOCATION OF THE FIRST FOUR PLUMBBOB SHOTS AT THE NEVADA TEST SITE IN RELATION TO OTHER SHOTS IN THE PLUMBBOB SERIES

the Test Director. The NTO consisted of personnel from the AEC, the DOD, and the FCD4. These personnel were assigned to four NTO test groups: the AFSWP Field Command Weapons Effects Test Group, the LASL Test Group, the UCRL Test Group, and the FCD4 Civil Effects Test Group (CETG). In addition to the projects of the test groups, the DOD conducted the operational training projects and support activities. A major area of support for NTO in which DOD personnel were active was air operational control and air support provided by AFSWC air and ground personnel (22; 24-25; 48).

Overall, the largest area of DOD participation in the NTO was with the Weapons Effects Test Group projects, designed to study yield and weapons effects characteristics in order to understand the militarily useful effects of nuclear weapons for offensive and defensive deployment (23-24). Personnel from DOD agencies and the four armed services participated in the experiments conducted by LASL, UCRL, and CETG, but participation was limited. The major portion of DOD participation in these experiments was performed by the 4FSWC 4926th Test Squadron (Sampling) in LASL and UCRL radiochemistry cloud-sampling projects (22).

The DOD operational training projects, designed to test service tactics and equipment and to train military personnel in nuclear detonation effects, were conducted at each of the four shots. Most of the projects were conducted in aircraft and often involved primarily the aircraft pilots (24).

The Air Force Special Weapons Center (AFSWC), at Kirtland Air Force Base, New Mexico, exercised operational control of all military aircraft flying in the area of the NTS during PLUMBBOB and provided air support to the NTO and its projects, in addition to conducting some test activities of its own. AFSWC was composed of units from the 4950th Test Group (Nuclear), including the 4926th Test Squadron (Sampling) and the 4935th Air Base

Squadron. These units operated out of Indian Springs AFB, 30 kilometers* south of Camp Mercury, and were supported bv the 4900th Air Base Group stationed at Kirtland 4FB. AFSWC air and ground personnel provided air support to NTO projects, conducting cloud-sampling and cloud-tracking missions, and providing courier, aerial surveys, and transportation services (22; 26; 59).

The Radiological Ssfetv Division of Revnolds Electrical and Engineering Company (REECo), augmented bv 38 personnel from the 1st Radiological Safetv Support Unit, Fort McClellan, Alabama, conducted radiation protection procedures established by the NTO (64). These safetv procedures, detailed in the Operation PLUMBBOB volume, were designed to minimize exposure to ionizing radiation by limiting radiation exposures to no more than three roentgens of whole-body gamma radiation for anv 13-week period and five roentgens annuallv. Unless approved by the Test Manager in advance, access to radiation areas bv AFSWP project participants was not allowed until the Test Manager declared the area open for recoverv operations. Personnel were not permitted into areas of 10 roentgens per hour (R/h) or greater unless they had received special permission from the Test Director (48). Project participants recovering test instruments from radioactive areas were accompanied bv radiological safety monitors who surveyed the radiation intensity in the recovery area and informed the project managers as to the radiological situation. To monitor cumulative exposures, project personnel were issued film badges. After the film badges were collected, developed, and evaluated, anv individuals whose accumulated dose approached or exceeded the established limits were not permitted further access to the forward area. Personnel decontamination procedures were implemented, and emergency evacuation plans were prepared for the test events (64).

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

The radiation protection procedures for AFSWC included the same exposure limits for aircrews and ground-crew personnel as those established for the NTO personnel, with the exception of cloud sampler pilots. These AFSWC personnel were authorized bv the Test Manager to receive a total of 7.5 roentgens of gamma radiation annuallv. Complete decontamination, Including removal of anticontamination clothing and showers, was required of all aircrew members following each project mission, regardless of the exposure received on the flight. Aircraft were decontaminated bv ground personnel or not used until radiation intensities decaved to permissible levels (1; 22; 48).

1.2 EXERCISE DESERT ROCK ACTIVITIES AT THE FIRST FOUR PLUMBBOB EVENTS

Manv DOD personnel involved in Shots BOLTZMANN through WILSON took part in training and technical service projects fielded hv Exercise Desert Rock, the 4rmv testing and training program conducted during Operation PLUMBBOB. In addition to the Desert Rock exercise troops, Camp Desert Rock troops provided communication, transportation, traffic control, and radiological safetv monitoring for Desert Rock projects at the four shots (31; 35). Soldiers from the 50th Chemical Service Platoon provided radiological safetv monitoring for Desert Rock personnel in the test area after each detonation (31-35; 55).

Radiation protection procedures for Exercise Desert Rock, like those of the NTO, are detailed in the PLUMBBOB Series volume. Procedures were designedto minimize potential exposure to ionizing radiation while allowing participants to accomplish project objectives. Desert Rock personnel were limited to no more than five roentgens of whole-hodv gamma radiation during anv six-month period. The radiation protection procedures of Exercise Desert Rock included provisions for (31-35; 55):

- Maintaining minimum safe distances from nuclear detonations

- Enforcing protective procedures for personnel observing the detonations
- Controlling access to radiation areas
- Film-badging and monitoring the cumulative exposures of Desert Rock personnel
- Decontaminating all equipment and personnel leaving the shot area after each detonation
- Preparing emergency evacuation plans for personnel in the forward area.

1.3 DOSIMETRY FOR PLUMBBOB PARTICIPANTS

For Operation PLUMBBOB, REECo maintained cumulative exposure lists of NTO and AFSWC personnel. The lists provided the shot-specific dosimetrv information described in the radiological safety sections of the following chapters. For example, lists were developed that showed the personnel who had, during a specific shot period, exceeded a cumulative dose of two roentgens. A few surviving disposition forms, specifving personnel exposures exceeding three roentgens, indicate that Exercise Desert Rock similarly monitored cumulative exposures. Personnel whose exposures reached five roentgens were prohibited from further entry into the shot area. Within the operational period encompassed bv this volume, one Desert Rock participant exceeded three roentgens. This participant, from Companv B, 84th Engineer Battalion, received an exposure of 4.9 roentgens through the time of Shot WILSON (44; 49-52). The Operation PLUMBBOB volume summarizes dosimetry totals and overexposure information for PLUMBBOB participants.

SHOT BOLTZMANN SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	28 May 1957, 0455 hours
YIELD:	12 kilotons
HEIGHT OF BURST:	500 feet (tower shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate military effects for specific applications against a variety of military targets
(3) To evaluate the effectiveness of military equipment and to indoctrinate personnel in the effects of a nuclear detonation
(4) To assess the effects of a nuclear detonation on civilian structures, products, and food supplies and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 18°C. Surface winds were calm at the time of detonation. Winds were from the south-southeast at 13 knots at 10,000 feet, 24 knots at 20,000 feet, and 21 knots at 30,000 feet.

Radiation Data: About one hour after the detonation, radiation intensities greater than 0.1 R/h were confined to within 1,300 meters around ground zero, except to the north.

Participants: Exercise Desert Rock troops, 4rmed Forces Special Weapons Project, Air Force Special Weapons Center and other Air Force personnel, Los Alamos Scientific Laboratorv, Federal Civil Defense Administration, other contractors.

CHAPTER 2

SHOT BOLTZMANN

Shot ROLTZMANN, the first nuclear weapons test of Operation PLUMBROB, was conducted at 0455 hours Pacific Daylight Time on 28 May 1957. Originally planned for 15 May, ROLTZMANN was postponed because of unfavorable weather conditions. The shot, which had a vield of 12 kilotons, was detonated from the top of a 500-foot steel tower in Area 7 of the NTS. The BOLTZMANN cloud reached a maximum altitude of 33,000 feet mean sea level. Fallout traveled northwest, with peak radiation levels of 0.1 R/h extending about 100 miles offsite (25; 64).

2.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT BOLTZMANN

More than 200 Desert Rock troops took part in projects associated with the BOLTZMANN event: two troop observer indoctrination projects, two radiological training projects, and two technical service projects. Table 2-1, on the next page, identifies the Desert Rock program types, their subordinate projects, the participating units, and the estimated number of DOD participants. The table also lists 176 Camp Desert Rock support personnel who observed the detonation (35).

2.1.1 Troop Observer Indoctrination Projects

Seventy-four Navy personnel participated in Project 50.2, Troop Observers, and 63 Air Force personnel took part in Project 53.3, Aircrew Observers. All observers, including the 176 Camp Desert Rock support personnel, took part in the same orientation and training activities for the event. They witnessed the detonation from an observation area 13 kilometers south of ground zero, at UTM coordinates 895925 (35).

Table 2-I: EXERCISE DESERT ROCK PROJECTS, SHOT BOLTZMANN

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	50 2	Troop Observers	Navy	74
	53 3	Aircrew Observers	Air Force	63
	-	Troop Observers	Camp Desert Rock Support Troops	176
Radiological Training	53 4	Radiological Defense Training	Air Force Radiological Defense School, Lowry AFB	38
		Chemical Biological, Radiological Survey Team Training	Fort Huachuca, Arizona	24
Technical Service	50 3	Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems	Army Signal Research and Development Laboratones	32
	505	Field Evaluation of Shielding for Heavy Equipment	Army Engineer Research and Development Laboratones	5

2.1.2 Radiological Training Projects

Project 53.4, Radiological Defense Training, was intended to teach radiological monitoring procedures under conditions similar to those anticipated for a nuclear battlefield. Thirtv-eight members of the Air Force Radiological Defense School, located at Lowry AFB in Denver, Colorado, participated in the project, witnessing the detonation with the observer personnel of Projects 50.2 and 53.3. Radiological safety personnel from the 50th Chemical Service Platoon preceded Project 53.4 personnel into the shot area. There, the radiological personnel conducted radiological surveys and marked the .01 and .10 R/h areas. At the .001 R/h line, thtv waited for project participants. At the declaration of recovery hour, 0608, the participants proceeded into the shot area accompanied hv a 50th Chemical Service Platoon monitor. They then located radiation intensities of up to 5 R/h and radioed their information to control stations, where the data were plotted on a map. The radiological safetv monitors remained with the participants during the project to enforce radiological safetv procedures and to provide technical assistance (24; 31; 35; 44).

The Sixth U.S. Army sponsored Chemical, Biological, Radiological (CBR) Survey Team Training. The purpose of the project was to train personnel from Sixth Army installations in radiological defense techniques. Two CBR teams from Fort Huachuca, each consisting of 12 monitors, participated in the project. The first team was at the test site from 24 to 30 May. After witnessing the shot with the Project 50.2 observers, the 12 monitors went to a predesignated area to study monitoring techniques under the supervision of the Desert Rock radiological safetv section (24; 44). The second CBK team was at the test site from 8 to 17 June. Although these 12 monitors arrived after the LASSEN shot, presumably to study monitoring techniques in the shot area, the LASSEN vield was too low for the purposes of the project. Instead, it is likely that the monitors used the BOLTZMANN survey area for the project since the radiation intensities would have been high enough to monitor.

Project 51.1, Navy Radiological Safetv Monitoring, sponsored bv the Navv Bureau of Yards and Docks, was also scheduled for Shot BOLTZMANN and was to involve 120 participants. Project personnel trained in an area of low contamination from Operation TEAPOT because Shot BOLTZMANN was delaved and participants were unable to witness anv PLUMBBOB shots. Participants left Camp Desert Rock before the first PLUMBBOB shot was fired (24; 31; 35).

2.1.3 Technical Service Projects

The Department of the Army sponsored two technical service projects at Shot ROLTZMANN to evaluate military equipment.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded bv 18 personnel from the Armv Signal Research and Development Laboratories, Fort Monmouth, New Jersey; seven participants from Fort Meade,

Marvland; and seven participants from Fort Huachuca, Arizona. The project had two purposes: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Armv fallout prediction methods. The fallout prediction unit for this project operated from a van parked near the Air Weather Station at Camp Mercury. Three radar units were located southeast of Yucca Lake, near UTM coordinates 893872, approximately 20 kilometers south of ground zero (12; 31; 44).

Project 50.5, Field Evaluation of Shielding for Heavy Equipment, was conducted in the BOLTZMANN shot area by volunteers from the Army Engineer Research and Development Laboratories. This project was the third phase of an experiment designed to determine the shielding and operational capabilities of an experimental D-8 bulldozer in decontaminating a contaminated field.

On 5 and 6 June, eight and nine days after the detonation, a D-8 bulldozer decontaminated a 930-square-meter area and a 280-square-meter area just northwest of ground zero by scraping off the topsoil. Five volunteers took turns operating the bulldozer. Figure 2-l shows project personnel and the bulldozer (31; 61).

2.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT BOLTZMANN

In addition to participating in the Exercise Desert Rock activities described in the previous section, Department of Defense personnel performed a variety of tasks during Shot BOLTZMANN that required them to enter the forward area. They conducted 11 projects sponsored by the AFSWP Field Command Weapons Effects Test Group, and thev assisted in three LASL and five CETG projects. The Air Force sponsored three operational

Figure 2-1: PROJECT 50.5 PERSONNEL WITH BULLDOZER USED TO SCRAPE CONTAMINATED SOIL

training projects. DOD personnel also participated in AFSWC and other support activities at Shot ROLTZMANN. The Air Force Special Weapons Center provided major support to two test group projects and aircraft to two others. AFSWC pilots also flew five missions for the Test Manager.

2.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Field Command Weapons Effects Test Group conducted 11 pro.jects at Shot ROLTZMANN, as listed in table 2-2. The personnel estimates given in this table, and in the project tables of the following chapters, reflect the minimum number of project participants in an experiment as given in the schedule of events for the shot or in the weapons test reports.

Project 2.5, Initial Gamma Radiation Intensitv and Neutron-induced Gamma Radiation of NTS Soils, was conducted bv the Army Signal Research and Development Laboratories. For this shot, the project was to determine the intensities of initial gamma radiation at ground level and in the air during the detonation. Seven stations were constructed 1,430 to 1,920 meters southeast of ground zero. Two dsvs before the detonation, radiation detection instruments were installed in the prepared stations. Four project personnel recovered the instruments, probablv completing their work within three days of the detonation (14; 23).

Project 2.7, Radio-wave Attenuation Studies, was fielded by Naval Research Laboratory personnel. The project was designed to study the interference effects of high levels of radiation on radio transmissions and radar operations. The specific purpose of the project was to observe the attenuation of radiowaves when transmitted through the fireball. Transmitters were placed in unmanned shielded bunkers 840 to 1,460 meters from ground zero. Scintillation detectors were also installed in some of the bunkers close to ground zero. Receivers were installed in

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

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
2 5	Initial Gamma Radiation Intensity and Neutron-Induced Gamma Radiation of NTS Soils	Army Signal Research and Development Laboratones	4
2 7	Radio-wave Attenuation Studies	Naval Research Laboratory	11
210	Initial Neutron and Gamma Arr-earth Interface Measurements	Air Force Special Weapons Center	2
4 2	Evaluation of Eye Protection Afforded by an Electromechanical Shutter	Tactical Air Command, Air Force School of Aviation Medicine, Naval Radiological Defense Laboratory; Wright Patterson Aero Medical Laboratory, Nellis AFB Hospital	*
51	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation	Navy Bureau of Aeronautics	*
53	In-flight Structural Response of the FJ4 Arrcraft to a Nuclear Detonation	Naval Air Special Weapons Facility	*
54	In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonatron	Navy Bureau of Aeronautics	14
55	In-flight Structural Resporse of the F-89D Arrcraft to a Nuclear Detonatron	Wright Air Development Center, Northrop Aircraft	7
64	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
65	Effects of Nuclear Detonations on Nike Hercules	White Sands Missile Range, Bell Telephone Laboratories	7
91	Technical Photography	AFSWP; Military Air Transport Service, EG and G	6
Los Alamos Scientific Laboratory Test Group			
11 2	Radiochemistry Sampling	Air Force Special Weapons Center	12
183	Mass Effect Spectroscopy	Naval Research Laboratory	*
Civil **Effects Test** Group			
37 2	Biophysical Aspects of Fallout	Air Force Special Weapons Center	*
37 2a	Physical Aspects of Fallout	Air Force Special Weapons Center	*
376	Applications of Radio-ecology Techniques	Air Force Special Weapons Center	*

* Unknown

Building 400, west of the Control Point and about 18 kilometers from ground zero. About three people spent ten days installing and tuning the equipment. From 0305 to 1655 hours on shot-dav, 11 participants occupied Building 400. At 1255 on shot-day, three personnel proceeded from the Control Point to the Banded Mountain Station, about seven kilometers north of ground zero. They remained in the area approximatelv two hours recovering equipment and data (7; 23; 30).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, was fielded under AFSWC supervision. The objective was to study how the air-ground interface affected the radiation produced by a nuclear detonation. Film badges were placed at two ground stations, 1,520 and 1,830 meters north-northwest of ground zero, and at heights up to approximately 90 meters on the tower constructed for Shot FRANKLIN in Area 3, 5,210 meters from the BOLTZMANN ground zero. At 0655, two hours after the detonation, two personnel left the Control Point to recover detectors from the ground stations, a procedure that was to take about 45 minutes. At 0755 on shot-day, these same two participants left the Control Point to recover badges and dosimeters from the FRANKLIN tower, an activitv that was to take approximatelv one hour (7; 23; 65).

Project 4.2, Evaluation of Eve Protection Afforded bv an Electromechanical Shutter, was to evaluate the effectiveness of an electromechanical shutter device in preventing or minimizing flash blindness, a condition produced bv the intense light of a nuclear detonation. Volunteers from the Tactical Air Command were the test subjects. The Air Force School of Aviation Medicine furnished the examiners for the tests, and personnel from the Navy Radiological Defense Laboratorv, the Wright Patterson Aero Medical Laboratorv, and Nellis Air Force Base Hospital provided technical support.

Two identical experimental stations were used at the shot. One station was in a C-47 aircraft (serial number 956), operated by Tactical Air Command personnel. The C-47, which took off from Indian Springs AFB at 0435 hours, flew in a left-hand holding pattern 19 kilometers southwest of ground zero until 15 minutes after the detonation. It then returned to Indian Springs AFB, landing at 0542 hours. The other station was in a trailer 16 kilometers from ground zero, at UTM coordinates 845924. Each station was equipped with a light-sensitive electromechanical shutter device for each subject and had facilities for testing from two to five volunteers. A trained examiner was present for each volunteer to determine the length of time required to recover useful vision. Project participants left Camp Mercury for the trailer about five hours before the shot. Upon completion of the testing, about one hour after the shot, all test volunteers returned to Camp Mercury and then went to Nellis AFB for complete ophthalmological evaluation.

In another aspect of this project, four or more rabbits were visuallv exposed at both of the experimental stations. Each animal was placed in a holder designed to minimize movement and ensure proper positioning for exposure. Ten of the control rabbits, which were exposed to the detonation without the shutter device present, received chorioretinal burns, indicating that sufficient energy was absorbed to cause permanent damage to the unprotected eye (7; 23; 28).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted by the Navv Bureau of Aeronautics. One objective was to measure the effects of the over-pressure and wind gusts produced by a nuclear detonation on the HSS-1 helicopter. Another objective was to study how blast effects might limit the HSS-1 capabilitv to deliver antisubmarine weapons. The project required the support of one helicopter pilot, ground controllers, and aircraft maintenance

personnel who equipped the helicopters with special instruments. An average of four practice runs were flown before the actual missions. For the shot, the HSS-1 helicopter (serial number 024), which left Indian Springs AFB at 0408 hours, flew left-hand, eight-nautical-mile holding patterns. At shot-time, the helicopter was positioned 270 degrees outbound, at a slant range of 4,900 meters from ground zero. Upon completing its mission, the HSS-1 returned to Indian Springs AFB, landing at OS30 hours (2; 7; 23; 63).

Project 5.3, In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation, was conducted by the Naval Air Special Weapons Facility. The objective was to measure the thermal and blast response of the FJ-4 and to determine its performance and deliverv capabilities during a nuclear detonation. Project personnel included the aircraft crew, ground controllers, and maintenance personnel responsible for the aircraft and instrumentation. The FJ-4 (serial number 467) left Indian Springs AFB at 0407 hours. When the BOLTZMANN shock arrived, the test aircraft was in a level flight pattern, heading away from the blast. After the detonation, the FJ-4 returned to Indian Springs AFB, landing at 0509 hours. Total gamma dose was recorded bv film badges located in the cockpit, ammunition bay, right drop tank, and nose-wheel well (2; 7; 23; 39).

Project 5.4, In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation, was conducted by the Air Force Cambridge Research Center to measure the thermal and blast wave response of the A4D-1 during flight and to determine its performance and delivery capabilities during a nuclear detonation. The A4D-1 (serial number 827) was a Navy, single-engine, modified delta wing, carrier-based jet attack aircraft with the capability of delivering nuclear weapons. Participants included one pilot,, ground controllers, and maintenance personnel responsible for the special painting and instrumentation of the

aircraft. Radiation in the aircraft was measured by four film badges located in the bottom portion of the nose section, six film badges in the cockpit map case, and various dosimeters located in the nose-wheel door and the leg pocket of the pilot's flight suit.

The aircraft took off from Indian Springs AFB 35 minutes before shot-time, entered its pattern 30 minutes before shot-time, flew two orbits approximately 35 nautical miles in length, and flew a final run over ground zero starting five minutes before shot-time. The test aircraft was flown on a straight and level course directly toward ground zero. At the time of detonation, the aircraft was 12,350 feet above the burst at a slant range of 4,150 meters. The aircraft returned directly to Indian Springs AFB and landed 20 minutes after the detonation (2; 7; 23; 62).

To provide radar support for Projects 5.1, 5.3, and 5.4, one party of six personnel left Camp Mercury at 2400 hours on the night before the detonation for the M-33 Radar Site approximately 19 kilometers south of ground zero. The party remained at the site through shot-time and left for Camp Mercury two or three hours after the detonation. Two other parties, one of 14 and one of five personnel, left Camp Mercury for the same site at 0005 hours on shot-day and arrived at the site at least four hours before the detonation. They remained through shot-time and left the site for Camp Mercury two or three hours after shot-time. A final party of ten left Camp Mercury for the radar site at 0205 hours on shot-day, arrived at the site two hours before the detonation, remained through shot-time, and returned to Camp Mercury one hour after the detonation (7).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was to determine the structural response of the aircraft to blast and thermal effects of a

nuclear detonation. Northrop Aircraft, contractor to the Wright Air Development Center, calibrated, maintained, and operated the instrumentation and associated equipment, and later analyzed the data. Wright Air Development Center and Northrop Aircraft jointly calculated the positions and developed the positioning methods. The F-89D aircraft left Indian Springs AFB at 0420 hours. Plans indicate that it was to be at an altitude of 20,000 feet and approximately three kilometers from ground zero at shot-time. The F-89D returned to Indian Springs AFB at 0507 hours (2; 7; 23; 58).

To provide radar support for Project S.5, one party of seven personnel departed from Camp Mercury at 0025 hours on shot-day for the MSQ Radar Site located approximately 30 kilometers southwest of ground zero. The party arrived about three hours and 30 minutes before the shot and remained through shot-time. On shot-day, a two-man party left for the radar site at 0130 hours, followed by a third participant at 0205 hours. The three personnel remained at the site through shot-time. The two parties and the additional participant left the site for Camp Mercury one to two hours after the shot (7).

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL System, was conducted by the Air Force Cambridge Research Center. The project used the Long Range Aids to Navigation (LORAN) system in an inverse fashion to detect the electro-magnetic pulse from the nuclear burst in order to determine the position and measure the yield of that burst. The Indirect Bomb Damage Assessment NAROL system tested on this operation included nets located at Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net consisted of two unmanned stations and one manned station (23; 36).

Project 6.5, Effects of Nuclear Detonations on the Nike Hercules, was to investigate the effects of nuclear radiation on

the Nike Hercules guided-missile system. The project was designed to familiarize radar crews with techniques to be employed and observations to be made following a nuclear detonation. The project was fielded bv personnel from the White Sands Missile Range, New Mexico, with assistance from the Bell Telephone Laboratories in Whippany, New Jersey (21). At 1800 hours on the dav before the shot, seven personnel left Camp Mercury and proceeded to a station at UTM coordinates 765032. Thev remained at the station through shot-time and until two hours after the shot to man missile and target-tracking radar (7).

Project 9.1, Technical Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the militarv effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Six personnel manned a photography station at the Project 6.5 radar site. The detonation was also photographed from the air by two or three Project 9.1 personnel in a C-47 aircraft from Indian Springs AFB. This C-47, with a crew of at least three from the Military Air Transport Service, left Indian Springs AFB at 0405 hours. At shot-time, the aircraft was eight nautical miles southwest of ground zero, flving eastbound at 10,000 feet. When its mission was complete, about 15 minutes after the shot, the aircraft returned to Indian Springs AFB (2; 7; 23). In addition, Edgerton, Germeshausen, and Grier (EG and G) provided technical photography support to AFSWP and the AEC. EG and G personnel operated camera stations during the shot to obtain fireball and cloud growth data (20).

2.2.2 Department of Defense Participation in the Los Alamos Scientific Laboratory Test Group Projects

The Los 41amos Scientific Laboratory Test Group conducted 14 projects at Shot BOLTZMANN. Of these, onlv two had DOD participation, as shown in table 2-2. Project 11.2, Radiochemistry Sampling, involved cloud sampling by pilots from AFSWC 4926th Test Squadron, an activity discussed in section 2.2.5 of this chapter. Project 18.3, Mass Effect Spectroscopy, involved some participation bv the Naval Research Laboratory. Information on this activity is limited, however, since a project report was not written following the operation (48).

2.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted eight projects at ROLTZMANN. Three of these projects are known to have involved DOD participation, as shown in table 2-2.

Project 37.2, Biophysical Aspects of Fallout, and Project 37.2a, Phvsical Aspects of Fallout, were conducted to delineate and characterize fallout patterns (42). Project 37.6, Applications of Radio-ecologv Techniques, was conducted to studv environmental assessment techniques (42). AFSWC provided a single C-47 aircraft during the shot for radio relay services, as discussed in section 2.2.5. From the C-47, the program director received fallout pattern predictions from Camp Mercury and communicated that information to ground teams, located about 30, 80, 130, and 190 kilometers from ground zero. From 0305 hours to shot-time, the program director continued the radio relay, so that he might transmit the final decision on proceeding with project activities to the ground teams and give them their station assignments (2).

2.2.4 Operational Training Projects

The primary objectives of the operational training program at BOLTZMANN were to test tactics and equipment and to train and indoctrinate Air Force personnel. The program consisted of the following projects:

- Project 53.5, Aircrew Indoctrination (Earlv Cloud Penetration)
- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.5, Aircrew Indoctrination (Earlv Cloud Penetration), was designed to enable Air Defense Command aircrews to witness a nuclear detonation and penetrate its cloud. Six F-86D aircraft flew at altitudes of 32,000 feet (2). Beginning at about 0447 hours, the aircraft orbited over the Las Vegas area, continuing until the sampler control aircraft gave authorization to proceed toward and into the cloud. At about 0550, after cloud penetration, the aircraft left the area to return to Nellis AFB (2; 24).

Project 53.7, Indirect Bomb Damage Assessment, was conducted to test IBDA equipment onboard an Air Force jet-fighter. Staff from the Wright Air Development Center installed Indirect Bomb Damage Assessment equipment in an F-89D aircraft (serial number 412) based at Indian Springs AFB. The F-89D, with a crew of one, took off at 0412 hours. At shot-time, the aircraft flew a right-hand 40-nautical-mile holding pattern and orbited 70 nautical miles east of ground zero at 35,000 feet (2). The F-89D returned to Indian Springs AFB at 0516 (2; 24).

Project 53.9, Photographic Reconnaissance Training, was intended to train Air National Guard Tactical Reconnaissance units in photographic missions over a nuclear target. Two RF-84F aircraft with one pilot each departed from George AFB, California,

and flew to the NTS, where they orbited above Lathrop Wells at 31,000 feet until the shot was fired. Upon clearance from the Air Operations Center, they began the photographic mission, flving toward ground zero. They crossed the shot area approximately 15 minutes after the detonation at an altitude of 10,000 feet. At about 0525 hours, upon completion of the run, they left the area to return to base (2; 24).

2.2.5 Air Force Special Weapons Center Activities

During Shot BOLTZMANN, AFSWC support to the test groups consisted of cloud-sampling missions, sample courier missions, radio relays, cloud-tracking missions, and security and helicopter surveys.

Cloud Sampling

Project 11.2, Radiochemistry Sampling, was sponsored by the Los Alamos Scientific Laboratory Test Group. Samples were gathered from the cloud for subsequent laboratory analyses. Three B-57s, including the sampler control aircraft, and six F-84Gs participated in the activity. Pilots from the 4926th Test Squadron (Sampling) flew the nine aircraft. Each sampler aircraft was outfitted with sampling equipment, radiac meters, filter papers, and integrating dosimeters. Pilots were on full oxygen before, during, and after cloud penetration (1-2).

The sampler control plane, with a pilot and a scientific advisor, directed the sampling. The two B-57 samplers each had a crew of two, while each F-84G had only a pilot. The aircraft collected samples at 30,000 feet. Following standard operating procedures, the first aircraft entered the area just after the detonation, and the last aircraft approached the cloud two hours later (l-2).

Courier Missions

On shot-day, the 4900th Air Base Group from Kirtland AFB flew sample return missions with C-47 aircraft. The missions entailed transporting cloud samples taken from sampler aircraft at Indian Springs AFB to the Los Alamos Scientific Laboratory for analysis (l-2).

Radio Relay

A C-47 aircraft (serial number 091), with at least three crew members, performed a radio relay for CETG Projects 37.2, 37.2a, and 39.7a. The aircraft left Indian Springs AFB at 2330 hours and flew a holding pattern at 11,000 feet 40 nautical miles southeast of ground zero, within communications distance of Camp Mercury. One hour after the shot, the C-47 completed its mission and returned to its home base, where it was decontaminated (2).

Cloud Tracking

Immediatelv after the detonation of Shot BOLTZMANN, one B-25, one B-29, and one B-50 aircraft flew cloud-tracking missions over and beyond the NTS. The purpose of the cloud-tracking missions was to determine the direction of movement of the radioactive cloud and to keep the airways clear of any private or commercial aircraft that might encounter radiation.

After cloud-sampling aircraft completed their missions, the Air Operations Center ordered the cloud-tracking aircraft to leave their holding patterns, approach the edge of the cloud at frequent intervals, and record the position of maximum intensity encountered on approach. The B-25 flew at about 15,000 feet, the B-29 at 20,000 feet, and the B-50 at 25,000 feet. The cloud-tracking missions continued until the Test Manager determined that the cloud presented no further hazard to aircraft flving commercial airways (l-2).

Security Sweep

Before the shot, one L-20 aircraft was dispatched from Yucca Airstrip near Camp Mercury to perform a preshot security sweep over the NTS. The aircraft had a crew of at least two, since the security sweep routine called for a security guard to accompany the pilot (2; 7).

Helicopter Surveys

Three H-21 helicopters flew various survey missions over the shot area after the detonation. One H-21 assessed and recorded detonation damage, the second H-21 recorded radiation intensities in the shot area, and the third helicopter made a damage survey of a tunnel area at ground zero. Each helicopter had a crew of two AFSWC personnel and two or three REECo radiological safety monitors and participants. After the mission, helicopters were monitored and decontaminated as required (l-2; 49).

2.3 RADIATION PROTECTION 4T SHOT BOLTZMANN

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that individuals would avoid unnecessary exposure to ionizing radiation while accomplishing their missions. Records that enabled the Nevada Test Organization to evaluate the effectiveness of their radiation protection programs include isointensitv contour maps, monitoring data, and some NTO personnel dosimetry information. The Operation PLUMBBOB volume provides a description of radiological safetv procedures and presents total dosimetrv information for Desert Rock and AFSWC participants.

Dosimetry Records

During the period 27 through 31 May, including the 28 May detonation of BOLTZMANN, the Personnel Dosimetry Branch issued 3,139 film badges and 801 pocket dosimeters. One NTO/DOD

individual, from the 1st Radiological Safety Support Unit, received a gamma exposure of 2.28 roentgens (49; 64).

Monitoring Procedures and Support

After the detonation, radiological safety monitors conducted both ground and aerial surveys of the terrain surrounding ground zero. Fifteen minutes after the detonation, 15 monitors traveling in seven vehicles performed the initial ground survey. The survey teams determined the 0.01 and 0.10 R/h radiation areas and marked the areas with signs. They then transmitted the results of their surveys to personnel in the Plotting and Briefing Branch, who used the information to prepare isointensitv maps. Resurveys were conducted about seven hours later, and again on 29 and 31 May and 1, 2, 5, 7, and 11 June (49; 64).

At 0530 hours on shot-day, a radiological safety check station was established on the main access road leading into Area 7 to control entry into the shot area. A second check station was established at 0730 hours on an access road into Area 2, parts of which had become contaminated from the detonation. Radiological safety personnel manned these stations continuously until 2300 hours on 1 June (49; 64).

The initial helicopter survey was conducted bv two crewmen and a radiological monitor. They left the Control Point heli-copter pad at 0510 hours, 15 minutes after detonation. The helicopter followed a predetermined route 25 feet above Area 7. Because of the ground haze and dust caused by the shot, however, no ground points could be discerned, and the helicopter returned to the Control Point. The helicopter was dispatched again at 0700 hours, more than two hours after the detonation. At this time, the helicopter successfully surveved Area 7, completing the mission at 0749 hours. The survev team encountered radiation intensities due to fallout up to 1.5 R/h. Intensities above 1.0 R/h were registered north and northeast of ground zero. Based on

the results of the initial surveys, the Test Manager declared recovery hour at 0608 (2; 49; 64).

Plotting and Briefing

Using information from the surveys, the Plotting and Briefing Branch developed isointensity contour maps. A copy of the initial contour map, with a mid-time of 0551 hours, is shown in figure 2-2. Figure 2-3 shows copies of the isointensity maps generated from 28 May, 29 May, 1 June, and 5 June (64).

Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion Areas, as defined in the series volume. The Plotting and Briefing Branch also issued the access permits required for entry into these areas. During the period of 28 May through 2 June, access permits were issued to 862 individuals involved in a total of 13 projects (64).

Decontamination Activities

During the period covering Shot BOLTZMANN, the Decontamination Branch decontaminated 62 vehicles (64).

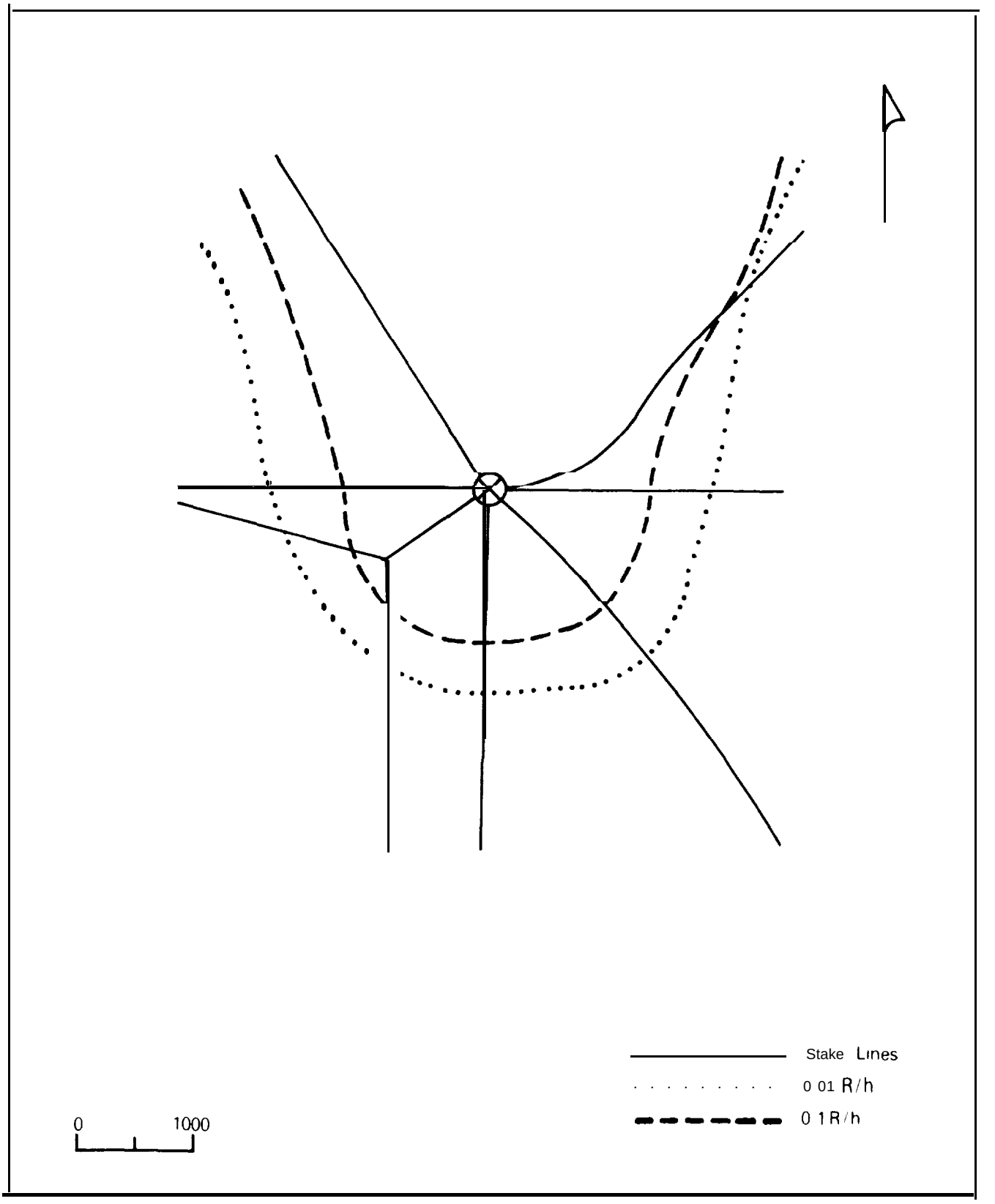
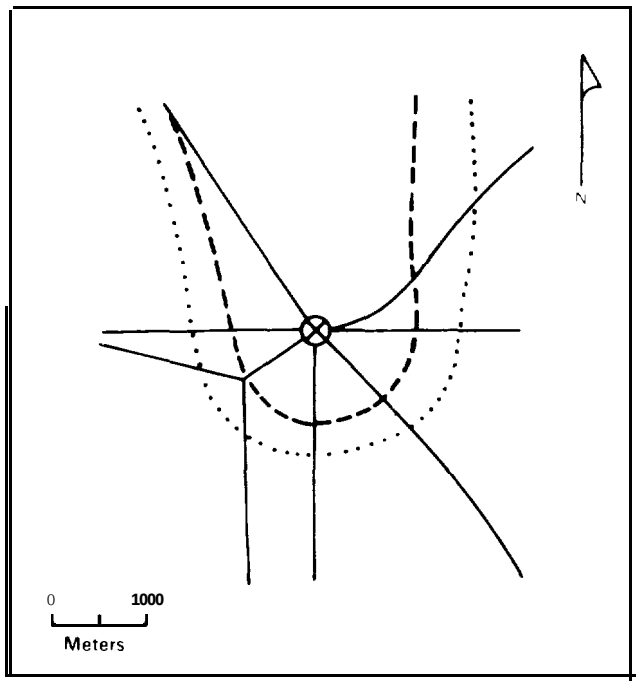
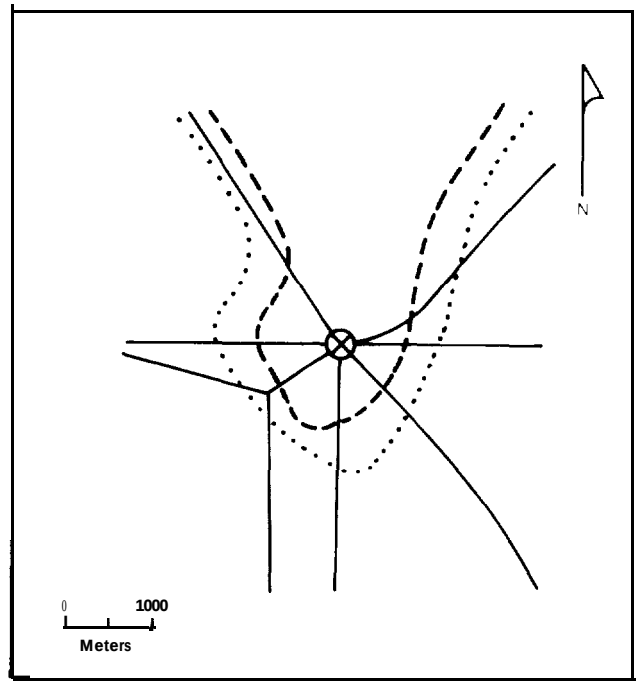


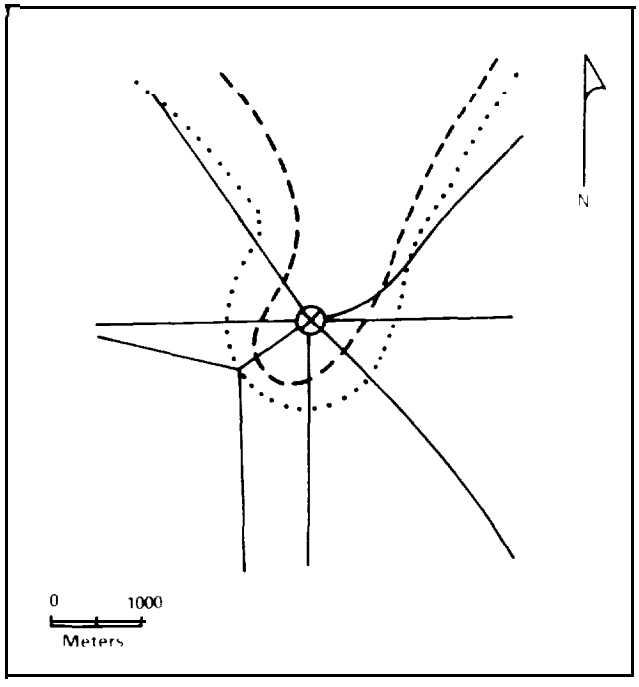
Figure 2-2: INITIAL SURVEY FOR SHOT BOLTZMANN, 28 MAY 1857, MID-TIME 0551



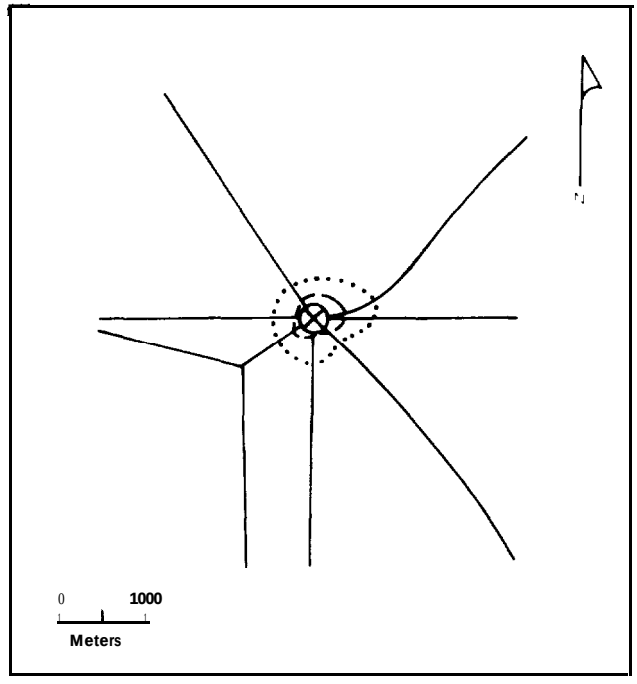
28 May, 1957, Mid-Time: 1319



29 May 1957, Mid-Time: 0648



1 June 1957, Mid-Time: 0550



5 June 1957, Mid-Time: 1352

Stake Lines
0 01 R h
0 1R h

Figure 2-3: SUBSEQUENT SURVEYS FOR SHOT BOLTZMANN

SHOT FRANKLIN SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	2 June 1957, 0455 hours
YIELD:	0.14 kilotons
HEIGHT OF BURST:	300 feet (tower shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate military effects for specific applications against a variety of military targets
(3) To assess the effects of a nuclear detonation on civilian structures, products, and food supplies and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 14°C, and the pressure was 878 millibars. One hour after the detonation, winds were calm up to 10,000 feet and six knots from the south at 16,000 feet.

Radiation Data: About one hour after detonation, radiation intensities greater than 0.1 R/h were confined to within 3,000 meters from ground zero, except to the north.

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

CHAPTER 3

SHOT FRANKLIN

Shot FRANKLIN was detonated with a yield of 0.14 kilotons at 0455 hours Pacific Daylight Time on 2 June 1957. The shot was fired on the top of a 300-foot steel tower in Area 3 of Yucca Flat. Sponsored by the Los 41amos Scientific Laboratorv, FRANKLIN had been planned for 15 Mrv but was postponed because of unsuitable weather (25; 48). The cloud resulting from the detonation reached an altitude of 16,700 feet and drifted north to northwest (25).

3.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT FRANKLIN

Some Desert Rock exercise troops participated in the two technical service projects associated with the FRANKLIN event: Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, and Project 50.7, Test of Ordnance Material (32; 35).

Project 50.3 was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Meade, and seven personnel from Fort Huachuca. The project was designed to test the capacity of Army radar equipment in detecting nuclear detonations and tracking clouds and to examine Armv fallout prediction methods. The fallout prediction unit for this project worked in a van parked near the Air Weather Station at Camp Mercury. Project personnel were at four radar stations located in a cluster southeast of Yucca Lake, near UTM coordinates 893872, about 15 kilometers from ground zero (12; 32; 44; 53).

Project 50.7, Test of Ordnance Material, was designed to determine the effect of the blast, thermal, and radioactive elements of nuclear explosions on selected items of Army equipment. The project was divided into four parts, each part testing a different type of ordnance. Three of the parts were conducted at Shot FRANKLIN. These were radiation studies conducted by Ballistic Research Laboratories, foxhole studies fielded by the Continental Armv Command, and vehicle damage tests fielded by the Detroit Arsenal.

Radiation studies, conducted in conjunction with the Field Command Weapons Effects Test Group Project 2.4, used unmanned tanks and vehicles placed 550 meters east of ground zero. Instrumentation was provided, installed, and recovered bv Project 2.4 personnel, whose activities are discussed in section 3.2. The foxhole studies were designed to test the protection provided bv foxholes, some with tanks and Ontos vehicles placed over them. For vehicle damage tests, Ontos vehicles and tanks were placed in areas near ground zero to incur direct and secondary blast damage (11; 32; 60).

3.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT FRANKLIN

In addition to participating in Exercise Desert Rock activities, Department of Defense personnel performed a variety of tasks that required them to enter the forward area. They conducted 14 projects sponsored by the AFSWP Field Command Weapons Effects Test Group, and they participated in three LASL Test Group and six CETG projects. The Air Force sponsored two operational training projects to indoctrinate personnel and test equipment. In addition to experiments and training projects, AFSWC and other support activities accounted for a number of other DOD participants. The Air Force Special Weapons Center supported the test group projects and flew routine missions for the Test Manager.

3.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted the projects identified in table 3-1. Project personnel, the numbers of whom are estimated in this table, often engaged in both pre- and postshot activities in the shot area. Following the detonation, thev were permitted into the shot area onlv after the Test Manager declared recoverv hour at 0715 hours.

The yield of Shot FRANKLIN, only 0.14 kilotons, was much lower than had been expected. As a result, many of the planned postshot activities were not conducted. Project personnel could collect data from experiments that were conducted sooner than had originally been anticipated. Because of the low yield, however, many of the projects did not produce useful results.

Project 1.1, Basic Airblast Phenomena, was conducted bv the Ballistic Research Laboratories. The primary objective of the project was to obtain data on overpressure and dynamic pressure at different times after the detonation and at different distances from ground zero. An additional objective was to evaluate modifications in gauge designs, instrument components, and measurement techniques. 4t 2100 hours the day before the detonation, two Ballistic Research Laboratories personnel left Gate 4, near the Buster-Jangle "Y" (BJY), to install 14 self-recording pressure-time gauges at eight stations along a blast line between 120 meters and 550 meters east of ground zero. Thev left the area bv 2200 hours (6; 13).

After the shot, on the day of the detonation, four project participants, including a radiological safetv monitor, spent an hour recovering the gauges (6; 13).

Table 3-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT FRANKLIN

Project	Title	Participants	Estimated DOD Personnel
Weapons Effects Test Group			
1 1	Basic Airblast Phenomena	Ballistic Research Laboratones	4
2 1	Soil Activation by Neutrons	Army Chemical Warfare Laboratones	*
2 3	Neutron Flux from Selected Nuclear Devices	Army Chemical Warfare Laboratories	4
2 4	Nuclear Radiation Shielding Studies	Army Chemical Warfare Laboratones	5
2 5	Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soils	Army Signal Research and Development Laboratones	4
2 6	Evaluation of New Radiac Instruments	Army Signal Research and Development Laboratones	3
4 1	Effects of Nuclear Detonations on a Large Biological Specimen (Swine)	Walter Reed Army Institute of Research	192
5 1	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonatron	Navy Bureau of Aeronautics	*
5 2	Structural Response and Gas Dynamics of an Airship Exposed to a Nuclear Detonation	Navy Bureau of Aeronaut&, Aeronautical Structures Laboratory of the Naval Air Matenal Center	33
5 5	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonatron	Wright Air Development Center, Northrop Aircraft	2
6 3	Attenuation of Electromagnetic Radiation through an Ionized Medium	Naval Air Development Center	6
6 4	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
6 5	Effects of Nuclear Detonations on the Nike Hercules	White Sands Missile Range, Bell Telephone Laboratories	7
9 1	Support Photography	AFSWP, Military Air Transport Service, EG and G	9
Los Alamos Scientific Laboratory Test Group			
112	Radiochemistry Sampling	Air Force Special Weapons Center	12
18 3	Mass Effect Spectroscopy	Naval Research Laboratory	*

*Unknown

Table 3-1: TEST GROUP PROJECTS WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT FRANKLIN (Continued)

Project	Title	Participants	Estimated DOD Personnel
	Civil Effects Test Group		
39 1	Radratron Measurements Utilizing the Arr Force Chemical Dosimeters	Air Force School of Avratron Medrcrne. Oak Ridge National Laboratory	2
39 5	Radiation Dosimetry for Human Exposure	Air Force School of Avratron Medrcrne	8
39 6	Biological Effects of Nuclear Radiation on the Monkey	Air Force School of Aviation Medrcrne	11
39 7	Delayed Effects of Radiation on Small Animals	Air Force School of Avratron Medicine	11
39 7a	Neutron Effects of Bomb Radiation on Large Animals	Air Force School of Aviation Medrcrne	56
39 8	Depth-dose Studies in Phantoms with Initial Bomb Gamma and Neutron Radratron	Naval Medical Research Institute	8

Project 2.1, Soil Activation by Neutrons, was conducted by the Army Chemical Warfare Laboratories. The project was to measure neutron-induced gamma-emitting radioisotopes in homogeneous soils and the consequent residual radiation levels in the vicinity of the detonation. Eventually, the data were to be used to predict the radiological hazard to people from such soil activation. To obtain the data, a helicopter survey team of two AFSWC personnel, two REECo monitors, and project personnel, left the Control Point to make early induced-field surveys from five to 30 minutes after the detonation. The helicopter team returned two hours and six hours later to perform similar survevs. The team lowered ionization chambers mounted on tripods to the ground 110 to 1,100 meters east of ground zero. The dose rates measured by these instruments were recorded in the helicopter (6; 40).

Project 2.3, Neutron Flux from Selected Nuclear Devices, was conducted by the Army Chemical Warfare Laboratories in

conjunction with Project 2.1. The project was designed to measure the output of neutrons from a nuclear detonation, the energy spectrum of the neutrons, and their range in air. An estimated two to four personnel spent about three days installing and inspecting the stations along the cable line.

Since some neutron-induced radioisotopes decay rapidlv, it was essential to return the neutron-detection disks to the laboratory for analysis as soon after the shot as possible. To accomplish this prompt retrieval, the five or six different types of neutron detectors at each of the stations were attached to a wire cable laid along the ground. The cable extended east of ground zero with ten detector stations, 110 to 1,100 meters from ground zero. Within one hour after the detonation, three project participants and a radiation monitor, in conjunction with three personnel from LASL Project 12.2, went by pickup truck to the end of the cable farthest from ground zero. While the monitor measured the radiation and clocked their time in the area, the participants secured the end of the cable to a tractor that had been prepositioned in the area. The tractor was provided by Project 12.2. Then the participants climbed aboard the truck and drove out of the area, dragging the neutron-detection arrays. Once safely beyond the radiation zone, the personnel stopped the truck, detached and gathered up the neutron-detectors, and placed them in the truck bed. Participants spent an estimated 30 minutes traveling to and from the test area and an estimated 30 minutes in the area. After proceeding through decontamination, the personnel took the samples to a laboratorv trailer near the Control Point for analysis (6; 54).

Project 2.4, Nuclear Radiation Shielding Studies, was fielded bv the Armv Chemical Warfare Laboratories. The project was designed to determine the effectiveness of armored vehicles and various types of armor in providing shielding from nuclear

radiation. In connection with their duties, project personnelprovided Instrumentation for the Exercise Desert Rock radiation study, Project 50.7, Test of Ordnance Material.

At 1930 hours on the dav before the detonation, two personnel left from Gate 4 and went to Area 3 to install radiation detection instruments in the vehicles and armor positioned in an arc about 550 meters east of ground zero. Thev left the area bv 2130 hours. One hour after the detonation, five participants left the Control Point, proceeded to the Yucca Lake road junction to meet the Project 4.1 recoverv party, and went to Area 3 to recover samples. They then returned to the Control Point (6; 60).

Project 2.5, Initial Gamma Radiation Intensitv and Neutron-induced Gamma Radiation of NTS Soils, was conducted by the Army Signal Research and Development Laboratories. For this shot, the project was to determine initial gamma intensity both on the ground and in the air. Measurements were to be taken at different times after the detonation and at different distances from ground zero. Seven stations were constructed at 460-meter intervals southeast of ground zero. Recovery of Instruments after the declaration of recoverv hour probablv took about four project participants a total of four days (6; 14).

Project 2.6, Evaluation of New Radiac Instruments, was conducted bv the Armv Signal Research and Development Laboratories. The project was to evaluate the abilitv of newlv developed radiation instruments to detect and measure gamma and neutron radiation. The neutron dosimeter svstem was evaluated hv exposing tissue-equivalent tactical neutron dosimeters and standard radiac meters to initial nuclear radiation. The readings were compared to those made with chemical dosimeters and with National Bureau of Standards film dosimeters.

Project personnel attached dosimeters and film packs to plvwood slats placed within linen-reinforced tubes eight centimeters in diameter and 1.2 meters in length. The dosimeters were probably placed in six locations by about three people working for a total of three days (15). About four hours after the detonation, the slats holding the tubes and dosimeters were recovered, probably by two project personnel working a total of four hours (6; 15).

Project 4.1, Effects of Nuclear Detonations on a Large Biological Specimen (Swine), was a medical experiment designed to investigate the effects of radiation from nuclear detonations on swine in an attempt to define more specificallv the radiation effects on humans. The project was sponsored bv the Walter Reed Armv Institute of Research. Project activities and analysis were performed bv 179 officers and enlisted personnel from the Medical Services of the Army, Air Force, and Navv. Thirteen civilians were also involved in the project.

Beginning at 1930 hours on the night before the detonation, work parties consisting of personnel from Projects 4.1, 39.6, and 39.7a placed 264 animals in cylinders. They then placed the cylinders at various locations around ground zero and left the area bv 2130 hours. Twenty minutes after the shot, an estimated 80 personnel, wearing protective clothing and respirators and accompanied bv radiological safety monitors, began recovery of the swine, a process that took about two hours. The animals were returned bv trucks to the holding pen area and checked for radiation contamination. The test had to be repeated at Shot WILSON because of the unexpectedlv low vield of FRANKLIN (6: 45; 50).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted bv the Navy Bureau of Aeronautics. The project was to measure effects of the overpressure and wind gusts produced bv a nuclear detonation on the HSS-1 helicopter. The deliverv capabilities of the HSS-1 for

antisubmarine warfare weapons, as limited by blast effects, was also studied. The shot required the support of one helicopter pilot, ground controllers, and aircraft maintenance personnel responsible for the special instrumentation of the helicopter. An average of four practice runs were flown prior to the actual missions. The helicopter flew a left-hand, eight-nautical-mile holding pattern. At shot-time, the heading for the helicopter was 240 degrees outbound at a slant range of 4,400 meters from ground zero. The aircraft was 8,000 feet above the ground (6; 63). At 0518 hours, the helicopter left the area. It landed at Indian Springs AFB at 0525 hours (3).

Project 5.2, Structural Response and Gas Dynamics of an Airship Exposed to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics and the Aeronautical Structures Laboratory of the Naval Air Material Center. The objective was to test several ASG-3 airships for their response characteristics when subjected to a nuclear detonation. Results were to be analyzed to determine airship effectiveness in the delivery of nuclear antisubmarine weapons. Four airships were scheduled for testing during FRANKLIN, but operations were plagued by difficulties. Before the shot, airships K-46 and K-92 were destroyed when a violent windstorm tore them from their mooring masts on Yucca Lake.

Two other airships, K-77 and K-40, survived the windstorm and were tested at FRANKLIN. At shot-time, airship K-77 was moored with its tail toward the burst at 5,460 meters horizontal range. After the passage of the shock wave, the airship became detached from the mast and consequently could not he remoored. Since the airship was secured by a bow line onlv, and represented a potential hazard if it broke free, it was eventuallv decided to deflate the envelope. The instrumentation aboard the airship was recovered after the airship deflated. Airship K-40 survived the

detonation, probably because of the shot's low yield, and was retested at Shot STOKES. Activities engaged 33 project personnel (3; 6; 27).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of that aircraft, in flight, to the blast and thermal effects of a nuclear detonation. Northrop Aircraft was contracted to assist the Wright Air Development Center in planning and conducting the tests. Northrop Aircraft calibrated, maintained, and operated the instrumentation and associated equipment, and later analyzed the measured data. Development of positions and positioning methods was accomplished jointly by Northrop Aircraft and the Wright Air Development Center. One F-89D aircraft (serial number 411) with two crew members participated. The aircraft left Indian Springs AFB at 0415 hours. Planning documents indicate that the F-89D was to be 19,000 feet above the ground and about two kilometers from ground zero at shot-time. The aircraft left the area at 0500 hours and landed at Nellis AFB at 0510 hours (3; 6; 23).

Project 6.3, Attenuation of Electromagnetic Radiation through an Ionized Medium, was sponsored bv the Naval Air Development Center. The objective was to determine the amount of electromagnetic energy absorbed or filtered out by the highly radioactive cloud that results from a nuclear detonation. The project involved one aircrew member, ground controllers, and aircraft maintenance personnel. An A4D-1 aircraft (serial number 831) carried electromagnetic energy transmitters in a pod tuned to six different frequencies. The aircraft, which took off from Indian Springs AFB at 0420, was positioned so that, at one minute after the detonation, the nuclear cloud was on a straight line between the aircraft and ground-based receivers. At the time of the detonation, the aircraft was five nautical miles from ground zero, at an altitude of about 40,000 feet. After the detonation,

the A4D-1 returned to Indian Springs AFB, landing at OS25 hours (3; 43).

Ground receivers were at a station at UTM coordinates 731961. Six men operated the station, which they occupied from approximatelv 1930 hours the night before the shot to about two hours after the shot (6).

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL Svstem, was conducted by the Air Force Cambridge Research Center. The project used the Long Range Aids to Navigation System (LORAN) in an inverse fashion to detect the electro-magnetic pulse from the nuclear burst in order to determine the position and measure the yield of that burst. The Indirect Bomb Damage Assessment (IBDA) NRROL system tested on this operation consisted of nets located at Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net consisted of two unmanned stations and one manned station (36).

Project 6.5, Effects of Nuclear Detonations on the Nike Hercules, investigated the effects of nuclear radiation on the Nike Hercules guided-missile system. The project was designed to familiarize radar crews with techniques to be employed and observations to be made following a nuclear detonation. The project was fielded bv personnel from the White Sands Missile Range, New Mexico, with assistance from the Bell Telephone Laboratories in Whippany, New Jersev. Seven project personnel probablv manned a radar station at UTM coordinates 765031 through the detonation and until two hours after the shot (6; 21).

Project 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the militarv-effects program

- Documentation of the overall military-effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Photographers took both color and black-and-white pictures of the detonation from an airborne camera station and a manned camera station in the forward area at UTM coordinates 884928 (6). 4n estimated seven personnel manned this station. Two or three photographers also took pictures from a C-47 aircraft (serial number 990), operated by at least three personnel from the Military Air Transport Service. The aircraft left Indian Springs AFB at 0335 hours. At shot-time, it was eight nautical miles southwest of ground zero, flving eastbound at 10,000 feet. After completing its mission, the C-47 returned to Indian Springs AFB, landing at 0545 hours (3). In addition, EG and G provided technical photography support to AFSWP and the AEC. EG and G personnel operated various camera stations during the shot to obtain fireball and cloud growth data (6; 20).

3.2.2 Department of Defense Participation in Los 41amos Scientific Laboratory Test Group Projects

The Los Alamos Scientific Laboratory Test Group conducted 14 projects at Shot FRANKLIN. Only two of the projects, listed in table 3-1, involved DOD personnel. Project 11.2, Radio-chemistry Sampling, required the gathering of samples from the cloud for laboratory analvses. Sampling, performed bv pilots from AFSWC 4926th Test Squadron, is discussed under AFSWC participation in section 3.2.5. Project 18.3, Mass Effect Spectroscopy, was conducted by the Naval Research Laboratorv. Information on this activity is limited, however, since a project report was not written following the detonation.

3.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted eight projects at FRANKLIN. Of those eight projects, five involved DOD personnel from the Air Force School of Aviation Medicine, and one involved personnel from the Naval Medical Research Institute. DOD participation in all these projects was probablv very limited.

Project 39.1, Radiation Measurements Utilizing the Air Force Chemical Dosimeters, was conducted by the Air Force School of Aviation Medicine and the Oak Ridge National Laboratory. At recovery hour, two participants proceeded to Area 3 to recover film badges (6; 17; 41; 57).

Four other CETG projects involved members of the Air Force School of Aviation Medicine (17; 37; 46):

- Project 39.5, Radiation Dosimetry for Human Exposure
- Project 39.6, Biological Effects of Nuclear Radiation on the Monkey
- Project 39.7, Delayed Effects of Radiation on Small Animals
- Project 39.7a, Neutron Effects of Bomb Radiation on Large Animals.

For these projects, which required early recovery, the CETG requested and probably received permission from the Test Manager for project participants to enter radiation areas that may have exceeded 10 R/h (50).

Project 39.5, Radiation for Human Exposure, involved four parties, each of two personnel. At 1900 hours on the day before the shot, they proceeded to Area 3 to place dosimeters. They left the area by 2200 hours. Six hours after the detonation, three parties of three men each recovered the dosimeters (6; 37).

For Project 39.6, Biological Effects of Nuclear Radiation on the Monkey, nine military personnel and one civilian left from Gate 4 at the BJY to place equipment in Area 3. They departed from the gate at 2000 hours on the day before the shot, and they left the test area after completing their mission at 2300 hours. Eleven personnel in three parties began recovery operations two hours after the detonation. Forty minutes later, they transferred the recovered equipment to vehicles and then returned to Camp Mercury (6; 17; 41; 46).

For Project 39.7, Delayed Effects of Radiation on Small Animals, three parties totaling 11 personnel left from Gate 4 at 2100 hours on the day before the shot. They placed animals and dosimeters in Area 3 and then left the area by 2300 hours of the same day. Fifteen minutes after the detonation, five parties with a total of 15 personnel proceeded through Gate 4 to Area 3 and recovered animals and dosimeters (6; 17).

Project 39.7a, Neutron Effects of Bomb Radiation on Large Animals, also involved personnel from the Air Force School of Aviation Medicine. Access permits for Shot FRANKLIN provided information on DOD participation in this project, conducted in conjunction with Projects 4.1 and 39.6. Eighteen vehicles carried 52 military personnel and four civilians involved in the project. Ninety minutes before the detonation, these 56 individuals met on the road to Yucca Airstrip. Twenty minutes after detonation, they entered the shot area to recover swine, an activity taking approximately two hours (6; 17; 45-46).

In addition to these projects involving Air Force personnel, Project 39.8, Depth-dose Studies in Phantoms with Initial Bomb Gamma and Neutron Radiation, involved personnel from the Naval Medical Research Institute. The objective of this experiment was to determine initial neutron and gamma dose in phantoms composed of material approximating the density of human tissue. Several

days before the detonation, personnel installed radiation dosimeters in phantoms the size of humans and then placed the phantoms at stations south of ground zero. They also placed dosimeters along a radial line north of ground zero.

At 2000 hours on the day before the detonation, eight personnel in two parties left Gate 4 to place equipment in Area 3. They returned from the area bv 2300 hours. Ten minutes after the detonation, eight personnel in two parties left their stations on the Yucca Airstrip road, where they had been stationed since one hour before the detonation, to recover dosimeters in the shot area (6; 17; 38). For this project, as for Projects 39.5, 39.6, 39.7, and 39.7a, the CETG requested and probablv received permission for participants to enter radiation areas that mav have exceeded 10 R/h (50).

3.2.4 Department of Defense Operational Training Projects

The primarv objectives of the operational training program were to test equipment and to train Air Force personnel. The Air Force sponsored two operational training projects at Shot FRANKLIN:

- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.7, Indirect Bomb Damage Assessment, was conducted bv the Wright Air Development Center. Project participants installed Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft (serial number 412), with only a pilot. The aircraft left Indian Springs AFB at 0407 hours. At shot-time, the F-89D flew a holding pattern 70 nautical miles east of ground zero. It left the area at 0507 and landed at Nellis AFB at 0604 (3; 24).

Project 53.9, Photographic Reconnaissance Training, was to indoctrinate Air National Guard Tactical Reconnaissance Units in conducting photographic missions over a nuclear target. Two RF-84F aircraft with one pilot each departed from George Air Force Base (AFB), California, and flew to the NTS, where they orbited above Lathrop Wells at 31,000 feet until the shot was fired. Upon clearance from the Air Operations Center, they began a photographic mission flying toward ground zero. The aircraft crossed the shot area approximately 15 minutes after the detonation at an altitude of 10,000 feet. Upon completion of the run, they returned to George AFB (3; 24).

3.2.5 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling missions, cloud-penetration flights, tracking missions, and aerial surveys. Documentation does not indicate that a courier mission was conducted at Shot FRANKLIN.

Cloud Sampling

Project 11.2, Radiochemistry Sampling, required the gathering of samples from the cloud for subsequent laboratorv analyses. Pilots of the AFSWC 4926th Test Squadron (Sampling) performed the cloud sampling for this project.

Prior to the shot, six AFSWC aircraft were prepared for the mission. Sample pods were secured to the wing-tips of the aircraft. One B-57 sampler control aircraft with one pilot and a LASL scientific advisor left Indian Springs AFB and was positioned outside the testing area before shot-time. The control aircraft flew a holding pattern at 30,000 feet, 50 nautical miles from ground zero (1; 3).

The five sampler aircraft proceeded as follows. Shortlv after the detonation, two F-84s with two crewmen each flew from

Indian Springs AFB and entered the vicinity of the burst. After the detonation, the control aircraft left its pattern to view the cloud from all sides. The scientific advisor guided the samplers to areas from which samples of the nuclear cloud were to be obtained. After finishing their missions, the first two F-84 samplers returned to Indian Springs AFB (1; 3).

Shortly after the first two F-84 sampler aircraft took off from Indian Springs AFB, another two F-84 aircraft with two crewmen each left Indian Springs AFR. These aircraft entered the sampling area following the pattern of the first F-84s, completed their mission, and returned to Indian Springs AFB (1; 3).

The fifth and final F-84 sampler, also with a crew of two, flew from Indian Springs AFB, entered the sampling area at 0605 hours, and returned to Indian Springs AFB at 0718 hours. The control B-57 was the first aircraft to enter the area at 0438 hours and the last to leave at 0730 hours (1; 3).

The sampler aircraft were outfitted with sampling equipment, radiac meters, filter papers, and integrating dosimeters. Pilots were on full internal oxygen before, during, and after cloud penetration (1; 3). 4fter the cloud-sampling missions, standard operating procedures were followed for sample removal from the aircraft and decontamination of personnnel, aircraft, and equipment. These procedures are discussed in the Operation PLUMBHOB volume.

Cloud Tracking

Immediately after the detonation, a B-50 and a B-29 aircraft from Kirtland AFB and a B-25 from Indian Springs AFB flew cloud-tracking missions over and beyond the NTS. The R-50 carried at least four participants, the B-29 up to ten, and the B-25 at least four. The purpose of the cloud-tracking missions was to determine the direction of the radioactive cloud and to keep the

airways clear of any private or commercial aircraft that might encounter radiation.

After the detonation, the Air Operations Center ordered the aircraft to leave their holding patterns, approach the edge of the cloud at frequent intervals, and note the position of maximum intensity encountered on approach. Cloud tracking continued until the Test Yanager determined that the cloud presented no further hazard to aircraft flying commercial airways (1). At the end of the cloud-tracking mission, aircraft and aircrews were monitored (1; 3).

Security Sweeps

Before and after the shot, two L-20 aircraft were dispatched from Yucca Airstrip to perform a security sweep over the NTS. The security sweep routine called for a security guard to accompany the pilot (1; 3).

Helicopter Surveys

Three H-21 helicopters conducted survey missions for the Test Manager. Two of the H-21s, each with a crew of two AFSWC personnel along with two REECo monitors, flew survey missions over the forward areas of FRANKLIN to record radiation intensities. The third H-21, with two AFSWC personnel, REECo monitors, and Project 2.1 participants, supported Project 2.1. After the missions, the helicopters returned to the helicopter pad at the Control Point and were monitored and decontaminated as required (1; 3; 50).

3.3 RADIATION PROTECTION AT SHOT FRANKLIN

The purpose of the radiation protection procedures developed for Operation PLUMBHOH was to ensure that individuals would avoid unnecessary exposure to ionizing radiation while accomplishing

their missions. Some of the procedures described in the PLUMBBOB volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of their radiation protection programs. The available information includes NTO iso-intensity contour maps, monitoring data, and some NTO personnel dosimetry data. Radiological safety procedures and dosimetry information for Desert Rock and AFSWC participants are described in the Operation PLUMBBOB volume.

Dosimetry Records

From 1 to 3 June 1957, including the 2 June detonation of FRANKLIN, the Personnel Dosimetry Branch issued 1,369 film badges and 851 dosimeters (64). No NTO personnel received a cumulative gamma exposure exceeding 2.0 roentgens (50; 64).

Logistics

The Logistics Branch issued anticontamination supplies to 882 people. These supplies consisted of coveralls, shoe covers, and respirators (64).

Monitoring Procedures and Support

Fifteen minutes after the detonation, a total of 15 monitors traveling in nine vehicles performed the initial ground survey. This survey was completed at 0645 hours. At 0600 on shot-day, radiological safety personnel established a check station at the RJY junction to control entry into the shot area. It was operated continuously by two-man crews until 2400 hours on 3 June (64). Resurveys were made on shot-day and on 3, 4, 6, and 10 June (64).

The initial helicopter survey was delayed because of dust in the shot area. The survey team, probably consisting of four personnel, finally departed from the Control Point helicopter pad at 0610 hours, 90 minutes after the detonation. The radiation

intensity encountered was 10 R/h 25 feet above ground zero at 0637 hours (50; 64). Based on the results of the initial surveys, the recovery hour was declared at 0950 hours.

Plotting and Briefing

Using information from the surveys, the Plotting and Briefing Branch developed isointensity contour maps. A copy of the initial contour map is shown in figure 3-l. Figure 3-2 shows copies of the isointensity maps generated from 3 to 10 June (64).

Information from the ground surveys allowed the Plotting and Briefing Branch to establish Full and Limited Radiological Exclusion areas, as defined in the Operation PLUMBBOB volume. The Plotting and Briefing Branch also issued access permits required for entrv into these areas. During the period covering the FRANKLIN detonation, 1,083 access permits were issued (64).

Decontamination Activities

During the period covering Shot FRANKLIN,. personnel of the Decontamination Branch decontaminated 94 vehicles at the Control Point 6 station. Personnel were decontaminated at facilities located in the radiological safety building (64).

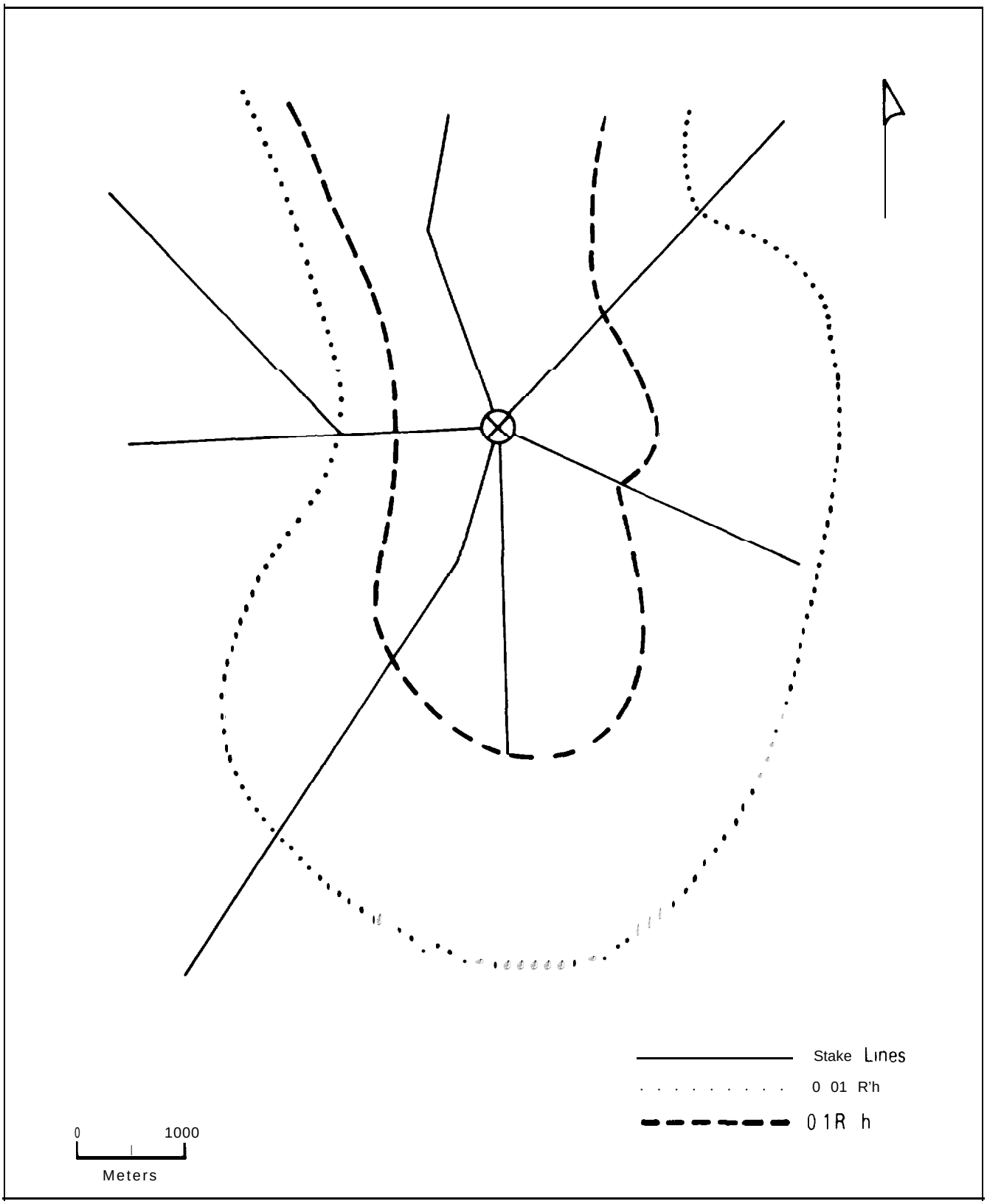
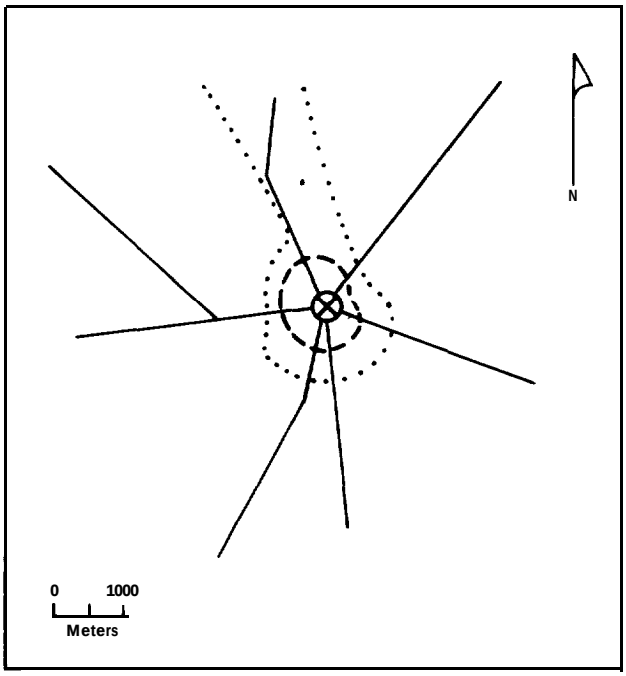
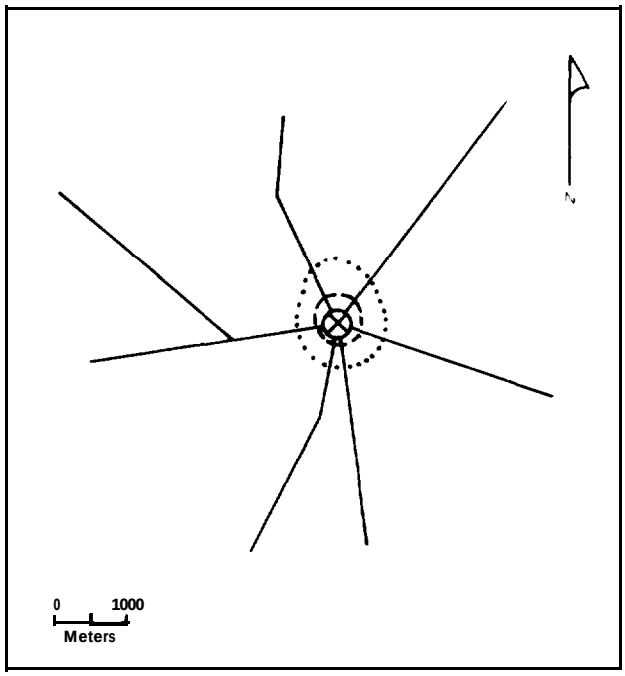


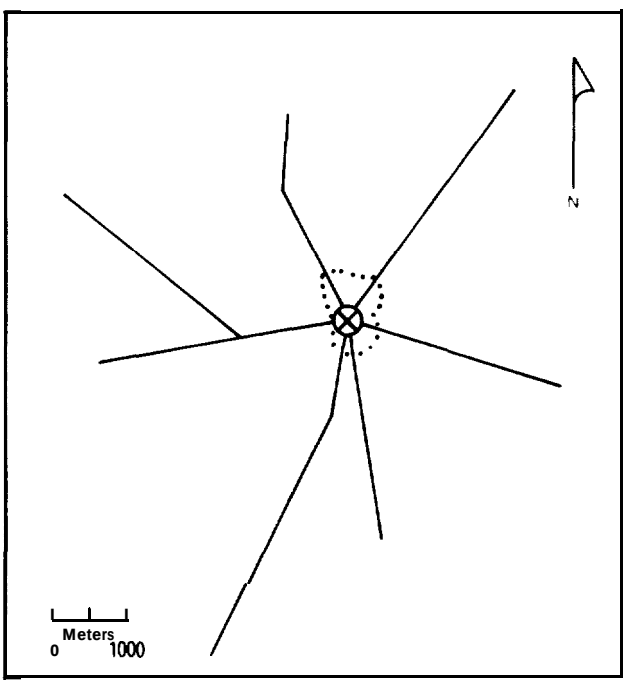
Figure 3-I: INITIAL SURVEY FOR SHOT FRANKLIN, 2 JUNE 1957, MID-TIME 0617



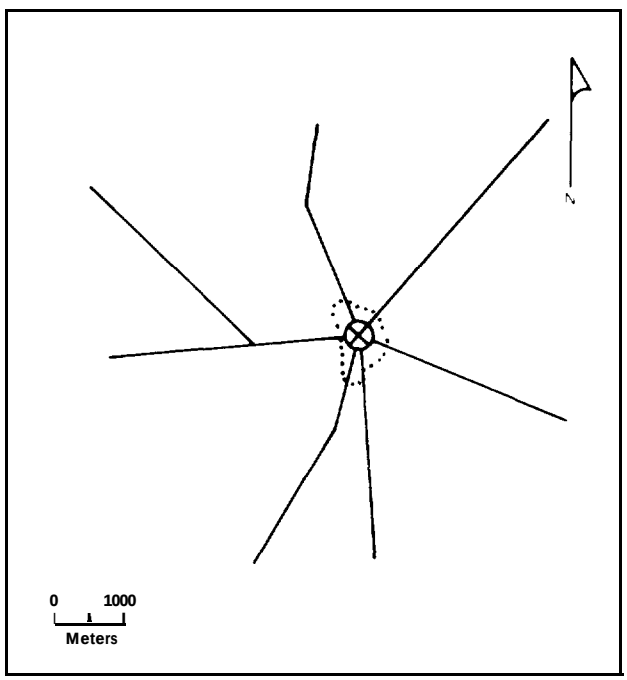
3 June 1957, Mid-Time: 0605



4 June 1957, Mid-Time: 1313



6 June 1957, Mid-Time: 1346



10 June 1957, Mid-Time: 0353

Stake Lines

0 01R/h

0 1R/h

Figure 3-2: SUBSEQUENT SURVEYS FOR SHOT FRANKLIN

SHOT LASSEN SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	5 June 1957, 0445 Hours
YIELD:	0.0005 kilotons
HEIGHT OF BURST:	500 feet (balloon shot)

Objectives: (1) To evaluate newly designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate military effects for specific applications against a variety of military targets
(3) To assess the effects of nuclear detonation on civilian structures, products, and food supplies and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 23“ C, and the surface winds were calm. Winds were eight knots from the west-southwest at 6,000 feet.

Radiation Data: During the initial survey, mid-time of 0527 hours, radiation intensities greater than 0.1 R/h were confined to within 360 meters of ground zero.

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

CHAPTER 4

SHOT LASSEN

Shot LASSEN, the first balloon-suspended device of Operation PLUMBBOB, as well as of the entire atmospheric testing program, was sponsored by the University of California Radiation Laboratory. Suspended at a height of 500 feet in Area 9 of the Nevada Test Site, the device had a yield of 0.0005 kilotons. The test was conducted at 0445 hours Pacific Daylight Time on 5 June 1957. The cloud reached a maximum altitude of 6,600 feet and traveled northeast, but it resulted in no measurable fallout offsite. Contamination in the shot area was mostly from neutron-induced activity, with intensities greater than 0.1 R/h detected only within 360 meters of ground zero about one hour after the shot (25; 64). Alpha radioactivity was also found in the shot area about 75 meters south of ground zero. As a result, the Test Director closed the shot area four hours after the detonation for a period of 35 hours (51).

4.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT LASSEN

A total of 205 Camp Desert Rock support troops observed LASSEN from News Nob, 21 kilometers from ground zero at UTM coordinates 848890. In addition, about 30 personnel took part in the two technical service projects conducted at the shot: Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, and Project 50.7, Test of Ordnance Material (24; 33; 35).

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud-Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Meade, and seven personnel from Fort

Huachuca. The project had two purposes: to test the capacity of Armv radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. Participants manning the radar sets were southeast of Yucca Lake, about 25 kilometers from ground zero. The fallout prediction unit worked in a van parked near the Air Weather Station at Camp Mercury (12; 33; 44; 53).

Project 50.7, Test of Ordnance Material, was sponsored by the Armv Chief of Ordnance. The purpose of the project was to= determine the effect of the blast, thermal, and radioactive elements of a nuclear detonation on selected items of Army equipment. The project was divided into four parts, each part testing a different tvpe of ordnance. Three of the parts were conducted at Shot LASSEN. These were radiation studies, foxhole studies, and vehicle damage tests (11).

Radiation studies consisted of unmanned tanks and vehicles placed 550 meters from ground zero. Instrumentation was provided, installed, and recovered by Project 2.4 personnel from the Chemical Warfare Laboratories. The fielding activities of these individuals are discussed in the Field Command Section of this chapter under Project 2.4, Nuclear Radiation Shielding Studies (11; 60). The foxhole study tested tne protection offered bv standard two-man foxholes, some with tanks and Ontos vehicles placed over them. For vehicle damage tests, vehicles and tanks were placed in areas near the ground zero of Shot LASSEN to incur direct and secondary blast damage (11; 33).

4.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT LASSEN

In addition to participating in Exercise Desert Rock activities, Department of Defense personnel performed a variety of tasks during Shot LASSEN that required them to enter the

forward area. The AFSWP Field Command Weapons Effects Test Group sponsored 13 projects, and DOD personnel participated in one UCRL Test Group project and one Civil Effects Test Group project. The Air Force sponsored two operational training projects. AFSWC supported the UCRL project and provided routine support to the Test Manager.

Closure of the shot area about four hours after the detonation affected some of the shot area recoveries, although recoveries scheduled to occur before that time appear to have proceeded as planned. The number of parties and personnel reported to have performed recovery operations corresponds closely to the number scheduled for participation from 30 minutes to two-and-one-half hours after the shot.

4.2.1 AFSWP Field Command Weapons Effects Test Group Projects

The Weapons Effects Test Group conducted 13 projects at Shot LASSEN, as indicated in table 4-l. The yield of the detonation, 0.0005 kilotons, was much lower than had been expected. Consequentlv, many of the projects did not produce useful results.

Project 2.1, Soil Activation by Neutrons, was conducted by the Army Chemical Warfare Laboratories. The project was designed to measure the neutron-induced gamma-emitting radioisotopes in homogeneous soils and the consequent residual radiation levels in the vicinity of ground zero. Eventually, the data were to be used to predict the radiological hazard from such soil activation. To obtain data, a helicopter survey team made early induced-field surveys from five to 30 minutes after the detonation. To perform its survey, the team lowered ionization chambers mounted on tripods to the ground at various distances southeast of ground zero. The team recorded the dose rates measured bv the ionization chambers.

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

Project	Title	Participants	Estimated DOD Personnel
	Weapons Effects Test Group		
21	Soil Activation by Neutrons	Army Chemical Warfare Laboratories	4
23	Neutron Flux from Selected Nuclear Devices	Army Chemical Warfare Laboratories	6
24	Nuclear Radiation Shielding Studies	Army Chemical Warfare Laboratories	6
25	Initial Gamma Radiation Intensity and Neutron-Induced Gamma Radiation of NTS Soils	Army Signal Research and Development Laboratories	4
26	Evaluation of New Radiac instruments	Army Signal Research and Development Laboratones	2
27	Radio-wave Attenuation Studies	Naval Research Laboratory	4
2 10	Initial Neutron and Gamma Air-earth Interface Measurements	Air Force Special Weapons Center, General Mills Company, Sandia Corporation	8
62	Measurement of the Magnetic Component of the Electromagnetic Field Near a Nuclear Detonation	Diamond Ordnance Fuze Laboratories	9
63	Attenuation of Electromagnetic Radiation through an Ionized Medium	Naval Air Development Center	*
64	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
65	Effects of Nuclear Detonations on the Nike Hercules	White Sands Missile Range, Bell Telephone Laboratories	7
82	Prediction of Thermal Protection of Uniforms and Thermal Effects on Standard Materials	Naval Material Laboratory	4
8 3a	Performance of a High-speed Spectrographic System	Naval Radiological Defense Laboratory	*
91	Support Photography	AFSWP, Military Air Transport Service, EG and G	10
	University of California Radiation Laboratory Test Group		
212	Radiochemistry Sampling	Air Force Special Weapons Center	7
	Civil Effects Test Group		
395	Radiation Dosimetry for Human Exposures	Air Force School of Aviation Medicine	*

* Unknown

Two personnel participated in the aerial survey program, working 90 to 900 meters southeast of ground zero along the Project 2.3 instrument line. The participants began their activities 30 minutes after the detonation and finished 30 minutes later (8; 40; 54).

Helicopter surveys were also scheduled for one-half, two-and-one-half, and six hours after the detonation. Two participants proceeded in a helicopter from the Control Point to the Project 2.3 instrument line southeast of ground zero. They conducted aerial surveys at 90-meter intervals from 910 meters to ground zero, spending an estimated 30 minutes in the area (8; 40; 54).

Project 2.3, Neutron Flux from Selected Nuclear Devices, was conducted by the Army Chemical Warfare Laboratories. The project, conducted in conjunction with Project 2.1, was designed to measure the output of neutrons from a nuclear detonation, the energy spectrum of neutrons, and their range in air. An estimated four project personnel spent 3 1/2 days installing and inspecting the detectors on the cable line. A tractor, to be used in pulling the cable from the area, was positioned the day before the shot behind a mound of dirt 1,550 meters from ground zero (54).

Since some neutron-induced radioisotopes decay rapidly, it was essential to return the neutron-detection disks to the laboratory for analysis as soon after the shot as possible. To accomplish a prompt retrieval, the detectors were attached to the cable at 90-meter intervals, from 90 to 910 meters south-southeast of ground zero. Within one hour after the detonation, six project personnel and a radiation monitor went in pickup trucks to the end of the cable farthest from ground zero. While the monitor measured the radiation and clocked their time in the area, the project personnel secured the end of the cable to the back of the tractor, which was driven about 910 meters, dragging the neutron-detection arrays. Once bevond the radiation zone,

the project personnel stopped the tractor, detached the detectors from the cable, gathered them up, and put them in the truck. The personnel took the samples to a laboratory trailer near the Control Point for analvsis (8; 54).

Project 2.4, Nuclear Radiation Shielding Studies, was fielded by the Army Chemical Warfare Laboratories. The project was designed to study the effectiveness of armored vehicles and various types of armor in providing shielding from nuclear radiation. This project was coordinated with the radiation studv of Exercise Desert Rock Project 50.7, Test of Ordnance Material, for which project personnel provided instrumentation.

In the weeks before the shot, personnel placed the vehicles and armor in an arc about 550 meters south of ground zero. They positioned dosimeters in the vehicles and armor on the day before the detonation. One hour after the detonation, five participants left the Control Point and went to Area 9, where they spent 30 minutes recovering the dosimeters. Ninety minutes after the detonation, one participant in a pickup truck left the Control Point to proceed to the BJY, where he picked up the dosimeters from the recovery party and then returned to the Control Point, having spent about one hour in the shot area (7-8; 60).

Project 2.5, Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soils, was conducted by the Army Signal Research and Development Laboratories. For this shot, the project was to determine initial gamma intensitv both on the ground and in the air. Measurements were to be taken at different times after the detonation and at different distances from ground zero. 4t 1800 hours on the evening before the shot, three personnel instrumented four balloons located 910 to 1830 meters southeast of ground zero. They spent four hours in the area. The balloons were launched bv Project 2.10 personnel. Four project personnel probablv completed recovery operations within three days of the detonation (8; 14).

Project 2.6, Evaluation of New Radiac Instruments, was conducted by the Army Signal Research and Development Laboratories. The project was intended to evaluate the ability of newlv developed radiation instruments to accuratelv detect and measure gamma and neutron radiation. In evaluating the neutron dosimeter system, tissue-equivalent tactical neutron dosimeters and standard radiac meters were exposed to initial nuclear radiations. The readings were compared to those made with chemical dosimeters and with National Bureau of Standards film dosimeters (15).

Project personnel attached dosimeters and film packs to plvwood slats placed within linen-reinforced tubes eight centimeters in diameter and 1.2 meters long at 13 stations 550 to 1,100 meters southeast of ground zero. After the shot, when radiological conditions permitted, two personnel recovered the instruments, a procedure taking about 20 minutes (8; 15; 51).

Project 2.7, Radio-wave Attenuation Studies, was conducted by the Naval Research Laboratory. The project was to studv the interference due to effects of high levels of radiation on radio transmissions and radar operations. At Shot LASSEN, however, the activities of project participants were limited to preliminary experiments designed to check and calibrate equipment for later shots. Bunker installations necessary for this project were not completed in time for use during LASSEN, and most of the experiments intended for the shot were conducted at subsequent events (8; 30).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, was designed to studv how the air-ground interface affected the radiation produced by a nuclear detonation. The project was conducted by AFSWC. The objective was accomplished by measuring the integrated gamma dose and neutron readings at points on the ground and at corresponding points at heights up to approximatelv 290 meters. By 2200 hours on the day before the

shot, eight personnel launched four balloons 910, 1,370, 1,830, and 2,290 meters southeast of ground zero. The balloons were supplied and handled by the General Mills Company, with technical assistance from Sandia Corporation (65). Three participants left the Control Point two hours after the detonation to recover fission foil detectors from the balloon stations, an operation taking about one hour (8; 65).

Project 6.2, Measurement of the Magnetic Component of the Electromagnetic Field Near a Nuclear Detonation, was conducted by the Diamond Ordnance Fuze Laboratories. The objective was to provide a record of the strength and characteristics of the magnetic field from a nuclear detonation as a function of time and distance. Instrumentation consisted of five completely self-powered recording stations 250 to 2,900 meters southwest of ground zero. Four personnel manned an instrument station at UTM coordinates 895855, 19 kilometers from ground zero, from about four hours before to one hour after the detonation. Four hours after the detonation, two other personnel proceeded to the station to prepare it for the arrival of the recovery team (8; 29).

Seven hours after the shot, nine personnel traveled in three vehicles to recover instrumentation. They began with the station 2,900 meters southwest of ground zero. They then proceeded to stations 1,520 and 760 meters from ground zero and then went to a manned station at the south end of Yucca Lake. They recovered instruments at the final two stations when the radiological situation permitted. Recovery consisted of retrieving data-recording packages and transporting them to Camp Mercury (8; 29).

Project 6.3, Attenuation of Electromagnetic Radiation through an Ionized Medium, was conducted by the Naval Air Development Center. Its objective was to determine the amount of electromagnetic energy that was absorbed or filtered out by the highly radioactive cloud that results from a nuclear detonation.

The project involved one aircrew member, ground controllers, and aircraft maintenance personnel. An A4D-1 aircraft carried transmitters in a pod tuned to six different frequencies. The aircraft took off from Indian Springs AFB 30 minutes before the detonation and was about 60 kilometers from ground zero heading southwest at the time of detonation. The aircraft, which flew at altitudes between 12,000 and 19,000 feet, proceeded toward ground zero but did not come closer than five kilometers to the cloud. The A4D-1 was positioned so that, one minute after the detonation, the cloud was on a straight line between the aircraft and the ground-based receivers. In addition to the other participants, six personnel proceeded to the manned station at UTM coordinates 732961, where they remained until one or two hours after the detonation (4; 8; 43).

Project 6.4, Accuracy and Reliability of the Short-baseline NAROL Systems, was conducted by the Air Force Cambridge Research Center. The project used the Long Range Aids to Navigation (LORAN) System in an inverse fashion to detect the electro-magnetic pulse from the nuclear burst in order to determine the position and measure the yield of the detonation. The Indirect Bomb Damage Assessment NAROL system tested in this operation consisted of nets located in Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net consisted of two unmanned stations and one manned station (8; 36).

Project 6.5, Effects of Nuclear Detonations on the Nike Hercules, investigated the effects of nuclear radiation on the Nike Hercules guided-missile system. Project 6.5 was fielded by personnel from the White Sands Missile Range, New Mexico, with assistance from Bell Telephone Laboratories (21). At 2330 hours on the evening before shot-day, seven personnel proceeded to the manned station at UTM coordinates 765031, 11 kilometers southwest of ground zero, where they remained until about two hours after the detonation to operate radar (8).

Project 8.2, Prediction of Thermal Protection of Uniforms and Thermal Effects on Standard Materials, was conducted by the Naval Material Laboratory. The project was designed to investigate the ability of laboratory experiments to accurately predict the effects of intense thermal radiation on live skin and tissue. Laboratory results were compared with actual skin burns in pigs exposed to thermal radiation from a nuclear detonation. One recording station was instrumented 1,200 meters south of ground zero (18). Four personnel were scheduled to proceed from the Control Point area to the station if there was a radiation field in the vicinity of the station. If no field existed, personnel were to proceed into the shot area only after the declaration of recovery hour to retrieve records and begin dismantling the station. Because of the low yield, the personnel probably did not enter the area as scheduled. Most likely, they entered the area after the Test Director reopened it for project activities 39 hours after the detonation (8; 18).

Project 8.3a, Performance of a High-speed Spectrographic System, conducted by the Naval Radiological Defense Laboratory, was designed to analyze the electromagnetic energy from a nuclear detonation. The high-speed electronic equipment would eventually be used during Operation HARDTACK II. The high-speed spectrographs of both the Naval Radiological Defense Laboratory and the Naval Research Laboratory were located a minimum of 12 kilometers from ground zero (47).

Program 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military effects program
- Documentation of the overall military effects program and production of an effects motion picture
- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to DOD projects.

Color and black-and-white pictures of the detonation were taken from both an airborne camera station and a manned camera station in the forward area. Eight personnel manned the ground station, at UTM coordinates 852045 about six kilometers south of ground zero, from five hours before to 30 minutes after the detonation (8). Two or three project participants took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. At shot-time, the aircraft was eight nautical miles southwest of ground zero, flving eastbound at 10,000 feet (4). In addition, EG and G provided technical photographv support to AFSWP and the AEC. At LASSEN, EG and G personnel operated camera stations to record fireball and cloud growth (8; 20).

4.2.2 Department of Defense Participation in Los Alamos Scientific Laboratory Test Group and University of California Radiation Laboratory Test Group Projects

Roth LASL and UCRL conducted experiments at Shot LASSEN. Three projects were conducted by LASL, none of which required DOD participation. Of the five projects conducted by UCRL, only Project 21.2, Radiochemistry Sampling, is known to have involved DOD participation. The project, which required air support from AFSWC, is discussed in section 4.2.5.

4.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted two projects at LASSEN. One of these, Project 39.5, Radiation Dosimetry for Human Exposures, involved DOD personnel from the Air Force School of Aviation Medicine. Accompanied by a REECo radiological safety monitor, two CETG personnel recovered neutron foil detectors 275 to 365 meters south-southeast of ground zero. Thev proceeded into the area about one hour after the shot and spent five to ten minutes completing their task (37; 51).

4.2.4 Department of Defense Operational Training Projects

The primary objectives of the operational training program were to test equipment and train Air Force personnel. The Air Force sponsored two operational training projects at Shot LASSEN:

- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training

Project 53.7, Indirect Bomb Damage Assessment, was conducted by the Wright Air Development Center. Personnel installed IBDA equipment aboard an F-89D aircraft from Indian Springs AFB. At shot-time, the F-89D which had a crew of one, flew a holding pattern 90 nautical miles long and five nautical miles east of ground zero (4; 24).

Project 53.9, Photographic Reconnaissance Training, was conducted to indoctrinate Air National Guard Tactical Reconnaissance units in photographic missions over a nuclear target. Two RF-84F aircraft departed from George AFB, California, and flew to the NTS, where they orbited above Lathrop Wells at 31,000 feet until the shot was fired. Upon clearance from the Air Operations Center, they began a photographic mission flying toward ground zero. Thev crossed the shot area approximately 15 minutes after the detonation at an altitude of 10,000 feet. Upon completion of the run, they returned to George AFB (4; 24).

4.2.5 Air Force Special Weapons Center Activities

AFSWC support consisted of cloud-sampling missions, sample courier missions, cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Project 21.2, Radiochemistry Sampling, was sponsored by the UCRL Test Group. The project required the gathering of samples

from the cloud for subsequent laboratory analvses. AFSWC pilots from the 4926th Test Squadron (Sampling) performed the cloud sampling. They used one B-57 sampler control aircraft and five F-84 sampler aircraft. One of the samplers, however, aborted its mission because of tip tank malfunction. Each sampler aircraft was outfitted with sampling equipment, radiac meters, filter papers, and integrating dosimeters. Pilots were on full internal oxvgen before, during, and after cloud penetration (1; 4).

The control aircraft was flown by a pilot accompanied by a scientific advisor from UCRL, while each F-84 had only a pilot. The F-84 aircraft collected samples at 30,000 feet, following the standard procedures for Operation PLUMBBOB (1; 4).

Courier Missions

On shot-dav, the 4900th Air Base Group from Kirtland AFB, using C-47 aircraft, flew sample return missions for Project 21.2. The missions entailed transporting cloud samples taken from sampler aircraft at Indian Springs AFB to UCRL for analvsis (1; 4).

Cloud Tracking

Immediatelv after the detonation, two B-25 aircraft, based at Indian Springs AFB, flew cloud-tracking missions over and bevond the NTS. The purpose of cloud-tracking was to determine the direction of the radioactive cloud and to keep the airwavs clear of any private or commercial aircraft that might encounter radiation (1; 4). The 4935th Air Base Squadron provided the aircraft and crews for cloud tracking, the 4926th Test Squadron provided instruments, and the 4900th Air Base Group Radiation Defense Unit maintained the instruments (1; 4).

After cloud-sampling aircraft completed their missions, the 4ir Operations Center ordered the cloud-tracking aircraft to leave their holding patterns, approach the edge of the cloud at

frequent intervals, and note the position of maximum intensitv encountered on approach. Because Shot LASSEN had such a low vield, the mission of one H-25 cloud tracker lasted onlv 30 minutes, until the Test Manager determined that the cloud presented no further hazard to aircraft flving commercial airwavs (1; 4). The other H-25 conducted a photographic mission rather than the cloud-tracking mission (1; 4; 22).

Securitv Sweeps

Two L-20 aircraft were dispatched from Yucca airstrip near the Control Point to perform preshot and postshot security sweeps over the NTS. The aircraft carried crews of at least two persons since the security sweep routine called for a security guard officer to accompanv the pilot (1; 4).

Helicopter Survevs

Four H-21 helicopters, each with an AFSWC crew of two and two REECo radiological safety monitors, performed special survev missions for the Test Manager. About 15 minutes after the detonation, one H-21 entered Area 2 to assess and record detonation damage. About 30 minutes after the detonation, another H-21 helicopter with Project 2.1 personnel entered the shot area to take radiation readings. The remaining two helicopters made radiological survev missions, discussed in section 4.3. Following their missions, the helicopters were monitored and decontaminated as required. 4 fifth H-21 helicopter was scheduled to perform a survev for a LASL project, but its mission was canceled (4).

4.3 RADIATION PROTECTION AT SHOT LASSEN

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that individuals would avoid unnecessarv exposure to ionizing radiation while accomplishing

the operational requirements of each activity or mission. Some of the procedures described in the series volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of their radiation protection programs. The available information includes NTO isointensitv plots, monitoring data, and some NTO personnel dosimetry information. Radiological safetv procedures and dosimetry information for Desert Rock and AFSWC participants are described in the Operation PLUMBBOB volume.

Dosimetrv Records

On 4, 5, and 6 June 1957, the Personnel Dosimetry Branch issued 798 film badges and 340 pocket dosimeters (64). No DOD participants at Shot LASSEN received a cumulative gamma exposure exceeding 2.0 roentgens (51).

Logistics

From the dav before Shot LASSEN to the dav before Shot WILSON (4 June to 17 June), the Logistics Branch issued anticontamination supplies to 1,123 people, as follows (64):

- 556 coveralls
- 931 pairs of shoe covers
- 856 respirators
- 2,394 other items.

The laundrv processed 8,282 pieces of anticontamination clothing (64).

Monitoring Procedures and Support

Fifteen minutes after the detonation of LASSEN, at 0500 hours, a total of 11 monitors traveling in six vehicles set out to perform the initial ground survey. At 0540 hours, alpha contamination was found 75 meters south of ground zero. The shot area was closed by the Test Director. Another five men in two vehicles conducted ground surveys in ad.jacent non-shot areas. 4

resurvey of the shot area was conducted at 0900 hours on 6 June, the dav after detonation, and after decontamination the area was opened for recoverv operations at 2000 hours that day (51; 64).

The initial helicopter survey team, consisting of two radiological safetv monitors and two AFSWC pilots, departed from the Control Point helicopter pad at 0500 hours, 15 minutes after the detonation. The team completed the survev at 0615 hours. The highest radiation intensitv encountered was 1 R/h, 25 feet above the BOLTZMANN ground zero, 50 minutes after the detonation. Aerial resurveys were not made for Shot LASSEN because ground resurvevs supplied sufficient information (51; 64).

Plotting and Briefing

Using information from the initial survey, the Plotting and Briefing Branch developed an isointensitv contour map. This map showed the 0.01 and 0.1 R/h contours in the shot area. A copy of the initial contour map, with a mid-time of 0527 hours, is shown in figure 4-1 (64). No map was prepared for the second ground survev.

Decontamination Activities

During the period covering Shot LASSEN, personnel of the Decontamination Branch decontaminated 124 vehicles and one electric generator. Personnel were decontaminated at facilities located in the radiological safetv building (64).

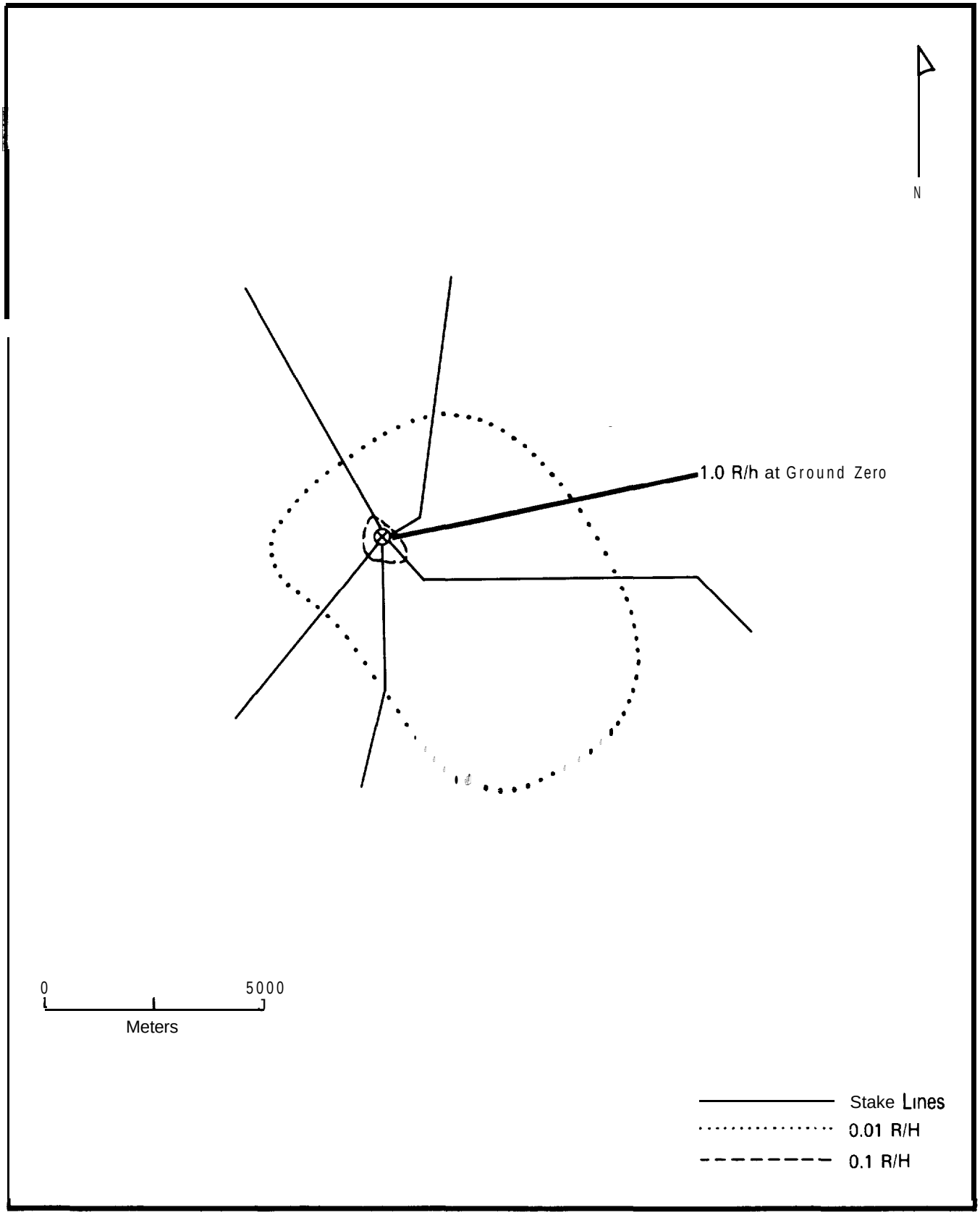


Figure 4-1: INITIAL SURVEY FOR SHOT LASSEN, 5 JUNE 1957, MID-TIME 0527

SHOT WILSON SYNOPSIS

AEC TEST SERIES:	PLUMBBOB
DOD EXERCISE:	Desert Rock VII and VIII
DATE/TIME:	18 June 1957, 0445 hours
YIELD:	10 kilotons
HEIGHT OF BURST:	500 feet (balloon shot)

Objectives: (1) To evaluate newlv designed devices for possible inclusion in the nuclear arsenal
(2) To evaluate military effects for specific applications against a variety of military targets
(3) To evaluate the effectiveness of military troops, equipment, and tactics and to indoctrinate personnel in the effects of nuclear detonations
(4) To assess the effects of a nuclear detonation on civilian structures, products, and food supplies and to evaluate Civil Defense emergency preparedness plans.

Weather: At shot-time, the temperature was 17°C, and the surface winds were four knots from the north-northwest. Winds were eight knots from the east-northeast at 10,000 feet, eight knots from the west-southwest at 20,000 feet, and 16 knots from the west-southwest at 30,000 feet.

Radiation Data: Onsite fallout was southwest of ground zero, with intensities up to 1.0 R/h detected an hour after detonation.

Participants: Exercise Desert Rock troops, Armed Forces Special Weapons Project, 4ir Force Special Weapons Center and other Air Force personnel, University of California Radiation Laboratory, Federal Civil Defense Administration, other contractors.

CHAPTER 5

SHOT WILSON

Shot WILSON was detonated with a yield of ten kilotons on 18 June 1957 at 0445 hours Pacific Daylight Time. Suspended from a balloon at a height of 500 feet in Area 9 of the Nevada Test Site, WILSON was sponsored by the University of California Radiation Laboratory. The WILSON cloud top reached a maximum height of 35,000 feet. The upper part of the cloud separated from the stem and blew northeast, with most of the fallout from the cloud occurring offsite. The stem blew to the southwest with the highest radiation intensities from fallout, about 1 R/h one hour after detonation, occurring onsite (25; 64).

Shot WILSON was one of three detonations during Operation PLUMBBOB from which observers had to be evacuated. Eighty-two Army, Marine Corps, and Air Force personnel, who watched the shot from the Control Point, were evacuated from the area five minutes after the blast. In addition, some technical project participants evacuated when fallout arrived at their positions west-southwest of ground zero (34-35; 66-67). The evacuation had been planned before the detonation because weather predictions indicated that light winds might be out of the north, moving from the site of detonation toward the Control Point at Yucca Pass (34; 64).

5.1 EXERCISE DESERT ROCK VII AND VIII OPERATIONS AT SHOT WILSON

More than 850 Desert Rock exercise troops took part in projects associated with the WILSON event, including four troop observer indoctrination projects, one radiological training project, and four technical service projects. Table 5-1 identifies these projects. In addition, the table lists 164 Camp

Desert Rock support troops. These troops, who were not assigned to any observer project, witnessed the detonation along with the observers assigned to the Army, Marine Corps, and Air Force projects (24; 34-35).

Table 5-I: EXERCISE DESERT ROCK PROJECTS, SHOT WILSON

Program Type	Project	Title	Participants	Estimated DOD Personnel
Troop Observer Indoctrination	502	Troop Observers	Army	41
	52 2	Marine Corps Observers	Marine Corps	15
	533	Aircrew Observers	Air Force	26
		Troop Observers	Camp Desert Rock Support Troops	164
Radiological Training	534	Radiological Defense Training	Air Force Radiological Defense School Lowry AFB	24
Technical Service	503	Evaluation of Medium Range Detonation detection and Cloud Tracking Systems	Army Signal Research and Development Laboratories	25
	505	Field Evaluation of Shielding for Engineer Heavy Equipment	Army Engineer Research and Development Laboratones	5
	507	Test of Ordnance Material	Army Chemical Warfare Laboratones	*
	508	Detection of Atomic Burst and Radioactive Fallout	Army Air Defense Board, 495th Antiaircraft Artillery Missile Battalion	557

*Unknown

5.1.1 Troop Observer Indoctrination Projects

Participants in the three troop observer indoctrination projects and the 164 Camp Desert Rock observers viewed the detonation from an observation area located seven kilometers from ground zero at UTM coordinates 834033, near BJY. Because of the possibility of light winds carrying fallout from the shot area, the observers were evacuated from the area five minutes after the detonation as a precautionary measure (34-35).

5.1.2 Radiological Training Projects

Project 53.4, Radiological Defense Training, was designed to train Air Force Strategic Defense personnel in radiological defense techniques. Twenty-four personnel from the Air Force Radiological Defense School participated in this project, observing the detonation approximately seven kilometers from ground zero along with other observer troops. After the detonation, radiological safety personnel from the 50th Chemical Service Platoon surveyed the shot area, marking the .01 and .10 R/h areas. They waited for the project personnel at the .001 R/h line. At the declaration of recovery hour, project participants proceeded in ten vehicles to the surveyed area, where they located predetermined radiation intensities not exceeding .005 R/h. They radioed readings to the control stations, where they were plotted on a map. Radiological safety monitors remained with the participants during their activities to enforce established safety criteria and procedures (24; 34-35; 44).

5.1.3 Technical Service Projects

The Department of the Army sponsored four technical service projects at Shot WILSON, as listed in table 5-1.

Project 50.3, Evaluation of Medium Range Detonation-detection and Cloud Tracking Systems, was fielded by 18 personnel from the Army Signal Research and Development Laboratories, seven personnel from Fort Meade, and seven personnel from Fort Huachuca. The two purposes of the project were: to test the capacity of Army radar equipment in detecting nuclear detonations and tracking radioactive clouds, and to examine Army fallout prediction methods. The fallout prediction unit for this project worked in a van parked near the Air Weather Station at Camp Mercury. Three radar stations were southeast of Yucca Lake, near UTM coordinates 893872, about 25 kilometers from ground zero (12; 44; 53).

Project 50.5, Field Evaluation of Shielding for Engineer Heavy Equipment, was conducted by the Army Engineer Research and Development Laboratories. This project was the third phase of an experiment designed to evaluate the operational capabilities of equipment in decontaminating a field and to determine the shielding characteristics of an experimental D-8 bulldozer in a contaminated field. Approximately five volunteers participated on a rotational basis during the two project activities (34-35; 61).

On the day before the shot, a lead-shielded D-8 bulldozer mounted on a trailer was moved to the Desert Rock Decontamination Station at UTM coordinates 848888 along with other Desert Rock vehicles, including Project 53.4 vehicles. Project 50.5 participants observed the detonation with the Desert Rock observers. About nine hours after the shot, the bulldozer was moved on the trailer to the .05 R/h line in two predesignated areas, one 930 square meters and the other 280 square meters, 1.6 kilometers east of ground zero. One operator then drove the bulldozer in and out of the ground zero area. He was not to come closer than 30 meters to ground zero. The bulldozer was left in the area overnight. The next day, participants returned and took turns using the bulldozer to decontaminate the area by scraping off the topsoil. Each operator followed a predesignated course that approached no closer than 30 meters to ground zero. Participants then departed from the area, leaving the bulldozer behind. They returned eight and nine davs after the shot to continue similar decontamination activities in progressivelv lower radiation fields. At the end of the project, the bulldozer was decontaminated at the Desert Rock Decontamination Station before it was returned to the Camp Desert Rock motor pool (34; 61). Figure 5-1 shows a rehearsal of the bulldozer decontamination activities.

In addition to the D-8 test, the project included transverse shielding measurements. Personnel took these measurements nine

Figure 5-1: A LIEUTENANT DIRECTS THE BULLDOZER DURING A REHEARSAL FOR THE DECONTAMINATION TASK OF PROJECT 50.5

hours after the detonation by driving the tractor from a location 800 meters north of ground zero to ground zero and back. The initial plan had been for the cab of the bulldozer to be airtight. Fresh air was circulated through decontamination filters, and air pressure in the cab was maintained at a level greater than normal atmospheric pressure to ensure against air leaks. However, there were visible leaks around the top door and around a side door constructed to accommodate the gearshift. Because of the gearshift's peculiar location, it could not fit in the totally enclosed cab. A small door was cut through the shielding to accommodate the gearshift. Each time the driver shifted gears, he had to open the door (61).

Project 50.7, Test of Ordnance Material, was fielded to determine the effect of the blast, thermal, and radioactive elements of nuclear explosions on selected items of Army equipment. The project was divided into four parts, each testing a different type of ordnance. Three of the parts were conducted at Shot WILSON: radiation studies, foxhole studies, and vehicle damage tests.

For radiation studies, Desert Rock participants placed unmanned tanks, vehicles, and steel hemispheres 550 meters south-southeast of ground zero. Project 2.4 personnel from the Army Chemical Warfare Laboratories provided, installed, and recovered the instrumentation. The fielding activities of these individuals are discussed in section 5.2.1. The foxhole studies tested the protection offered by standard two-man foxholes, some with unmanned tanks and Ontos vehicles placed over them. For vehicle damage tests, Ontos vehicles and tanks were placed in an arc 550 meters southeast of ground zero to incur direct and secondary blast damage. The vehicles were placed in the area before the shot, and damage surveys were made after the detonation when radiation intensities had decayed to acceptable levels (11; 35; 60).

Project 50.8, Detection of Atomic Burst and Radioactive Fallout, was conducted by the Army Air Defense Board, supported by the 495th Antiaircraft Artillery Missile Battalion. The objective was to determine how well equipment authorized for a typical Army unit could determine the location, height of burst, and yield of a nuclear detonation. Radar sets were positioned before the detonation at UTM coordinates 752048 and 922632, approximately 11 kilometers west-southwest and 47 kilometers south of ground zero, and offsite about 125 kilometers from ground zero. The station 11 kilometers from ground zero was evacuated 21 minutes after the shot because of fallout in the area. The project involved 557 Army participants (34; 66-68).

5.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC, OPERATIONAL TRAINING, AND SUPPORT ACTIVITIES AT SHOT WILSON

In addition to Exercise Desert Rock activities, Department of Defense personnel performed a variety of tasks during Shot WILSON that required them to enter the forward area. They conducted 21 projects sponsored by the Field Command Weapons Effects Test Group, and they participated in one UCRL Test Group project and eight CETG projects. The Air Force sponsored three operational training projects. In addition to experiments and operational training projects, AFSWC and other support activities accounted for a number of other DOD participants. The Air Force Special Weapons Center supported test group projects for LASL and UCRL and flew routine missions for the Test Manager. Since Shots LASSEN and WILSON had the same ground zero, the major portion of the fielding effort for the projects was conducted before LASSEN.

5.2.1 AFSWP Field Command Weapons Effect Test Group Projects

Table S-2 identifies the Field Command Weapons Effects Test Group projects.

Project 1.1, Basic Airblast Phenomena, was conducted bv the Ballistic Research Laboratories. The primary objective was to obtain data on overpressure and dvnamic pressure at different times after the detonation and at different distances from ground zero. An additional objective was to evaluate modifications in gauge designs, instrument components, and measurement techniques. Before the detonation, two Ballistic Research Laboratories personnel installed 25 gauges 180 to 910 meters southeast of ground zero (9; 13). 4n estimated two to four project personnel, including a radiation monitor, recovered some of the distant gauges late on shot-day. An estimated two people recovered the rest of the gauges within the next few days (9; 13).

Project 2.1, Soil Activation by Neutrons, was conducted bv the Army Chemical Warfare Laboratories. The project was to measure neutron-induced gamma-emitting radioisotopes in homogeneous soils and the consequent residual radiation levels in the vicinity of air bursts. Eventuallv, the data were to be used to predict the radiological hazard from such soil activation. To obtain data, a helicopter survey team made early induced-field surveys about 45 minutes after the detonation. The team lowered ionization chambers mounted on tripods to the ground at various distances from ground zero. The dose rates measured bv the ionization chambers were recorded in the helicopters (9; 40).

Ground personnel and an additional aerial survey team also participated in the project. Personnel from Projects 2.1, 2.2, 2.3, and 2.4 manned a station about 460 meters east of the BJY, at UTM coordinates 853033. Five minutes after the detonation, two Project 2.1 personnel left the manned station and proceeded to a location 910 meters south-southwest of ground zero, where

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

Project	Title	Participants	Estimated DOD Personnel
	Weapons Effects Test Group		
11	Basic Airblast Phenomena	Ballistic Research Laboratories	24
21	Soil Activation by Neutrons	Army Chemical Warfare Laboratories	24
22	Neutron-Induced Activity in Soil Elements	Naval Radiological Defense Laboratory	14
23	Neutron Flux from Selected Nuclear Devices	Army Chemical Warfare Laboratories	*
2.4	Nuclear Radiation Shielding Studies	Army Chemical Warfare Laboratories	6
25	Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soils	Army Signal Research and Development Laboratories	4
26	Evaluation of New Radrac Instruments	Army Signal Research and Development Laboratones	5
27	Radio-wave Attenuatron Studies	Naval Research Laboratory	4
28	Evaluation of Military Dosrmeters and Radrac Instruments	Naval Material Laboratory	4
210	Initial Neutron and Gamma Air-earth Interface Measurements	Air Force Special Weapons Center, General Mills Company, Sandra Corporation	10
41	Effect of Nuclear Detonations on a Large Biological Specimen (Swine)	Walter Reed Army Institute of Research	192
42	Evaluation of Eye Protection Afforded by an Electromechanical Shutter	Tactical Air Command, Wright Air Development Center; Air Force School of Aviation Medicine, Navy Radiological Defense Laboratory, Wright Patterson Aero Medical Laboratory, Nellis AFB Hospital	*
51	In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonatton	Navy Bureau of Aeronautics	*
55	In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation	Wright Air Development Center, Northrup Aircraft	2
62	Measurement of the Magnetic Component of the Electromagnetic Field Near a Nuclear Detonation	Diamond Ordnance Fuze Laboratones	21
63	Attenuation of Electromagnetic Radiation through an Ionized Medium	Naval Air Development Center	*
64	Accuracy and Reliability of the Short-baseline NAROL System	Air Force Cambridge Research Center	*
65	Effects of Nuclear Detonations on Nike Hercules	White Sands Missile Range, Bell Telephone Laboratories	5
82	Prediction of Thermal Protectron of Uniforms and Thermal Effects on Standard Materials	Naval Material Laboratory	2
83a	Performance of a High-Speed Spectrographic System	Naval Radiological Defense Laboratory	*
91	Support Photography	AFSWP, Military Air Transport Service, EG and G	9

*Unknown

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

Project	Title	Participants	Estimated DOD Personnel
University of California Radiation Laboratory Test Group			
21 2	Radiochemistry Sampling	Air Force Special Weapons Center	16
Civil Effects Test Group			
37 2 37 2a	Biophysical Aspects of Fallout, Physical Aspects of Fallout	Air Force Special Weapons Center	3
37 6	Application of Radio-ecology Techniques	Air Force Special Weapons Center	*
395	Radiation Dosimetry for Human Exposures	Air Force School of Aviation Medicine	12
39 6	Biological Effects of Nuclear Radiation on the Monkey	Air Force School of Aviation Medicine	10
39 7a	Neutron Effects of Bomb Radiation on Large Animals	Air Force School of Aviation Medicine	64
39 8	Depth-dose Studies in Phantoms with Initial Gamma and Neutron Bomb Radiation	Naval Medical Research Institute	*

* Unknown

they conducted recovery operations. They were to depart from the area 90 minutes after the detonation. Four personnel in a helicopter conducted three aerial survevs of the Project 2.3 instrument line, 180 to 1,100 meters south-southeast of ground zero, 30 minutes, three hours, and six hours after the shot (9; 40; 54).

Project 2.2, Neutron-induced Activity in Soil Elements, was fielded by the Naval Radiological Defense Laboratory to measure the neutron-induced radioactivity in soils of various types and composition (16). Two project personnel placed special aluminum containers, each containing four trays of selected soil samples, in the ground 460 and 640 meters from ground zero. Each cylinder was closed with a latched top and covered with a plastic weather

shield that was removed a few hours before shot-time. At 2400 hours on the night before the shot, 14 men traveled in four vehicles to a station east of the BJY, which they manned by shifts until two days after the shot. The 14 personnel received the aluminum containers from the aerial recovery team. A helicopter team began recovery three minutes after the shot. Their helicopter was outfitted with a winch and marine grapnel that connected to a pickup hoop on the soil containers. The team spent approximately 30 minutes retrieving the containers and transporting them to the manned station.

After recovery of the station containers, samples were taken to the mobile laboratory for analysis. Initial observations were made on those elements with short half-lives. The mobile laboratory was set up at an aircraft revetment constructed for a previous operation along the road leading toward Area 7 from HJY, 15 kilometers north of the Control Point. Samples were returned to this position and measurements made of their spectral characteristics during the 24 hours after the detonation. Some longer-lived isotopes were studied after the mobile laboratory had been returned to Camp Mercury, and others were studied after return of the samples to the Naval Radiological Defense Laboratory (9; 16).

Project 2.3, Neutron Flux from Selected Nuclear Devices, was conducted by the Army Chemical Warfare Laboratories in conjunction with Project 2.1. The project was designed to measure the output of neutrons from a nuclear detonation, the energy of the neutrons, and their range in air. Project 2.10 personnel performed the fielding and recovery requirements of Project 2.3. Their activities are discussed under Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements. To measure neutron flux at various heights above the ground, Project 2.3 personnel provided 17 detectors to Project 2.10 (9; 54).

Project 2.4, Nuclear Radiation Shielding Studies, was fielded by the Army Chemical Warfare Laboratories. The project was designed to study the effectiveness of tanks and various types of armor in providing shielding against nuclear radiation. This project was coordinated with the radiation study of Exercise Desert Rock Project 50.7, AFSWP Project 4.1, and CETG Project 39.7a. Several hours before the shot, project participants accompanied Project 4.1 and 39.7a personnel to the shot area, where they placed dosimeters and swine in the tanks. Five minutes after the detonation, four personnel proceeded into the shot area to recover the dosimeters and swine, completing their part of the operation 90 minutes after the detonation. One hour after the detonation, another party of five joined in the recovery activities (9; 11; 60).

Project 2.5, Initial Gamma Radiation Intensity and Neutron-induced Gamma Radiation of NTS Soils, was conducted by the Army Signal Research and Development Laboratories. For this shot, the project was to determine initial gamma intensity both on the ground and in the air. Measurements were to be taken at different times after the detonation and at different distances from ground zero. At 1800 hours on the day before the detonation, four men installed radiation detection instruments in seven stations 1,370 to 2,740 meters south-southeast of ground zero. They left the area by 2200 hours. Personnel retrieved the instruments after the detonation (9; 14).

Project 2.6, Evaluation of New Radiac Instruments, was conducted by the 4rmy Signal Research and Development Laboratories. The project was to evaluate the ability of newly developed radiation instruments to accurately detect and measure gamma and neutron radiation. In evaluating the neutron dosimeter system, tissue-equivalent tactical neutron dosimeters and standard radiac meters were exposed to the initial nuclear radiation. The readings were compared to those made with chemical dosimeters and with National Bureau of Standards film dosimeters.

Project personnel attached dosimeters and film packs to plvwood slats placed within linen-reinforced tubes eight centimeters in diameter and 1.2 meters long. The dosimeters were placed 1,190, 1,230, 1,280, 1,330, 1,370, and 1,420 meters southeast of ground zero. About four hours after the detonation, five participants recovered the tubes (9; 15).

Project 2.7, Radio-wave Attenuation Studies, was fielded by the Naval Research Laboratory. The objective was to study the interference effects of high levels of radiation on radio transmissions and radar operations. Transmitters were placed in unmanned bunkers between 840 and 1,460 meters north of ground zero. Scintillation detectors were also placed in some of the bunkers close to ground zero, and receivers were installed in Building 400, 22 kilometers south of ground zero. When radiation levels permitted, four personnel spent four hours recovering data 270 to 960 meters south of ground zero (9; 30).

Project 2.8, Evaluation of Militarv Dosimeters and Radiac Instruments, was conducted by the Naval Material Laboratory. The project was intended to determine the accuracy of several tvpes of Navy radiac equipment in measuring radiological hazards in the field under anticipated conditions of nuclear warfare. The equipment consisted of one masonite phantom, simulating the density and dimensions of a human, loaded with selectively shielded standard depth-dose detectors and dosimeters, and one masonite phantom containing two recording ratemeters. About 45 minutes after shot-time, the equipment was transported into the field and positioned where the gamma field was about 50 R/h. Project personnel probablv received special permission to proceed into this radiation field since entry into areas greater than 10 R/h required permission from the Test Director. Fifty-three hours after the equipment had been installed in the field, three project personnel accompanied by a radiological safety monitor recovered the phantoms and took them to the laboratory for analvsis (9; 19).

Project 2.10, Initial Neutron and Gamma Air-earth Interface Measurements, conducted by the Air Force Special Weapons Center, was designed to studv how the air-ground interface affected the radiation produced bv a nuclear detonation. This objective was accomplished bv measuring the integrated gamma dose and neutron readings at points on the ground and at corresponding points at heights up to approximatelv 950 feet. Four tethered helium balloons carrving the instruments were launched the dav before WILSON at distances of approximatelv 1,370, 1,830, 2,290, and 2,780 meters from ground zero. The balloons were supplied and handled by the General Mills Company, with the technical assistance of Sandia Corporation. The balloon at 2,290 meters apparentlv leaked and came down, since it was missing at shot-time. The three remaining balloons were destroved by the shot (9; 65).

Project 4.1, Effect of Nuclear Detonations on a Large Biological Specimen (Swine), conducted by the Walter Reed Army Institute of Research, was designed to investigate the effects of radiation from a nuclear detonation on swine in an attempt to define more specifically the effects on humans. The project was conducted in conjunction with Project 39.7a, and personnel probablv received permission from the Test Director to enter forward areas where radiation levels may have exceeded 10 R/h. Project activities and analvsis were done bv 179 officers and enlisted men from the Medical Services of the Army, Navy, and Air Force. Thirteen civilians were also involved in the project.

During the night before the detonation, about 100 men placed 264 animals in cylinders positioned 1,050 to 1,280 meters northwest of ground zero, 1,165 to 1,420 meters southeast of ground zero, and 780 meters southeast of ground zero. Thev also placed swine in the Project 2.4 tanks. Four parties began retrieving the animals 20 minutes after the detonation. One party of five served as a radio relay for animal recovery. Two

parties, each of 32 participants, worked with Project 39.7a personnel. The last party, consisting of 40 men, recovered the animals. All parties left the area two-and-one-half hours after the shot (9). The swine were returned in trucks to the holding pen area, where they were checked for trauma, given surgery when necessary, and observed to determine the onset of symptoms of radiation sickness (9; 45; 60).

Project 4.2, Evaluation of Eye Protection Afforded by an Electromechanical Shutter, was intended to evaluate the effectiveness of an electromechanical shutter device for preventing or minimizing flash blindness, a temporary condition produced by the intense light of a nuclear detonation. Tactical Air Command personnel flew a C-47 aircraft used in this project, sponsored by Wright Air Development Center. Test subjects were volunteers from the Tactical Air Command. The Air Force School of Aviation Medicine furnished the examiners and rabbits for the tests, and personnel from the Navy Radiological Defense Laboratory, the Wright Patterson Aero Medical Laboratory, and the Nellis Air Force Base Hospital provided technical support (28).

Personnel used two identical experimental stations. One station was in a C-47 aircraft orbiting 18 kilometers southeast of ground zero, and the other was in a trailer 13.9 kilometers from ground zero at UTM coordinates 845972. Each station was equipped with a light-sensitive electromechanical shutter device for each subject. There were from two to five positions for human subjects, four of whom participated at WILSON. A trained examiner was present for each human subject. Times to recover useful vision, as measured by the ability to read aircraft instruments, and the return of night vision, as measured on a nyctometer, were determined and recorded. Five hours before the shot, participants left Camp Mercury by truck to proceed to the ground station. Thirty minutes after the shot, personnel left the trailer to return to Camp Mercury and then to proceed to

Nellis AFB, where they received complete ophthalmological evaluation (28).

Four or more rabbits were also exposed at each location. Each animal was placed in a holder designed to minimize movement and ensure proper positioning for exposure. Ten control animals received chorioretinal burns, indicating that sufficient energy was absorbed to cause permanent chorioretinal damage to the unprotected eye (28).

Project 5.1, In-flight Structural Response of the HSS-1 Helicopter to a Nuclear Detonation, was conducted by the Navy Bureau of Aeronautics. The project was intended to measure the effects of the overpressure and wind gusts produced by a nuclear detonation on the HSS-1 helicopter. The delivery capabilities for antisubmarine warfare weapons, as limited by blast effects, were also studied. The shot required the support of one helicopter pilot, ground controllers, and aircraft maintenance personnel responsible for the special instrumentation of the helicopter. An average of four practice runs were flown prior to the actual mission.

The helicopter flew left-hand, eight-nautical mile holding patterns. At shot-time, the helicopter was at an altitude of 5,910 feet and at a distance of 4,270 meters from ground zero (5; 63).

Project 5.5, In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation, was designed to determine the structural response of the F-89D in flight to the blast and thermal effects of a nuclear detonation. Northrop Aircraft was contracted to assist the Wright Air Development Center in planning and conducting the project. Northrop calibrated, maintained, and operated the instrumentation and associated equipment, and later analyzed the measured data. Development of

positions and positioning methods was done jointly by Northrop Aircraft and Wright Air Development Center. One F-89D aircraft with two crew members flew one complete 12-minute, left-hand holding pattern to position the aircraft. At the time of detonation, the aircraft was headed toward ground zero at an altitude of 16,880 feet and at a slant range of 11 kilometers from the burst. At shock arrival, the aircraft had descended to 16,820 feet above the ground and was at a slant range of seven kilometers from the burst. The aircraft was in the test area for approximately 30 minutes. Film badges were placed in the pilot's and observer's positions (5; 23; 58).

Project 6.2, Measurement of the Magnetic Component of the Electromagnetic Field Near a Nuclear Detonation, was conducted by the Diamond Ordnance Fuze Laboratories. The objective was to provide a record of the strength and characteristics of the magnetic field generated by a nuclear detonation as a function of time and distance. Instrumentation for Project 6.2 consisted of five completely self-powered recording stations located at intervals of about 250 to 3,000 meters from ground zero. An estimated nine personnel spent at least three days digging holes at five stations for the recording packages, lining the holes with concrete, and installing the packages. Four hours after the detonation, an estimated two personnel went to a station at UTM coordinates 895855 for recovery preparation. Another nine personnel recovered instrumentation at three unmanned stations eight hours after the detonation, after which they proceeded to the station at UTM coordinates 895855 and then continued recovery at the two other stations when radiological conditions permitted. The operations involved removing data and recording packages and transporting them by truck to Camp Mercury for analysis (9; 29).

Project 6.3, Attenuation of Electromagnetic Radiation through an Ionized Medium, was conducted by the Naval Air Development Center. Its objective was to determine the amount of

electromagnetic energy that was absorbed or filtered out by the highlv radioactive cloud that results from a nuclear detonation. The project involved one aircrew member, ground controllers, and aircraft maintenance personnel. An A4D-1 aircraft based at Indian Springs AFB carried electromagnetic energy transmitters in a pod tuned to six different frequencies. At the time of the detonation, the A4D-1 was 30 nautical miles north of ground zero at an altitude of 26,000 feet and heading inbound. The aircraft was to approach about three miles from the cloud. The aircraft was positioned so that, at one minute after detonation, the ionized cloud was on a straight line between the aircraft and the ground-based receivers (5; 43).

Project 6.4, Accuracv and Reliability of the Short-baseline NAROL System, used the Long Range Aids to Navigation (LORAN) System in an inverse fashion to detect the electromagnetic pulse from the nuclear burst in order to determine the position and measure the yield of that burst. The Indirect Bomb Damage Assessment NAROL system tested on this operation consisted of nets located at Albuquerque, New Mexico; Vale, Oregon; and Rapid City, South Dakota. Each NAROL net consisted of two unmanned stations and one manned station (36).

Project 6.5, Effects of Nuclear Detonations on Nike Hercules, investigated the effects of nuclear radiation on the Nike Hercules guided-missile system. Fielded by personnel from the White Sands Missile Range, New Mexico, with assistance from the Bell Telephone Laboratories, the Nike Hercules radar system was exposed with little or no shielding because the primary interest was in the effects of neutron and gamma radiation. To determine the effects of neutron and gamma radiation on the guidance system, standard vacuum-tube and experimental transistorized versions of that system were exposed at three sites (21). Ten personnel manned a station at UTM coordinates 765031 in support of the project and then left the station two hours after

the shot. When radiological conditions permitted, five participants were to recover equipment and instrumentation from three stations in the vicinity of ground zero (9; 21). It is possible that project personnel located near the Project 50.8 manned station had to evacuate their position shortly after the detonation because of fallout from the burst.

Project 8.2, Prediction of Thermal Protection of Uniforms and Thermal Effects on Standard Materials, was conducted bv the Naval Material Laboratory. The project was designed to investigate the ability of laboratory experiments to accurately predict the effects of intense thermal radiation on live skin and tissue. Laboratory results were compared with actual skin burns in pigs exposed to thermal radiation from a nuclear detonation. One recording station was instrumented at a distance of 1,190 meters from ground zero. After the detonation, eight personnel recovered the instruments (113).

Project 8.3a, Performance of a High-speed Spectrographic System, was conducted by the Naval Radiological Defense Laboratory. The purpose was to field-test spectrographic equipment that would analyze the electromagnetic energy from high altitude detonations during Operation HARDTACK II, a later series of atmospheric nuclear weapons tests. The levels and characteristics of the electromagnetic energy were to be measured and analyzed by this high-speed electronic equipment. The high-speed spectrographic systems were located a minimum of 12 kilometers from ground zero (47).

Program 9.1, Support Photography, was sponsored by AFSWP to provide the following support services:

- Technical photographic support of the military-effects program
- Documentation of the overall military-effects program and production of an effects motion picture

- Documentation of the detonation for release through the Joint Office of Test Information and for historical purposes
- General photographic support to Department of Defense projects.

Color and black-and-white photographs were taken both from an airborne camera station and a manned camera station in the forward area at UTM coordinates 852045. At shot-time, 13 personnel manned the camera station in the forward area and took pictures. They left the station 30 minutes after the detonation (9; 20). An additional two or three personnel also took pictures from a C-47 aircraft operated by personnel from the Military Air Transport Service. At shot-time, the aircraft was eight nautical miles southwest of ground zero, flying eastbound at 10,000 feet (5). In addition, EG and G provided technical photographv support to AFSWP and the AEC. EG and G personnel operated camera stations to record fireball and cloud growth (20).

5.2.2 Department of Defense Participation in Los Alamos Scientific Laboratory Test Group and University of California Radiation Laboratory Test Group Projects

Both the Los Alamos Scientific Laboratory and the University of California Radiation Laboratory conducted scientific experiments at Shot WILSON. Only UCRL Project 21.2, Radiochemistrv Sampling, involved DOD participation. This project required air support from AFSWC and is discussed in section 5.2.5.

5.2.3 Department of Defense Participation in Civil Effects Test Group Projects

The Civil Effects Test Group conducted 13 projects at WILSON. Of these 13 projects, eight involved DOD personnel as shown in table 5-2. Because some experiments required early recovery, the CETG requested and probably received permission from the Test Director for participants in Projects 39.5, 39.6,

39.7a, and 39.8 as well as Project 4.1 to enter forward areas where radiation levels may have exceeded 10 R/h (17; 52).

Project 37.2, Biophysical Aspects of Fallout, was designed to characterize fallout debris, and Project 37.2a, Physical Aspects of Fallout, was conducted to delineate and characterize fallout patterns. Project 37.6, Applications of Radio-ecology Techniques, was designed to evaluate environmental assessment techniques. AFSWC provided a C-47 and a crew for a radio relay at these projects. This participation is discussed in section 5.2.5 (5; 42).

Project 39.5, Radiation Dosimetry for Human Exposures, involved personnel from the Air Force School of Aviation Medicine. At 2245 on the night before the detonation, an eight-man party, traveling in four vehicles, placed dosimeters in the vicinity of ground zero. They left the area by 0045 on shot-day. Five minutes after the detonation, four parties, each of three personnel, left the Yucca Airstrip road for Area 9. About 25 minutes after the shot, they recovered dosimeters located along a line southeast of ground zero and instruments from stations 370 to 1,140 meters southeast of ground zero. After spending 16 to 20 minutes in recovery operations, they left the area and proceeded to the Radiological Safety Check Point, where they transferred the dosimeters and instruments to other vehicles (9; 37; 52).

Project 39.6, Biological Effects of Nuclear Radiation on the Monkey, involved personnel from the Air Force School of Aviation Medicine. At 2330 on the night before the shot, ten personnel placed 72 animals in Area 9. They left the area at 0200 the next morning. Seven military personnel and one civilian entered Area 9 two hours after the detonation to recover test animals from the exposure site. Their activities took 20 minutes. 4fter recovering the animals, these participants went to the Radiological

Safetv Check Point and transferred the animals to an uncontaminated truck, which transported the animals to the laboratory. The truck that had been at the exposure site was sent to the decontamination station for standard decontamination procedures (9; 41; 46).

Project 39.7a, Neutron Effects of Bomb Radiation on Large Animals, involved personnel from the Air Force School of Aviation Medicine. The project was conducted in conjunction with Project 4.1.

About 20 minutes after the detonation, 31 military personnel and one civilian monitor recovered test animals that had been placed 1,050 meters to 1,280 meters from ground zero. Including travel time, this activity required one hour and 45 minutes. At the same time, another 33 military personnel and one civilian monitor left Gate 4 to recover animals from exposure sites at distances of 1,170 meters to 1,420 meters from ground zero. Including travel time, this activitv also required one hour and 45 minutes (9; 17; 45).

In addition to these projects, Project 39.8, Depth-dose Studies in Phantoms with Initial Gamma and Neutron Bomb Radiation, involved personnel from the Naval Medical Research Institute. The objective was to determine initial neutron and gamma dose in phantoms composed of material approximating the densitv of human tissue. Personnel placed dosimeters in the phantoms, which thev then positioned at six stations south of ground zero. They installed other dosimeters along a radial line north of ground zero.

Ten minutes after the detonation, three men recovered instruments at two stations 1,050 and 1,190 meters southeast of ground zero. Two other men recovered instruments at five stations 1,100, 1,200, 1,300, 1,400, and 1,500 meters southwest

of ground zero. The three men spent six minutes in the shot area, and the other two men spent ten minutes (9; 17; 38; 52).

5.2.4 Department of Defense Operational Training Projects

The primary objectives of the operations1 training program were to indoctrinate Air Force personnel and to test equipment and techniques. The Air Force conducted three operational training projects at Shot WILSON:

- Project 53.5, Aircrew Indoctrination (Early Cloud Penetration)
- Project 53.7, Indirect Bomb Damage Assessment
- Project 53.9, Photographic Reconnaissance Training.

Project 53.5, Aircrew Indoctrination, was designed to enable Air Defense Command aircrews and commanders to witness a nuclear detonation and penetrate its cloud. Two F-102s participated in the project, orbiting at altitudes of 35,000 feet over the Las Vegas area until directed by the sampler control aircraft to enter the cloud. After penetration, the aircraft proceeded to the recovery base. The missions of four other F-102s scheduled for participation were canceled before takeoff (5; 24).

Project 53.7, Indirect Bomb Damage Assessment, was conducted by Wright Air Development Center personnel, who installed Indirect Bomb Damage Assessment equipment aboard an F-89D aircraft from Indian Springs AFB. At shot-time, the aircraft, which had a crew of one, flew a right-hand, 40-nautical mile holding pattern and orbited 72 nautical miles east of ground zero (5; 24).

Project 53.9, Photographic Reconnaissance Training, was intended to indoctrinate Air National Guard Tactical Reconnaissance Units in conducting photographic missions over a nuclear target. Two RF-84F aircraft with one pilot each departed from

George AFB, California, and flew to the NTS, where they orbited above Lathrop Wells at 31,000 feet until the shot was fired. Upon clearance from the Air Operations Center, they began a photographic mission toward ground zero. They crossed the shot area approximately 15 minutes after the detonation at an altitude of 10,000 feet. Upon completion of the run, they returned to base for decontamination procedures (5; 24).

5.2.5 Air Force Special Weapons Center Activities

Air Force Special Weapons Center support consisted of cloud-sampling missions and sample courier missions for UCRL, a radio relay for CETG, and cloud-tracking missions, security sweeps, and aerial surveys.

Cloud Sampling

Project 21.2, Radiochemistry Sampling, was sponsored by the University of California Radiation Laboratory Test Group. The project required the gathering of samples from the nuclear cloud for subsequent laboratory analyses. AFSWC 4926th Test Squadron, a principal mission unit of the 4950th Test Group, performed the cloud-sampling missions and provided two B-57s, four F-84s, and four T-33s for the mission. Each sampler aircraft was outfitted with sampling equipment, radiac meters, filter papers, and dosimeters. Pilots were on full internal oxygen before, during, and after cloud penetration (1; 5).

Each B-57 had a crew of two, each F-84 had a crew of one, and each T-33 probably had a crew of two. One B-57 served as the control aircraft and followed standard operating procedures at 35,000 feet. The samplers followed Instructions from the control aircraft to penetrate the cloud (5).

Courier Missions

On shot-day, the 4900th Air Base Group from Kirtland AFB, using a C-47 aircraft, flew sample return missions for Project 21.2. The missions entailed transporting cloud samples taken from sampler aircraft at Indian Springs AFB to the University of California Radiation Laboratory for analysis (1; 5).

Radio Relay

AFSWC provided one C-47 aircraft for radio relay services at CETG Projects 37.2, 37.2a, and 37.6. The C-47, carrying at least three people, flew a left-hand holding pattern 20 nautical miles southeast of ground zero at 12,000 feet. After the mission, the C-47 returned to its home base for decontamination (5; 17).

Cloud Tracking

Immediatelv after the detonation, aircraft from Kirtland AFB and Indian Springs AFB flew cloud-tracking missions over and beyond the NTS. The purpose of the cloud tracking was to determine the direction of the radioactive cloud and to keep the airways clear of any private or commercial aircraft that might encounter radiation (1).

The 4935th Air Base Squadron provided the aircrew and aircraft for the cloud-tracking mission. The 4926th Test Squadron provided instruments for B-25 cloud-tracking aircraft, while the AEC provided radiation measurement instruments for B-50 cloud-tracking aircraft. The 4900th Air Base Group Radiation Defense Unit maintained the instruments (1; 5).

After cloud-sampling aircraft completed their missions, the Air Operations Center ordered cloud-tracking aircraft to leave their holding patterns. They approached the edge of the cloud at frequent intervals and noted the position of maximum intensity they encountered on approach. Cloud tracking continued until the

Test Manager determined that the cloud presented no further hazard to aircraft flying commercial airways (1).

At the end of the cloud-tracking mission, aircraft and aircrews were monitored. Regardless of the radiation levels detected, the pilots underwent complete decontamination by showering and receiving a reissue of clothing. Radiation levels on aircraft from Indian Springs AFB were allowed to decay, or the aircraft were decontaminated in accordance with directives of the Test Aircraft Unit. Aircraft from Kirtland AFB were monitored on landing by the Passive Defense Unit of Kirtland AFB (1).

Security Sweeps

Two L-20 aircraft were dispatched from the Yucca airstrip near the Control Point to perform pre- and postshot security sweeps over the NTS. The aircraft carried crews of at least two persons for each mission since the security sweep called for a security guard officer to accompany the pilot (1; 5).

Helicopter Surveys

Three H-21 helicopters, each with an AFSWC crew of two and REECo radiological monitors, conducted special survey misions after the detonation. Three minutes after the detonation, one helicopter with Project 2.2 personnel left the Control Point to recover canisters from Project 2.2 stations in the shot area. The second and third H-21s left the Control Point 15 minutes after the detonation to conduct a radiation survey of Area 9 and other areas and a bomb damage survey of Areas 2 and 9, respectively. After the missions, the helicopters were monitored and decontaminated as required (1; 5; 52).

5.3 RADIATION PROTECTION AT SHOT WILSON

The purpose of the radiation protection procedures developed for Operation PLUMBBOB was to ensure that individuals would avoid

unnecessary exposure to ionizing radiation while allowing them to accomplish the operational requirements of each activity or mission. Some of the procedures described in the series volume resulted in records that enabled the Nevada Test Organization to evaluate the effectiveness of their radiation protection programs. The available information includes NTO isointensity plots, monitoring data, and some NTO personnel dosimetry information. Radiological safety procedures and dosimetry information for Desert Rock and AFSWC participants are described in the Operation PLUMBBOB volume.

Dosimetrv Records

On 17, 18 and 19 June, the Personnel Dosimetrg Branch issued 545 film badges and 320 pocket dosimeters (64). Dosimetry data indicate that ten NTO/DOD participants received cumulative gamma exposures ranging from 2.01 to 2.77 roentqens. Of these ten, four were from the Chemical Warfare Laboratories, three from the Naval Material Laboratory, and three from AFSWC. In addition, a participant from the Evans Signal Laboratory received a 3.69 roentgens cumulative gamma exposure, which exceeded the NTO limit of three roentgens per quarter (52).

Logistics

For Shot WILSON, the Logistics Branch issued anticontamination supplies to 703 people, as follows (64):

- 521 coveralls
- 643 pairs of shoe covers
- 422 respirators.

The laundrv processed 7,788 pieces of anticontamination clothing, as well as 595 pieces for Indian Springs AFB personnel (64).

Monitoring Procedures and Support

The Initial ground survey was delayed until 0607 hours. A total of 11 monitors traveling in eight vehicles performed that

initial survey. Resurveys were made later on shot-day and on 19, 20, 21, 23, and 27 June (64).

The initial helicopter survey was postponed in accordance with the evacuation order, which also affected the observers at the Control Point. The survey team consisted of two radiological monitors, one AEC representative, and two AFSWC pilots (64). The team departed by helicopter from the Control Point helicopter pad at 1145 hours, seven hours after the detonation. The team made three surveys over the area at heights of 25, 50, and 100 feet. The highest radiation intensitv encountered was 100 R/h at 25 feet directly above ground zero two hours after the detonation. Readings at other locations within the shot area were no higher than 0.2 R/h (52; 64).

Plotting and Briefing

Using information from the survevs, the Plotting and Briefing Branch developed isointensity contour maps. A copy of the initial contour map is shown in figure 5-2. Figure 5-3 shows the resurvev maps generated from 18 to 21 June (64).

Decontamination Activities

During the period covering Shot WILSON, personnel of the Decontamination Branch decontaminated 72 vehicles and 35 electrical instruments at the Control Point 6 station. Personnel were decontaminated at facilities located in the radiological safety building (64).

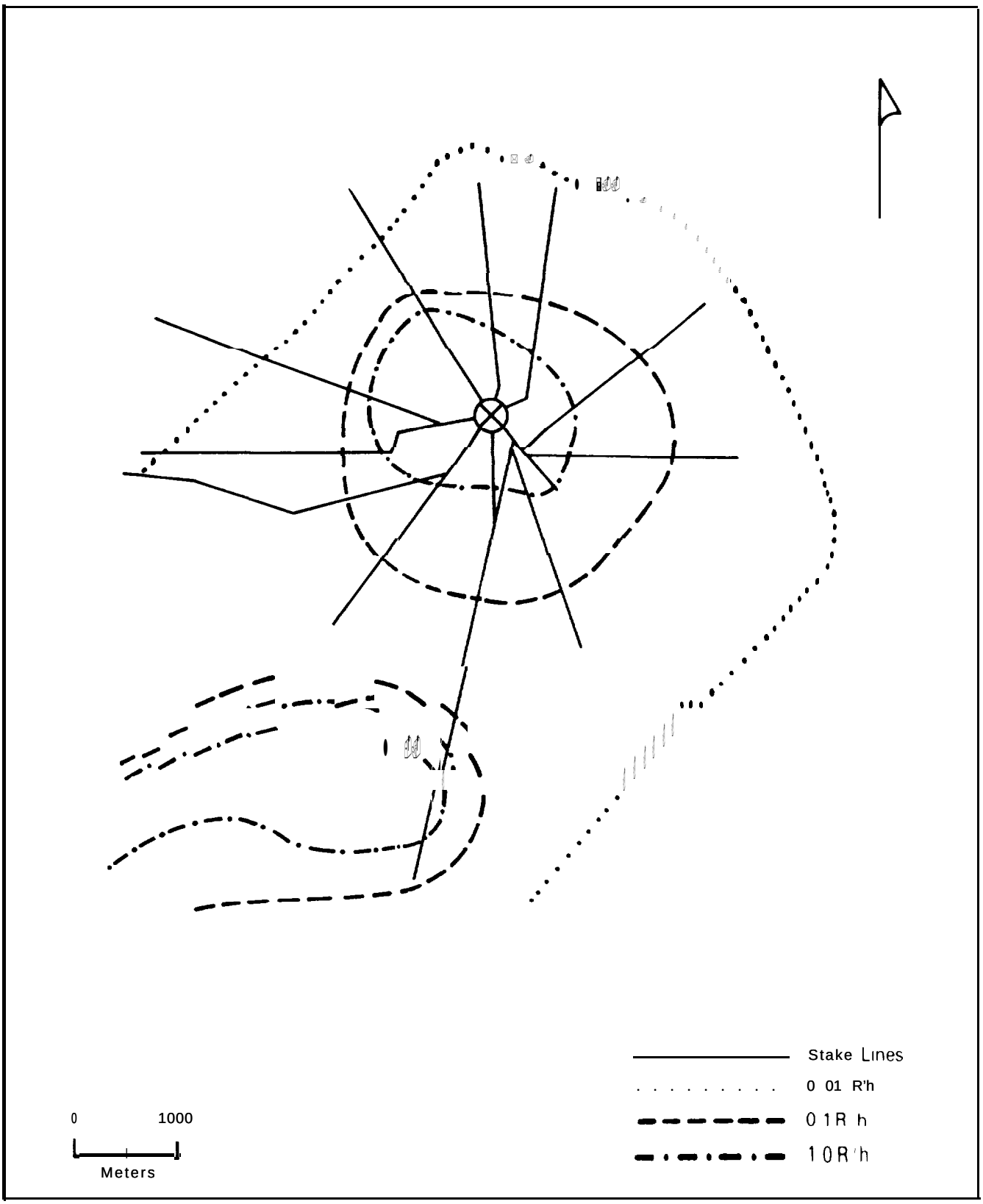
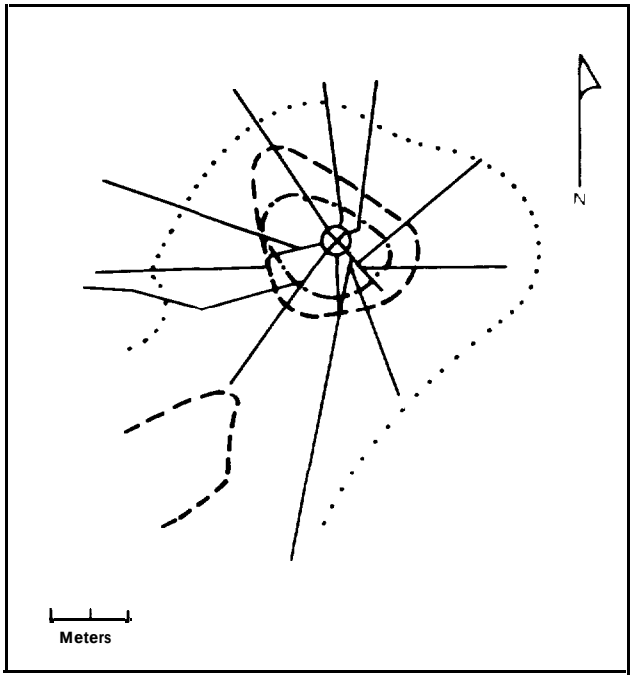
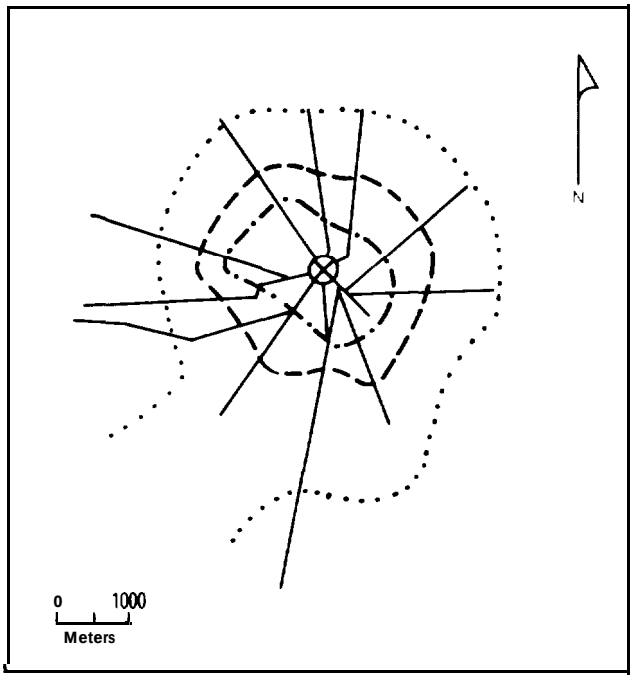


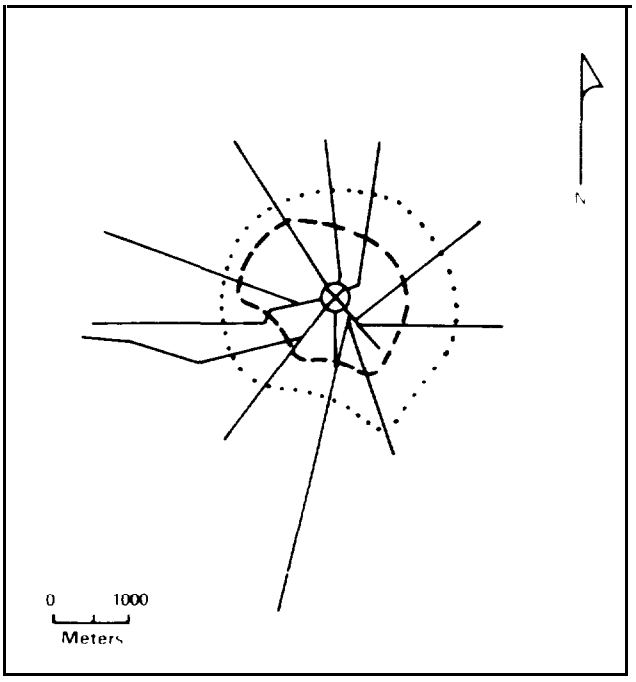
Figure 5-2: INITIAL SURVEY FOR SHOT WILSON, 18 JUNE 1957, MID-TIME 0639



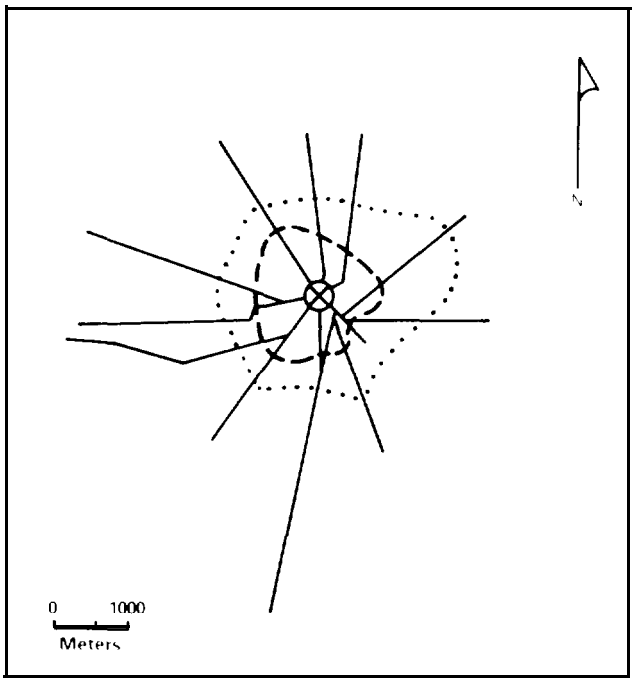
18 June 1957, Mid-Time: 1131



19 June 1957, Mid-Time: 0526



20 June 1957, Mid-Time: 0523



21 June 1957, Mid-Time: 0524

Stake Lines
0 01 R'h
0 1R/h
10R/h

Figure 5-3: SUBSEQUENT SURVEYS FOR SHOT WILSON

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The BOLTZMANN through WILSON volume was completed after the publication of the series volume. References 6-10, 20, 44, 49, and 68 do not appear in the PLUMBBOB series 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 reference list was prepared. It 1s anticipated that many of the documents marked unavailable mav become available during the declassification review process. The following addresses are being provided for that purpose.

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San Francisco, CA
ATTN: Director

Veterans Administration-RO
Denver, CO
ATTN: Director

Veterans Administration-RO
Hartford, CT
ATTN: Director

Veterans Administration-RO
Wilmington, DE
ATTN: Director

Veterans Administration-OFC Central
Washington, D. C.
ATTN: Dept Veterans Benefit, Central Ofc
ATTN: Director
ATTN: Board of Veteran Appeal

Veterans Administration-RO
St. Petersburg, FL
ATTN: Director

Veterans Administration-RO
Atlanta, GA
ATTN: Director

Veterans Administration-RO
Honolulu, HI
ATTN: Director

Veterans Administration-RO
Chicago, IL
ATTN: Director

Veterans Administration-RO
Seattle, WA
ATTN: Director

Veterans Administration-RO
Indianapolis, IN
ATTN: Director

Veterans Administration-RO
Des Moines, IA
ATTN: Director

Veterans Administration-RO
Wichita, KS
ATTN: Director

Veterans Administration-RO
Louisville, KY
ATTN: Director

Veterans Administration-RO
New Orleans, LA
ATTN: Director

Veterans Administration-RO
Togus, ME
ATTN: Director

Veterans Administration-RO
Baltimore, MD
ATTN: Director

Veterans Administration-RO
Boston, MA
ATTN: Director

Veterans Administration-RO
St. Paul. MN
ATTN: Director

Veterans Administration-RO
Jackson, MS
ATTN: Director

Veterans Administration-RO
Huntington, WV
ATTN: Director

Veterans Administration-RO
St. Louis, MO
ATTN: Director

Veterans Administration-RO
Ft. Harrison, MT
ATTN: Director

National Archives
ATTN: Librn

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Lincoln, NE
ATTN: Director

Veterans Administration-RO
Reno, NV
ATTN: Director

Veterans Administration-RO
Manchester, NH
ATTN: Director

Veterans Admlnistration-RO
Newark, NJ
ATTN. Director

Veterans Administration-RO
Milwaukee, WI
ATTN: Director

Veterans Administration-RO
Albuquerque, NM
ATTN. Director

Veterans Admlnlstration-RO
Buffalo, NY
ATTN: Director

Veterans Administration-RO
New York, NY
ATTN: Director

Veterans Adminlstratlon-RO
Winston-Salem, NC
ATTN: Director

Veterans Administration-RO
Fargo, ND
ATTN: Director

Veterans Admlnlstration-RO
Cleveland, OH
ATTN· Director

Veterans Administration-RO
Muskogee, OK
ATTN: Director

Veterans Admlnlstration-RO
Portland, OR
ATTN: Director

Veterans Administration-RO
Pittsburgh, PA
ATTN: Director

Veterans Administration-RO
Philadelphia, PA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
San Juan, Puerto Rico
ATTN. Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Columbia, SC
ATTN: Director

Veterans Administration-RO
Sioux Falls, SD
ATTN: Director

Veterans Administration-RO
Houston, TX
ATTN: Director

Veterans Administration-RO
Waco, TX
ATTN: Director

Veterans Administration-RO
Salt Lake City, UT
ATTN: Director

Veterans Admlnistraiton-RO
White River Junction, VT
ATTN: Director

Veterans Administration-RD
Roanoke, VA
ATTN: Director

Veterans Admlnlstration-RO
Cheyenne, WY
ATTN. Director

Veterans Administration-RO
San Diego, CA
ATTN: Director

Veterans Administration-RO
Boise, ID
ATTN. Director

Veterans Administration-RO
Detroit, MI
ATTN. Director

Veterans Administration-RO
Nashville, TN
ATTN. Director

The White House
ATTN. Domestic Policy Staff

DEPARTMENT OF ENERGY CONTRACTORS

Lawrence Liver-more National Lab
ATTN: Tech Info Dept Library

Los Alamos National Lab
ATTN: Library
ATTN: ADPA MMS 195

Sandia National Lab
ATTN. W. Hereford
ATTN Central Library

Reynolds Electrical & Engr Co., Inc
ATTN CIC
ATTN. W. Brady

OTHER

Adams State College
ATTN: Librn

Akron Public Library
ATTN: Librn

Alabama State Dept of Archives & History
ATTN: Military Records Div

University of Alabama
ATTN: Reference Dept, Dralier 3
ATTN: Director of Libraries (Reg)

University of Alaska Library at Anchorage
ATTN. Librn

University of Alaska
ATTN: Dir of Libraries

Albany Public Library
ATTN: Librn

Alexander City State Jr College
ATTN: Librn

Allegheny College
ATTN: Librn

Allen County Public Library
ATTN. Librn

Altoona Area Public Library
ATTN: Librn

American Statistics Index
Congressional Info Service, Inc
ATTN: Cathy Jarvey

Anaheim Public Library
ATTN: Librn

College of Wooster
ATTN: Gov Docs

Angelo State University Library
ATTN: Librn

Angelo Iacoboni Public Library
ATTN: Librn

Anoka County Library
ATTN: Librn

Appalachian State Unlverslty
ATTN. Library Docs

Arizona State University Library
ATTN: Librn

University of Arizona
ATTN: Gov Doc Dept/C. Bower

Arkansas College Library
ATTN: Library

Brooklyn College
ATTN. Doc Div

OTHER (Continued)

Arkansas Library Comm
ATTN: Library

Arkansas State University
ATTN: Library

University of Arkansas
ATTN: Gov Docs Div

Austin College
ATTN: Librn

Atlanta Public Library
ATTN: Ivan Allen Dept

Atlanta University
ATTN: Librn

Auburn University Library at Mongomery (Reg)
ATTN: Librn

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

Bangor Public Library
ATTN: Librn

Bates College Library
ATTN. Librn

Baylor University Library
ATTN: Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

State University College
ATTN: Gov Docs

Akron University
ATTN: Gov Docs

Boston Public Library (Reg)
ATTN: Docs Dept

Bowdoin College
ATTN: Librn

Bowling Green State University
ATTN: Lib Gov Docs Services

Bradley University
ATTN: Librn

Brandeis University Library
ATTN. Docs Section

Brigham Young University
ATTN: Librn

Brigham Young University
ATTN: Docs Collection

Brookhaven National Laboratory
ATTN: Tech Library

OTHER (Continued)

Broward County Library Sys
ATTN Librn

Brown University
ATTN: Librn

Bucknell University
ATTN: Reference Dept

Buffalo & Erie Co Public Library
ATTN: Librn

State University Library of California at Fresno
ATTN. Library

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

University of Callfornia at San Diego
ATTN Docs Dept

State College Library of California at Stanislaus
ATTN. Library

California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Llbrn

California State Unlverslty at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Llbrn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Llbrn

California University Library
ATTN: Gov Docs Dept

California Unlverslty Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN. Librn

Kearney State College
ATTN: Gov Docs Dept

Cambria County Library Sys
ATTN: Librn

Carleton College Library
ATTN: Librn

OTHER (Continued)

Carnegie Library of Pittsburgh
ATTN: Llbrn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Llbrn

Casper College
ATTN. Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Missouri State Univ
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN. Librn

Charleston County Library
ATTN. Librn

Charlotte & Mechlenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Llbrn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

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

Cincinnati University Library
ATTN: Librn

Citadel, Daniel Library
ATTN: Llbrn

Claremont Colleges Libraries
ATTN. Doc Collection

Clemson University
ATTN- Dir of Libraries

OTHER (Continued1

Cleveland Public Library
ATTN: Docs Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: Docs Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: Docs Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

University of North Carolina at Asheville
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

OTHER (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College So Cpus
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: Docs Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN. Librn

Burlington Library
ATTN. Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: Docs Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN. Librn

East Islip Public Library
ATTN: Librn

OTHER (Continued)

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

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN. Librn

Eastern Kentucky University
ATTN. Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Oocs Dept

Eastern New Mexico University
ATTN. Llbrn

Eastern Oregon College Library
ATTN. Librn

Eastern Washington University
ATTN. Llbrn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTY: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN. Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN. Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: Docs Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Dir of Library (Reg)
ATTN: Docs Dept

Fond Du Lac Public Library
ATTN: Librn

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

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Llbrn

Gardner Webb College
ATTN. Docs Library

Gary Public Library
ATTN: Librn

Geauga Cty Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Llbrn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN. Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Grinnell College Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN. Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

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

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN. Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

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

University of Illinois Library
ATTN. Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

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

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN:: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN. Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN Librn

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

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN. Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN. Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

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

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

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

Kenyon College Library
ATTN. Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Lewis University Library
ATTN: Librn

Library and Statutory Dist & Svc
2 cy ATTN. Librn

Earlham College
ATTN. Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

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

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

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN. Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Manchester City Library
ATTN: Llbrn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Llbrn

Principia College
ATTN: Librn

University of Maryland
ATTN. McKeldin Library Docs Div

University of Maryland
ATTN. Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
ATTN: Librn

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

Memphis State University
ATTN: Librn

Mercer University
ATTN. Librn

Mesa County Public Library
ATTN: Librn

Miami Dade Community College
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
ATTN: Librn

Murray State University Library
ATTN: Lib

OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN. Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN. Librn

Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Llbrn

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: Llbrn

Natrona County Public Library
ATTN: Llbrn

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: Llbrn

New Mexico State Library
ATTN Llbrn

New Mexico State University
ATTN. Lib Docs Div

University of Yew 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. Llbrn

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 Llbrn

OTHER (Continued)

State University of New York
ATTN. Librn

New York State University
ATTN: Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Llbrn

Niagara Falls Public Library
ATTN Llbrn

Nicholls State University Library
ATTN Docs Div

Nieves M Flores Memorial Library
ATTN. Llbrn

Norfolk Public Library
ATTN R. Parker

North Carolina Agricultural & Tech State University
ATTN Llbrn

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

University Library of North Carolina at Greensboro
ATTN. Llbrn

University of North Carolina at Wilmington
ATTN Librn

North Carolina Central Unlverslty
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 cf Emergency Svcs
ATTN Librn

OTHER (Continued)

Northeast Missouri State University
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
ATTN: Gov Docs Dept

Northern Illinois University
ATTN: Librn

Northern Michigan University
ATTN: Docs

Northern Montana College Library
ATTN: Librn

Northwestern Michigan College
ATTN. Librn

Northwestern State University
ATTN. Librn

Northwestern State University Library
ATTN: Librn

Northwestern University Library
ATTN: Gov Pubs Dept

Norwalk Public Library
ATTN: Librn

Northeastern Illinois University
ATTN: Library

University of Notre Dame
ATTN: Doc Ctr

Oakland Community College
ATTN. Librn

Oakland Public Library
ATTN: Librn

Oberlin College Library
ATTN: Librn

Ocean County College
ATTN: Librn

Ohio State Library
ATTN. Librn

Ohio State University
ATTN: Lib Docs Div

Ohio University Library
ATTN. Docs Dept

Oklahoma City University Library
ATTN: Librn

Oklahoma City University Library
ATTN. Librn

OTHER (Continued)

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

University of Oklahoma
ATTN: Docs Div

Old Dominion University
ATTN: Doc Dept Univ Lib

Olivet College Library
ATTN: Librn

Omaha Public Library Clark Branch
ATTN: Librn

Onondaga County Public Library
ATTN: Gov Docs Sec

Oregon State Library
ATTN: Librn

University of Oregon
ATTN: Oocs Sec

Ouachita Baptist University
ATTN: Librn

Pan American University Library
ATTN: Librn

Passaic Public Library
ATTN. Librn

Queens College
ATTN: Docs Dept

Pennsylvania State Library
ATTN: Gov Pubs Sec

Pennsylvania State University
ATTN: Lib Doc Sec

University of Pennsylvania
ATTN: Dir of Libraries

University of Denver
ATTN: Penrose Library

Peoria Public Library
ATTN: Business, Science & Tech Dept

Free Library of Philadelphia
ATTN: Gov Pubs Dept

Philipsburg Free Public Library
ATTN: Library

Phoenix Public Library
ATTN: Librn

University of Pittsburgh
ATTN: Docs Office, G8

Plainfield Public Library
ATTN: Librn

OTHER (Continued)

Popular Creek Public Library District
ATTN: Librn

Association of Portland Library
ATTN. Librn

Portland Public Library
ATTN: Librn

Portland State University Library
ATTN: Librn

Pratt Institute Library
ATTN: Librn

Louisiana Tech University
ATTN Librn

Princeton University Library
ATTN Oocs Div

Providence College
ATTN: Librn

Providence Public Library
ATTN: Librn

Public Library Cincinnati & Hamilton County
ATTN: Librn

Public Library of Nashville and Davidson County
ATTN: Librn

University of Puerto Rico
ATTN. Doc & Maps Room

Purdue University Library
ATTN: Librn

Quinebaug Valley Community College
ATTN Librn

Auburn University
ATTN. Microforms & Docs Dept

Rapid City Public Library
ATTN: Librn

Reading Public Library
ATTN: Librn

Reed College Library
ATTN. Librn

Augusta College
ATTN: Librn

University of Rhode Island Library
ATTN: Gov Pubs Ofc

University cf Rhode Island
ATTN: Dir of Libraries

Rice University
ATTN: Dir of Libraries

Louisiana College
ATTN: Librn

OTHER (Continued)

Richland County Public Library
ATTN: Librn

Riverside Public Library
ATTN: Librn

University of Rochester Library
ATTN Docs Sec

University of Rutgers Camden Library
ATTN Librn

State University of Rutgers
ATTN· Librn

Rutgers University
ATTN Dir of Libraries (Reg)

Rutgers University Law Library
ATTN: Fed Docs Dept

Salem College Library
ATTN. Librn

Samford University
ATTN. Librn

San Antonio Public Library
ATTN. Bus Science & Tech Dept

San Diego County Library
ATTN. C. Jones, Acquisitions

San Diego Public Library
ATTN. Librn

San Diego State University Library
ATTN Gov Pubs Dept

San Francisco Public Library
ATTN Gov Docs Dept

San Francisco State College
ATTN: Gov Pubs Coll

San Jose State College Library
ATTN: Docs Dept

San Luis Obispo City-County Library
ATTN. Librn

Savannah Public & Effingham Liberty Regional Library
ATTN. Librn

Scottsbluff Public Library
ATTN: Librn

Scranton Public Library
ATTN: Librn

Seattle Public Library
ATTN. Ref Docs Asst

OTHER (Continued1

Selby Public Library
ATTN: Librn

Shawnee Library System
ATTN: Llbrn

Shreve Memorial Library
ATTN: Librn

Silas Bronson Public Library
ATTN Librn

SIOUX City Public Library
ATTN. Librn

Skidmore College
ATTN. Librn

Slippery Rock State College Library
ATTN: Librn

South Carolina State Library
ATTN Librn

University of South Carolina
ATTN: Llbrn

University of South Carolina
ATTN. Gov Docs

South Dakota School of Mines & Technical Library
ATTN. Llbrn

South Dakota State Library
ATTN. Fed Docs Dept

University of South Dakota
ATTN: Docs Llbrn

South Florida University Library
ATTN: Llbrn

Southeast Missouri State University
ATTN Librn

Southeastern Massachusetts University Library
ATTN: Docs Sec

University of Southern Alabama
ATTN Librn

Southern California University Library
ATTN: Docs Dept

Southern Connecticut State College
ATTN: Library

Southern Illinois University
ATTN: Llbrn

Southern Illinois University
ATTN: Docs Ctr

Southern Methodist University
ATTN: Llbrn

University of Southern Mississippi
ATTN. Library

OTHER (Continued)

Southern Oregon College
ATTN: Library

Southern University in New Orleans Library
ATTN: Librn

Southern Utah State College Library
ATTN: Docs Dept

Southwest Missouri State College
ATTN: Library

University of Southwestern Louisiana Libraries
ATTN: Librn

Southwestern University
ATTN: Librn

Spokane Public Library
ATTN: Ref Dept

Springfield City Library
ATTN: Docs Sec

St Bonaventure University
ATTN: Librn

St Joseph Public Library
ATTN. Librn

St Lawrence University
ATTN. Librn

St Louis Public Library
ATTN. Librn

St Paul Public Library
ATTN. Librn

Stanford University Library
ATTN Gov Docs Dept

State Historical Soc Library
ATTN. Docs Serials Sec

State Library of Massachusetts
ATTN. Librn

State University of New York
ATTN: Librn

Stetson University
ATTN. Librn

University of Steubenville
ATTN. Librn

Stockton & San Joaquin Public Library
ATTN. Llbrn

Stockton State College Library
ATTN Librn

Albion College
ATTN Gov Docs Llbrn

OTHER (Continued)

Superior Public Library
ATTN: Librn

Swarthmore College Library
ATTN: Ref Dept

Syracuse University Library
ATTN: Docs Div

Tacoma Public Library
ATTN: Librn

Hillsborough County Public Library at Tampa
ATTN: Librn

Temple University
ATTN: Llbrn

Tennessee Technological University
ATTN. Llbrn

University of Tennessee
ATTN: Dir of Libraries

College of Idaho
ATTN. Librn

Texas A & M University Library
ATTN: Librn

University of Texas at Arlington
ATTN Library Docs

University of Texas at San Antonio
ATTN. Library

Texas Christian University
ATTN. Librn

Texas State Library
ATTN. U.S. Docs Sec

Texas Tech University Library
ATTN: Gov Docs Dept

Texas University at Austin
ATTN. Docs Coll

University of Toledo Library
ATTN. Llbrn

Toledo Public Library
ATTN. Social Science Dept

Torrance Civic Center Library
ATTN. Librn

Traverse City Public Library
ATTN. Librn

Trenton Free Public Library
ATTN. Llbrn

Trinity College Library
ATTN. Librn

Trinity University Library
ATTN: Docs Coll

OTHER (Continued)

Tufts University Library
ATTN: Docs Dept

University of Tulsa
ATTN: Llbrn

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

Uniformed Services University of the Health Sciences
ATTN. LRC Library

University Libraries
ATTN. Dir of Lib

University of Maine at Oreno
ATTN. Llbrn

University of Northern Iowa
ATTN Library

Upper Iowa College
ATTN: Docs Coll

Utah State University
ATTN. Librn

University of Utah
ATTN Special Collections

University of Utah
ATTN. Dir of Library

Utica Public Library
ATTN: Llbrn

Valencia Library
ATTN: Librn

Valparaiso University
ATTN. Llbrn

Vanderbilt University Library
ATTN. Gov Docs Sec

University of Vermont
ATTN: Dir of Libraries

Virginia Commonwealth University
ATTN: Llbrn

Virginia Military Institute
ATTN: Llbrn

Virginia Polytechnic Institute Library
ATTN: Docs Dept

Virginia State Library
ATTN Serials Sec

University of Virginia
ATTN. Pub Docs

Volusia County Public Library
ATTN: Librn

OTHER (Continued)

Washington State Library
ATTN: Docs Sec

Washington State University
ATTN: Lib Docs Sec

Washington University Libraries
ATTN: Dir of Lib

University of Washington
ATTN. Docs Div

Wayne State University Library
ATTN: Llbrn

Wayne State University Law Library
ATTN: Docs Dept

Weber State College Library
ATTN: Llbrn

Wesleyan University
ATTN: Docs Librn

West Chester State College
ATTN: Docs Dept

West Covina Library
ATTN: Llbrn

University of West Florida
ATTN: Llbrn

West Georgia College
ATTN: Llbrn

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: Llbrn

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: Llbrn

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: Llbrn

University of Wyoming
ATTN: Docs Div

Yale University
ATTN: Dir of Libraries

Yeshiva University
ATTN: Llbrn

Yuma City County Library
ATTN: Librn

Simon Schwob Mem Lib, Columbus Col
ATTN. Librn

DEPARTMENT OF DEFENSE CONTRACTORS

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