

**OPERATIONS  
FLINTLOCK AND LATCHKEY**

**EVENTS**

**RED HOT, PIN STRIPE, DISCUS  
THROWER, PILE DRIVER, DOUBLE  
PLAY, NEWPOINT, MIDI MIST**

**5 MARCH 1966-26 JUNE 1967**

**United States Underground Nuclear Weapons Tests  
Underground Nuclear Test Personnel Review**

**Prepared by Field Command, Defense Nuclear Agency**

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) This report is a personnel-oriented history of DOD participation in underground nuclear weapons testing during Operations FLINTLOCK and LATCHKEY, test events RED HOT, PIN STRIPE, DISCUS THROWER, PILE DRIVER, DOUBLE PLAY, NEW POINT, and MIDI MIST, from 5 March 1966 to 26 June 1967. It is the second in a series of historical reports which will include all DOD underground nuclear weapons tests and all DOE underground nuclear weapons tests with significant DOD participation from 1962 forward. In addition to these historical volumes, a later restricted distribution volume will identify all DOD participants (military, civilian, and civilian contractors) and will list their radiation dosimetry data.			
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18. SUBJECT TERMS (Continued)

Nevada Test Site (NTS)	DOUBLE PLAY	MIDI MIST
Underground Test (UGT)	PIN STRIPE	LATCHKEY
DISCUS THROWER	FLINTLOCK	RED HOT
PILE DRIVER	NEW POINT	

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## SUMMARY

Seven Department of Defense (DOD)-sponsored underground test events were conducted from 5 March 1966 to 26 June 1967 to study weapons effects. Three were shaft-type and four were tunnel-type nuclear tests. The following table summarizes data on these events:

OPERATION	FLINTLOCK					LATCHKEY	
TEST EVENT	<i>RED HOT</i>	<i>PIN STRIPE</i>	<i>DISCUS THROWER</i>	<i>PILE DRIVER</i>	<i>DOUBLE PLAY</i>	<i>NEW POINT</i>	<i>MIDI MIST</i>
DATE	5 MAR 66	25 APR 66	27 MAY 66	2 JUN 66	15 JUN 66	13 DEC 66	26 JUN 67
LOCAL TIME (hours)	1015 PST	1138 PDT	1300 PDT	0830 PDT	1000 PDT	1300 PST	0900 PDT
NTS LOCATION	AREA 12	AREA 11	AREA 8	AREA 15	AREA 16	AREA 11	AREA 12
TYPE	TUNNEL	SHAFT	SHAFT	TUNNEL	TUNNEL	SHAFT	TUNNEL
DEPTH (feet)	1,330	970	1,105	1,518	1,076	825	1,230
YIELD (kilotons)	LOW*	LOW*	22	62	LOW*	LOW*	LOW*

\* INDICATES LESS THAN 22 KILOTONS

Releases of radioactivity to the atmosphere were detected both onsite and offsite after RED HOT (tunnel-type), PIN STRIPE (shaft-type), DOUBLE PLAY (tunnel-type), and MIDI MIST (tunnel-type). Releases of radioactivity were detected only within the confines of the Nevada Test Site (NTS) after the PILE DRIVER (tunnel-type) event. No release of radioactivity was detected onsite or offsite after the DISCUS THROWER (shaft-type) and NEW POINT (shaft-type) test events.

As recorded on Area Access Registers, 15,443 individual entries to radiation exclusion areas were made after the above DOD test events. Of this number 1,259 were by DOD-affiliated personnel (including military personnel, DOD civil servants, and DOD contractor personnel). The remainder were United States Atomic Energy Commission (AEC), other government agency, and contractor personnel.

The average gamma radiation exposure per entry for all personnel was 33 mR. The average gamma radiation exposure per entry for DOD-affiliated personnel was 83 mR. The maximum exposure of a non-DOD individual during an entry was 1,955 mR. The maximum exposure of a DOD-affiliated individual was 1,855 mR. These exposures occurred on 15 December 1966 during reentry and recovery operations after the NEW POINT event.

## PREFACE

The United States Government conducted 194 nuclear device tests from 1945 through 1958 during atmospheric test series at sites in the United States and in the Atlantic and Pacific Oceans. The United States Army Manhattan Engineer District implemented the testing program in 1945, and its successor agency, the AEC, administered the program from 1947 until testing was suspended by the United States on 1 November 1958.

Of the 194 nuclear device tests conducted, 161 were for weapons development or effects purposes, and 33 were safety experiments. An additional 22 nuclear experiments were conducted from December 1954 to February 1956 in Nevada. These experiments were physics studies using small quantities of fissionable material and conventional explosives.

President Eisenhower had proposed that test ban negotiations begin on 31 October 1958, and had pledged a one-year moratorium on United States testing to commence after the negotiations began. The Conference on Discontinuance of Nuclear Weapons Tests began at Geneva on 31 October 1958; the U.S. moratorium began on 1 November, and the AEC detected the final Soviet nuclear test of their fall series on 3 November 1958. Negotiations continued until May 1960 without final agreement. No nuclear tests were conducted by either nation until 1 September 1961 when the Soviet Union resumed nuclear testing in the atmosphere. The United States began a series of underground tests in Nevada on 15 September 1961, and U.S. atmospheric tests were resumed on 25 April 1962 in the Pacific.

The United States conducted several atmospheric tests in

Nevada during July 1962, and the last United States atmospheric nuclear test was in the Pacific on 4 November 1962. The Limited Test Ban Treaty, which prohibited tests in the atmosphere, in outer space, and underwater was signed in Moscow on 5 August 1963. From resumption of United States atmospheric testing on 25 April 1962 until the last atmospheric test on 4 November 1962, 40 weapons development and weapons effects tests were conducted as part of the Pacific and Nevada atmospheric test operations. The underground tests, resumed on 15 September 1961, have continued on a year-round basis through the present time.

In 1977, 15 years after atmospheric testing stopped, the Center for Disease Control (CDC)\* noted a possible leukemia cluster within the group of soldiers who were present at the SMOKY test event, one of the Nevada tests in the 1957 PLUMBBOB test series. After that CDC report, the Veterans Administration (VA) received a number of claims for medical benefits filed by former military personnel who believed their health may have been affected by their participation in the nuclear weapons testing program.

In late 1977, the DOD began a study to provide data for both the CDC and the VA on radiation exposures of DOD military and civilian participants in atmospheric testing. That study has progressed to the point where a number of volumes describing DOD participation in atmospheric tests have been published by the Defense Nuclear Agency (DNA) as the executive agency for the DOD.

On 20 June 1979, the United States Senate Committee on Veterans' Affairs began hearings on Veterans' Claims for Dis-

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\*The Center for Disease Control was part of the U.S. Department of Health, Education, and Welfare (now the U.S. Department of Health and Human Services). It was renamed The Centers for Disease Control on 1 October 1980.

abilities from Nuclear Weapons Testing. In addition to requesting and receiving information on DOD personnel participation and radiation exposures during atmospheric testing, the Chairman of the Senate Committee expressed concern regarding exposures of DOD participants in DOD-sponsored and Department of Energy (DOE)\* underground test events.

The Chairman requested and received information in an exchange of letters through 15 October 1979 regarding research on underground testing radiation exposures. In early 1980, the DNA initiated a program to acquire and consolidate underground testing radiation exposure data in a set of published volumes similar to the program underway on atmospheric testing data. This volume is the second of several volumes regarding the participation and radiation exposures of DOD military and civilian personnel in underground nuclear test events.

#### SERIES OF VOLUMES

Each volume of this series will discuss DOD-sponsored underground test events, in chronological order, after presenting introductory and general information. The volumes will cover all underground test events identified as DOD-sponsored in Announced United States Nuclear Tests, published each year by the DOE Nevada Operations Office, Office of Public Affairs, except events conducted as nuclear test detection experiments where reentries and, subsequently, exposure of participants to radiation did not occur.

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\*The U.S. Department of Energy succeeded the U.S. Energy Research and Development Administration (ERDA) in October 1977. ERDA had succeeded the U.S. Atomic Energy Commission on 19 January 1975.

An additional volume will discuss general participation of DOD personnel in DOE-sponsored underground test events, with specific information on those events which released radioactive effluent to the atmosphere and where exposures of DOD personnel were involved.

A separate volume will be a census of DOD personnel and their radiation exposure data. Distribution of this volume will necessarily be limited by provisions of the Privacy Act.

#### METHODS AND SOURCES USED TO PREPARE THE VOLUMES

Information for these volumes was obtained from several locations. Security-classified documents were researched at Headquarters, DNA, Washington, DC. Additional documents were researched at Field Command, DNA, the Air Force Weapons Laboratory Technical Library, and Sandia National Laboratories in Albuquerque, New Mexico. Most of the radiation measurement data were obtained at the DOE, Nevada Operations Office (DOE/NV), and its support contractor, the Reynolds Electrical & Engineering Company, Inc. (REECO), in Las Vegas, Nevada.

Unclassified records were used to document underground testing activities when possible, but, when necessary, unclassified information was extracted from security-classified documents. Both unclassified and classified documents are cited in the List of References at the end of each volume. Locations of the reference documents also are shown. Copies of most of the unclassified references have been entered in the records of the Coordination and Information Center (CIC), a DOE facility located in Las Vegas, Nevada.

Radiation measurements, exposure data, event data, and off-site reports generally are maintained as hard copy or microfilm

at the REECO facilities adjacent to the CIC, or as original hard copy at the Federal Archives and Records Center, Laguna Niguel, California. A master file of all available personnel exposure data for nuclear testing programs on the continent and in the Pacific from 1945 to the present also is maintained by REECO for DOD and DOE.

#### ORGANIZATION OF THIS VOLUME

A Summary of this test event volume appears before this Preface and includes general objectives of the test events, characteristics of each test event, and data regarding DOD participants and their radiation exposures.

An Introduction following this Preface discusses reasons for conducting nuclear test events underground, the testing organization, the NTS, and locations of NTS underground testing areas.

A chapter entitled Underground Testing Procedures explains the basic mechanics of underground testing, purposes of effects experiments, containment features and early containment problems, tunnel and shaft area access requirements, industrial safety and radiological safety procedures, telemetered radiation exposure rate measurements, and air support for underground tests.

A chapter on each test event covered by the volume follows in chronological order. Each test event chapter contains an event summary, a discussion of preparations and event operations, an explanation of safety procedures implemented, and listings of monitoring, sampling, and exposure results.

Following the event chapters are a Reference List and appendices to the text including a Glossary of Terms and a list of Abbreviations and Acronyms.

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## CHAPTER 1

### INTRODUCTION

The first United States nuclear detonation designed to be fully contained underground was the RAINIER tunnel event conducted in Nevada on 19 September 1957. This was a weapons related experiment with a relatively low yield of 1.7 kilotons (kt). The second tunnel event was a safety experiment on 22 February 1958 also conducted in Nevada. This experiment, the VENUS event, resulted in a yield less than one ton. These two tests were the beginning of a United States underground program that is currently the only method of testing permitted by treaty.

#### 1.1 HISTORICAL BACKGROUND

While technical conferences between the United States and the Soviet Union on banning nuclear detonation tests continued, and concern regarding further increases in worldwide fallout mounted, a number of nuclear tests were conducted underground during 1958 in Nevada. Prior to the United States testing moratorium, six safety experiments in shafts, five safety experiments in tunnels, and four weapons development tests in tunnels were conducted.

However, radioactive products from several of these tests were not completely contained underground. Containment of nuclear detonations was a new engineering challenge. Fully understanding and solving containment problems would require years of underground testing experience.

When the United States resumed testing 15 September 1961, 32 of the first 33 test events were underground and the other was a

cratering experiment with the device emplaced 110 feet below the surface. The DOMINIC I test series in the Pacific and the DOMINIC II test series in Nevada during 1962 were the last atmospheric nuclear detonation tests by the United States.

The commitment of the United States to reduce levels of worldwide fallout by refraining from conducting nuclear tests in the atmosphere, in outer space, and underwater was finalized when the Limited Test Ban Treaty with the Soviet Union was signed on 5 August 1963.

## 1.2 UNDERGROUND TESTING OBJECTIVES

The majority of United States underground tests have been for weapons development purposes. New designs were tested to improve efficiency and deliverability characteristics of nuclear explosive devices before they entered the military stockpile as components of nuclear weapons.

Safety experiments with nuclear devices were conducted in addition to weapons development tests. These experiments tested nuclear devices by simulating detonation of the conventional high explosives in a manner which might occur in an accident during transportation or storage of weapons.

Weapons effects tests utilized device types equivalent to weapons, or actually to be used in weapons, to determine the effects of weapon detonations on structures, materials, and equipment. The devices generally were provided by one of the weapons development laboratories. However, the DOD sponsored weapons effects tests, and such tests usually involved greater numbers of participants and were more complex than the other categories of tests previously mentioned.

Effects of shock waves on rock formations, buildings, other structures, materials, and equipment have been tested. Effects of other detonation characteristics such as heat and radiation have been studied in the same manner. The most complex weapons effects tests have been those simulating high altitude detonations by using very large evacuated pipes hundreds of feet in length and containing experiments.

### 1.3 TEST EVENTS IN THIS VOLUME

Weapons effects tests conducted from 5 March 1966 to 26 June 1967 during Operation FLINTLOCK and Operation LATCHKEY are discussed in this volume. Test events and objectives are listed below.

1. RED HOT, 5 March 1966, to study ground shock.
2. PIN STRIPE, 25 April 1966, to study the effects of a nuclear detonation environment on equipment and materials.
3. DISCUS THROWER, 27 May 1966, to study ground shock transmission and characteristics in a specific type of geologic structure.
4. PILE DRIVER, 2 June 1966, to study nuclear detonation effects on underground structures.
5. DOUBLE PLAY, 15 June 1966, to investigate the effects of a nuclear detonation environment on equipment and materials.
6. NEW POINT, 13 December 1966, to determine the effects of a nuclear detonation environment on equipment and materials.

7. MIDI MIST, 26 June 1967, to investigate the effects of a nuclear detonation environment on equipment and materials.

#### 1.4 DOD TESTING ORGANIZATION AND RESPONSIBILITIES

Administering the underground nuclear testing program at NTS was a joint AEC-DOD responsibility. The parallel nature of the AEC-DOD organizational structure is shown in Figure 1.1.

##### 1.4.1 Responsibilities of the Defense Atomic Support Agency

The Armed Forces Special Weapons Project (AFSWP) was activated on 1 January 1947 (when the Atomic Energy Commission was activated) to assume residual functions of the Manhattan Engineer District. The DOD nuclear weapons testing organization was within AFSWP until 1959 when AFSWP became the Defense Atomic Support Agency (DASA)\*. The responsibilities of Headquarters, DASA, in Washington DC, included providing consolidated management and direction for the DOD nuclear weapons effects and nuclear weapons testing program. The technical direction and coordination of DOD nuclear weapons testing activities was delegated to Field Command, DASA (FCDASA) until 1 August 1966 and then to Test Command, DASA (TCDASA), headquartered in Albuquerque, New Mexico.

The responsibilities of FCDASA and TCDASA in 1966 and 1967 regarding DOD nuclear weapons testing activities were:

1. exercising technical direction of nuclear weapons effects tests of primary concern to the Armed Forces, and weapons effects phases of developmental or other tests of nuclear weapons involving detonations within the continental United States and overseas;

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\*DASA became the Defense Nuclear Agency (DNA) on 1 July 1971.

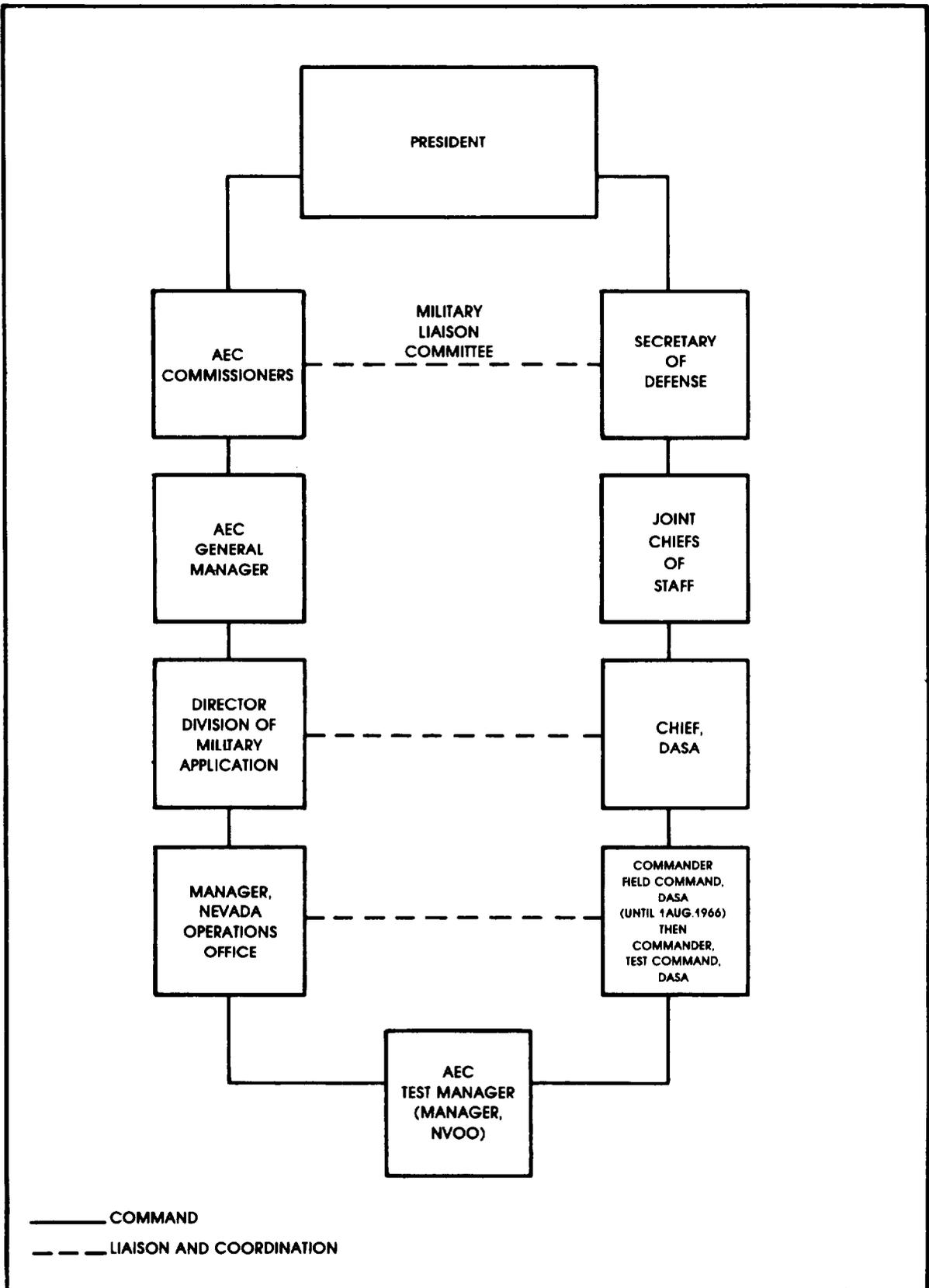


Figure 1.1 Federal Government Structure for Continental Nuclear Tests (During 1966)

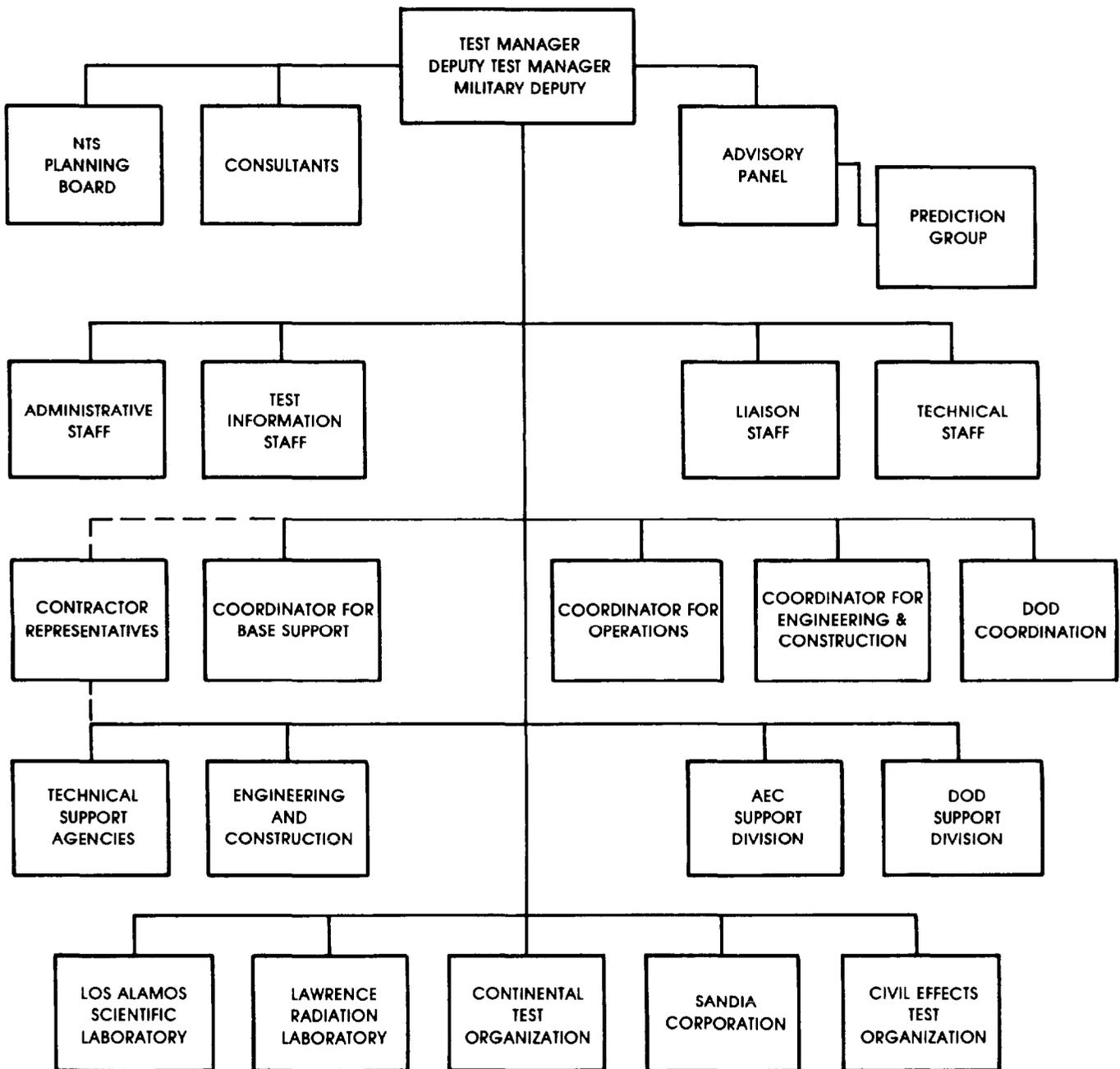
2. coordinating and supporting all DOD activities and assisting in the support of the AEC in the conduct of joint tests involving nuclear detonations within the continental United States;
3. completing detailed plans, preparing for and conducting technical programs, and assisting in the preparation of technical and operational reports on tests; and
4. coordinating military operational training, and the DOD aspects of official visitor and public information programs. (The official visitor and public information programs were integrated with the AEC organization during joint AEC-DOD continental tests).

These missions were accomplished for DOD underground nuclear tests through the Test Command Weapons Effects and Tests Group (TCWT), its predecessor, FCWT, and its Continental Test Organization (CTO).

The FCWT (and later TCWT) testing organization included Task Unit 8.1.3 for Pacific operations; administrative operations at Sandia Base in Albuquerque, New Mexico; and operations at the Nevada Test Site. The CTO conducted DOD underground nuclear tests in conjunction with the AEC weapons development laboratory test groups.

#### 1.4.2 Nevada Test Site Organization

In the joint AEC-DOD testing program, FCWT (later TCWT) and CTO were a part of the Nevada Test Site Organization (NTSO) as shown in Figure 1.2. The Military Deputy to the Test Manager was the Deputy Chief of Staff, TCWT, and TCWT personnel provided DOD coordination and support.



\_\_\_\_\_COMMAND  
 - - - - -LIAISON AND COORDINATION

Figure 1.2 Nevada Test Site Organization (In 1966)

The CTO was a Test Group along with the Los Alamos Scientific Laboratory (LASL), the Lawrence Radiation Laboratory (LRL), Sandia Corporation (SC), and the Civil Effects Test Organization (CETO). The CTO is shown in Figure 1.3. In addition to his position as Military Deputy to the Test Manager, the Deputy Chief of Staff, TCWT, was also the CTO Test Group Director.

The Programs Division was responsible for scientific programs conducted by the CTO. Engineering and construction of test facilities and experiment installations were administered by the Support Division. The Operations Division was responsible for preparing technical and operations plans, and coordinating air support operations with the Air Force Special Weapons Center (AFSWC), the Tactical Air Command, and the AEC.

#### 1.4.3 Air Force Special Weapons Center Support

The commander of AFSWC was requested by TCDASA to provide air support to the NTSO during nuclear tests at NTS. Direct support was provided by the Nuclear Test Directorate, the Special Projects Division, and the 4900th Air Base Group of AFSWC. The 4900th Air Base Group provided C-47 aircraft for shuttle service between Kirtland AFB, New Mexico, and Indian Springs AFB (ISAFB). The 4900th also provided U-3A aircraft and crews to perform low-altitude cloud tracking, and C-47 aircraft and crews for radio relay and courier missions.

Other Air Force organizations providing support to the NTSO under AFSWC control on a temporary basis were as follows:

1. Elements of the 1211th Test Squadron (Sampling), Military Air Transport Service, McClellan AFB, were detached to ISAFB. Their primary task was cloud sampling. This included maintaining the B-57 sampling aircraft, conducting cloud sampling, removing the sample filters, and

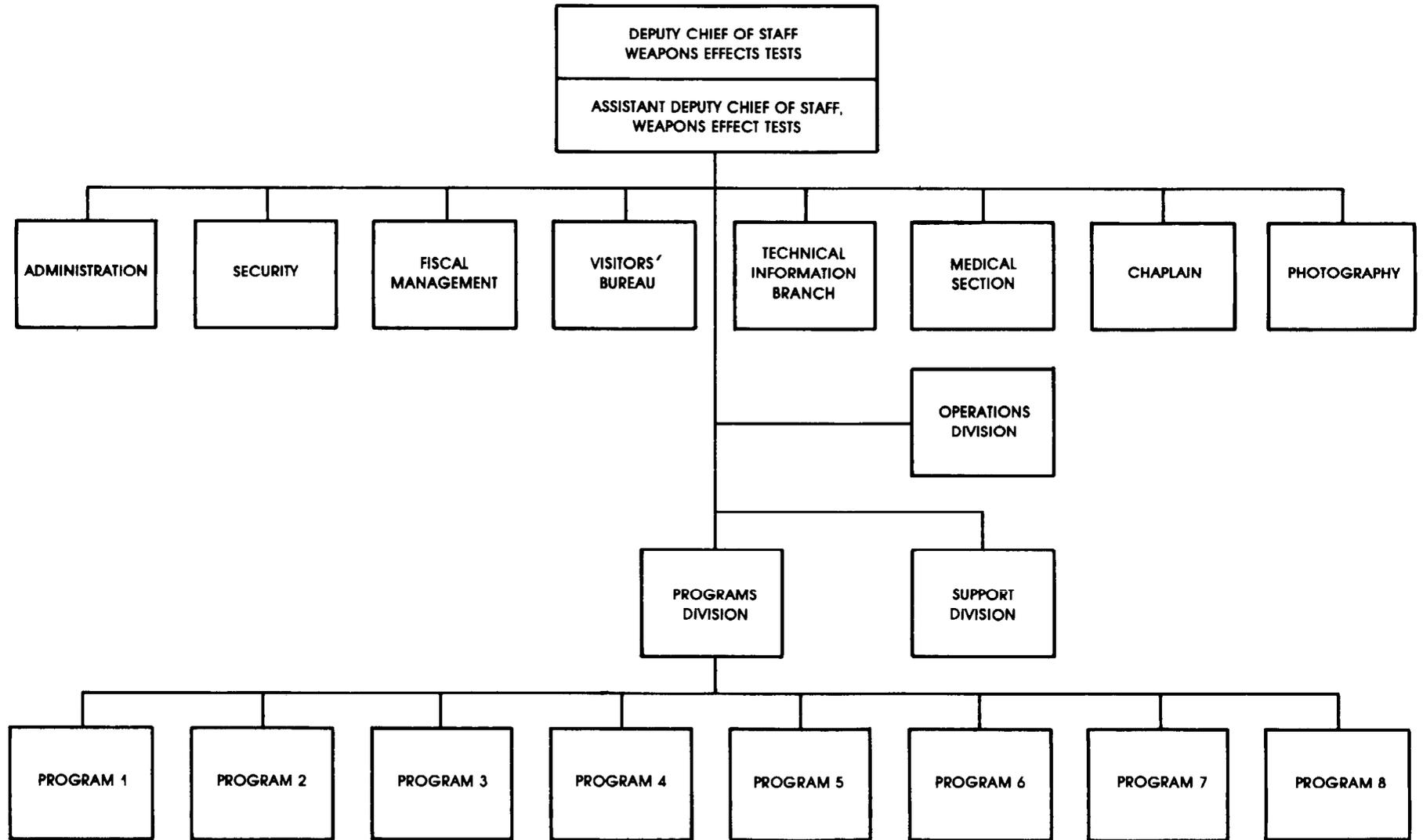


Figure 1.3 Continental Test Organization (In 1966)

packaging and loading the samples onto courier aircraft. Personnel from this unit also assisted NTSO radiological safety personnel in providing support at ISAFB, including decontamination of aircraft, crews, and equipment.

2. Elements of the 4520th Combat Crew Training Wing, Tactical Air Command, Nellis AFB, provided support functions, such as housing, food, and logistics, to the units operating from ISAFB and Nellis AFB. In addition, they conducted security sweep flights over NTS, and control tower operations, fire-fighting, and crash rescue services at ISAFB. They also maintained and provided equipment for the helicopter pad at the NTS Control Point and other helicopter pads at Forward Control Points.
3. The 55th Weather Reconnaissance Squadron, Military Air Transport Service, McClellan AFB, supplied one aircraft and a crew to perform high-altitude cloud tracking.
4. The Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson AFB, provided aircraft and crews to perform technical projects.

Complete Air Force support as described in this section was available for the DOD cratering event, DANNY BOY, discussed in Chapter 4 of the first volume of this series and during the last atmospheric nuclear weapons tests at NTS in July 1962. As the DOD underground testing program continued, and the probability of venting radioactive effluent to the atmosphere decreased, less cloud sampling and tracking support was required. However, air support for security sweeps of areas surrounding test locations and for photography missions during events was a continuing requirement.

## 1.5 RELATIONSHIP OF THE DOD, THE AEC, AND CONTRACTOR ORGANIZATIONS

The DOD was responsible for establishing nuclear weapons criteria, developing and producing delivery vehicles, obtaining military effects data, and defense against nuclear attack.

The AEC was responsible for development, production, and supply of nuclear weapons to the Armed Forces in quantities and types specified by the Joint Chiefs of Staff (JCS). The AEC, in association with the DOD, also was responsible for providing field nuclear test facilities in the continental United States and overseas.

### 1.5.1 Weapons Test Division (STWT, DASA) and the Nevada Operations Office (AEC/NVOO)

The principal points of field coordination between the AEC and the DOD were at Las Vegas and the Nevada Test Site. The STWT, DASA, represented the Director, DASA, and DOD; and the AEC/NVOO represented the AEC in the field for continental tests. Each of these organizations' primary interest was field testing of nuclear weapons. Daily close liaison was maintained between the STWT, DASA, and the AEC/NVOO during planning phases for field test programs of primary interest to the DOD.

During test operations, military and AEC personnel were combined into a single test organization. Normally, the senior member of the combined test organization was the Manager, NVOO. His deputy was the Director, Weapons Test Division, DASA. Other personnel in this joint test organization were selected from those available on a best-qualified basis. In accomplishing this, personnel were drawn not only from STWT and NVOO but from other agencies of DASA, the Armed Forces, military laboratories, military contractors, universities, civilian laboratories, AEC

laboratories, AEC contractors, other government agencies, and from other sources when special qualifications or knowledge were required.

The Nevada Test Site was an AEC installation. The Manager, NVOO, was responsible for operation of this installation. The DOD and the AEC laboratories were the principal users of the Test Site. The Weapons Test Division, DASA, was the single military agency and point of contact for the Manager, NVOO, for all matters pertaining to DOD field test programs, and supported all DOD agencies operating at the Test Site.

To accomplish these two major responsibilities, STWT, DASA, had an office, the Nevada Operations Branch (NOB), in the AEC Building in Las Vegas. The Nevada Operations Branch, STWT, DASA, maintained daily liaison with NVOO at the top management level on all DOD matters pertaining to field operations and had under its control the Nevada Test Site Section to support DOD agencies at the site. For DOD agencies, the office also provided a point of contact to assist in matters of interest with NVOO and to provide transportation and quarters in Las Vegas. All DOD personnel and DOD contractor personnel connected with nuclear field tests were under administrative control of this office while in Las Vegas and at the Nevada Test Site.

The Nevada Test Site Section coordinated activities and supported DOD agencies operating at the Test Site. This section was located at the DOD Compound in Mercury (see section 1.5) and provided office and laboratory space, transportation, test equipment, and logistical and administrative support.

#### 1.5.2 Test Organizations

Before 1957, the Test Director for each series had been a representative of the Los Alamos Scientific Laboratory. For the

1957 PLUMBBOB series, a staff member of the Lawrence Radiation Laboratory was appointed to the position, reflecting the growing participation by Lawrence Radiation Laboratory in test operations. After 1961, the Test Director for events of primary interest to the DOD was an officer from one of the Services. The Test Director was responsible for overall coordination and scientific support for the entire scientific test program; for planning and coordination; and for positioning, arming, and detonating test devices. Generally, the AEC weapons laboratories provided the nuclear devices for DOD test events.

Other officials of the joint test organization were responsible for various functions, such as logistical support, weather prediction, fallout prediction, blast prediction, air support, public information, radiological safety, industrial safety, and fire protection.

LOS ALAMOS SCIENTIFIC LABORATORY was established early in 1943 at Los Alamos, New Mexico, for the specific purpose of developing an atomic bomb. Los Alamos scientists supervised the test detonation of the world's first atomic weapon in July 1945 at the TRINITY site in New Mexico. The Laboratory's continuing assignment was to conceive, design, test, and develop nuclear components of atomic weapons. The Laboratory was operated by the University of California.

LAWRENCE RADIATION LABORATORY was established as a second AEC weapons laboratory at Livermore, California, in 1952. The Laboratory's responsibilities were essentially parallel to those of the Los Alamos Scientific Laboratory. Devices developed by LRL were first tested in Nevada in 1953, and they have been tested in each continental and Pacific series since. The contract under which the LRL performed work for the AEC was administered by the Commission's San Francisco Operations Office. This Laboratory also was operated by the University of California.

SANDIA LABORATORY (later Sandia Laboratories) at Sandia Base, Albuquerque, New Mexico, was the AEC's other weapons laboratory. It was established in 1946 as a branch of the Los Alamos Scientific Laboratory, but in 1949 it assumed its identity as a full-fledged weapons research institution operated by the Sandia Corporation, a non-profit subsidiary of Western Electric. Sandia Laboratory's role was to conceive, design, test, and develop the non-nuclear phases of atomic weapons and to do other work in related fields. In 1956, a Livermore Branch of the Laboratory was established to provide closer support to developmental work of the LRL. Sandia Corporation also operated ballistic test facilities for the AEC at the Tonopah Ballistics Range near Tonopah, Nevada.

DEFENSE ATOMIC SUPPORT AGENCY was located in Washington, D.C. and was composed of personnel of the Armed Services and civilian DOD employees. It was activated on 6 May 1959 to assume certain residual functions of the Manhattan Engineer District and to assure continuity of technical military interest in nuclear weapons. The broad mission of DASA was planning specified technical services to the Army, Navy, Air Force, and Marine Corps in the military application of nuclear energy. Among the services performed were maintaining liaison with the AEC laboratories in the development of nuclear weapons, planning and supervising the conduct of weapons effects tests and other field exercises, providing nuclear weapons training to military personnel, and storing and maintaining nuclear weapons. Early in the program for testing nuclear devices and weapons, DASA was charged with the responsibility for planning and integrating with the AEC for military participation in full scale tests. After the Nevada Test Site was activated, this planning responsibility was broadened to include conducting experimental programs of primary concern to the Armed Forces and coordinating other phases of military participation including assistance to the AEC. The Director, DASA, was responsible to the Joint Chiefs of Staff and the Secretary of Defense.

Weapons Test Division (STWT) at Sandia Base, New Mexico, carried out the weapon field testing responsibilities and seismic research responsibilities (VELA-UNIFORM) for the Director, DASA. This organization maintained close liaison with the AEC Nevada Operations Office. Personnel from the STWT became the military members of the Joint AEC-DOD test organization at the Nevada Test Site and other continental United States test areas. All participation of DOD agencies and their contractors in nuclear field tests was coordinated and supported by STWT.

Nevada Operations Branch (NOB) located in Las Vegas, Nevada, maintained daily liaison with the AEC/NVOO, and supervised the STWT Test Site Section at the Nevada Test Site. In addition to the continental test responsibilities, STWT provided key personnel for the military scientific test unit, and managed the technical and scientific programs for DOD agencies and contractors during overseas tests.

### 1.5.3 Support Contractors

In keeping with its policy, the Atomic Energy Commission utilized private contractors for maintenance, operation, and construction (including military and civil defense construction) at the Nevada Test Site. Personnel of the Nevada Operations Office administered all housekeeping, construction, and related services activity, but performance was by contractors. The major contractors were the following:

Reynolds Electrical & Engineering Company (REECo) was the principal AEC operational and support contractor for the NTS, performing community operations, housing, feeding, maintenance, construction, and scientific structures support services. REECo maintained offices in Las Vegas and extensive facilities at the NTS.

Edgerton, Germeshausen & Grier, Inc., (EG&G) of Boston, Massachusetts, was the principal technical contractor, providing control point functions such as timing and firing, and diagnostic functions such as scientific photography and measurement of detonation characteristics. EG&G facilities were maintained in Las Vegas and at the NTS.

Holmes & Narver, Inc., (H&N) performed architect-engineer services for the NTS and was the principal support contractor for the Commission's off-continent operations. H&N had a home office in Los Angeles, and also maintained offices in Las Vegas and at the NTS.

Fenix & Scisson (F&S) of Tulsa, Oklahoma, was the consultant for NTS drilling activities.

Numerous other contractors, selected on the basis of lump-sum competitive bids, performed various construction and other support functions for the AEC and the DOD.

## 1.6 THE NEVADA TEST SITE

An on-continent location was selected for conducting nuclear weapons tests, construction began at the Nevada Proving Ground (NPG) in December 1950, and testing began in January 1951. This testing area was renamed the Nevada Test Site in 1955.

The original NPG boundaries were expanded as new projects and testing areas were added. Figure 1.4 shows the present NTS location bounded on three sides by the Nellis Air Force Range. The area of NTS is about 1,350 square miles. The testing location was selected for both safety and security reasons. The arid climate, lack of industrialization, and exclusion of the public

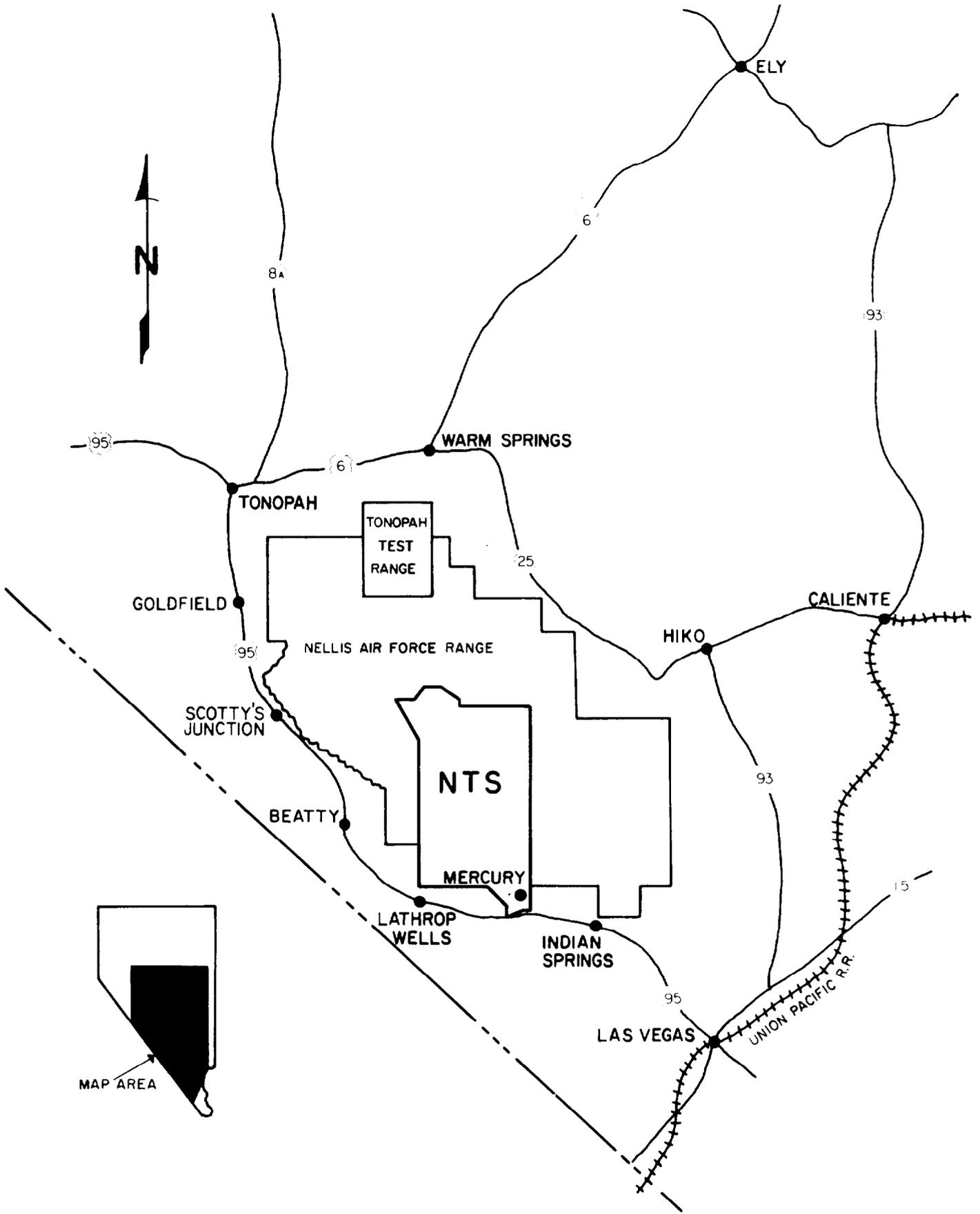


Figure 1.4 Nellis Air Force Range and NTS in Nevada

from the Nellis Air Force Range have combined to result in a very low population density in the area around the NTS.

The only paved roads within the NTS and the Air Force Range complex were those constructed by the government for access purposes. The NTS testing areas were physically protected by surrounding rugged topography. The few mountain passes and dry washes where four-wheel-drive vehicles might enter were posted with warning signs and barricades. NTS security force personnel patrolled perimeter and barricade areas in aircraft and vehicles. Thus, unauthorized entry to NTS was difficult, and the possibility of a member of the public inadvertently entering an NTS testing area was extremely remote.

Figure 1.5 shows the NTS, its various area designations, and the locations of the seven test events covered by this volume. Generally, the "U" means an underground location, the number the area, and the "a" the first test location in an area. In addition, for underground tunnels, the "a.03" indicates the third drift in a tunnel complex as U16a.03 in Figure 1.5. A low mountain range separates the base camp, Mercury, from the location of early DOD atmospheric weapons effects tests on Frenchman Flat in Area 5. A few shaft-type underground tests also were conducted in this area. The elevation of Frenchman Dry Lake in the middle of the Flat is about 3,100 feet.

A mountain pass separates Frenchman Flat from Yucca Flat testing areas. The pass overlooks both Frenchman and Yucca Flats and contains the control point complex of buildings including Control Point Building 1 (CP-1) where timing and firing for most atmospheric tests was performed, and Control Point Building 2 (CP-2) where radiological safety support was based.

Yucca Flat testing areas include Areas 1, 2, 3, 4, 7, 8, 9, and 10. Underground tests were conducted in some of these areas

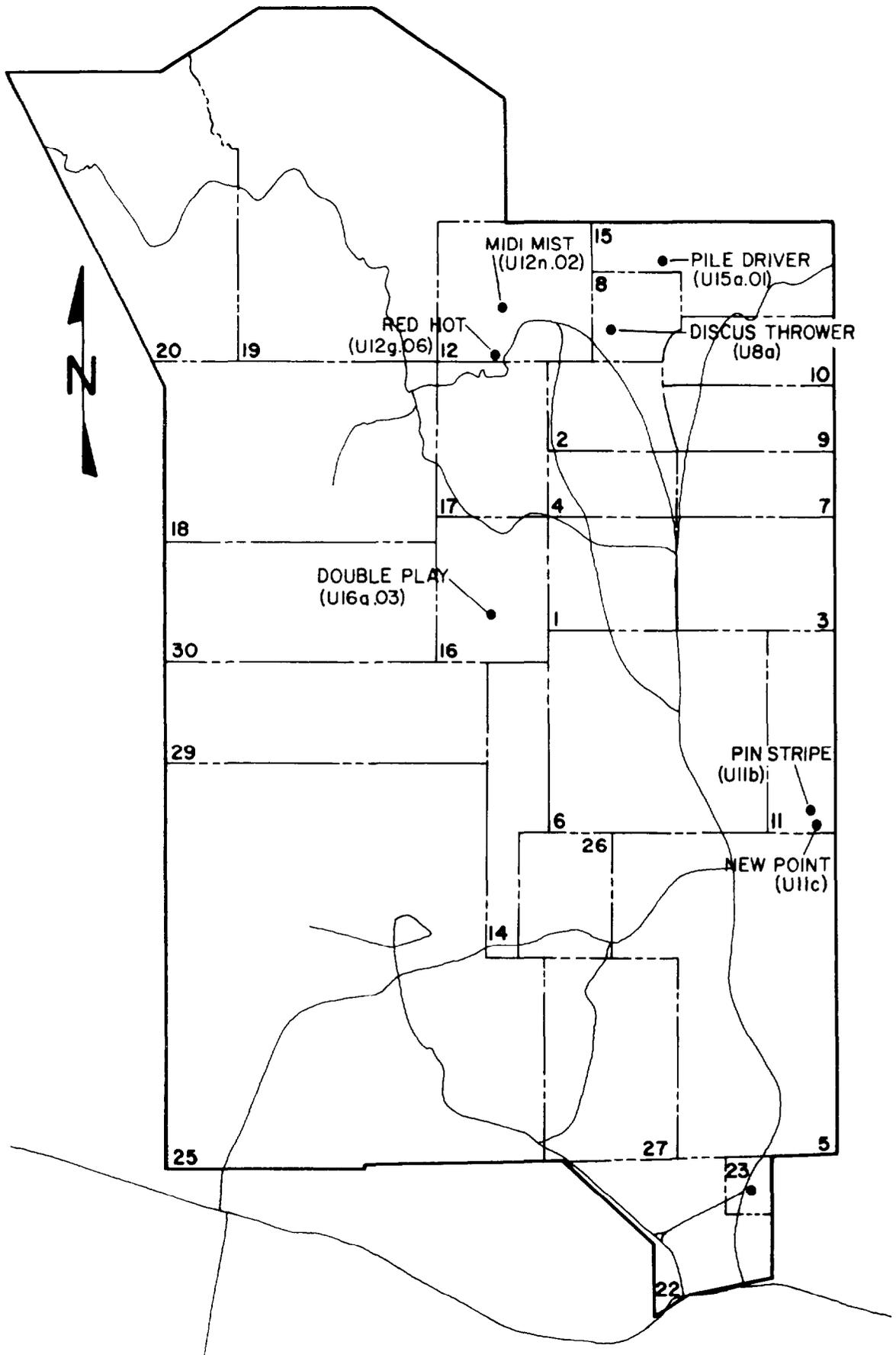


Figure 1.5 The Nevada Test Site

and generally were shaft emplacement types. The elevation of Yucca Dry Lake at the south end of Yucca Flat is about 4,300 feet. To the west of Yucca Flat, in another basin, is the Area 18 testing location. Some DOD atmospheric tests were conducted in Area 18, and one DOD cratering event, DANNY BOY, was conducted on Buckboard Mesa in this area at an elevation of about 5,500 feet. Area 16 is in the mountains west of Yucca Flat toward Area 18. The single Area 16 tunnel complex at an elevation of about 5,400 feet was a DOD underground testing location.

Rainier Mesa is in Area 12 northwest of Yucca Flat, and the top of the Mesa is at an elevation of about 7,500 feet. All tunnel-emplacment type events on NTS that were not in the Area 16 tunnel complex or the Area 15 shaft and tunnel complex were in Rainier Mesa. The major Rainier Mesa tunnel complexes were B, E, G, N, and T tunnels.

Area 15 is in the foothills at the north end of Yucca Flat. An access shaft drops nearly 1,500 feet below the surface elevation of 5,100 feet. Three DOD events were conducted in Area 15. The first two events were discussed in the first volume of this series. The third event utilized the access shaft for the first event which was deepened to about 1,400 feet for this event, as described in this volume.

## CHAPTER 2

### UNDERGROUND TESTING PROCEDURES

Underground tests conducted at NTS prior to 15 February 1962 primarily were for weapons development or safety experiment purposes. The experience gained contributed substantially to the DOD weapons effects testing program to be conducted underground. However, these later DOD underground tests generally were of greater complexity than previous underground tests. Also, a number of technical problems remained to be solved.

Obtaining satisfactory test data was an important objective, but equally important was the objective of assuring safety of test participants and the public. This chapter discusses underground testing methods, problems encountered, and safety procedures used during DOD underground weapons effects tests conducted from 5 March 1966 to 26 June 1967.

#### 2.1 EMPLACEMENT TYPES

The DOD conducted seven underground nuclear test events during this period. Table 2.1 lists these events and pertinent data including emplacement type. An emplacement type not discussed in this volume is one that results in excavating or ejecting material from the ground surface to form a crater (see Crater Experiment in the Glossary of Terms). There were three shaft and four tunnel types of DOD events during the period covered by this volume. These are discussed in this section.

##### 2.1.1 Shaft-Type

A shaft-type nuclear detonation is intended to be contained

OPERATION	FLINTLOCK					LATCHKEY	
	RED HOT	PIN STRIPE	DISCUS THROWER	PILE DRIVER	DOUBLE PLAY	NEW POINT	MIDI MIST
DATE	5 MAR 66	25 APR 66	27 MAY 66	2 JUN 66	15 JUN 66	13 DEC 66	26 JUN 67
LOCAL TIME (hours)	1015 PST	1138 PDT	1300 PDT	0830 PDT	1000 PDT	1300 PST	0900 PDT
NTS LOCATION	AREA 12	AREA II	AREA 8	AREA 15	AREA 16	AREA II	AREA 12
TYPE	TUNNEL	SHAFT	SHAFT	TUNNEL	TUNNEL	SHAFT	TUNNEL
DEPTH (feet)	1,330	970	1,106	1,518	1,075	825	1,230
YIELD (kilotons)	LOW★	LOW★	22	62	LOW★	LOW★	LOW★

★ INDICATES LESS THAN 22 KILOTONS

TABLE 2.1  
DOD TEST EVENTS  
5 MARCH 1966 - 26 JUNE 1967

underground. The shaft is usually drilled, but sometimes mined, and it may be lined with a steel casing or be uncased. The nuclear device is emplaced at a depth established to contain the explosion. This depth also is selected to allow formation of a subsidence crater. At detonation time, a cavity is formed by vaporized rock under pressure which holds surrounding broken rock in place until the cavity cools sufficiently to decrease pressure. As broken rock falls into the cavity formed by the detonation, the chimney of falling rock reaches the surface and a subsidence crater forms. Figure 2.1 shows a typical subsidence crater and postevent drilling operation.

### 2.1.2 Tunnel-Type

A tunnel-type nuclear detonation is intended to be completely contained. The nuclear device is emplaced in a mined opening at a depth which usually does not allow chimneying of broken rock to the surface. A tunnel emplacement may be at the end of a single horizontal tunnel into a mountain or mesa, in one tunnel of a complex of horizontal tunnels used for experiments and other nuclear detonations, in a horizontal tunnel from the bottom of a vertical shaft, or in an opening of variable size and shape mined from a tunnel or the bottom of a shaft. Figure 2.2 shows the portal of a typical DOD tunnel complex.

## 2.2 DIAGNOSTIC TECHNIQUES

The major advantage of underground testing was containment of radioactive material. One of the major disadvantages was increased difficulty in determining characteristics of a detonation. Photographing a fireball growing in the atmosphere was no longer possible. Samples of a radioactive cloud for analysis no longer could be obtained by sampling aircraft. Measurements of thermal radiation, nuclear radiation, and blast were complicated

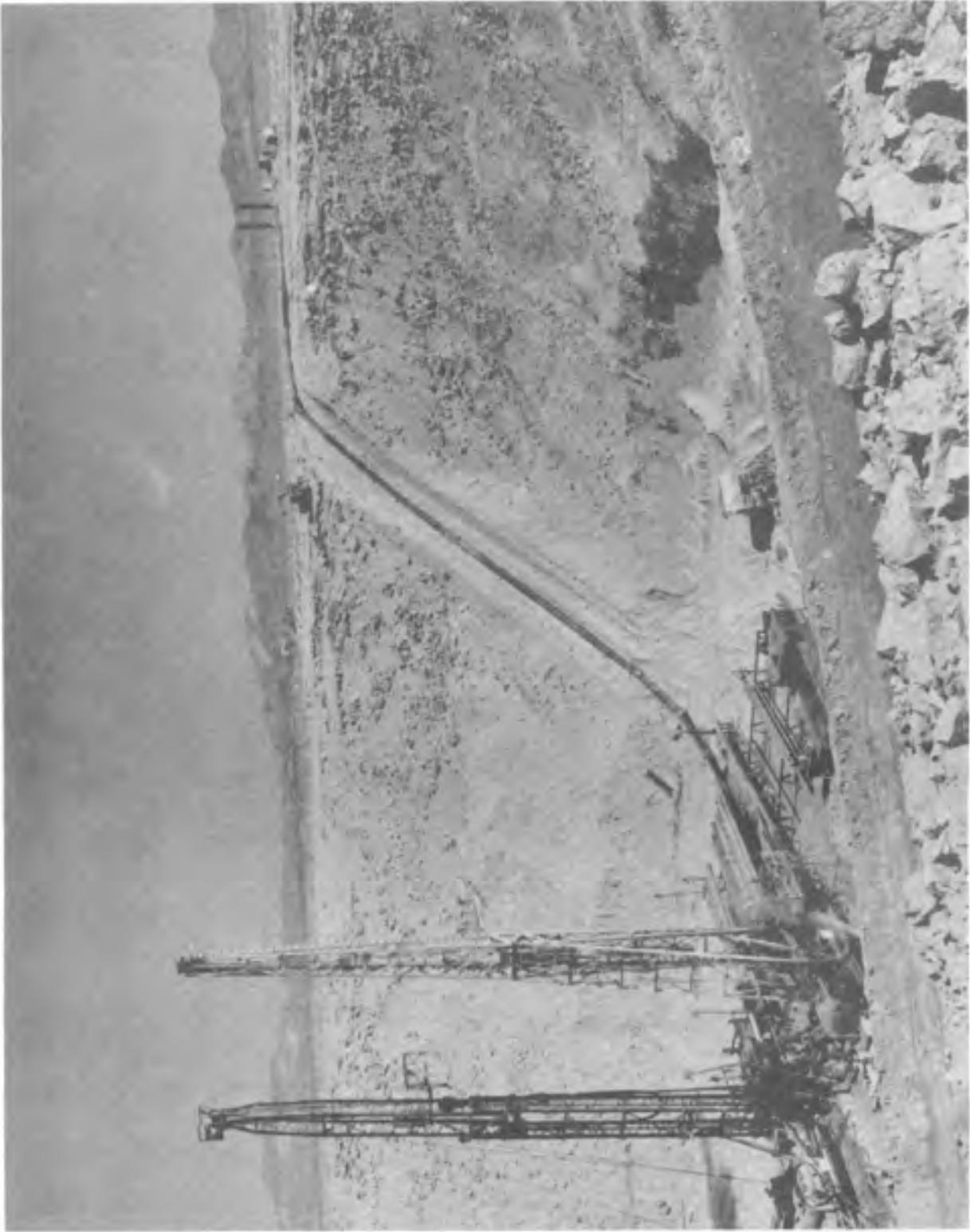


Figure 2.1 A Typical Subsidence Crater and Postevent Drilling Operation



Figure 2.2 Portal of Typical DOD Tunnel Complex

by the confining underground structures. These disadvantages were overcome by developing new diagnostic techniques, some of which are discussed below.

### 2.2.1 Radiation Measurements

Measurements of radiations from an underground detonation were made possible by developing a system of remote detectors and cabling to send signals to recording facilities located on the surface. Detectors utilizing various physical characteristics of the radiations to be measured were installed near the nuclear device. High-specification coaxial cable and connectors carried the measurement signals to the surface where electronic equipment recorded the signals.

The detector signals were on the way to recording equipment in billionths of a second after a detonation, before detectors were destroyed. These measurement systems required the most advanced electronic technology available. Indeed, considerable research and development was necessary to acquire and refine these capabilities.

### 2.2.2 Radiochemical Measurements

Because clouds from atmospheric detonations no longer were available to sample, techniques were developed to obtain samples of debris from underground detonations for radiochemical analyses and subsequent yield determinations. The first systems were radiochemical sampling pipes leading directly from the device emplacements to filtering equipment on the surface. These pipes required fast-closure systems to prevent overpressure from venting radioactive effluent to the atmosphere after samples were collected.

While these systems functioned as intended for most detona-

tions, the systems did not function properly during some tests, and radioactive effluent was released to the atmosphere. Subsequently, the use of radiochemical sampling pipes to the surface was discontinued.

The major radiochemistry sampling method which continued in use for shaft detonations was postevent core drilling. The objective of this drilling was to obtain samples of solidified radioactive debris which had collected in a molten pool at the bottom of the cavity produced by the detonation. This method required and resulted in development of precise directional drilling techniques and several advancements in the science of core drilling.

### 2.2.3 Line-of-Sight (LOS) Pipes

Most of the DOD shaft-type detonations included LOS pipes from the device emplacement to the surface. These pipes allowed effects experiments to be conducted as well as measurement of radiations from the detonations.

However, the LOS pipes to the surface required fast-closure systems as did the radiochemical sampling pipes, and use of LOS pipes to the surface also resulted in some releases of radioactive effluent to the atmosphere. Thus, the frequency of DOD shaft-type events, including use of these pipes to the surface, decreased, but the use of horizontal LOS pipes in underground tunnel complexes became frequent and a valuable weapons effects testing system.

## 2.3 EFFECTS EXPERIMENTS

Weapons effects experiments were the primary reason for conducting DOD underground nuclear detonations. The effects of blast, heat, and radiation from a nuclear detonation in the at-

mosphere had been studied extensively. Structures, equipment, and materials had been exposed to atmospheric detonations, and military hardware also had been exposed to underwater detonations. Underground testing provided an opportunity to study effects of ground shock and motion, and, of particular importance, the effects of a nuclear detonation environment on equipment and materials at a simulated high altitude.

The simulation of a high-altitude detonation was made possible by enlargement and improvement of the LOS pipe system discussed in section 2.2.3. Large-diameter pipes hundreds of feet long were constructed underground. The device was emplaced at the end of the pipe. An access tunnel sometimes was constructed parallel or at an angle to the LOS tunnel, and tunnels connected the two at intervals. Hatches allowed access to the LOS pipe and sealing of the pipe. Equipment and materials were installed at locations within the LOS pipe. The atmosphere in the LOS pipe was reduced in pressure by vacuum pumps, to simulate a high altitude, before the detonation. Thus, testing of weapons effects was extended from atmospheric and underwater to underground and at simulated high altitudes.

#### 2.4 CONTAINMENT FEATURES AND PROBLEMS

Completely containing radioactive material underground while accomplishing diagnostic measurements and effects tests proved to be a major engineering challenge. Original efforts considered only detonation containment in competent rock formations. It was necessary to modify the original efforts to consider zones of weakness in rock caused by faults and containment failures caused by diagnostic and experiment structures. In addition, decreased compressibility of rock caused by high water content with subsequent greater ground motion and stress toward the surface caused containment failure. Failures also were caused by unanticipated

additional overpressure of secondary gas expansion or steam pressure. The major containment features and problems that evolved are discussed below.

#### 2.4.1 Shaft Containment

Some of the first shaft-type safety experiments were in open shafts. When nuclear yields were produced, the open shafts did little to contain the radioactive debris. The first method used to contain nuclear detonations in shafts was stemming, or filling the shaft with aggregate and sand after device emplacement. Later stemming was used that had ground-matching characteristics, such as transmission of shock waves and other properties that would not contribute to containment failure.

Keyed concrete plugs at different depths in the shaft stemming sometimes were used. The shaft diameter was enlarged at the plug construction location so the poured concrete plug would key into the ground surrounding the shaft and provide more strength against containment failure. Combinations of concrete and epoxy were used later, and epoxy has replaced concrete as a plug material for some shaft-type emplacements.

Radiochemical sampling pipes, LOS pipes, and other openings in stemming and plug containment features had to be closed rapidly after the detonation to prevent venting of radioactive effluent to the atmosphere. Fast-gate closure systems driven by high explosives or compressed air were developed to seal the openings. After some of these systems did not prevent releases of effluent to the atmosphere, use of openings to the surface for diagnostic or experiment purposes was discontinued for several years until technology improved.

Scientific and other cables from the device emplacement to the surface were another source of containment problems. While

cables could be imbedded in concrete and epoxy, which effectively prevented leakage along the outside of the cables, radioactive gases under high pressure traveled along the inside of cables as a conduit to the surface. This problem was solved by imbedding the inner components of cables in epoxy at convenient locations or intervals, such as at connectors, in a technique called gas blocking.

The most serious containment problems were caused by unanticipated geologic and hydrologic conditions at particular test locations. Even careful and rigorous calculations, engineering, construction, and preparations were inadequate when the presence of a geologic zone of weakness near the detonation point and toward the surface was unknown.

Another similar problem was the presence of higher water content than anticipated in rock formations surrounding or near the detonation point. This problem caused (1) greater shock transmission and ground movement by decreasing rock compressibility, (2) additional secondary gas expansion when the water turned to steam, (3) a much higher and longer-sustained pressure from the detonation point toward the surface, and (4) subsequent failure of the geologic or constructed containment mechanisms.

Recognizing and understanding geologic and hydrologic conditions at each test location was necessary before these containment problems could be solved. As additional information became available through drilling and intensive geologic studies, these problems were resolved by investigations of proposed detonation locations and application of detailed site selection criteria.

#### 2.4.2 Tunnel Containment

As with shaft-type detonations, containment methods used for tunnel events were designed using basic characteristics of the

nuclear detonation. Tunnel configurations were constructed with device emplacements strategically located to cause sealing of the access tunnel by force of the detonation. Additional containment features were used to contain radioactive debris.

A short distance from the projected self-sealing location toward the tunnel entrance (portal), one or more sandbag plugs were installed. Two plugs, each about 60 feet in length, were a typical installation. Farther toward the portal, and before entering the main tunnel in a complex with more than one test location, a keyed concrete plug with a metal blast door was constructed. The blast door was designed to contain any gases, with pressures up to 75 pounds per square inch (psi), that might penetrate the plugs.

Also as with shaft-type detonations, the unknown presence of undesirable geologic and hydrologic conditions sometimes caused venting of radioactive effluent either through the overburden (ground above the tunnel) to the surface, through fissures opened between the detonation point and the main tunnel, or through the plugs and blast door to the main tunnel vent holes and portal. More substantial containment features evolved as containment problems became better understood and tunnel events became more complex.

Generally, the sandbag plugs became solid sand backfill hundreds of feet long, and the blast door evolved into a massive overburden (equivalent) plug separating test location tunnels from the main tunnel. The plug typically was 20 to 30 feet of keyed concrete with a large steel door containing a smaller access hatch, and was designed to withstand overpressure up to 1000 psi.

Use of the LOS pipe in tunnel events necessitated development of additional containment and closure systems. The LOS pipe

tunnel and its access tunnels were separated from the main tunnel by the overburden plug. Additional containment and closure systems were for protection of the LOS pipe and its experiments as well as preventing release of effluent to the surface.

Generally, the tunnel volume outside of the pipe was filled with stemming, grouting, or by other means to facilitate containment, while the inside of the pipe and its experiments were protected by fast-closure systems. Various systems were in use including compressed air or explosive-driven gates and doors which closed off the LOS pipe from the detonation within a small fraction of a second after detonation time.

The same gas blocking techniques as used in shaft events were used to prevent leakage of radioactive gases along or through cables from the diagnostic and experiment locations to the surface. Additionally, a gas seal door usually was installed in the main drift nearer the portal than the overburden plug. Utility pipes, such as for compressed air, that passed through stemming and plugs also were sealed by closure systems.

Containment systems evolved to the point that release of detectable radioactivity to the atmosphere seldom occurred.

## 2.5 TUNNEL AND DRILLING AREA ACCESS REQUIREMENTS

Access to underground workings and drilling sites was controlled for a number of reasons. During construction, safety of both workers and visitors in these locations could have been jeopardized by carelessness or seemingly harmless activities of untrained and uncontrolled visitors. When security-classified material was in these locations, only personnel with appropriate security clearances were permitted access. The presence, or anticipated presence, of radioactive material in these locations

required access control for radiological safety purposes. Access requirements established for the above purposes are discussed below.

#### 2.5.1 Tunnel Access Control

During construction and preparations for a DOD event in a tunnel or other underground working, the tunnel superintendent was responsible to the project manager for safety of personnel underground. All persons going underground, or the supervisors of working groups, were required to enter appropriate information in the tunnel log book. Visitors and other personnel not assigned to work in the tunnel obtained permission for entry from the superintendent, or his representative, and were apprised of tunnel conditions and safety regulations. In the event of an accident or other emergency condition underground, the log book provided information on numbers of personnel and their locations underground.

When classified material was in the tunnel, and during initial reentry after an event, the DOD Test Group Director, or his representative, was responsible for entry and safety of personnel underground. Security personnel checked for proper security and entry clearances, and maintained records of all personnel entering the tunnel.

Control of tunnel access reverted to tunnel management personnel after tunnel reentry and recoveries. Entry procedures and use of the tunnel log book were then as discussed above.

Additional access controls were instituted for radiological safety purposes after an event or during construction and event preparations when radioactivity from a previous event could be encountered. Part or all of a tunnel complex could be established as a radiation exclusion (radex) area.

All persons entering radex areas were logged on Area Access Registers. Names and organizations represented were listed. Radiation exposures for the year were listed upon entry and added to with self-reading pocket dosimeter measurements upon exit. This was to assure that personnel approaching radiation exposure guide limits would not be allowed to enter radex areas and accumulate exposures above guide amounts.

Before entry, personnel were dressed in anticontamination clothing and respiratory protection as needed for the particular radiological conditions in the tunnel. Upon exit, anticontamination clothing was removed, personnel were monitored for radioactive contamination, and decontamination was accomplished, if necessary.

#### 2.5.2 Drilling Area Access Control

Access to drilling areas was controlled by the drilling superintendent and the DOD Test Group Director for the same reasons as controlling access to underground workings. During drilling of an emplacement shaft, and during postevent drillback operations to recover radioactive core samples, personnel safety and compliance with safety regulations were emphasized continuously.

During preevent drilling activities, all visitors were required to contact the drilling superintendent before entry to the drilling site. Names of visitors and purposes of visits were entered in the daily drilling report, and it was assured that visitors had hard hats and understood safety regulations.

When classified materials, including the nuclear device, were brought into the area for emplacement, the DOD Test Group Director controlled access to the area with assistance from security force personnel as in similar tunnel operations. After the event, when the drill site was a radex area, during classified

material removal, or during postevent drilling, both security and radiological safety access controls were in effect as discussed under Tunnel Access Control.

## 2.6 INDUSTRIAL SAFETY CONSIDERATIONS

Implementation of an effective industrial safety program was an important part of any heavy construction operation. Mining and drilling operations had a particularly high accident potential. These operations at the NTS involved additional safety problems resulting from detonation-induced unstable ground conditions and potential for encountering toxic gases, explosive mixtures, and radioactivity.

Tens of miles of underground workings were constructed. More depth of big holes (three-foot diameter or larger) were drilled than the total drilled in the rest of the world. Directional and core drilling to recover radioactive debris samples after underground nuclear detonations advanced the science of these drilling techniques. These operations were accomplished under unusual conditions with accompanying difficult safety problems.

However, the lost-time accident frequency for the NTS support contractor employing most of the NTS personnel (REECO) was only one-tenth of the frequency for the heavy construction industry at large (as determined by annual surveys and reports for 300 heavy construction corporations). This excellent safety record was attained by continuing attention to indoctrinating and training NTS personnel, investigating and determining causes of accidents at NTS, implementing and enforcing safety regulations, and, most important, maintaining the safety awareness of NTS personnel.

This was a joint effort by the DOE and DNA, and their prede-

cessors, and by the many other government agencies and contractors at the NTS. Administered by REECo, the safety program enjoined all NTS personnel to conduct operations safely, and was exemplified by the signs on the portal of a typical DOD tunnel complex as shown in Figure 2.2, including "Safety With Production Is Our Goal."

The safety procedures for all NTS operations are voluminous and cannot be included in this report. Appendix C of this report is an example of pertinent safety procedures: General Tunnel Re-entry Procedures for Department of Defense and Sandia Laboratory Tests. As these procedures indicate, several aspects of industrial safety are interrelated. Information on monitoring levels of radioactivity and personnel exposures to radiation is presented in the next section, 2.7 Radiological Safety Procedures.

Monitoring of toxic gases and explosive mixtures was an important aspect of safety in underground workings, on drill rigs, and in drillhole cellars (enlarged first part of drillhole for valving and other equipment). Toxic gases and explosive mixtures were created by both the nuclear detonations and the mining and drilling operations. The Draeger multi-gas detector and MSA explosimeter were used to detect such gases. The Fyrite or J&W oxygen indicators were used to determine the oxygen content of the working atmosphere.

Requirements were that tunnel and drill rig breathing atmosphere contain at least 19.5 percent oxygen. During the period covered by this volume, standard operating procedures of the Radiological Sciences Department required that breathing air contain less than the levels of toxic gases and explosive mixtures listed in the following table.

<u>Gases</u>	<u>Maximum Concentration</u>
Carbon monoxide, CO	50 ppm
Carbon dioxide, CO <sub>2</sub>	5000 ppm
Nitric oxide plus nitrogen dioxide, NO + NO <sub>2</sub>	25 ppm
Nitrogen dioxide, NO <sub>2</sub>	5 ppm
Explosive mixtures	10% of LEL (lower explosive limit)

Procedures for controlling explosive mixtures and toxic gases after each test event are discussed in event chapters as appropriate.

## 2.7 RADIOLOGICAL SAFETY PROCEDURES

Procedures were developed in an effort to evaluate radiological, toxic, and other hazards, and protect workers and the public from unnecessary exposures. The following were primary written procedures and implementation methods used at the NTS from 1966 through 1967.

### 2.7.1 U.S. Atomic Energy Commission Nevada Test Site Organization - Standard Operating Procedure, Chapter 0524, Radiological Safety

Chapter 0524, which appears as Appendix D to this volume, defined responsibility, and established criteria and general procedures for radiological safety associated with NTS programs. Some but not all of the major areas discussed are film badge procedures, radiation surveys, entry into controlled areas and radiation exposure guides. Roles of the onsite REECO Radiological Sciences Department and the offsite United States Public Health Service (PHS) are defined in NTSO Chapter 0524.

2.7.2 Standard Operating Procedures for the Radiological Safety Department, REECo, dated January 1961. These procedures were updated annually beginning in 1966.

These procedures were prepared to address in more detail the radsafe aspects discussed in the latest revision of AEC NTSO-SOP Chapter 0524. The same major areas were discussed but in a more detailed manner.

2.7.3 REECo Radiological Sciences Department Information Bulletins

The Information Bulletins were formalized instructions for performing specific radiological safety and industrial hygiene tasks. They defined a situation, delineated responsibility, and described methods to be used in performing the task.

2.7.4 Detailed procedures as outlined in REECo Radiological Sciences Department Branch Operating Guides

These were informal internal procedures written to address a particular known or anticipated operational activity.

2.7.5 Implementation of radiological procedures; required equipment, devices, and capabilities for monitoring radiation levels in the environment; and monitoring external and internal exposures of personnel.

Equipment and devices used for these purposes and necessary capabilities were as follows:

A. Portable Radiation Detection Equipment

- Eberline PAC 3G (alpha)
- Eberline PAC 1SA (alpha)
- Technical Associates Juno SRJ-7 (medium range alpha, beta, gamma)

- Technical Associates Juno HRG-7 (high range gamma)
- Teletector 6112 (high range beta, gamma)
- Standard SS-2 (tritium)
- Bendix T-290 (tritium)
- Floor Monitor (alpha)
- Floor Monitor (low range beta, gamma)
- Portal Monitors (low range beta, gamma)
- Eberline E-112B (low range beta, gamma)
- Precision 111 (low range gamma)
- Eberline E-500B (high range gamma)
- Victoreen Radector AGB-500B SR (high range gamma)
- Jordan AGB 10 KG SR Rad Gun (high range gamma)
- UW-1, underwater (gamma)
- Gateway Monitor (gamma alarm)
- Eberline PNC-1 (neutron)
- FN-1a (fast neutron)
- Technical Associates Hand and Foot Counters (low range beta, gamma)

B. Air Sampling Equipment

Portable gasoline driven air sampling units (Model 102, REECO-designed)

High-volume air samplers (Staplex and Gelman)

Low-volume air samplers (Gelman)

Continuous and sequential samplers

C. Laboratory Analysis Capability

The radiological safety laboratory analyzed air, soil, water, surface swipe, fallout tray, nasal swab, urine, and wound swab samples for some or all of the following activities: gross alpha and beta, gross fission products, tritium, strontium-90, plutonium-239, and spectrographic analysis of specific gamma-emitting radio-

nuclides. The laboratory also analyzed some of the above samples for nonradioactive materials, such as beryllium, through use of an emission spectrograph and by wet chemistry procedures. A spectrophotometer was used to analyze other materials.

#### D. Monitoring of Personnel Exposures

The DuPont type 301-4 film packet was replaced with the NTS combination personnel dosimeter and security credential holder in 1966 to provide increased personnel dosimetry capability necessary to meet the radiation exposure problems associated with nuclear rocket testing and underground nuclear detonations. The holder, designed to accommodate a DuPont type 556 film packet, a fast neutron packet, an identification plate, criticality accident components, the security credential, and a snap-type clip, had capabilities for determining beta, gamma, X-ray, thermal neutron, fast neutron, high range gamma, and high range neutron doses. The DuPont 556 film packet contained two component films, type 519 (low range) and type 834 (high range). Gamma exposure ranges of the two components were 30 mR to 10R and 10R to 800R, respectively. The NTS combination personnel dosimeter and security credential holder is shown in Figure 2.3.

Film badges were exchanged routinely each month for all individuals, and upon exit from a radex area when it was suspected that an individual had received 100 mR or more of exposure.

Personnel entering radex areas also were issued self-reading pocket dosimeters which indicated accumulated exposure. Upon exit, pocket dosimeter readings were entered on Area Access Registers and added to the yearly

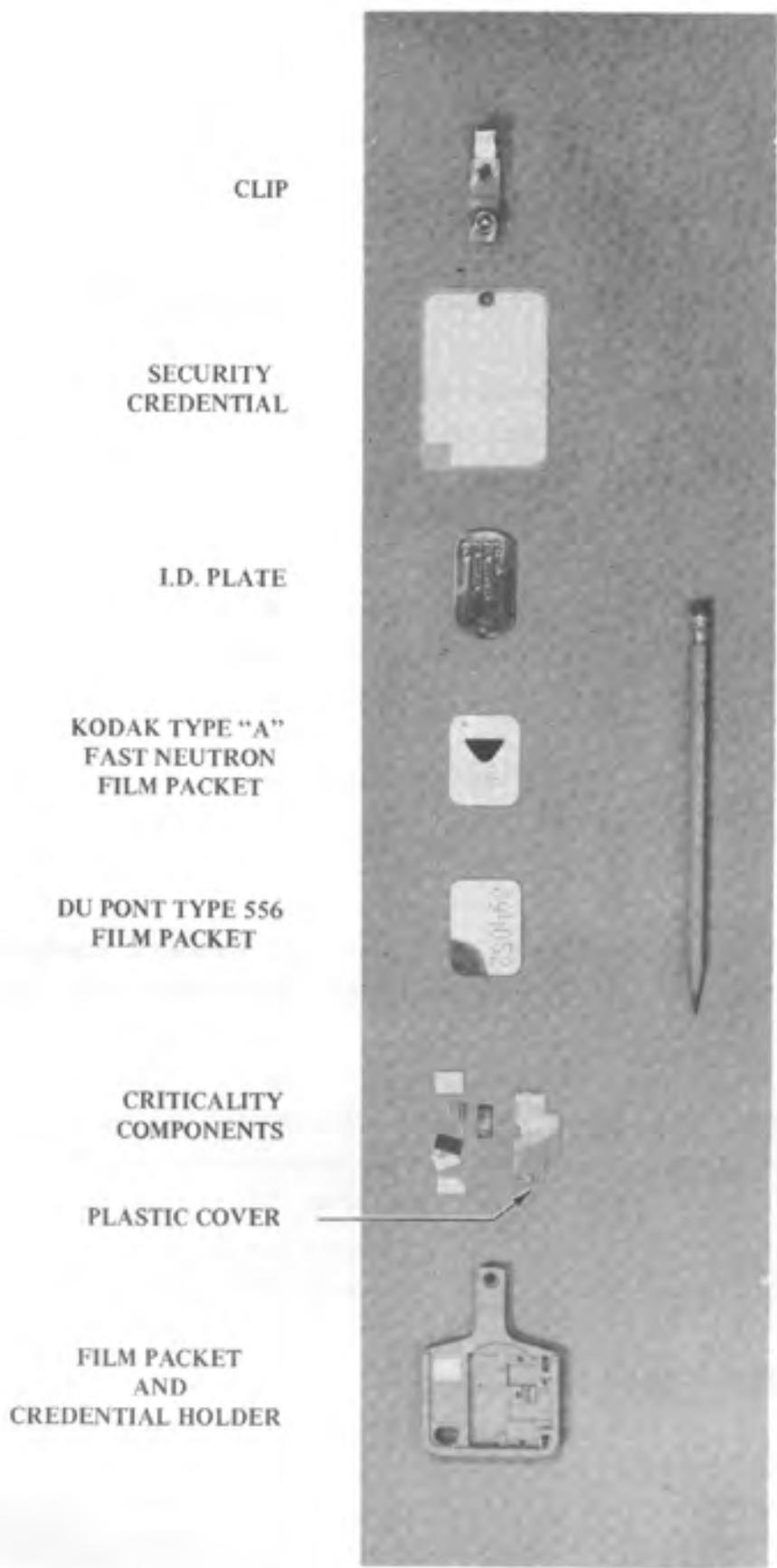


Figure 2.3 Combination Personnel Dosimeter and Security Credential Holder

and quarterly accumulated exposures from the automated daily NTS radiation exposure report. Pocket dosimeter readings were only estimates because several factors caused those readings to be less accurate than the doses of record determined after processing film packets.

This use of Area Access Registers helped to maintain personnel exposures below the whole-body exposure guides in Chapter 0524: 3000 mrem per quarter and 5000 mrem per year. Personnel with exposures from the report plus any dosimeter reading since the report in excess of 2500 mrem per quarter or 4500 mrem per year were advised not to enter radex areas and their supervisory personnel were so notified.

2.7.6 Additional methods used for control of radex areas and to prevent spread of contamination to uncontrolled areas were as follows:

A daily log book was maintained by Radsafe monitors for each of the radex area locations. These logs were used to record the following information:

- A. Work accomplished: Where people worked and what work was accomplished were briefly described. Any unusual conditions, such as equipment failure and operational difficulties, were listed.
  
- B. Visitors: First and last names of visitors were entered. Their destination and reason for their visit were included where possible. Time they exited the area and results of personnel monitoring were recorded.

C. Unusual occurrences: Any unusual events which occurred during the shift were recorded. This entry included accidents, high-volume water seepage, or any other occurrence of an unusual nature.

D. Surveys and samples: Information collected was recorded as follows:

Survey type - Routine or Special\*

Sample type - Routine or Special\*

\*Indicate requester's name for Special type.

E. Date and signature: The date and shift were entered at the beginning of the work period and the log book was signed before leaving the shift.

Personnel leaving radex areas removed anticontamination clothing and equipment and placed them in special containers for later laundering or disposal at the designated NTS burial site. Personnel then were monitored to assure radiation levels were below those listed on page 250 of Appendix D, AEC NTSO-SOP Chapter 0524, Radiological Safety. Personnel decontamination was accomplished if radiation levels were above specified limits. Decontamination usually was accomplished by vacuuming, removing radioactive particles with masking tape patches, washing hands or localized skin areas with soap and water, or showering with soap and water.

Vehicles and equipment removed from radex areas were monitored to assure radiation levels were below those listed on page 250 of Appendix D for release on the NTS. Limits for release of vehicles and equipment off the NTS were 0.3 mR/h beta plus gamma

radiation at contact and no detectable alpha activity. Vehicles and equipment normally were decontaminated by vacuuming and steam cleaning with water or detergent solutions.

## 2.8 TELEMETERED MEASUREMENTS OF RADIATION LEVELS

Beginning in the early 1960's, various applications of radiation measurement telemetry were developed at the NTS to determine radiation levels at critical underground and surface areas following nuclear detonations. Multi-detector systems with range capabilities from 0.5 mR/h to 500 R/h and from 10 mR/h to 10,000 R/h, continuously monitored locations of concern after being emplaced and calibrated prior to each test event. Ion chamber detectors were hard-wire-linked by telephone trunk lines to exposure rate meters at a central console in Control Point Building 2. Detector locations were as far as thirty-five miles from the console.

These remote radiation monitoring systems provided data for reentry personnel participating in radiation surveys and recovery operations after detonation of a nuclear device. The systems aided in substantially reducing radiation exposure of personnel involved in reentry programs, and were useful in detecting any venting or leaking of radioactive effluent to the atmosphere from an underground detonation.

### 2.8.1 Evaluation and Development of Telemetry Systems

The radiation telemetry systems developed and used had specific applications depending upon distance, terrain, environment, and operational needs.

A. Remote Area Monitoring Station (RAMS)

The primary method used was a system of Tracerlab TA-6 (GM) tube gamma detectors with Model 261 direct readout meters. The meter had a two-range scale, 0 to 10 R/h and 0 to 100 R/h. This system was limited to a 35-mile radius transmission range, and had limited shock resistance capability.

B. Radio-Link Telemetry

This EG&G-developed system was a line-of-sight radio-linked system, transmitting the desired information on VHF frequencies from a field unit to a main control console. The ionizing radiation-induced signal was then read out as cycles per second on an event-per-unit-time meter. Detectors provided information which was automatically displayed on digital tape showing the time of measurements, locations, and radiation intensities.

2.8.2 Remote Area Radiation Detection Monitoring Support

Approximately two hundred remote radiation detector channels were available to continuously monitor radiological conditions and assess exposure rates before the test area was entered after detonation. Approximately 16 detector units were positioned in the test area before a shaft-type event. Detectors were placed in circular arrays at appropriate distances from SGZ which varied with device yield and predicted wind direction (see Figures 2.4 and 2.5). Variable numbers of detectors were used aboveground and underground during tunnel-type events. An additional 20 to 35 permanently established remote radiation detector stations operated continuously at living areas, work areas, and other locations throughout NTS (Figure 2.6). A large number of additional channels were available for additional detector locations and

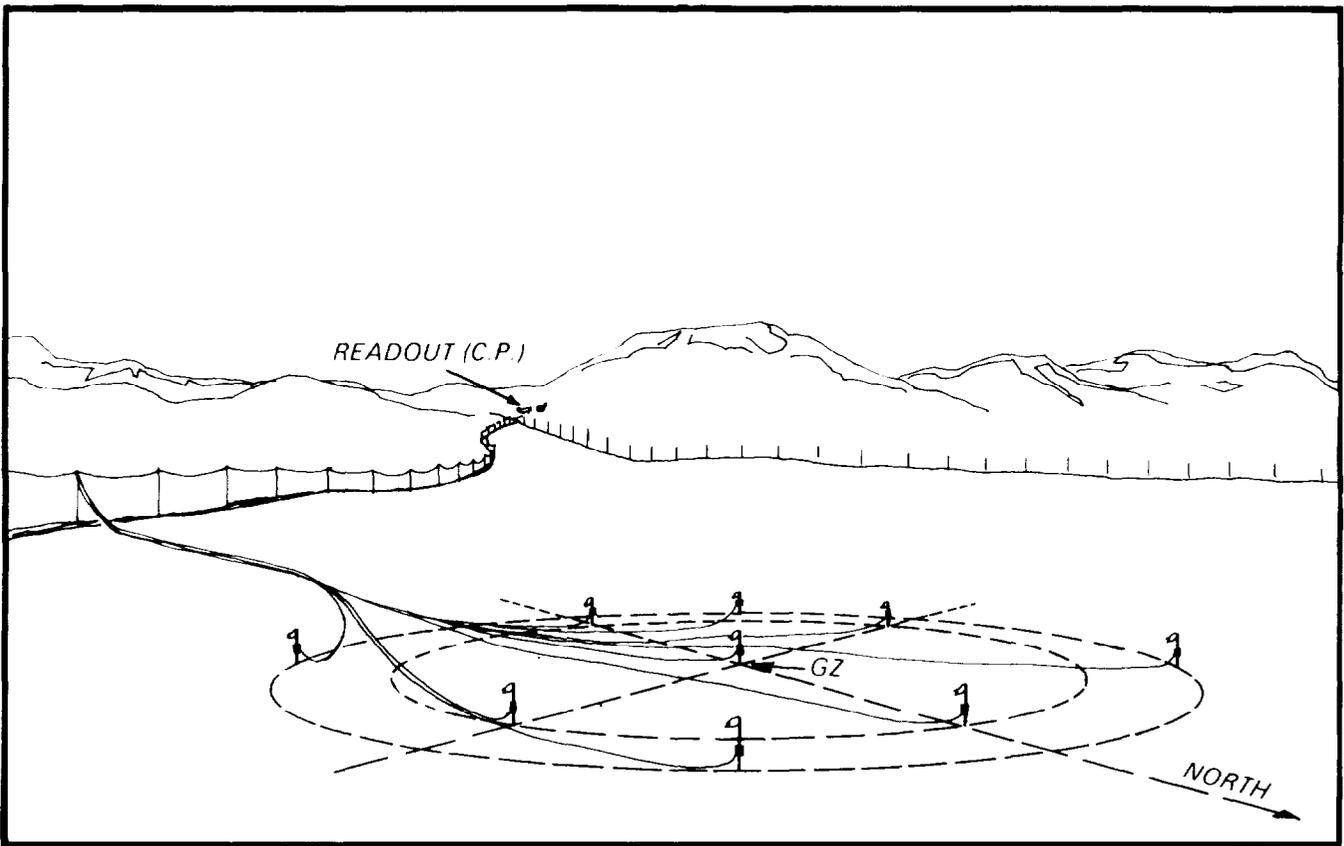


Figure 2.4 Typical Remote Radiation Detection Monitoring System for Shaft-Type Emplacement Site

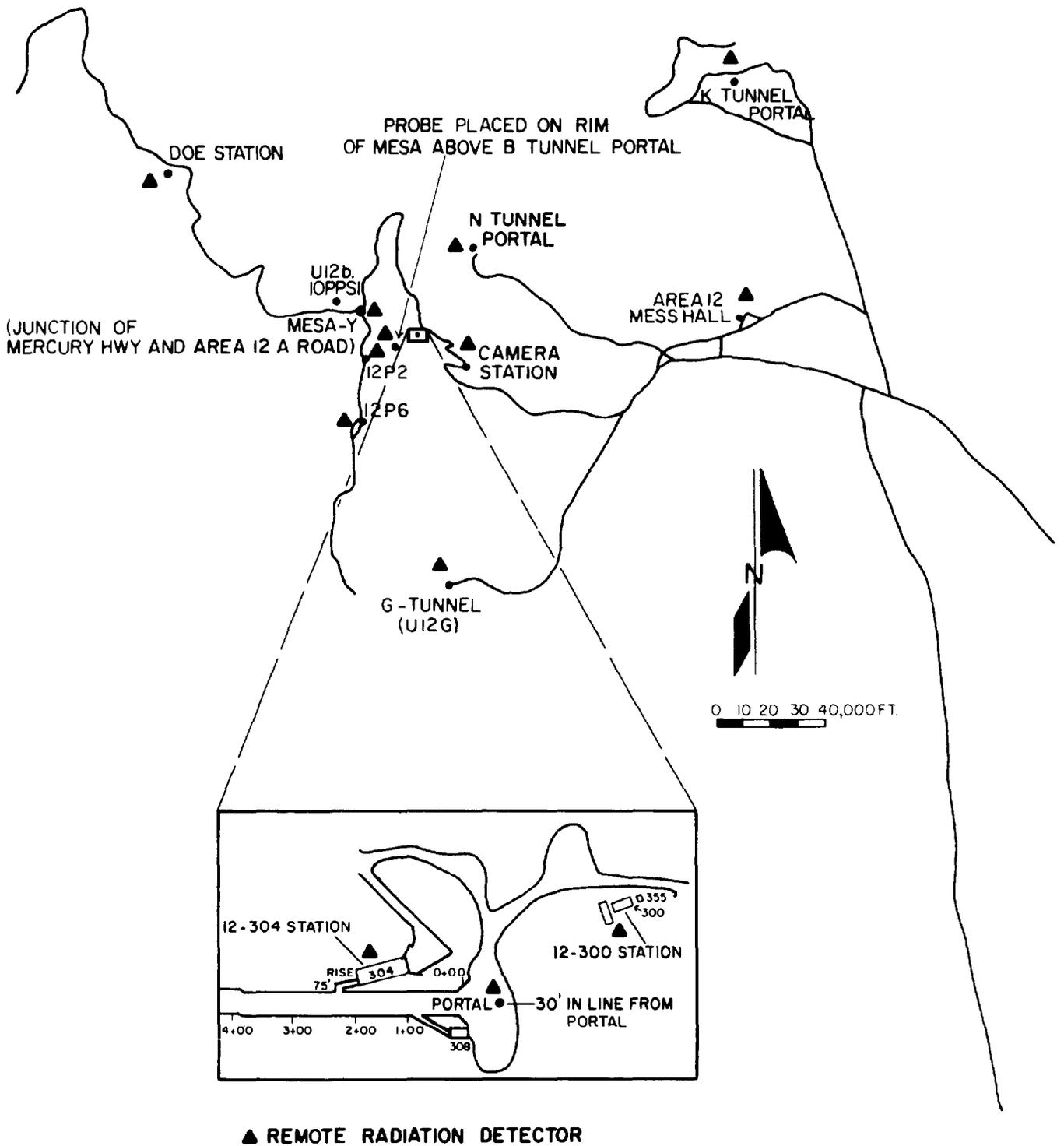


Figure 2.5 Typical Remote Radiation Detection Monitoring System for Tunnel-Type Emplacement Site

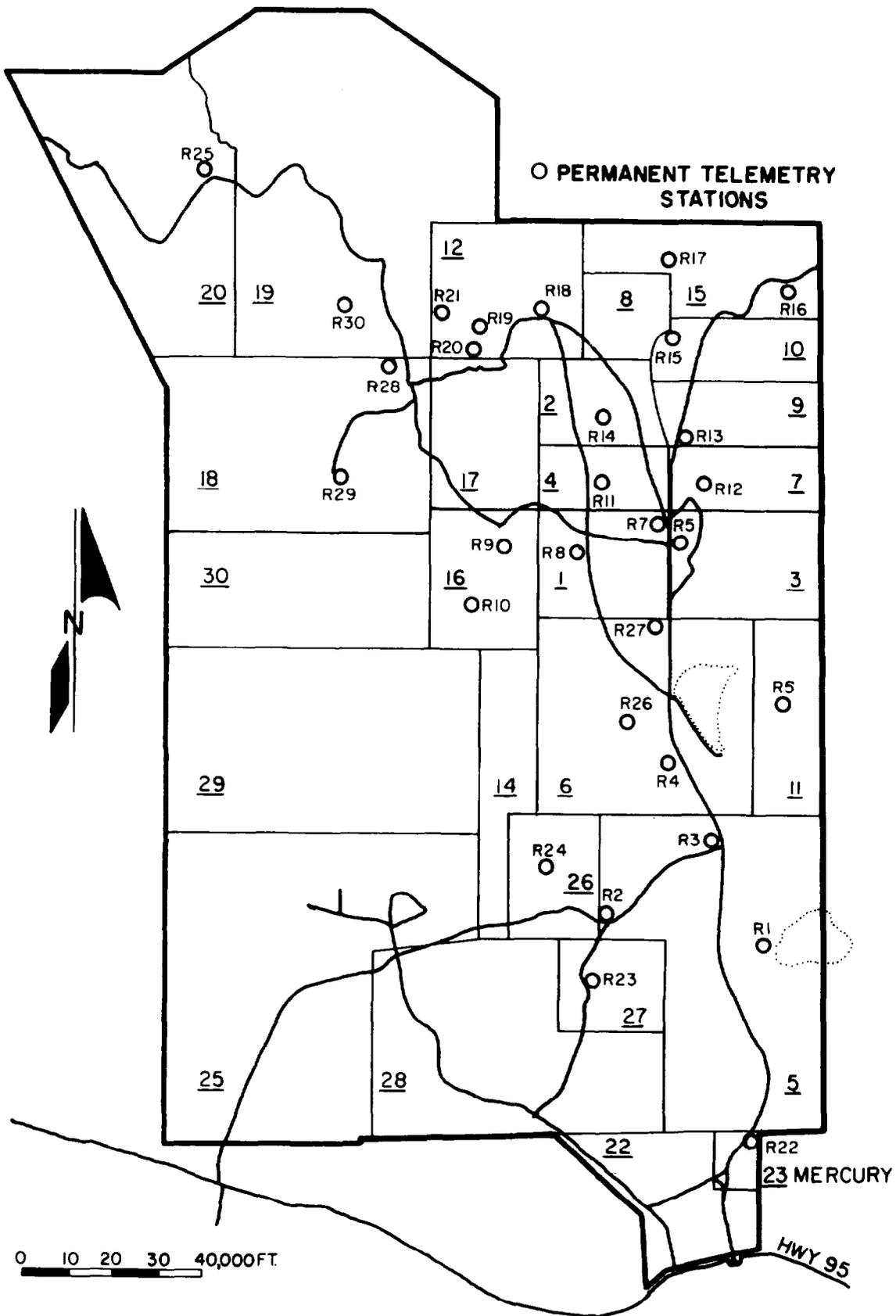


Figure 2.6 Typical Permanently Established Remote Radiation Detector Stations Operated Continuously Throughout the NTS

substitute channels. Event-related telemetry detectors operated from zero time until it was determined that no release of radioactivity would probably occur, or until any released radioactivity had decayed to near-background levels at the telemetry stations. As telemetry systems evolved, readout locations were positioned near the FCP or at locations where telephone lines were available, in addition to those events where readouts were located at CP-2.

Radiation telemetry data were supplemented with information collected by a mobile air sampling program. Model 102 air sampling units were used to obtain samples of any radioactive effluent released at event time or during the postevent drilling operations. Test Groups used an average of 21 units during each test event. Prior to each nuclear experiment, these samplers were placed at specified locations around the test area and remained in position until drillback operations were completed or the Test Group Director authorized the removal of the units.

## 2.9 AIR SUPPORT REQUIREMENTS

The AFSWC provided direct support to NTSO for DOD underground tests, and other Air Force organizations provided support under AFSWC control as described in section 1.3.3 of this report. However, less air support was required as the probability of venting radioactive effluent to the atmosphere decreased with development of more effective containment techniques.

### 2.9.1 Changes in Air Support Requirements

After 1962, Air Force cloud sampling and cloud tracking aircraft generally were not required, except for AEC cratering events where radioactive effluent clouds were anticipated. The value of analyzing particulate and gaseous cloud samples to de-

termine characteristics of a detonation decreased. Passage of the radioactive effluent through variable amounts and temperatures of rock and other media selectively retained some radionuclides underground, and changed known ratios of fission products previously used during analysis of atmospheric detonation cloud samples.

The first change in cloud sampling and tracking support was to a lighter Air Force aircraft, the U-3A, with an Air Force pilot and PHS monitor. The PHS monitor also performed aerial monitoring of selected locations near surface ground zero and along the path of any effluent cloud. This air support later was performed by PHS and contractor personnel in their own aircraft.

The Air Force L-20 or a U-6A aircraft, with an Air Force pilot and a security guard from the NTS security force, continued to provide security sweep coverage of the NTS perimeter and test areas until use of helicopters began in 1968. Perimeter sweeps were conducted daily, during reasonable flying weather, to assure that unauthorized vehicles were not entering the NTS over rough terrain or around security barricades on secondary roads. Air security sweeps of the immediate test area were conducted for a few hours before each detonation to assist in clearing the test area and to assure that unauthorized vehicles were not approaching it from directions not controlled by manned security stations.

Air support for photography missions during test events and initial radiation surveys after each event did not change. Helicopters with Air Force pilots generally were used with contractor photographers and Radsafe monitors.

#### 2.9.2 Radsafe Support for Indian Springs AFB

Radsafe support facilities had been established at ISAFB

during the atmospheric nuclear device testing series. During 1962 tests, and subsequent DOD underground tests requiring support aircraft staged from ISAFB, REECO provided all radsafe support functions available at the NTS. This included Radsafe monitors stationed at the ISAFB radsafe quonset facility, and a complete stock of film dosimeters (badges), radiation detection instruments, and anticontamination clothing and equipment for use by aircrews and ground crews.

Radsafe monitors issued and exchanged film dosimeters (badges), issued self-reading pocket dosimeters, dressed Air Force personnel in anticontamination clothing, provided respiratory protection equipment, monitored aircraft and personnel after events, decontaminated personnel, and assisted ground crew personnel with decontamination of aircraft.

Figures 2.7 through 2.9 show decontamination and monitoring of typical B-57 cloud sampling aircraft used during the 1960's for cratering events, and other events when the possibility of radioactive effluent was anticipated.

Aircrews departing from contaminated aircraft removed anticontamination clothing and equipment at the radsafe facility, showered, and were monitored to assure complete decontamination before they dressed in regulation clothing and were released. Ground crews who removed particulate and gaseous cloud sample collection media from aircraft or who participated in aircraft decontamination were subject to the same personnel decontamination procedures.

### 2.9.3 Radsafe Support for Helicopters

Although ISAFB radsafe support extended to all participating aircraft, special helicopter radsafe procedures were implemented because these aircraft landed at NTS and staged from helicopter

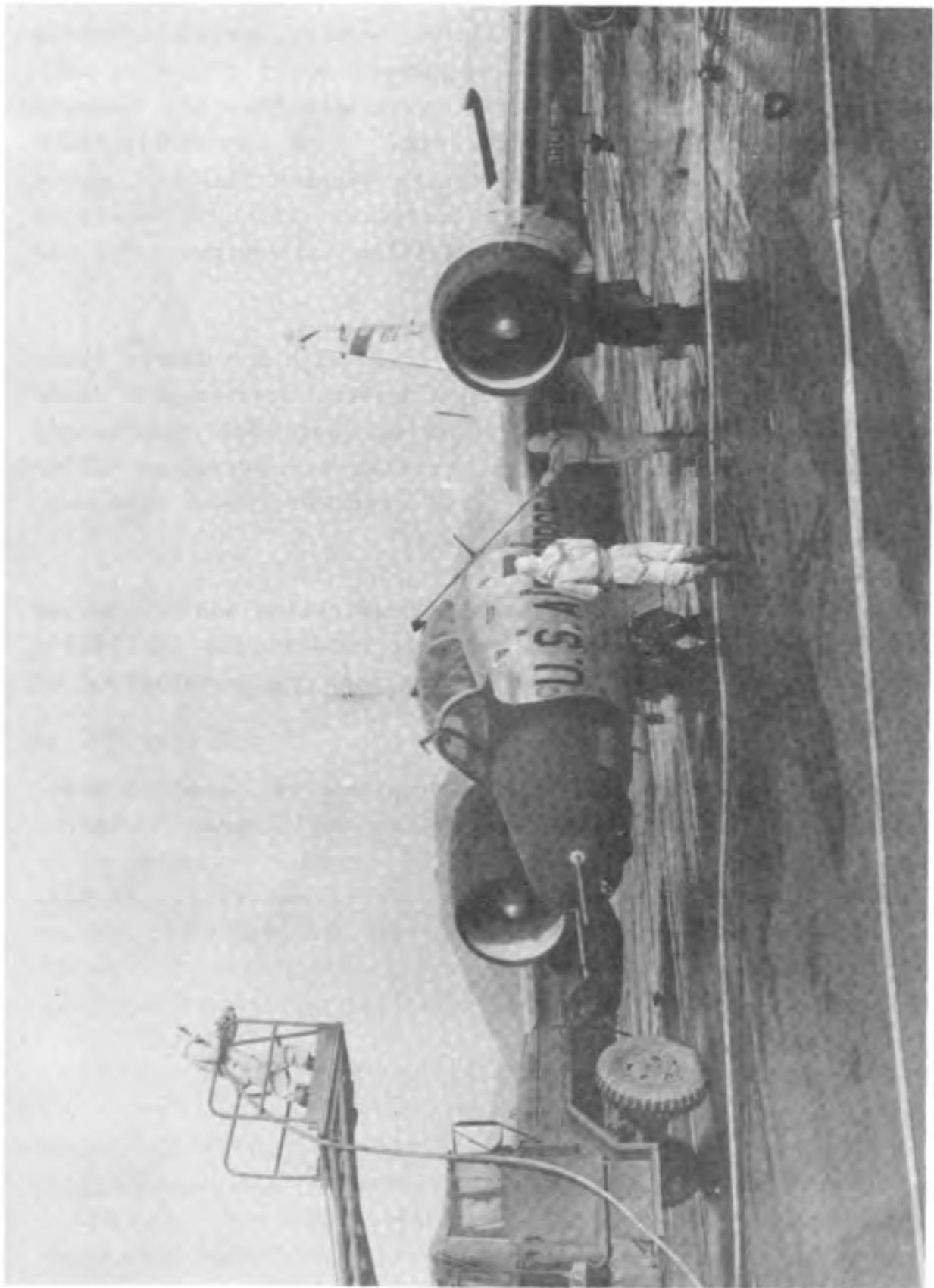


Figure 2.7 Air Force Personnel Decontaminating A B-57 Cloud Sampling Aircraft



Figure 2.8 Air Force and Radsafe Personnel Monitoring A B-57 After Decontamination



Figure 2.9 Radsafe Monitor Measuring Exposure Rate on a B-57 Aircraft

pads located east of Mercury Highway at the Control Point area and near a Test Director's Forward Control Point (FCP) established for a particular underground event. Helicopter pilots usually landed at these locations, and were briefed at the Control Point or particular Forward Control Point regarding their scheduled missions or other operational missions.

If the mission involved possible contamination of the aircraft, Radsafe monitors lined the floor of the aircraft with plastic, or kraft paper, and masking tape to facilitate decontamination. Pilots and crew members were dressed in anticontamination clothing and provided with film badges, pocket dosimeters, and respiratory protection equipment if airborne radioactive material was anticipated.

Upon completion of missions, helicopters returned to the landing pads where they were decontaminated by Radsafe monitors. Pilots and crew members were decontaminated at an adjacent forward Radsafe base station, or at Control Point Building 2 where the pocket dosimeters were collected and read, and film badges were exchanged if exposures of 100 mR or more were indicated by pocket dosimeters.

## CHAPTER 3

### RED HOT EVENT

#### 3.1 EVENT SUMMARY

The RED HOT event was a DOD underground nuclear detonation with a yield less than 20 kt conducted at 1015 hours Pacific Standard Time (PST) on 5 March 1966 at tunnel site U12g.06 in Area 12 of the NTS. The device was emplaced 1,330 feet beneath the surface, in a tuff medium, on the flat surface of a hemispherically-shaped cavity (Figure 3.1). The experiment was a weapons effects test to study ground shock. Eleven projects were involved including safety documentation, structural support, and scientific studies. The detonation was not completely contained; some physical damage and contamination of the tunnel complex resulted, and minor levels of radioactive effluent from this event were detected offsite. Additional information is in section 3.3 "Event-Day and Continuing Activities."

#### 3.2 PREEVENT ACTIVITIES

##### 3.2.1 Responsibilities

The DOD Test Group Director was responsible for the safe conduct of all RED HOT activities in Area 12. Responsibilities of AEC and AEC-contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DASA, and the AEC Nevada Operations Office. The DOD was responsible for preevent installation and postevent removal of equipment necessary for its project activities.

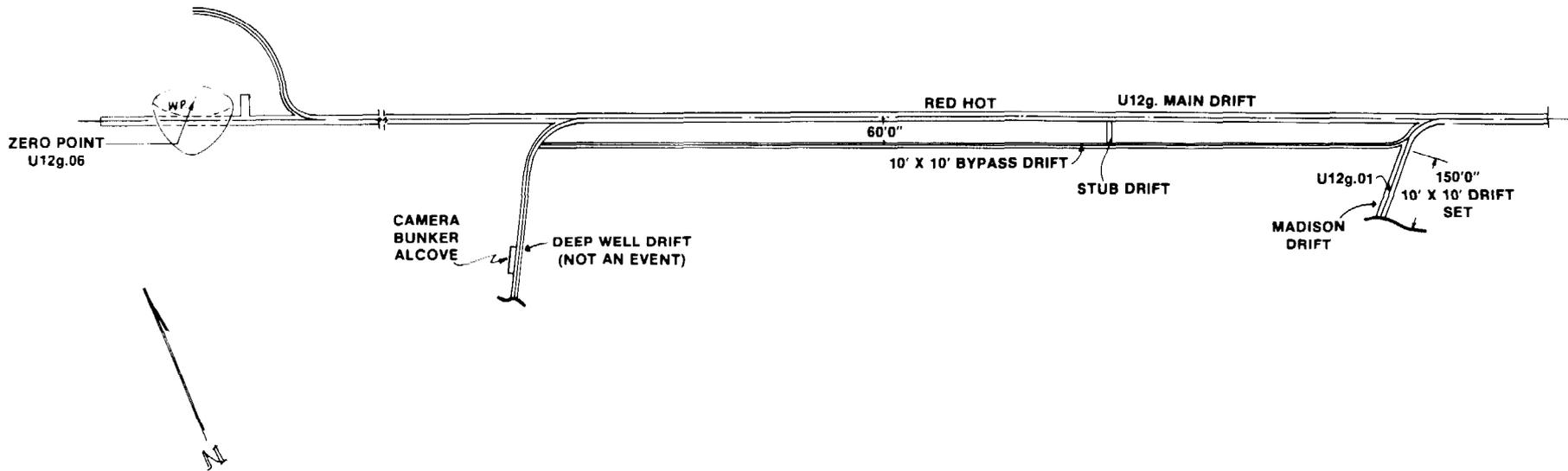


Figure 3.1 RED HOT Event

### 3.2.2 Planning and Preparations

A "RED HOT Reentry Plan" described preevent preparations and postevent procedures used to assure safe and economical reentry. Radiation sensing instruments and tunnel condition indicators were located throughout the event complex. In addition, REECO Radiological Sciences Department (Radsafe) personnel were provided with "Detailed Initial Reentry Procedures" for reentry and recovery operations. Stemming design in the access tunnels incorporated necessary provisions to maximize safety of reentry. Geophones were installed to monitor cavity activity and collapse.

Figure 3.1 shows the tunnel complex for the RED HOT event including the tunnel used for the MADISON event (a weapons-related event detonated 12 December 1962), and the drift for the Deep Well experiment (an experiment related to RED HOT). Air sampling pipes were installed through both the sand bag plugs and the gas seal door. These were used during reentry to sample air just forward of the door and plugs for immediate analysis and evaluation. Two 10,000 cfm positive displacement blowers with balanced flow rates were used to provide necessary tunnel ventilation. Three evacuated flasks for obtaining air samples through plug No. 4 from the GZ side were placed on the portal side of the plug. Tunnel vent lines from the portal to plug No. 4, to the general area of Station 42+00 in the main drift, to the general area of Station 3+50 in the Deep Well drift, to the MADISON drift, and to blind drifts were in place at zero time. Vent line monitors and air samples were used to determine the quantity and quality of any radioactive effluents released to the atmosphere during tunnel ventilation.

#### A. Radiological Safety Support

Detailed radiological safety reentry plans were submitted to participating agencies prior to the event.

Test area maps with appropriate reference points were prepared. Reference markers, radiation decay recorders, and air sampling equipment were positioned in the test area. Reentry routes into the test area were established during "dry runs." Party monitors were briefed regarding reentry, sample recovery, manned stations, and security station requirements.

A mobile issue facility for anticontamination clothing, respiratory devices, instruments, and dosimetric devices was positioned prior to the event at the security barricade near the FCP. A personnel and vehicle decontamination facility was established adjacent to the mobile issue facility. When authorized by the Test Group Director, these facilities were repositioned to a convenient location near the tunnel portal.

Radsafe monitors were stationed at all Wackenhut Services, Inc. (WSI) security roadblocks and at all work areas within the exclusion area to perform surveys and provide other support as directed.

All personnel at manned stations were provided with appropriate anticontamination clothing and equipment, and Radsafe monitors were in attendance. Radsafe had personnel stationed at the DOD Test Group Director's FCP prior to the RED HOT detonation ready to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment, portable instruments, and self-reading pocket dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Anticontamination materials available included coveralls, head covers, shoe covers, full-face masks, sup-

plied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

#### B. Telemetry and Air Sampling Support

A remote area monitoring system (RAMS) was installed with the detection units located underground and on the surface and readouts located outside the controlled area. This system was functioning at zero time so that tunnel and surface radiation conditions could be determined. RAMS console readings were recorded every 15 minutes until tunnel ventilation was started. All telemetry stations remained active until the DOD Test Group Director requested their deactivation.

There were 45 RAMS units, 13 inside the tunnel complex and 32 on the surface, which recorded data (Tables 3.1 and 3.2). The detection range of the units was 1 mR/h to 1,000 R/h.

Readout information from these detectors was recorded at CP-1 and CP-2.

Thirty-five air sampler trailer units were positioned at various locations in the test area for this event. These were started a minimum of three hours prior to scheduled device detonation and were set on continuous sampling mode.

#### C. Security Coverage

Muster and control stations were established on D-day. All personnel entering or exiting the controlled area were required to stop at the muster or control stations for issuance or return of their muster or stay-in bad-

TABLE 3.1  
 RED HOT EVENT  
 RAMS UNIT LOCATIONS  
 5 March 1966

Station	Location	
	UNDERGROUND	
1	2+75 feet	(275 feet; main drift)
2	0+25 feet	(25 feet; main drift)
3	43+00 feet	(4,300 feet main drift; just outside plug No. 3)
4	5+00 feet	(500 feet; deep well drift)
5	2+89 feet	(289 feet; deep well drift)
6	3+25 feet	(325 feet; deep well drift)
7	39+00 feet	(3,900 feet; main drift)
8	58+28 feet	(5,828 feet; main drift)
9	32+00 feet	(3,200 feet; main drift)
10	5+00 feet	(500 feet; MADISON drift)
11	24+50 feet	(2,450 feet; main drift)
12	15+50 feet	(1,550 feet; main drift)
13	39+00 feet	(3,900 feet; main drift)

TABLE 3.2  
 RED HOT EVENT  
 RAMS UNIT LOCATIONS  
 5 March 1966

Station	Location
14	447 feet from SGZ at 45° Azimuth
15	451 feet from SGZ at 71° Azimuth
16	385 feet from SGZ at 113° Azimuth
17	439 feet from SGZ at 161° Azimuth
18	538 feet from SGZ at 176° Azimuth
19	608 feet from SGZ at 331° Azimuth
20	605 feet from SGZ at 343° Azimuth
21	594 feet from SGZ at 305° Azimuth
22	1,024 feet from SGZ at 193° Azimuth
23	827 feet from SGZ at 206° Azimuth
24	884 feet from SGZ at 237° Azimuth
25	889 feet from SGZ at 274° Azimuth
26	916 feet from SGZ at 298° Azimuth
27	1,406 feet from SGZ at 333° Azimuth
28	1,072 feet from SGZ at 2° Azimuth
29	1,034 feet from SGZ at 44° Azimuth
30	1,065 feet from SGZ at 74° Azimuth
31	1,021 feet from SGZ at 92° Azimuth
32	2,030 feet from SGZ at 119° Azimuth
33	2,450 feet from SGZ at 63° Azimuth
34	3,306 feet from SGZ at 346° Azimuth
35	1,815 feet from SGZ at 323° Azimuth
36	2,434 feet from SGZ at 310° Azimuth
37	2,434 feet from SGZ at 272° Azimuth
38	3,583 feet from SGZ at 272° Azimuth
39	4,165 feet from SGZ at 293° Azimuth
40	4,684 feet from SGZ at 315° Azimuth
41	5,250 feet from SGZ at 56° Azimuth
42	3,053 feet from SGZ at 87° Azimuth
43	5,515 feet from SGZ at 125° Azimuth
44	4,074 feet from SGZ at 160° Azimuth
45	3,806 feet from SGZ at 204° Azimuth

ges. All personnel were required to have proper security clearances for the area. Control of the area was maintained by the use of roadblocks, access authorizations and a Schedule of Events. Parties could enter the controlled area only with the permission of the Test Group Director or Test Manager. Wackenhut Services Incorporated security guards were responsible for activating roadblocks and directing the flow of traffic.

D. Air Support

Lookout Mountain Air Force Station (LMAFS) photo personnel and DOD aerial photo personnel were in a UH-43D helicopter positioned a safe distance from the tunnel portal at zero time. In addition to the two photo helicopters, an Air Force U-3A aircraft, a pilot and a copilot were made available to a PHS aerial monitoring team for cloud tracking purposes. The PHS also operated two Turbo-Beech and one C-45 aircraft for cloud sampling purposes. The EG&G Martin 404 (NATS) aircraft was on standby in Las Vegas. The three PHS aircraft were code named Vegas 2, Vegas 7, and Vegas 8, respectively.

Vegas 2 was the primary cloud locating and sampling plane. It was equipped with cryogenic and electrostatic precipitator sampling systems, an Andersen sampler, a gross activity air sampler, and gamma detection equipment. Vegas 7 was equipped for its first mission with a variable time-controlled sequential air sampler, an electrostatic precipitator and low background beta counter, differential beta-gamma detection equipment, and a gross gamma detection system. For the second mission it was equipped with a cryogenic sampler, a gross air sampler, beta-gamma detection equipment, and a gross gamma detection system. Vegas 8 was assigned to cloud

tracking and carried a high volume tracking filter, sequential air sampler, low background beta counter, and gamma detection system.

### 3.2.3 Late Preevent Activities

RED HOT detonation was originally scheduled for 1000 hours on 1 March 1966. The muster station was activated at 0000 hours on 1 March and the first security sweep was completed at 0200 hours. A second security sweep began at 0300 hours and was completed at 0500 hours. Experimenter personnel from SC, EG&G, DOD, Stanford Research Institute (SRI), and Engineering Physics (EPCO) were in the area performing button up activities from 0530 hours to 0630 hours. At that time, Area 12 was cleared and the muster station moved to the junction of Orange Road and Rainier Mesa Road (southeast of Area 12). The arming party entered the area at 0720 hours, the muster station was moved to the junction of Rainier Mesa Road and Area 2 Road (further southeast from the event), and at 0733 WSI personnel began a security sweep of Area 12. At 0833, arming was complete and the party exited the closed area.

The event was "scrubbed" at 0848 hours; however, WSI personnel were advised to maintain the closed area until the arming party disarmed the device. This was accomplished between 0900 hours and 0930 hours; thereafter, the area was reopened.

A 24-hour delay was called at 1945 hours on 1 March 1966. Preliminary steps were taken toward test execution on 2 March and 3 March; however, both days the event was "scrubbed."

On 4 March 1966, the first and second security sweeps were completed at 0430 and 0600 hours respectively. A Test Manager's readiness briefing was held, and the arming party entered the area at 0850 hours. Permission to arm was granted at 0930 hours,

and the arming party left the area at 0942 hours. After several delays from 1031 hours to 1432 hours, the decision was made to delay for an additional 24-hours. At 1445 hours the arming party departed for GZ to disarm the device, completing the task at 1520 hours.

### 3.3 EVENT-DAY AND CONTINUING ACTIVITIES

Between 0000 and 0600 hours on 5 March 1966, the following experimenter activities were being conducted:

- REECo personnel performed final checks of CCTV camera equipment.
- SC personnel made final instrumentation adjustments at GZ, checked recording equipment at the Hydyme trailer, and made final adjustments on three geophones located 2,450 feet east of GZ and three geophones located 3,900 feet east of GZ all in the tunnel. Final adjustments also were made in van GMT-2 located in the trailer park outside the tunnel portal, and in van E-12 located two miles east of the tunnel portal.
- EG&G personnel loaded cameras and turned on equipment at photo stations No. 1 and No. 2.
- SRI personnel performed final checks and button up of vans located at the tunnel portal, and proceeded to SGZ on Rainier Mesa to make final instrument checks and button up an instrument van.
- EPCO personnel conducted final checks and button up of their instrument van.
- BRL personnel checked system battery conditions and took final

pressure, temperature, and humidity readings at their instrument van.

Most of the above activities occurred on each previous attempt to execute this event.

The first and second security sweeps were conducted from 0140 hours to 0400 hours. A Test Manager's readiness briefing was conducted at 0715 hours with a scheduled zero time of 1000 hours. The muster station was relocated to just north of the Area 2 access road at 0800 hours. Arming was complete at 0803 and the area was clear of personnel by 0813 hours.

Radsafe personnel arrived at the Test Director's FCP at 0840 hours, opened the mobile check station, and dressed out reentry personnel in anticontamination clothing and equipment.

At 0915 hours, a photo party of two LMAFS personnel plus a USAF crew in a UH-43D helicopter were in position 3,000 feet east of the portal at an altitude of 3,000 feet. A DOD photo party of three plus a USAF crew in a UH-43D helicopter were in position 1,500 feet east of the portal at an altitude of 1,500 feet.

The required countdown began at 0930 hours on radio nets 1, 2, 6, and 8. Ten minutes prior to scheduled device detonation the siren on CP-1 ran for 30 seconds, and the red lights on top of the building were turned on until after detonation.

RED HOT zero time was 1015 hours PST on 5 March 1966.

A dust cloud formed outside the portal after detonation. There was no radiation above background associated with this cloud (or elsewhere outside the tunnel) until eight minutes after device detonation when venting began. All RAMS units inside the portal except stations 10, 11, and 12 ceased functioning immedi-

ately. Within two minutes, RAMS No. 11 had risen to 900 R/h; within six minutes RAMS No. 10 in the MADISON drift had risen to 100 R/h and continued increasing. Ventilation was turned on so that the imminent release of activity could be filtered, and RAMS No. 12 readings promptly increased to 110 R/h. Thereafter, RAMS units outside the portal indicated varying levels of activity during the release, which continued for more than six hours. The highest RAMS reading outside the tunnel was 200 R/h at H+19 minutes. After 48 hours, however, all onsite radiation levels had decreased to background with the exception of those within the tunnel and at the tunnel portal.

### 3.3.1 Cloud Tracking and Monitoring

Approximately 20 minutes after zero time (1015 PST), Vegas 2 made its first pass over SGZ at 7,000 feet above mean sea level (MSL) where 50 mR/h was measured. Two additional passes over SGZ showed activity levels continuing to rise, reaching 450 mR/h by 1041 hours. Additional circling of SGZ further indicated the release was moving in a general westerly direction. Based on this information, a sampling flight path was established 2.7 miles to the west of SGZ at 7,500 feet MSL and normal to the expected cloud trajectory. First contact with the cloud's leading edge occurred at 1051 hours. Position of the contact point indicated the cloud was initially moving on a course of 250 degrees true at about 6.5 mph. Sample collection continued until 1127 hours on the initially established course. The final sampling pass was made from a position 1.5 miles farther to the west at the same altitude and flown directly back toward SGZ upon reaching the cloud center line. A minimum dose rate reading of 5 mR/h on the axial pass was observed at the starting position with the maximum readings of 50 mR/h occurring approximately 0.25 miles west of SGZ. Peak dose rate readings for all previous sample runs were approximately 25 mR/h to 30 mR/h.

Gross gamma information obtained on the last sample pass along the cloud axis indicated westerly movement of the cloud had ceased. Similar information was obtained at this time by Vegas 7 making cloud height and trajectory measurements. Flying at 8,300 feet MSL at 1137 hours, Vegas 7 reported the leading edge had reached the PHS farm in Area 15, thereby establishing a trajectory of approximately 70 degrees true.

Between 1035 and 1140 hours, cloud height measurements had determined the lower limit to be at an average altitude of 6,500 feet MSL and the top at 9,000 feet MSL. At this time, it had developed a length of 11 miles, an average width of 1.8 miles, and a depth of 2,500 feet, with a resultant volume of  $3 \times 10^{12}$  cubic feet.

Vegas 7 returned to the area on a sampling mission between 1320 and 1410 hours. Repeated flights at 7,500 feet MSL were made over SGZ and in circular patterns in the immediate vicinity of SGZ to determine the existence of any continuing release. No continuing release was detected.

At 1520 hours, Vegas 8 departed McCarran Airport for a cloud tracking mission in the area immediately to the north of SGZ. At 1618 hours, mid-time of the first sample of Vegas 8's tracking mission, the northern edge of the cloud was located at 9,500 feet MSL and was found to extend from Gold Reed to the northern tip of the Belted Range. Activity varied from approximately two times background over Gold Reed to ten times background over the Belted Range. A second sample run was flown on a reciprocal heading over the first sample run course confirming the first results. At 1710, sample run number three began over the southern tip of the Kawich Range at 9,500 feet MSL on a true course of 180 degrees terminating at the northern boundary of NTS. The cloud was first detected over Gold Reed at three times background and increased rapidly to approximately 75 times background at the ter-

minal position. Sample run number four began at 1742 hours over Black Mountain at 9,500 feet MSL on a true course of 90 degrees, continued to the western boundary of Groom Lake then north on a true course of 00 degrees terminating five miles southwest of Queen City Summit. Cloud activity twice background was first detected four miles east of Black Mountain and continued uninterrupted to a position directly east of the northern tip of the Belted Range. Maximum activity of approximately 140 times background occurred at 1748 hours five miles north of Gate 700.

On D-day from H+4 hours to H+8 hours, an Air Force Tactical Air Command (AFTAC) C-54 aircraft tracked and sampled from NTS north-northwest to approximately 38 degrees north, 117 degrees west at 7,000 to 9,000 feet MSL.

On 6 March, Vegas 8 departed McCarran Airport for a cloud trajectory mission through north central Nevada. Flight sample runs were made between each of the following locations in order as given: Mercury, Beatty, Lida Junction, Tonopah, a point 60 miles from Tonopah on a true heading of 28 degrees, Currant, Austin, a point 10 miles north of Battle Mountain, Austin, and a point 30 miles south of Austin.

A C-130 aircraft operating from Tonopah found activity in Big Smokey and Monitor Valleys at about 7,000 feet MSL. A C-135 also searched east of NTS in an area bounded by Salt Lake City, Ogden, and Rock Springs, Utah; and Grand Junction, Colorado at altitudes between 10,000 and 13,000 feet MSL. Results from this flight were negative.

### 3.3.2 Surface Reentry Activities

Initial safety and radiological surveys were performed under the direction of the Test Group Director in accordance with the

"Radiological Safety Support Plan for RED HOT." The initial radiation survey began at 1111 hours and was completed at 1153 hours on 5 March 1966.

Two vehicle-borne Radsafe teams, consisting of two radiation monitors each, performed the initial ground survey. They were referenced as team No. 1 and team No. 2. After release by the DOD Test Group Director, the two parties proceeded from the FCP via the Area 12 Main Access Road toward the U12g portal area, surveying enroute. Initial radiation survey readings are shown in Table 3.3. The maximum measurement of 7,000 mR/h was at the rope fence in the portal area.

Radsafe Team No. 1 proceeded to the vicinity of the portal and as radiation intensities allowed, obtained radiation measurements at the portal and other locations of interest in the area. Upon completion of the survey, team No. 1 proceeded to a point immediately outside the newly established radex area near the entrance to the portal area. A temporary mobile check station facility was then established at this location.

Team No. 2 proceeded to the film-instrumentation trailer park, surveying enroute. During this survey, film was recovered from the trailers. Four SRI personnel were escorted to the trailer area by a Radsafe monitor to perform experiment recovery. After completion of the trailer park survey, team No. 2 controlled access to the portal area.

Each area and all contaminated or radioactive materials were marked to indicate radiation levels present. Personnel entering radiation areas or working with contaminated material were briefed concerning potential exposure and safety precautions and provided with anticontamination clothing, equipment, and materials.

TABLE 3.3  
 RED HOT EVENT  
 INITIAL RADIATION SURVEY DATA  
 5 March 1966

<u>Time</u>	<u>Location</u>	<u>Gamma Exposure Rate (mR/h)</u>
1111	Stake M-143 (7.2 miles SE of portal)	Bkg*
	Stake M-147 (6.2 miles SE of portal)	Bkg*
	Stake M-151 (5.2 miles SE of portal)	Bkg*
	Stake M-155 (4.3 miles E of portal)	Bkg*
	Stake M-162 (3.5 miles NE of portal)	Bkg*
	Stake M-163 (3.4 miles NE of portal)	Bkg*
1130	Stake M-167 (2.8 miles NE of portal)	0.2
1138	Stake M-170 (2 miles NE of portal)	0.5
1139	Stake M-175 (1.4 miles NE of portal)	1.0
1140	Stake 12-G-6 (1.1 miles NE of portal)	1.5
1141	Stake 12-G-7 (1.0 mile NE of portal)	15.0
1141	G Tunnel pad entrance	50.0
1145	Cable run west	500.0
1145	Rope fence (center)**	1,000.0
1146	Rope fence (west)	1,500.0
1151	Rope fence (west)	7,000.0
1153	Rope fence (east)	5,000.0

\*Background radiation measurement

\*\*Because the possibility of venting had been considered, the area in front of the tunnel portal had been roped off to prevent anyone from getting in a direct line with the tunnel. The rope ran east and west across the portal area, parallel to the axis of the tunnel, and 100 feet north of the portal.

After use, anticontamination clothing and equipment were laundered and returned to stock for subsequent reissue. Those items which could not be decontaminated to permissible levels were buried at the designated disposal site in Area 5.

On 5 and 6 March, reentries were made to the portal area to recover film and various other experiment data. According to plan, tunnel reentry was not to take place prior to 21 March 1966.

On March 6 at 0720 hours, the security and Radsafe control station was moved to the junction of Orange Road and Mercury Highway in Area 12. From 0940 hours to 1400 hours, four DOD personnel, five SC personnel, and two LASL personnel entered the closed area to recover film and tapes. At 1510 hours, a Radsafe monitor, one DOD representative, and mining department personnel entered the controlled area to seal the portal. They completed the task and exited the area at 1522 hours.

At 1730 hours, an air sampling trailer was placed in front of the tunnel portal. On 7 March 1966, sometime between a radiation survey at 0230 hours and the next entry into the area at 0530, an explosion took place. The air sampling trailer was destroyed by the explosion. Portal gates, portal coverings, and vent lines were damaged. The explosion was caused by explosive gas trapped underground which ignited for some unknown reason. No personnel were in the area at the time. The rope and barricade fence which had been constructed before the event completely blocked access into the portal area. Before and after the explosion anyone proceeding beyond the barricade was accompanied by a Radsafe monitor and wore appropriate respiratory protection. The portal gates and coverings were repaired, and no reentries into the tunnel were permitted until 17 March.

No other experimenter reentries were recorded between 7 March and 16 March.

### 3.4 POSTEVENT ACTIVITIES

#### 3.4.1 PHS Ground Monitoring Support

Winds on D-day were light and variable, moving the radioactive effluent very slowly to the north-northeast. By the time the cloud had penetrated into the offsite populated areas, it was diffused over a large area and most of the very short lived radionuclides were not detected.

Eight PHS ground monitoring personnel were located north and northeast of SGZ. Four were stationed onsite and four were offsite along Highway 25 from Hancock Summit to Warm Springs. One of these monitors later checked along Highway 6 from Warm Springs to Clark Station. No radiation intensities above background were measured by any ground monitors in the offsite areas.

Six milk samples were collected following this event. Each milk sample was counted for 40 minutes using a 400-channel analyzer viewing an energy range from 0 to 2 MeV. No radioiodines were detected in these samples. Chemical analyses indicated that strontium isotopes were all below 20 pCi/l.

Vegetation samples were collected in the projected effluent trajectory to detect any deposition on the ground. They also were obtained at most milk sampling locations, with an effort made to take samples representative of the cows' feed. Twenty-seven vegetation samples were collected from offsite locations and analyzed for gamma emitting isotopes. Only one sample, collected at Battle Mountain, Nevada, on 7 March, showed the presence of fresh fission products (iodine-131 and iodine-133).

One water sample was collected from a stock tank at Nyala, Nevada, on 7 March. Another sample was collected at Nyala and a

sample was obtained at Twin Springs Ranch on 8 March. None of these samples contained fresh fission products.

Small (less than 1 to 81 picocuries per m<sup>3</sup>) amounts of radioiodine isotopes were found on filter media from thirteen off-site air sampling stations.

### 3.4.2 Tunnel Reentry

The ventilation blowers were restarted on 17 March 1966. At 0945 hours on 24 March, a work party accompanied by a Radsafe monitor entered the area to remove the gate from the tunnel portal. The gate was removed at 1100 hours and miners began hooking up the vent line to the main blowers.

On 6 April 1966 at 1225 hours, the reentry team entered the tunnel which was found to be blocked by debris approximately 2,500 feet in from the portal. Bioassay samples were taken from reentry personnel before and after tunnel entry.

On 7 April at 1000 hours, a party entered to perform explosive mixture checks of tunnel air before the work party entered. They entered as far as the MADISON drift turnoff, noting significant amounts of debris, but no toxic gas or explosive mixtures. Because of problems with the MADISON fan generator, no reentries were made for the remainder of the day.

Reentry mining and debris removal continued until the MADISON drift was reentered on 9 May 1966 from 1330 hours to 1530 hours. At this time, a decision was made not to mine through the main drift but to drive a parallel bypass drift from the MADISON drift toward the Deep Well drift. Work on the bypass drift began on 27 April at 1330 hours. On 29 June 1966 reentry teams reentered the main drift through a crossover from the bypass drift. Contact readings of 7 R/h were recorded in the main drift. DOD

photo team, SC inspection party, and visitor party personnel entered the main drift from 1530 to 1615 hours. Upon their exit the entrance to the crossover drift was barricaded.

### 3.4.3 Industrial Safety

Checks were made on each shift for radiation levels, toxic gases, and explosive mixtures. These measurements were then recorded in the monitors' log book. Maximum industrial hygiene readings for the RED HOT event were:

1. 70,000 ppm CO in the cavity above the "Y" in the tunnel on 26 April 1966.
2. 100 percent of the LEL in the main drift on 19 April 1966.
3. 10 ppm NO + NO<sub>2</sub> at the reentry mining face on 19 May 1966.

Industrial safety codes, including specific codes for mining, tunneling, and drilling were established by REECo and were emphasized during all operations.

### 3.4.4 Postevent Drilling Activities

On 30 April 1966 at 2230 hours, drillback from the top of Rainier Mesa into the RED HOT cavity began. The abandonment valve was closed after completion of the drillback operation on 3 May 1966 at 1545 hours. No core samples with sufficient activity for radiochemical analyses were obtained.

Later in the day on 30 April, DOD had a blower hooked onto the abandonment valve so that air could be removed from the

cavity, thus reducing pressure in the cavity. Cavity ventilation was conducted through 5 May 1966.

### 3.5 RESULTS AND CONCLUSIONS

Telemetry coverage began at 1015 hours on 5 March 1966 and continued until 1500 hours on 13 April 1966. Maximum measurements underground and on the surface were:

Greater than 1,000 R/h at Station 5+00 (500 feet inside MADISON drift) at 1205 hours on 5 March 1966.

200 R/h at surface station 161 degrees azimuth 439 feet from the portal at 1034 hours on 5 March 1966.

The initial reentry survey began at 1111 hours and ended at 1153 hours on 5 March 1966. The maximum measurement of 7 R/h was at the rope fence around the portal area at 1151 hours on 5 March 1966.

Postevent mining began on 6 April 1966 at 1255 hours. Mining and recovery operations were completed on 26 July 1966.

Surface drillback into the RED HOT cavity began at 2230 hours on 30 April 1966 and was completed at 1545 hours on 3 May 1966. The maximum radiation measurement was 10 mR/h on the drill platform at 1535 hours on 3 May 1966.

The highest alpha radiation measurement was 3,500 cpm at 1430 hours at the Radsafe alcove on 29 June 1966.

No radiation intensities above background were measured in offsite areas by ground monitors, dose rate recorders, or film badges. Small amounts of radioiodines were found on filter media

from 13 offsite air sampling stations. No fresh fission products were found in milk or water samples taken.

Personnel exposures received during individual entries to RED HOT radex areas from 5 March 1966 through 26 July 1966 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	3921	740	16
DOD Participants	140	80	19

It was the opinion of the PHS that no health hazard in the offsite area was produced by the RED HOT event.

## CHAPTER 4

### PIN STRIPE EVENT

#### 4.1 EVENT SUMMARY

PIN STRIPE was a DOD underground detonation with a yield of less than 20 kt conducted at 1138 hours Pacific Daylight Time (PDT) on 25 April 1966 at shaft site U11b in Area 11 of NTS. The device was emplaced in a mined shaft at a depth of approximately 970 feet. The event was conducted to study the effects of a nuclear detonation environment on equipment and materials. An LOS pipe with a maximum diameter of 36 inches extended to the surface as part of the study.

Venting began one minute after detonation and continued until cavity collapse occurred approximately five minutes after detonation. Seepage from the SGZ area began seven hours after detonation and continued until 28 hours after detonation. Venting was not through the LOS pipe or shaft stemming but through an unanticipated geologic fissure. Radioactive effluent from this event was detected both onsite and offsite. These occurrences are discussed in greater detail in section 4.3. The event was fielded for the DOD by Sandia Laboratory, which was responsible for furnishing, emplacing, and detonating the PIN STRIPE device. Fourteen projects were conducted by the DOD, laboratories, and contractors.

#### 4.2 PREEVENT ACTIVITIES

##### 4.2.1 Responsibilities

The DOD Test Group Director was responsible for safe conduct of all PIN STRIPE project activities in Area 11. Responsibili-

ties of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DASA, and the Nevada Operations Office. The DOD was responsible for preevent installation and postevent removal of equipment necessary for their project activities.

#### 4.2.2 Planning and Preparations

The "PIN STRIPE Reentry Plan" described preevent preparations and postevent procedures used to conduct safe and economical reentry and recovery within the desired time frame. In addition, Radsafe personnel were provided with "Detailed Initial Reentry Procedures" for reentry and recovery operations.

##### A. Construction and Experiment Readiness

Construction at the PIN STRIPE site started in October 1965 with preparation for shaft mining. Actual mining commenced in November, and the shaft was completed in early March 1966. Installation of cable troughs, scientific cabling, trailer park, and preparation of the mobile tower proceeded in parallel and was completed in February 1966 (Figure 4.1). The main trailer park was established 650 feet east of SGZ, 100 feet closer than for WISHBONE and DILUTED WATERS (these events were described in the first volume of this series), to save on cable and decrease signal losses. Two trailers were more heavily shock-mounted and placed 350 feet from SGZ to allow recording of low level signals with little or no amplification and low signal loss.

During this field construction phase, all experimenters were completing fielding preparations and fabricating their experiments. These activities were accomplished at a relatively easy pace due to stretchout in the PIN

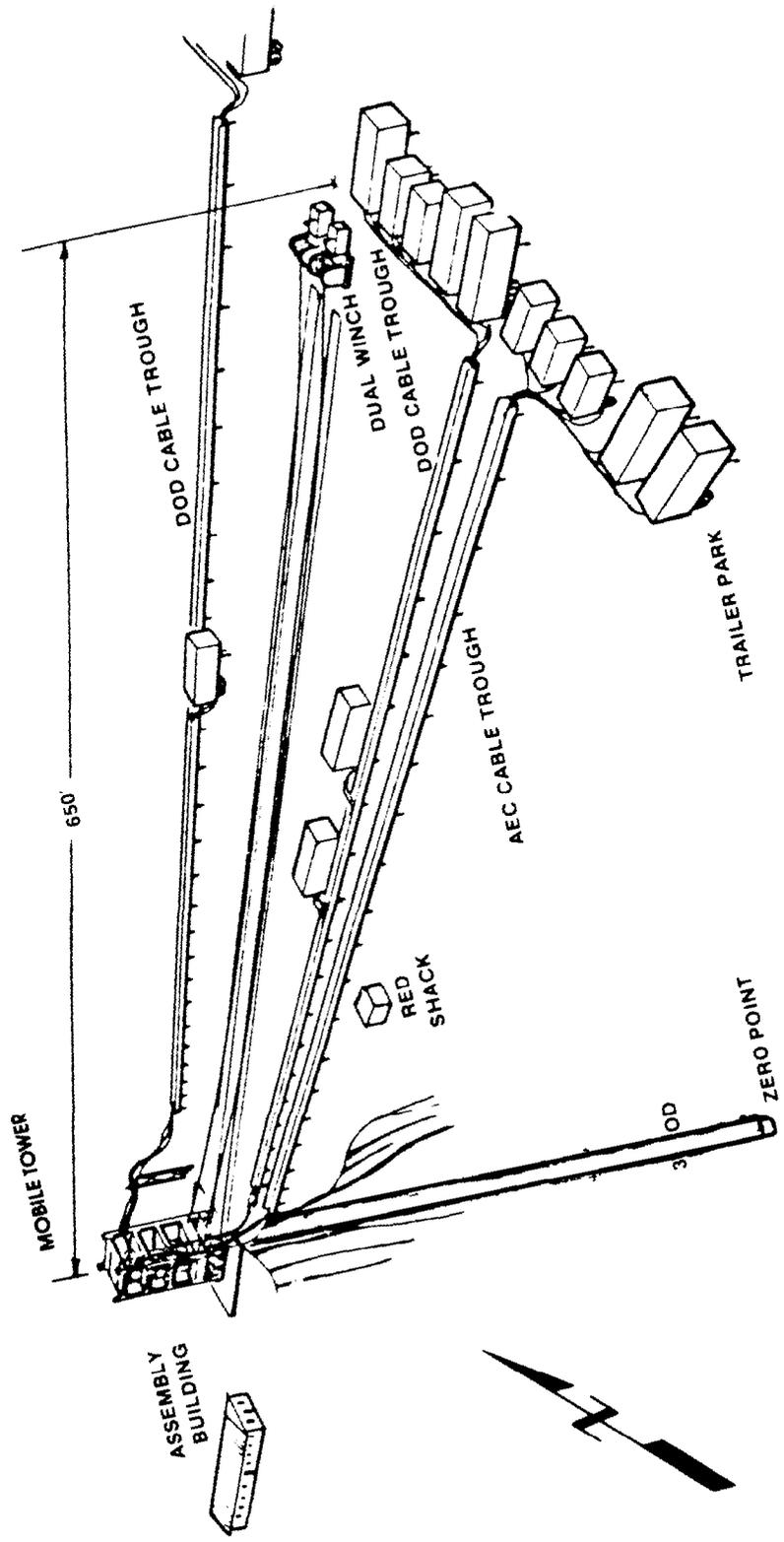


Figure 4.1 PIN STRIPE Test Configuration

STRIPE test schedule. Experimenters started arriving onsite in late January 1966 to set up and check out their instrumentation trailers and prepare experiments for mounting on a mobile tower in February and March.

Early in the field installation phase, advantages of electric motor-driven generators for furnishing isolated, regulated, power to instrumentation trailers over the previously used diesel-engine-driven generators were considered. While motor generators offered better overall reliability, there was some question as to possible difficult ground isolation and power losses during area power outages before and just after zero time. The controversy was settled when it became apparent that only a very few motor-driven generators could be made available. Thus, most instrumentation trailers were powered by the usual diesel generators while only a few, the Harry Diamond Laboratories (HDL) trailers, were powered by motor generators.

The line-of-sight (LOS) pipe and closure hardware were delivered several pieces at a time during February and March 1966 and were installed one section at a time starting from the bottom of the shaft. This installation procedure was in contrast to installation of the entire pipe string from the surface as had been done in previous drilled-hole LOS pipe tests. Installation of pipe sections and closure hardware into the shaft piecewise allowed continuing access to them until stemming took place. Just prior to starting pipe installation it was discovered that bolts to be used to fasten pipe sections together were of substandard quality (lacking in tensile strength). Although no major problem was encountered, pipe installation and dry runs were delayed several days while new bolts were procured.

Signal dry runs began in late February for a planned period of four weeks prior to the full power, full frequency (FPPF) dry run. Several electrical leakage paths between various signal cable shields and earth ground were discovered and subsequently eliminated.

Once the LOS pipe was installed and checked out, walls were removed from the tower sides and access was reduced for safety reasons. The mobile tower was then moved to its final position, straddling the pit from which the top of the LOS pipe protruded. The cables leading from the experiments back to the instrumentation trailers were supported on scaffolding-type cable towers adjacent to the test tower. Due to the movement of the tower and scientific cables and the long intervening time since the FPPF dry run, a mandatory participation dry run was held to once more check continuity and operation of the entire experimental and electrical system.

#### B. Radiological Safety Support

Detailed radiological safety reentry plans were submitted to participating agencies prior to the test event. Test area maps with appropriate reference points were prepared. Reference markers, radiation decay recorders, and air sampling equipment were positioned in the test area. Reentry routes into the test area were established during "dry runs." Party monitors were briefed regarding reentry, sample recovery, manned stations, and security station requirements.

Remote area monitoring stations and air sampling units were installed according to DOD and laboratory specifications. Radsafe monitors were stationed at all WSI security roadblocks and work areas within the exclusion

area to perform surveys and provide other support as directed.

Documenting any radioactive effluent release was the primary mission of Radsafe personnel assigned to manned stations. All additional personnel at manned stations were provided with appropriate anticontamination clothing and equipment, and Radsafe monitors were in attendance.

Radsafe provided monitoring teams and supervisory personnel for initial surface radiation surveys, aerial surveys by helicopter, and reentry parties as needed. Radsafe personnel were standing by at the FCP prior to detonation ready to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Anticontamination materials available included coveralls, head covers, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

#### C. Telemetry and Air Sampling Support

RAMS units were located as follows:

8 - underground stations

1 - SGZ

4 - 100 feet from SGZ at 90° intervals beginning at 45° azimuth

- 6 - approximately 500 feet from SGZ at varying degrees azimuth
- 5 - approximately 710 feet from SGZ at varying degrees azimuth
- 12 - 1,000 feet from SGZ at 30° intervals beginning at 15° azimuth
- 12 - 2,000 feet from SGZ at 30° intervals beginning at 0° azimuth

D. Security Coverage

Muster and control stations were established on D-day. All personnel entering or exiting the controlled area were required to stop at the muster or control stations for issuance or return of their muster or stay-in badges. All personnel were required to have proper security clearances for the area. Control of the area was maintained by using roadblocks, access permits, and a Schedule of Events. Parties could enter the controlled area only with permission from the Test Manager or the DOD Test Group Director. WSI security guards were responsible for activating roadblocks and directing traffic flow.

E. Air Support

The two PHS sampling aircraft were Vegas 8, a PHS twin turboprop Beechcraft; and Vegas 2, a PHS twin-engine Beechcraft C-45. Only Vegas 2 was used on this event because the other twin-turboprop Beechcraft, Vegas 7, was undergoing manufacturer's engine changes and structural modifications. The main sampling aircraft was Vegas 8, which provided initial monitoring and sampling, and also flew two trajectory missions--one on the day of the event, and the other on the following day. Vegas 2

was flown to obtain a gas sample four hours after the event. The EG&G/NATS aircraft, a Martin 404, was on standby at McCarran Airport in Las Vegas.

#### 4.2.3 Late Preevent Activities

Final checks were made on all systems, and the test was scheduled for 19 April. Unfavorable winds (both speed and direction) plagued the test for six days. Although an unsuccessful attempt to execute on one other day (between 19 and 25 April) was made, PIN STRIPE was not executed until 25 April.

#### 4.3 EVENT-DAY AND CONTINUING ACTIVITIES

The readiness briefing on 24 April initially scheduled the test event for 1000 hours on the morning of 25 April. However, undesirable wind direction and low wind speeds caused postponement at that time. NTS and PIN STRIPE surface wind criteria required a southerly wind of at least 5 knots (approximately 5.8 mph) to provide adequate fallout protection for the trailer park as well as the rest of the test site, and to comply with the Limited Nuclear Test Ban Treaty. The 30-minute countdown finally began at 1108 hours. PIN STRIPE was detonated at 1138 hours PDT with detonation time surface winds of 6 mph from 190° azimuth.

For about the first minute after detonation, all indications were as expected; i.e., the ground heaved and some amount of dust was thrown into the air. At H+1 minute, the winches were started to withdraw the mobile tower from the expected subsidence area. At approximately the same time, effluent began to emerge from the ground at a point some 150 feet southwest of SGZ. The point of emergence lengthened into a line extending toward SGZ in a few seconds and further away from SGZ a few tens of seconds later. A gray cloud formed, growing until subsidence occurred. The subsi-

dence crater was a maximum of only 14 feet deep and elliptical, approximately 135 by 245 feet, elongated in the direction of the surface crack from which the effluent emerged. Crater volume was 33,000 cubic yards.

The cloud rose to an altitude of about 2,000 feet over the test area as it was blown by winds in a north-northeast direction. As planned for such an occurrence, winds did not take effluent directly over the trailer park. However, significant radiation exposure of trailers and recording equipment inside them was caused by gamma shine from the radioactive material in the cloud. Winds continued to blow the cloud over the northeastern portions of the NTS and offsite.

RAMS unit measurements of radiation levels in the trailer park rose to 400 R/hour for 2 to 3 minutes. Radioactivity decayed rapidly, until at about H+20 minutes, the readings had decayed to 15 to 20 R/hour. Permission was granted by the Test Manager at H+20 minutes to proceed with high priority data recovery. The initial hazards survey party and priority film recovery parties then departed the reentry assembly area with instructions not to enter areas where the exposure rate was greater than 17 R/hour. All high priority film recovery was completed by H+35 minutes. The remainder of the film and oscillograph paper was recovered by H+80 minutes.

Since very little radioactive material was deposited in the PIN STRIPE area, the radiation readings dropped fairly rapidly. Crews had disassembled the mobile tower and prepared it for experiment recovery by H+6 hours. Radiation dosimetry devices on the tower were recovered and several experiment packages were removed from the tower by H+7-1/2 hours.

#### 4.3.1 Cloud Tracking and Sampling, and Offsite Monitoring

The effluent cloud rose to about 5,500 feet MSL within 9 minutes after detonation, and to 10,500 feet MSL by one hour after detonation with a north-northeast trajectory. After approximately three hours travel time at about 10 miles per hour, it turned easterly and began to spread out. By the time the cloud had traveled about 90 miles with increasing speed (to near 20 miles per hour), the cloud front extended approximately 90 miles.

PHS provided aerial sampling and measurements for the PIN STRIPE event. Also, AFTAC, Nevada Aerial Tracking System (NATS), and Aerial Radiation Monitoring System (ARMS) aircraft tracked and sampled the cloud during the night. The two PHS sampling aircraft were Vegas 8, a PHS twin-turboprop Beechcraft, and Vegas 2, a PHS twin-engine Beechcraft C-45. Vegas 8 provided initial monitoring and sampling, and also flew two trajectory missions--one on the day of the event and the other on the following day. Vegas 2 was flown to obtain a gas sample four hours after the event.

Shortly after the event, Vegas 8 began overflying the cloud to determine radiation levels and trajectory. On the basis of the levels of activity, it was decided to wait until H+1 hour before entering the cloud. Vegas 8 then entered the cloud path to obtain information on the size and shape of the release and to collect samples for subsequent laboratory analysis. After close-in cloud characterization, trajectory flights were made to determine the path taken by the release.

Prior to the start of sampling, the direction of the visible cloud was noted and a circuit of the cloud was flown to obtain an estimate of size and shape. A sampling pattern was set up across the projected cloud trajectory and was flown repeatedly while

sampling. A sampling altitude was selected by visually examining the cloud rather than during a vertical penetration so as not to unduly contaminate the aircraft before beginning sampling. After collecting samples and data on cloud size, two spiral descents were made through the cloud to determine the vertical distribution of activity.

The first trajectory flight served mostly to determine the rate of dispersion and decay in concentration of activity to aid in planning for the next day. This flight consisted of two legs across the cloud position as reported by the NATS aircraft.

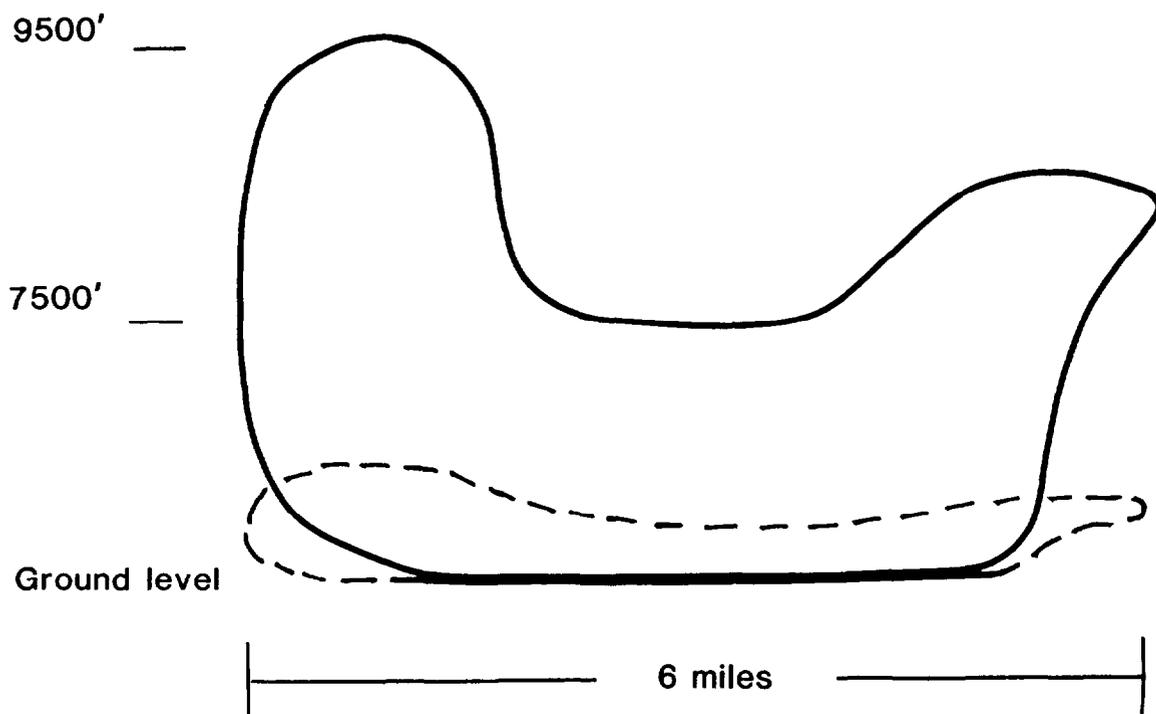
The sampling path for cloud quantitation was established initially between the south end of Papoose Lake and Camera Station Butte in Area 3. Cloud arrival time at Papoose Lake was 1240 hours, establishing the average speed at 10 miles per hour.

Clearance was requested for Vegas 8 to enter the Bombing and Gunnery Range and was received at 1309 hours. The cloud at that time was traveling at about  $29^\circ$  from SGZ, was 12 miles wide, and 8 miles long.

The end view of the visible cloud at 1220 hours was similar to the view shown in Figure 4.2. It was because of this saddle that sampling was performed at 7500 feet MSL in order to remain in the main body of the cloud.

Four sets of six sequential samples were collected during passage through the cloud. Since the cloud was wider than anticipated, the first two sets of sequential samples covered only about one-half of the cloud width. The last two essentially spanned the cloud.

Two additional sequential sample sets were collected during spiral descents through the cloud over the pass seven miles



**PIN STRIPE**

**DASHED LINE INDICATES CLOUD TO SAME SCALE AS THE BASE,  
SOLID LINE INDICATES AN EXAGGERATED VERTICAL SCALE.**

Figure 4.2 End View of Cloud at 1220 Hours - Looking North

northeast of Groom Lake. On the basis of information from the other aircraft, the first descent began at 15,000 feet MSL at 1348 hours at a planned rate of descent of 2,000 feet per minute with 45-second sampling intervals. Once the descent started, the press of radio communications made it impossible for the pilot to maintain this rate, and the sixth sample was completed at 9,100 feet MSL. However, the cloud top was located at 11,800 feet MSL. A second descent was made from 13,200 feet MSL at a rate of 1,000 feet per minute with one-minute sampling intervals.

Vegas 2 was the gas sampling aircraft. It had an elevator-type platform that was lowered to approximately five feet below the aircraft with five sampling probes mounted on the platform. Tubing conducted the air sample into the airplane with sweeping "S" bends to the cryogenic sampler, which was the only sampling equipment used in Vegas 2.

Vegas 2 was called in to collect a cryogenic sample and met Vegas 8 in the vicinity of the spiral descents. Sampling began at 1504 hours near Highway 25 west of Hancock Summit, and continued until 1606 hours. Low levels of activity prevented cloud edge measurement which, in turn, precluded cloud volume calculation for this mission.

Vegas 8 was washed with water and detergent to reduce low level contamination and detection instrument background. It then flew a cloud trajectory mission between 1805 and 2030 hours. Shortly after takeoff the power inverter supplying the sensitive detection systems failed. Information from NATS at 1825 hours indicated cloud activity from Caliente to north of Pioche.

Between 1913 and 1925 hours, a set of sequential samples was collected from 37 miles north of Pioche to Pioche at 13,000 feet MSL. A second set of samples was collected between 1940 and 2004 hours from Pioche to 72 miles south.

Vegas 8 again departed on 26 April, still without the use of permanently-installed detection systems. It was hoped that on-board beta counting of the collected samples would enable the crew to locate the cloud. However, the low levels of activity and high background prevented this. The two-inch diameter interval samples were collected for consecutive ten-minute periods along the flight path at 13,000 feet MSL. Laboratory counting of samples collected on this flight indicated the possibility of some activity over Utah, but with positive contact from between Grand Junction and Meeker to just south of the Colorado border.

The PHS-NV extended milk sampling network was placed in operation throughout Utah, Colorado, Wyoming, and southern Idaho. Also, the extended air sampling network was fully alerted. A peak radiation reading of 8 mR/h was recorded about 14 miles east of Coyote Summit, NV (about 50 miles from SGZ). This reading decreased to 2 mR/h within 30 minutes after the peak reading. The cloud transport speed was approximately 10-15 knots. Indications were that the cloud was dispersing.

The NATS plane had a positive contact with the cloud on 26 April with the cloud approximately 300 miles due east of NTS; airborne readings registered from two to ten times background. The air mass containing effluent also was located on 26 April over an area extending from southern Wyoming south to southwestern Kansas. The cloud mass appeared to be dispersing, and there was evidence that its radioactive content was being diffused. The last positive aerial contact made by the ARMS aircraft was on 26 April at the southeastern Colorado border late in the afternoon.

Vegas 8 intercepted the cloud between Denver and Pueblo, Colorado at approximately 1230 hours 26 April, at 14,000 feet MSL. The air mass had shifted to the north and was located between central Minnesota and central Kansas. Rain showers were

encountered by the cloud in its passage. The rain and snow in North Dakota, Minnesota, and Kansas had a leaching effect on any effluent still present in the air mass. PHS, NATS, ARMS, and USAF aircraft continued to track the air mass until no further positive identification could be made that day.

During daylight hours of 27 April, the NATS aircraft flew a pattern from Wichita, Kansas, north to International Falls, Minnesota and returned to Minneapolis, Minnesota. The last positive contact with airborne radioactivity was at 13,000 feet MSL over Pawnee City, Nebraska, about 1320 hours EDT. The NATS mission was terminated in Minneapolis at approximately 1800 hours Eastern Daylight Time (EDT), on 27 April. During the flight, extreme turbulence (as well as snow and rain) was encountered. The NATS aircraft later returned to Nevada. The ARMS aircraft was grounded at Scottsbluff, Nebraska, because of high winds.

The highest radiation level in a populated area near NTS was 1.45 mR/h at Hiko, Nevada, at 1600 hours PDT on 25 April. The 8 mR/h level at Coyote Summit was in an unpopulated area.

External exposure rates at Hiko were well below levels of concern, resulting in a calculated maximum whole-body exposure of 12 mR compared to the 500 mR per year offsite individual whole-body exposure guide (see Appendix D). Although internal exposures were expected to be low, precautionary measures were taken to minimize radioiodine doses to the thyroid through the milk chain (possible through fallout on feed for dairy cows).

Arrangements were made for 134 dairy cows at one Hiko dairy to be placed on dry feed (hay). This was implemented following the afternoon milking on 27 April. Also, a mobile thyroid counting trailer was moved from PHS-NV to the Alamo-Hiko, Nevada, area on 27 April.

From 27 through 30 April, thyroids of 78 adults and children from surrounding towns were measured for radioiodines. Based on these measurements, the projected thyroid doses averaged about 50 mrem, with two persons receiving thyroid doses in the range of 150 to 300 mrem. For comparison, the offsite individual thyroid exposure guide established by AEC Headquarters was 1500 mrem per year.

Milk samples collected and analyzed by the PHS network for Wyoming, Utah, and Colorado showed no detectable radioiodine except for samples collected near Provo, Utah. These samples showed small amounts of iodine-131. Subsequent sample results indicated background levels within two days for this area.

#### 4.3.2 Radiation Surveys and Reentry Activities

The PIN STRIPE initial radiation survey began at 1213 hours and was completed at 1223 hours on 25 April 1966. Readings are shown in Table 4.1. Additional surveys of the test area were continued until 2400 hours and are shown in Table 4.2.

All survey data were reported, as collected, to the net 3 radio control operator.

Radsafe personnel were stationed at the DOD Test Group Director's FCP to perform initial and subsequent ground surveys as required; provide emergency rescue and support as directed; provide and issue anticontamination equipment, portable instruments, and dosimetric devices; perform personnel, equipment, and vehicle decontamination; and operate a sample return station. A mobile facility for issue of anticontamination equipment, portable instruments, and dosimetric devices was positioned at the FCP along with a mobile decontamination unit.

TABLE 4.1  
 PIN STRIPE EVENT  
 INITIAL RADIATION SURVEY DATA  
 25 April 1966

<u>Time</u>	<u>Location (from SGZ)</u>	<u>Gamma Exposure Rate (mR/h)</u>
1213	Stake UE5F (1 mile SW)	0.6
1215	U11b equipment yard	70.0
1215	Stake U11B4 (1/2 mile SE)	80.0
1216	Trailer Compound	5,000.0
1218	10 feet east of tower	17,000.0*
1221	Stake 5C35 (1/4 mile SW)	1,700.0
1223	100 yards from SE perimeter	7,000.0

\*This exposure rate was measured at contact with the ground, and was not a personnel exposure rate.

TABLE 4.2  
PIN STRIPE EVENT  
RADIATION SURVEY DATA  
25 April 1966

<u>Time</u>	<u>Location (from SGZ)</u>	<u>Gamma Exposure Rate (mR/h)</u>
1614	Stake 5C20 (3-1/4 miles SW)	12.0
1626	Stake 5C25 (2-1/4 miles SW)	80.0
1633	Stake 5C29 (1-1/2 miles SW)	120.0
1633	Stake 5C29 (1-1/2 miles SW)	250.0*
1643	Stake 5C33 (3/4 mile SW)	55.0
1646	Stake 5C36 (SGZ)	6.5
1658	Stake 5C42 (1-1/2 miles SE)	2.0
1719	Stake 5C51 (2-1/2 miles NE)	1.4
1719	Stake 5C51 (2-1/2 miles NE)	1.5*
1743	Stake 5C42 (1-1/2 miles SE)	1.1
1745	Stake 5C36 (SGZ)	4.0
1759	Stake 5C33 (3/4 mile SW)	35.5
1807	Stake 5C29 (1-1/2 miles SW)	85.0
1817	Stake 5C25 (2-1/4 miles SW)	50.0
1826	Stake 5C20 (3-1/4 miles SW)	8.0
2200	Security Station 256-C	5.0
2320	Security Station 256-C	2.5
2400	Security Station 256-C	0.2

\*Contact reading

Decontamination units were positioned at entrances to controlled areas. Personnel and equipment were monitored and decontaminated as necessary. Drill rigs and associated equipment used in postevent activities also were monitored and decontaminated as necessary.

Each area and all contaminated and radioactive materials were marked to indicate radiation levels present. Personnel entering radiation areas or working with contaminated material were briefed concerning potential exposure and safety precautions, and were provided with anticontamination clothing, equipment, and materials.

#### 4.4 POSTEVENT ACTIVITIES

##### 4.4.1 Subsidence Crater Reentry

From approximately 1620 hours to 1635 hours on 11 May 1966, reentry party personnel dressed in anticontamination clothing for entry into the crater area. Each person was issued one 200 mR and one 1 R pocket dosimeter in addition to one Victoreen Radector radiation detection instrument. Acme full-face masks and MSA masks were readied and placed in a large plastic bag to be issued at the crater site if there was an indication of escaping gases or airborne dust particles. The party then traveled to the forward security barricade (located on the access road at the east side of the trailer compound), and subsequently was cleared into the area at 1645 hours.

The party entered the crater area inside the perimeter fence from the west and proceeded to the west side of the crater (1 R/h gamma field) (Figure 4.3). Then the party walked the crater edge to the fissure area on the south side of the crater (exposure rate varied from 1 R/h gamma to a maximum of 5 R/h gamma at three

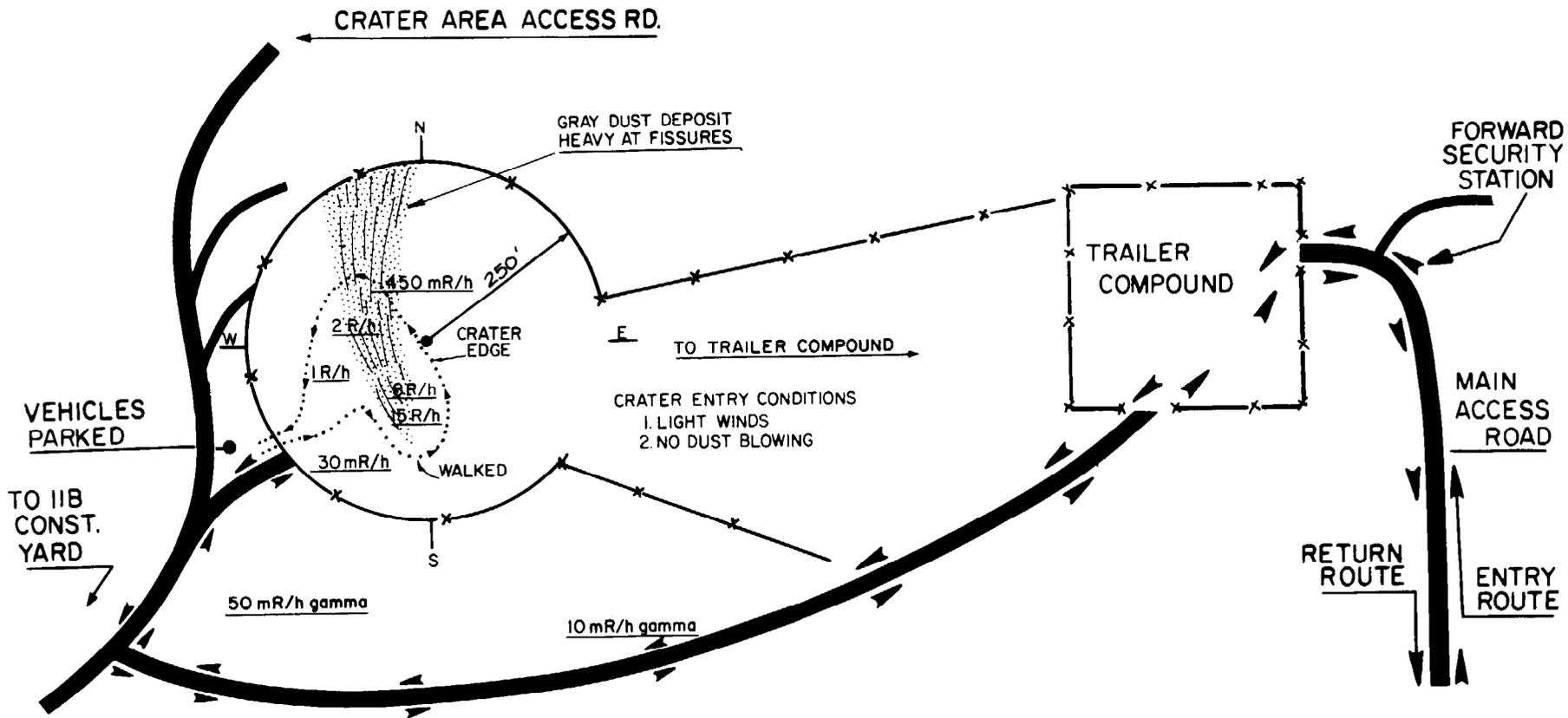


Figure 4.3 Ullb Crater Entry - 11 May 1966

feet above ground, and 15 R/h gamma contact). This survey was completed in three to four minutes. The party entered the crater area from the south side and walked to the shaft area where they spent three to four minutes. They exited the crater at approximately 1705 hours. Upon arrival at the vehicles, shoe covers, hoods, and gloves were removed. This was to avoid contamination of vehicles. The party exited the area at 1715 hours.

Upon arrival at the Radsafe facility, the entry party personnel undressed, were monitored, were decontaminated as necessary, and had film badges exchanged. The average exposure reading per pocket dosimeter was 155 mR. Vehicles were surveyed and personnel exited the area.

#### 4.4.2 Postevent Drilling

The postevent drill rig and crew arrived at the drill site and began setting up on 14 July. Between 18 July and 28 July 1966, continuous drilling problems were experienced. As a result of the problems the operation was suspended, the rig dismantled and decontaminated, and the cap welded on the hole by 2030 hours on 28 July 1966. The maximum radiation reading recorded during postevent drilling activities was 100 mR/h in the cellar at 0040 hours on 17 July 1966.

#### 4.4.3 Industrial Safety

Toxic gas levels and explosive mixtures were monitored frequently. Industrial safety codes, including specific codes for mining, tunneling, and drilling were established by REECO and were emphasized during all operations.

#### 4.5 RESULTS AND CONCLUSIONS

The maximum telemetry reading was greater than 1,000 R/h at a station 100 feet from SGZ on 25 April 1966 at 1139 hours. The initial survey began at 1213 hours and was completed at 1223 hours on 25 April 1966. The maximum gamma reading was 17 R/h (ground contact) 10 feet east of the tower at 1218 hours on 25 April 1966. No alpha radiation was detected.

Postevent drilling began during day shift on 14 July 1966, and the rig was dismantled and equipment removed on 28 July 1966. The maximum gamma exposure rate detected was 100 mR/h in the cellar at 0040 hours on 17 July 1966. No alpha radiation was detected.

Personnel exposures received during individual entries to PIN STRIPE radex areas from 25 April 1966 to 1 August 1966 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	1873	835	48
DOD Participants	185	215	102

Radioactivity from the PIN STRIPE event was detected off-site. Calculated external and internal exposures at the offsite populated area with the highest exposure rates were less than AEC Chapter 0524 offsite exposure guides.

## CHAPTER 5

### DISCUS THROWER EVENT

#### 5.1 EVENT SUMMARY

The DISCUS THROWER event was a DOD underground detonation with a yield of 22 kt conducted at 1300 hours PDT on 27 May 1966 at shaft site U8a in Area 8 of the NTS. The device was emplaced in a 36-inch diameter shaft at a depth of 1,105 feet, and a short distance above an interface between two rock formations. The event was conducted to study ground shock transmission and characteristics in this type of geologic structure. The primary project consisted of 13 instrumented drill holes spaced at intervals in a line out to about 4,000 feet from the emplacement hole. Fourteen projects were conducted by DOD agencies and contractors. A subsidence crater formed 53 minutes after detonation. No radioactive effluent from this event was detected onsite or off-site.

#### 5.2 PREEVENT ACTIVITIES

##### 5.2.1 Responsibilities

The DOD Test Group Director was responsible for the safe conduct of all DISCUS THROWER project activities in Area 8. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DASA, and the AEC Nevada Operations Office. LASL was responsible for furnishing, emplacing, and detonating the DISCUS THROWER device. The DOD was responsible for preevent installation and postevent removal of equipment necessary for their project activities.

### 5.2.2 Planning and Preparations

The "DISCUS THROWER Reentry Plan" described preevent preparations and postevent procedures used to conduct a safe and economical reentry within the desired time frame.

#### A. Construction and Test Readiness

The experimental layout was completed by 31 March 1966, except for Hole No. 13, which was added in late April. The full power full frequency dry run was held on 16 May 1966, and the device was placed downhole on 23 May 1966. Except for several power outage problems beyond experimenter control, all systems functioned satisfactorily during the dry runs.

#### B. Radiological Safety Support

Detailed radiological safety reentry plans were submitted to participating agencies prior to the test event. Test area maps with appropriate reference points were prepared. Reference markers, radiation decay recorders, and air sampling equipment were positioned in the test area. Reentry routes into the test area were established during "dry runs." Party monitors were briefed regarding reentry, sample recovery, manned stations, and security station requirements.

Radsafe provided monitoring teams and supervisory personnel for initial surface radiation surveys, aerial surveys by helicopter, and reentry parties as needed. Radsafe personnel were standing by at the FCP prior to detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment, portable instruments and dosimeters; operate

area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Radsafe manned stations had as a primary mission the documentation of any radioactive effluent released. All personnel at other manned stations were provided with appropriate anticontamination clothing and equipment, and Radsafe monitors were in attendance. Radsafe monitors were stationed at all WSI security roadblocks and work areas within the exclusion area to perform surveys and provide support as directed.

Anticontamination materials available included coveralls, head covers, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

Sufficient Radsafe personnel were standing by at the FCP to implement rescue and emergency support, and to provide radiological area control as exclusion areas were established based upon reported survey data.

A mobile issue facility for anticontamination clothing, respiratory devices, instruments, and dosimetric devices was positioned prior to the event at the security barricade near the FCP. When authorized by the Test Group Director, this facility was repositioned to a convenient location. A personnel and vehicle decontamination facility was established adjacent to the mobile issue facility.

#### C. Telemetry and Air Sampling Support

All remote area monitoring stations and air sampling units were installed according to DOD and LASL speci-

fications. Twenty-nine remote area monitoring system units were located as follows:

- 1 - Near SGZ
- 1 - 90 feet from SGZ at 0° Azimuth
- 1 - 50 feet from SGZ at 180° Azimuth
- 1 - 120 feet from SGZ at 180° Azimuth
- 1 - 4,800 feet (trailer park) from SGZ at 130° Azimuth
- 12 - 30° intervals on the 1,000-foot arc beginning at 15° Azimuth
- 12 - 30° intervals on the 2,000-foot arc beginning at 0° Azimuth

All telemetry stations remained active until the DOD Test Group Director requested their deactivation.

Air sampling units with radiation detector recorders were in operation at zero time on the 2,000-foot arc at 30° intervals beginning at 15°.

#### D. Security Coverage

Muster and control stations were established on D-day. Stations were established at the intersection of Orange and Area 12 roads, Gate 700, and at manned stations. All personnel entering or exiting the controlled area were required to stop at muster or control stations for issuance or return of their muster or stay-in badges. All personnel were required to have proper security clearances for the area. Area control was maintained using roadblocks, access authorizations, and a Schedule of Events. Parties could enter the controlled area only if they were listed on the Test Manager's Schedule of Events or with the permission of the Test Group Director. WSI security guards were responsible for activating roadblocks to direct traffic flow.

## E. Air Support

Two Air Force aircraft were required to support DOD documentary photography projects. A UH-43D helicopter from Indian Springs AFB, Nevada, was utilized for still aerial photography and a U-6A fixed wing aircraft was used for motion aerial photography of the area around SGZ at zero time in order to document surface effects and effluent release, if any. The PHS used a U-3A aircraft for cloud tracking.

On standby, in the event they were needed were a UH-43D helicopter at CP-1 for use as needed by the Test Manager, a Martin 404 (NATS) aircraft for cloud tracking to be conducted by EG&G, and a C-45 aircraft for cloud sampling to be performed by PHS. A Cessna 206 was utilized by American Aerial Survey (AAS) for the postevent aerial survey.

### 5.2.3 Late Preevent Activities

On 26 May, 14 DOD/DASA personnel were in the trailer park near SGZ for final preparations. In addition, one DOD person was in the trailer park to check photo equipment. Three Air Force Weapons Laboratory (AFWL) personnel installed magnetic recording tape. Nine SC personnel made a final check of the recording equipment at the recording trailer park and five SC personnel made checks of the RAMS and air samplers in the trailer park near SGZ. Seven Waterways Experiment Station (WES) personnel made final adjustments at the trailer park and two WES people checked the equipment in hole No. 13, fifty feet northwest of SGZ. Four U.S. Coast & Geodetic Survey (USC&GS) personnel installed seismic equipment in Areas 2, 4, and 8. Four EG&G personnel checked the

### 5.3 EVENT-DAY ACTIVITIES

On 27 May from 0001 hours to three hours before scheduled device detonation, DOD/DASA personnel were at the trailer park near SGZ for final preparations and to check the photo equipment. USC&GS made final adjustments to the seismic equipment in Areas 2, 4 and 8. During this same time period Radsafe personnel started the air sampling trailers and AFWL personnel made final instrument checks.

EG&G photo personnel loaded the cameras and activated equipment at stations 1 and 2. SC personnel made final adjustments at the trailer park, adjusted geophones, and checked RAMS and air samplers in the trailer park.

At 0100 hours WSI made the first security sweep of the area in a U-6A aircraft. At approximately 0121 hours the second security sweep was begun, and it was completed at 0307 hours.

From 0800 hours to 1230 hours USAF and security personnel made sweeps of the closed area.

A Test Manager's readiness briefing was held at approximately 0900 hours. At this time, permission was granted to arm the device.

The UH-43D photo helicopter was in position at 1005 hours.

Due to a power failure at CP-1 at 1018 hours, the arming party was authorized to reenter the area at 1030 hours. At 1200 hours, after the power failure problem was solved, permission was granted for the device to be rearmed, and by 1206 hours the device was again armed and the arming party was on their way out of the area.

The required countdown began on radio nets 1, 2, 6, and 8.

Ten minutes before device detonation the siren on the CP-1 building ran for 30 seconds, and the red lights on top of the building were turned on until after device detonation.

DISCUS THROWER zero time was 1300 hours PDT on 27 May 1966.

Reentry into the area was authorized at 1400 hours, and the postevent aerial survey was authorized to begin at approximately 1450 hours.

#### 5.3.1 Radiation Surveys and Reentry Activities

The initial radiation survey began at 1403 hours and was completed at 1510 hours by Radsafe monitoring personnel. All survey data were reported to the net 3 radio control operator when measurements were made. No readings above "background" were detected.

D-day experiment recoveries were performed by LMAFS, DNA, AFWL, SC, WES, USC&GS, and EG&G personnel. Only background radiation readings were recorded.

Air samplers on the 2,000-foot arc remained in continuous sampling mode, and filters were collected every four hours after the initial pickup until it was determined that there was no release, at which time the sampler filters were collected every eight hours.

### 5.4 POSTEVENT ACTIVITIES

#### 5.4.1 Postevent Drilling

An Ideco 40 drill rig designated PS-2D was set up and drilling began at 1018 hours on 10 August 1966. After several attempts

to clear an obstruction and continue drilling, a decision was made at 1455 hours to cease work on PS-2D and move to PS-1D.

The Ideco 40 was moved to PS-1D and drilling began on 11 August at 0455 hours. Drilling continued until approximately 1100 hours on 12 August when the decision to abandon PS-1D was made. PS-1D surface casing was capped at 1335 hours.

A Boyles (angle) drill rig had been brought into the area on 11 August, necessary preparations were made, and it began drilling at 1204 hours on 15 August. This drilling operation was designated PS-1A. Drilling and core sampling continued through 0140 hours on 18 August. A total of seventeen core samples were pulled with a maximum contact radiation intensity of 300 mR/h for a single core sample.

The maximum radiation exposure rate to personnel was 5 mR/h when the PS-2D blowout preventer was removed at 1030 hours on 18 August 1966.

During postevent drilling, the area and all contaminated or radioactive materials were marked to indicate radiation levels present. Personnel entering radiation areas or working with contaminated material were briefed concerning potential exposure and safety precautions and were provided with anticontamination clothing, equipment, and materials.

Decontamination units were positioned at entrances to controlled areas. Personnel and equipment were monitored and decontaminated as necessary. Drill rigs and associated equipment used in postevent activities also were monitored and decontaminated, if necessary.

#### 5.4.2 Industrial Safety

Checks were made on each shift for radiation levels, toxic

gases, and explosive mixtures. These measurements were then recorded in the monitors' log book. Industrial safety codes for mining, tunneling, and drilling were established by REECo and emphasized during all operations.

### 5.5 RESULTS AND CONCLUSIONS

Telemetry coverage began at 1301 hours on 27 May 1966 and ended at 1600 hours on 1 June.

The remote air sampling array placed around U8a was operative from 0100 hours 27 May until 1500 hours 29 May. Analysis of samples collected indicated no radioactivity which reasonably could be attributed to this event.

The initial reentry survey was conducted from 1403 hours to 1510 hours on 27 May. Only background radiation readings were obtained.

Postevent drilling began at 1018 hours on 10 August and was completed on 18 August at 0140 hours. The maximum reading of 5 mR/h was detected at PS-2D when the blowout preventer was removed at 1030 hours on 18 August.

Personnel exposures received on individual entries to DISCUS THROWER radex areas during postevent drilling from 11 August through 18 August 1966, are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	523	0	0

## CHAPTER 6

### PILE DRIVER EVENT

#### 6.1 EVENT SUMMARY

The PILE DRIVER event was a DOD underground nuclear detonation with a yield of 62 kt conducted at 0830 hours PDT on 2 June 1966 at tunnel site U15a.01 in Area 15 of the NTS. This area previously was used for the HARD HAT and TINY TOT events which were described in the first volume of this series. The device was emplaced in granite 1,518 feet below the surface and about 1,400 feet from the access shaft.

The purpose of this event was to study nuclear detonation effects on underground structures. The PILE DRIVER tunnel complex (Figure 6.1) was located approximately 1,400 feet below ground in a granitic rock. The HARD HAT shaft, previously excavated to a depth of 785 feet, was extended to reach the PILE DRIVER depth (Figure 6.2). The complex contained an array of 73 cylindrical test sections, each section designed to test one or more variables. Test sections generally were located in six arcuate drifts 100 feet above the working point. These six drifts were identified as X, Y, A, B, D, and C at nominal slant ranges from the working point of 320, 390, 480, 670, 840, and 940 feet, respectively. Sixty-five of the 73 test sections were lined, one was unlined and unsupported, and seven were reinforced with rock bolts and chain link fabric. Figure 6.3 shows test sections in the underground tunnel layout. Twenty-seven projects were conducted by DOD, laboratory, university, and other contractor personnel to obtain desired information.

No surface collapse was predicted, and none occurred. Approximately 12 hours after device detonation, minor seepage of

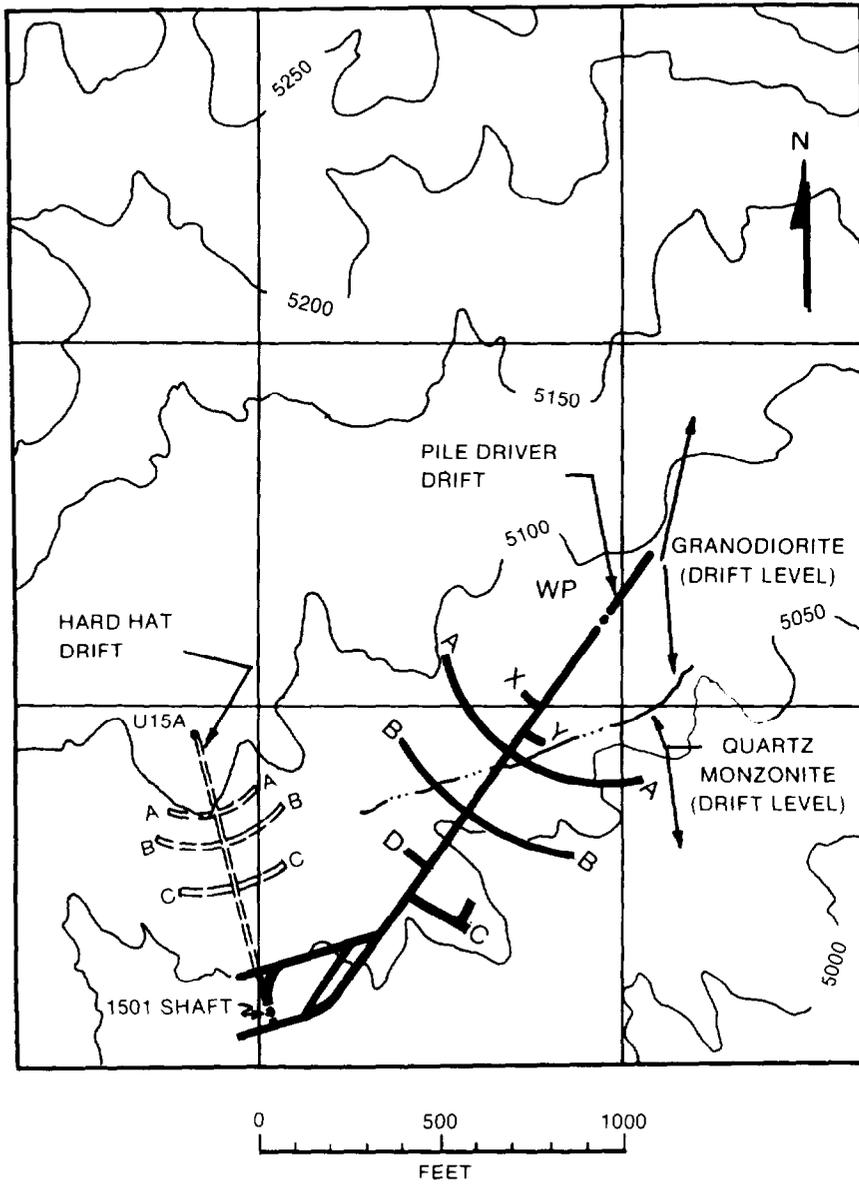


Figure 6.1 PILE DRIVER Underground Tunnel Complex



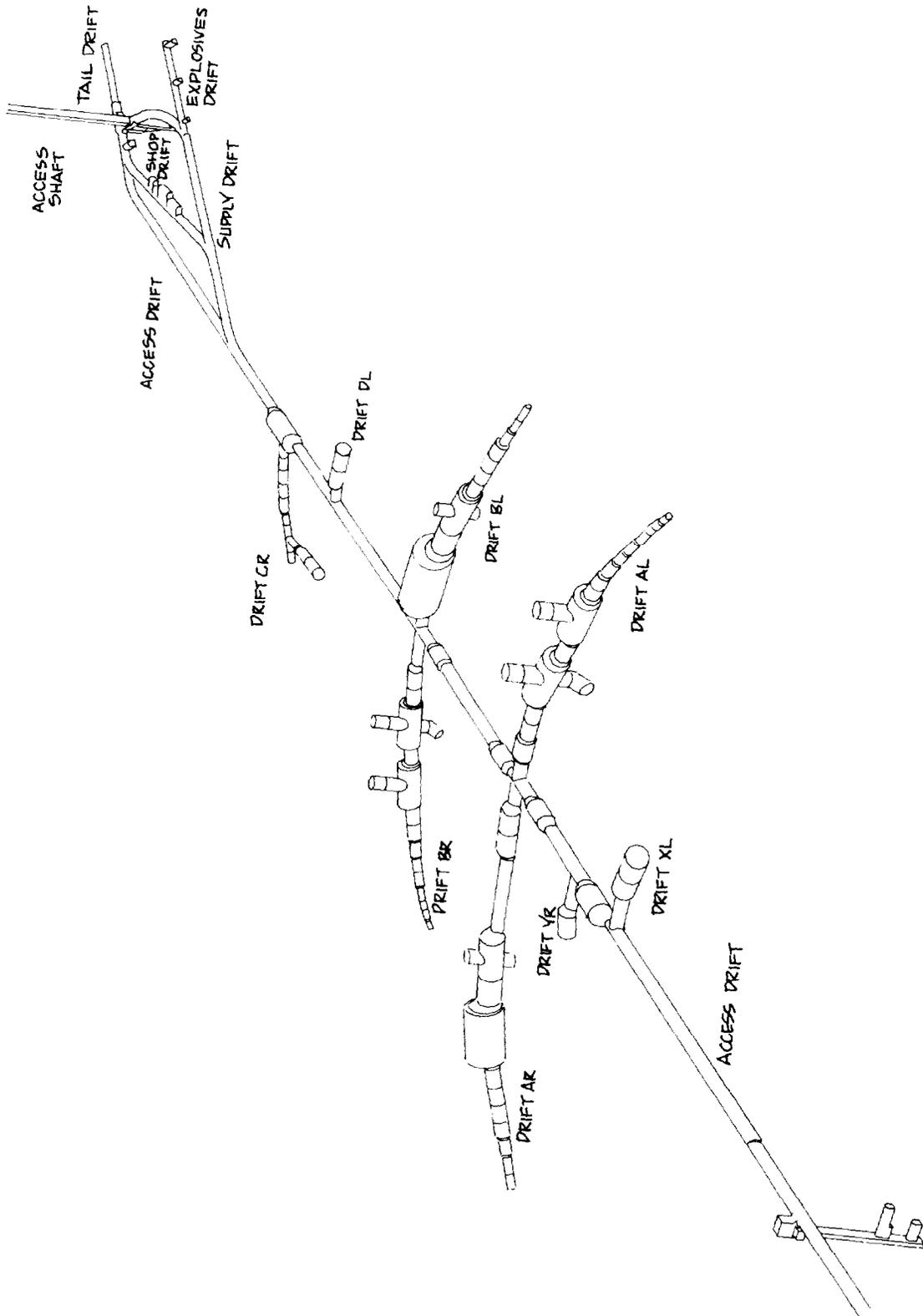


Figure 6.3 PILE DRIVER Event - Tunnel Layout

radioactive effluent through cracks at SGZ occurred and continued for 11 hours. No radioactive effluent from this event was detected offsite.

## 6.2 PREEVENT ACTIVITIES

### 6.2.1 Responsibilities

The DOD Test Group Director was responsible for safe conduct of all PILE DRIVER activities in Area 15. Responsibilities of AEC and AEC-contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DASA, and the AEC Nevada Operations Office. LASL was responsible for providing and installing the nuclear device. SC was responsible for stemming and for installation of necessary measuring devices and equipment. The DOD was responsible for pre-event installation and postevent removal of equipment necessary for its project activities.

### 6.2.2 Planning and Preparations

The "PILE DRIVER Reentry Plan" described preevent preparations and postevent procedures used to assure safe and economical reentry within the designated period of time.

#### A. Radiological Safety Support

All personnel at manned stations were given appropriate anticontamination clothing and equipment, and Radsafe monitors were in attendance. Radsafe personnel were stationed at the DOD Test Group Director's FCP prior to the PILE DRIVER detonation to perform surveys and provide emergency support as directed; provide and issue anticontamination equipment, portable instruments, and

self-reading dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination as required.

Anticontamination materials available included coveralls, head covers, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

Detailed radiological safety reentry plans were submitted to participating agencies prior to the event. Test area maps with appropriate reference points were prepared. Reference markers, radiation decay recorders, and air sampling equipment were positioned in the test area. Reentry routes into the test area were established during "dry runs." Party monitors were briefed regarding surface reentry, sample recovery, manned stations, and security station requirements.

#### B. Telemetry Support

A remote area monitoring system was installed with the detection units located underground and on the surface, and readouts located outside the controlled area. This system was functioning at zero time so that shaft collar, shaft, and tunnel radiation conditions could be determined. RAMS console readings were recorded every 15 minutes until tunnel ventilation was started. A total of 39 RAMS units provided information for surface reentry and later tunnel reentry. They were located as follows:

<u>RAMS</u> <u>No.</u>	<u>Location</u>
1	Main drift at 440 feet from shaft
2	Access drift at 240 feet

<u>RAMS</u> <u>No.</u>	<u>Location</u>
3	Shop drift
4	Explosive drift
5	Shaft station
6	Supply drift at 60 feet
7	Shaft filter plug
8	HARD HAT drift
9	Shaft collar
10	2,110 feet from SGZ at 2° N
11	1,920 feet from SGZ at 39° NNE
12	1,620 feet from SGZ at 57° NE
13	1,680 feet from SGZ at 91° E
14	1,870 feet from SGZ at 107° ESE
15	1,900 feet from SGZ at 121° ESE
16	1,280 feet from SGZ at 127° ESE
17	1,830 feet from SGZ at 157° SSE
18	1,640 feet from SGZ at 178° S
19	1,940 feet from SGZ at 213° SSW
20	1,150 feet from SGZ at 246° SW
21	1,370 feet from SGZ at 289° W
22	1,670 feet from SGZ at 339° NNW
23	2,940 feet from SGZ at 348° NNW
24	2,740 feet from SGZ at 13° NNE
25	2,790 feet from SGZ at 33° NE
26	2,670 feet from SGZ at 43° NE
27	3,060 feet from SGZ at 69° NE
28	2,540 feet from SGZ at 117° SE
29	2,460 feet from SGZ at 135° SE
30	2,970 feet from SGZ at 156° SSE
31	2,670 feet from SGZ at 180° S
32	2,360 feet from SGZ at 294° W
33	2,680 feet from SGZ at 309° NW
34	4,850 feet from SGZ at 49° NE
35	3,670 feet from SGZ at 104° E

<u>RAMS No.</u>	<u>Location</u>
36	3,430 feet from SGZ at 197° S
37	3,600 feet from SGZ at 215° SW
38	4,250 feet from SGZ at 238° SW
39	4,200 feet from SGZ at 266° W

#### C. Security Coverage

Muster and control stations were established on D-day. All personnel entering or exiting the controlled area were required to stop at muster or control stations for issuance or return of their muster or stay-in badges.

All personnel were required to have proper security clearances for the area. Control of the area was maintained by the use of roadblocks, access authorizations, and a Schedule of Events. Parties could enter the controlled area only if they were listed on the Test Manager's Schedule of Events or with permission of the Test Group Director. WSI security guards were responsible for activating roadblocks and directing traffic flow.

#### D. Air Support

An Air Force U-3A aircraft, pilot, and co-pilot were made available to a PHS aerial monitoring team for cloud tracking purposes. Photo support was performed by LMAFS personnel in a USAF U-6A aircraft and DOD personnel in a USAF UH-43D helicopter. A PHS Turbo Beechcraft was available for cloud sampling, as were a PHS C-45 and the EG&G/NATS Martin 404.

#### 6.2.3 Late Preevent Activities

On D-1, personnel representing EG&G, SRI, BTL, SC, and LASL

were in the area performing final button up activities. A Test Manager's readiness briefing was conducted at 1500 hours.

### 6.3 EVENT-DAY AND CONTINUING ACTIVITIES

The final readiness briefing for the Test Manager and Advisory Panel was conducted at approximately 0600 hours.

Required countdowns began on radio nets 1, 2, 6, and 8 at 0800. Ten minutes prior to device detonation the siren on the CP-1 building ran for 30 seconds, and the red lights on top of the building were turned on until after device detonation.

PILE DRIVER zero time was 0830 hours PDT on 2 June 1966.

#### 6.3.1 Test Area Monitoring

Telemetry coverage began at zero time on 2 June and was discontinued at 0900 hours on 23 July 1966. Initially, all RAMS units in the underground complex were driven negative by the electromagnetic pulse except for the unit in the HARD HAT drift, which indicated 83 mR/h at zero time. Readings from the detector steadily decreased, reaching background levels by H+90 minutes. Other underground units indicated only background when they recovered from the electromagnetic pulse, but began showing positive readings by the afternoon of 3 June. The maximum underground reading was 1.4 R/h at 1000 hours on 11 June at the detector located at 440 feet in the main drift.

The shaft collar unit measured 1 mR/h until 2125 hours when a pulse up to 30 mR/h occurred followed by a steady decrease to background by 0310 hours on 3 June. Other surface detectors continued to read background until nine and one-half hours after detonation when minor seepage of radioactive effluent through

cracks at SGZ began. This seepage involved only gaseous radio-nuclides, and a peak reading of 75 mR/h occurred at 0310 hours on 3 June. The release ceased at approximately 0730 hours on 3 June. Surface RAMS unit readings, which began decreasing again after the release ceased, continued to decrease until all surface units were indicating background by 2400 hours on 3 June.

Remote air sampling began at zero time and continued until 0930 hours on 23 June. No samples from these stations showed detectable activity which reasonably could be attributed to this event.

### 6.3.2 Radiation Surveys and Surface Reentry Activities

Initial safety and radiation surveys were performed under the direction of the Test Group Director in accordance with the "Radiological Safety Support Plan" for PILE DRIVER. The PILE DRIVER initial radiation survey began at 0900 hours and was completed at 1000 hours on 2 June 1966. No radiation above background was detected during the initial survey or at the Sandia trailer park and check station areas through 2400 hours on 2 June, although activity was detected by RAMS units at the shaft and SGZ areas.

After completion of the initial survey, a radex area was established. Personnel entering radex areas or to be working with contaminated material were briefed concerning potential exposure and safety precautions, and were provided with anticontamination clothing, equipment, and materials.

During PILE DRIVER, decontamination units were positioned at entrances to controlled areas. Personnel and equipment were monitored and decontaminated as necessary. Drill rigs and associated equipment used in postevent activities also were monitored and decontaminated, if necessary.

### 6.3.3 Surface Experiment Recoveries

Surface recovery of experiment tapes and film was conducted between 1015 hours and 1600 hours on D-day. Personnel from DASA, SC, SRI, EG&G, LASL, and American Car and Foundry, Inc. (ACFI) entered the radex area for this purpose. Radiation levels were background during these activities. No personnel were allowed beyond the SC and SRI trailer parks.

On D+2 at 0704 hours, two SRI personnel entered the SRI trailer park to perform additional experiment recovery operations. This recovery was completed at 0730 hours. Radiation readings in the trailer park were 0.1 mR/h.

## 6.4 POSTEVENT ACTIVITIES

### 6.4.1 Radiation Area Requirements

Respiratory protection had been required as a precautionary measure for personnel working directly over the shaft during shaft reentry preparations. However, no further radex area requirements were needed after shaft entry. Radsafe and industrial hygiene monitoring support continued throughout the shaft and tunnel reentries and postevent drilling activities.

### 6.4.2 Shaft Reentry Activities

Reentry operations began on 20 June 1966 at 1400 hours, with the lowering of a television camera down the access shaft to observe damage. Since only minor radiation exposures occurred from 20 June until 29 June, radex area requirements were discontinued on 29 June. Shaft reentry was completed after shaft rehabilitation and when access was gained onto the top of the sand-muck

pile at the bottom of the shaft on 31 January 1967. No radiation, toxic gas, or explosive mixture problems were encountered.

#### 6.4.3 Tunnel Reentry Mining and Experiment Recovery Activities

Reentry down the main drift proceeded concurrently with operations in CR drift. Once the enlarged section at the intersection of CR drift had been safely supported, mucking of the sand-filled, 10x10-foot access drift continued. Placement of steel sets and lagging to provide personnel protection continued as the heading advanced.

From 31 January to 31 March, the main drift was cleared and mining continued toward reentering the CR drift. Ventilation was installed and reentry to the CR drift began at 0810 hours on 31 March. DOD personnel entered the drift to perform an inspection, provide photographic documentation, and recover some experiments. Radiation levels were 0.04 mR/h (near background) in the drift. Additional instrument recovery was performed in the CR drift by Corps of Engineers personnel from 3 April through 10 April.

On 7 April, a party of four DOD personnel entered the CR drift to Section 5 and 6 to perform photographic documentation and instrument recovery. The photo team provided movie documentation of CR drift on 10 April and again on 11 April.

A small hole was drilled into the DL drift on 13 April to test for radioactive and toxic gases. Since the levels were minimal, work to reenter the DL drift began. On 14 April, work on the DL and main drifts continued and a film recovery team entered the CR drift.

A USAF photo crew worked in CR1 and CR2, the main drift, and the shop drift on 17 April. During the same time, a DOD recovery team recovered an experiment in the DL drift. BTL personnel con-

ducted experiment recovery operations in the DL drift from 19 April through 28 April. Work continued in the CR and main drifts.

On 3 May 1967, work to reenter BL and BR drifts began. Instrument recovery in the BR drift was begun on 8 May when miners uncovered a canister. Section no. 2 in the DL drift was opened on 8 May. Instrument recovery in the BR drift continued on 10 and 11 May. On 19 May, work began to dig out camera canisters in the BL drift and continued through 23 May. EG&G personnel removed cameras and film from both BL and DL drifts at this time.

Section no. 4 of the BR drift was reached on 25 May, instruments were removed, and photographic documentation provided.

Work continued in all drifts with XL, AL, AR, and YR drifts reached and reentered from 9 June through 31 July 1967. By 28 August 1967, reentry of the entire test complex was completed. No radiation, toxic gas, or explosive mixture problems were encountered.

#### 6.4.4 Postevent Drilling Activities

A vertical exploratory hole, U15.01 PS-1V, was drilled into the top of the chimney formed by the PILE DRIVER event. This exploratory drilling was conducted from 21 July to 2 August 1967. Its chief objectives were to determine the chimney void volume, chimney height, and maximum vertical extent of increased permeability due to fracturing.

Radioactivity levels of 5 mrad/h beta plus gamma were measured at the blooie line by Radsafe monitors when a depth of 650.9 feet was reached. The blooie line was then closed, thus preventing air from being exhausted to the surface. At 654.9 feet, the drill string was raised 29.5 feet to add a section of

pipe. When the string was lowered, it was discovered that the hole had caved to a depth of 631.6 feet. Drilling was difficult and, because of the danger of the drill string becoming stuck in the hole, the drilling operation was concluded. The following day, Radsafe monitors measured unusually high concentrations of CO<sub>2</sub> in an underground exploratory drift near the chimney. It was concluded that the slight overpressure in the chimney had caused CO<sub>2</sub> from the chimney region to leak into this drift along fractures and joints. A 100 cubic feet per minute exhaust fan installed at the drill hole collar kept the cavity gas from bleeding into underground workings and alleviated this condition.

#### 6.4.5 Industrial Safety

Radsafe monitors routinely checked for the presence of CO, CO<sub>2</sub>, NO, NO<sub>2</sub>, hydrocarbons, and explosive mixtures during each shift.

Industrial safety codes, including specific codes for mining, tunneling, and drilling were established by REECO and emphasized during all operations.

### 6.5 RESULTS AND CONCLUSIONS

Telemetry coverage began at 0830 hours on 2 June and ended at 0900 hours on 23 July 1966. The maximum measurement was 1.4 R/h at 1000 hours on 11 June 1966 from a detector located in the main tunnel.

The initial radiation survey began at 0900 hours and was completed at 1000 hours on 2 June. Readings were background throughout the survey.

Postevent mining to effect experiment recovery began at 2115

hours on 12 July and was completed at 2400 hours on 16 June 1967, although experiment recovery continued through August 1967. The maximum radiation measurement during this period was 3 mR/h in the shaft collar area on 16 and 17 June 1966. No alpha radiation was detected.

Personnel exposures received during individual entries to the PILE DRIVER radex area, which was established from 2 June to 29 June 1966, are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	173	110	2.7
DOD Participants	25	110	10.8

No radiation intensities above background were detected in offsite areas by ground monitors, dose rate recorders, or film badge stations. It was the opinion of the PHS that no health hazard was produced in the offsite area by the PILE DRIVER event.

## CHAPTER 7

### DOUBLE PLAY EVENT

#### 7.1 EVENT SUMMARY

The DOUBLE PLAY event was a DOD underground nuclear detonation with a yield less than 20 kt conducted at 1000 hours PDT on 15 June 1966 at tunnel site U16a.03 in Area 16 of the NTS. Device emplacement was within a tunnel in a tuff medium, 1,075 feet vertically beneath the surface and 920 feet from the nearest ground surface. This tunnel was part of the complex where the MARSHMALLOW and GUMDROP events discussed in the first volume of this series were conducted (Figure 7.1). DOUBLE PLAY was a weapons effects test which investigated the effects of a nuclear detonation environment on equipment and materials. There were 13 projects conducted by DOD, laboratory, and other contractor personnel. No surface collapse was predicted and none occurred. Containment was not complete, and low levels of radioactivity were detected offsite. Section 7.3.1 further describes this effluent release.

#### 7.2 PREEVENT ACTIVITIES

##### 7.2.1 Responsibilities

The DOD Test Group Director was responsible for the safe conduct of all DOUBLE PLAY project activities in Area 16. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Field Command, DASA, and the AEC Nevada Operations Office. LRL provided the device and performed the surface drillback, and SC and DOD were involved in recovery

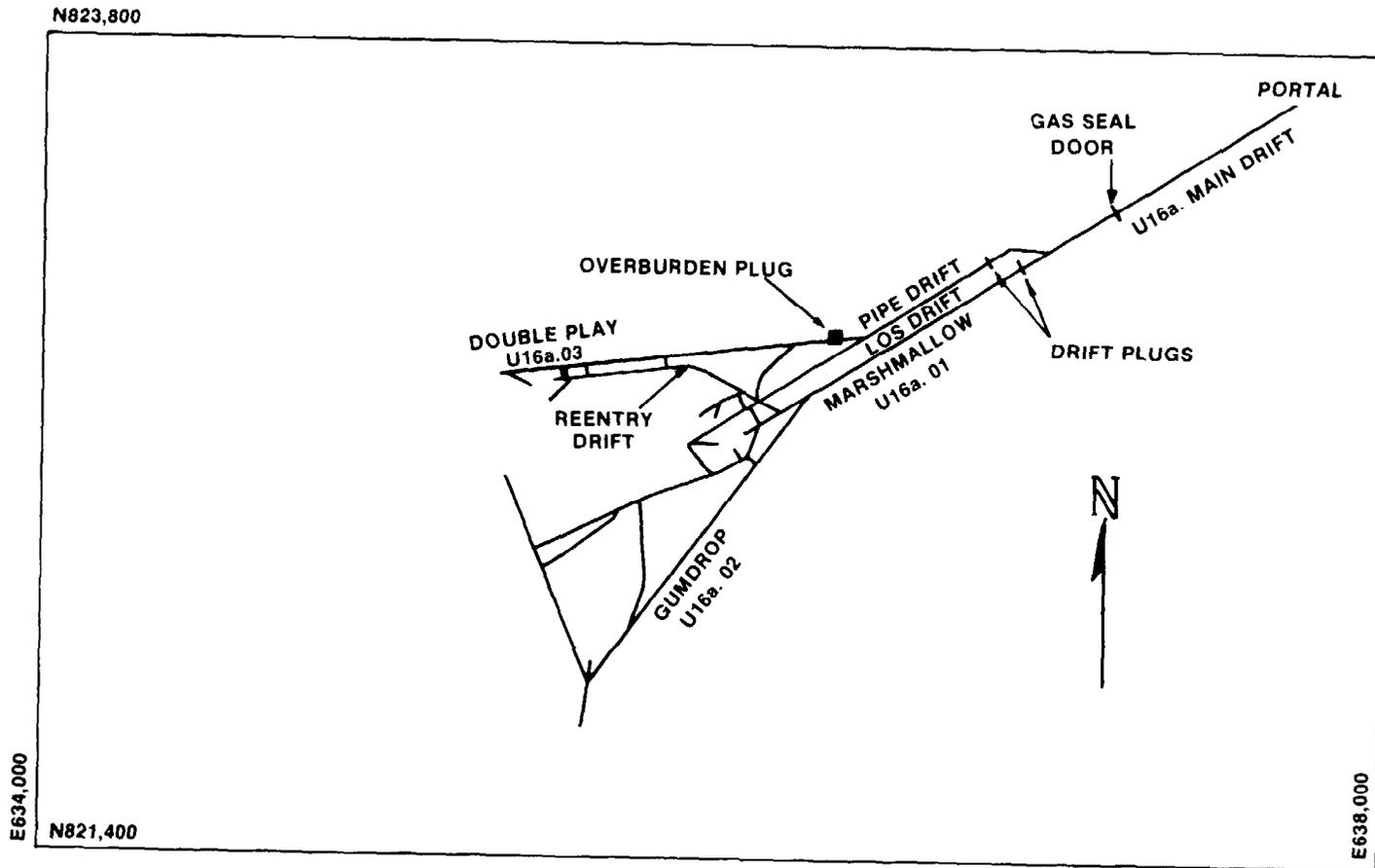


Figure 7.1 U16a Tunnel Complex

operations. The DOD was responsible for preevent installation and postevent removal of equipment necessary for its project activities.

#### 7.2.2 Planning and Preparations

The "DOUBLE PLAY Reentry Plan" described preevent preparations and postevent procedures used to produce safe and economical reentry and recovery within the desired time frame. Stemming design incorporated necessary provisions to maximize safety of reentry.

##### A. Radiological Safety Support

Participating agencies were provided with detailed reentry plans prior to this event. Test area maps with appropriate reference points were prepared. Reference markers, radiation decay recorders, and air samplers were positioned in the test area. "Dry runs" were conducted to establish reentry routes into the test area. Radiation monitors were briefed regarding reentry, sample recovery, manned stations, and security station requirements.

All personnel at manned stations were provided with appropriate anticontamination materials and Radsafe monitors were in attendance.

Radsafe provided monitoring teams and supervisory personnel for surface radiation surveys, aerial surveys by helicopter, and tunnel reentry parties. Radsafe personnel were stationed at the DOD Test Group Director's FCP to perform initial and subsequent ground surveys as required; provide and issue anticontamination equipment, portable instruments and dosimetric devices; perform

personnel, equipment, and vehicle decontamination; and operate a sample return station. Anticontamination materials available included coveralls, head covers, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

B. Telemetry and Air Sampling Support

Thirty-five Jordan RAMS were in place, calibrated, and operational at zero time; 9 inside the tunnel and 26 at aboveground locations (Table 7.1).

Nineteen air sampling trailers were placed in an array on the surface, calibrated, and operational by zero time (Table 7.2).

C. Security Coverage

Muster and control stations were established on D-day. All personnel entering or exiting the controlled area were required to stop at muster or control stations for issuance or return of their muster or stay-in badges.

All personnel were required to have proper security clearances. Control was maintained by using roadblocks, access authorizations, and a Schedule of Events. Parties could enter the controlled area only if they were listed on the Test Manager's Schedule of Events or with permission of the Test Group Director. WSI security guards were responsible for activating roadblocks and directing traffic flow.

D. Air Support

Two USAF aircraft from ISAFB supported DOD documentary

TABLE 7.1

DOUBLE PLAY EVENT RAMS UNIT LOCATIONS  
15 June 1966

Station	Location
UNDERGROUND	
1	1,965 feet from portal (inside blast door)
2	1,730 feet from portal
2a	1,760 feet from portal (inside blast door)
3	1,725 feet from portal
3a	2,300 feet from portal
4	1,570 feet from portal
5	1,320 feet from portal (MARSHMALLOW pipe tunnel)
6	1,120 feet from portal
7	870 feet from portal
8	670 feet from portal (inside gas seal door)
9	640 feet from portal (outside gas seal door)
ABOVEGROUND	
10	Portal
11	580 feet from portal at 0° Azimuth
12	585 feet from portal at 24° Azimuth
13	275 feet from portal at 45° Azimuth
14	322 feet from portal at 76° Azimuth
15	713 feet from portal at 161° Azimuth
16	402 feet from portal at 214° Azimuth
17	464 feet from portal at 229° Azimuth
18	496 feet from portal at 239° Azimuth
19	155 feet from portal at 273° Azimuth
20	265 feet from portal at 309° Azimuth
21	480 feet from portal at 330° Azimuth
22	584 feet from portal at 341° Azimuth
23	1,385 feet from portal at 21° Azimuth
24	4,013 feet from portal at 64° Azimuth
25	943 feet from portal at 108° Azimuth
26	923 feet from portal at 127° Azimuth
27	986 feet from portal at 173° Azimuth
28	1,131 feet from portal at 239° Azimuth
29	2,230 feet from portal at 247° Azimuth
30	1,354 feet from portal at 267° Azimuth
31	SGZ
32	Vent (Before North filter)
33	Vent (After North filter)
34	Vent (Before South filter)
35	Vent (After South filter)

TABLE 7.2  
 DOUBLE PLAY EVENT  
 AIR SAMPLING ARRAY  
 15 June 1966

Station	Location
1	580 feet from portal at 0° Azimuth
2	461 feet from portal at 35° Azimuth
3	275 feet from portal at 45° Azimuth
4	322 feet from portal at 76° Azimuth
5	148 feet from portal at 119° Azimuth
6	30 feet from portal at 180° Azimuth
7	402 feet from portal at 214° Azimuth
8	155 feet from portal at 273° Azimuth
9	264 feet from portal at 309° Azimuth
10	480 feet from portal at 330° Azimuth
11	1,336 feet from portal at 12° Azimuth
12	1,445 feet from portal at 56° Azimuth
13	4,013 feet from portal at 64° Azimuth
14	1,946 feet from portal at 74° Azimuth
15	2,230 feet from portal at 247° Azimuth
16	1,354 feet from portal at 267° Azimuth
17	1,722 feet from portal at 277° Azimuth
18	2,403 feet from portal at 316° Azimuth
19	SGZ

photography projects. A UH-43D helicopter for still aerial photography, manned by APC personnel, orbited in an 800-foot radius semicircular flight pattern at 1,500 feet in altitude upwind from the tunnel. Motion picture photography of SGZ at zero time was performed by LMAFS personnel in a U-6A aircraft which orbited in a 3,000-foot radius semicircular pattern, 3,000 feet in altitude, upwind from the tunnel.

The PHS was provided a USAF U-3A aircraft for cloud tracking and a C-45 aircraft for cloud sampling. A Turbo Beechcraft was on standby to be used for cloud sampling, if needed.

WSI security personnel performed security sweeps in a USAF U-6A aircraft, and an additional USAF UH-43D helicopter was on standby for the Test Manager's use, if needed.

The EG&G/NATS Martin 404 aircraft was on standby at McCarran Airport in Las Vegas if needed for cloud tracking purposes.

### 7.2.3 Late Preevent Activities

Personnel conducting experiments, performing final dry runs, and checking instrumentation on D-1 represented SRI, LMSC, EG&G, APC, SC, DNA, KOA, AVCO, AFWL, GE and BTL.

A Test Manager's readiness briefing was conducted at 1500 hours on 14 June.

## 7.3 EVENT-DAY AND CONTINUING ACTIVITIES

From 0001 to 0640 hours on 15 June 1966, Radsafe monitoring

personnel started the air sampling trailers; LMSC personnel checked the vacuum pumps and TV systems at the test chamber and assembly building; EG&G personnel checked all photo stations; SC personnel made final instrument checks at the recording trailer park, checked the geophones and buttoned up instrumentation at the instrumentation alcove, and were at the reentry safety trailer; and GE personnel checked out instrument cassettes. DOD personnel checked cabling at the experiment chamber, made instrument checks, and performed a last-minute inspection of the U16a.03 tunnel and portal area. Simultaneously, SRI personnel buttoned up their operations.

The arming party entered the area at 0305 hours. A security sweep at 0640 hours confirmed that all personnel were clear of the area except the arming party. A final readiness briefing was conducted approximately two hours before scheduled device detonation. At this time permission was granted to arm the device.

From two hours to 30 minutes before device detonation, USAF and security personnel in the U-6A aircraft made a final sweep of the closed portion of Area 16.

The device was armed and the arming party departed the area by 0926 hours. DOD and PHS aircraft were in position by 0941 hours.

Required countdowns were broadcast on radio nets 1, 2, 6, and 8. Ten minutes before device detonation the siren on CP-1 ran for 30 seconds, and the red lights on top of the building were turned on until after device detonation.

DOUBLE PLAY zero time was 1000 PDT on 15 June 1966.

### 7.3.1 Effluent Releases

There were four effluent release situations following the DOUBLE PLAY event.

The first release, which began at 1002 hours (H+2 minutes) on D-day, was through aboveground cable hole locations used for the MARSHMALLOW Event. A RAMS unit located aboveground near the point of release indicated a radiation reading of 1 R/h at 1002 hours which steadily increased to a maximum of 40 R/h at 1023 hours (H+23 minutes). A decision was made by DOD representatives to send a party into the area to seal the leaks. A maximum radiation reading of 3 R/h at contact with the cable and cable holes at the north cable run was measured before the work party began sealing the leaks and applying water glass at 0745 hours on 16 June. By the time the water glass had been applied at 1145 hours, radiation intensity had decreased to 0.9 R/h. Readings steadily decreased thereafter, reaching background at 1700 hours on 19 June (D+4 days).

The second release, this time through the portal, began at 1005 hours (H+5 minutes) on D-day. After reaching a maximum of 8 R/h at 1129 hours, radiation readings steadily decreased. This effluent release continued until 1151 hours on 17 June when tunnel ventilation was turned on. At that time radiation readings from the RAMS unit located at the portal increased from 2.5 mR/h at 1100 hours to 110 mR/h at 1200 hours. After 1200 hours, readings again steadily declined until 1200 hours on 23 June when an increase from 1.3 mR/h to 13 mR/h occurred. This was due to a reactor test in another area of the NTS. After this, readings continued to decline until background was reached at 2400 hours on 1 July 1966. Background readings were reported at this unit until the unit went off line on 3 July.

A third release situation began on 17 June at 1151 hours when the tunnel ventilation system was turned on. Primarily, noble gas radionuclides passed through the vent line filter system until 1336 hours on 17 June when ventilation system operation was discontinued. Before ventilation was implemented, all four RAMS units at or near the filter boxes read less than 500 mR/h. Readings were:

	<u>Reading Before</u> <u>Start of Ventilation</u>	<u>Reading After</u> <u>Start of Ventilation</u>
Before North Filter	32 mR/h	1.5 R/h
After North Filter	14 mR/h	800.0 mR/h
Before South Filter	18 mR/h	950.0 mR/h
At South Filter	430 mR/h	20.0 R/h

The highest reading during this ventilation was 50 R/h at the south filter box at 1330 hours on 17 June.

The fourth release began when the ventilation system was restarted at 1536 hours on 17 June because explosive gases had accumulated in the tunnel complex. Ventilation continued until 0900 on 18 June 1966. Readings on RAMS units at or near the filter boxes steadily declined from the following maximums:

Before North Filter - 245 mR/h  
 After North Filter - 230 mR/h  
 Before South Filter - 200 mR/h  
 At South Filter - 50 R/h

Telemetry was discontinued at 2200 hours on 11 July 1966.

### 7.3.2 Test Area Monitoring

Telemetry began at 1001 hours on D-day and continued until

2200 hours on 11 July 1966. Four separate release situations were monitored and were discussed in section 7.3.1. Maximum readings detected by underground units were in excess of 1,000 R/h. The maximum reading aboveground was 50 R/h at the south filter box at 1330 hours on 17 June.

The initial radiation survey began at 1107 hours and ended at 1116 hours on 15 June 1966 (Table 7.3).

Two Radsafe parties in vehicles, each party consisting of two monitors, performed the initial survey. They were referred to as Radsafe Survey Party No. 1 and Radsafe Survey Party No. 2. When released by the Test Group Director, the two parties proceeded from the FCP along the telephone pole road to the Area 16 main access road and then to the tunnel portal area, surveying enroute.

Party No. 1 proceeded into the portal area to the vicinity of the portal entrance. Upon completion of the initial survey, Party No. 1 then obtained radiation measurements at the portal entrance and locations of interest in the portal area. Party No. 1 then returned to a point immediately outside the established radex area by the office trailer park.

Radsafe Survey Party No. 2 proceeded to the film instrumentation trailer park, surveying enroute. Upon completion of the trailer park survey and when directed by Radsafe Control, Party No. 2 proceeded to survey SGZ and returned to the portal area to await further assignments. All survey data were reported to the net 3 radio control operator as measurements were made. Plotting facilities were maintained at the FCP and CP-1.

A mobile facility for issue of anticontamination equipment, portable instruments, and dosimetric devices was positioned at the FCP. A mobile decontamination unit was positioned adjacent to it.

TABLE 7.3  
 DOUBLE PLAY EVENT  
 INITIAL RADIATION SURVEY DATA  
 15 June 1966

<u>Time</u>	<u>Location (From Portal)</u>	<u>Gamma Exposure Rate (mR/h)</u>
1107	Stake 16C28 (1 1/2 miles NE)	Bkg*
1108	Stake 16C29 (1 1/4 miles NE)	Bkg
1109	Stake 16C30 (1 mile NE)	Bkg
1110	Stake 16C31 (3/4 mile NE)	Bkg
1111	Stake 16J15 (1/4 mile N)	2
1114	150 Feet NE of portal	50
1116	Portal recovery area	20

\*Background radiation measurement

### 7.3.3 Data Recovery

Film recovery from the portal area was authorized on D-day and accomplished without incident. Recovery parties accompanied the initial survey team at 1045 hours and made recoveries at that time. Upon reentry into the area SRI, EG&G, SC, LMSC and DOD personnel made recoveries of film and tape. A survey of the portal and reentry safety trailer was conducted by SC personnel. Reentry operations were completed at 1135 hours. Due to the presence of radioactive effluent, the area was cleared after this reentry and surveillance was maintained. Urine samples were taken from all reentry team personnel. Results are discussed in section 7.4.1.

Recovery parties entered the area again on 16 June to remove cameras from the EG&G camera bunker.

### 7.3.4 Aerial Radiation Surveys

#### A. EG&G/NATS Mission

The EG&G/NATS aircraft was dispatched at 1254 hours on D-day to locate and track the radioactive effluent released. Initial contact was made with the effluent cloud at 1325 hours near SGZ. Radioactivity slightly above background was found at three locations between the test site and a point 200 miles northeast of the event location at 9,000 feet MSL. This activity soon dissipated to undetectable levels.

At 1805 hours the aircraft returned to Las Vegas for refueling. Upon landing, weather conditions in the tracking area and downwind sectors were reviewed. Considering adverse weather conditions, further efforts to track during the night were dismissed as unsafe. A very early morning attempt to relocate the effluent was scheduled for 16 June.

The aircraft was airborne at 0528 hours on 16 June, and the mission was completed at 1625 hours with no activity above background detected.

B. PHS Missions

PHS personnel flew two aerial sampling missions in support of the DOUBLE PLAY event on 15 June 1966. Aircraft 91264 (Vegas 7) was equipped for cloud sampling and determination of cloud volume. It carried an Andersen sampler, a gross air sampler, a sequential sampler, and gamma detection equipment on the first mission. The same aircraft also was flown on a second mission with essentially the same equipment as used earlier in the sampling and cloud volume determination.

1. Mission 1

At 1012 hours PDT (H+12 minutes) Vegas 7 began circling SGZ at an altitude of 7,500 feet MSL and at a distance of approximately two miles. First contact with the cloud occurred at 1014 hours one-half mile south of Tippipah Springs. A sampling path was established from a point one mile east of Tippipah Springs and running west to Reservoir Peak at 7,500 feet MSL.

Continued sampling passes over the path from 6,500 to 9,000 feet MSL until 1040 hours indicated a near constant width of one mile with the base at 6,800 feet MSL and top at 8,500 feet MSL. A second sampling path was established directly over, and parallel to, the Pahute air strip at 1045 hours at an altitude of 7,500 feet MSL. The leading edge of the cloud arrived over the air strip at 1047 hours. Between 1040 and 1145 hours, repeated sampling runs were made normal to the cloud tra-

jectory over Pahute air strip, and from this position through the longitudinal axis to the portal at altitudes between 6,500 and 8,500 feet MSL. Data analysis subsequently indicated a downwind velocity for the cloud of 13 mph on a trajectory of approximately 315° true.

At 1050 hours, a maximum exposure rate of 0.2 mR/h was measured over Pahute air strip at 7,500 feet MSL. The maximum reading during the entire mission was 1.4 mR/h at 8,000 feet MSL over the portal. The latter reading held within +0.1 mR/h at this location from about 1015 hours until the aircraft departed the area at 1145 hours. The release was not visible at any time.

## 2. Mission 2

At 1332 hours, Vegas 7 reentered the area passing over the portal at 7,500 feet MSL on a true heading of 315°. A reading of 1.8 mR/h was measured above the portal. No further readings were indicated as the flight continued to the Pahute air strip.

At 1337 hours a second flight path began over the air strip at 8,500 feet MSL on a true heading of 90°, terminating over BJY. Cloud presence was first detected at a point approximately 6.2 miles from the portal on a true course of 340°, continuing for two miles. Repeated passes were flown over the course between 6,500 and 9,500 feet MSL with a maximum concentration at 7,700 feet MSL. At 1341 hours, a reading of 0.12 mR/h was measured 6.5 miles from the portal at 7,500 feet MSL on a true course of 015°. Between 1340 and 1500 hours, a slow eastward drift in the cloud was observed, and by 1525 hours the new trajectory of 015° true was determined.

At 1545 hours, a reading of 0.09 mR/h (3 times background) was measured 23 miles from the portal on a course of 015° true at 8,000 feet MSL. The second mission was terminated at 1550 hours.

Because the primary purpose of the second mission was to determine the concentration and direction of any continuing release, total cloud volume measurements were not made.

Results indicated that the release was primarily noble gases and radioiodines.

#### 7.4 POSTEVENT ACTIVITIES

##### 7.4.1 Tunnel Reentry and Experiment Recovery

The AEC authorized tunnel ventilation from 1151 to 1330 hours, 17 June 1966. Because explosive gas mixtures accumulated in the tunnel, ventilation was restarted at 1537 hours on 17 June and continued periodically until 21 September 1966. No reentries into the tunnel were made until 12 July 1966. During the interim, the general area was cleaned up and preparations for reentry were made.

Initial tunnel reentry began at 1045 hours on 12 July and was completed at 1210 hours. A second reentry party entered the tunnel at 1500 hours and exited at 1533 hours. At 1540 hours, a third party entered the tunnel and recovered tape and cameras from the 16+25 (1,625 feet in from the portal) alcove. The exposure rate at this location was 600-700 mR/h.

Washing down of the tunnel began on 12 July and was completed on 13 July. This operation was conducted to settle dust

and reduce contamination. Sand was then spread on the floor in front of the blast plug. All tunnel work was performed wearing anticontamination clothing and full-face masks. Workers exiting the tunnel required extensive decontamination of clothing and equipment.

A reentry party reached the blast door on 14 July at 1350 hours where they reported a radiation reading of 3 R/h. Film and samples were recovered.

During the next several days, work continued in the tunnel. Since the radiation readings near the plug were greater than 1 R/h, MSA all-purpose masks were worn in addition to anticontamination clothing by all personnel working in the area. The tunnel was washed down at the GUMDROP "Y" and the MARSHMALLOW "Y."

On 18 July the tunnel supervisor was contacted and advised that his personnel were approaching 2500 mrem for the quarter. The decision was made to suspend operations for that shift and bring in miners having lower exposures.

General Electric personnel and miners entered the 16+25 alcove to recover equipment on 19 July. The maximum exposure indicated by pocket dosimeters for persons making this recovery was 450 mrem.

By 21 July, the vent line had been installed through the overburden plug. From 21 July to 28 July, the tunnel was thoroughly washed down and clean sand was spread on the floor.

At 1000 hours on 28 July, the blast door entry party was briefed on operations beyond the door and began dressing out. Two Radsafe personnel and two miners entered the tunnel, surveyed the area near the test chamber, and opened the blast door. They installed electrical cord to supply power for an air sampler lo-

cated at the test chamber. No toxic or explosive gases were detected; however, the radiation reading inside the test chamber was 4-5 R/h. This party exited the tunnel at 1050 hours. Elapsed time behind the blast plug was six minutes. Photography party personnel began dressing out at 1045 hours. The Test Group Director and his party, accompanied by two Radsafe monitors, reentered the test chamber at 1100 hours. Photos of the chamber were taken by DOD photography documentation personnel, and at 1125 hours, the party exited the tunnel. Elapsed time behind the blast plug was six minutes.

GUMDROP reentry drift damage was assessed on 29 July. No masks were required from the portal to the gas seal door, however, complete anticontamination clothing was required. Water-glass was sprayed from the gas seal door to the "Y".

On 2 August, a DOD inspection party again entered the test chamber. Maximum radiation readings were 8 R/h gamma ten feet from the test chamber, 15 R/h contact with the tunnel floor, 5 R/h inside the test chamber, and 6 R/h contact inside the test chamber. There were no detectable toxic gases or explosive mixtures beyond the blast door.

An experiment recovery operation began at 1030 hours on 3 August. Recovery team members used supplied-air equipment due to the large amount of dust in the recovery area. Operations were completed and personnel exited the tunnel at 1525 hours. No radiation or industrial hygiene problems were encountered. Urine samples were taken from party personnel and their film badges were changed. Results are discussed in section 7.4.1.

Inspection of the LOS pipe began at 1022 hours on 10 August 1966. The radiation reading 260 feet from the end of the pipe was 15 R/h gamma, which was the maximum reading for this reentry. Pipe inspection was complete at 1050 hours.

Two LMSC personnel accompanied by a miner, two operators, and three Radsafe personnel reentered to 32 feet beyond the blast plug to perform a recovery operation at 1210 hours on 15 August. The group exited the tunnel at 1320 hours. Between 1445 hours and 1545 hours another reentry team entered the test chamber to recover some additional LMSC experiments.

No further experiment recoveries were performed until 16 September 1966 when LMSC personnel removed two camera units from the test chamber. Recoveries from the test chamber by DOD, LMSC, and SC personnel continued through 23 September. Recovery operations were completed and the test chamber was secured on that date.

Work continued in the tunnel with initial reentry into the DOUBLE PLAY drift occurring on 7 October. Reentry personnel were dressed in required sets of anticontamination clothing and masks including two pairs of coveralls and gloves. The maximum radiation level encountered was 15 R/h gamma. Sample recovery in this drift was conducted on 20 and 21 October 1966 by DOD, KOA, and SC personnel. Photographic documentation was performed by DOD personnel.

On 25 October, SC personnel reentered the tunnel for an inspection of the DOUBLE PLAY test chamber; 01, 02 & 03 reentry drifts; and alcoves 1 through 5. This reentry was completed at 1500 hours. Film badges were changed and urine samples taken.

On 14 November a gate was installed across the MARSHMALLOW drift entrance to prohibit access. An additional gate was installed at 11+25 feet in the main drift. After installation of these gates, a wire fence was installed to help control access and radiation warning signs were put up.

Urine samples taken from personnel were analyzed for gamma

activity and tritium concentrations throughout DOUBLE PLAY reentry operations. These results indicated minor exposures to tritium, radioiodines, and ruthenium radionuclides. Observed tritium concentrations in urine indicated average personnel exposure rates of less than 15 mrem/wk.

#### 7.4.2 Postevent Drilling

Postevent drilling began at 1000 hours on 22 July 1966 on postevent hole PS-1A to recover solidified melt samples for analysis. Drilling was done to a total depth of 1,195 feet. Directional surveys were run as the hole was drilled and gamma logged, and a total of 14 core samples were taken. The abandonment valve was closed at 1330 hours 28 July 1966.

Postevent drilling began on sidetrack PS-1AS at 1210 hours on 2 August 1966 at 860 feet. Drilling was done to a total depth of 1,149 feet, directional surveys and gamma logging were accomplished, and a total of 15 samples were taken. The abandonment valve was closed at 1815 hours on 6 August 1966.

The maximum core sample intensity for a single core sample was 210 mrad/h beta plus gamma and 20 mR/h gamma at contact.

Operational and maintenance support for the drilling vent line radioactive effluent monitoring system was provided on a 24-hour per day basis from 2 August through 6 August 1966 on the DOUBLE PLAY postevent drilling operation.

On 2 December 1966, full time Radsafe support was discontinued.

#### 7.4.3 Industrial Safety

Toxic gases and explosive mixtures were continuously moni-

tored. Maximum readings in the tunnel complex were 100 percent of LEL for explosive mixtures, 7,500 ppm CO, and 10,000 ppm CO<sub>2</sub> at the MARSHMALLOW vent line on 17 June 1966. A maximum concentration of 20 ppm NO + NO<sub>2</sub> was measured on 21 October 1966 at alcove No. 5.

Industrial safety codes, including specific codes for mining, tunneling, and drilling were established by REECo and emphasized during all operations.

## 7.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 1001 hours on 15 June 1966, and ended at 2200 hours on 11 July 1966. The maximum measurement in the tunnel complex was greater than 1,000 R/h occurring from 1001 hours on 15 June 1966 to 0240 hours on 16 June 1966 in the MARSHMALLOW tunnel at 1,320 feet, and at 10 other underground stations for lesser durations.

The initial reentry survey teams began measurements at 1107 hours and completed the survey at 1116 hours on 15 June 1966. The maximum gamma reading detected during the survey was 50 mR/h at 1114 hours 150 feet northeast of the portal. No alpha radiation was detected.

The maximum personnel exposure rate detected at postevent hole PS-1AS was 3 mR/h gamma on the platform at 0800 hours on 5 August 1966. No alpha radiation was detected.

Personnel exposures received during individual entries into DOUBLE PLAY radex areas from 15 June to 29 December 1966 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	4,824	1,100	61
DOD Participants	351	1,100	149

Minor levels of radioactivity were detected offsite, but it was the opinion of the PHS that there were no offsite health hazards associated with the DOUBLE PLAY event.

## CHAPTER 8

### NEW POINT EVENT

#### 8.1 EVENT SUMMARY

The NEW POINT event was a DOD underground detonation which had a yield less than 20 kt and was conducted at 1300 hours PST on 13 December 1966 at shaft site Ullc in Area 11 of NTS. The device was emplaced at a depth of 825 feet in a 66-inch diameter steel-cased drill hole, and an LOS pipe with a maximum inside diameter of 36 inches extended to the surface. Figure 8.1 shows the NEW POINT test configuration including the winch mechanism to remove the experiment tower before crater subsidence. NEW POINT was a test to determine the effects of a nuclear detonation environment on equipment and materials. The experiment program included 18 projects conducted by the DOD, laboratory, and contractor personnel.

Crater subsidence occurred approximately 13 minutes after detonation. Containment was complete. No radioactive effluent was detected onsite or offsite from this event.

#### 8.2 PREEVENT ACTIVITIES

##### 8.2.1 Responsibilities

The DOD Test Group Director was responsible for safe conduct of all NEW POINT project activities in Area 11. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Test Command, DASA, and the AEC Nevada Operations Office. LRL was responsible for providing and emplacing the

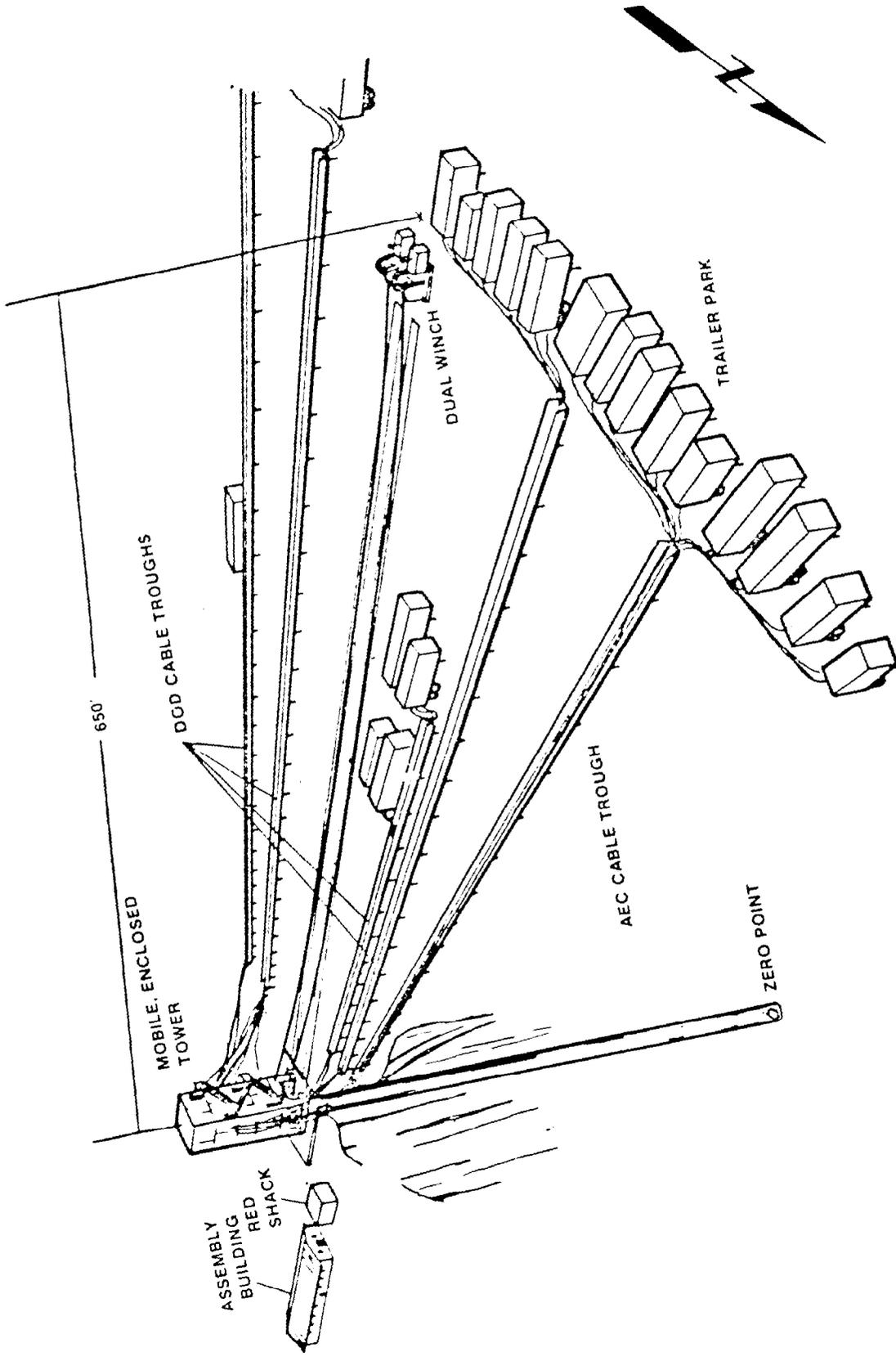


Figure 8.1 NEW POINT Test Configuration

device. SC was responsible for arming. The DOD was responsible for preevent installation and postevent removal of equipment necessary for its project activities.

### 8.2.2 Planning and Preparations

The "NEW POINT Reentry Plan" described preevent preparations and postevent procedures used to conduct safe and economical reentry and recovery within the desired time frame. In addition, Radsafe personnel were provided with "Detailed Initial Reentry Procedures" for reentry and recovery operations.

#### A. Construction and Experiment Readiness

The site selected for NEW POINT was prepared for drilling and the area cleared and graded during April 1966. Drilling of the 825-foot deep NEW POINT hole (Ullc) began in May. The casing was 66 inches in diameter.

During the spring of 1966, while cable and other long lead-time items were being procured and the site was being readied for construction, experimenters were preparing their experiments in their laboratories. Experiment design, fabrication, and checkout continued through the summer while construction was underway at the NEW POINT site.

On previous similar events cable troughs from the tower to the trailer park were permanently-emplaced structures. They had solid plywood bottoms, on which cable bundles were laid, and they were supported three feet above the ground by 4 x 4-inch posts driven into the ground. On PIN STRIPE, numerous electrical isolation problems were experienced between cable bundles in the

troughs. NEW POINT cable troughs were designed to prevent recurrence of problems due to moisture and cable bundle tangles. Troughs were open-slat platforms to allow drainage, and the slats themselves were covered with sheet plastic to prevent moisture absorption. A sufficient number of troughs which were wider than those used on previous events were employed so that each project's cable bundles were physically separated. The cable troughs were fabricated and emplaced during July and August.

In late September, instrumentation trailers began to arrive at the site and be installed in the trailer park located 650 feet from SGZ. Trailers were furnished with electrical power (mostly by electric motor generators to electrically isolate them from ground) and were shock mounted with rigid foam beneath the wheels and underbodies to attenuate expected ground shock to safe levels. Checkout of trailer sequencing and recording systems was accomplished concurrently with cable checkout and connection. A total of 29 instrumentation trailers, which contained oscilloscopes, tape recorders, and oscillographs, were emplaced. Figure 8.2 shows trailer locations and the complete NEW POINT layout.

The mobile tower was constructed during the summer and assembled at NTS in early October. Several practice recoveries of the tower were made with different combinations of winches, power sources, and controls to confirm the ability of the tower, and its recovery system, to function properly; and, to measure the time to move the tower 300 feet, the distance necessary to insure that it would not fall into the crater. During these tests, each floor was weighted as it would be during the event, and scrap cables were attached to the cable support arms to

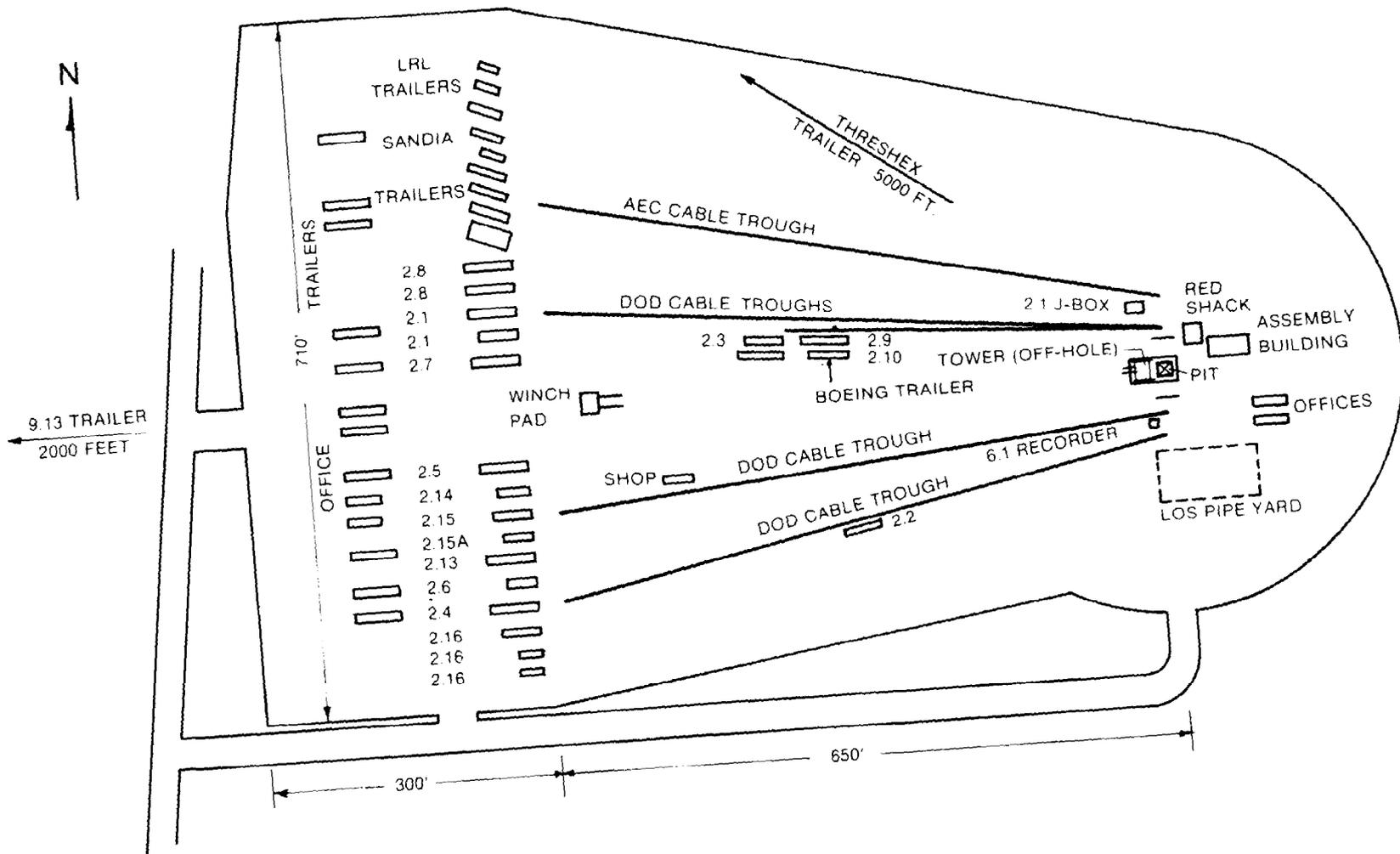


Figure 8.2 NEW POINT Area Layout

simulate the drag of experiment cable bundles. No problems were encountered, and satisfactory performance was demonstrated.

LOS pipe sections and closure hardware were delivered to NTS and checked out during October. A dry run emplacement of the LOS pipe string was performed at the end of October to insure that proper alignment could be obtained.

After completion of tower dry runs, outer experiment cassettes were installed on the tower. Inner cassettes containing experiments were then installed, cables to recording equipment were connected, and checkout of experiment/recording systems was started.

Coordinated signal dry runs began in early November and were held daily in preparation for the full power full frequency (FPFF) dry run scheduled for 29 November. Dry runs were employed to insure proper operation of the central timing system, which furnished discrete timing signals, and to verify operation and proper sequencing of instrumentation trailers, recording equipment, experiment circuitry, and other functions related to device and LOS pipe systems.

In addition to the timing and firing system indicated above, a monitoring system provided personnel in the event control room at CP-1 with indications of instrumentation trailer power and temperature and experiment status for most NEW POINT experiments. The large number of experiments made it necessary to organize display of these status monitors to assist in quickly recognizing conditions which would warrant a hold in the countdown to attempt repairs to malfunctioning equipment. The pos-

sible impact of such a hold on other experiments could have been damaging enough that it was considered inadvisable to invoke a hold unless monitors indicated a significant portion of the test was compromised.

An electrical logic system was used to indicate when conditions were catastrophic to a significant number of experiments. Experiments were weighted, based on a priority system, and the catastrophe criterion was increased as the 30-minute countdown progressed, committing more experiments and device subsystems. To complement this monitor arrangement, a hold relay was provided to the majority of experimenters and was to be manually actuated in the event of a countdown hold. By using this relay, an experimenter could arrange to hold equipment in a passive mode until the countdown was resumed and the relay deactivated. Thus, it was possible to hold the countdown even after experiments using the hold relay were committed. Although such holds were practiced during dry runs, the final countdown proceeded without incident.

The FFFF dry run was held on 29 November with all experiments, device, and closure systems participating in as near event time electrical configuration as possible. The purpose of the FFFF was to demonstrate electrical compatibility of all systems and to identify any electrical interference problems prior to device emplacement. The first FFFF attempted was declared successful.

On 30 November, the device canister was closed and LOS pipe string insertion was begun. Several days were taken to emplace the pipe and align it to provide a perfectly vertical LOS. Next, the Spooler pipe section was located over the pipe cap and aligned with the LOS. A steel

bellows (not evacuated) was connected between the Spoollex pipe and the top of the LOS pipe completing the LOS to the surface. After completing these alignment activities, checkout of Spoollex experiments and placement of required Spoollex experiment shielding, stemming was begun.

The annulus between the LOS pipe and the 66-inch diameter cased hole was filled with sand as prescribed in the stemming plan.

#### B. Radiological Safety Support

Participating agencies were provided with detailed radiological safety reentry plans prior to the event. Test area maps with appropriate reference points were prepared. Reference markers, radiation decay recorders, and air sampling equipment were positioned in the test area. Reentry routes into the test area were established during "dry runs." Party monitors were briefed regarding reentry, sample recovery, manned stations, and security station requirements.

All remote area monitoring stations and air sampling units were installed according to DOD and Laboratory specifications five days before scheduled device detonation. Radsafe monitors were stationed at all WSI security roadblocks and all work locations within the exclusion area to perform surveys and provide other support as directed.

Sufficient Radsafe personnel were standing by at FCP to provide rescue and emergency support, and radiological area control when exclusion areas were established. Anticontamination equipment, portable instruments, and

dosimetric devices were issued from a mobile facility, which was located at the FCP along with a mobile decontamination unit.

Documenting any radioactive effluent release was the primary mission of Radsafe personnel assigned to manned stations. All additional personnel at manned stations were provided with appropriate anticontamination clothing and equipment, and Radsafe monitors were in attendance.

Radsafe also provided monitoring teams and supervisory personnel for initial surface radiation surveys, helicopter surveys, and reentry parties as needed. Radiation monitoring personnel were standing by at the FCP prior to detonation to perform surveys; provide emergency support as directed; provide and issue anticontamination equipment, portable instruments, and dosimeters; operate area control check stations; and perform personnel, equipment, and vehicle decontamination, as required.

Radsafe facilities were stocked with anticontamination materials such as coveralls, head covers, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

### C. Telemetry and Air Sampling Support

Twenty-three remote area monitoring system units were located as follows:

- 1 - SGZ
- 5 - at 277° at 320 feet, 259° at 655 feet, 285° at 675 feet, 300° at 735 feet and 290° at 5,000 feet from SGZ.

- 5 - at 45° intervals on the 750-foot arc, beginning at 0°
- 12 - at 30° intervals on the 5,000-foot arc, beginning at 30°

All telemetry units had a range of 0-1,000 R/h. Equipment for readout of data from these units was located in the SC/DOD telemetry trailer located inside the CP-1 compound.

Eighteen air sampling units were in operation at zero time. These units were located at 20° intervals on the 2,000-foot arc, starting at 20°.

D. Security Coverage

Muster and control stations were established on D-day. All personnel entering or exiting the controlled area were required to stop at muster or control stations for issuance or return of their muster or stay-in badges. All personnel were required to have proper security clearances. Control was maintained using roadblocks, access authorizations, and a Schedule of Events. Parties could enter the controlled area only if they were listed on the Test Manager's Schedule of Events or with the permission of the Test Group Director. WSI security guards were responsible for activating roadblocks and directing traffic flow.

E. Air Support

The PHS and USAF provided aerial monitoring and sampling services for the NEW POINT event. Monitoring aircraft consisted of one USAF U-3A with a USAF pilot and copilot

and two PHS monitors who checked for radioactive effluent. The NATS Martin 404 and a Turbo Beechcraft were on standby in Las Vegas but were not called. Aerial surveys were conducted preevent and postevent. Postevent aerial photography was conducted by APC and LMAFS personnel in a UH-1F helicopter; and a postevent aerial photography mission was performed by AAS personnel in a Cessna 206 aircraft.

### 8.2.3 Late Preevent Activities

Experimenter personnel were in the closed area on 6 December performing final button up activities. The only area control was security control of the SGZ area.

Final stemming of the annulus and the Spoolex pit was completed. The tower was moved over the pit and aligned with the LOS pipe. Wood/honeycomb crush boards were placed under the tower tracks to absorb ground shock in excess of the tower design specification, and steel frames were bolted to the concrete pad to restrict vertical and sideways tower motion. Experiment cables and other equipment were arranged in their event-time configuration in readiness for the event scheduled for the morning of 7 December.

Rain had fallen during the day on 6 December, turning to thunderstorms and torrential rains late in the afternoon and evening. The rain caused two major problems which required considerable effort to resolve. Rain water leaking into the tower at cable holes and doors caused pallets and several cassettes to be electrically grounded to the tower. This was corrected by mopping and using heaters to dry wet areas. Rain also saturated crushable foam used to shock-mount instrumentation trailers, particularly foam in shallow pits dug under trailer wheels. The water-saturated foam easily crushed under the weight of the

trailers, causing them to settle and tilt. A crash effort quickly was instituted to replace the wet foam with dry foam wrapped in sheet plastic. Despite these last minute problems, all experiments and systems were ready for the scheduled event.

### 8.3 EVENT-DAY AND CONTINUING ACTIVITIES

Adverse winds on 7 December prevented detonation on the scheduled date. Poor high altitude wind conditions (which could have resulted in any radioactive release being blown to occupied areas or beyond U.S. borders) also were experienced the following two days. Another attempt to detonate was made on 10 December, but surface winds were not suitable.

Between 0001 and 0700 hours on 13 December final instrument checks were made by personnel from HDL, LMSC, GE, NOL, AVCO, ECOM, NDL, WANL, AFWL, RADC, Boeing, PA, Nortronics, Hughes, WES, LRL, and SC. Three WES personnel made final adjustments on recording equipment and ran calibrations in the Project 9.13 Trailer located 2,000 feet west of SGZ. Three parties of three EG&G personnel each loaded cameras and turned on equipment at five photo stations. Instrumentation adjustments to geophones were made by four SC personnel. REECO, SC, and DOD parties performed final button up of the trailer park areas.

A readiness briefing conducted at 0700 hours resulted in zero time being scheduled for 1030 hours. The arming party entered the closed area at 0730 and departed at 0925 hours. The Radsafe facility was opened at 0800 hours to dress out reentry personnel. At 0931 the closed area was again checked by security personnel and found to be clear except for approved personnel at manned stations. At 1025 hours, zero time was again rescheduled. At 1230 hours the U-3A aircraft developed oil pressure trouble and landed at Desert Rock air strip; however, the Test Manager's

helicopter and the PHS Turbo Beechcraft were in place at 1255 hours.

The countdown was broadcast on radio nets 1, 2, 6, and 8. Ten minutes before device detonation the siren on CP-1 ran for 30 seconds, and the red lights on top of the building were turned on until after device detonation.

NEW POINT zero time was 1300 hours PST on 13 December 1966.

All control room monitors indicated normal functioning of the device, instrumentation, and other systems. Immediate observable effects were the anticipated ground shock and some airborne dust. The detonation was completely contained.

Telemetry coverage began at zero time and was discontinued at 0800 hours on 15 December 1966. The maximum reading of 50 R/h was recorded at SGZ at H+1 minute after which this RAMS unit ceased functioning. All other units steadily decreased from initial readings (H+1 minute) ranging from 1.1 R/h (320 feet at 277° from SGZ) to 1 mR/h (at numerous locations). All radiation readings were the result of induced radioactivity from experiments and equipment and gamma shine from these locations.

At about H+30 seconds, tower winches were manually started from the control room. The tower was withdrawn to its recovery point, about 325 feet west of SGZ, in 2.8 minutes. The winch start signal also fired two HE charges to sever a cable bundle between the tower and the Project 2.1 junction box to prevent it from snagging. At H+5 minutes power in the area was remotely cut off to prevent electrical hazards upon reentry.

The surface around SGZ subsided at H+13 minutes, producing a surface crater approximately 210 feet in diameter. The crater was unusual in two respects. First, while the rim was relatively

circular, it had two distinct depths; approximately the northern half had very steep walls and was 80 to 90 feet deep. The remainder was relatively shallow, about 30 feet deep. Secondly, the center of the crater was offset about 30 feet to the northeast of the concrete pad and pit around the drill hole. The pad rested, intact, at the bottom of the 30-foot deep portion of the crater.

### 8.3.1 Surface Reentry and Recovery Activities

Two mobile Radsafe monitoring teams performed initial radiation surveys which began at 1326 hours and were completed at 1355 hours on 13 December 1966 (Table 8.1). All positive measurements were from induced radioactivity of experiments and equipment and gamma shine from these locations. A maximum reading of 500 mR/h was detected at 1352 hours at the Boeing Trailer located 15 feet from the tower. All survey data were reported to the net 3 radio control operator when measurements were made.

After the radex area was established, all contaminated or radioactive materials were marked to indicate radiation levels present. Personnel entering radex areas were briefed concerning potential exposure and safety precautions and provided with anti-contamination clothing, equipment, and materials.

On 13 December at 1350 hours, recovery parties entered the closed area to recover oscilloscope film, magnetic tape, and other data. Experimenter organizations participating were DASA, HDL, ACFI, ECOM, BAC, NDL, WAL, NC, BTL, HAC, SC, LMSC, EG&G, NOL, GE, LRL, APC, GA, and USGS. These efforts were completed by 1500 hours without difficulty and according to the practiced re-entry plan. Instrumentation trailers and their contents survived the ground shock undamaged.

TABLE 8.1  
 NEW POINT EVENT  
 INITIAL RADIATION SURVEY DATA  
 13 December 1966

<u>Time</u>	<u>Location</u>	<u>Gamma Exposure Rate (mR/h)</u>
1326	Stake 5Y11	Bkg*
	Stake 5Y12	Bkg
	Stake 5Y13	Bkg
	Stake 5Y14	Bkg
	Stake 5Y15	Bkg
	Stake 5Y16	Bkg
	Stake 5Y17	Bkg
1328	Stake 5Y18	Bkg
	Stake 5Y19	Bkg
	Stake 5Y20	Bkg
	Stake 5Y21	Bkg
1330	Junction of 5Y and 11B roads	Bkg
1331	Stake 11B1	Bkg
1332	Stake 11B2	Bkg
1333	11B road and U11C access road inter- section	0.15
1334	South perimeter fence	10.0
1335	North end of trailer park	1.5
1336	East perimeter fence	1.2
1338	North perimeter fence	2.5
1339	Skid 3	1.5
1350	100 feet NW of tower	10.0
1352	Boeing Trailer - 15 feet from tower	500.0
1355	East side of trailers	4.0

\*Background radiation reading

The lower portion of the tower stairway was replaced, and passive dosimetry equipment was recovered from the experiment cassettes by 1615 hours. At 1700 hours, free access to all areas except the crater, tower, and trailers adjacent to the tower was permitted.

#### 8.4 POSTEVENT ACTIVITIES

##### 8.4.1 Experiment Recovery

At 0800 hours on 14 December, an LRL reentry party was dressed in anticontamination clothing and equipment in order to perform recovery of the highly radioactive (from activation) AEC recording cassette from the first floor of the tower. This recovery operation was completed at 1100 hours at which time personnel from DASA, HDL, ACFI, ECOM, NDL, WAL, NC, SC, EG&G, and GA were allowed to perform their tower recovery operations. These activities were completed on 15 December. During tower operations, radiation surveys were performed and Radsafe monitors were in attendance.

A TV camera was lowered into the LOS pipe to examine its interior. Pipe walls were clean down to about 280 feet, at which point the pipe had broken in tension at a weak weld, probably during ground shock. Sand filled the pipe from the break presumably down to the closed upper ball valve making further examination impractical.

On 16 December a fence was constructed around the crater and the tower was moved inside the fence. Both tower and fence were marked with radiation warning signs.

#### 8.4.2 Postevent Drilling

Postevent drilling on PS-1A to obtain core samples for analysis began at 2100 hours on 14 December. Core sampling began at 2145 hours on 16 December and was completed at 0015 hours on 17 December. A total of 16 core samples was taken with a maximum contact radiation reading of 40 R/h for a single core sample.

On 17 December at 0100 hours, sidetrack drilling began on PS-1AS at a depth of 693 feet. Core sampling began at 1145 hours and was completed at 1649 hours on 17 December. Twenty-seven core samples were taken with a maximum contact radiation reading of 25 R/h for a single core sample. At 1800 hours, a burst of gas reading greater than 200 mR/h came through the disconnected drill pipe. Drillers were given masks to wear and air samples were taken. Mud was pumped on top of the Otis plug to try to seal the leak. At 1905 hours the rotating head was removed and no more gas was detected. The abandonment valve was closed at 2100 hours. The rig was decontaminated to acceptable levels and removed; then the area was fenced.

#### 8.4.3 Industrial Safety

Toxic gas and explosive mixture levels were monitored continuously. No readings above permissible levels were detected.

Industrial safety codes, including specific codes for mining, tunneling, and drilling were established by REECO and emphasized during all operations.

### 8.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 1301 hours on 13 December 1966, and ended at 0800 hours on 15 December 1966. The maximum

gamma exposure rate detected was 50 R/h at SGZ at 1301 hours on 13 December 1966. This radioactivity was induced activity in equipment and material from prompt neutrons before closure systems sealed the LOS pipe.

Initial survey teams began at 1326 hours and the survey was completed at 1355 hours on 13 December 1966. The maximum gamma reading detected was 500 mR/h at the Boeing Trailer located 15 feet from SGZ at 1352 hours on 13 December. No alpha radiation was detected.

Personnel exposures received during individual entries into NEW POINT radex areas from 13 to 18 December 1966 are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	642	1,955	84
DOD Participants	144	1,855	206

Postevent drilling began at 2100 hours on 14 December and the abandonment valve was closed at 2100 hours on 17 December 1966. No alpha radiation was detected. Maximum gamma exposure rates detected during drillback operations were:

Postevent Hole No. 1A - 0.6 mR/h in the cellar from 2130 to 2400 hours on 16 December 1966.

PS-1A Core - 40 R/h at contact.

Postevent Hole No. 1AS - 200 mR/h from the pipe at 1800 hours on 17 December 1966.

PS-1AS Core

- 25 R/h at contact.

No radioactivity above normal background levels was detected offsite by ground and aerial monitoring teams, by stationary dose rate recorders, or in any environmental samples either after the detonation or during subsequent sample recovery operations. No fresh fission products were detected in any environmental sample collected offsite throughout this period, and no prefilter air samples contained levels of gross beta activity above normal background.

It was the opinion of the PHS that no radioactive contamination of the offsite area resulted from this event.

## CHAPTER 9

### MIDI MIST EVENT

#### 9.1 EVENT SUMMARY

The MIDI MIST event was a DOD underground detonation with a yield less than 20 kt conducted at 0900 hours PDT on 26 June 1967 at tunnel site U12n.02 in Area 12 of the NTS. The device was emplaced in a tuff medium 1,230 feet from the nearest free surface. MIDI MIST investigated the effects of a nuclear detonation environment on equipment and materials. The experiment program included 16 projects conducted by DOD, laboratory, and other contractor personnel. U12n.02 drift for MIDI MIST was constructed in an extension of the existing U12n tunnel complex (Figure 9.1).

Low levels of radioactive effluent were detected offsite by aircraft only.

#### 9.2 PREEVENT ACTIVITIES

##### 9.2.1 Responsibilities

Safe conduct of all MIDI MIST project activities in Area 12 was the responsibility of the DOD Test Group Director. Responsibilities of AEC and AEC contractor personnel were in accordance with established AEC/DOD agreements or were the subject of separate action between Test Command, DASA, and the AEC Nevada Operations Office. Because LRL fielded the test device, the LRL Test Group Director was responsible to the Test Manager for radiological safety within a 5,000-foot radius of SGZ. This responsibility was in effect from the time the device was moved to the emplacement site until zero time. At zero time, the Test

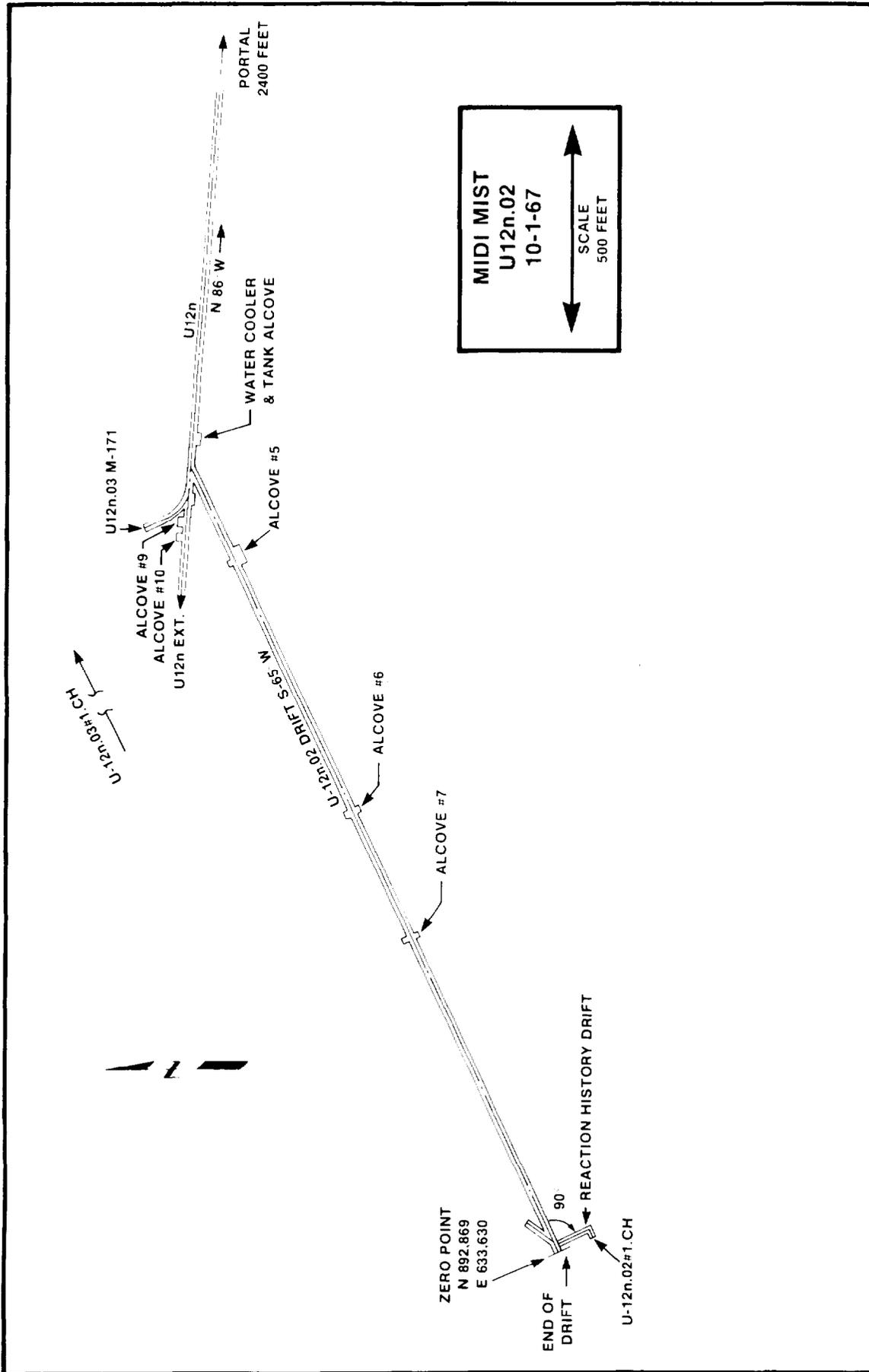


Figure 9.1 MIDI MIST Event U12n.02 in U12n and Extension Complex

Manager relieved the LRL Test Group Director of responsibility pursuant to the provisions of the NTS-SOP and assigned responsibility to the DOD Test Group Director. The DOD was responsible for preevent installation and postevent removal of equipment necessary for its project activities.

#### 9.2.2 Planning and Preparations

The "MIDI MIST Reentry Plan" described preevent preparations and postevent procedures used to assure safe and economical reentry. In addition, Radsafe personnel were provided with "Detailed Initial Reentry Procedures" for reentry and recovery operations. Stemming design incorporated necessary provisions to maximize reentry safety.

Mining and test area preparations were conducted in the 02 drift for MIDI MIST and in the 03 drift for a future event. Various experiment alcoves were mined, test instrumentation was installed, and the LOS pipe and associated hardware were installed. Fifty-three instrumentation trailers were used to record data from this event.

Sand stemming and blast doors had been emplaced in the tunnel. The plugs provided containment, reduced radioactivity in the reentry area, and minimized reentry problems. Blast doors contained any debris that passed the stemming. Radiation sensing instruments provided remote detection of tunnel radiation levels while tunnel condition indicators remotely monitored the condition of the tunnel.

##### A. Radiological Safety Support

Participating agencies were provided with detailed radiological safety reentry plans prior to the test event. Test area maps with appropriate reference points were

prepared. Reference markers, radiation decay recorders, and air sampling equipment were positioned in the test area. Reentry routes into the test area were established during "dry runs." Radiation monitors were briefed regarding reentry, sample recovery, manned stations, and security station requirements.

All personnel at manned stations were provided with anticontamination clothing and equipment, and Radsafe monitors were in attendance.

A mobile issue facility for anticontamination clothing, respiratory devices, instruments, and dosimetric devices was positioned prior to the event at the security barricade near the FCP. When authorized by the Test Group Director, this facility was repositioned to a convenient location near the tunnel portal. A personnel and vehicle decontamination facility was established adjacent to the mobile issue facility.

Radsafe monitors were stationed at all WSI security roadblocks and at all work areas within the exclusion area to perform surveys and provide other support as directed. Sufficient Radsafe personnel were standing by at the FCP to provide rescue and emergency support, and radiological area control as exclusion areas were established.

Radsafe provided monitoring teams and supervisory personnel for initial surface radiation surveys, helicopter surveys, and tunnel reentry parties. Radsafe personnel were stationed at the DOD Test Group Director's FCP to perform initial and subsequent ground surveys as required; provide emergency rescue and support as directed; provide and issue anticontamination equipment, portable

instruments, and dosimetric devices; perform personnel, equipment, and vehicle decontamination; and operate a sample return station.

Anticontamination materials available included coveralls, head covers, shoe covers, full-face masks, supplied-air breathing apparatus, plastic suits, gloves, plastic bags, and masking tape.

#### B. Telemetry and Air Sampling Support

A RAMS installation was installed with the detection units located underground and on the surface, and readouts located outside the controlled area. This system was functioning at zero time so that tunnel radiation conditions could be determined. RAMS console readings were recorded every 15 minutes until tunnel ventilation was started. Forty-nine remote telemetry radiation monitoring stations provided coverage as follows:

<u>RAMS No.</u>	<u>Aboveground Location</u>
*1	31 feet from portal at 328° Azimuth
2	67 feet from portal at 45° (vent filter system)
3	67 feet from portal at 45° (vent filter system)
*4	67 feet from portal at 45° (vent filter system)
*5	67 feet from portal at 45° (vent filter system)
6	400 feet from portal at 16° Azimuth
7	275 feet from portal at 89° Azimuth
8	363 feet from portal at 164° Azimuth
9	482 feet from portal at 192° Azimuth
*10	558 feet from portal at 228° Azimuth
11	416 feet from portal at 291° Azimuth

RAMS  
No.

Aboveground Location

12	648 feet from portal at 333° Azimuth
13	2,570 feet from portal at 328° Azimuth
14	2,234 feet from portal at 342° Azimuth
15	1,817 feet from portal at 355° Azimuth
16	1,316 feet from portal at 20° Azimuth
17	666 feet from portal at 69° Azimuth
18	1,369 feet from portal at 137° Azimuth
*19	1,964 feet from portal at 163° Azimuth
*20	1,822 feet from portal at 191° Azimuth
*21	2,773 feet from portal at 234° Azimuth
*22	2,813 feet from portal at 256° Azimuth
23	2,742 feet from portal at 301° Azimuth
24	2,766 feet from portal at 316° Azimuth
25	6,056 feet from portal at 115° Azimuth
*26	3,086 feet from portal at 282° Azimuth
27	3,550 feet from portal at 282° Azimuth
28	3,228 feet from portal at 288° Azimuth
29	3,160 feet from portal at 288° Azimuth
30	3,240 feet from portal at 289° Azimuth
31	4,760 feet from portal at 259° Azimuth
32	4,816 feet from portal at 270° Azimuth
33	4,805 feet from portal at 273° Azimuth
*34	5,016 feet from portal at 305° Azimuth
34a	3,320 feet from portal at 267.5° Azimuth

Underground Location

*35	1,300 feet inside 02 drift
36	963 feet inside 02 drift
37	300 feet inside 02 drift
*38	300 feet inside 03 drift
*39	3,000 feet in from portal in main drift

<u>RAMS</u> <u>No.</u>	<u>Underground Location</u>
40	2,940 feet in from portal in main drift
41	2,740 feet in from portal in main drift
*42	300 feet inside 01 drift
*43	59 feet inside 01 drift
44	1,675 feet in from portal in main drift
45	1,475 feet in from portal in main drift
46	700 feet in from portal in main drift
47	50 feet in from portal in main drift
*CC	Cloud chamber alcove 60 feet inside 01-05 drift

\*Read out on strip chart recorder near portal.

Twenty-one air samplers were placed in a surface array, calibrated, and operational at zero time.

#### C. Security Coverage

Muster and control stations were established on D-day. All personnel entering or exiting the controlled area were required to stop at the muster or control stations for issuance or return of their muster or stay-in badges. All personnel were required to have proper security clearances for the area. Control of the area was maintained by the use of roadblocks, access authorizations, and a Schedule of Events. Parties could enter the controlled area only if they were listed on the "Test Manager's Schedule of Events," or with permission of the Test Group Director. Two reentry control points were established:

- 1) two and one-half miles south of the Area 12 Camp for those persons scheduled to enter the U12n portal area to recover experimental data, and

- 2) at the intersection of Stockade Wash Road and Pahute Road for those personnel scheduled to enter the Rainier Mesa trailer parks to recover experimental data.

WSI security guards were responsible for activating roadblocks and directing traffic flow.

#### D. Air Support

Aircraft support for this event was as follows:

<u>Type</u>	<u>Organization</u>	<u>Mission</u>
U-6A	Security	D-day Security Sweep
UH-1F	DOD	Photo
UH-1F	LMAFS	Photo
U-3A	USAF/PHS	Cloud Tracking
Turbo Beech	PHS	Cloud Sampling
Turbo Beech	PHS	Cloud Sampling*
Martin 404	EG&G/NATS	Cloud Tracking*

\*On standby at McCarran Airport in Las Vegas, Nevada.

MIDI MIST was originally scheduled for detonation on 23 June 1967. Muster stations were activated at 1400 hours on 22 June by WSI guards. All roadblocks were activated at 1402 hours. The first security sweep began at 1403 hours and was completed at 1835 hours. At 2300 hours, the second sweep began with completion at 0045 hours on 23 June. At 0116 hours, DOD requested that the trailer park on Rainier Mesa be rechecked. Only prearming personnel were to remain in the area. The Rainier Mesa sweep was completed at 0220 hours. The aerial security sweep began at 0548 hours and was completed at 0655 hours.

Permission to arm the device was granted at 0650 hours on 23 June. The device was armed and the area cleared by 0912 hours. A delay of zero time was called at 0945 hours and the event was cancelled at 1315 hours. The arming party departed for N-tunnel at 1430 hours, and the device was disarmed by 1550 hours. The HE experiments were disarmed by 1600 hours. The event was postponed until 26 June.

### 9.2.3 Late Preevent Activities

A readiness briefing was held at 1530 hours on 25 June. Experimenters were in the closed area all day performing button up activities. Experimenter organizations represented were SC, EG&G, AFWL, BRL, LMSC, RADC, GA, LASL, AVCO, NOL, LRL, SRI, and DOD. The first security sweep was performed by WSI and completed at 1930 hours.

### 9.3 EVENT-DAY AND CONTINUING ACTIVITIES

The second security sweep of the closed area was completed at 0050 hours on 26 June. At 0245 hours, permission was granted to arm the HE experiments; permission to arm the device was granted at 0540 hours. Manned photo station personnel were in their assigned positions by 0605 hours. WSI personnel conducted a final security sweep which was completed at 0635 hours. HE and device arming parties were out of the closed area and the area cleared by 0737 hours.

The final weather briefing for the Test Manager and Advisory Panel was conducted approximately two hours before planned device detonation.

Required countdown began on radio nets 1, 2, 6, and 8. At ten minutes before device detonation the siren on CP-1 ran for 30

seconds, and the red lights on top of the building were turned on until after device detonation.

MIDI MIST zero time was 0900 hours PDT on 26 June 1967.

Telemetry measurements began at 0901 hours. The maximum gamma exposure rate detected was 275 R/h at underground station 36 at 0901 hours. Measurements supplied by 25 operating RAMS units located aboveground indicated no activity above background radiation until 1322 hours when tunnel ventilation systems were turned on. These readings were verified by reentry team monitors who checked out all trailer parks including those on top of Rainier Mesa. The five RAMS units inside the tunnel complex along the main drift averaged 6.6 mR/h six hours after detonation. The first indication of effluent activity occurred at 1340 hours and the controlled release continued until approximately 0900 hours on 27 June at which time the radiation readings from the vent line monitors decreased to background. About 4,500 curies of radioactivity were released through 22 hours after detonation, and the remote monitoring instrument at the tunnel entrance was measuring 6.5 mR/h at that time.

#### 9.3.1 Surface Reentry Activities

Initial safety and radiological surveys were performed under the direction of the Test Group Director in accordance with the "Radiological Safety Support Plan for MIDI MIST." Initial survey teams were released at 1002 hours by the Test Group Director. At 1006 hours two vehicle-borne Radsafe parties, consisting of two monitors each, began the initial survey which was completed at 1015 hours. All initial survey readings were background because release of gaseous activity through the vent line filter system had not begun.

All survey data were reported to the net 3 radio control

operator when measurements were made. Plotting facilities were maintained at the FCP and CP-1. Radsafe control was located in the operations trailer at FCP.

Each area and all contaminated or radioactive materials at the portal and, later, underground were marked to indicate radiation levels present. Personnel entering radiation areas or working with contaminated material were briefed concerning potential exposure and safety precautions, and provided with anticontamination clothing, equipment, and materials.

After use, anticontamination clothing and equipment were laundered and returned to stock for subsequent reissue. Items which could not be decontaminated to permissible levels were buried at a designated disposal site.

### 9.3.2 Experiment Recovery

Experiment recovery began at 1045 hours. DOD personnel traveled to Rainier Mesa instrument trailer park and reaction history trailer park to control data recovery teams. Those organizations recovering data from the Rainier Mesa instrument trailer park were SC, EG&G, AFWL, BRL, RADC, GA, LASL, AVCO, NOL, LRL and SRI. LRL and DOD personnel recovered data from the reaction history trailer park. Separate recovery activities were being conducted at the portal area, where DOD personnel were controlling operations by LMSC, LRL, and SC representatives. Film and tape recovery was accomplished without encountering detectable radiation.

Permission was granted at 1200 hours for SC personnel to operate the gas sampling system at the portal. At 1415 hours, SC personnel disconnected cables at the reaction history cable hole near SGZ and four cable holes at the Rainier Mesa instrument trailer park. They also disconnected cables at the portal area.

EG&G personnel recovered film from photo stations No. 1 and 2 at 1643 hours. No further experiment recoveries were performed on 26 June 1967.

### 9.3.3 Initial Tunnel Reentry

Initial tunnel reentry began at 1830 hours on 26 June. The reentry team entered the tunnel to the gas seal door where the maximum radiation reading encountered was 10 mR/h. They then opened the gas seal door. By 1845 hours they had inspected the 900 psi door on the portal side and noted that it was in good condition. A 15 mR/h maximum radiation reading was recorded at this location. No explosive mixtures or toxic gases were detected.

The initial tunnel reentry team began their exit at 1910 hours and the second reentry team entered the tunnel to open the 900 psi door and remove the sand bags from the opening. No further tunnel reentry activities were conducted on 26 June 1967.

## 9.4 POSTEVENT ACTIVITIES

### 9.4.1 Tunnel Reentry

Each participant in tunnel reentry operations was certified by the Bureau of Mines as having satisfactorily completed training in the use of the two-hour McCaa breathing apparatus, along with instruction in mine rescue procedures.

Tunnel reentry activities began again at 1053 hours on 27 June when a reentry team entered the tunnel complex to "walk out" the 02 drift. By 1107 hours all vent lines were in place, the radiation intensity was less than 0.5 mR/h, and no explosive mixtures or toxic gases were detected. Upon reaching scientific sta-

tion No. 5 at 1130 hours, radiation readings again were taken. No toxic gases or explosive mixtures were detected and the maximum radiation reading was 100 mR/h at contact. Scientific station No. 6 was reached at 1135 hours. The maximum radiation intensity was 200 mR/h at contact with the scientific station No. 6 door. A slight indication of toxic gases (approximately 100 ppm CO) was detected between scientific station No. 6 and No. 7.

Minor repair to the vent line, which had been broken approximately 10 feet beyond scientific station No. 7 on the working point side, was accomplished on 28 June.

#### 9.4.2 Postevent Mining and Experiment Recovery

Postevent mining began at 1030 hours on 29 June 1967. After all tunnel repair was complete and the ventilation system was operational, personnel from experimenter organizations, accompanied by Radsafe monitors, were allowed to enter the tunnel and perform recovery operations. Those personnel performing recovery tasks were from LMSC, LRL, GA, SC, AFWL, AMC, EG&G, and DOD. Experiment recoveries proceeded as planned. There were no radiation or industrial hygiene problems encountered. Recovery operations went smoothly, experiments were recovered from the tunnel and LOS pipe, and the effort was terminated on 14 July 1967. The maximum gamma reading obtained was 130 mR/h on contact with the inside of Station No. 9 at 1130 hours on 5 July 1967. The maximum alpha radiation measurement was 20,000 cpm per 55 cm<sup>2</sup> on LASL equipment located between test chamber Nos. 6 and 7 at 1840 hours on 29 June 1967.

Later in July, a decision was made to perform reentry mining to study the stemmed areas and learn as much as possible about a successfully contained event. About 900 feet of LOS pipe was removed and a reentry drift was mined from July 1967 to 6 December

1967 on the left side and parallel with the experimental drift. No radiation problems were experienced.

#### 9.4.3 Postevent Drilling

Drilling began on PS-1A at 0930 hours on 16 July 1967. After encountering several problems with drilling equipment, sufficient depth was reached to begin the core sampling operation at 1347 hours on 20 July. Twenty-four samples were obtained, with a maximum contact radiation intensity of 23 R/h for a single core sample, and the operation was concluded at 2010 hours that same day.

A sidetrack hole, PS-1AS was begun at a depth of 1,160 feet at 2255 hours on 20 July. The first core sample was obtained at 1750 hours on 21 July. A total of 21 samples were taken with a maximum contact radiation intensity of 7 R/h for a single core sample.

Postevent drilling operations were completed and the abandonment valve closed at 0416 hours on 22 July 1967.

#### 9.4.4 Industrial Safety

Reentry was not made beyond ventilation, 1,000 ppm CO, or 10 percent LEL of gas mixtures. Checks were made on each shift for radiation levels, toxic gases, and explosive mixtures. These measurements were then recorded in the monitor's log book. Maximum industrial hygiene readings for the MIDI MIST event were:

1. 100 percent of the LEL in the 02 drift on 22 September 1967.
2. 70,000 ppm CO in the 02 drift on 22 September 1967.

3. 20 ppm NO + NO<sub>2</sub> at the reentry work face on 23 September 1967.
4. 15,000 ppm CO<sub>2</sub> in the 02 drift on 28 September 1967.

Appropriate safety measures were taken to protect mining personnel from those hazardous conditions. Industrial safety codes, including specific codes for mining, tunneling, and drilling were established by REECO and emphasized during all operations.

The Test Plan required that all explosives and all electro-explosive components, toxic materials, or radioactive materials were handled, stored, and transported in accordance with the applicable section of the Army Material Command Regulations AMCR-385-224, and AEC NTS-SOPs.

The portal construction area and the tunnel were hard hat and foot protection (safety shoes, safety boots, miners boots or toe guards) areas. Each participating agency provided its own industrial safety apparel.

Eye protection, safety glasses, or cover-all goggle types were worn whenever explosives of any configuration were being handled. Conductive booties were worn over shoes at all times in the Explosive Assembly Building. Conductive safety shoes could be worn in lieu of the conductive booties provided they had not been worn on gravel or dirt surfaces.

## 9.5 RESULTS AND CONCLUSIONS

Telemetry measurements began at 0901 hours on 26 June 1967, and ended at 1600 hours on 30 June 1967. The maximum gamma expo-

sure rate detected was 275 R/h at underground Station 36 at 0901 hours on 26 June 1967.

The initial reentry survey teams entered the area at 1006 hours and completed the survey at 1015 hours on 26 June 1967. The maximum gamma reading obtained was background radiation (0.05 mR/h). No alpha radiation was detected.

Postevent mining began at 1030 hours on 29 June 1967 and ended at 0730 hours on 3 August 1967. The maximum gamma reading obtained was 130 mR/h on contact with the inside of Station No. 7 at 1130 hours on 5 July 1967. The maximum alpha radiation measurement was 20,000 cpm per 55 cm<sup>2</sup> on LASL equipment located between test chamber Nos. 6 and 7 at 1840 hours on 29 June 1967. There was no change in the radiation intensities underground during the postevent recovery operations from 14 July to 3 August 1967.

The maximum personnel gamma exposure rates detected during postevent drillback operations were:

Postevent Hole No. 1A - 0.3 mR/h in the cellar at 1700 hours on 20 July 1967.

PS-1A Core - 23 R/h at contact.

Postevent Hole No. 1AS - 15.0 mR/h in the cellar at 0230 hours on 22 July 1967.

PS-1AS Core - 7 R/h at contact.

No alpha radiation was detected. Postevent operations were completed on 4 January 1968.

Personnel exposures received during individual entries to

MIDI MIST radex areas from 26 June 1967 to 3 January 1968, including tunnel work in preparation for another test event, are summarized below. Average exposures are from self-reading pocket dosimeters as recorded on Area Access Registers. Maximum exposures are from film dosimeter records.

	<u>No. of Entries Logged</u>	<u>Maximum Exposure (mR)</u>	<u>Average Exposure (mR)</u>
All Participants	3,487	625	18
DOD Participants	414	285	8

## REFERENCE LIST

References are not indicated within the text of this report, but are included in this list by chapter or part. Most references are available for review at, or through, the DOE/NV Coordination and Information Center (CIC). Security-classified references are located at the DNA/HQ Technical Library in Alexandria, Virginia, but are available only to persons with appropriate security clearances and a need for classified information contained in the references.

The CIC is operated by REECO, the custodian of nuclear testing dosimetry and other radiological safety records for DOE/NV, and the custodian for DNA of reference documents for reports on DOD participation in atmospheric, oceanic, and underground nuclear weapons testing events and series. Arrangements may be made to review available references for this report at the CIC by contacting one of the following:

Health Physics Division  
U.S. Department of Energy  
Nevada Operations Office  
2753 South Highland Avenue  
Post Office Box 14100  
Las Vegas, NV 89114

Commercial: (702) 295-0994  
FTS: 575-0994

or

Manager, Coordination and Information Center  
Reynolds Electrical & Engineering Co., Inc.  
Post Office Box 14400  
Las Vegas, NV 89114

Commercial: (702) 295-0748  
FTS: 575-0748

Source documents available through the National Technical Information Service (NTIS) may be purchased from NTIS at the address and telephone number listed below:

National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161

Commercial: (703) 487-4650  
(Sales Office)

References available through public bookstores, through the U.S. Government Printing Office, and only at the CIC are listed without asterisks. Asterisks after references or groups of references indicate availability as follows:

- \* Available through the NTIS and also located at the CIC.
- \*\* Located in the REECO Technical Information Office adjacent to the CIC, available through the CIC, and may be subject to Privacy Act restrictions.
- \*\*\* Located in the DNA/HQ Technical Library, and subject to security clearance requirements.

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13. Atomic Energy Commission, Nevada Operations Office, Report of the Test Manager, Operation Latchkey, 1 July 1966 through 30 June 1967, NVO-36, May 1968, Unpublished.
14. REECO Environmental Sciences Department field record archives are maintained chronologically and by test event and include the following:
  - a. Procedures, Reentry Plans, Radsafe Plans, and Schedules of Events. \*\*
  - b. Correspondence. \*\*
  - c. Reports, including onsite Radsafe and offsite PHS event reports. \*\*
  - d. Exposure reports, Radsafe log books, Area Access Registers, radiation survey forms, telemetry forms, and other sampling and dosimetry forms. \*\*



## APPENDIX A

### GLOSSARY OF TERMS

Access Shaft Headframe	A framed structure above the shaft collar, necessary for lowering and hoisting the elevator cage, personnel, and equipment in tunnel shafts.
Activation Products	Nuclides made radioactive by neutrons from a nuclear detonation interacting with usually nonradioactive nuclides. Also called induced activity.
Advisory Panel	A group of experts formed to advise the user (see Testing Organizations) Test Director concerning operational factors affecting a test detonation.
AFSWC	The Air Force Special Weapons Center, located at Kirtland Air Force Base, Albuquerque, New Mexico. AFSWC provided air support to the AEC Test Manager for NTS testing activities.
AFSWP	The Armed Forces Special Weapons Project was activated on 1 January 1947, when the AEC was activated, to assume residual functions of the U.S. Army Manhattan Engineer District.
Air Support	Aircraft, facilities, and personnel required for various support functions

during testing, such as cloud sampling, loud tracking, radiation monitoring, photography, and personnel and equipment transport.

Alpha Particle

A particle emitted spontaneously from the nucleus of the radionuclide, primarily heavy radionuclides. The particle is identical with the nucleus of a helium atom, having an atomic mass of four units and an electric charge of two positive units.

Andersen Sampler

The standard H. H. Andersen six-stage inertial impactor, modified by the addition of a seventh stage filter, designed to collect particles on the basis of mass and density at a given intake rate.

Anticontamination  
Clothing

Outer clothing worn to prevent contamination of personal clothing and the body and spread of contamination to uncontrolled areas.

Atmospheric Test  
Series

Each of several series of U.S. tests conducted from 1945 to 1962, when nuclear device detonations and experiments were conducted primarily in the atmosphere.

Attenuation

The process by which photons or particles from radioactive material are

GLOSSARY OF TERMS (continued)

reduced in number or energy on passing through some medium.

Background Radiation

- 1) Natural environmental radiation.
- 2) The radiations of man's natural environment, consisting of cosmic rays and those radiations which come from the naturally radioactive atoms of the earth, including those within man's body.
- 3) The term also may mean radiation extraneous to an experiment.

"Beer Mug" Dosimeters

Dosimetric devices installed in a protective shield the size and shape of a beer mug (see Dosimeter).

Beta Particle

A negatively charged particle of very small mass emitted from the nucleus of a radionuclide, particularly from the fission product radionuclides from nuclear detonations. Except for origin, the beta particle is identical with a highspeed electron.

BJY

The intersection of Mercury Highway with roads originally constructed for the BUSTER-JANGLE 1953 atmospheric test series, located at the NW corner of Area 3 on the NTS.

Blast Door

May be in blast plug, but originally was in its own keyed plug toward the

## GLOSSARY OF TERMS (continued)

portal from the blast plug. Evolved into an overburden plug with a large steel door containing a smaller access hatch and designed to withstand up to 1000 psi overpressure. May be welded or bolted closed during detonation. Sometimes a loosely used substitute term for a gas seal door.

### Blast Plug

Barrier constructed underground as a primary containment feature. May be constructed with sandbags (see Sandbag Plugs), solid sand backfill, concrete (see Keyed Concrete Plug), or other materials. Some plugs may have openings through them that are sealed with blast doors, and sometimes sandbags are added to protect the opening temporarily during detonation.

### Blooie Line

Pipe line used to remove cuttings from the drill string to the settling pond.

### Bluebird Teams

Vehicle-borne teams consisting of 2 radiation monitors, each with equipment and materials to distinguish, follow, delineate and sample at ground level any effluent release from a nuclear detonation at the NTS. They usually were positioned within the secured area to be free to move about as directed without having to gain access through security stations into the test area.

### Button up Activities

Preparations made prior to a detonation

GLOSSARY OF TERMS (continued)

during which time all facilities and areas were secured as required, vehicles and equipment were removed, and fixtures were prepared to withstand detonation shock.

Cable Drift

A passageway tunnel, usually parallel to the LOS drift, also known as the access or reentry drift, in which cables from various experiments in the LOS pipe were installed toward a cable alcove and then through a sealed shaft to the surface.

Cal-Seal

A commercial sealant that is high density, quick-drying, high strength, and resilient concrete.

Cassette

A holder or container for a sample, an experiment, or a group of experiments.

Cellar

The larger diameter, first part of a drilled hole where valving and other equipment are located.

Chamber

A natural or man-made enclosed space or cavity.

Check Points or  
Check Stations

Geographic locations established and staffed to control entry into restricted areas.

Chimney

The volume of broken rock above an underground detonation cavity that falls

GLOSSARY OF TERMS (continued)

downward when decreasing cavity gas pressure can no longer support the column of broken rock.

Cloud Sampling

The process of collecting particulate and gaseous samples of an effluent cloud to determine the amount of airborne radioactivity, and/or for subsequent analysis of detonation characteristics. Sampling usually was accomplished by specially equipped aircraft.

Cloud Tracking

The process of monitoring and determining the drift and movement of an effluent cloud, either by radar or by radiation monitoring and visual sighting from aircraft.

Coaxial Cable

A high-frequency telephone, telegraph, television, or scientific data transmission cable consisting of a conducting outer metal tube enclosing and insulated from a central conducting core.

Collar

See "Shaft Collar"

Console

A cabinet or panel containing instrumentation for monitoring or controlling electronic or mechanical devices.

Containment

The process of confining radioactive products of a nuclear device detonation underground.

GLOSSARY OF TERMS (continued)

- Contamination
- 1) Radioactive material in an undesirable location, usually fission and activation products of a nuclear detonation, or fissionable material from a device, incorporated with particles of dust or device debris.
  - 2) The process of depositing radioactive material on, or spreading it to, an undesirable location, such as personnel, structures, equipment, and other surfaces outside a controlled area.
- Crater
- The depression formed on the earth's surface by a near-surface, surface, or underground detonation. Crater formation can occur by the scouring effect of airblast, by throw-out of broken surface material, or by surface subsidence resulting from underground cavity formation and subsequent rock fall, or chimneying to the surface.
- Crater Experiment
- A test designed to breach and excavate the ground surface, thereby forming an ejecta crater; as opposed to a sink or subsidence crater.
- D-Day
- The term used to designate the day on which a test takes place.
- D + 1 day
- The first day after a test event.

GLOSSARY OF TERMS (continued)

Decontamination	The reduction of amount or removal of contaminating radioactive material from a structure, area, object, or person. Decontamination may be accomplished by (1) treating the surface to remove or decrease the contamination; (2) letting the material stand so that the radioactivity is decreased as a result of natural decay; or (3) fixing and covering the contamination to attenuate the radiation emitted.
Device	Nuclear fission or fission and fusion materials together with the arming, fusing, firing, chemical, explosive, canister, and diagnostic measurement equipment, that have not reached the development status of an operational weapon.
Dog Hole	An area smaller than an alcove which has been mined into the tunnel rib. Normally used to store small equipment or tools.
DOD	The U.S. Department of Defense. The federal executive agency responsible for the defense of the United States. Includes the military services and special joint defense agencies.
Dose	A quantity (measured or accumulated) of ionizing (or nuclear) radiation energy absorbed by a medium, including a person.

GLOSSARY OF TERMS (continued)

Dose Rate	As a general rule, the amount of ionizing (or nuclear) radiation energy that an individual or material would absorb per unit of time. Dose rate is usually expressed as rads (or rems) per hour or multiples or divisions of these units.
Dosimeter	An instrument or device used to indicate the total accumulated dose of (or exposure to) ionizing radiation. Instruments or devices worn or carried by individuals are called personnel dosimeters.
dpm	Disintegrations per minute; a measure of radioactivity. Literally, atoms disintegrating per minute.
Draeger Multi-Gas Detector	An instrument used to detect toxic gases, such that a sample of the ambient atmosphere is drawn through a selected chemical reagent tube which indicates the concentration of a toxic gas.
Dressed-Out	Dressed in anticontamination clothing and associated equipment.
Drift	A secondary passageway tunnel, usually horizontal, from or between main tunnels or shafts.
Drillhole Designations	PS-1V: Post-Shot drill hole number 1 - vertical

GLOSSARY OF TERMS (continued)

PS-1D: Post-Shot drill hole number 1 - directional

PS-1A: Post-Shot drill hole number 1 - angle

Each 'S' added after any of the above notations indicates a "sidetrack" or change of direction in the drillhole.

Dry Runs

Rehearsals or practices in preparation for an actual test event.

Effects Experiments

Experiments with the purpose of studying the effects of a nuclear detonation environment on materials, structures, equipment, and systems. Includes measurements of the changes in the environment caused by the nuclear detonation, such as ground movement, air pressures (blast), thermal radiation, nuclear radiation, and cratering.

Explosimeter

A battery-operated detector calibrated to indicate the concentration in the ambient atmosphere of explosive gases and vapors as percent of the lower explosive limit (LEL) of methane gas.

Explosive-Proof

Flashlight

A flashlight constructed in such a manner that its use will not cause or create an explosion in an explosive gas atmosphere.

## GLOSSARY OF TERMS (continued)

- Exposure** A measure expressed in roentgens (R) of the ionization produced by gamma rays (or x-rays) in air [or divisions of R;  $1/1000$  R = milliroentgen (mR)]. The exposure rate is the exposure per unit of time, usually per hour but sometimes smaller or larger units (e.g., R/min, R/day, mR/h).
- Film Badge** Used for the indirect measurement of exposure to ionizing radiation. Generally contains 2 or 3 films of differing sensitivity. Films are wrapped in paper (or other thin material) that blocks light but is readily penetrated by radiations or secondary charged particles resulting from radiations to be measured. The films are developed and the degree of darkening (or density) measured indicates the radiation exposure. Film dosimeters commonly are used to indicate gamma and x-ray exposures, and also can be designed to determine beta and neutron doses.
- Fission** The process whereby the nucleus of a particular heavy element splits into (generally) two nuclei of lighter elements, with an accompanying release of energy. The most important fissionable, or fissile, materials are uranium-235 and plutonium-239. Fission is caused by the absorption of a neutron.

GLOSSARY OF TERMS (continued)

Fission Products	A general term used for the complex mixture of radioactive nuclides (see Radionuclides) produced as a result of nuclear fission.
Fissionable Material	A synonym for fissile material, also extended to include material that can be fissioned by fast neutrons only, such as uranium-238. Used in reactor operations to mean reactor fuel.
Forward Control Point	A geographic location in the forward test area, usually adjacent to the closed (or secured) test area.
Fusion	The combination of two very light nuclei (of atoms) to form a relatively heavier nucleus, with an accompanying release of energy. Also called thermonuclear fusion.
Gamma Log	Instrument used to measure natural radiation levels in a preemplacement hole, and after an event to measure radiation in the cavity.
Gamma Rays	Electromagnetic radiations of high energy emitted from the nuclei of radionuclides, or bundles of energy called photons, which usually accompany other nuclear reactions, such as fission, neutron capture, and beta particle emission. Gamma rays, or photons, are identical with x-rays of the same energy, except that x-rays result from

GLOSSARY OF TERMS (continued)

electron reactions and are not produced in the nucleus.

Gamma Shine

Measurable gamma radiation intensity from an approaching radioactive cloud or passing cloud, as opposed to measurements from or in gamma emitting fallout. Also gamma radiation scattered by air molecules, as opposed to direct radiation from a gamma source.

Gas Seal Door

A door constructed in a tunnel gas seal plug. Both are designed to prevent venting of gases.

Gas Seal Plug

A plug employing epoxy, plastic, or other material, designed and installed to prevent the passage and venting of gases.

Geiger-Mueller Counter

An instrument consisting of a Geiger tube and associated electronic equipment used to detect and measure (and sometimes record) nuclear radiation.

Geophones

Electronic instruments which detect and record rock falls and earth movements by the use of sound.

Ground Zero

The point on the ground or water at which a surface, near surface, tower-type, or ballon-type nuclear detonation occurs; as opposed to an airburst where the detonation is high in the air, or an underground detonation where the

GLOSSARY OF TERMS (continued)

surface is relatively unaffected (see Surface Ground Zero).

H-Hour

Time zero or exact time of detonation to the minute, second, or fraction of a second; as opposed to H + 1 which implies one hour after detonation, unless time units of seconds or minutes are listed.

Hard Copy

The original paper document used in research.

Hot Line

A location on the edge of a radex area where exiting personnel remove anticon-  
tamination clothing and equipment and are monitored for contamination and de-  
contaminated as necessary before re-  
lease.

Ion

An atomic particle or part of a mole-  
cule bearing an electric charge, usual-  
ly a positively charged ion and a nega-  
tively charged ion are formed as a pair  
(e.g., A negatively charged electron  
displaced from its positively charged  
remaining atom).

Ionizing Radiation

Any particulate or electromagnetic ra-  
diation capable of producing ions, di-  
rectly or indirectly, in its passage  
through air or matter. Alpha and beta  
particles produce all ion pairs direct-  
ly, while the electrons of initial ion  
pairs produced by gamma rays and x-rays

in turn produce secondary ionization in their paths.

Isotopes

Different types of atoms within the same element, all reacting approximately the same chemically, but differing in atomic weight and nuclear stability. For example, the element hydrogen has three isotopes; normal hydrogen is the most abundant, heavy hydrogen is called deuterium, and radioactive hydrogen is the radioisotope called tritium.

Keyed Concrete Plug

A concrete plug of greater diameter than the shaft or tunnel cross section, such that the concrete is poured into the surrounding rock, providing greater strength against overpressure from the nuclear detonation.

Leukemia Cluster

An apparent but unexpected or extraordinary group of leukemia cases within some number or group of persons.

LOS Tunnel (as opposed to LOS Pipe)

A mined opening for installation of the LOS pipe.

LOS Pipe

A line-of-sight pipe pointed at a device. A large diameter pipe, hundreds of feet long, constructed underground to simulate high altitude conditions.

GLOSSARY OF TERMS (continued)

Manhattan Engineer District	The U.S. Army predecessor organization to the U.S. Atomic Energy Commission.
Manned Stations	Locations inside the closed and secured area which are occupied by authorized personnel during an event.
Microbarograph	An instrument that measures and records small changes in atmospheric pressures.
mR	A radiation exposure term (see Exposure).
Mucking	Removal of loose rock from drilling and mining operations.
Noble Gases	Those inert gases which do not react with other elements at normal temperature and pressure (i.e., helium, neon, argon, krypton, xenon and sometimes radon).
Nuclear Device (vs. weapon or bomb)	A device in which most of the energy released in a detonation results from reactions of atomic nuclei, either fission, or fission and fusion. A device under development (see Device) is not considered a weapon or bomb. Both A- (or atomic) bombs and H- (or hydrogen) bombs could be called atomic weapons because both involve reactions of atomic nuclei. However, it has become customary to call weapons A-bombs if the

GLOSSARY OF TERMS (continued)

energy comes from fission, and H-bombs if most of the energy comes from fusion (of the isotopes of hydrogen - see definition). A developmental nuclear device is not a weapon or weapon component until it can be mated to a delivery system.

Nuclear Device Tests

Tests carried out to supply information required for the design, improvement, or safety aspects of nuclear weapons, and to study the phenomena and effects associated with nuclear explosions.

Nuclear Weapon Tests

Tests to provide development and weapons effects information, which may or may not utilize a deliverable nuclear weapon.

Otis Plug

Plug used to seal postevent drill holes. This is a permanent plug.

Overburden Plug

A keyed concrete plug toward the portal from the blast plug, containing a blast door, and withstanding pressures as high as the rock above GZ to the surface, or overburden, could withstand.

Party Monitors

Radiation monitors assigned to reentry and recovery parties or groups.

Pipe String

Pieces of drill pipe that are added as drilling continues.

GLOSSARY OF TERMS (continued)

- Privacy Act                      The Privacy Act of 1974. Public Law 93-579. An Act to amend Title 5, U.S. Code, by adding Section 552a to safeguard individual privacy from the misuse of Federal Records, to provide that individuals be granted access to records concerning them which are maintained by federal agencies, to establish a Privacy Protection Study Commission, and for other purposes.
- rad                                 Abbreviation for radiation absorbed dose. A unit of absorbed dose of radiation representing the absorption of 100 ergs of ionizing radiation per gram of absorbing material, including body tissue.
- Radex Area                        An acronym for radiation exclusion area. A radex area is any area which is controlled for the purpose of protecting individuals from exposure to radiation and/or radioactive material.
- Radiation Exposure               Exposure to radiation may be described and modified by a number of terms. The type of radiation is important: external exposure is to beta particles, neutrons, gamma rays and X-rays; internal exposure is from radionuclides deposited within the body emitting alpha, beta, gamma or x-radiation and irradiating various body organs. (see Dose and Exposure).

GLOSSARY OF TERMS (continued)

Radioactive Effluent	The radioactive material, steam, smoke, dust, and other particulate debris released to the atmosphere from an underground nuclear detonation.
Radioactive or Fission Products	A general term for the complex mixture of radionuclides produced as a result of nuclear fission (see Activation Products).
Radionuclides	A collective term for all types of radioactive atoms of elements as opposed to stable nuclides (see Isotopes).
Recovery Operations	Process of finding and removing experiments, by-products, or data from the test area after a test event.
rem	A special unit of biological radiation dose equivalent; the name is derived from the initial letters of the term "roentgen equivalent man or mammal." The number of rem of radiation dose is equal to the number of rads multiplied by the quality factor (QF) and the distribution factor (DF) of the given radiation.
roentgen	A special unit of exposure to gamma (or X-) radiation. It is defined precisely as the quantity of gamma (or X-) rays that, when completely stopped, in air, will produce positive and negative ions

GLOSSARY OF TERMS (continued)

with a total charge of  $2.58 \times 10^{-4}$  coulomb in one kilogram of dry air under standard conditions.

Safety Experiments

Device tests conducted to determine the safety of nuclear weapons during transportation and storage. Elements of the conventional high explosive portions of the devices were detonated to simulate accidental damage and to determine the potential for such simulated damage to result in significant nuclear yield. Data gained from the tests were used to develop devices that could withstand shock, blast, fire, and other accident conditions without producing a nuclear detonation.

Sandbag Plugs

Barriers used in tunnels, constructed of sandbags, to help contain underground detonations and minimize damage to underground workings.

Seismic Motion

Earth movement caused by an underground nuclear detonation, similar to a minor earthquake.

Shaft

A long narrow passage sunk into the earth. Shafts for device emplacement, ventilation, or access to underground workings may be drilled or mined.

Shaft Collar

The area immediately around the shaft at ground level, usually cemented,

GLOSSARY OF TERMS (continued)

	which supports the headframe and other equipment.
Shield Walls	Walls or barriers used to protect equipment or instrumentation from heat, blast, and radioactivity.
Slushing Operations	The process of moving broken rock with a scraper or scraper bucket. May be used on the surface or underground, where ore or waste rock is slushed into hoppers or other locations for removal.
Spalling	Rock disintegration by flaking, chipping, peeling, or layers loosening on the outside edges. May be caused immediately by rock stressing in proximity to a detonation point. Also results later, after continued stressing from temperature change expansion and contraction. Spalling also may result or begin when rock containing moisture is raised to a high temperature, and expanding vapor creates fractures.
Stemming	The materials used to back-fill or plug the emplacement shaft, drift, or LOS drift to contain the overpressure and radioactive material from a nuclear detonation.
Suitcase Analyzer	A portable radiation analysis instrument used to analyze samples in the field or in other locations than a laboratory.

GLOSSARY OF TERMS (continued)

Surface Ground Zero	The location on the ground surface directly above an underground zero point or directly below an airburst.
Test Event	The immediately preceding preparations for, including arming and firing, and the testing of a nuclear device, including the detonation and concurrent measurements and effects.
Testing Organizations	Organizations conducting nuclear tests at the NTS (see DOD, LASL, LRL and SL).
Trailer Park	The location of modified trailers and vans which contain measurement and recording equipment attached to cables coming from underground detectors and experiments. Usually located at least 900 feet from SGZ.
Tunnel	An underground horizontal or nearly horizontal passageway.
Tunnel Access	Entry to a tunnel or tunnel complex upon approval of the Test Director during test operations, or upon approval of the Tunnel Superintendent during routine operations.
Tunnel Complex	A composite of passageways branching from and including the main tunnel or access tunnel from a shaft.
Tunnel Walk-Out	A visual, walking inspection of the tunnel or tunnel complex, usually as a

GLOSSARY OF TERMS (continued)

	part of the initial reentry after a detonation, to check for hazards of any and all kinds prior to allowing general access to the underground workings.
2-Hour McCaa Breathing Apparatus	A self-contained respiratory device that supplies two hours of breathing oxygen.
Underground Structures Program	The construction and fabrication of test structures underground for the purpose of detonation effects evaluation.
User	An organization conducting tests at the NTS (See Testing Organizations).
Vela-Uniform	Department of Defense (DOD) program designed to improve the capability to detect, identify, and locate underground nuclear explosions.
Venting	Release of radioactive material, steam, smoke, dust and other particulate debris through a zone of weakness from the detonation-formed cavity into the atmosphere.
Water Glass	A colloidal suspension in water of a sodium silicate compound. A hardening gel commonly used as a preservative, an adhesive, in plaster, and in cement. Used at NTS as a grout to seal cracks

GLOSSARY OF TERMS (continued)

and fissures, and, in dilute form, has been sprayed on surfaces for dust and contamination control purposes.

Weapons Effects

Experiments

Experiments with the purpose of studying the effects of a nuclear detonation environment on materials, structures, equipment, and systems. Includes measurements of the changes in the environment caused by the nuclear detonation, such as ground movement, air pressures (blast), thermal radiation, nuclear radiation, and cratering.

Weapons Development

See Nuclear Device Tests

Weather Briefings

Meetings of test-associated administrators, advisors, and other technical personnel prior to each test event to evaluate weather conditions and forecasts on event day, and make decisions on any necessary operational schedule changes.

Workings

An excavation or group of excavations made in mining, quarrying, or tunneling, used chiefly in the plural, such as "the workings extended for miles underground."

X-rays

Electromagnetic radiations produced by electron reactions, as opposed to emission of gamma rays by nuclei. Other-

wise high energy x-rays are identical with gamma rays of the same energy.

Yield

The total effective energy released by a nuclear detonation. It is usually expressed in terms of the equivalent tonnage of TNT required to produce the same energy release in an explosion. The total energy yield is manifested as nuclear radiation (including residual radiation), thermal radiation, and blast and shock energy; the actual distribution depending on the medium in which the explosion occurs and also upon the type of weapon.



## APPENDIX B

### ABBREVIATIONS AND ACRONYMS

The abbreviations and acronyms in the following list are used in Volume II of the DOD underground testing reports. Additional information and definitions may be found in the text and in the Glossary of Terms.

AAS	American Aerial Survey
ACFI	American Car and Foundry
AEC	Atomic Energy Commission
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
AFTAC	Air Force Technical Applications Center
AFWL	Air Force Weapons Laboratory
AMC	Army Material Command
APC	Army Pictorial Center
ARF	Armour Research Foundation
ARMS	Aerial Radiation Monitoring System
AVCO/RAD	AVCO Corporation
BAC	Boeing Aircraft Corporation
Bkg	Background Radiation Measurement
BJY	BUSTER-JANGLE roads intersection
BRL	Ballistics Research Laboratory
BTL	Bell Telephone Laboratories
CCTV	Closed Circuit Television
CDC	Center for Disease Control
CETO	Civil Effects Test Organization
CIC	Coordination and Information Center
CO	Carbon monoxide
CO <sub>2</sub>	Carbon dioxide
CP-1	Control Point Building 1
CP-2	Control Point Building 2
cps	Counts per second
CTO	Continental Test Organization
D-Day	The day a nuclear detonation takes place
DASA	Defense Atomic Support Agency
DF	Distribution Factor
DNA	Defense Nuclear Agency
DOD	Department of Defense
DOE	Department of Energy
dpm	Disintegrations per minute
ECOM	U.S. Army Electronics Command
EDT	Eastern Daylight Time
EG&G	EG&G, Inc. (formerly Edgerton, Germeshausen, & Grier)

ABBREVIATIONS AND ACRONYMS (continued)

EPCO	Engineering Physics Company
ERDA	Energy Research and Development Administration
FCDASA	Field Command, Defense Atomic Support Agency
FCDNA	Field Command, Defense Nuclear Agency
FCP	Forward Control Point
FCWT	Field Command Weapons Effects and Tests Group
F&S	Fenix and Scisson, Inc.
FPPF	Full Power Full Frequency
FSI	Federal Services, Incorporated
GA	General Atomic Corporation
GE	General Electric Corporation
GM	Geiger-Mueller
GZ	Ground Zero
HAC	Hughes Aircraft Company
HDL	Harry Diamond Laboratories
HE	High explosives (conventional)
H&N	Holmes & Narver, Inc.
ICC	Interstate Commerce Commission
IITRI	Illinois Institute of Technology, Research Institute
ISAFB	Indian Springs Air Force Base
ISO	Isotopes, Incorporated
JCS	Joint Chiefs of Staff
KOA	Ken O'Brien and Associates
kt	Kilotons
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory (now Los Alamos National Laboratory)
LEL	Lower explosive limit
LLNL	Lawrence Livermore National Laboratory
LMAFS	Lookout Mountain Air Force Station
LMSC	Lockheed Missile and Space Corporation
LOS	Line-of-sight
LRL	Lawrence Radiation Laboratory (now Lawrence Livermore National Laboratory)
MPC	Maximum permissible concentration
MRC	Moleculon Research Corporation
mrem/qt	Millirem per quarter
mrem/yr	Millirem per year
mR/h	Milliroentgens per hour
MSA	Mine Safety Appliance
MSL	Mean sea level
NATS	Nevada Aerial Tracking System
NC	Northrup Corporation
NDL	Army Chemical Corps Nuclear Defense Laboratory
NOB	Nevada Operations Branch
NOL	Naval Ordnance Laboratory
NO <sub>2</sub>	Nitrogen dioxide
NO+NO <sub>2</sub>	Nitric oxide plus nitrogen dioxide
NPG	Nevada Proving Ground
NRDS	Nuclear Rocket Development Station
NTS	Nevada Test Site
NTSO	Nevada Test Site Organization

ABBREVIATIONS AND ACRONYMS (continued)

NVOO	Nevada Operations Office
PA	Picatinny Arsenal
PDT	Pacific Daylight Time
PHS	United States Public Health Service
ppm	Parts per million
psi	Pounds per square inch
PST	Pacific Standard Time
QF	Quality Factor
Radex Area	Radiation Exclusion Area
RADC	Rome Air Development Center
rad/h	Radiation absorbed dose per hour
Radsafe	Radiological Safety Department (formerly Division), REECo
radSAFE	Radiological Safety, in general
RAGS	Remote area gas sampler
RAMS	Remote area monitoring station
RARS	Remote area recording station
RCG	Radioactivity concentration guide
RDS	Remote data station
REECo	Reynolds Electrical & Engineering Company, Incorporated
rem	Roentgen equivalent man or mammal
R/h	Roentgens per hour
RMS	Radector monitoring station
RPG	Radiation protection guide
SC	Sandia Corporation (now Sandia National Laboratories)
SGZ	Surface Ground Zero
SL	Sandia Laboratories (now Sandia National Laboratories)
SNL	Sandia National Laboratories
SOP	Standard operating procedures
SRI	Stanford Research Institute
STWT/DASA	Weapons Test Division/Defense Atomic Support Agency
SWC	Special Weapons Center
TC	Test Controller
TCDASA	Test Command, Defense Atomic Support Agency
TCM	Tunnel condition monitor
TCWT	Test Command, Weapons Effects & Test Group
TGD	Test Group Director
TNT	High explosive chemical (trinitrotoluene)
USAEL	United States Army Electronic Laboratory
USAF	United States Air Force
USC&GS	United States Coast and Geodetic Survey
USGS	United States Geological Survey
USWB	United States Weather Bureau
VA	Veterans Administration
WANL	Westinghouse Astronuclear Laboratory
WES	Waterways Experiment Station
WP	Working Point
WSI	Wackenhut Services, Incorporated



## APPENDIX C

SC-M-68-227

### GENERAL TUNNEL REENTRY PROCEDURES FOR DEPARTMENT OF DEFENSE AND SANDIA LABORATORY NUCLEAR TESTS

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#### ABSTRACT

This document describes preshot preparations and postshot procedures for safe and economical reentry into a tunnel area after a nuclear detonation. Associated responsibilities, possible hazards, reentry ground rules, preshot preparations, communications, reentry parties and equipment, initial tunnel reentries, and recovery of scientific experiments are explained.

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GENERAL TUNNEL REENTRY PROCEDURES FOR  
DEPARTMENT OF DEFENSE AND SANDIA LABORATORY NUCLEAR TESTS

1. Introduction

The Health Physics Division began tunnel reentries in 1962. The procedures that are given in this document represent a compilation of a series of tunnel reentry procedures that have been continually improved based upon experience and better instrumentation. The reentry plan presented describes preshot preparations and postshot procedures for safe and economical reentry and scientific recovery in a tunnel area.

2. Responsibilities

Responsibilities for safe and economical tunnel reentry procedures after a nuclear detonation indicated herein for AEC or AEC contractor (i.e., Sandia Laboratory) personnel are in accord with established AEC/DOD agreement or are the subject of separate action between TC/DASA and NVOO.

a. AEC-NVOO

- (1) The Test Manager is responsible to the AEC for the safety of all the participating personnel at sites under the jurisdiction of NVOO and has approval authority over decisions effecting the safety of these personnel. (Ref: NTSO Draft 0524-013a.)
- (2) The NVOO Operational Safety Division will advise the DOD Test Group Director (TGD) and the Reentry Control Group on all problems pertaining to health and safety.

b. Sandia Laboratory

- (1) The Sandia Laboratory Health Physics Division has three responsibilities: It specifies the necessary measuring devices and equipment to indicate the postshot condition of the tunnel; it provides the Reentry Control Group; and it documents any release of radioactive material.
- (2) The Chief of the Reentry Control Group will act as advisor to the TGD on surface and tunnel reentry safety until the tunnel has been cleared for normal operation.
- (3) The Reentry Control Group will provide consultants who will advise on tunnel reentry procedures. These consultants will be familiar

with the experimental setup and with possible postshot tunnel conditions and hazards.

- (4) The Reentry Control Group will arrange the necessary support for reentry and recovery, e.g., it will provide mine rescue trained personnel, Rad-Safe support (see Annex A), Industrial Hygiene Support, etc.
- c. TC/DASA or Sandia Laboratory Test Group Director
- (1) The TGD is responsible for the safe conduct of all activities in the tunnel area. He will authorize and initiate both a tunnel condition survey and reentry and recovery operations with the concurrence of the Test Manager.
  - (2) The TGD will be responsible for initiating all action for the preshot installation and postshot removal of equipment and services required for Test Group support activities except those items covered as AEC responsibilities in the AEC/DOD agreement.

### 3. Possible Hazards

- a. Radiation. Radiation in tunnel reentry areas may result from any one of the following:
  - (1) Leak of radioactive gases or materials through fissures or fractures from ground zero.
  - (2) Failure of the tunnel stemming.
  - (3) Activation and/or dispersion of samples in the experimental chamber.
- b. Explosive or toxic gases. Various explosive and toxic gases released as direct or secondary products of the detonation may be present in concentrations dangerous to personnel.
- c. Explosives. Undetonated HE may remain either intact or scattered in the tunnel.
- d. Toxic materials. Beryllium may pose a toxic problem to personnel particularly if it becomes dispersed in the air and/or deposited on recovery samples.
- e. Tunnel damage. Damage to the tunnel may result from the device generated shock wave.
  - (1) Collapse of the tunnel would not normally be expected beyond the stemming; however, partial or total collapse may occur at greater distances from ground zero. Reentry through collapse zones must be preceded by mining through broken ground or by driving a new parallel drift.

- (2) Heave of the tunnel floor may cause slabbing or spallation of the rock and failure of utility lines, railroad track, tunnel sets, and lagging. This damage will create safety hazards which must be removed prior to experimental recoveries.
- f. High pressure gas. High pressure (2200 psi) gas cylinders normally exist within the tunnel complex.

#### 4. Reentry Ground Rules

- a. Initial reentry and each subsequent phase will be initiated upon authorization of the TGD with concurrence of the Test Manager, and control will be retained by the TGD until all recovery operations are completed and tunnel access is returned to AEC control. Only those personnel authorized by the TGD and the Chief of the Reentry Control Group will be permitted in the portal area and tunnel.
- b. Tunnel communications will be by a hard wire portable phone system.
- c. Tunnel parties will be controlled by the Chief of the Reentry Control Group who is located at the tunnel portal. Tunnel parties may be recalled at his direction. Only one team will be in the tunnel at any single time unless directed otherwise by the Chief of the Reentry Control Group.
- d. A tunnel party will return to the portal under any of the following conditions:
  - (1) Upon decision of the Team Chief.
  - (2) When any member of Teams 1, 2, 3, and 4\* show a McCaa oxygen supply less than 30 atmospheres or a Draeger pressure less than 450 psi.
  - (3) Upon loss of communications with the Reentry Control Group at the portal.
- e. Team 4 (Rescue Team) will be dispatched upon direction of the Chief of the Reentry Control Group, the Team Chief in the tunnel, or if communications should be lost with any team in the tunnel (allowing a reasonable time for the team to exit after loss of communication).
- f. All observations during reentry will be communicated through the Chief of Party to the Chief of the Reentry Control Group and recorded for future reference.

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\* See Paragraph 7, "Reentry Parties and Equipment," for a description of the personnel, function, and equipment of each team.

- g. Personnel radiation exposure limits are those set by NTS SOP Chapter 0524. The radiation dose limit for the operation is 3 Rem per calendar quarter. A person's exposure, however, will be terminated when his pocket dosimeter reaches 2.0 Rem, assuming his exposure history would allow 3 Rem during this operation.
- h. Tunnel reentry will not be made before the tunnel ventilation has been turned on and samples of the air monitored at the portal. Evaluation of the sample must indicate that reentry can be made within the limitations of this procedure.
- i. Reentry will not be made beyond ventilation, 10R/hr, 1000 ppm CO, or 10 percent of the lower explosive limit of explosive gas mixtures. Teams 1, 2, 3, and 4 may be exempted from these requirements under extenuating circumstances by mutual decision of the Chief of the Reentry Control Group and the Chief of the Party.
- j. The Rescue Team will always be stationed near the portal with a train for immediate dispatch.

##### 5. Summary of Preshot Preparations for Reentry

- a. Stemming should provide fireball containment and should reduce radioactivity and explosive gas in the reentry area. The overburden plug should contain any debris that may pass the stemming. The gas seal door should contain any gases that penetrate the overburden plug.
- b. Remote radiation sensing instruments will provide knowledge of tunnel radiation levels, while tunnel condition indicators (geophones, pressure and temperature gages, and explosimeters) remotely monitor the tunnel.
- c. Air sampling lines for gas chromatography are normally installed through both the gas seal door and the overburden plug. Each installation is provided with suitable remotely operated valves. Samples may be drawn from the inside of the gas seal door, from both sides of the overburden plug, and from near the stemming. Sampling from these lines will help determine the explosive and toxic gas concentrations in the tunnel prior to reentry.
- d. Valves are normally installed in the vent lines and makeup ports in the gas seal door and overburden plug. An axial vane fan is located on the makeup valves to reduce negative pressure. The valves and fan are remotely operated from a manned location and will have position monitors to indicate whether they are fully open or fully closed. The position monitors will also show whether the fan power is on or off.

- e. The following items ordinarily have power turned on through and after zero time:
  - (1) Tunnel utilities and instrumentation. Power to these items will be turned off near zero time.
  - (2) Geophone transmitter trailer. This supplies power to the geophone and the pressure and temperature amplifiers which must be left on to monitor for cavity collapse and pressure changes.
  - (3) Ventilation fans. Power will be controlled remotely.
  - (4) Radiation detectors.
  - (5) Explosimeters.
  - (6) Ventilation and gas sampling valves. Power will be controlled remotely.
- f. The Sutorbilt fans will be installed so they will pull air through the vent line filter system before it is released to the atmosphere. One Sutorbilt fan will be used for a back-up in case the other fan fails.
- g. Ventilation.
  - (1) The ventilation system is installed so that all areas of the tunnel that are not closed off are swept with fresh air from the portal.
  - (2) After zero time and when the TGD gives his approval (with the consent of the Test Manager), the tunnel ventilation system will be turned on, exhaust and makeup air will be supplied from the portal through valves in the gas seal door and, if possible, the overburden plug. There will be valves that can be remotely operated in both vent lines at the gas seal door and, if possible, at the overburden plug. Vent line samples will be taken to monitor for radioactive, explosive, and/or toxic effluents.

## 6. Communications

A communication system with the necessary wire on a portable reel will be used during initial reentry. A back-up reel will be available. All conversation between the reentry party and reentry control will be recorded.

7. Reentry Parties and Equipment

The reentry parties will consist of the personnel and equipment described in the following table:

Party Name	Equipment
a. Teams 1, 2, and 3 - Tunnel Reentry Party (1) Chief of Party (2) Rad-Safe monitor (3) Industrial Hygiene monitor (May be performed by Rad-Science personnel) (4) Tunnel safety (5) Scientific Advisor (as required)	Full Radex clothing Bureau of Mines approved 2-hour self-contained oxygen breathing apparatus Radiation detectors Explosive gas meter Toxic gas detectors Oxygen percent meter Hard wire communications
b. Team 4 - Tunnel Rescue Party (1) Chief of Party (2) Three to six REE Co. Mine Rescue (3) Two monitors for Rad-Safe and Industrial Hygiene	Full Radex clothing Bureau of Mines approved 2-hour self-contained oxygen breathing apparatus Radiation detectors Toxic gas detectors Explosive gas meters Wire litters Hard wire communications
c. Team 5 - Tunnel Scientific Assessment Team (as required) (1) Chief of Party (2) Rad-Safe and Industrial Hygiene monitors (3) Scientific Advisors (4) Mine support	Full Radex clothing Respiratory protection (as required) Radiation detectors Toxic gas detectors Explosive gas meter Hard wire communications
d. Team 6 - Tunnel Work Party (1) Chief of Party (2) Rad-Safe and Industrial Hygiene monitors (3) REE Co. Miners	Full Radex clothing Respiratory protection (as required) Radiation detectors Toxic gas detectors
e. Team 7 - Tunnel Scientific Recoveries to Experimental Chamber (see Para. 9 for details)	Full Radex clothing Respiratory protection (as required)
f. Team 8 - HE Disposal Group (as required)	Full Radex clothing Respiratory protection (as required)
g. Team 9 - Medical Support M. D. and medical technician	Necessary medical equipment Ambulance

## 8. Initial Tunnel Reentries

- a. After the event the TGD will review radiation and tunnel condition monitors. When he determines that it is safe, and with the agreement of the Test Manager, the tunnel ventilation system will be turned on EXHAUST. Makeup air will be supplied from the portal through the valves in the plugs.
- b. Prior to entry into the tunnel, all experimental cables and all electrical and telephone lines going into the tunnel through the portal will be either locked open or disconnected. All other cables going into the tunnel will be disconnected and taped or cut and grouted as necessary. Along with the pressure, temperature, and geophone instruments, the remote radiation monitoring system and the remote explosimeters will be left connected. No circuit into the tunnel or into the instrumentation trailers will be closed when personnel are either in the tunnel or directly in front of the portal (including an area extending 50 feet on either side of the portal).

The Chief of the Reentry Control Group will advise the TGD on tunnel conditions by reviewing surface conditions, exhaust gas information, tunnel radiation, tunnel condition indicators, and seismic information. This review will determine when tunnel reentry may actually begin.

When cleared by the TGD and the Test Manager and when all surface recoveries and power checks are complete, Team 1 will be allowed to make the initial tunnel reentry. There will be no change in the tunnel ventilation setup or in utilities while Teams 1 through 5 are underground. The number of people in the portal area and trailer parks will be held to a minimum.

- c. Team 1 will be the first group to reenter and will proceed to the gas seal door. A train may be used to supply transportation to the gas seal door, conditions permitting. Team 1 will continuously monitor for radioactivity and for toxic and explosive gases. Pressure gages at the gas seal door will be checked, and if no pressure is observed, a sample will be taken through the door to determine the environment on the other side of the door. Under safe conditions, Team 1 will then open the gas seal door. They will inspect the tunnel to the overburden plug. The pressure gages at the overburden plug will be checked and if no pressure is observed, a sample will be taken through the plug to determine the environment on the other side of the plug. Team 1 will then withdraw to the portal area. If remote ventilation has not been established previously behind the overburden plug, the work party (Team 6) will then reenter and take the necessary steps to establish ventilation through the

plug. They will then exit the tunnel, and samples will be taken from the vent line to verify earlier remote sampling. A second work party may be required to open the overburden plug door and remove the material from the manway.

Team 2 will reenter with an engine and car containing the necessary equipment to open the overburden plug door. This group will take in the reel of communication wire and connect it up to the existing communication line jack at the overburden plug to reestablish communications with the reentry control group at the portal. Team 2 will open the manway door and will continuously monitor for radioactivity and for toxic and explosive gases. They will then withdraw to the portal with the engine.

Team 3 will reenter to the overburden plug and reestablish communications using the reel connected to the communication line jack. The team will walk out the remaining drift continuously monitoring for radioactivity and for toxic and explosive gases. They will also observe the vent lines to assure themselves that the lines are intact. Team 3 will proceed to the stemming, if possible, noting tunnel and pipe conditions. They will then return to the end of the experimental pipe and establish ventilation in the pipe if time and conditions permit. Swipes will be taken on the vent port of the test chamber and checked for contamination. These will be later analyzed for Be and isotope identification.

The mission of Teams 1, 2, and 3 is to verify that the tunnel complex is within acceptable levels for toxic and radioactive gases and to check the condition of the pipe and tunnel.

- d. If Teams 1, 2, and 3 determine that tunnel rehabilitation may be safely conducted, they will leave the tunnel and Team 6 will make temporary repairs as needed to the vent line or tunnel. A Rad-Safe monitor will remain with Team 6 while in the tunnel and continue to monitor for radiation and toxic gases.
- e. The object of Teams 1 and 3 will be to explore as much of the tunnel on one reentry as possible. Previous experience has shown that McCua or Draeger Teams can explore up to 4500 feet in 1-1/2 hours with a 1/2 hour safety margin. If an additional initial reentry is required to fully explore the tunnel, Team 4 (with Rad-Safe and Industrial Hygiene monitors) will complete the tunnel exploration with Team 1 standing by as Tunnel Rescue.

9. Tunnel Scientific Recoveries from the Experimental Chamber

- a. Scientific recoveries in the tunnel will not be permitted until Team 1, 2, or 3 has searched all drifts and verified that the tunnel is clear of dangerous amounts of toxic, explosive, and radioactive gases.
- b. Before scientific recoveries may begin, repair of the tunnel along the recovery route to the experimental chamber must be complete. This activity may include repairing broken lagging and removing hazardous obstacles as well as repairing railroad track and vent lines. The tunnel lights will be turned on before all scientific recoveries except film recoveries begin. All cabling extending into a crushed zone will be cut.
- c. Team 5 will conduct a technical survey and perform the necessary actions to begin scientific recoveries.
- d. Team 7 will then be permitted to proceed to the experimental chamber and begin the removal of samples in order of priority. A Rad-Safe/ Industrial Safety monitor will be present at all times. This monitor will advise the Chief of the Reentry Control Group, who is responsible for terminating scientific recovery, whenever the tunnel environment becomes dangerous. A Rad-Safe check station will be established at each Scientific Station to control contamination.



APPENDIX D

U. S. ATOMIC ENERGY COMMISSION  
STANDARD OPERATING PROCEDURE  
NEVADA TEST SITE ORGANIZATION

NTSO-0524-01

Chapter 0524

RADIOLOGICAL SAFETY

0524-01 Radiological Safety

011 Purpose

The purpose of this Standard Operating Procedure is to define responsibility and to establish criteria and general procedures for radiological safety associated with NTS programs. Additional operational instructions relating to radiological safety for particular activities may be published as a part of the Test Manager's Operational Plan.

012 Responsibilities

- a. Test Manager. The Test Manager is responsible to the AEC for the protection of participating personnel and off-site populations from radiation hazards associated with activities conducted at the NTS. By mutual agreement between the Test Manager and a scientific user, control of rad-safety within the area assigned for a particular activity may be delegated to the user's Test Group Director during the period of time when such control could have a direct bearing on the success or failure of the scientific program.
- b. Test Group Director. Whenever operational rad-safety control is delegated to a Test Group Director under provisions of 012a above, he is responsible to the Test Manager for establishment and notification of safety criteria within the assigned area. Under such conditions, he will be responsible for submitting a detailed rad-safety operational plan to the Test Manager for concurrence.
- c. Area Manager, LVAO. The Area Manager is delegated the on-site rad-safety responsibility for the NTS, except for those periods in which operational control of specified areas may be delegated to the Test Group Director under 012a above.

The Area Manager is also delegated responsibility for the off-site radiological safety operations associated with NTS activities.

- d. Radiological Safety Advisor. The NTSO Rad-Safety Advisor is responsible to the Test Manager for staff supervision of rad-safety policies and procedures at the NTS.
- e. AEC Radiological Safety Officer. The AEC Radiological Safety Officer is responsible to the Area Manager, LVAO, for the direction and coordination of the on-site and off-site rad-safety programs, except for those periods when operational control of specified areas is delegated to a Test Group Director under 012a above.
- f. Off-Site Radiological Safety Officer. The Officer-in-Charge, U. S. Public Health Service Off-Site Activities Office, LVAO, is designated as the Off-Site Rad-Safety Officer and is responsible to the Area Manager, LVAO, through the AEC Rad-Safety Officer, for operation of the off-site program.
- g. Project Manager, Reynolds Electrical and Engineering Co., Inc. The Project Manager provides on-site rad-safety support services to the Area Manager, LVAO, and to Test Group Directors as required.
- h. Participating Agencies. The official in charge of each agency or organizational group participating in NTS field activities is responsible to the appropriate NTSO official designated above for compliance by his personnel with established rad-safety policies, procedures and controls. Each official in charge of a participating group is also responsible at all times to his parent organization for the radiological safety of personnel under his supervision.

#### 0524-02 Organization

The chart showing the organizational relationship of the rad-safety activities is shown in Figure I on the following page.

#### 0524-03 Radiation Incidents Reports

See NTSO Chapter 0502 and NTSO Appendices 0502-04, A, B, and C for detailed reporting procedures.

#### 0524-04 On-Site Rad-Safety Operations

##### 041 Purpose

The purpose of this on-site plan is to set forth procedures to be followed by all participants in connection with on-site rad-safety operations at the Nevada Test Site.

042 Definition of On-Site Terms

- a. Certified Monitor: Any person certified to the Test Manager or his designated representative as a qualified monitor by a Test Group Director or his Radiological Safety Representative.
- b. RPG: Radiation Protection Guide is the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation dose as far below this guide as practicable.
- c. RCG: Radioactivity Concentration Guide is the concentration of radioactivity in the environment which is determined to result in whole body or organ dose equal to the Radiation Protection Guide.
- d. MPD: The Maximum Permissible Dose in rems that can be accumulated at any age is equal to five times the number of years beyond age 18, thus  $MPD = 5(N-18)$  where N is the age.
- e. NTS: The Nevada Test Site, excluding Desert Rock and Area 51, but including Mercury and the Jackass Flat area.
- f. On-Site: The area within the NTS boundaries including Mercury.
- g. Radex: Radiological Exclusion Area.
- h. Controlled Area: Refers to any area within the NTS boundaries where for safety or any other purpose it is necessary to control entry of personnel.
- i. User: Those organizations having an approved technical program.
- j. REECo: Reynolds Electrical & Engineering Company, Inc., the support contractor for the Nevada Test Site.

043 Responsibilities

- a. The Project Manager, REECo, is responsible to the Area Manager, LVAO, for furnishing radiation safety support services as follows:

1. Providing rad-safety support, including qualified monitors, to user organizations as required.
  2. Making radiological surveys, mapping and properly marking all contaminated areas, and distribution of this survey information.
  3. Conducting a personnel radiation dosimetry program.
  4. Maintaining and calibrating radiation detection equipment.
  5. Procuring, issuing, and decontaminating rad-safety clothing, supplies, and equipment as required.
  6. Providing radioactive source material and waste disposal control within the Nevada Test Site.
  7. Operating personnel- and equipment-decontamination facilities.
  8. Providing advice and assistance in matters pertaining to radiological safety.
  9. Conducting occupational and bio-assay program.
  10. Providing necessary support services for the off-site rad-safety program as required.
  11. Conducting rad-safety training courses as required.
  12. Preparing final on-site reports containing radiological data following each test operational period, special reports as requested, and detailed operational plans for each future program.
  13. Providing a stand-by emergency monitoring team to handle unforeseen incidents associated with radiation.
  14. Providing a repository for records and source documents pertaining to personnel dosimetry for all OTO field activities and all prior weapons test series.
  15. Conducting analysis of samples for radioactivity and for certain toxic materials.
- b. The Support Contractor will prepare and keep current a manual containing the Standard Operating Procedures (SOP) for providing rad-safety support services to users and contractors at NTS as outlined in 043a above.

- c. Whenever a Test Group Director has been delegated responsibility for on-site rad-safety under subsection 012a above, the Test Manager's operation order will specifically list those functions in subsection 043a for which the Support Contractor will be responsible to the Test Group Director.

044 Radiation Protection Guides

a. Radiation Exposure Criteria

1. The radiation exposure criteria for all test personnel at the NTS are established for each series of tests by AEC Headquarters.
2. AEC Manual Chapter 0523 and 0524 contain the radiological safety criteria for peaceful uses.
3. External Whole Body Radiation
  - (a) Quarterly Dose. Shall not exceed 3 rems (gamma + neutron).
  - (b) Yearly Dose. Shall not exceed 5 rems (whole body gamma + neutron) except as listed below.
  - (c) Exceptions
    - (1) If the individual's MPD minus his previous lifetime cumulative dose is less than 5 rem no exposure which will cause him to exceed his MPD will be authorized.
    - (2) If the individual's MPD minus his previous lifetime cumulative occupational dose is greater than 5 rem an added exposure may be allowed provided the parent organization has maintained an accurate record of the individual's lifetime radiation exposure. The Test Manager is authorized to approve an increase in the exposure, and in no case will more than 12 rem per year be authorized. All work requests must be fully justified by the user as to the need and requirement to receive an authorization to exceed the 5 rem per year radiation dose.

(3) The Test Manager may approve requests from the Director, DOD Test Group for an increase in the operational radiation exposure when submitted in accordance with the special limits prescribed by the Armed Forces.

(d) Accidental Dose. Provisions of NBS Handbook 59 shall pertain in the case of an accidental or emergency exposure.

4. Radiation Concentration Guides. The maximum permissible body burdens and concentrations (MPC) in air and water of radio-nuclides are contained in National Bureau of Standards Handbook 69 (June 1959).

b. Radiation Contamination from Weapons Testing

1. Allowable vehicle and equipment contamination must not exceed:

7 mr/hr (gamma)

400 d/m/55 cm<sup>2</sup> (removable alpha by swipe)

1000 d/m/55 cm<sup>2</sup> (fixed alpha)

By "fixed" alpha is meant that no change in the alpha contamination level can be detected by swiping a one square-foot area and monitoring the swipe. These measurements are made by portable survey instruments.

2. Personnel contamination should be maintained as low as possible and decontamination exercised when levels exceed those shown:

Item	Alpha d/m/55 cm <sup>2</sup>	Gamma mr/hr
Outer Clothing	1000	7
Shoes	1000	7
Skin or Underclothing	200	1

3. Respirator protective devices will be maintained at a contamination level less than 1 mr/hr (beta+gamma) or 200 d/m/55 cm<sup>2</sup> (alpha fixed or removable).

4. Equipment or vehicles, alpha contaminated to levels in excess of  $10,000 \text{ d/m}/55 \text{ cm}^2$ , will be decontaminated by mobile equipment in the field prior to transporting to the decontamination pad.
- c. Radiation levels from reactor testing. Maximum permissible radiation levels will be as specified in the Test Group Director's Operational Plan.

045 Film Badge Procedures

- a. All personnel entering NTS must wear a current gamma-measuring film badge. These will be attached and worn with the security badge, and will be routinely exchanged each month.
- b. Neutron film badges will be issued to individuals working with neutron sources, or working in the reactor areas when required by test operations. These badges will be exchanged and processed whenever an individual or group of individuals could have received a dose greater than 100 mrem or at the end of each calendar quarter, whichever is sooner.
- c. Dosimeters will be worn by all personnel working in a radiation area in which it is possible to receive in a normal working day a radiation dose greater than 100 mrem.
- d. Film badges will be exchanged by all personnel at the nearest Rad-Safety facility immediately after leaving a radiation area or zone in which a pocket dosimeter reading shows a dosage of 100 mr or greater, or at any time a greater exposure is suspected. These badges will be processed each work day.
- e. Individuals returning to their home stations, or otherwise terminating their participation with an activity at the NTS, will turn in their film badges as a part of the Mercury check-out procedures. Film badges will be collected and processed each work day for these departing individuals and the dosage results will be reported to the appropriate agency within 24 hours from processing if the film badge processing indicates a dosage greater than 100 mrem.

046 Radiological Surveys.

When operational rad-safety control has been delegated to a Test Group Director under 012a, the Director will be responsible for the initial radiation survey of the specified area after an operation. Permission for entry into the area prior to completion

of the initial survey lies solely with the Director. After the radiological situation has stabilized, he will advise all other parties of the situation, and will permit operations in the area in accordance with his published safety plan.

047 Entry into Controlled Area

- a. The Test Group Director or Area Manager, LVAO (as appropriate), is responsible for establishing a controlled area when required for reasons of radiation safety. These areas will normally be established when: (1) the radiation intensities require precautions to limit personnel exposure, (2) it is anticipated that radiation or use of radioactive material could cause a problem, (3) it is possible through an accident or otherwise that an experimental program could produce radiation, or (4) the Test Group Director or Area Manager considers it desirable for any safety reason to control entry of personnel.
- b. Procedures to control access of personnel will be established by the Area Manager, LVAO, or by the Test Group Director if the provisions of subsection 012a apply. The specific details on access procedures and precautions necessary to protect personnel from the radiation hazards associated with a particular program will be contained in the Test Group Director's Operation Plan.
- c. In the event of an emergency, the Test Manager, Test Group Director, or their authorized representatives may authorize entry into a precise location. This authorization may be verbal.

048 Radiation Exposure Control

- a. Control of Exposure
  1. Recovery parties will not enter areas with radiation intensities in excess of 10 r/hr unless specifically authorized by cognizant authority.
  2. Surveys to establish isointensity lines greater than 1000 mr/hr will not be conducted as a routine function for each experiment.
  3. Construction activities in radex areas will be accomplished only at the discretion of the Area Manager, LVAO.
  4. Eating and smoking in radex areas or controlled area will be prohibited.

b. Monitors

1. Participating organizations will normally provide their own monitors. If they are unable to so do, the REECo Rad-Safety Organization will provide monitors.
2. The REECo Rad-Safety Organization will provide training courses for project monitors as required.
3. All participating organizations will provide a list of certified monitors to the REECo Rad-Safety Division.

c. Anti-Contamination Clothing and Equipment. Necessary rad-safety equipment, including instruments, clothing, respirators, film badges and dosimeters may be obtained at the Rad-Safety Building (CP-2) or the Reactor Test Area Rad-Safety Facility.d. Decontamination

1. Vehicles and equipment found to be contaminated will be taken to the decontamination station adjacent to the Rad-Safety Building (CP-2) or the Reactor Test Area Rad-Safety Facility.
2. Monitoring and decontamination of aircraft will be provided by the on-site rad-safety organization when requested.

049 Radioactive Material Controla. Definitions

1. Controlled Radioactive Sources: Any encapsulated radioactive source that has an associated dose rate greater than 1.5 rem/hr at one yard.
2. Registered Radioactive Sources:
  - (a) Plutonium, Polonium and Radium: those greater than 0.1 millicuries
  - (b) Barium <sup>140</sup>, Strontium <sup>89</sup>, Strontium <sup>90</sup>, Yttrium <sup>91</sup>: those greater than 0.135 mc
  - (c) All other sources greater than 1.35 mc not controlled under 049 a-1 above.

b. Radioactive Source Control Procedures

1. In advance of receipt of source at NTS, the using agency is responsible for submitting to the Area Manager, LVAO, for information and comment (with a copy to the Assistant Manager for Test Operations, ALO), written operating and radiological safety procedures for controlling the use of any radioactive source as defined in a-1 above. The following information is required:
  - (a) Time of arrival at NTS.
  - (b) Isotope or isotopes involved.
  - (c) Proposed use of the radioactive material.
  - (d) Statement that shipment will comply with ICC shipping regulations or other appropriate AEC regulations.
  - (e) Where the source will be stored.
  - (f) Final disposition of source.
  - (g) Operating procedures which will be followed in storing and working with the source.
  - (h) Name of individual responsible for radiological safety.

The Assistant Manager, OTO, will review all operational plans and procedures and will furnish the using agency with appropriate comments.

2. The senior on-site representative of user scientific laboratory, agency, or organization is responsible for notifying the REECo Rad-Safety Division in advance of the movement of any radioactive material, as defined in a-1 above, to other locations unless covered by operational procedures established in b-1 above.
3. Agencies using calibration sources will be familiar with radiological safety procedures for use of radioactive sources. The REECo Rad-Safety Division will assist user agencies in developing operational plans and procedures on request.

4. All radioactive material as defined in 049a, exclusive of source and nuclear material (SSN) brought onto the NTS, will be registered with the REECo Rad-Safety Division at the time of entry onto the test site.
  5. The Area Manager, LVAO, is responsible for making periodic inspection of user agency source control procedures and reporting such inspections with appropriate recommendations to the Assistant Manager for Test Operations, ALO.
- c. Radioactive Waste Material Control Procedures
1. The REECo Rad-Safety Division is responsible for disposing of radioactive waste material, on the NTS, except as defined in c-2 below. A radiological safety plan and control procedures will be submitted by REECo to the Area Manager, LVAO, for review and comment, with a copy to the Assistant Manager for Test Operations, ALO.
  2. Disposal of radioactive waste material as a result of operations in the 400 and 401 areas is the responsibility of the Project Test Group Director.
- d. Removal of Radioactive Material
1. All shipments of radioactive materials, except as exempted in d-2 below, will be labelled according to appropriate Interstate Commerce Commission, Civil Aeronautics Board, U. S. Coast Guard, and U. S. Postal regulations. Arrangements for packaging shipments will be the responsibility of the organization initiating the shipment. Shipping records will be initiated on an on-site Rad-Safety shipping form and will be completed and certified by the REECo Rad-Safety organization.
  2. Scientific samples, instruments and equipment designated by the Test Group Director are exempt from the above procedural requirements when transported by courier vehicle or fly-away aircraft. A suitable record of exempted material will be maintained by the REECo Rad-Safety Organization.
- e. Reports and Records
1. The REECo Rad-Safety Division is responsible for submitting monthly to the Area Manager, LVAO, a map showing the specific areas of radioactive contamination within NTS, showing locations, levels and types of radiation.

2. The REECo Rad-Safety Division is responsible for maintaining an up-to-date master file showing the ownership, source strength and specific location of all radioactive sources on the Nevada Test Site.

#### 0410 Dosimetry and Records

- a. The REECo Rad-Safety Organization will provide dosimetry and record services for both the on-site and off-site organizations and maintain dosimetry records on all on-site personnel. Dosage reports will be submitted for all personnel to the Area Manager, LVAO, and to the Test Group Director on a monthly basis. The Test Group Director and the Area Manager, LVAO, will also be provided with a report of all integrated exposure in excess of 2 rems (gamma + neutron) on a daily and monthly basis as outlined.
- b. A quarterly exposure report will be furnished to the Area Manager, LVAO, and to the Assistant Manager, Office of Test Operations, ALO.
- c. Record disposition policies and regulations shall be in accordance with the provisions of AEC Appendix 0203-091-11, Sections 5 and 6.

#### 0411 Documenting Decontamination

At the time any area decontamination has been completed, REECo will submit a record in quadruplicate to the Test Manager, including such data as: a map of the area showing radiation intensities, radiation levels at specific locations prior to decontamination, radiation levels upon completion, effect of character of terrain on radiation intensities, type of equipment used on the job, dosages equipment operators received, effectiveness of the decontamination, time required to complete the decontamination, photographs, and any other pertinent facts relating to the problem.

#### 0412 Counting Laboratory

A counting laboratory for determining gross radioactivity will be operated in Mercury by the On-Site Rad-Safety Organization. Analysis for specific material such as plutonium, tritium, and beryllium will be made for user organizations as a routine support service, if requested.

0524-05 Off-Site Rad-Safety Operations051 Purpose

- a. The purpose of this plan is to set forth the general procedures to be followed by the U. S. Public Health Service Off-Site Rad-Safety Organization in providing off-site radiological safety support on a continuous basis and for test activities at the Nevada Test Site.
- b. Detailed monitoring and sample collection procedures are contained in the Off-Site Radiological Safety Plan.

052 Definition of Terms

The Off-Site Area is defined as the area surrounding NTS to a radius of about 250 miles.

053 Responsibilities

- a. During non-test periods the Public Health Service Off-Site Rad-Safety Organization is responsible to the Area Manager, LVAO, for:
  1. Analyzing data and preparing final off-site reports of previous series and special reports as requested.
  2. Preparing detailed operational plans for forthcoming series.
  3. Maintaining an active film badge program as required to fully document the gamma dosage to off-site populations and communities.
  4. Maintaining an active public education program, including periodic visits to communities.
  5. Maintaining an environmental sampling program, including air, water, and foodstuffs.
  6. Maintaining liaison with State and local health officials in the off-site area.
  7. Providing an off-site monitoring service.
- b. During a test period the Public Health Service Off-Site Rad-Safety Organization is responsible to the Area Manager, LVAO, for:

1. Providing the same services as during the non-test period, on an expanded scale to meet increased testing activities.
2. Fully documenting the off-site radiological situation following each test activity in which radioactive fallout could be detected off-site.
3. Maintaining an up-to-date map of the off-site area showing the locations and levels of any radiation.
4. Investigating inquiries and incidents of a medical nature from the off-site populace in accordance with the procedure contained in NTSO-SOP Chapter 0701.

054 Operational Guide - Radiation Exposure

The off-site radiological safety criterion is 0.5 roentgens per year whole body gamma exposure and one-tenth of the maximum permissible concentration of radioisotopes in air and water as listed in NBS Handbook 69. These MPC's may be averaged over a period up to one year.

055 Objectives

The objectives of the off-site radiological safety activities are as follows:

- a. To verify the off-site radiological situation associated with test site activities to insure public safety.
- b. To have trained personnel available to take emergency measures prescribed by the Atomic Energy Commission should an unacceptable situation develop.
- c. To obtain an adequate record of the radioactivity in the off-site area.
- d. To maintain public confidence that all reasonable safeguards are being employed to preserve public health and property free from radiation hazards.
- e. To investigate reports of incidents attributed to radioactivity which could result in claims against the Government or create unfavorable and unwarranted public opinion.
- f. To accumulate data to provide a basis for a better evaluation of cumulative radiation dose to people.

056 Organization

- a. By a Memorandum of Understanding between the PHS and the AEC-ALO, the PHS is responsible to staff and operate the off-site radiological safety program at NTS.
- b. PHS-commissioned officers will be permanently assigned to the Las Vegas Area Office in support of this activity. The number of officers so assigned will be by mutual agreement between the Division of Radiological Health, Public Health Service, and the Office of Test Operations.
- c. The Officer-in-Charge, PHS Off-Site Activities, is the Off-Site Rad-Safety Officer.
- d. The permanent staff will be augmented during test periods by personnel assigned through the Division of Radiological Health, PHS.

057 Operational Plana. Survey Results

1. Monitoring radiation readings will be radioed to Net Control at Mercury Bldg. 155 by the monitoring teams.
2. A carbon copy of all monitoring data will be forwarded immediately after each test activity to the Office of the Test Manager.
3. The results will be posted on a large-scale wall map in Bldg. 155 as received. The intensity and time of reading will be noted at each reading location.
4. An interim off-site radiological safety report will be prepared following each test activity for submission to the Area Manager, LVAO.

b. Environmental Sampling

1. Air sampling stations will be established in the larger population centers. Results from these stations assist in delineating the fallout pattern and documenting negative values outside the fallout area.

2. Water samples will be collected periodically at representative places such as public water supplies, stock watering ponds, and ground water surface discharge and will be counted for gross radioactivity.
3. Milk samples will be collected periodically from dairy farms, processing plants, and retail outlets in the off-site area.
4. Food samples will be collected to obtain data on internal radiation hazards to the off-site population.
5. A representative number of water, milk and food samples showing above normal gross levels will be analyzed for specific significant isotopes.

c. Public Education

1. Public relations is recognized as one of the more important functions of the off-site program. Educational activities will be directed toward individuals and groups through informal discussions, distribution of pertinent literature, showing of movies, and matter-of-fact question answering.
2. The Office of Test Information, NTSO, will furnish guidance and direction as necessary in the conduct of off-site public relations.

d. Film Badge Program

1. Film badges will be strategically placed in populated places, along highways and trails in non-populated areas, and inside and outside buildings, and will be exchanged monthly.
2. The film badges will be supplied and processed after exposure by the REECo Rad-Safety Organization.

e. Liaison with Public Health Officials

Continuous liaison will be maintained with State and local health officials. For operational periods notification of testing activities will be coordinated with appropriate test officials.

f. Instrumentation

1. Monitoring instruments for detecting alpha, beta, and gamma activity will be furnished and maintained by the Support Contractor.
2. Continuous recorders will be placed in communities to present a visual record of gamma radiation levels in these localities.

g. On-Site Data Collection--Reactor Operations:

The assignment of areas of responsibility for collection of data on site for periods of reactor testing will be as mutually agreed upon by the "Committee for Environmental-Radiation Studies."

058 Medical Activities

When required by test site activities, a medical officer will be assigned by the PHS Liaison Officer Network Coordinator to the staff of the Off-Site Rad-Safety Officer. He will be responsible for maintaining liaison with local physicians, answering inquiries of a medical nature, investigating complaints and conducting public relations.

059 Veterinary Activities

- a. A veterinarian will be assigned by the Veterinary Corps, U. S. Army, to the AEC Las Vegas Areas Office.
- b. Programmatic direction and administration will be supplied by the Area Manager, LVAO.
- c. The Veterinary Officer is responsible for maintaining liaison with the local veterinarians managing the off-site animal project, answering inquiries from ranchers, and investigating complaints. He will also collect biological specimens for radiochemical analysis and will perform special studies as directed.

0510 Communications

- a. The primary method of communications will be by a low-band VHF radio net. All off-site vehicles will be equipped with a 2-way radio on this net. Automatic repeater stations will be used to provide complete coverage.

- b. Telephone service will be used as a secondary method of communication.
- c. The Support Contractor will maintain and operate the radio net.

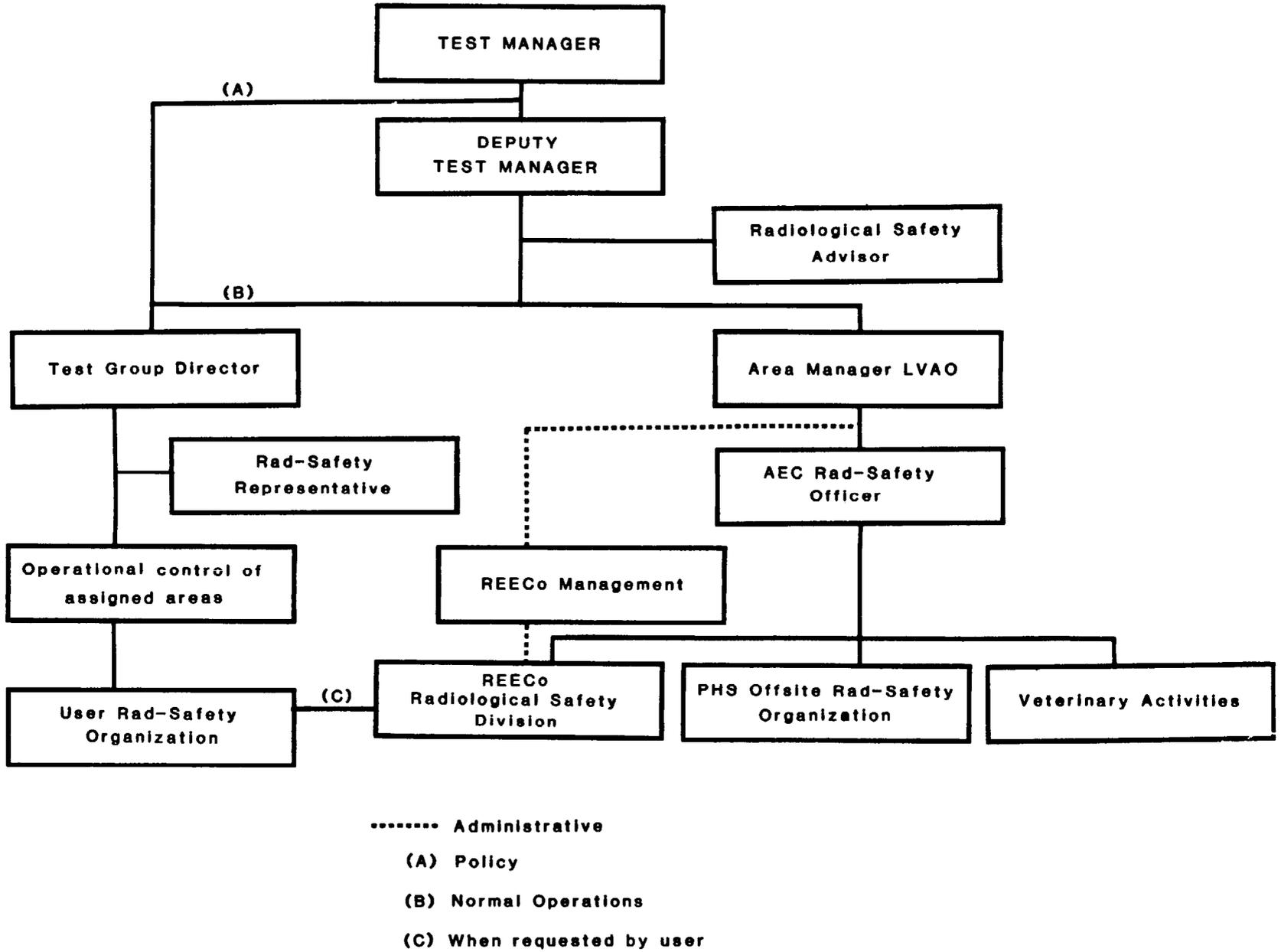
0511 Counting Laboratory

A low-level radiochemical laboratory will be operated at Mercury for determining gross radioactivity and specific radiochemical tests that are desirable for environmental samples in order that the Nevada Test Site Organization will be able to better evaluate cumulative low-level radiation dose to people.

0512 Emergency Plan

The Emergency Plan for evacuation of off-site population groups is outlined in NTSO SOP Chapter 0601-04.

FIGURE 1 ORGANIZATION CHART, RAD-SAFETY ACTIVITIES





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