NVO 34

PROJECT MANAGER'S REPORT

PROJECT STERLING

UNITED STATES ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE

December 1967

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PREFACE

This report is concerned with the administration, operational planning, public safety, engineering and construction, and logistics performed by NVOO in support of the technical and scientific experiments carried out under Project Sterling.

Included is a summary of the technical and scientific purposes of the experiment and and account of the field test. Results and more detailed information concerning the technical and safety aspects of Project Sterling can be found in the technical and safety program reports being issued by the Division of Technical Information Extension, USAEC, Oak Ridge, Tennessee. These reports are being prepared by the agencies who participated in the technical and safety program, and a complete listing can be found in Appendix A.

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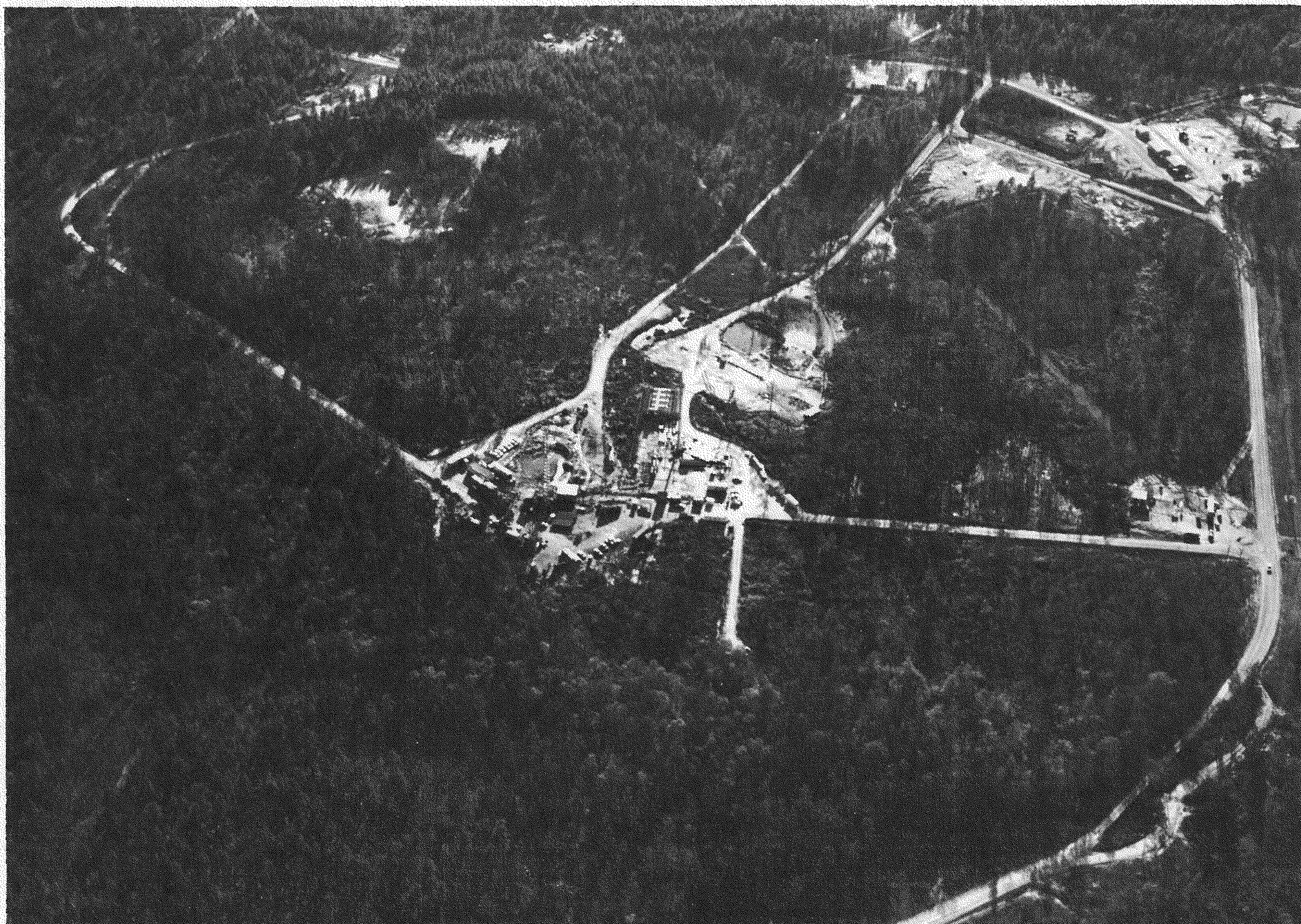

Looking South and West Over the Sterling Site

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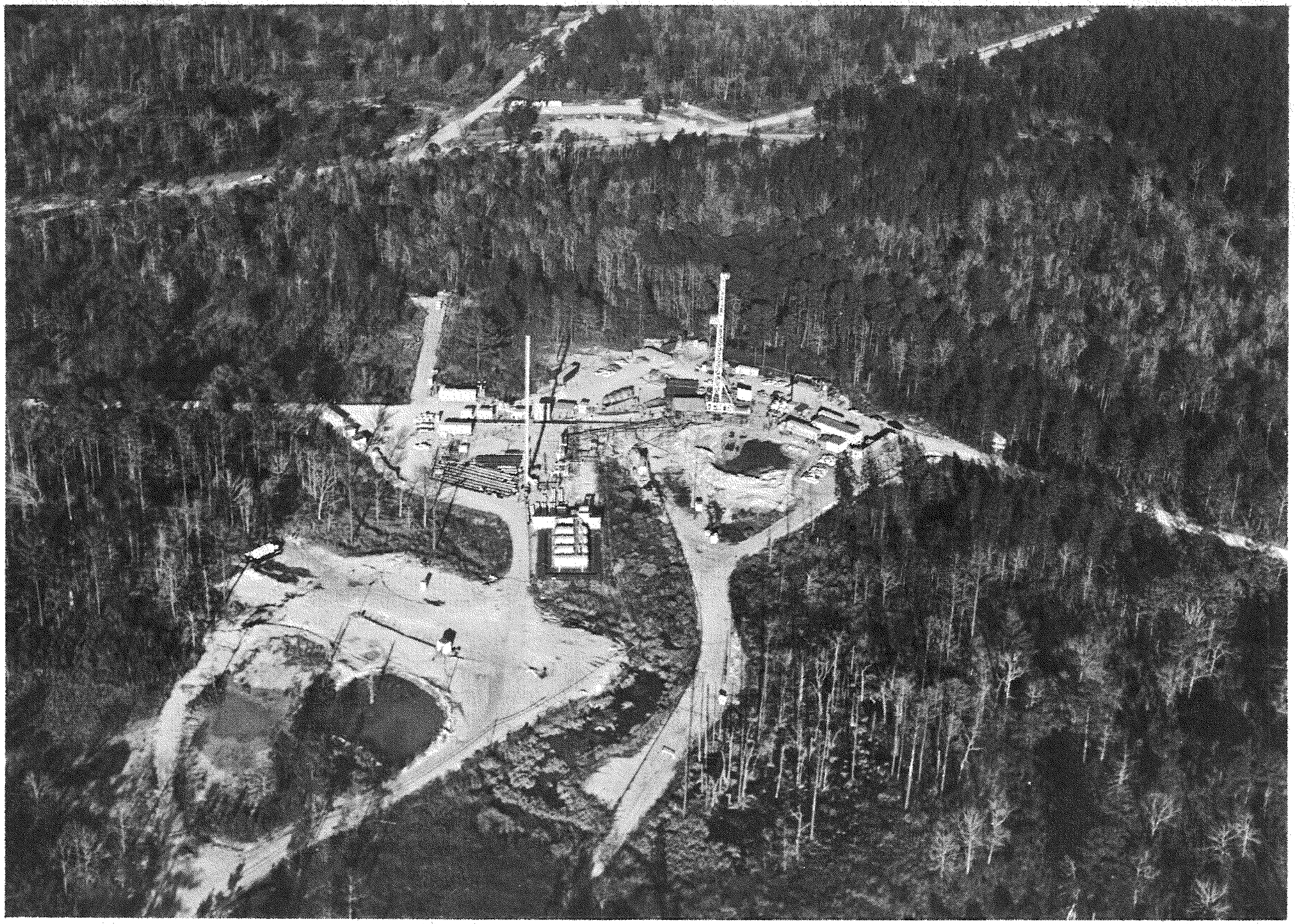

Looking North Over Sterling Ground Zero

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ABBREVIATIONS

Listed below are the agencies and contractors that participated in Project Sterling. For the most part they are referred to in this report by the listed abbreviations:

AEC	U. S. Atomic Energy Commission
AFSWC	Air Force Special Weapons Center, DASA, DOD
AFTAC	Air Force Technical Applications Center
ARFRO-ESSA	Air Resources Field Research Office-ESSA, Las Vegas
ARPA	Advanced Research Projects Agency, DOD
ARTC	Air Route Traffic Control Center, FAA, Houston
ALOO	Albuquerque Operations Office, AEC
DASA	Defense Atomic Support Agency, DOD
DMA	Division of Military Application, AEC
DOD	U. S. Department of Defense
EG&G	EG&G, Inc.
ERC	Environmental Research Corporation
ESSA	Environmental Science Services Administration
FC/DASA	Field Command, Defense Atomic Support Agency
WETG	Weapons Effects Test Group, DASA
F&S	Fenix and Scisson, Inc., Petroleum Consultants
FAA	Federal Aviation Agency
H-NSC	Hazleton-Nuclear Science Corp.
H&N	Holmes and Narver, Inc.
Isotopes	Isotopes, Inc.
JAB	John A. Blume & Associates, Research Division
LRL	Lawrence Radiation Laboratory, University of California

NFOG	Nuclear Field Operations Group, AFSWC
NVOO	Nevada Operations Office, USAEC
REECo	Reynolds Electrical & Engineering Co., Inc.
SAN	San Francisco Operations Office, USAEC
SC	Sandia Corporation
SRI	Stanford Research Institute
SROO	Savannah River Operations Office, USAEC
TI	Texas Instruments, Inc.
USAF	U. S. Air Force
USBuM	U. S. Bureau of Mines
USC&GS	U. S. Coast & Geodetic Survey, ESSA
USGS	U. S. Geological Survey
USPHS	U. S. Public Health Service
WES	Waterways Experimental Station U. S. Army Corps of Engineers
WSI	Wackenhut Services, Inc.
WRPU	Weather and Radiation Prediction Unit-ARFRO-ESSA

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INTRODUCTION

The Sterling experiment, detonated December 3, 1966, was the first decoupled underground nuclear detonation. This experiment used the existing Salmon cavity and the original Salmon emplacement hole. The experiment involved the detonation of a 350-ton device in a decoupled emplacement centered in a 110-foot diameter cavity about 2,700 feet below the ground surface in the Tatum Salt Dome--approximately 110 miles NE of New Orleans, Louisiana, and 22 miles SW of Hattiesburg, Mississippi.

The principal purpose of the Sterling experiment was (1) to determine the extent of decoupling of a sprung cavity in salt; specifically, to determine the decoupling ratio as a function of frequency; (2) to determine the accuracy of decoupling calculations for a sprung cavity; and (3) to define any operational problems associated with the reuse of a cavity.

Project Sterling is a part of the Vela Uniform program which is sponsored and funded by the Advanced Research Projects Agency (ARPA) of the Department of Defense. Vela is the short title of a research and development program directed toward locating, detecting, and identifying underground, surface, and high altitude nuclear detonations.

The phase of Vela relating to underground detonations, Vela Uniform, has as its purpose the improvement of our knowledge of the characteristics of seismic waves generated by man-made explosions, especially as they relate to the detection and identification of underground nuclear explosions.

The following are the four joint AEC-DOD Vela Uniform nuclear events conducted thus far:

(1) Project Shoal

Detonated on October 26, 1963, having a yield of 12.2 ± 1.2 kt at a depth of 1205 feet in the Sand Springs Range near Fallon, Nevada. This met the requirements for an experiment in a granite medium and an active earthquake area.

(2) Project Dribble (Salmon Event)

Detonated on October 22, 1964, having a yield of 5.3 ± 0.5 kt at a depth 2700 feet in the Tatum Salt Dome near Hattiesburg, Mississippi. The objectives were to provide data for calculating, correlating, and evaluating results of seismic instrument readings to gain more complete knowledge of coupled (tamped) and decoupled explosions.

(3) Project Long Shot

Detonated on October 29, 1965, having a yield of 80 kt at a depth of 2300 feet on Amchitka Island in the Aleutian chain. The objective was to obtain a new set of seismic travel-time curves from an underground disturbance in a high-incident earthquake area.

(4) Project Sterling

Detonated on December 3, 1966, having a yield of 350 tons (0.35 kt) in the center of a 110-foot diameter cavity about 2700 feet below the surface in the Tatum Salt Dome near Hattiesburg, Mississippi. The objectives are stated above.

CHAPTER I

PLANNING, AUTHORITIES, AND ORGANIZATION

1.1 BACKGROUND

On December 28, 1958, at the request of the Department of State, the Special Assistant to the President appointed the Berkner Panel (under the Chairmanship of Dr. Lloyd V. Berkner) to review the feasibility of improving the Geneva system. The Panel reported on the need for fundamental research in seismology.

In March 1959, Messrs. Latter, LeLevier, Martinelli, and McMillian of the Rand Corporation published a report entitled "A Method of Concealing Underground Nuclear Explosions." The method became known as "decoupling." This theory was briefly outlined in LRL Report No. UCRL-7323, "Prepared Statement on the Theory of Decoupling and the Status of Project Dribble, for the Joint Committee on Atomic Energy, Congress of the United States."

The detonation of a nuclear device suspended within a large cavity was recommended as a means of testing the theory that decoupling or muffling would greatly reduce the seismic or ground motion signals from an underground explosion. Scientists agreed that a salt dome was the most advantageous site for such an experiment.

Decoupling theory may be briefly described as follows: If a large enough cavity were created underground, and a nuclear device of the right yield were detonated at the center of it, the air would cushion the shock and relatively little of the energy of the detonation would be transmitted to the cavity wall. Therefore, the earth shock or seismic signal transmitted to distant seismographs would be extremely small when compared to the energy transmitted from a tamped explosion of the same yield and at the same position.

The summary report of the Berkner Panel published in July 1959, taking note of difficulties in detecting the difference between some underground nuclear detonations and some earthquakes, recommended experiments comprising the following:

(1) Fundamental research in seismology

(2) Procurement of instruments for a world-wide seismic research program

(3) Development of improved seismic instruments

(4) Construction and operation of prototype seismic detection stations

(5) An experimental program of underground detonations encompassing high explosives and, where necessary, nuclear explosions

The Panel recommended firing a number of underground nuclear detonations in different locations and under varying conditions as a source of ground motion that could be recorded by improved detection instruments. Suggested placements were in granite, in an earthquake-prone area, in salt, and in varying geological formations at the Nevada Test Site. Four Vela Uniform events conducted thus far are discussed in the Introduction.

1.1.1 Experiments Leading to Sterling

Project Cowboy[1]

This experiment was conducted in a salt mine and surrounding areas in the vicinity of Winnfield, Louisiana, between August 1959 and March 1960. It was designed to check the decoupling principle using chemical explosives up to 1,000 pounds. Interpretations of the Cowboy experiments, published in March 1961 by Herbst, Werth, and Springer, concluded that the experiments supported the decoupling theory and made the prediction that the seismic signals from a fully tamped nuclear explosion would be 200 to 300 times greater than the signal from a decoupled explosion of the same energy yield.

Project Dribble[2]

An experimental program was established in early 1960 to test the decoupling principle using nuclear explosives in the Tatum Salt Dome near Hattiesburg, Mississippi. The program included 4 nuclear events which consisted of tamped and decoupled shots of 100 tons (0.1 kt) and 5 kt.[3] On September 20, 1962, Project Dribble was redefined to include the following shots:

EVENT	YIELD	DEPTH OF BURIAL
Salmon	5 kt	2700 ft in 17 1/2-in. diam hole
Sand	100 ton	2000 ft in 95-ft diam sphere
Tar	100 ton	2000 ft in 17 1/2-in. diam hole

The Salmon Event was originally scheduled for detonation in July 1963 with Sand and Tar to follow about 9 months later; however, in April and May 1963 serious construction difficulties were encountered in drilling the shot hole for Salmon, and the shafts for the Sand cavity. The Salmon Event was detonated on October 22, 1964; its yield was 5.3 ± 0.5 kt. Sand and Tar were indefinitely suspended.

1.1.2 Sterling

Following the Salmon detonation[4], the postshot program was started in January 1965 and completed on June 30, 1965. This program consisted of radiologic and chemical sampling, and cavity investigations in relation to both the Salmon detonation and the possible use of the Salmon cavity for additional experiments.

1 *During the period from September 1959 to January 1960 this project was also referred to as Project Peacock.*

2 *Formerly known as Project Ripple.*

3 *For complete history of Project Dribble see the Project Manager's Report-Project Dribble (Salmon Event) NVO 24, July 1966.*

4 *For the technical summary of the Salmon results see LRL Report No. UCRL-14487, Revision 1 - "The Salmon Seismic Experiment," November 15, 1965.*

The postshot investigations suggested the possible use of the cavity for a decoupling experiment. The cavity was dry, about 100 feet in diameter, and dimensionally stable. The Salmon emplacement hole was rehabilitated and was available along with 2 postshot survey holes for another experiment.

Because of the alterations of the geological medium as a result of the Salmon detonation, the amount of decoupling was quite uncertain. Since the *in situ* properties of the altered medium could not be determined, it was impossible to make definitive predictions for the Sterling experiment. The interpretation of the Sterling decoupling ratio was also complicated due to the differences in the frequency content of the Sterling and Salmon seismic signals. A further difficulty lay in reproducing the details of the seismometer installations to duplicate the Salmon arrangement. For these reasons, a tamped high-explosive (HE) charge was included in the Sterling experiment. The high-explosive experiment and Sterling could be fired close together in time and their signals could be recorded by the same instruments.

On November 17, 1966, LRL prepared and detonated a 2-ton chemical high-explosive in a hole located at WP-4 at a depth of 2700 feet. The travel paths from the high-explosive detonation and Sterling to the seismic stations were almost identical.

The Sterling Event was scheduled for detonation on November 29, 1966. However, technical difficulties were encountered and the Sterling Event was subsequently detonated on December 3, 1966.

At the present time postshot cavity reentry and investigation is under consideration.

1.2 SITE INVESTIGATION AND EVALUATION

The site investigation and evaluation, and the site exploratory program can be found in the *Project Manager's Report-Project Dribble (Salmon Event),* NVO 24, July 1966.

For a detailed description of the Salmon cavity see LRL REPORT No. UCRL-14280, Revision 1, "Post-Explosion Environment Resulting from the Salmon Event."

1.3 AUTHORIZATIONS

(1) A letter from the Director, ARPA, to the Director, DMA, USAEC dated August 9, 1960, contained the Joint AEC/DOD agreement on the division of responsibility for conduct of the Vela Uniform Program.

(2) DMA TWX dated July 8, 1966, to the Manager, NVOO provided authorization to proceed with engineering, construction, and support for Project Sterling.

(3) "Planning Directive (PL 3-8-66) Project Sterling," August 12, 1966 and "Project Sterling Planning & Program Directive," September 1966, provided guidance and direction for the planning and preparation of Project Sterling.

(4) "Operation Order NV-Opo-3-66 -- Project Sterling," October 21, 1966, authorizing the field execution of Project Sterling.

(5) DMA TWX dated November 28, 1966, to the Manager, NVOO, authorizing the execution of Sterling in Station 1A in the Tatum Salt Dome (See Appendix B.)

1.4 ORGANIZATION AND RESPONSIBILITIES

1.4.1 Organization

The organizational chart for Project Sterling is presented in Appendix C. The chart illustrates an organization system which provided for field operations during the operational phase of the Project to be carried out under a Project Manager (NVOO) who reported directly to AEC/HQ and directed the execution of the field program. The Project Manager was supported by the Deputy Project Manager (NVOO); scientific and technical advisors; and a staff functioning in the areas of public information, administration, liaison, public safety, operations coordination, engineering, construction and support (See Appendix D.) During the field execution of the experiment the Deputy Project Manager was responsible for these staff functions.

Field programs included the Technical Program, the Operational Safety Program, the Security Program, and the Engineering, Construction, and Support Program. The Site Manager, assigned by NVOO, supervised and coordinated the on-site logistic and construction activities and acted as on-site representative for the Project Manager and the NVOO staff.

1.4.2 Responsibilities

a. DOD (ARPA)

ARPA was responsible for establishing and defining program objectives and for overall policy guidance, management, and funding (exclusive of services to be provided and funded by the AEC as agreed upon).

b. AEC

DMA was responsible for direction of AEC program activities, and for coordination of funding requirements. NVOO was responsible for the overall direction and execution of the project.

c. LRL

LRL was responsible for providing the nuclear device and for the design and development of the technical measurements program for the Sterling Project, based on the scientific objectives identified by ARPA and the AEC. LRL provided a Test Director and staff to coordinate, direct, and execute the technical program. The Test Director was also responsible for interpreting and reporting experimental results.

1.5 BOARDS AND PANELS

1.5.1 Panel of Consultants

A Panel of Safety Consultants recommended by the National Academy of Sciences was established to provide advice and recommendations concerning the safe execution of Project Sterling. The Panel consisted of the following consultants:

Dr. Perry Byerly	Seismology (University of California)
Dr. Lydik S. Jacobsen	Structural Response (Agbabian-Jacobsen and Associates)
Dr. Nathan M. Newmark	Structural Response (University of Illinois)
Mr. Sheppard T. Powell	Hydrology (Sheppard T. Powell & Associates)
Mr. Lewis G. Von Lossberg	Hydro-geology (Sheppard T. Powell & Associates)
Mr. Thomas F. Thompson	Engineering geology and hydrology (Consultant)
Dr. George B. Maxey	Hydrology (Desert Research Institute-University of Nevada)
Dr. Don U. Deere	Foundations and Structural Response (University of Illinois)
Mr. Stanley D. Wilson	Foundations and Soil Stability (Shannon & Wilson, Inc.)

Members were continuously apprised of all safety aspects within their respective disciplines dating from the project's inception until the detonation of the Sterling Event. Preliminary operational safety plans began in the fall of 1966, and culminating in the final plan dated November 1966, were distributed to the Panel members for their critical review and concurrence. By continuous surveillance of the safety plans and data generated as the project advanced, the Safety Panel was assured that the project would be conducted with no hazard to people, livestock, or structures in the area.

On October 17, 1966, the Panel participated in an extensive review of the conditions and possible hazards presented by the event and developed the following statement:

> "The Panel, as constituted by the undersigned, submits the following opinion based on conferences and reports of U. S. Geological Survey, John A. Blume & Associates, Hazleton-Nuclear Science Corporation, and Environmental Research Corporation, and is in accord with the preliminary Operational Safety Plan for Sterling. Judging from the (a) Salmon observations, (b) empirical data from previous shots, and (c) related theoretical interpretation and predictions, no hazard with regard to safety to people, livestock or structures in the area is anticipated from the proposed Sterling Event."

1.5.2 Scientific Advisor and Panel

The Project Sterling Scientific Advisory Panel was chaired by Dr. Harry L. Reynolds, LRL Scientific Advisor to the Project Manager, to evaluate the safety problems associated with execution of the event. The Panel consisted of the following members:

Dr. H. L. Reynolds, LRL	- Chairman
Dr. C. S. Maupin, REECo	
Mr. J. C. Pales, ARFRO-ESSA	
Mr. J. R. McBride, USPHS	
Mr. F. D. Cluff, AEC, NVOO	
Dr. Roy Maxwell, AEC, Wash.	

The first briefing, chaired by Dr. Reynolds, was held in Las Vegas, Nevada on October 5, 1966, to review typical climatological data in the Hattiesburg area in the early winter.

Two subsequent briefings were held at the CP Compound at the Sterling site at 1500 hours, December 2, and 0400 hours, December 3, 1966. The first was chaired by Dr. C. S. Maupin and covered the meteorological conditions, the safety program, and the public information plan. Wayne Woodruff, Test Director, gave a general presentation of the event including the surface seismic program. He emphasized the importance of an early shot time, from a technical standpoint, due in part to the difficulties experienced with the device cooling systems. (See paragraph 3.6.2) The second briefing prior to the event was chaired by Dr. Harry L. Reynolds and was concerned primarily with a review of the weather conditions immediately before shot time on December 3.

1.5.3 Test Evaluation Panel

The Test Evaluation Panel Consisted of:

R. H. Thalgott, NVOO	- Chairman
W. E. Ogle, LASL	- Member
R. H. Goeckermann, LRL	- Member
B. F. Murphey, Sandia Corp.	- Member
O. R. Placak, USPHS	- Member
P. W. Allen, ARFRO-ESSA	- Member
J. J. Neuer, DASA	- Member
C. S. Maupin, REECo,	- Consultant
P. J. Mudra, NVOO	- Executive Secretary

Plans for the Sterling Event were first reviewed by the Test Evaluation Panel during its meeting of October 5, 1966. After considerable discussion of these plans, it was concluded that, although containment considerations appeared to be more than adequate, execution of the Sterling Event in the existing Salmon Event cavity would, in some respects, be unique to underground testing. For this reason it was determined by the Panel that under current test category definitions Sterling should be assigned to Category B, rather than the A category originally recommended by LRL. This change was agreed to by the Laboratory and Sterling was unanimously voted to Category B.

Subsequent to the October 5 meeting, members of the Panel were advised verbally of a modification to the stemming plans for Sterling and by teletypes OOA:PJM-950 and OOA:PJM-857, "Thalgott to distribution," dated November 19, 1966 and November 21, 1966, of the necessity for installing a nitrogen pressurization system which required the use of a 1/4-inch copper tubing from the device canister to the surface. After reviewing this information, all Panel members or their alternates voted to continue Sterling in Category B.

The second and final full review of the Sterling Event by the Test Evaluation Panel occurred during a regular meeting on November 30, 1966. Except for a minor change in stemming material, used immediately above the cavity, there were no new changes which might affect containment. Sterling was continued as a Category B Event.

In concurrence with the findings of the Test Evaluation Panel, the Manager, NVOO, requested execution authority from the DMA in a memorandum dated October 14, 1966. This request was later supplemented by a teletyped request, dated November 22, 1966, in which the DMA was advised that, after reviewing data regarding stemming modifications and installation of the nitrogen pressurization system, the Panel had reaffirmed its B category for Sterling. Execution authority was granted by the DMA in teletype MA:ALR:329-1, dated November 28, 1966. (See Appendix B.)

CHAPTER II

SCIENTIFIC ACCOUNT

2.1 SCIENTIFIC MEASUREMENTS

The experimental program for Sterling was divided into 4 parts: (1) a surface seismic measurements program in the 15 to 243 km range to provide the primary information; (2) a subsurface measurements program to provide data pertinent to the theoretical calculations, especially if the decoupling factor should prove to be quite small; (3) yield measurements for the nuclear explosive; and (4) DOD projects other than seismic-related.

2.1.1 Surface Seismic Measurements

a. Technical Program

Surface seismic motion measurements were recorded at stations ranging in distance from 15 to 243 km from Surface Zero. The dynamic ranges were sufficient to record the data.

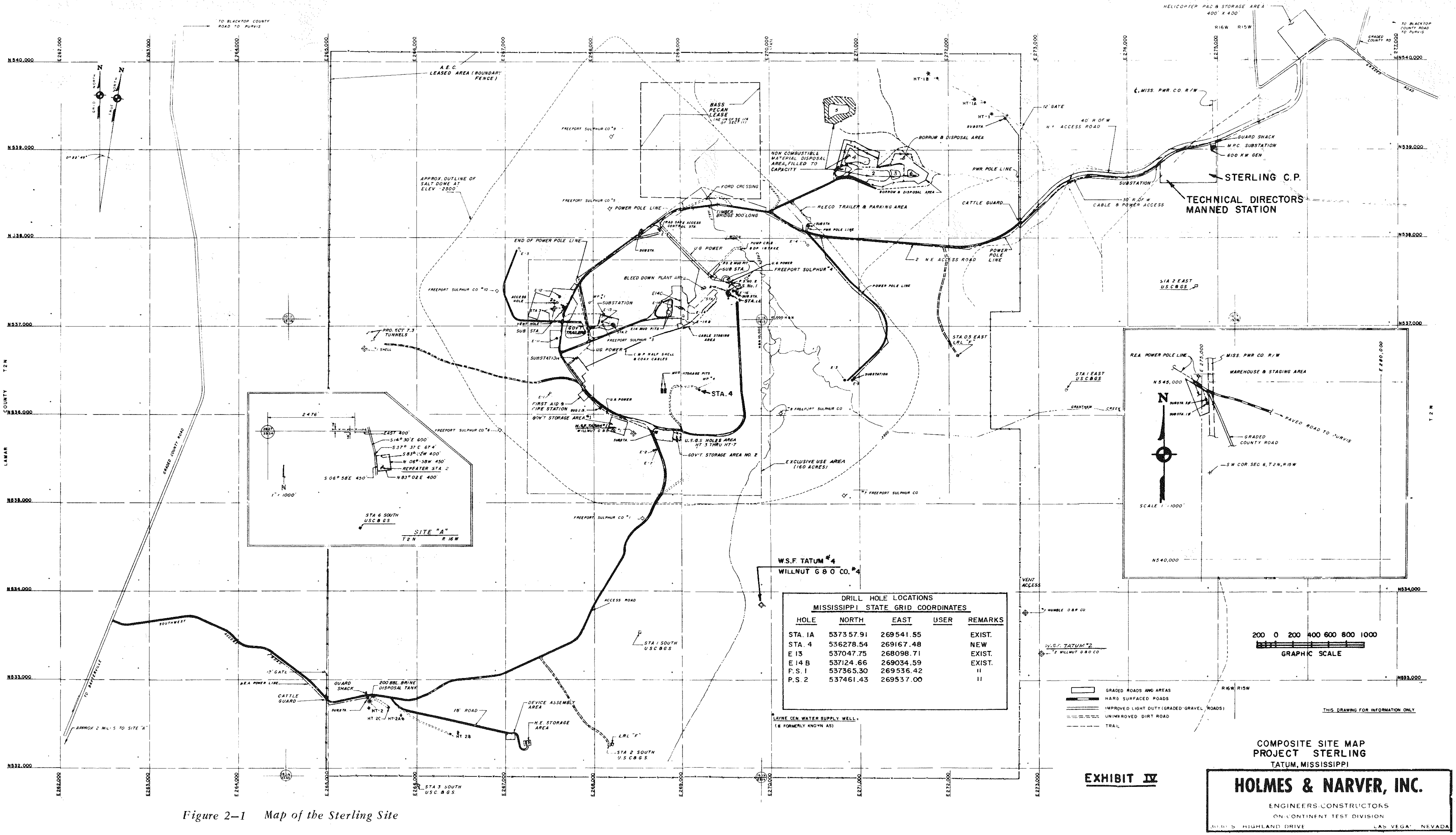
An HE comparison shot detonated at Station 4 (WP 4, Figure 2-1), located about 1,142 feet SSE of Sterling Surface Zero, provided data for a comparison of seismic signals between a tamped HE charge and the nuclear detonation. The shot consisted of a tamped 4,500 pound chemical explosion detonated at the same depth (2,700 feet) as the Salmon and Sterling shots.

b. Offsite Surface Seismic Measurements

1. AFTAC

Long Range Seismic Measurement (LRSM) Mobile Stations-- The LRSM program operated 4 portable seismograph systems and 2 mobile seismological observatories during Project Sterling. The sites occupied by LRSM teams are shown in Figure 2-2. The Jena, Louisiana (JE-LA) and Eutaw, Alabama (EU-AL) sites were occupied by LRSM mobile observatories. The 4 portable systems were set up on a circular configuration about the Sterling shot point with a nominal radius of about 68 km.

Seismograms and spectra of the Project Sterling Events, recorded by both mobile observatories and portable systems, can be found



DRILL HOLE LOCATIONS
MISSISSIPPI STATE GRID COORDINATES

HOLE	NORTH	EAST	USER	REMARKS
STA. 1A	537357.91	269541.55		EXIST.
STA. 4	536278.54	269167.48		NEW
E 13	537047.75	268098.71		EXIST.
E 14 B	537124.66	269034.59		EXIST.
F.S. I	537365.30	269536.42		"
P.S. 2	537461.43	269537.00		"

Figure 2–1 Map of the Sterling Site

in Technical Note No. 5/67, dated March 21, 1967, Geotech Division, Teledyne Industries.

The remainder of the LRSM stations and the 5 seismological observatories were in routine operation at the time of Sterling.

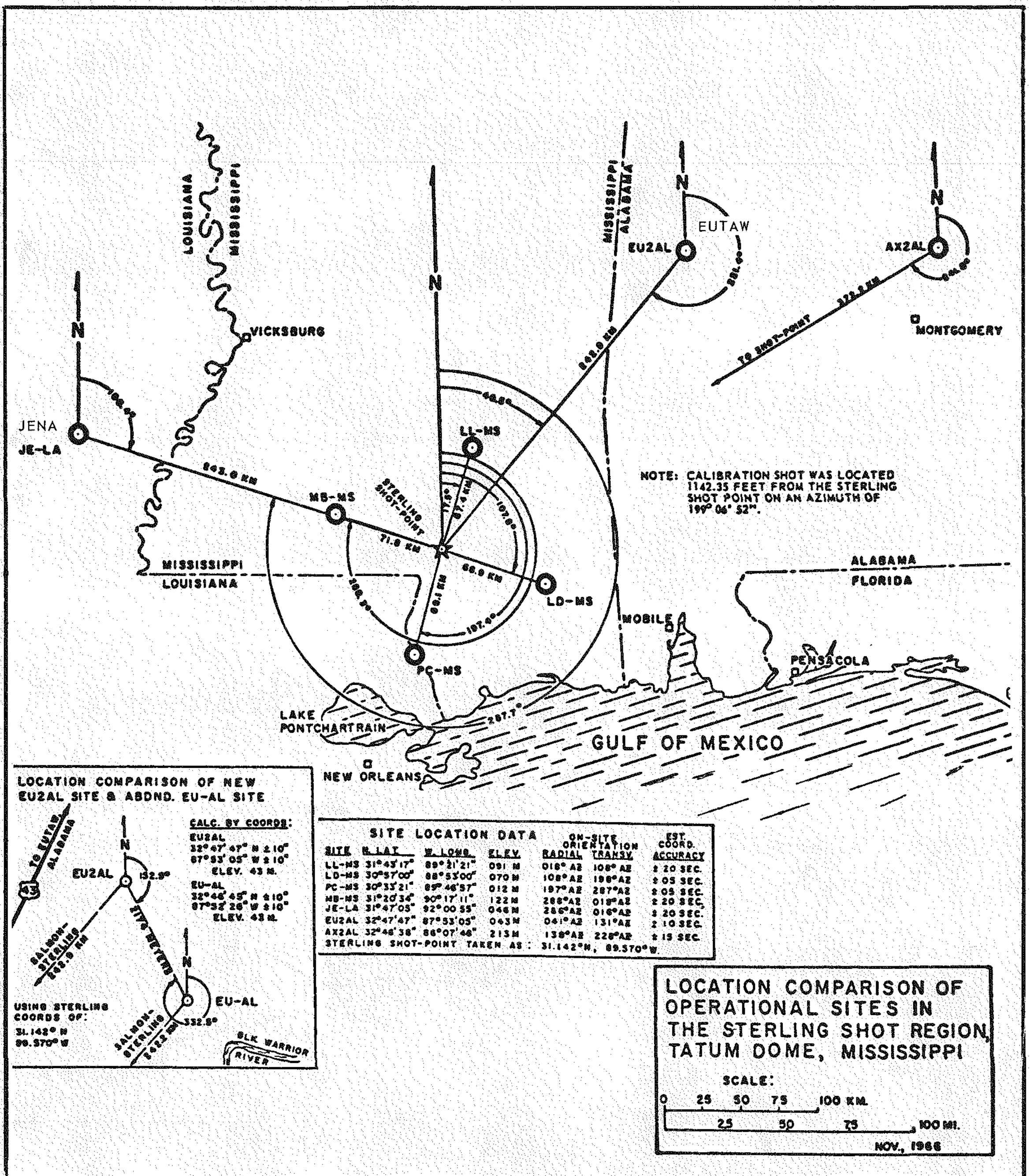


Figure 2–2 AFTAC Long Range Seismic Measurement Stations

2. USGS

U. S. Geological Survey refraction survey systems were used for these experiments. Each system records the signal from 8 seismometers on both photographic paper and magnetic tape; 6 of the seismometers register vertical ground motion and 2 register horizontal ground motion. The 6 vertical seismometers were placed at 500-meter intervals and the 2 horizontal seismometers were located at one of the vertical seismometer positions near the center of the spread. Seismometers were buried 6 to 12 inches deep, firmly placed, and covered. Station locations are presented in Figure 2-3. Seismogram playbacks are included in USGS Technical Letter, Crustal Studies 48, dated February 1, 1967.

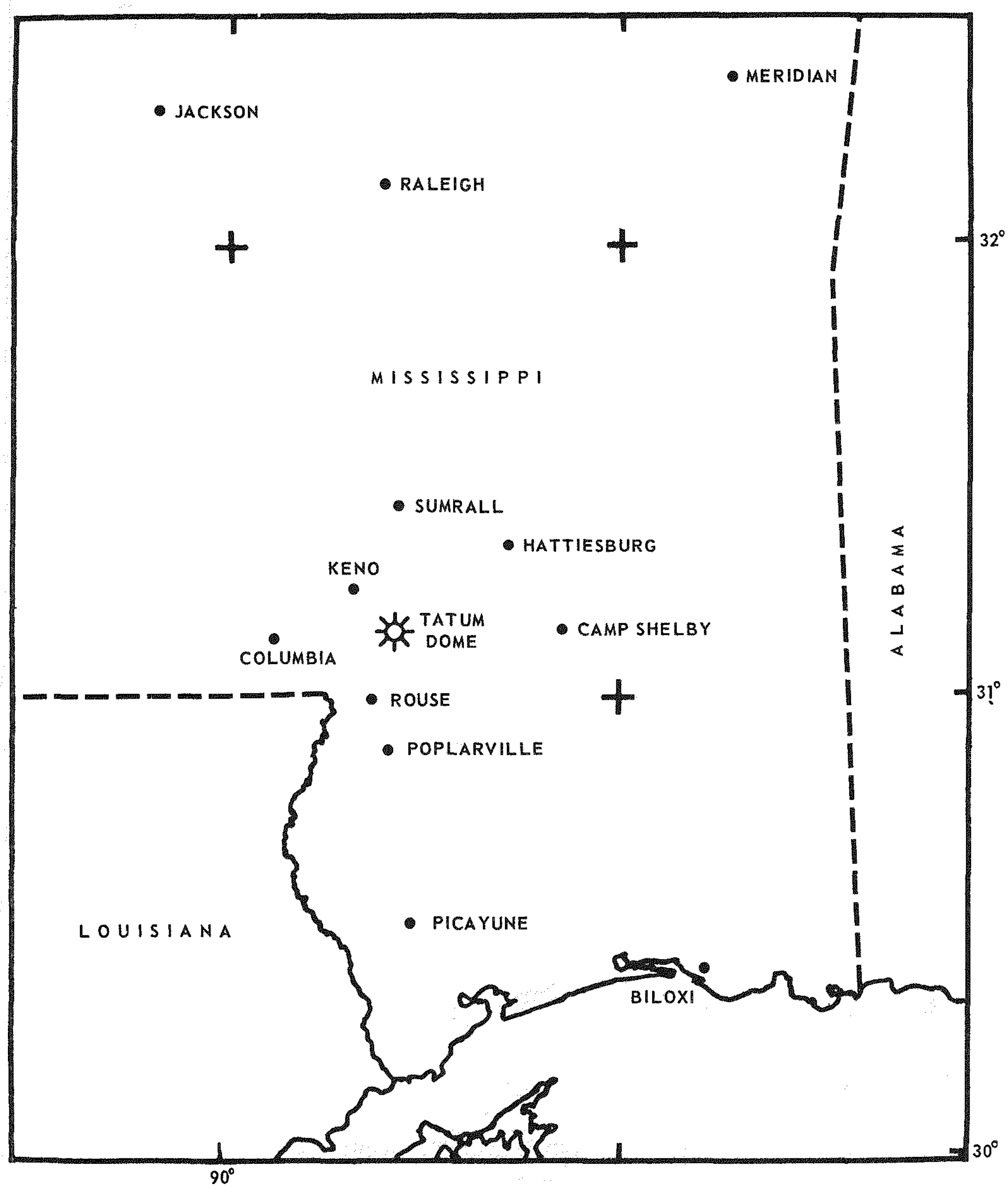


Figure 2–3 USGS Refraction Survey System Stations

3. USC&GS

In addition to close-in coverage for the Project Manager's Safety Program, the USC&GS operated 2 stations for technical program data. These stations, designated 10-S and 20-S, were located at distances of 15.8 km and 31.7 km respectively, from Sterling GZ and were operated for both Sterling and the HE comparison shot to provide comparative data. These same locations were instrumented on Project Salmon. (See Figure 2-4.) Seismograms of the Sterling and the HE experiment can be found in USC&GS Operations Report, E-105.

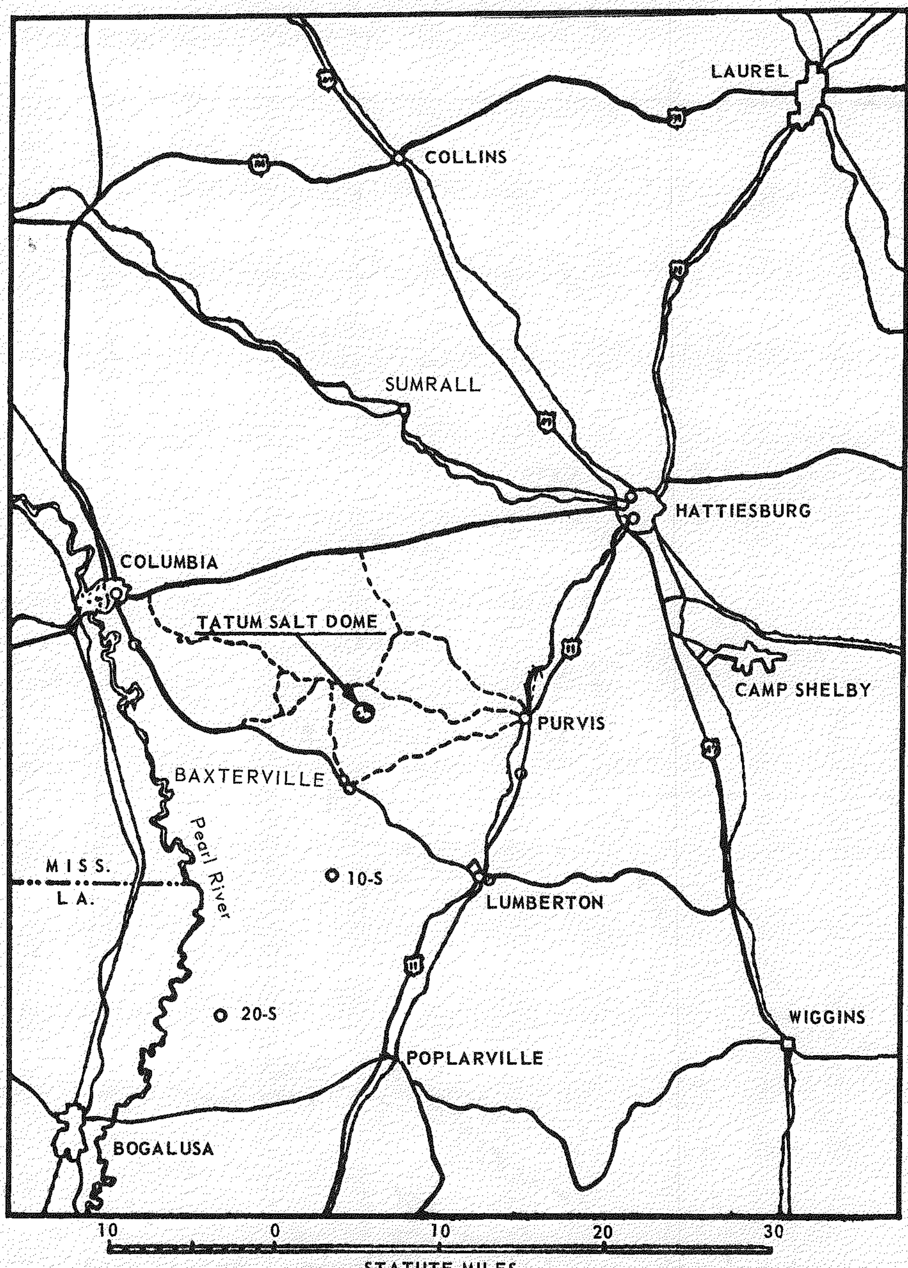


Figure 2–4 USC&GS Seismic Stations 10–S and 20–S

2.1.2 Subsurface Measurements Program

a. Free Field Ground Motion - SC

Most of the Free Field Ground Motion instruments installed by Sandia Laboratory for the Salmon experiment of 1964 were operable. A number of these instruments were reconnected because if Sterling decoupled poorly the signals from these gauges would be pertinent. Figure 2-5 indicates the gauge stations positions for Sterling. For gauge station orientation in relation to Sterling GZ, refer to Figure 2-1. All stations with the exception of those in Boring E5 and on the surface were used for Sterling.

In addition, 2 new instrument stations were installed for the Sterling and HE comparison shots. These stations, both at shot level, were E14B-27 in Boring E14B and E13-27 in Boring E13. Both Boring E14B and E13 were existing holes and needed only minor cleaning operations to be used for the Sterling operation. Both new instrument stations included horizontal radial accelerometers and velocity gauges oriented toward the Sterling shot point, and a horizontal radial accelerometer oriented toward the Sterling HE comparison shot position. These new stations included duplicate accelerometers and, where feasible, velocity gauges with set ranges differing by approximately an order of magnitude.

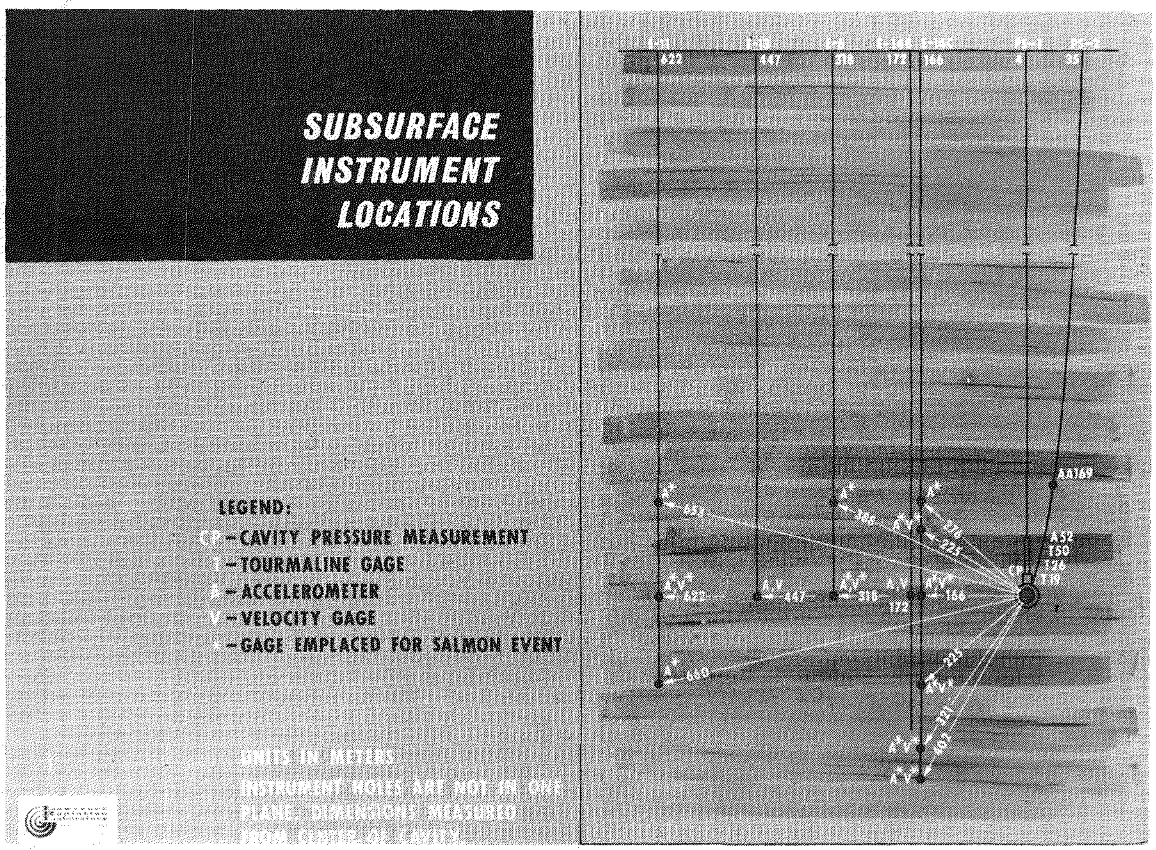


Figure 2–5 Subsurface Instrument Locations for Sterling

Several data conditioning circuits were added to the recording system to provide analog information on magnetic tape in the form of integrals of the gauge output; i.e., as displacement-time data from velocities and as reduced displacement potential-time data from displacements. In addition, several experimental circuits were used to derive the vector radial particle velocity records for stations above and below shot level by electronically summing the individual components.

Copies of the oscillographic playback records are found in Sandia Corporation Report, SC-TM 67-64, dated February 1967.

b. Close-In Inelastic Effects--LRL

These measurements were to obtain data to interpret the cause of an unexpectedly low decoupling ratio, if this occurred. They could also be used to check some of the close-in predictions of the decoupling calculations.

The measurements were concentrated in the vicinity of the Salmon cavity wall and used Salmon postshot exploratory Holes 1 and 2 (PS-1 and -2) for instrument emplacement. For station orientation in relation to Surface Zero, see Figures 2-1 and 2-6.

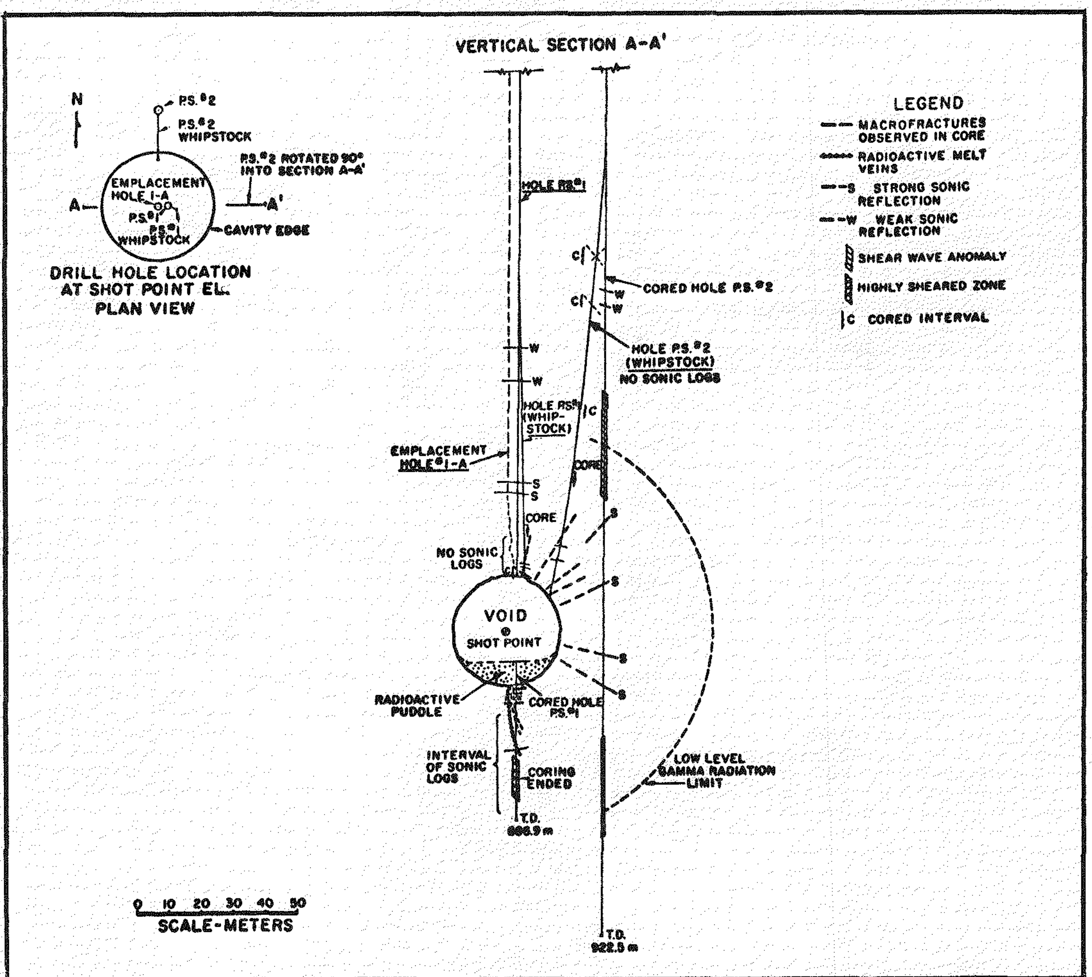


Figure 2–6 Postshot Drillholes of Dribble Instrumented for Sterling

1. Cavity Pressure: This experiment attempted to determine the cavity pressure using a measurement of the fluid pressure history in an oil-filled reservoir located a few feet away from the cavity wall and communicating with the cavity through a fluid column. Four gauges were used in measuring the reservoir pressure. This instrumentation was emplaced in Salmon PS-1.

2. Stress History: These measurements gave a time history of the stress conditions at a particular spatial point in the medium. The active elements used for these measurements were tourmaline crystals which are electronically programmed to act as charge generators with the analog signal developed on a load capacitor. Each of 7 units used in this program was designed and emplaced for delineation of a single component of stress. These measurements were made in Salmon PS-1.

3. Cavity Collapse: For this measurement, a collapse slifer technique was used wherein a coaxial cable of measured electrical length was emplaced in Salmon PS-1. Cavity collapse is indicated by changes in the cable lengths. The downhole ends of the emplaced cable were firmly attached to the top of the Cavity Pressure Chamber assembly. The wire rope supporting the Pressure Chamber assembly was severed after the hole grouting, thus allowing the chamber to fall into the cavity if the cavity roof came down.

4. Acceleration: Material accelerations were made at 2 different stations in Salmon PS-2. Accelerometers with a wide dynamic range were used due to uncertainty in the magnitude of the decoupling ratio.

   Data from a Columbia accelerometer was integrated and results compared with the velocity and displacement predictions made by computer. The data from both a Statham and Sandia accelerometer was used to calculate reduced displacement potentials which were then compared with E-14 complex results (range of 169 meters) for possible assymetries in seismic energy pattern.

2.1.3 Yield Measurements--LRL

The yield was arrived at by comparing explosive performance to calculations and previous experience.

2.1.4 DOD-Sponsored Projects

Two programs attached to Sterling were related to developing nonseismic detection and on-site inspection technology. They were directly funded by and reported to DOD, and the Test Director's organization provided on-site coordination and support.

a. Project 7.19--Detection of Radionuclides--Isotopes, Inc.

   The intent was to conduct preshot and postshot air sampling and analysis to detect possible increases in levels of radioactivity. The results of early preshot sampling and analysis precluded continuation of the project.

b. Project 7.8--Energy Spectrum Analysis--Texas Instruments, Inc.

Texas Instruments conducted an experiment designed to gather and evaluate data obtained from highly sensitive radioactivity measurements on subsurface and surface gas samples and on samples of gas stripped from water. Analysis of the energy spectrum enables determination of specific radioactive isotopes present in samples.

2.2 ON-SITE SAFETY MEASUREMENTS

The Project Manager retained overall responsibility for Project Sterling safety programs. However, during a period of time, determined jointly by the Project Manager and Test Director, when execution of on-site radiological functions had direct bearing on the success or failure of the scientific program, control of radiation and criticality safety was delegated to the Test Director. During this time period the Test Director utilized the organization of the Project Manager in establishing and enforcing on-site safety criteria. The Test Director was delegated responsibility beginning on the day the device arrived and continued through the period of immediate data recovery, until it was determined that no postshot radiological hazard existed. During this period, the Test Director operated a trailer containing the readout of the Remote Area Monitoring System (RAMS) units, geophones, zero site wind information and closed circuit TV of the GZ area. RAMS, wind, and TV data were transmitted to the Project Manager and the Scientific Advisory Panel as input relating to the on- and off-site safety.

2.2.1 On-site Safety

Immediately prior to the nuclear detonation, a postshot reentry plan was prepared by the Test Director. All reentries into the on-site area after the detonation were under the direction of the Test Director as outlined in the plan or as prevailing conditions warranted. Immediately after the Sterling detonation, a postshot radiation safety survey of the on-site area was conducted to apprise the Test Director of the radiological safety conditions to be encountered by recovery parties. In addition, each recovery/reentry party was accompanied by a qualified Radiological Safety monitor while in the data recovery areas. During this period, the Test Director exercised control over all personnel entering the on-site area at the Tatum Dome. LRL Hazards Control and the Project Manager's on-site Rad Safe organization provided qualified monitors for the recovery parties and conducted the postshot radiation survey of the experimental area.

2.2.2 Remote Area Monitoring System--REECo and LRL

An array of RAMS units was installed on the surface around the zero location for remote monitoring of the surface radiation levels immediately following the detonation. Additionally, a single RAMS unit was placed several hundred feet down the emplacement hole and another single unit placed at the collar of Station 1A. (Refer to Chapter IV, Figure 4-9.)

2.2.3 Geophone Listening--SC and LRL

A vertical array of postshot listening devices was installed in E14C, as well as collapse slifer instrumentation in PS-1, for detection of underground disturbances immediately following the detonation. This information was continuously recorded in the Test Director's Trailer.

2.2.4 Surface Television Monitoring--ACFI and LRL

Closed circuit television was operated to observe Ground Zero at shot time.

2.2.5 Surface Photograph--EG&G

Zero time photography consisted of 2 fixed camera station locations for the purpose of effluent history documentation in the event of a release.

2.2.6 Zero Site Weather--ARFRO-ESSA

Facilities were installed to provide surface wind direction and speed at the zero site with readout in the Test Director's Trailer.

2.3 POSTSHOT EXPLORATION

Although no postshot exploration was conducted, provision to reenter the cavity through the 9-5/8 inch casing on which the device was lowered was incorporated in the Sterling emplacement hardware and cable design.

2.4 TEST DIRECTOR'S STAFF

2.4.1 Administrative and Technical Support

a. Field Services--LRL

This group was responsible for daily and long-range operational coordination of the various technical programs and support groups involved. This included collection and consolidation of all requirements for items such as transportation, communications, office and warehouse space, and equipment and other related items. In addition, they assisted in scheduling and notification of all signal dry runs, were responsible for establishing access lists to restricted areas, and prepared schedules, reports, and correspondence deemed necessary by the Test Director.

b. Field Test Logistics

On-site warehousing and on-site shipping services were furnished by this group to all technical agencies that requested such service. Temporary storage at the experimental site was arranged. At the conclusion of the program, facilities and assistance were available for packaging and shipment of material from the site.

c. Hazards Control--LRL

LRL Hazards Control provided a staff representative responsible to the Test Director for the shot-time on-site safety program, using the organization of the Project Manager in establishing and enforcing on-site safety criteria.

d. Documentary Photography--LRL

Important activities of the experiment were recorded in the form of movies and stills in both color and black and white by the Photographic Section of the Graphic Arts Department. Additional photographic coverage was available through this group, consistent with their responsibilities and limitations. Facilities for the storage and processing of film were available when required.

e. Classification Guidance--LRL

The plans for Sterling were reviewed by the AEC and LRL Classification Offices. Classification guidance for Project Sterling was issued by the AEC Nevada Operations Office on August 17, 1966 (reference No. PAA:JHP-238, classified "Confidential, Restricted Data"). This guidance, along with supplementary guidance issued, provided the basis for answering the majority of classification questions concerning Project Sterling.

2.4.2 Engineering Support

a. Device Systems Engineer-LRL

LRL provided a Device Systems Engineer who assumed the responsibility for all device activities. He also advised the Test Director in matters relative to the compatibility and readiness of the timing and firing system.

b. Timing and Firing--EG&G

EG&G was responsible for providing all timing signals required by the various experimenters as well as the actual firing signals for the detonation of the Sterling device and HE shot. All signals originated from the Timing-and-Firing Trailer located at the CP. In general, signals to experimenters on-site were provided via hardwire and signals to experiments off-site were transmitted via radio.

c. Engineering and Construction--LRL

This section was responsible to the Test Director for the development of all engineering-and-construction (E-C) criteria for the technical program. In the early planning stages, they developed the scientific engineering design criteria, and participated in the review of contract documents. During the construction period, they served in a liaison capacity between the A-E, (architect-engineer) AEC, and Test Director, reviewing construction activities to assure consistency with the needs of the technical programs. Once the operational phase began, all field support associated with the technical program was coordinated by this section upon request of scientific personnel.

d. Electrical Systems Engineer--LRL

The Electrical Systems Engineer was responsible to the Test Director for the electrical and electronics systematics for all technical participants.

e. Electrical Cable Coordinator--LRL

The electrical cable coordinator was responsible for the gathering of cable criteria, overseeing its installation, and assuring continuity.

f. HE Test--LRL

Procurement, assembly, arming, and supervision of the emplacement of the explosive was done by LRL. Timing and firing was accomplished in the same manner and by the same group as described for the nuclear detonation.

g. Grouting Services--Waterways Experiment Station

WES provided technical support to the Test Director in the grouting of all instrument and emplacement holes. While actual placement of grout was accomplished by other contractors, WES provided the designs and tests of the mixtures used. Their laboratory design of these mixtures was in accordance with needs specified by the Test Director. WES personnel in the field furnished surveillance over the batching, mixing, and placement of all grout for the technical program. WES also provided personnel and equipment to monitor the weight of the device hardware and stemming material in the emplacement hole. In addition, the experience of the WES personnel was invaluable in suggesting and giving solutions to certain technical programs in the stemming of holes penetrating the cavity.

2.5 EMPLACEMENT PLAN

2.5.1 HE Shot

The HE chemical explosive shot was emplaced at Station 4, located approximately 1,142 feet south of Station 1A (Sterling GZ). Station 4 is a 12 1/4-inch diameter hole, 2,717 feet deep, with an underreamed section 39 inches in diameter by 8 feet long at the bottom. A charge of about 4,500 pounds of nitromethane was placed in the underreamed section of Station 4, with 500 feet of pea gravel stemming above the charge. The remainder of the hole above the pea gravel was left unstemmed. Following the HE shot and prior to the nuclear event, this hole was filled with brine.

2.5.2 Nuclear

The nuclear explosive was emplaced at the center of the Salmon cavity, using the recovered Salmon emplacement hole (Station 1A). The device was lowered on 9 5/8-inch OD diameter casing. The emplacement hole was stemmed with 560 feet of solid, grout plug at the bottom, with 2,100 feet of granular material to the surface. (See Figures 2-7 through 2-15.)

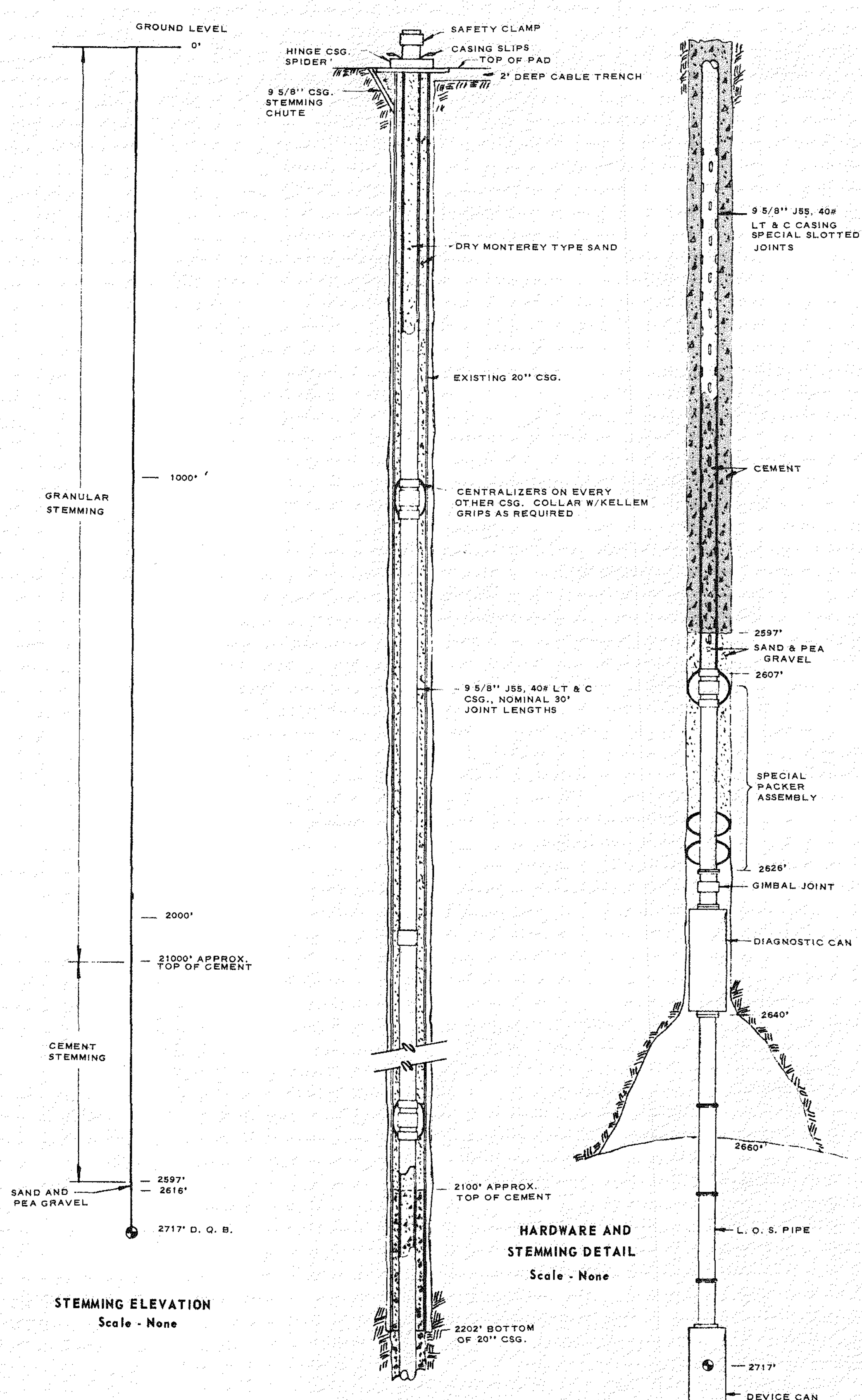


Figure 2–7 Station 1A Emplacement and Stemming Plan

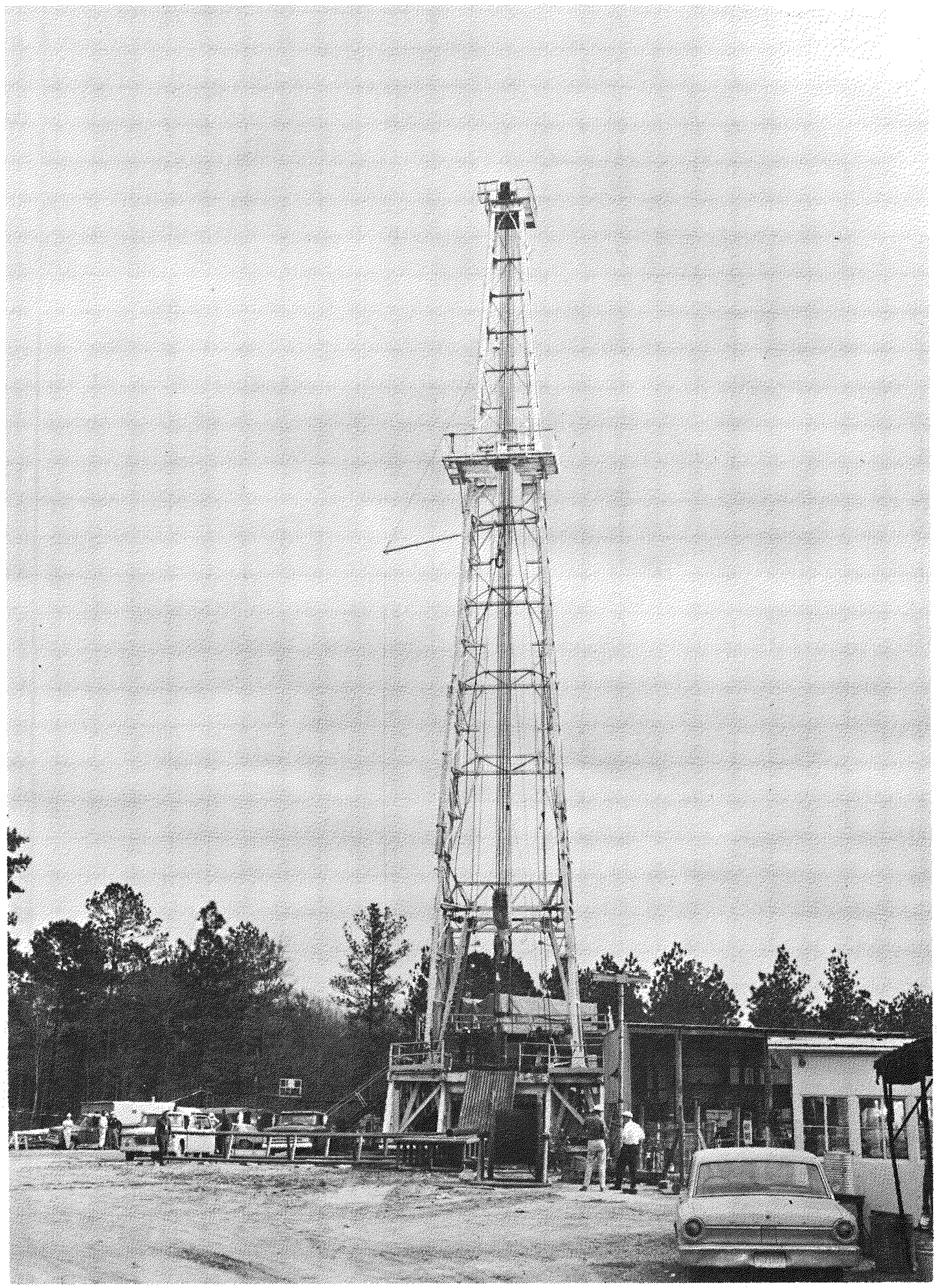


Figure 2–8 The Drill Rig Over the Shot Hole

Figure 2–9 Device Package Being Lowered into the Emplacement Hole

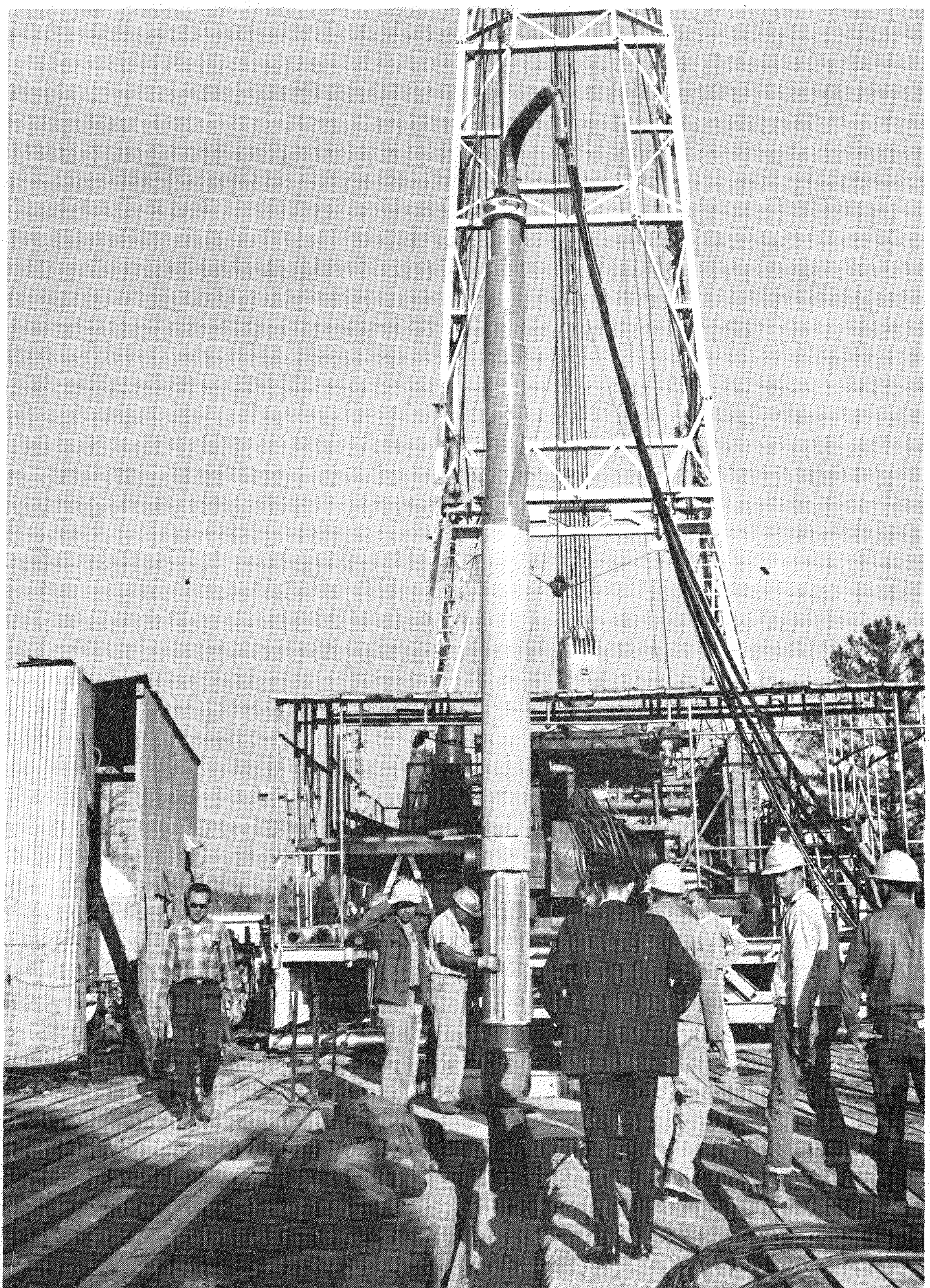


Figure 2–10 Device Cannister Being Lowered into Emplacement Hole

Figure 2–11 The Device Cannister Suspended Over the Shot Hole

Figure 2–12 Preparing to Lower the Packer Assembly

Figure 2–13 Lowering the Packer Assembly

Figure 2–14 Lowering the Packer Assembly with the Device Cannister

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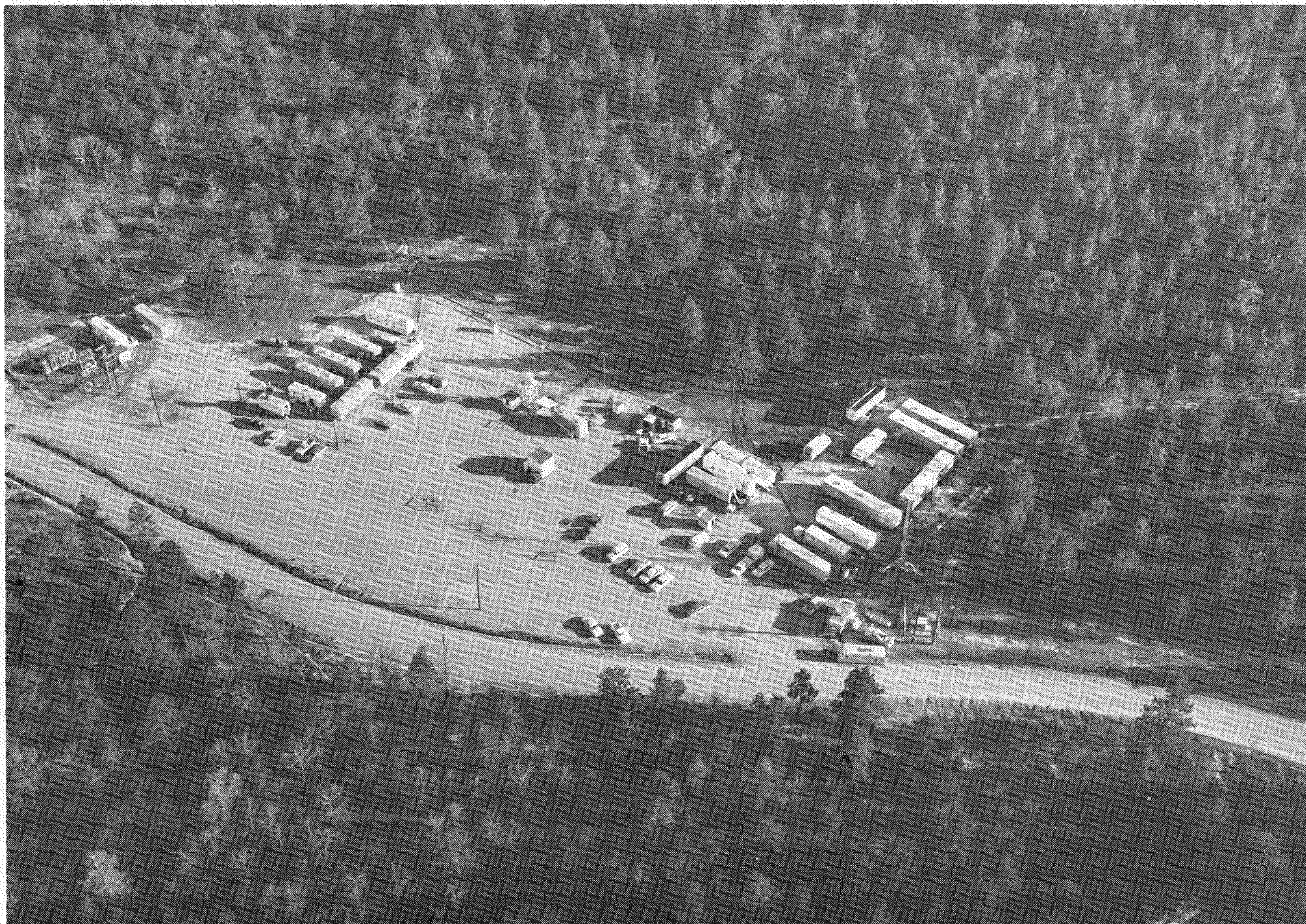

Figure 2–15 The Combined CP and Test Director's Manned Barricade

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2.6 SUPPORTING FACILITIES

2.6.1 CP

The Salmon CP and TDMS areas were incorporated for Sterling at the Salmon TDMS area. Some expansion was necessary to additionally accommodate the Project Manager's organization. All Sterling postshot functions of the Test Director's organization were conducted from this Salmon-identified TDMS area. This included timing and firing, postshot RAMS, and geophone readout/record data, CCTV coverage of the Surface Zero location and the assembly of all personnel, except those exempted by the Test Director, concerned with postshot data recovery and safety monitoring of the site. The CP area was graded and stabilized to accommodate about 25 trailers and had the necessary utilities for the proper functioning of all project activities at this location. (See Figure 2-15.)

2.6.2 Recording Areas

a. GZ Recording Park - LRL facilities at this location (Figure 2-1) recorded device performance and the signals from the PS-1 and PS-2 instrumentation.

b. Salmon Recording Trailer Park - SC facilities at this location recorded material motion data from E-6, E-11, E-13, and E-14 complex (Figure 2-1).

2.6.3 Device Assembly Area

The Salmon device assembly area (Figure 2-1) was reused for Project Sterling. This site consisted of a graded and stabilized area, fenced for security purposes, and provided with utilities to support one trailer. In the vicinity of the assembly area, an earth revetment was available for assembly and storage of high explosives.

2.6.4 Scientific Cable

Instrument and timing-and-firing cables of various types were reused from Salmon or newly installed as necessary between the CP, the emplacement locations, the instrument locations, and recording facilities.

2.7 CHRONOLOGY

2.7.1 Background

On October 22, 1964, a nominal 5 kt nuclear explosive was detonated at the Tatum Salt Dome Site near Hattiesburg, Mississippi. This shot, the Salmon Event of Project Dribble, was fired as a part of the joint AEC/DOD sponsored Detection Program under the technical direction of LRL.

Salmon was fired at the bottom of a normal 18-inch OD hole at a depth of 2,717 feet below the surface in a tightly tamped configuration. The device was suspended on a string of 5 1/2-inch OD 17 #J-55 casing in which every third joint was slotted to permit equalization of stemming. The hole was cased to a depth of 2,200 feet and uncased from 2,200 feet to TD. The hole was stemmed with 600 feet of salt-matching instrument grout and 2,100 feet of dry pea gravel.

Following the Salmon detonation, an uncollapsed nearly spherical cavity was found to exist. This cavity had an equatorial diameter of approximately 110 feet and a vertical height of 87 feet. Two postshot holes were drilled into the cavity to permit sampling and testing of the cavity. (See Figure 2-6.) These holes were left capped at the surface at the conclusion of the Salmon Project After determining that the cavity created by the Salmon Event was standing and appeared to be stable, an experiment was proposed to evaluate the decoupling properties of that cavity by firing a low yield device in the center of the cavity. This experiment was nicknamed ROGUE and later became Project Sterling.

2.7.2 Sterling Shot Data

The Project Sterling nuclear explosive was executed in the cavity created by the Salmon explosion. Sterling had a yield of 350 tons (0.35 kt). Detonation took place on December 3, 1966, at 12:15:00 GMT (0615 CST).

CHAPTER III

PROJECT OPERATIONS

3.1 OPERATIONS COORDINATION

On-site project operations for the Sterling Event including coordination of technical, safety and security programs were implemented by the Operations Coordination Center. The Project Manager's Instructions and Schedule of Events were issued for guidance and compliance by all project participants.

3.2 REAL ESTATE

The major item of real estate at Project Sterling is the Tatum Dome Leasehold comprising about 1470 acres in Lamar County, Mississippi. Other important parcels near the Tatum Dome Leasehold are the Control Point and Test Director's Manned Station, Warehouse and Storage Area, Official Observer Area, Helicopter Pad, and the Communications Tower Site. All these areas, except for the Official Observer Area and the Helicopter Pad, were holdovers under renewable lease agreements from the Salmon Event of Project Dribble.

NVOO also had the Project Office and parking lot in Hattiesburg, Mississippi. For Project Sterling, NVOO arranged office space in Hattiesburg for USPHS and the Joint (AEC/DOD) Office of Information. Office space was also arranged in Purvis, Mississippi for USC&GS. In addition to the Tatum Dome Leasehold and office space in Hattiesburg and Purvis, 12 permits were obtained for USC&GS seismic stations. Ten stations were from 1 to 5 miles from GZ around the site; one was 10 miles south of GZ; and one was 20 miles southwest. On the 10 close-in stations, arrangements included construction of 3'x5'x6" concrete pads with access rights to the pad locations. On the 2 more distant stations, permits were obtained for parking a USC&GS instrument van and setting out instrument lines.

Control of real estate activities other than administrative space in Hattiesburg and Purvis was centralized in the Project Operations Division, NVOO. Requests for real estate with descriptions and purpose of requests were submitted to the Director, Project Operations Division, NVOO, or to the AEC Site Manager, Project Sterling, as appropriate.

The AEC Site Manager forwarded requests to the Director, Project Operations Division, NVOO. Agencies under the technical control of the Test Director, LRL, submitted requests to the Test Director for review and forwarding to the Director, Project Operations Division, NVOO.

After review and coordination by the Project Operations Division, the requests were forwarded, through appropriate AEC channels, to the U. S. Corps of Engineers, Mobile, Alabama. All negotiations and arrangements with the owners for real estate were conducted by the Corps of Engineers for the AEC, except arrangements for the USGS seismic stations which were made by USGS.

3.3 SAFETY AND WELFARE OF AREA RESIDENTS

3.3.1 Fire Protection

A fire truck with operators was stationed at the warehouse area as standby during the evacuation period, for use at residences of evacuated residents if required. Three pickups and operating personnel with radios and fire extinguishers were also on standby at strategic locations. In case of a fire in the evacuation area, these units were available for immediate emergency use while awaiting the arrival of the fire truck.

3.3.2 Housing Facilities

A survey of motel and hotel facilities in surrounding communities was made to assure that sufficient housing accommodations could be made available if evacuated residents desired them.

3.3.3 Water Facilities

A supply of filled arctic type water cans was maintained at the warehouse area to furnish potable water to residents whose water supply (wells) might be damaged from the detonation. A water truck was also available to furnish emergency water for livestock, if required.

3.3.4 Ambulance

One ambulance was on standby, with a USPHS doctor, at Baxterville, Mississippi, to provide emergency service to residents and others as required; arrangements were made for an additional ambulance if needed.

3.3.5 Transportation

Transportation was made available, as requested by USPHS, to aid residents being evacuated if the residents indicated a need for this service.

3.3.6 Propane/Butane Mechanic

A propane/butane gas systems mechanic was on standby at the warehouse to assist residents if gas heaters or appliances should become inoperative as a result of evacuation or the detonation.

3.4 AIR OPERATIONS

Arrangements for aircraft support were made by the Project Operations Division, NVOO, and aircraft requests were submitted to the Director, Project Operations Division. During the operational period, aircraft requirements were coordinated through the OCC at the Project Site.

The Air Operations Plan was prepared and issued by the Nuclear Field Operations Group of AFSWC.

The air space within a 20-mile radius of GZ to an altitude of 15,000 feet MSL was specified a restricted area on D-day by the FAA, except for aircraft participating in the event. A representative of the FAA, Houston, Texas office, was at the CP on D-day. The FAA Office in Houston issued NOTAM's (Notice to Airmen) for air space restrictions.

On D-day, 7 aircraft were required, of which 4 were helicopters. All aircraft were stationed at the Hattiesburg Municipal Airport except on D-1 when the helicopters were stationed at the Helicopter Pad for use on D-day. Because of the early shot time, with resulting poor visibility, the helicopters remained on the pad at H-hour. The ARMS aircraft and the USPHS C-45 were airborne during H-hour. The U3A remained at the Municipal Airport. After H-hour, when visibility permitted, one helicopter made several low-level passes over and around SGZ for radiation monitoring purposes.

3.5 OPERATIONS FIELD OFFICES

A field office for the Deputy Project Manager for Operations was established in Hattiesburg, Mississippi, on October 31, 1966. A trailer located behind the main AEC office was used for this purpose. This office was closed on December 6, 1966.

The Operations Coordination Center (OCC) at the Project Sterling CP was activated on November 10, 1966, and was placed on a 2-shift basis starting at 0800 hours, November 19 when the device was delivered to GZ. An Operations Coordinator was on standby at Hattiesburg for the overnight hours and was on call to all agencies in case coordination assistance was required. The OCC was placed on a 24-hour basis beginning November 26. The OCC was closed at 1800 hours, December 5.

3.6 OPERATIONAL PROBLEMS

There were 3 last minute operations coordination problems for Sterling: (1) Unanticipated cultural seismic noise which required roadblocks at distant seismic stations; (2) due to signal propagation problems at shot time, there were not enough radios for the far-out seismic stations, nor for the USPHS population evacuation; and (3) the roadblocks required the recruiting of additional personnel.

3.6.1 Seismic Station Noise Controls

Essentially the Laboratory found that vehicle traffic in the vicinity of the off-site seismic stations caused high cultural seismic noise that had not been identified earlier. A last minute request was made to the OCC to control traffic with roadblocks during the HE calibration shot and the Sterling Event.

At a meeting of the Project Manager's Advisory Panel on November 7, at NVOO, the Test Director requested that some system of traffic control be established around 3 or 4 seismic stations (USGS and USC&GS) ranging from 10 to 30 miles from GZ.

a. <u>Calibration Detonation</u>

On November 14, at a meeting of LRL, USGS, USC&GS, and NVOO at Hattiesburg, LRL requested that traffic controls be established around 8 seismic stations, 7 to 50 miles from GZ, for the HE calibration shot to be detonated at 0400 hours, November 17, at Station 4.

In order to comply with this request, personnel were recruited from REECo, WSI, and USPHS to man roadblocks at critical locations on roads leading to or near geophone lines laid out at the various seismic stations. Roadblocks varied from 2 at each of 4 locations to a high of 5 roadblocks for one seismic station. A total of 23 roadblocks were manned. Roadblock locations were selected on a crash basis by OCC personnel. Each station was visited by the individual assigned to make it easier for him to locate it in the dark of the shot morning.

The HE calibration detonation was executed as scheduled at 0400 hours, November 17. All roadblocks were manned by 0300 hours as planned. USPHS, REECo, and WSI are to be commended for the excellent cooperation they extended in order to meet the scheduled time.

b. Project Sterling Detonation

As a result of the information obtained from the HE calibration shot, LRL and USGS deemed it advisable to request traffic controls at 2 additional seismic stations, one about 10 miles south of GZ and the other about 70 miles north. In addition to vehicle traffic control, the Laboratory requested that efforts be made to hold rail traffic between Purvis and Picayune, Mississippi, from H-10 minutes to H + 40 minutes, on the Southern Railway. Trains traveling between these towns would tend to obliterate signals on several seismic stations in the vicinity of the railroad route. This was accomplished through the excellent cooperation of the railroad officials in the Hattiesburg office of the Southern Railway.

3.6.2 Communications

The area of communications presented another problem. Shortage of mobile radios threatened to hinder some of the programs, particularly (1) the USPHS effort in population survey and evacuation procedures, and (2) the maintenance of adequate communications between the CP/TDMS and the off-site seismic stations. This problem was overcome by establishing priorities for delivery of additional equipment owned by participating agencies, and by loaning radio equipment not committed at event time.

The HE detonation also revealed that existing communication facilities between the CP/TDMS and far-out seismic stations were not adequate. Additional equipment was obtained and installed and some mobile radio units were interchanged to overcome this problem prior to the execution of Sterling.

3.6.3 Personnel Shortage

Shortage of personnel for the seismic station roadblocks presented another problem. As the personnel used for the HE detonation were required for other important duties during the nuclear detonation, REECo was requested to provide the necessary manpower for the roadblocks. Residents within the immediate vicinity of the seismic stations were recruited for this purpose, and on D-day all roadblocks were manned as scheduled.

3.7 SCHEDULE

3.7.1 Project Manager's Special Instructions and Schedule of Events

The "Project Manager's Special Instructions" were published on November 25, 1966, after coordination with the LRL Test Director. The "Schedule of Events" was published on November 30. Late submittal of agency event cards delayed issuance of the "Schedule of Events."

3.7.2 Original D-day

D-day was originally set for November 29, 1966. Technical difficulties with the refrigeration system were encountered on November 23 and a new date was tentatively set for December 1. Later, difficulties were encountered while grouting the shot hole and on December 1, a new date was set for December 5. On the morning of December 2, however, new difficulties were encountered with the refrigeration system, and it was decided to set the detonation time for 0600 hours, December 3, because of the possible deteriorating effect that a loss of cooling could have on the device. A readiness briefing was set for 1500 hours at the Sterling CP on December 2.

3.7.3 Readiness Briefing - December 2, 1966, 1500 hours

H-hour was set for 0600 hours, December 3, 1966, and muster of the leasehold area started at 1600 hours, December 2. All off-site roadblocks were in position at 0550 hours, December 3. The device was detonated at 0615 hours, December 3, 1966. All roadblocks were released, on- and off-site, by 0800 hours, and all areas were opened at this time except the GZ area. Nine roadblocks around Zone "B" (2-mile perimeter) and 7 roadblocks around the downwind sector, Zone "C," were manned by the Mississippi Highway Patrol.

3.8 ROADBLOCK AND EVACUATION PROCEDURES

Evacuation of residents from the selected evacuation zones was the responsibility of USPHS. However, the establishment and readjustment of roadblocks controlling access to the evacuation zones were the responsibility of the OCC.

The area surrounding Sterling GZ was divided into three zones for evacuation and control purposes:

(1) Zone "A" included the fenced Tatum Dome Leasehold area consisting of 1470 acres. No residences are in this area. Roadblocks controlling Zone "A" were manned by WSI.

(2) Zone "B" was the area extending from the fenced leasehold out to a radius of 2 miles surrounding Sterling GZ. Residents within this area were to be evacuated preshot on a voluntary basis. Roadblocks controlling this area were to be manned by civil authorities.

(3) Zone "C" was a truncated downwind sector beginning at the 2-mile radius and extending out to the 5-mile radius from Sterling GZ. Residents in this area were not to be evacuated preshot. Roadblocks controlling this area were to be manned by civil authorities.

Roadblock locations on the 2- and 5-mile perimeters were selected, numbered, and staked. The area was further divided into 30-degree sectors, and roadblock locations along the sector lines between the 2 perimeters were also selected, numbered and staked. Thus, when the downwind sector was finally determined, the persons who were to man the roadblocks could proceed to their assignment without undue delay. Roadblock locations were marked on area maps which were issued to the various concerned agencies.

Several days prior to D-day the District Inspector, Mississippi Highway Patrol, District of Hattiesburg, was given a set of maps and briefed on evacuation and control procedures which would be in effect during the area closure and control period. On the morning of D-day, before departing for the Project Site, the patrolmen assigned to roadblock duty were briefed by a member of the staff of the AEC Deputy Project Manager for Operations on the procedures and special instructions at their particular stations. As the patrolmen were not familiar with the locations of the roadblocks, they were escorted to their stations by members of the OCC.

Excellent cooperation was received from the Mississippi State Highway Patrol. Their efforts, willingness, and efficiency contributed greatly to the successful culmination of Project Sterling. This is particularly outstanding considering the short notice available when technical problems dictated advancing the shot time 48 hours ahead of the scheduled December 5 date. The Highway Patrol provided their own transportation and used their own communications system on normal frequency. The District Inspector and one of his assistants, who operated the Highway Patrol radio, were at the OCC during the event to relay necessary instructions to the roadblock personnel.

At the readiness briefing held at 1500 hours, December 2, it was decided to set H-hour at 0600 on December 3. Because of the wind direction forecast for 0600 hours, a downwind sector of 90° towards the north, bearing 300° to 30°, was selected as Zone "C." Roadblocks around Zones "B" and "C" were in position by 0300 hours. At the 0400 readiness briefing on D-day, it was revealed that the wind direction was now forecast from the north, necessitating a change of the downwind sector. A new 90° sector, bearing 150°-240°, was selected. This resulted in a shifting of personnel from the north 90° sector to the roadblocks surrounding the new downwind sector to the south. This was accomplished efficiently and all roadblocks were in place by 0550 with no delay to the event. Project Sterling was detonated at 0615 hours. Because of visibility conditions the shot was delayed 15 minutes from the scheduled time.

A total of 16 roadblocks were manned by the Mississippi Highway Patrol, 9 on the 2-mile perimeter, Zone "B," and 7 around the final downwind sector, Zone "C." Three units held in reserve at the CP were used to accelerate the manning of the new downwind sector after the 0400 briefing.

An OCC representative was at the main roadblock on the Purvis-Columbia road, 2 miles east of the site, to screen project personnel requiring access to the site. One other OCC representative was at a roadblock at Zone "C" to assist in relocating roadblocks if necessary.

Immediately after the conclusion of the readiness briefing of December 2, USPHS advised the residents in the 2-mile radius area of the scheduled shot time for the next morning. Most residents had previously indicated that they would leave their homes on the evening of D-1. All residents, except one family of two, did leave on the evening of December 2. The one family remained at home until 0300 on December 3, to take care of brooders with a large number of chickens. USPHS obtained information from the residents as to their destination and how each could be contacted.

In order to safeguard the property of the evacuees while they were away from their residences, the Lamar County Sheriff maintained surveillance patrols throughout the area from about 1700 hours, December 2, to 0300 hours, December 3, when the roadblocks around the area were activated. Excellent cooperation was received from the Lamar County Sheriff's Office in supporting the AEC.

At about H + 45 minutes the Project Manager issued directions for the return of the evacuated residents to their homes. The residents were contacted by representatives of USPHS who began escorting families through the roadblocks to their residences. At H + 1 hour and 45 minutes all roadblocks were removed and residents returned at will. The evacuation and return of residents was conducted in an efficient and orderly manner. Persons evacuated were paid at an approved rate for the time they spent away from their residences. Evacuation payments were completed by 1200 hours on the day of the event.

3.9 MANPOWER REQUIRED FOR OPERATIONS COORDINATION CENTER

An original force of 2 OCC personnel arrived on site October 29, 1966. One man was assigned to the Operations Field Office in Hattiesburg. The second man began setting up the OCC trailer at the CP and conducting road and area surveys for positioning of roadblocks. Two additional men arrived on site on November 20. A fifth man arrived on November 25.

3.10 CLAIMS

In order to accurately evaluate possible complaints or damage claims, or both, from the Sterling detonation, preshot surveys were made of selected structures by John A. Blume and Associates, Engineers. In addition, seismic stations were installed by USC&GS at various selected locations surrounding the shot point; all domestic water wells were surveyed and documented within 5 miles of GZ by USGS.

Arrangements were made with the General Adjustment Bureau to have personnel on hand at shot time to answer complaints as soon as possible.

3.11 SS NUCLEAR MATERIAL MANAGEMENT

SS Nuclear Material Accountability Facility NAB at NTS maintained the accountability of SS Material used in the project, and prepared the necessary Certificates of Expenditure which were forwarded to the Chief of Security for execution by the AEC Project Manager and the LRL Test Director.

CHAPTER IV

SAFETY PROGRAMS

4.1 WEATHER AND RADIATION PREDICTIONS

4.1.1 Responsibilities, Objectives, and Organization

The Air Resources Field Research Office of the Environmental Science Services Administration (ARFRO-ESSA) was responsible for providing meteorological data and weather forecasting for Sterling. The primary objective of ARFRO, Las Vegas, was to provide predictions of the dispersion of any radioactive effluent which might have been released as a result of Sterling. Specific tasks of ARFRO were to measure, analyze, and disseminate meteorological data to Sterling participants. This data was to be collected prior to the shot, and collected continuously during the minutes and hours surrounding Zero Time; later data was collected to provide postshot analyses, records, and reports consonant with the technical experiment demands.

The technical program and safety measures both established the Sterling weather requirements as follows:

(1) Surface wind speeds of less than approximately 20 mph.

(2) Cloud ceiling and visibility sufficient to permit aircraft operations at and below the predicted upper limit of vertical mixing.

(3) No precipitation.

The Weather and Radiation Prediction Unit (WRPU) was responsible for the collection and interpretation of meteorological data and for advising test personnel on matters influenced by the state of the atmosphere. The WRPU functioned under the direction of the Director, Safety Evaluation Division, NVOO, with operational control of the unit exercised by the Project Manager (NVOO) during the execution period of Sterling. The Meteorologist in Charge, ARFRO, Las Vegas, acted as chief of the unit, which was composed entirely of technical personnel provided by that office. From the scheduled D-7 days to the actual shot time the unit consisted of 10 personnel: 6 meteorological technicians, who conducted surface, radiosonde, and winds-aloft observations and processed meteorological data; 1 electronics technician, who maintained meteorological equipment; and 3 meteorologists, who provided forecasts of meteorological parameters and prepared radiation estimates.

4.1.2 Procedures

The installation of meteorological equipment at the Sterling site was begun in October 1966. Instruments were located to provide data which would best satisfy the stringent safety requirements set forth in the Operational Safety Plan.

An M-33 Radar Upper-wind Station and a Meteorological Observations Trailer were emplaced in the CP area, about 1 mile ENE of GZ. A low-level wind direction and speed sensor was installed atop a 57-foot tower erected about 240 feet SW of GZ, with data telemetered to analog recorders in the Technical Director's Trailer and the Weather Operations Trailer in the CP area. A second low-level wind direction and speed sensor was installed at the top of a 40-foot tower in the CP area, with data telemetered to analog recorders in the Weather Operations Trailer only. Pibal Upper-wind Stations were established off-site at the Columbia, Hattiesburg, and Lumberton Airports, 18 miles NW, 21 miles NE, and 12 miles SE of GZ, respectively.

Hard-wire telemetry was used to transmit data from the low-level wind instrumentation to the Technical Director's Trailer and the Weather Operations Trailer. Radio and telephone communications were used to transmit data from the off-site winds-aloft stations. Facsimile and teletype receivers were installed in the Weather Operations Trailer for reception of regional and national meteorological information.

The original readiness date for the Sterling experiment was 0600 CST, November 29. Commencing November 19 (D-10) the following meteorological observations were conducted daily on a routine basis at the CP:

(1) Upper winds at 3-hour intervals from 0000 to 1500 CST.

(2) Hourly surface weather observations on a 24-hour-per-day basis.

Commencing D-5, upper-air pressure, temperature, and humidity observations were conducted at 0000 CST and at 0600 CST.

On D-day, which was rescheduled to December 3, the schedule of observations was as follows:

(1) Upper winds from the CP area at hourly intervals, beginning at 0000 CST. The frequency of these observations was increased to half-hourly as the H- hour, 0600 CST, approached.

(2) Upper winds from both Hattiesburg and Columbia Airports at hourly intervals, beginning at 0100 CST.

(3) Upper-air observations of pressure, temperature, and humidity in the CP area as required, commencing at 0100 CST.

(4) Low-level wind observations from the 2 on-site tower locations as required.

(5) Hourly surface weather observations supplemented by additional observations as necessary.

Climatological statistics applicable to Sterling were compiled as described above in the publication, "Final Report of Weather and Surface Radiation Prediction Activities for the Salmon Event - Project Dribble," by the Staff, USWB Research Station, Las Vegas, Nevada, December 14, 1965. Climatological data cited in the above document were supplemented by those obtained on-site during the operational phase of the Salmon Event.

At the request of the Project Manager (NVOO), special frequency summaries, by hour, of surface wind speed, cloud cover, rain, fog, and aircraft ceiling were prepared for the months of October, November, and December. These frequency studies indicated a high probability of meteorological conditions favorable for conducting Sterling during the early morning.

Teletype data and facsimile charts were the major source of information used in the preparation of the briefing forecasts. Radar reports concerning the precipitation field over Mississippi were provided by telephone by the Radar Observations Section, Weather Bureau Office, New Orleans. These data were plotted and analyzed whenever precipitation activity posed a threat to operations at the Sterling site. Regional streamline analyses of wind data at the 2-, 5-, and 10,000 foot levels MSL, supplemented by analyses of the surface weather pattern as required, were performed locally to provide additional weather information.

On the day of the event, the wind data obtained from local upper-wind observation sites and instrument positions were analyzed at each reporting time to define the existing wind field, determine the trajectory of radioactive materials should leakage occur, delineate the area which would be affected by such a release, and estimate the arrival time of the radioactivity at downwind locations. Temperature profiles were analyzed to determine the thermal stability of the atmosphere and its effect on potential effluent cloud height.

4.1.3 Weather and Radiation Briefings

Formal weather and radiation briefings were presented to the Project Manager and his Advisory Panel at 1500 CST, December 2, and 0400 CST, December 3.

Each formal briefing presentation consisted of the following graphic displays:

(1) The latest surface analysis when required to clarify the forecast.

(2) The latest 5,000-foot MSL streamline analysis.

(3) A streamline prognosis for H-hour at 2- or 5,000 foot MSL, the altitude selected depending upon the predicted vertical extent of the potential gaseous cloud.

(4) Forecast air trajectories in 6-hour increments to H + 24 hours at 2 and 5,000-foot MSL.

(5) Forecast clouds, weather, and low-level winds during the period from H-hour to H + 12 hours.

(6) Predicted vertical profiles of wind and temperature at H-hour.

(7) The predicted total external gamma dose due to cloud passage as a function of distance downwind from GZ which would result from the short-period leakage of radioactive gases.

(8) The orientation and extent of the area which would be affected by an accidental release of radioactivity, as determined from the predicted shot-time winds.

4.1.4 Weather Chronology

On December 2, the Sterling site marked the western periphery of a ridge of high pressure which extended eastward into the Atlantic. This system produced partly cloudy skies and light southerly winds over the southern half of Mississippi. A weak cold front, orientated NE-SW, was positioned over extreme northern Mississippi and was moving south-eastward. Behind this frontal system, which extended from New England into central Texas, a huge high pressure area, or anticyclone, blanketed the north-central states. This anticyclone was expected to continue moving eastward, pushing the cold front well south of the Sterling site by 0600 CST, December 3. This pattern would produce extensive cloudiness, a likelihood of light rain showers, and southeasterly surface winds over the Sterling site. Winds-aloft were expected to remain essentially westerly.

A readiness briefing was held at 1500 CST, December 2, and the weather forecast (valid from 0600 to 1800 CST, December 3) was presented. It is summarized as follows:

(1) The predicted vertical temperature profile indicates that the mixing layer will extend to about 500 feet above the surface initially and deepen, by mid-day, to about 5,000 feet above the surface.

(2) The winds at scheduled shot-time, 0600 CST, will veer from 140° at 5 knots at the surface, to 230° at 15 knots at 5,000 feet MSL. As the day progresses, surface winds will become more southerly and upper winds more westerly. Wind speeds at all levels will increase.

(3) Scattered-to-broken stratocumulus and altocumulus clouds and possible scattered, light, rain showers are anticipated.

(4) The air trajectory at 2,000 feet MSL is expected to be toward the north, and at 5,000 feet MSL, toward the east.

The briefing charts used in the presentation are shown in Figure 4-1. A follow-on weather briefing was held at 0400 CST, December 3, by which time it was apparent that the surface high pressure area was not moving eastward as rapidly as previously anticipated. In addition, the cold front, which passed over the Sterling site near midnight, had not moved as far to the south as had been forecast. Rain and fog were occurring in many areas to the rear of the front. These circumstances required that the following revisions be made to the previous weather forecast:

(1) Vertical mixing of any effluent cloud would be confined to the 1st 1,000 feet above the surface.

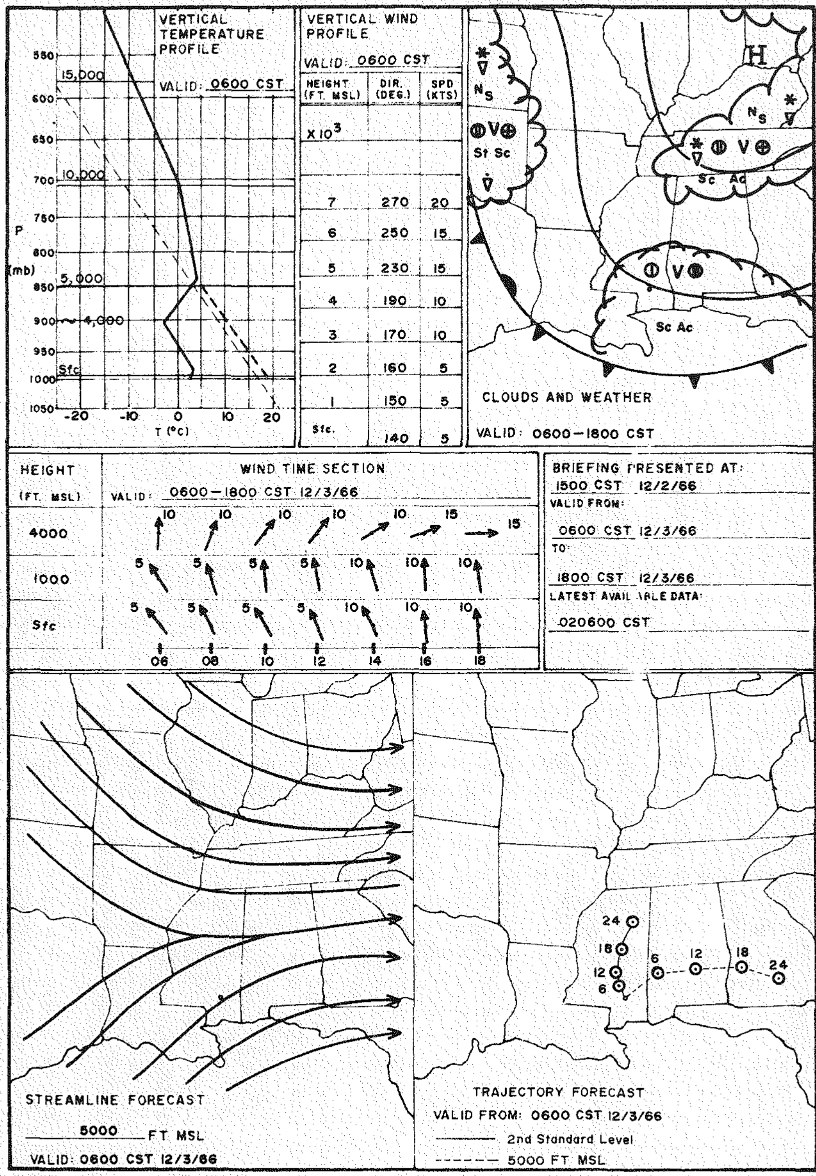

Figure 4—1 Weather Briefing Chart — 1500 CST, December 2, 1966

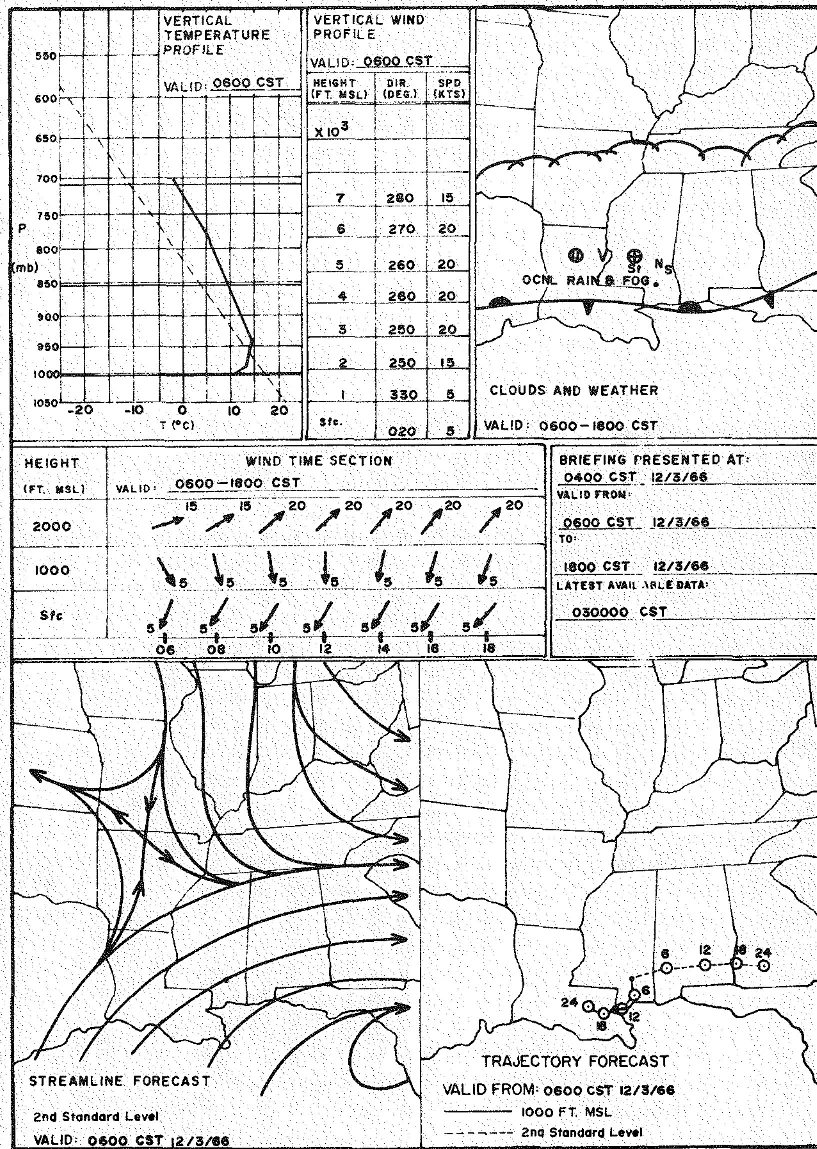

Figure 4—2 Weather Briefing Chart — 0400 CST, December 3, 1966

(2) The forecast winds at scheduled shot-time will back from 020° at 5 knots at the surface to 330° at 5 knots at 1,000 feet MSL. Above this point, winds will change abruptly to westerly at speeds of 15-20 knots. The winds in the 1st 1,000 feet above the surface will become more easterly during the day but little change in speed is anticipated. The winds above this level will become more southwesterly with time and speeds will increase slightly.

(3) The air trajectory at 1,000 feet MSL will be directed toward the south initially, shifting sharply westward after H + 12 hours. The trajectory at 2,000 feet MSL will be directed toward the east.

(4) Broken-to-overcast stratocumulus, stratus, and nimbostratus clouds are expected over the area. The occurrence of occasional rain and fog at the Sterling site is also anticipated.

The charts used in the 0400 CST briefing presentation are shown in Figure 4-2.

Meteorological conditions were acceptable for conducting the Sterling Event on the morning of December 3 and, at 0615 CST, the device was detonated. At shot-time, winds were ENE at 9 knots at the surface, backing with height to NW at 9 knots at 1,000 feet MSL. Lapse, or neutral, stability conditions existed from the surface to about 500 feet, with an extremely stable layer, almost 1,500 feet thick, above that point.

The shot-time vertical temperature profile; surface weather map at 0600 CST, December 3; and surface and 2,000-feet MSL streamline patterns at 0600 CST, December 3, are presented in Figures 4-3, 4-4, 4-5, and 4-6, respectively.

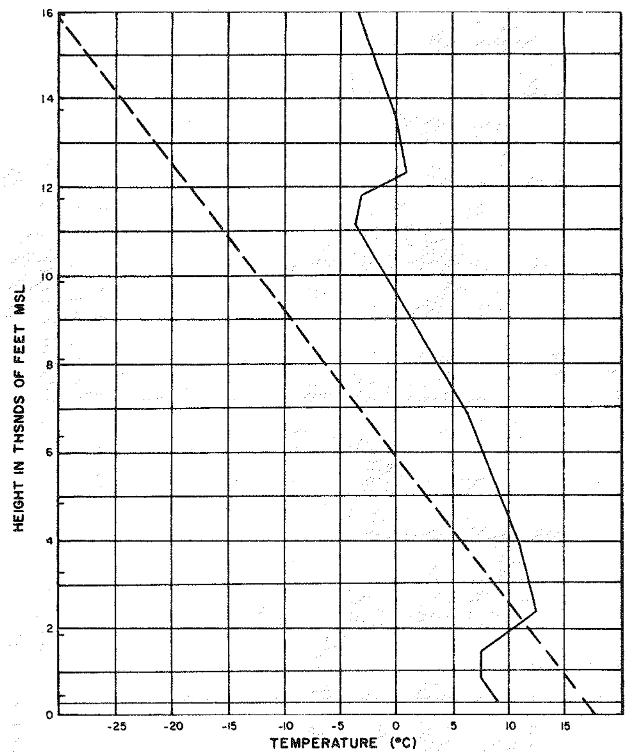

Figure 4–3 Vertical Temperature Profile – 0615 CST, December 3, 1966

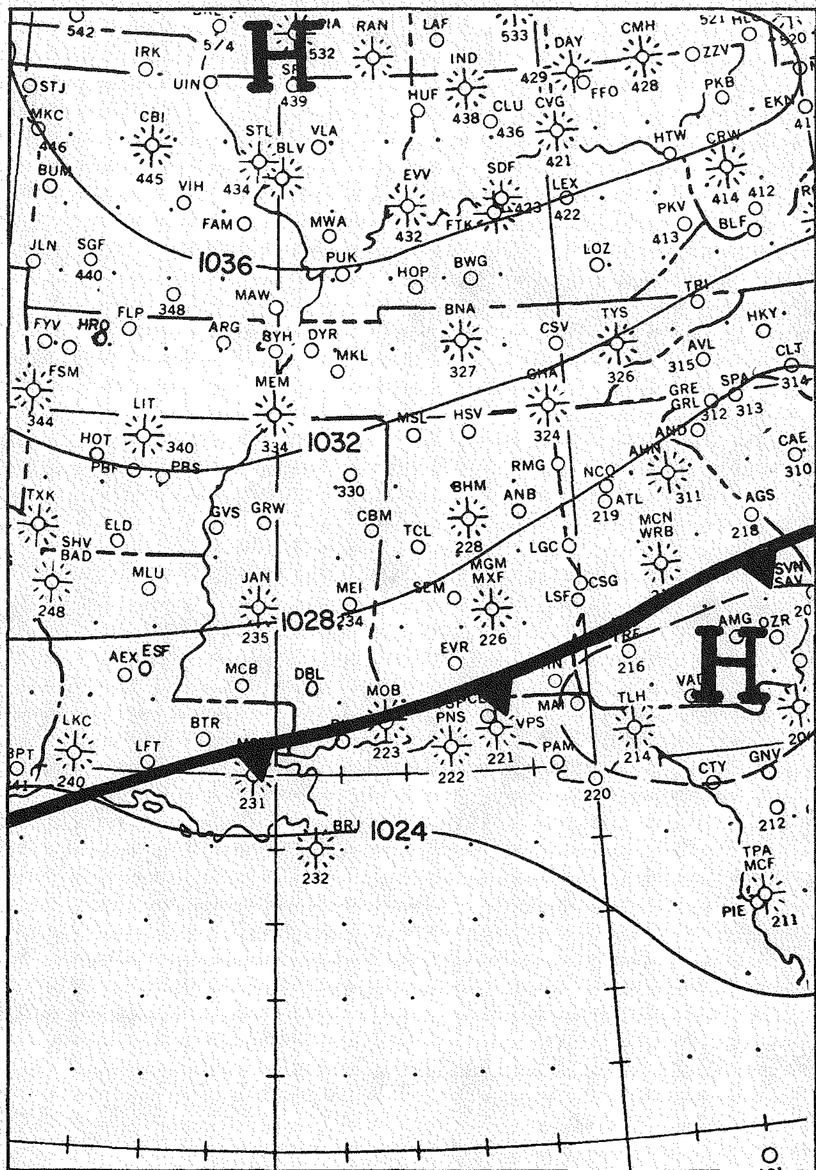

Figure 4-4 Surface Analysis - 0600 CST, December 3, 1966

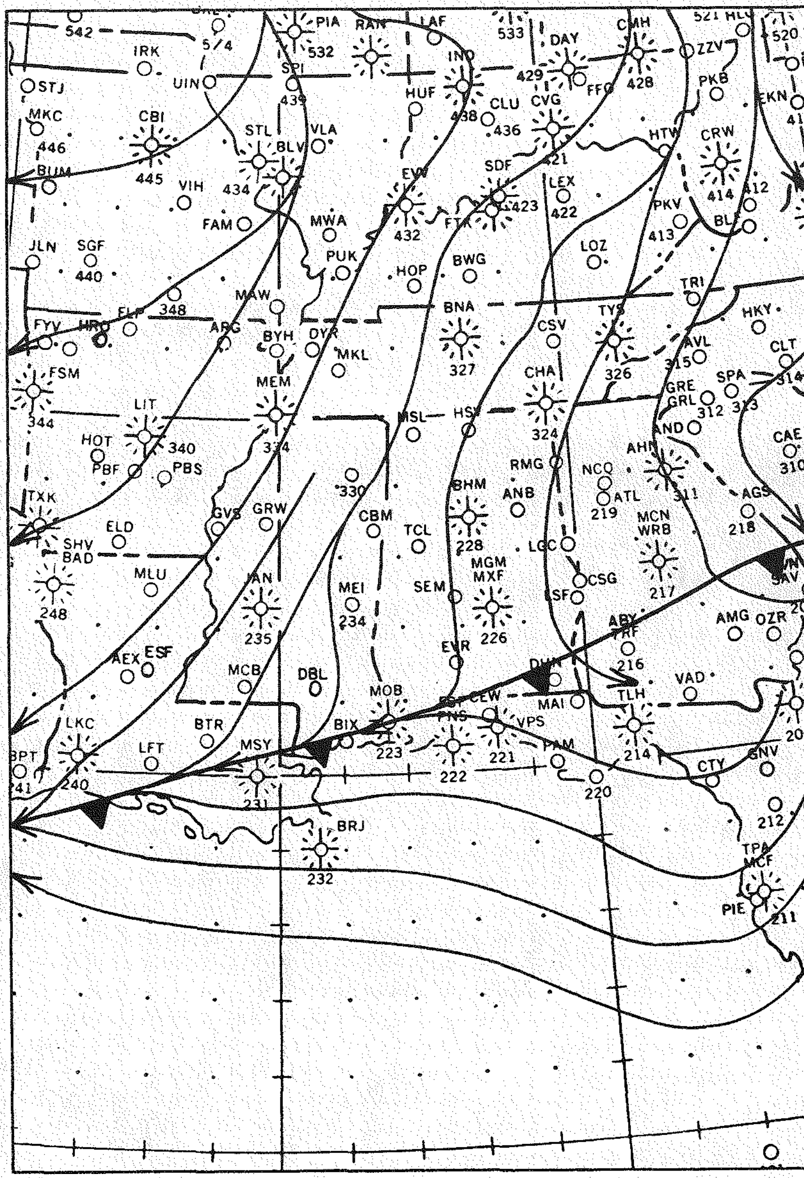

Figure 4-5 Surface Streamline Analysis - 0600 CST, December 3, 1966

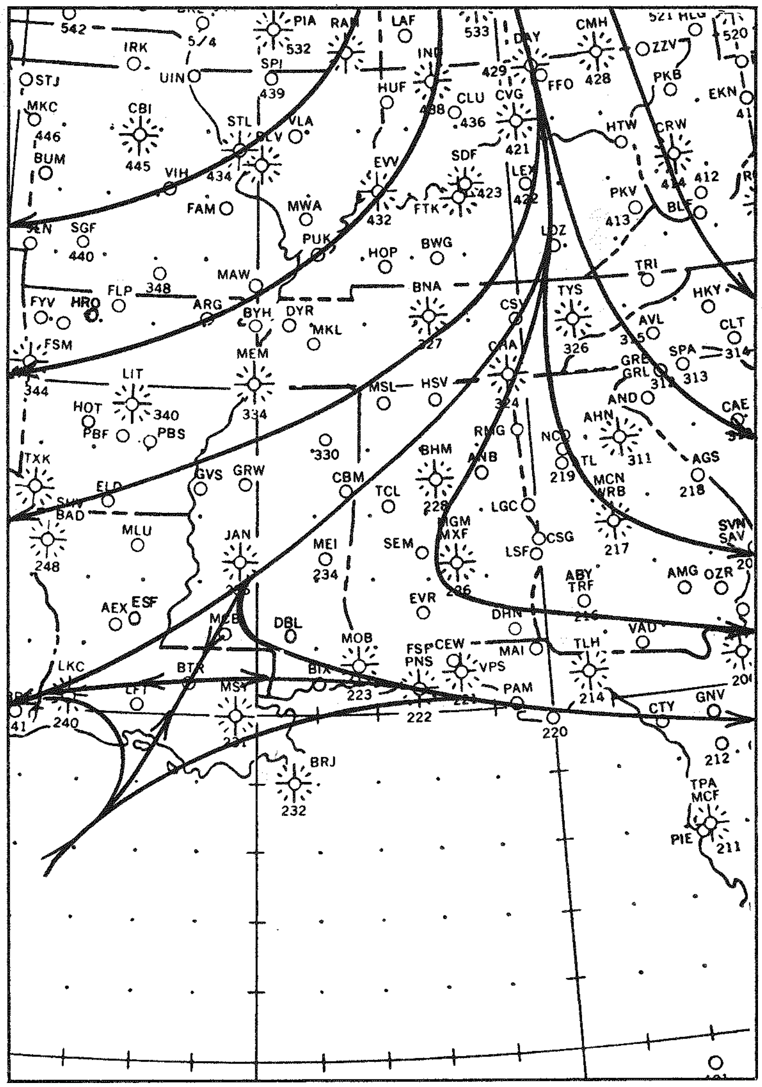

Figure 4–6 2000–foot MSL Streamline Analysis – 0600 CST, December 3, 1966

A complete tabulation of meteorological observations for December 3 is available on request from ARFRO, Las Vegas, Nevada. The tabulation has been omitted from this report since the release of radioactivity into the atmosphere as a result of the detonation was not detectable off-site and therefore did not constitute any hazard whatsoever to the off-site population.

4.1.5 Weather Forecast Verification

One measure of forecasting skill is the comparison of the Briefing Meteorologist's wind forecasts and "persistence forecasts" with the wind profile actually observed at shot-time. The persistence forecast is made by assuming that the last wind profile observed prior to preparation of the briefing forecast will persist until shot-time. The above comparison is presented in Table 4-1, and error evaluations in both speed and direction for each forecast level are shown.

TABLE 4–1 Wind Forecast Verification

EVENT DATE: 12/3/66
EVENT TIME : 0615 CST

BRIEFING DATE: 12/3/66
BRIEFING TIME : 0400 CST
VALID TIME : 0615 CST

BRIEFING DATE: 12/3/66
BRIEFING TIME : 1500 CST
VALID TIME : 3/0600 CST

HEIGHT MSL (10000')	OBSERVED WIND DIR SPD	PREDICTED WIND DIR SPD	0600 Z PERSISTENCE WIND DIR SPD	ERROR PREDICTED WIND DIR SPD	ERROR PERSISTENCE WIND DIR SPD	PREDICTED WIND DIR SPD	1200 Z PERSISTENCE WIND DIR SPD	ERROR PREDICTED WIND DIR SPD	ERROR PERSISTENCE WIND DIR SPD
7	310 12	280 15	--- ---	030 03	--- ---	270 20	260 21	040 08	050 09
6	310 13	270 20	--- ---	040 07	--- ---	250 15	280 20	060 02	030 07
5	290 15	260 20	--- ---	030 05	--- ---	230 15	290 19	060 00	000 04
4	280 18	260 20	--- ---	020 02	--- ---	190 10	290 17	090 08	010 01
3	260 18	250 20	230 23	010 02	030 05	170 10	260 17	090 08	000 01
2	290 13	250 15	230 18	040 02	060 05	160 05	240 17	130 08	050 04
1	310 09	330 05	270 09	020 04	040 00	150 05	220 05	160 04	090 04
Sfc	065 09	020 05	300 04	045 04	125 05	140 05	Calm	075 04	--- ---

Note: DIRECTIONS ARE RECORDED IN WHOLE DEGREES AND SPEEDS IN WHOLE KNOTS.
Note: PERSISTENCE WIND FORECAST IS THE LATEST ACTUAL WINDS-ALOFT REPORT AVAILABLE TO THE FORECASTER AT THE TIME THE FORECAST WAS PREPARED.

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4.1.6 Radiation Chronology

Prior to the event, the radioactivity which would be produced by the Sterling detonation was confidently expected to be wholly contained within the Salt Dome. The only conceivable accident was the possible emission of a small amount of radioactivity, primarily in the form of noble gases, through a crack or fissure in either the stemming system or the surrounding earth.

The maximum credible accident condition provided to the Radiation Prediction Unit by Lawrence Radiation Laboratory for Sterling postulated a total of 200 Curies of activity at H + 1 minutes released into the atmosphere within a period of several minutes after detonation. Using this source term, a decay rate of $t^{-1.2}$, the predicted wind conditions, and the estimated vertical rise of the effluent, a prediction was made of the total external gamma dose along the cloud centerline due to the effluent cloud passage.

The orientation and estimated crosswind extent of the region over which the cloud would be advected by the predicted winds was presented to the Project Manager and his Advisory Panel to apprise them of the potential area of concern.

Figure 4-7 depicts the predicted total gamma exposure dose levels presented at the final 0400 CST briefing on December 3. The initial meteorological conditions used to prepare these estimates were an effluent rise to 500 feet above the surface, a directional shear in the wind ladder through the cloud layer of 30°, and a mean cloud transport speed of 5 mph. Figure 4-8 delineates the area over which any effluent was expected to pass. The initial centerline bearing for any release of activity was predicted to be 185° from GZ.

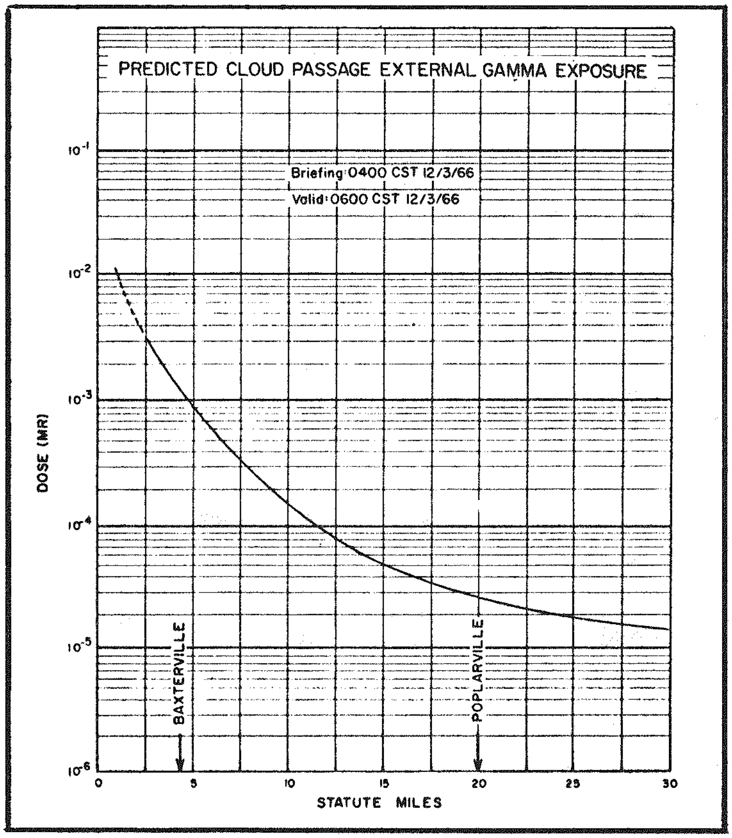

Figure 4–7 Predicted Total Possible Gamma Exposure Dose from Cloud Passage

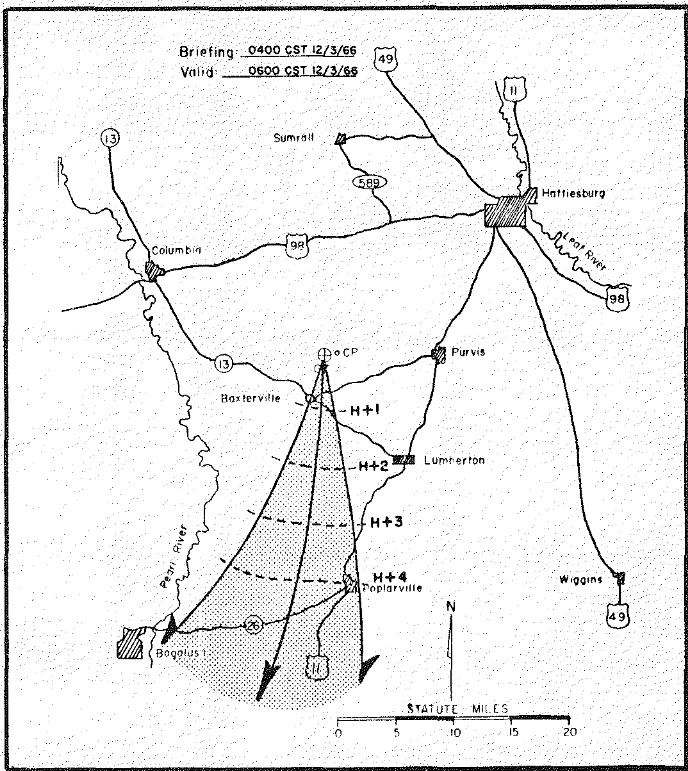

Figure 4–8 Predicted Cloud Path

4.1.7 Radiation Verification

On-site radiation data were provided by REECo and LRL. Off-site surface radiation data were provided by USPHS. These data were supplemented by aerial survey measurements conducted by USPHS and EG&G.

The radiation measurements made by these organizations at Zero Time, and for a period of several hours following, indicated that radiation levels remained at background. During midmorning, however, the presence of a small amount of radioactive gas was detected in the timing and firing cable. To prevent this activity from seeping along the cable to the Timing and Firing Trailer complex, the cable was severed about 1,900 feet from GZ and the end sealed. During the sealing process, a small amount of gaseous radioactivity, composed mostly of noble gases, was released into the atmosphere after being bubbled through the liquid sealing compound. Radiation levels produced by this release were negligible. No positive measurements were reported by those ground or aerial instruments surrounding the release point. (See the discussion in the following paragraph 4.2.1.) All available evidence verifies that the release of activity was extremely small and did not, in any way, constitute a hazard to the off-site population.

4.1.8 Postshot Activities

At the direction of the Project Manager, the WRPU maintained a postshot round-the-clock observing and forecasting capability at the Sterling site in case a radiation emergency should arise and cloud tracking activities be necessary. This support was continued through December 4, after which time it was determined that the accidental release of radioactivity into the atmosphere was no longer a threat. On-site meteorological support was then terminated and all ARFRO personnel returned to Las Vegas.

4.2 RADIATION SAFETY

4.2.1 On-Site Radiation Safety

a. Responsibilities

The Radiological Sciences Department of REECo was delegated the basic responsibility of providing radiological safety services for Sterling. The department acted under the direction and in support of the Hazards Control Division of Lawrence Radiation Laboratory. Basic radiological safety responsibilities are listed as follows:

--Controlling and documenting the presence and disposition of radioactive materials

--Controlling, measuring and recording personnel exposures to radioactive materials

--Maintaining and issuing all necessary protective clothing and equipment

--Decontaminating personnel, equipment, and ground areas as necessary

--Providing, maintaining, and calibrating radiation detection instruments and sampling equipment

--Performing qualitative and quantitative analysis of radioactive samples, including evaluation of data obtained.

The Sterling radiation safety program was begun on August 29, and terminated on December 31.

b. Equipment and Facilities

1. Portable Radiation Detection Instruments: There were 3 types of portable radiation detection instruments used by monitoring personnel--Eberline E-500B Geiger Counter, Victoreen Radector Model AGB-500 SR, and the Eberline PAC-3G Gas Proportional Counter. Beta-gamma radiation could be detected with these instruments in intensities as low as 0.02 mR/hr, or as high as 500 R/hr. Alpha radiation could be detected from less than 100 counts/min to greater than 100,000 counts/min.

2. RAMS Units: The Remote Area Monitoring System or RAMS unit was used to provide remote readout at a removed central location of radiation levels which might occur as a result of Sterling. The Sterling RAMS detector units consisted of gamma detector probes (Neher-White ionization chambers) with a self-contained power

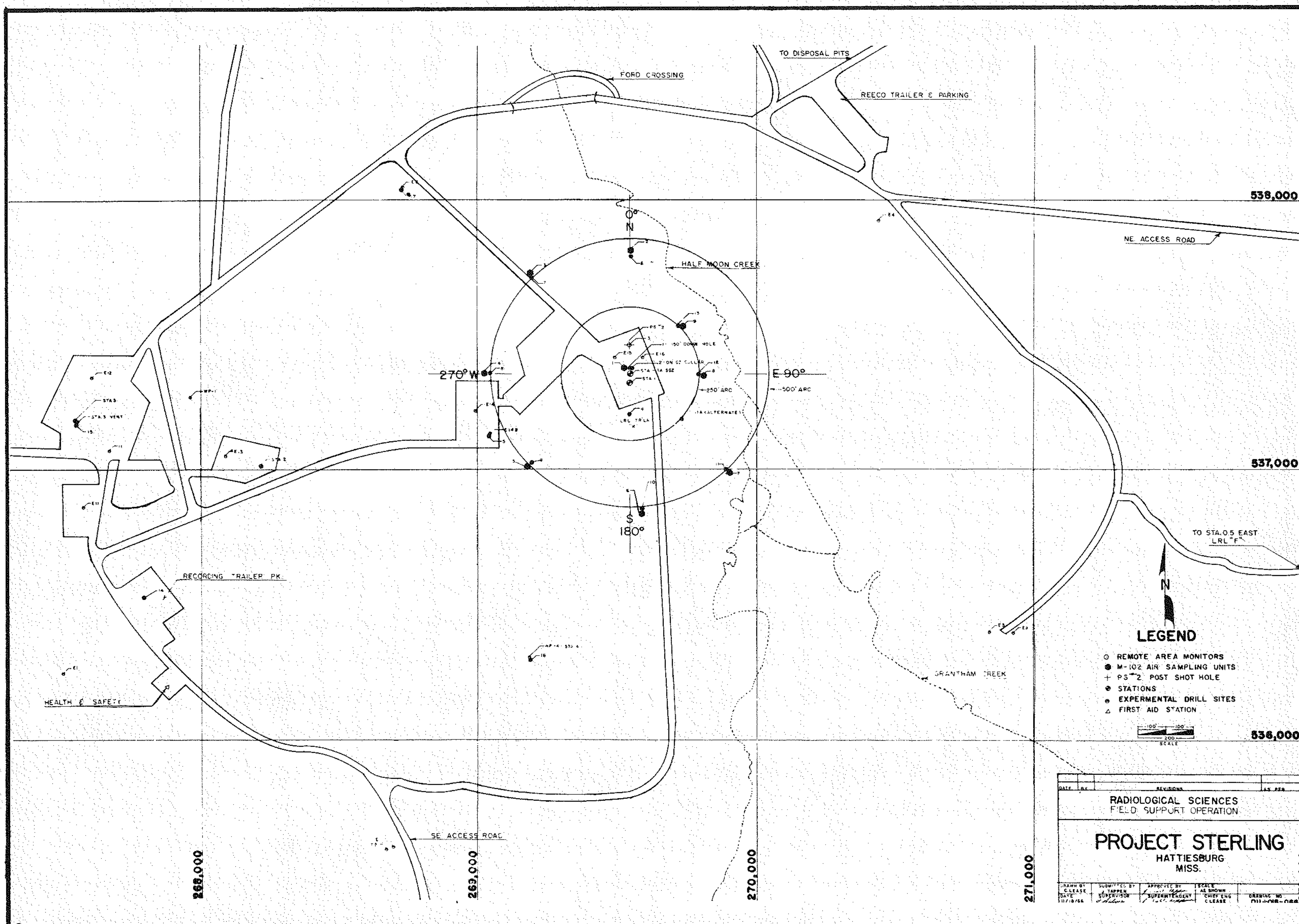

Figure 4–9 RAMS and Air Sampler Locations

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supply. One unit was installed 100 feet below ground surface in the stemmed emplacement hole. Seventeen additional units were located on a 500-foot arc around SGZ and at other related locations as shown in Figure 4-9. These units were connected with field wire to meters installed in the Radiological Sciences Mobile Laboratory Van located at the TDMS with slave connection to Honeywell dual pen recorders in the Technical Director's Trailer. The meters were provided with remote polarity and range switching capability. The meters were logarithmically scaled in ranges of 1 to 1,000 mR/hr and 1 to 1,000 R/hr. Continuous operation of the RAMS units commenced on D-3 days.

3. Stationary Radiation Detection Equipment: Stationary radiation detection equipment was strategically located at the test site to provide backup monitoring of personnel and equipment.

   (a) Portal Monitor - This unit was installed in the Check Station doorway to provide external whole body monitoring of personnel entering the Check Station. The unit consisted of an array of Geiger-Mueller tubes framing the doorway and connected to individual alarm meters. Alarm levels were adjustable and were normally set at 0.5 mR/hr.

   (b) Gateway Monitors - These units were installed at the site access gates to monitor personnel and vehicular traffic. They consisted basically of scintillation detector probes connected to alarm meters. Alarm levels were adjustable and were normally set at 0.5 mR/hr.

4. The Dupont Type 556 gamma film packet was used as the personnel film dosimeter. A lead strip of 28 mil thickness was attached to the packet to provide uniform gamma energy response of the film components. The film components used and their respective measurement ranges were:

   Film Type 519. . .30 mR to 4R
   Film Type 834. . .4 R to 800 R

5. Self-reading ionization dosimeters of 2 dose ranges were maintained for local issue to personnel entering areas of potential radiation exposure. The measurement range of the dosimeters was 0 to 200 mR and 0 to 5 R respectively.

6. A Manifold Air Sampler was used principally in sampling for airborne radioactivity at work locations related to preshot drilling and emplacement activities.

7. Portable Air Samplers were used principally to collect particulate air samples from various site locations for environmental condition documentation.

8. Effluent Air Samplers (M-102) : M-102 Effluent Air Samplers were used to collect air samples in case of an effluent release directly associated with the shot. The units were located around SGZ as shown in Figure 4-9. Continuous operation of these air

samplers for the event commenced at H - 4 hours. Two M-102 air samplers were Jeep-mounted to provide immediate, mobile, air-sampling capability.

9. Evacuated Cylinders: Scott "Air Pack" cylinders were evacuated to about 20 Inches of H_20 negative pressure with a Gelman positive displacement vacuum pump. The evacuated cylinders were used to obtain "grab" samples for gamma spectrum analysis.

10. Explosimeters and Draeger Tubes: Although not radiological in nature, Draeger tubes and Explosimeters were maintained and used by the department to routinely survey areas for explosive mixtures or toxic gas atmospheres.

11. Mobile Laboratory Van: An instrument van was maintained as a laboratory facility at the test site. It housed gross-alpha, -beta, and -gamma counters, a vibrating reed electrometer, and basic field laboratory apparatus for sample preparations and gross analysis.

12. Mobile Radiation Measurements Van: A second mobile laboratory van was located at the TDMS and housed a multichannel analyzer for gamma-spectrum analysis, gross-alpha, -beta, and -gamma counters, and other related analytical equipment for comprehensive evaluation of environmental samples.

13. Protective Clothing and Equipment: An ample supply of protective coveralls, gloves, hoods, rubber boots, and respiratory devices was maintained at the site area.

14. Decontamination Facilities: (a) A decontamination unit consisting of 3 sinks, a shower head, and water storage tank was available for personnel decontamination. (b) The Project Dribble Decontamination Pad was reactivated for the Project Sterling Program. (c) The Project Dribble mobile laundry units were also reactivated and were located at the Decontamination Pad. (d) A mobile steam generator was made available for decontamination of large equipment items or surfaces. (e) The Project Dribble fire truck was reactivated and served also as a decontamination truck to provide a mobile pressurized water supply.

15. Support Facilities: (a) A modified mobile trailer was used as a control and issue facility for all associated radiological equipment and instrumentation. This Check Station was located at the junction of the north access road to GZ and the main access roadway during preshot preparation. The trailer was relocated to the TDMS area for the event. (b) A modified mobile trailer provided the necessary work and storage space for maintenance and repair of equipment.

c. Preshot Procedures

Radiological safety support activities during this period were primarily directed to the reopening and rehabilitation of the Salmon Event emplacement and postshot drill holes, and to the emplacement of the Project Sterling device and related instrumentation. Associated activities included the restoration and restocking of Rad Safe facilities suspended from use following the Salmon Event, and the installation of equipment for postevent radiation and effluent surveillance and documentation.

1. Monitoring and Surveillance: Radiation surveys of established Project Dribble radiation/security areas were conducted weekly.

   (a) Continuous radiation monitoring coverage was provided for all drilling and emplacement activities at the GZ area. During drilling operations, routine radiation surveys were conducted on a 1- to 2-hour frequency, dependent on the drilling depth. Radiation and swipe surveys were performed on all equipment and instrumentation withdrawn from the drill holes.

   Dose rate measurements were made at an average distance of 3 feet from the surface of interest. Contact measurements were made with the detecting probe on or adjacent to the surface being monitored. The average survey dose rate recorded during all preshot drill hole activities was 0.06 mR/hr. The maximum contact measurement detected on downhole equipment and instrumentation was 1.0 mR/hr which was easily removed at the location. In one instance, the inside surfaces of the Blooie Line were found to be internally contaminated to 4.0 mR/hr. This section of line was removed and stored in the Bleeddown Plant area for subsequent disposal.

   Particulate samples were collected from the air flowing through the Blooie Line as successive drilling depths of 10 feet were achieved. The maximum radioactivity recorded was 1.14×10^{-4} uCi/g gross gamma. In all instances of positive radiation detection, the Blooie Line discharge was already being routed through a water wash particulate settling tank (Blooie Tank).

   (b) No toxic or EM gases were detected at the SGZ drill holes. EM and toxic gases were detected at the Station 4 open casing after detonation of the HE calibration shot. The maximum concentrations noted were combustible mixtures equivalent to to 100% of the lower explosive limit, 7,000 ppm CO, and 3.0% CO_2. These were surge type encounters. Access to the immediate area was restricted until all gases dissipated.

   (c) Monitors with portable radiation detection instruments were assigned to the following functions or locations for Zero Time: initial surveys, manned stations, muster area, helicopter flights, special surveys, or preliminary surveys. Their locations at H-hour are shown in Figure 4-10.

2. Personnel Dosimetry: During drilling and emplacement activities all personnel assigned to work areas of potential exposure to radiation were issued gamma film packets. These were exchanged at the beginning of each month.

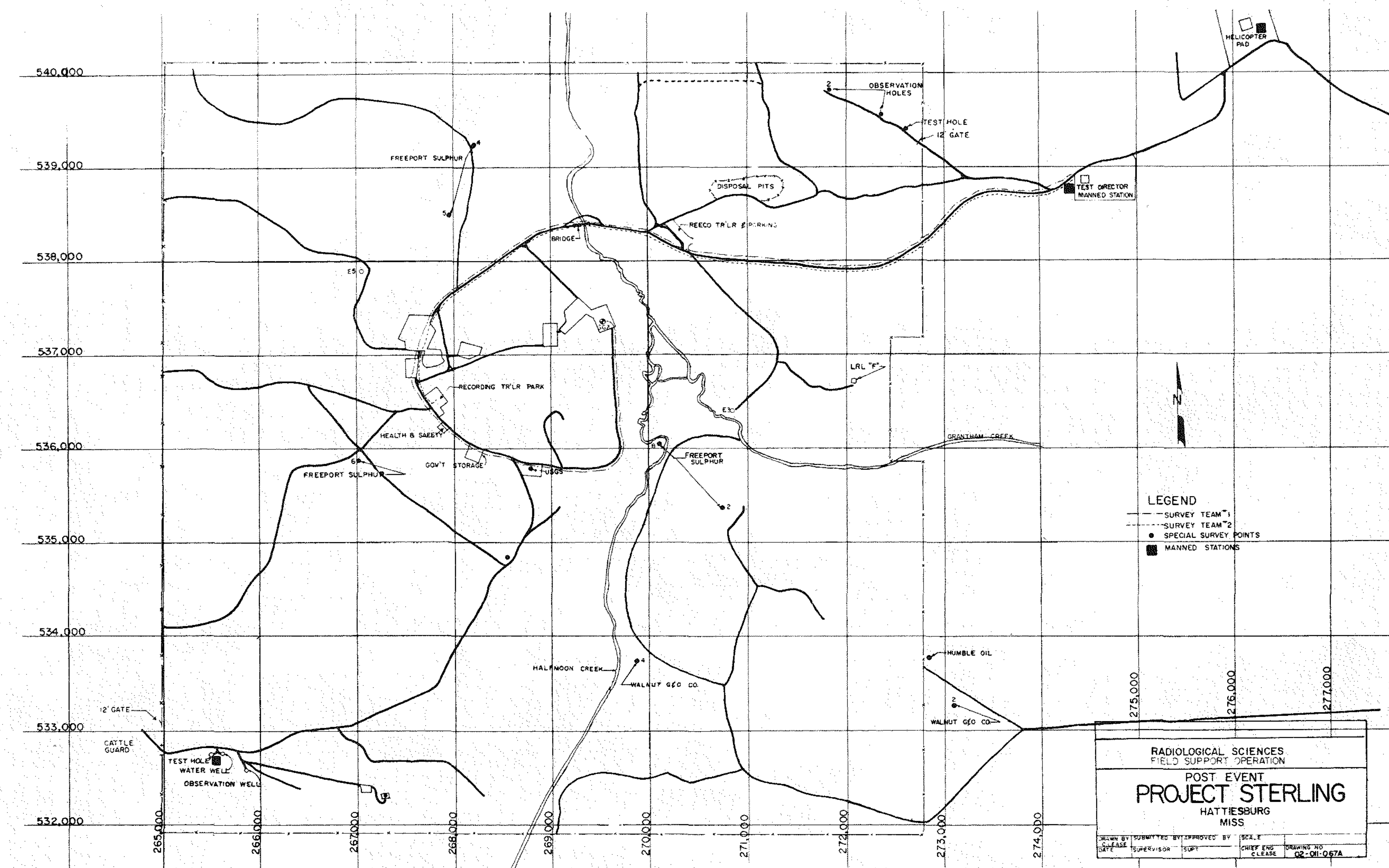

Figure 4–10 Survey Routes and Personnel Locations

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3. Environmental Sampling:

(a) During drilling and emplacement, continuous air samples were collected at work areas around GZ at a frequency commensurate with work schedules and activities. Sampling locations were dictated by the work in progress and included the drill rig floor, drill collars, Blooie Line exhaust area, and open drill casings.

Samples were analyzed for gross-alpha, -beta, and -gamma activity. The maximum detectable activity recorded was $2.36 \times 10^{-12}\ \mu Ci/cc$ gross gamma of air. It was collected at the open casing of Postshot Drill Hole No. 1 during instrument emplacement.

A 24 hour high volume air sample was collected monthly from each of 6 site locations as a continuation of the Project Dribble postevent program. The sampling locations are shown in Figure 4-11.

(b) Soil samples were collected monthly from each of 6 site locations as a continuation of the Project Dribble postevent program. The sampling locations are shown in Figure 4-11.

c. Water samples were collected weekly from the site industrial water well, and monthly from 8 surface water locations (Figure 4-11). No radioactive contamination was detected in the water samples.

4. Radioactive Waste Management: The remains of radioactive waste materials generated during Project Dribble were stored in the Bleeddown Plant and the Decontamination Pad areas. These areas were fenced and posted, and access was controlled by the industrial guard force.

Waste materials consisted primarily of miscellaneous pipe and 35,000 gallons of waste water stored in the Blooie Tank, bleeddown storage tanks, and Decontamination Pad storage tank.

The minor amount of waste material generated during Project Sterling was also stored in the above areas and tanks.

Prior to Sterling Zero Time, all the liquid contents of the Blooie Tank and bleeddown storage tanks were transferred to 55-gallon metal drums and jelled for later disposal.

Details of the jelling procedure and disposition of all radioactive waste materials associated with the Tatum Salt Dome Test Site will be compiled in a final report on cleanup of the Tatum Salt Dome Site.

d. Postshot Procedures

Support provided for the postshot period essentially encompassed two phases of activity: (1) surveillance and sampling immediately associated with the detonation and (2) radiological services for all

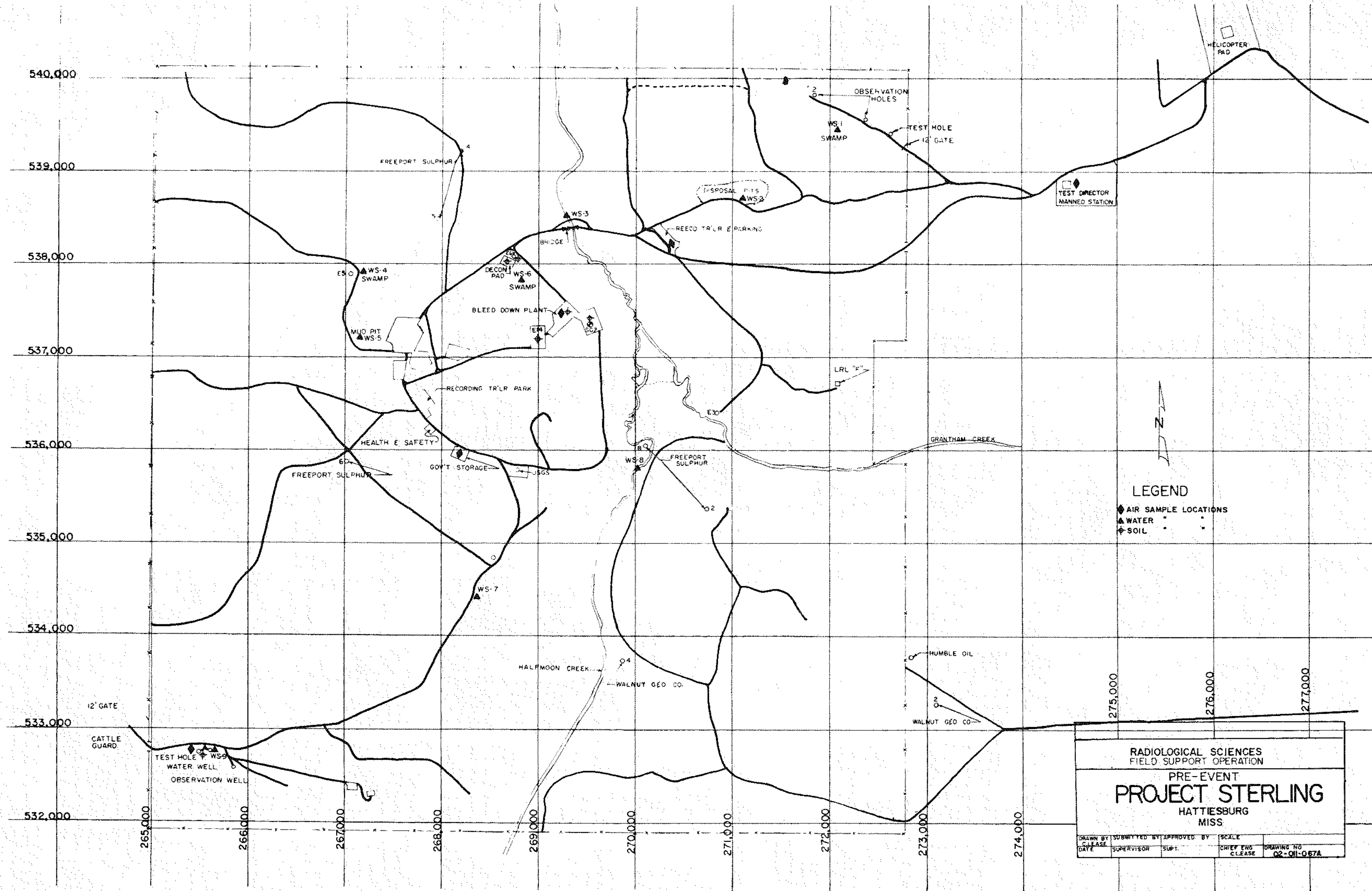

Figure 4-11 On-Site Environmental Sampling Locations

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postshot cleanup and removal activities. These are reported sequentially as they occurred.

1. Shot Time Surveillance and Monitoring:

   (a) Remote Area Monitoring System - There was no radiation detected immediately following the detonation; however, a positive radiation measurement was recorded on the downhole detector probe commencing at H + 155 minutes. Details are reported in the following paragraph (d) "Radioactive Gas Leak."

   (b) Initial Reentry Surveys - Two initial radiation survey teams were dispatched by the LRL Technical Director at about H+30 minutes. These teams surveyed the SGZ perimeter road to the recording trailer park, where one team stopped to survey the trailer park. The other team proceeded along the perimeter road to the SGZ area via the south access road. (See Figure 4-10.)

   Upon completion of comprehensive radiation surveys of the Recording Trailer Park and SGZ areas, the teams remained in these areas to provide support for reentry parties.

   All radiation measurements indicated only normal background activity (less than 0.03 mR/hr).

   (c) Site Surveys - Two survey teams were dispatched at about H+1 hour to survey various test and observation holes and the related access roadways within the test site (Figure 4-10).

   All radiation measurements indicated normal background only.

   (d) Radioactive Gas Leak - At H+155 minutes, a positive radiation measurement was recorded from the Station 1A downhole gamma detector probe.

   Radiation monitors were dispatched to the SGZ area to evaluate the situation and obtain air samples. The RAMS at this time showed only nominal exposure rates of 0.3 mR/hr. Preliminary surveys established the situation as one of gas migration contained within the timing-and-firing cables. This was substantiated by subsequent sample analysis, a complete area survey, and continuous surveillance of the remote area monitoring system.

   In order to halt the gas migration and avoid potentially significant environmental release, the cables were cut and the ends placed in a 55 gallon metal drum filled with Cal-Seal (a plaster of paris type material). This action effectively halted the migration although a minor emission did occur during cutting and sealing. The release was nominal and quickly dissipated as determined by gamma spectrum analysis of air samples taken at the drum and environmental locations around SGZ. (See the following paragraph 2. "Air Sampling".)

A continuous gamma monitor-recorder unit (consisting of a detector probe, battery power supply, and strip chart recorder) was installed near the top of the Cal-Seal drum to monitor any change in activity levels.

The maximum radiation measurements observed at specific locations were 150 mR/hr at the downhole gamma detector probe, 200 mR/hr at contact with the exposed surface cables, and 1.3 R/hr at contact with the drum containing the Cal-Seal. The maximum dose rate to which personnel were exposed for a short period was 190 mR/hr while working near the Cal-Seal drum. Radioactivity measurements at the cables reached maximum levels at H + 275 minutes.

2. Air Sampling: The M-102 air samplers located at SGZ and the 500-foot arc (Figure 4-9) were operated continuously from H-4 hours to H + 105 minutes. Analysis of the collected samples revealed only naturally occurring radioactivity.

   An air sampler was operated continuously at SGZ from H + 105 minutes to H + 32 hours. Analysis of the collected samples revealed only natural radioactivity.

   The full set of 500-foot arc samplers were restarted at H + 195 minutes and operated continuously to H + 435 minutes. Analysis of these samples showed only natural radioactivity. At this time, radioactivity levels at the cables were on a definite decline and all observations indicated complete containment. Selected air samplers on the arc downwind from SGZ were continued in operation to H + 32 hours. Analysis of these samples also showed only natural radioactivity.

   The only positive detection of gaseous escape was obtained in the immediate area of the cut cables and was insignificant as shown by the following:

   - A filtered air sample collected over the Cal-Seal drum from H + 195 minutes to H + 5 hours contained the following isotopes:

     Prefilter -- rubidium 88
     Charcoal -- rubidium 88, xenon 135, and no detectable iodine.

   - An evacuated cylinder grab sample was collected over the cut cables. A gamma spectrum analysis showed only rare gases and their daughters. The radioiodine content was less than 0.01%. The xenon 135 content was less than 10%.

3. Personnel Protective Measures: All reentry and initial survey parties were fully suited and taped in protective clothing, and were provided with full face respirators incorporating MSA all purpose cannisters.

4. Personnel Dosimetry: All personnel entering the controlled access area following the event were issued gamma film packets and 2 pocket dosimeters (high and low range).

Following the release of access control, personnel were required to wear only the gamma film packet.

There were no cases of personnel exposure greater than 30 mR.

5. Site Demobilization: Radiation monitoring service was provided for all postevent cleanup and removal activities as required. Radiation surveys were conducted on all equipment and materials prior to removal from the GZ area. All items released for off-site use measured less than 0.1 mR/hr at contact. Miscellaneous items, such as device cables, Cal-Seal drum, etc., reading greater than 0.1 mR/hr were removed and placed in the waste storage areas.

   A working inventory of supplies and equipment were left onsite pending ultimate site disposal. The remainder of the equipment was returned to NTS.

6. Environmental Sampling: Sampling of soil, water, and air was reinstituted on a pre-event schedule as a continuation of the over-all Tatum Salt Dome environmental condition documentation.

7. Radioactive Waste Management: The liquid contents of decontamination pad storage tanks were transferred to 55 gallon metal drums and jelled for subsequent shipment and disposal.

8. Decontamination: There were no cases of personnel contamination.

   All equipment contamination detected was nominal and easily decontaminated on location.

   All drums of jelled liquid waste were externally decontaminated in preparation for shipment to Oak Ridge National Laboratory for disposal. Swipe surveys of each drum after decontamination revealed no detectable contamination.

4.2.2 Off-Site Radiation Safety

a. Responsibilities

The Off-site Radiation Safety program for Sterling was conducted by the U. S. Public Health Service Off-site Radiological Safety Organization. Authorization for this program was established by the AEC-USPHS Memorandum of Understanding and NTSO-SOP Chapter 0524-05, "Off-site Rad-Safety Operations," revised June 26, 1961. Operational supervision of the off-site program during testing periods was delegated by the Project Manager to the Radiological Safety Officer. The functions of the Public Health Service were as follows:

1. Determination by mobile and fixed monitoring stations and aerial surveys of the extent of airborne, surface and subsurface contamination off-site resulting from Sterling.

2. Maintenance of a comprehensive record of radioactivity associated with the operation, including fluctuations in background data.

3. Insurance of continuing public health protection, including sampling of various media such as water, milk, soil, vegetation, and animal tissue, as required.

4. Preparations for effecting emergency measures in the event an unacceptable situation developed.

5. Dissemination of necessary public information in surrounding communities to maintain public confidence in the safe conduct of the operation.

6. Investigation of incidents that might be attributed to the operation.

7. Distribution and collection of film badges.

8. Provision of mobile monitoring teams in selected populated places surrounding the operation site.

9. Location of air-sampling equipment and securing of local personnel for operation of the sampling stations.

10. Evacuation of certain portions of the off-site area* including

    -Evacuation of certain portions of the off-site area (0 to 2.0 miles from Surface Zero) as a precautionary measure in the event an unforeseen emergency developed.

    -Medical support relative to evacuating individuals living in the off-site area, who were not physically able to evacuate themselves.

The Off-site Radiological Safety Organization for Sterling was staffed principally by personnel from the Southwestern Radiological Health Laboratory, Las Vegas, Nevada (SWRHL) Southeastern Radiological Health Laboratory, Montgomery, Alabama (SERHL); and Northeastern Radiological Health Laboratory, Winchester, Massachusetts (NERHL); and reserve PHS officers on temporary duty.

The Project Officer was Dr. Melvin W. Carter, Ph.D., Officer in Charge, SERHL, Montgomery, Alabama. The Off-site Radiological Safety Officer was Mr. O. R. Placak, Officer in Charge, SWRHL, Las Vegas, Nevada.

The activities of the Public Health Service were coordinated with the state and local health departments of Mississippi and Louisiana.

b. Preliminary Activities

1. Population Survey: Prior to the detonation, USPHS personnel completed a population survey of the area within 5 miles of the test site in order to update the information gathered in 1963-64 for the Salmon Event. This survey was extended out to 10 miles, from 270° clockwise to 45°. Results of the survey were used to develop an evacuation plan for certain portions of the off-site area. The following information was obtained at each household:

The offsite area is defined as that area within a 50-mile radius of Surface Zero (excluding the test site area), or only as far beyond this area as USPHS activities are required.

- The name of the head of the household

- The names and ages of all individuals living in the home

- In the event of evacuation:
  Any illness that might require medical attention
  Transportation requirements

A USPHS medical officer, using the information gathered by the population survey, visited all the homes within a 5-mile radius where people lived who might need medical attention if an unforeseen emergency developed.

2. Milk Shed Survey: A milk shed survey was conducted within a 50-mile radius to update the information gathered in 1963-64 for the Salmon Event. The following information was obtained:

- The locations of dairy farms within a 50-mile radius of the test site and the number of cows at each farm

- The names of the drivers who collected the milk

- The location of milk processing plants that received the milk

The milk shed survey was conducted to develop emergency procedures if milk in the off-site area was contaminated as a result of the Sterling Event, also to develop a milk sampling program in the area to establish existing background levels. This survey was coordinated with the state and local health departments of Mississippi and Louisiana.

3. Environmental Sampling Program: An environmental sampling program to determine existing levels of radioactivity and normal variations in these levels was begun in May 1963 for Salmon. This program included air, water, milk, and vegetation media. The samples were representative of an area bounded by a 50-mile radius from the test site. These samples were analyzed at SERHL, Montgomery, Alabama; reports were issued on a monthly basis. After the bleed down activities of March 1965 the Salmon environmental sampling program was decreased to a minimum, which consisted of 5 air sampling stations and 15 water sampling stations. The majority of these stations were within a 5-mile radius of the test site. Prior to the Sterling Event this program was expanded again to represent a 50-mile radius coverage.

c. Procedures

1. Evacuation: Prior to the shot, project officials determined that as a precautionary measure it would be advisable to evacuate those residents living within a 2-mile radius of the test site. USPHS was given the responsibility of developing this evacuation plan.

   Using the information gathered from the population survey, the residents who lived within a 2-mile radius of the test site were visited and asked if they would evacuate the day before the shot. They were asked to evacuate the day before since shot-time was scheduled for 0600. It was determined by project officials that the evacuation could be performed with less inconvenience to the people the day before, rather than on shot day.

Off-site personnel gathered information as to what time each resident would evacuate and where he would go. They were given the USPHS phone number and were instructed to call "collect" if they had any questions regarding the shot.

In conjunction with contacting the evacuees, a USPHS medical doctor visited all potential medical cases within a 5-mile radius of the test site and evaluated these cases in regard to evacuation. It was his responsibility to determine whether or not the ill people in the off-site area should be evacuated as precautionary measure prior to the shot.

Thirty-one families representing 127 people within a 2-mile radius of the test site were contacted in regard to evacuation. All of the families indicated that they would evacuate the day before the shot with the exception of one family who planned to leave the day of the shot, at 0300. (See Figure 4-12 for the evacuation area.)

2. Ground Monitoring: 25 ground monitoring teams were employed in the field. Instruments used for field monitoring were the Eberline Model E-500B, Precision Scintillator Model 111, and Radector Model 500. All vehicles were equipped with two-way radios and mobile air sampling equipment. The monitors were directed in the field through a central communications control. Monitoring missions were conducted from H - 30 minutes to H + 6 hours, at which time it was determined that no detectable release of activity had occurred. USPHS officers were on standby through H + 18 hours. (See Figure 4-12 for off-site roads monitored, all with negative results.)

3. Aerial Monitoring: A two-man Public Health Service aerial monitoring team made numerous treetop passes over Surface Zero. Instruments used were an Eberline Model E-500B, Precision Scintillator Model 111, and Radector Model 500. This operation continued intermittently through H + 4 hours and 21 minutes to ascertain that no radioactivity had escaped through venting or leaking that would result in contamination of the off-site area. No activity above background was detected off-site.

   A USPHS C-45 aircraft was used for sampling airborne radioactivity. This aircraft was equipped to sample gaseous as well as particulate radioactive material. No activity was detected above background levels by airborne sampling.

   Thirty-nine medical cases within a 5-mile radius were checked by the project medical officer. These cases ranged from nervous conditions to heart conditions. He determined that it would be advisable to evacuate one person in this area in relation to medical problems.

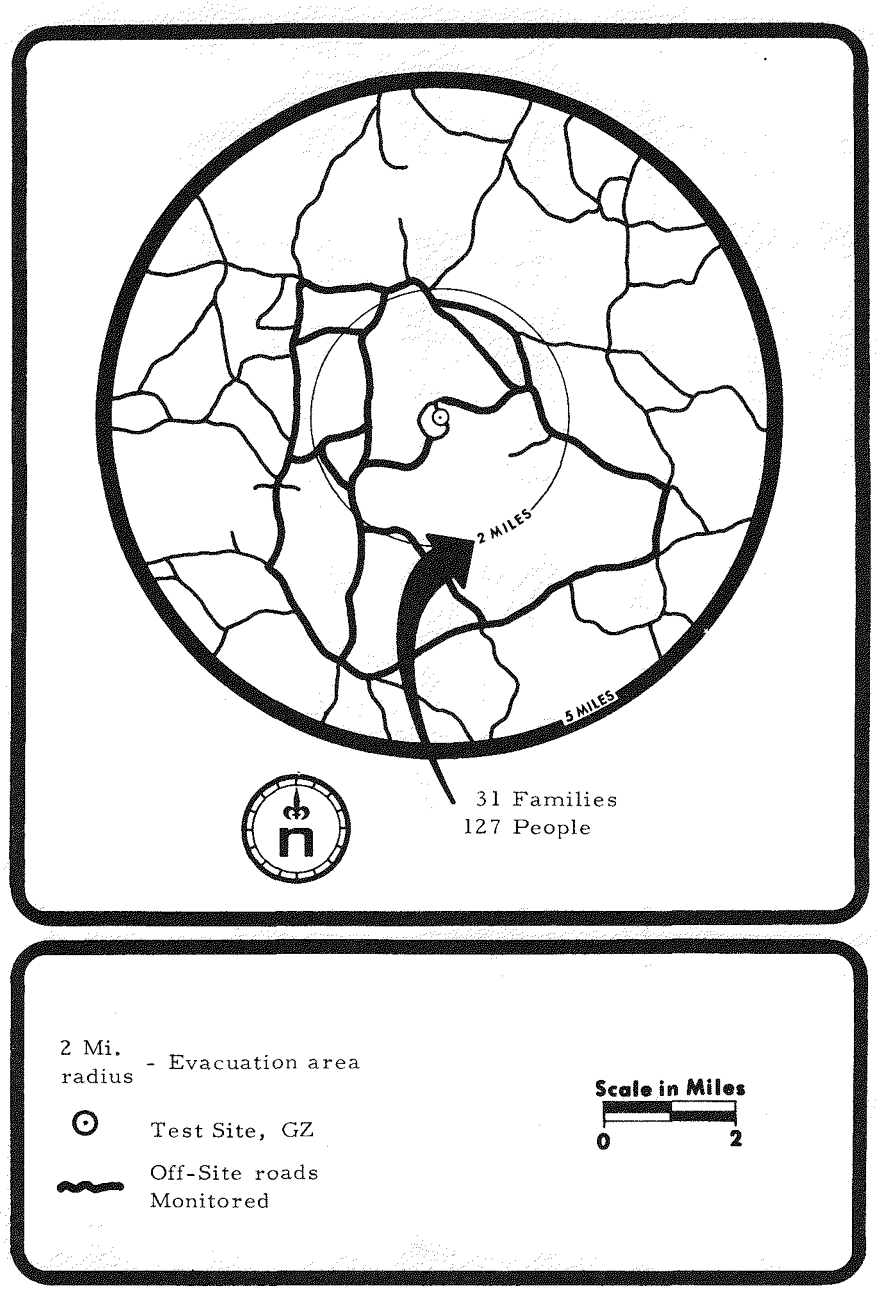
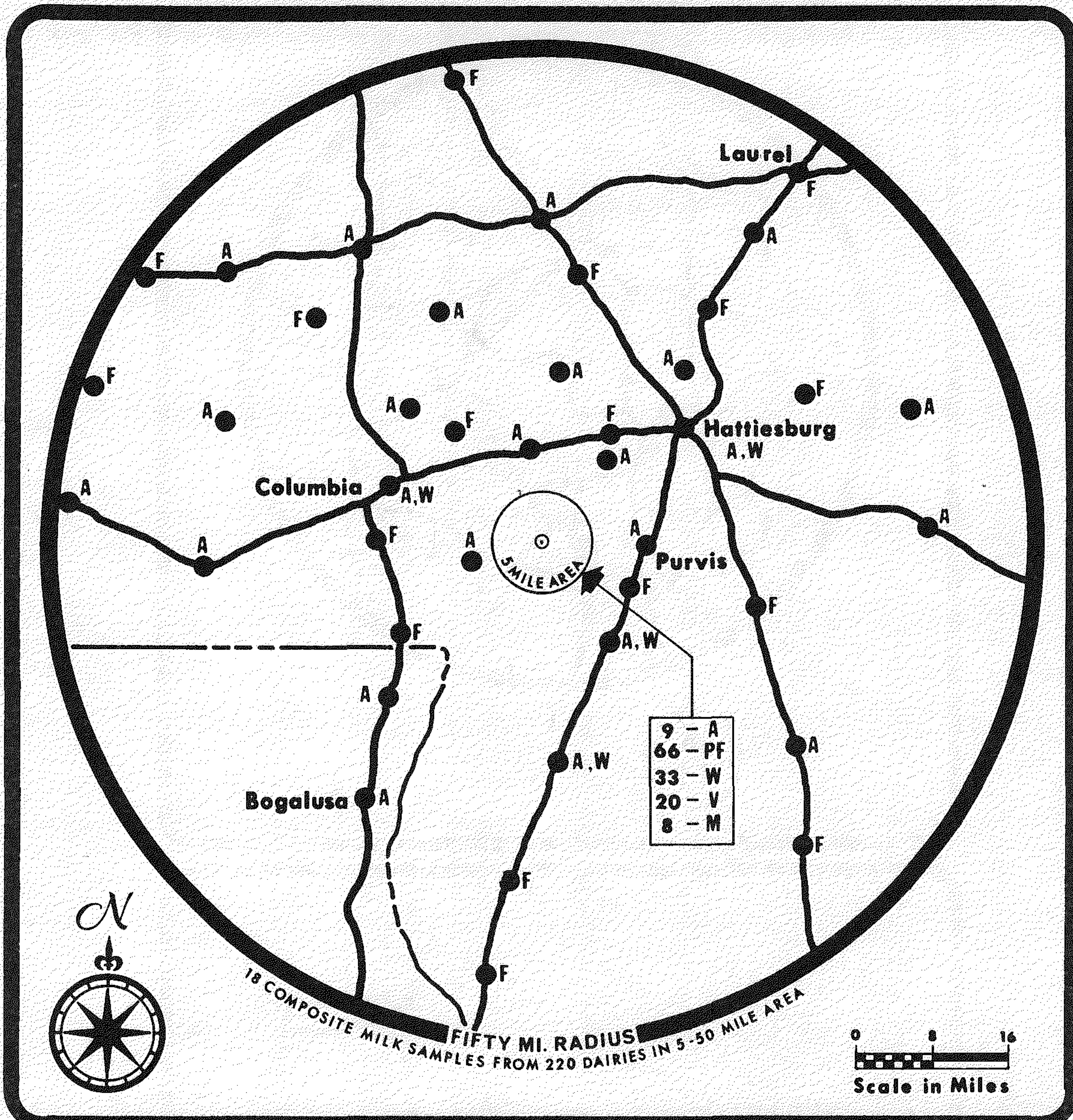


Figure 4-12 Off-Site Roads Monitored in Evacuation Area

4. Film Badge Program: 50 film badge stations, 4 badges per station, were established within a 50-mile radius prior to the shot. These stations were activated on November 23, 1966. Nine of the stations were within a 5-mile radius of the test site. Sixty-six personal film badges were distributed within a 5-mile radius of the site. One person per household was badged within a 2-mile radius. The remainder of the 5-mile area badges were distributed 360° around the site. (For the locations of film badges, see Figure 4-13.)



⊙ — Ground Zero
A — Air Sampling Station and F
F — Film Badge Station
PF — Personal Film Badge
W — Water Sampling Station
V — Vegetation Sampling Station
M — Milk Sampling Station
● — Sampling Point

Figure 4-13 Off-Site Environmental Sampling Coverage

Collection of these badges was begun on December 8, 1966. None of the badges indicated radiation exposure above detectable limits.

5. Environmental Sampling: Environmental samples representing air, milk, water, and vegetation were collected prior to and after the shot. The off-site environmental sampling coverage in operation at shot time is given in the following listing:

TYPE OF SAMPLE	NUMBER OF STATIONS
Air	33
Milk	26 8 stations, 1-2 cows, within 5-mile radius; 18 milk routes (composite samples representing 220 dairies within a 50-mile radius).
Water	37
Vegetation	20

These sampling stations were scattered throughout the area extending from the test site boundary to a 50-mile radius from GZ. (See Figure 4-13.)

Special samples of air, vegetation, water, and milk, collected after the shot, indicated no activity above background.

6. Laboratory Analyses: Prior to the shot, a USPHS laboratory was established in Hattiesburg. SERHL in Montgomery, Alabama, performed routine analyses of environmental samples; the special samples collected at shot time were analyzed in Hattiesburg.

d. Results

The Sterling Event took place at 0615 hours December 3, 1966. No activity was detected by radiation monitoring or laboratory analysis that could be attributed to the contamination of the off-site area. The evacuation of the 31 families from the 2-mile area was conducted smoothly and without incident.

4.3 SEISMIC SAFETY

4.3.1 Ground Motion Predictions

Initial predictions of ground motion were prepared by Environmental Research Corporation (ERC) and submitted by letter March 10, 1966. A table provided predicted particle velocities at selected distances. Two values were shown at each distance: One assuming a decoupling factor of 170 (based on estimates of full decoupling given in UCRL-14487, Revision-1, dated November 16, 1965), the other for a tamped event. Predictions for a tamped explosion showed the upper limit of possible motions in the event that no decoupling occurred. In view of the low level of motions anticipated, ERC stated that no significant hazards were anticipated even if fully coupled.

On November 4, 1966, ERC submitted final seismic predictions in Report NVO-1163-92, "Summary Report of Predictions, Sterling Event." Because of the successful predictions for the Salmon Event, it was expected that ground motions from Sterling could also be predicted with a high degree of accuracy if the degree of decoupling could be reliably estimated. However, determination of the degree of decoupling was the major purpose of the experiment. The Sterling Technical Concept, dated July 7, 1966, indicated that decoupling might vary between factors of 20 to 160, depending on alteration of the cavity wall caused by the Salmon Event. For purposes of safety, predictions of ground motion were made for a fully coupled case. This was believed to represent an absolute upper limit of ground motion. To provide seismic motion predictions which would be more realistic than the upper-limit, fully coupled case, the smaller decoupling factor of 20 was applied to all predictions.

Predictions of peak particle acceleration, displacement, and velocity were made for surrounding communities and at selected points of interest. This was done for both the fully coupled case and the decoupling factor of 20. Fully coupled, the predicted distances to 0.1g acceleration and 1 cm/sec particle velocity were 5.1 km and 7.0 km, respectively. The only town within these distances was Baxterville. For a decoupling factor of 20, predicted distances to 0.1g and 1 cm/sec were 730 meters and 1150 meters respectively from Surface Zero. No communities are located within these distances. Because Salmon caused no damage to any oil or gas wells or pipelines in the area, it was predicted that Sterling (a much smaller yield) would not produce motions large enough to endanger any of these facilities.

At NVOO's request, a representative of ERC was at the site at shot time for rapid analysis of the recorded ground motions. Preliminary peak motions were tabulated and submitted that day to a representative from Safety Evaluation Division, NVOO. Initial comparison of observed motions with predictions showed that peak values were about 1/40 to 1/60 of the predictions for a fully coupled (tamped) explosion.

4.3.2 Seismic Measurements

The U. S. Coast & Geodetic Survey Special Projects Field Party recorded transitory earth particle motions in the distance range from 1.64 kilometers to 33 kilometers from the event: (a) to document earth motions received in populated areas, (b) to describe the symmetry of maximum motion, (c) to compare the results with studies of previous underground detonations, and (d) to provide additional data for evaluating the theory of decoupling.

Two Strong-Motion stations, 3 Wood-Anderson stations, and 2 NGC-21 stations were operated for an HE calibration shot preceeding the nuclear event. Excellent records were obtained from all stations, totaling 30 channels of velocity acceleration, and displacement data. The HE calibration event was designed to help confirm proper dynamic range of the seismic instrumentation for the nuclear event.

Ten Strong-Motion stations, 1 NGC-23 station, 4 Wood-Anderson stations, and 8 NGC-21 stations were operated for the nuclear event. Fifty-nine channels of displacement, 33 channels of velocity, and 1 channel of acceleration were obtained.

The seismic signal from the nuclear event could not be seen above the background noise at the NGC-23 station. In most cases, the displacement meters in the Strong-Motion seismographs did not detect any ground motion from the nuclear event or the HE shot. In those cases where motion was detected, the record amplitudes were too small to measure. Also, the record amplitudes from the Wood-Anderson seismographs for both events were very small, and consequently the reliability of the scaled data is somewhat less than optimum.

It should be noted that the strong-motion accelerometers responded proportionately to displacement instead of acceleration for the nuclear event and to a lesser degree the high explosive shot. This was due to the short period ground motion produced by the events relative to the natural period of the accelerometer. The Nuclear and HE test locations are listed in Table 4-2. The station locations are indicated in Table 4-3. Event data from the HE shot and from Sterling are shown in Tables 4-4 and 4-5. Maps of station locations are shown in Figures 4-14 and 2-4.

TABLE 4-2 GRID COORDINATES OF HE AND NUCLEAR TEST LOCATIONS

HIGH EXPLOSIVE SHOT

Mississippi Grid Coordinates: N 536 278.54, E 269 167.48

Geodetic Coordinates: N 31° 08.28', W 89° 34.27'

Depth: 2700 feet below the surface.

Emplacement and Medium: Tamped charge in halite

Date: 17 November 1966

Time: 1000:00 GMT

Yield: 2 tons

STERLING EVENT

Mississippi Grid Coordinates: N 537 357.91, E 269 541.55

Geodetic Coordinates: N 31° 08' 31.6", W 89° 34' 11.8"

Depth: 2700 feet below the surface.

Emplacement and Medium: Sprung cavity in halite. Cavity is roughly spherical, having approximate dimensions of 26.5 meters high by 33.6 meters wide.

Date: 3 December 1966

Time: 1215:00.0 GMT

Yield: Approximately 350 tons

TABLE 4-3 SEISMIC MEASUREMENT STATION LOCATIONS

STATION	INST.	FROM S.Z. – DISTANCE – BEARING	DESCRIPTION OF LOCATIONS
# 1	SM	2.41 km - N 2.61° E	L. J. BRYANT RESIDENCE
# 2	SM	2.49 km - N 90° E	GEORGE ANDERSON RESIDENCE
# 3	SM	5.91 km - S 71.9° E	J. W. ENTREKIN RESIDENCE
# 4	SM	1.64 km - N 44.4° E	FRED DOBSON RESIDENCE
# 5	SM	5.15 km - S 14.7° E	R. C. READY RESIDENCE
# 6	SM	4.65 km - N 8.61° E	MRS. BESSE ANDERSON RESIDENCE
# 7	SM	4.21 km - S 66.8° W	FRANK COOPER RESIDENCE
# 8	SM	1.89 km - S 87.4° W	TOXIE SPEIGHT RESIDENCE
# 9	SM	5.33 km - N 45.9° W	GREENVILLE BAPTIST CHURCH
#10	SM	3.42 km - N 23.1° W	J. R. HIGGINBOTHAM RESIDENCE
BAXTERVILLE	'21	6.5 km - S 22.7° W	HIGH SCHOOL
BAXTERVILLE	'21	6.0 km - S 22.7° W	POST OFFICE
PURVIS	WA	15.8 km - N 90° E	MASONIC LODGE
PURVIS	'21	18.0 km - S 63° E	BASS MEMORIAL ACADEMY (Approx. 5 miles south of Purvis)
LUMBERTON	WA	19 km - S 45° E	HIGH SCHOOL
LUMBERTON	'21	19 km - S 45° E	LUMBERTON STATE BANK
COLUMBIA	WA	27 km - N 63° W	MARION CENTRAL HIGH SCHOOL (in town)
COLUMBIA	'21	26 km - N 65° W	MARION CENTRAL HIGH SCHOOL (approx. 6 miles south of town)
HATTIESBURG	WA	33 km - N 54° E	UNIV. OF SOUTHERN MISSISSIPPI STADIUM
HATTIESBURG	'23	33 km - N 54° E	METHODIST HOSPITAL
HATTIESBURG	'21	33 km - N 54° E	SOUTHERNAIRE MOTEL
10-SOUTH	'21	15.8 km - S 9.8° W	Approx. 6 Miles south of BAXTERVILLE
20-SOUTH	'21	31.7 km - S 25° W	20 miles SSW of Sterling

Note: THE GEOLOGIC MEDIUM UNDERLYING EACH STATION IS DEEP ALLUVIUM.

Legend:

SM = USC&GS STRONG-MOTION SEISMOGRAPH
WA = WOOD-ANDERSON SEISMOGRAPH
'21 = NGC 21 RECORDING UNIT
'23 = NGC 23 RECORDING UNIT

TABLE 4-4 EVENT DATA FROM HIGH EXPLOSIVE SHOT

STATION, DISTANCE AND BEARING	COMPONENT & INSTR.	ACCELERATION $\times 10^{-4}$ g's	DISPLACEMENT $\times 10^{-5}$ cm	VELOCITY CM/SEC $\times 10^{-4}$	PERIOD SEC
#4	V Acc.		36.4		0.065
1.75 km	L Acc.		37.6		0.14
N 48° E	T Acc.		20.2		0.12
#1	V Acc.		97.1		0.13
2.43 km	L Acc.	5.48			0.16
N 9° 50'E	T Acc.				
Purvis Masonic	L W.A.		1.79		0.30
Lodge	T W.A.		2.50		0.45
15.8 km N 90° E					
10 Miles South	V '21			14.6	0.200
17.8 km	L '21			9.37	0.395
S 9.8° W	T '21			5.56	0.240
	V '21			13.0	0.250
	V '21			9.37	0.235
	V '21			15.7	0.230
Lumberton High	L W.A.		3.57		0.69
School 19.5 km	T W.A.		2.86		0.49
S 45.5° E					
20 Miles South	V '21			3.75	0.240
31.7 km	L '21			3.21	0.315
S 24.6° W	T '21			1.70	0.270
	V '21			4.16	0.240
	V '21			3.41	0.280
	V '21			3.28	0.305
Hattiesburg	L W.A.		1.43		0.90
Stadium 33.0 km	T W.A.		1.07		0.70
N 54° E					

Note: ACC. = STRONG MOTION ACCELEROMETER.

TABLE 4-5 EVENT DATA FROM STERLING

STATION, DISTANCE AND BEARING	COMPONENT & INSTR.	ACCELERATION $\times 10^{-4}$ g's	DISPLACEMENT $\times 10^{-4}$ cm	VELOCITY CM/SEC $\times 10^{-3}$	PERIOD SEC
#4	V Acc.		19.1		0.025
1.64 km	L Acc.		11.7		0.095
N 44.4° E	T Acc.		9.70		0.080
#8	V Acc.				
1.89 km	L Acc.		6.80		0.049
S 87.4° W	T Acc.				
#1	V Acc.		25.8		0.115
2.41 km	L Acc.		6.33		0.081
N 2.61° E	T Acc.				
#2	V Acc.		11.5		0.07
2.49 km	L Acc.		5.90		0.08
N 90° E	T Acc.		4.07		0.09
#10	V Acc.		2.64		0.045
3.42 km	L Acc.		2.09		0.130
N 23.1° W	T Acc.				
#7	V Acc.		6.01		0.029
4.21 km	L Acc.				
S 66.8° W	T Acc.		2.19		0.030
#5	V Acc.	5.18			0.22
5.15 km	L Acc.				
S 14.7° E	T Acc.				
#9	V Acc.		4.60		0.049
5.33 km	L Acc.				
N 45.9° W	T Acc.		3.36		0.111
Lumberton	N-S WA		0.357		0.30
19 km S 45° E	E-W WA		0.179		0.40
Columbia	N-S WA		0.0893		0.60
27 km N 63° W	E-W WA		0.0536		0.67
Hattiesburg	N-S WA		0.0536		0.50
33 km N 54° E	E-W WA		0.0714		0.40

TABLE 4-5 EVENT DATA FROM STERLING (Continued)

STATION, DISTANCE AND BEARING	COMPONENT & INSTR.	ACCELERATION $\times 10^{-4}$ g's	DISPLACEMENT $\times 10^{-4}$ cm	VELOCITY CM/SEC $\times 10^{-3}$	TE SEC	TT SEC
Baxterville High	Z '21			15.7	0.05	2.44
6.5 km	Major '21			14.9	0.07	
S 22.7° W	Minor '21			6.24	0.06	
Baxterville Post	Z '21			19.5	0.042	2.35
Office 6 km	Major '21			10.7	0.075	
S 22.7° W	Minor '21			6.24	0.055	
Bass Memorial	Z '21			3.24	0.15	4.45
Academy 18 km	Major '21			0.848	0.095	
S 63° E	Minor '21			0.757	0.11	
10 Miles South	Tc* '21			0.900	0.128	4.42
15.8 km	Rc* '21			2.23	0.200	
S 9.8° W	Z1c* '21			4.64	0.076	
	Z2 '21			2.16	0.062	
	Z3 '21			2.52	0.071	
	Z4 '21			2.34	0.051	
Lumberton State	Z '21			0.950	0.23	?
Bank 19 km	Major '21			1.50	0.24	
S 45° E	Minor '21			0.769	0.26	
Marion High	Z '21			0.649	0.06	6.58
School 26 km	Major '21			0.361	0.16	
N 65° W	Minor '21			0.270	0.09	
20 Miles South	Tc* '21			0.271	0.16	7.55
31.7 km	Rc* '21			0.561	0.29	
S 25° W	Z1 '21			0.452	0.241	
	Z2 '21			0.525	0.22	
	Z3 '21			0.570	0.249	
	Z4c*			0.452	0.230	
Southernaire	Z '21			0.577	0.255	7.47
Motel 33 km	Major '21			0.577	0.222	
N 54° E	Minor '21			0.722	0.140	

Note 1: THE * IDENTIFIES THE CLUSTER OF THREE SEISMOMETERS.

Note 2: STATIONS NOT INCLUDED IN THIS TABLE SHOWED IMMEASURABLE RECORD MOTION.

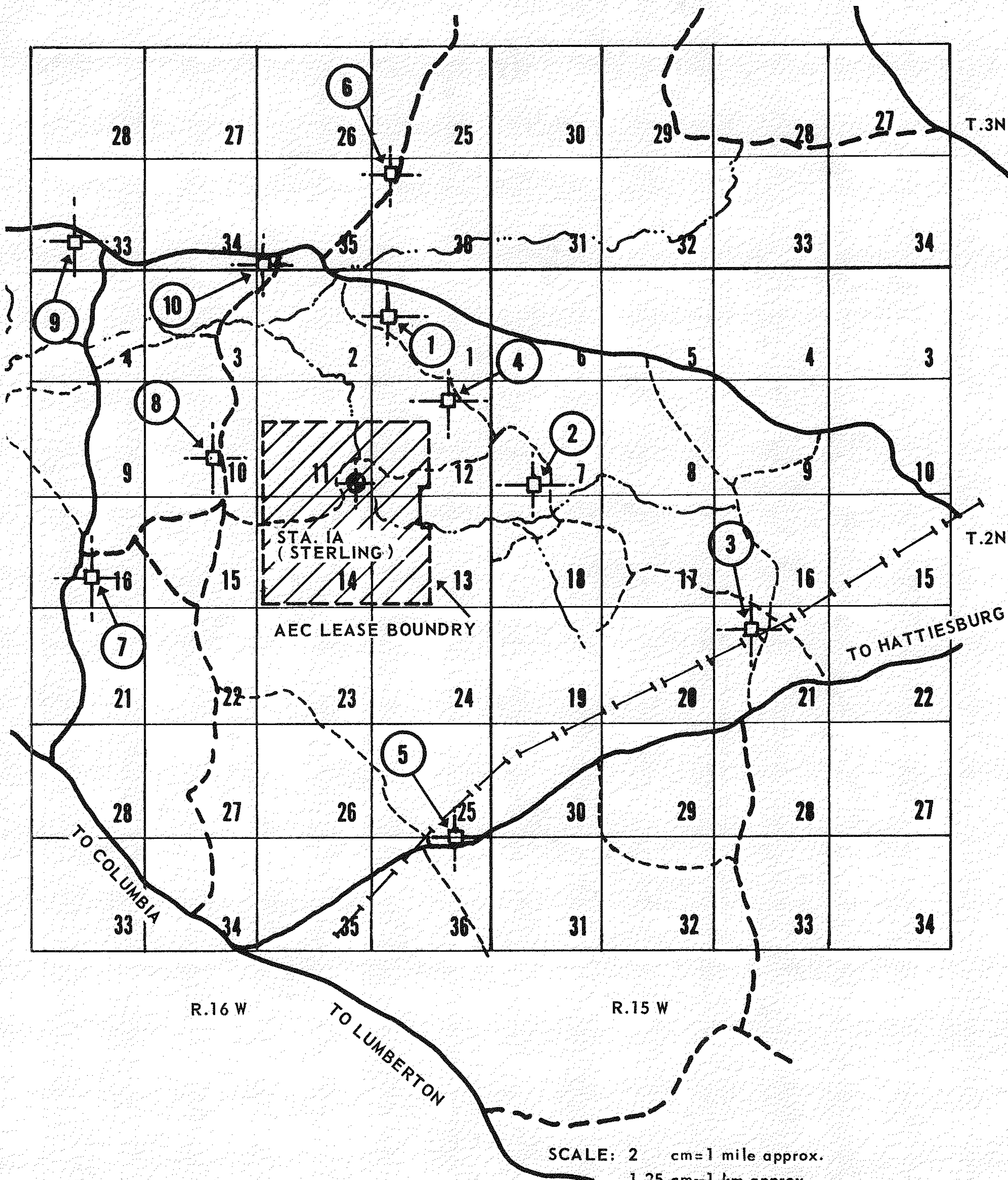


Figure 4–14 USC&GS Strong Motion Seismograph Stations

4.4 HYDROLOGICAL AND GEOLOGICAL INVESTIGATIONS

4.4.1 Responsibilities

The U. S. Geological Survey, Water Resources Division, participated in Project Sterling by making investigations of the water resources on and in the vicinity of Tatum Dome. Previous geological studies conducted for the Salmon Event were observed to be adequate and were also used for the Sterling Event. The purpose of the hydrological investigation was to obtain background information concerning the ground-water and surface-water conditions prior to the Sterling detonation, particularly for evaluation of damage claims that might result therefrom. Data were necessary for making comparisons and evaluations between pre- and postshot conditions as they relate to safety evaluations of the project.

The mobile laboratory from Denver was taken into the field for a study of the corrosion potential of ground water in the vicinity of the site. Samples were also collected from 32 wells and streams for chemical and radiochemical analysis in the Denver laboratory.

4.4.2 Observation Wells

A network of observation wells (both shallow and deep) has been maintained in the vicinity of Tatum Dome for several years--some since 1961. These are used to observe seasonal changes of water level and the effects of ground-water withdrawals on the aquifers, and for documenting water-level changes that might be attributed to the Sterling experiment, and others. Several wells were installed and instrumented with float-type recorders for monitoring preshot and postshot trends of the water levels in various aquifers on the dome and nearby. A few float-type recorders were placed on unused shallow domestic wells within the 5-mile radius of GZ.

4.4.3 Aquifer and Stream Response

Response to the Sterling Event was shown by water-level changes monitored with float-type recorders in some wells on the dome. The maximum rise in water level measured with these recorders was 0.35 foot in Station 3 vent shaft. A well in the calcite caprock of the dome rose 0.16 foot. A lack of response was indicated by the records for wells in the rim-syncline around the dome and in wells several miles from GZ which gave no indication of the event. Two shallow domestic water wells, located 2 and 3 miles respectively west of the shot point, were unaffected by the event, and negative results were measured in other wells at varying distances from the Tatum Dome.

Pressure transducers were installed in wells HT-2(four transducers), HT-3, HT-5, and E-9 below packers and wired to a high-speed recorder to study the pressure pulses in the aquifers as part of the event. An HE calibration shot (2 tons, tamped, equal to 0.002 kt) on November 28 and the nuclear decoupled shot (0.35 kt) on December 3 gave pressure responses nearly identical in magnitude.

The water-pressure response in well HT-2(four transducers), at a distance of 6,180 feet from GZ, was very slow and barely detectable with a 1 psi transducer. The response in well HT-3, at a distance of 1,780 feet from GZ, was 0.08 foot; the pressure peaked in less than 1 second and declined with minor oscillations back to preshot pressure in 6.5 seconds. The response in well HT-5, at a distance of 1,800 feet from GZ, was 0.18 foot; the pressure peaked in 0.5 second and returned to preshot pressure in a little more than 2 seconds, but minor oscillations continued for several seconds. The frequency was about 1.5 cycles per second. The response in well E-9, at a distance of 1,700 feet from GZ, was 0.45 foot; the pressure peaked in 1.3 seconds and declined very slowly to preshot pressure. The frequency of oscillations was about 5 cycles per second.

The Sterling Event produced no increase in streamflow of Half Moon Creek or Lower Little Creek, as had the earlier Project Salmon Event. This was revealed by continuous-stage recorders, one of which had been in operation on Lower Little Creek since 1961 to record the flow characteristics, and the other on Half Moon Creek for shorter periods, pre- and postshot for both events. A recording conductance meter was used at the Half Moon gaging station to monitor conductance values of streamflow from October 1966 to the present, and showed no increase in values attributable to Project Sterling.

4.4.4 Water Well Complaints

A reinventory of all domestic water wells within a 5-mile radius of GZ was completed in November 1966. The wells were visited and checked to determine yield, water levels (if possible), visible condition of exposed pipes and pumping equipment, appearance of the water and the overall general condition of wells. A postshot inventory was conducted on all wells within 2 miles and random sampling of wells out to 5 miles of the dome. These wells were checked to note any physical and chemical changes in the water which might have been attributed to Sterling.

Six water well claims have been filed since the Sterling Event and these complaints were investigated and reports written to the Deputy Manager for Operations concerning them. Most of the complaints reported a decrease in well yield, but no evidence could be found to substantiate any connection between the decrease in water yield and the Sterling Event. Decreased yield commonly is the result of clogging of the lower check valve with rust flakes or fine-grained sediment produced from the aquifer or a deterioration of the well screen.

4.5 GROUND WATER CONTAMINATION

Investigations and results related to the previously fired Salmon Event indicated that essentially all of the explosion-produced radionuclides were confined to the salt mass of Tatum Dome. There was no reason to conclude, therefore, that deleterious radiocontamination of ground-water supplies would result from Sterling.

Hazleton-Nuclear Science Corporation (H-NSC) conducted investigations to support the Sterling hydrologic safety objectives, and to show that hazardous concentrations of radionuclides attributable to Sterling did not enter the ground-water system. H-NSC efforts included a review of available information collected pre- and postshot, and pre- and postshot reconnaissance and sampling to supplement data received from other agencies.

4.5.1 Preshot Predictions

Preshot investigations indicated it was not likely that hazardous concentrations of detonation-produced radionuclides, attributable to Sterling, would enter directly into the hydrogeologic environment surrounding Tatum Dome. However, the possibility existed for microventing and some radioactive gas transfer from the explosion zone into aquifers overlying or intersecting the Tatum Dome.

The concentration of volatile radionuclides which might be found in postshot sampling was expected to be high enough to be detected, but well below radiation protection standards. In the unlikely event that other radiocontaminants produced by Sterling were not confined to the salt mass and were introduced into the ground-water system, it was believed that movement of these contaminants, as also the movement of dissolved volatile radionuclides within the aquifers, would be slow. In addition, ion exchange characteristics of the aquifers will significantly retard the movement of most radionuclides with respect to the conveying ground-water. The combination of low ground-water velocities (1 to 10 feet per year), radioactive decay, and radionuclide absorption would probably limit movement of contaminants to a maximum of a few thousand feet from the point of introduction, at which short distance the concentration of nuclides would be reduced to acceptable concentrations.

4.5.2 Pre-and Postshot Studies

H-NSC investigations were aimed primarily at showing that hazardous concentrations of radionuclides did not enter the ground-water system as a consequence of the Sterling Event. In order to accomplish this task and to supplement data received from other agencies, H-NSC conducted sampling and reconnaissance trips to the Tatum Dome Site.

Two site visits were made to Tatum Dome: the first about one month before the Sterling Event (October 31-November 4, 1966), and the second about two months after the detonation (January 30-February 3, 1967). On each occasion samples of well water and surface water were taken in addition to purging CO_2 gas from water derived in wells.

Preshot water samples were from Wells HT-4 and HT-2c located 1700 and 5000 feet respectively, SW from SGZ; the surface water sample was collected from Half Moon Creek at a point about 1000 feet north of SGZ. Postshot water samples were from Wells HT-5 (about 50 feet south of HT-4) and HT-2c, and from the same point on Half Moon Creek. Gross radiochemical analyses of these samples were matched with analytic results collected by other agencies for comparative purposes.

Samples of purged CO_2 gas were collected pre- and postshot at the well sites (HT-4, HT-5, HT-2c) in order to determine preshot background levels of carbon 14 and to compare results with postshot levels.

4.6 CONTAINMENT AND STEMMING

The Environmental Research Corporation (ERC) made an evaluation of the phenomenology affecting containment and the adequacy of the stemming plan. Results were presented in Report NVO-1163-92 (October 10, 1966). It was concluded that radioactivity from Sterling would be completely contained.

Based on pressure and temperature considerations, it was predicated that the cavity would not be significantly enlarged by the Sterling detonation. The increase in cavity radius was expected to be about 1 foot, largely as a result of thermal effects. Although the theoretical maximum initial pressure was slightly higher than the overburden pressure, no containment failure was expected. It was doubtful that this theoretical maximum pressure would be attained. Even if reached, it would drop well below overburden pressure in a matter of milliseconds. It was predicted that the cracking radius and radioactive injection into these cracks would be much less than observed at Salmon.

Thus, no contamination hazards would result from cracking. It was expected that little, if any, surface spalling would occur and that a chimney would not be formed. Evaluation of the stemming design indicated its adequacy to prevent escape of radioactivity.

All factors considered, it was concluded that no radioactivity would escape to the surface. Also, no hazards to aquifers or grout seals were anticipated.

As predicted, Sterling was completely contained.

4.7 INDUSTRIAL SAFETY, FIRE PROTECTION, AND MEDICAL SERVICES

The REECo Radiological Sciences Department was delegated the function of providing general Health and Safety services for the Project Sterling program. This implied direct responsibility for all REECo employees and for all REECo provided facilities. Health and Safety services were provided to other prime contractors in an advisory capacity and on an "as requested" basis.

4.7.1 Industrial Safety

a. General Support

All areas of general occupancy or traffic were appropriately posted to reflect safety requirements and approved practices. This included such items as speed limits, power line height clearances, explosive areas, bridge load limits, barricades, hard-hat requirements, etc. Safety reminders and promotional materials were maintained and posted at distinct locations.

A stock of general safety equipment items were maintained and issued to Sterling personnel as appropriate. The equipment included such items as hard-hats, safety goggles, face shields, etc.

Safety engineers from the NTS REECo Safety and Safety Evaluation Division, NVOO, visited the test site to review the safety program.

b. Safety Inspections

Routine safety inspections were conducted of all test site facilities and the Hattiesburg office areas. Safety discrepancies were reported to responsible REECo supervisory personnel for REECo related facilities, and to the AEC Site Manager for non-REECo related facilities. A total of 49 hazards were detected in the course of 9 inspections. All hazards were corrected.

c. Safety Meetings and Orientations

Safety meetings and employee orientations were routinely conducted for REECo field personnel. Unsafe work habits and conditions were discussed, and the current safety reports were reviewed.

d. Personnel Injuries

There were 13 cases of reported minor injuries. All contributing factors were investigated and corrected. Two lost-time injuries were reported by the drilling contractor.

e. Vehicle Accidents

There was one federal vehicle accident. It involved a minor collision with a non-federal vehicle and was caused by the driver of the non-federal vehicle. The federal vehicle was assigned to ARFRO-ESSA (U. S. Weather Bureau). All appropriate report forms were submitted.

4.7.2 Fire Protection

a. Equipment

A 1000-gallon capacity, 4-wheel-drive fire truck was maintained at the Sterling Test Site. Appropriate portable fire extinguishers were strategically located at the test site and the Hattiesburg office. The extinguishers were routinely inspected and maintained.

b. Personnel

All Radiological Sciences personnel and REECo field supervisors were trained in the operation and use of fire fighting equipment.

c. Emergency Call Procedures

Standard call procedures were published and appropriately posted throughout all areas to assure an effective response capability.

No fire emergencies were reported.

4.7.3 Medical Services

a. Physician

A local physician was retained as advisor for the medical program, and to provide professional service as required.

b. First Aid

Qualified Aidmen were assigned to provide first aid coverage in conjunction with test site activities.

A First Aid Station was established in a central location within the test site area. It was equipped with the necessary medical supplies and communications for immediate first hand treatment of occupational and nonoccupational illnesses and injuries. An ambulance was maintained in continuous readiness and was provided with first aid kits, a resuscitating unit, and related equipment.

c. Treatment Summary

A total of 26 occupational and nonoccupational illnesses and injuries were treated at the First Aid Station.

Four minor injuries required referral to a physician for followup treatment.

4.8 SPECIAL SAFETY MEASURES

4.8.1 Oil and Gas Field Surveys

The survey was conducted in accordance with the "Operational Safety Plan for Project Dribble - Sterling Event," dated November 1966.

All oil and gas structures within a 5-mile radius of GZ were examined and photographed in detail, but only selected facilities and installations beyond the 5-mile radius were surveyed.

The preshot survey was begun 12 days before the detonation, on November 21, 1966. The above-mentioned facilities were inspected, and photographs were taken to provide documentation of any physical changes.

Representatives of the producing and pipeline companies of the Baxterville area were advised of the scheduled date for detonation and the degree of ground shock that was expected.

The postshot survey began immediately after the detonation at 0615 hours December 3. The same facilities as documented in the preshot survey were examined and photographed.

No damage was observed either by on-the-spot inspection or examination of photographs.

No damage was reported by the producing or pipeline companies.

4.8.2 Air Space Advisory

The Radiological Safety Branch, Safety Evaluation Division, NVOO, was responsible to the Project Manager for the preparation of the Air Space Advisory Plan in cooperation with the Air Operations Office of the Project Operations Division. An Air Space Advisory Plan was necessary to delineate an air space where any contaminated air mass from the detonation (should an effluent release occur) would be predicted to move, and through which nonparticipating military and civilian aircraft would be advised not to fly. Had any effluent release occurred, such predesignation of potentially hazardous air space would have avoided startling pilots flying near the test site, prevented unintentional penetration of a contaminated air mass, and minimized traffic hazards to participating project aircraft.

According to Paragraph 3.9 of the "Project Sterling Operational Safety Plan," it was desirable to sterilize a parcel of airspace surrounding the test site in order to reduce to a minimum any hazard to the flying public which could result from release of radioactive effluent.

It was the responsibility of the Federal Aviation Agency, Houston Air Route Traffic Control Center (ARTC Center), to take all necessary action to appropriately publicize the Sterling Event and to identify to the public that area to be closed. Accordingly, flight was restricted in the airspace lying within a 20 nautical mile radius of 31°08' 31.5"N/89°34'11.78"W, from 15,000 feet MSL to the ground surface between 0001 - 1200 hours CST.

General Aviation District Offices at New Orleans, Louisiana; Jackson, Mississippi; Shreveport, Louisiana; Birmingham, Alabama; and Houston, Texas, assumed responsibility for advising all small airport operators within a 150-mile radius of the detonation site of this event. Houston ARTC Center also furnished appropriate information so that the following Flight Service Stations could issue an Airmen's Advisory concerning this event:

Esler-Alexandria	Montgomery
Jackson	McComb
Lafayette	New Orleans
Meridian	Pensacola
Mobile	Shreveport
Monroe	Tuscaloosa

In addition to actions enumerated above, Houston ARTC Center also prepared a message outlining details of the anticipated nuclear detonation and forwarded it to the following military facilities requesting that they assume responsibility for appropriate dissemination to all flying units within their command:

Headquarters, 2nd Air Force, Barksdale AFB
Eighth Coast Guard District, New Orleans, Louisiana
Headquarters, 14th Air Force, Gunter AFB
Naval Air Station, Corpus Christi, Texas
Headquarters, Air Training Command, Randolph AFB
McDill AFB, Tampa, Florida
Eglin AFB, Florida
Headquarters, 4th Army, San Antonio, Texas
Headquarters, 15th Air Force, March AFB
Pensacola NAS, Florida
Headquarters, 8th Air Force, Westover AFB
Headquarters, Tactical Air Command, Langley AFB

This message was also sent to the

FAA Regional Office, Fort Worth, Texas
FAA Regional Office, Atlanta, Georgia
Memphis ARTC Center, Memphis, Tennessee

Airspace surrounding the detonation site 8 miles west of Purvis, Mississippi, is under radar surveillance from FAA radar equipment located at Alexandria, Louisiana. The scopes from this radar equipment are in the Houston ARTC Center. Appropriate directives were issued within Houston ARTC Center for all controller personnel to route IFR traffic around the area.

The Houston ARTC Center representative arrived at the Project Sterling site at 0445 CST on the date of the detonation. He remained until 0900 hours at which time the Project Manager released him to return to his duty station.

At 0829 on December 3, 1966, Houston ARTC Center issued a teletype message to all offices and facilities concerned that the detonation had occurred and that the area was now cleared for air traffic.

4.8.3 Structural Response Program

John A. Blume & Associates Research Division (JAB) was the structural response contractor for Sterling. JAB conducted condition surveys, operated instrumentation for structural response, and provided observers for structural response during Zero Time.

During the first week in October 1966, a survey was made of existing structures in the site area to select representative vulnerable buildings to be monitored, instrumented, and observed prior to, during, and just after the Sterling detonation. The survey included inspection of new structures in the area not covered in previous surveys.

The selected structures are located in close proximity to the site area and in cities and towns from which most damage claims for the Salmon Event were received. Alternate locations were also selected. Brick, block, or stucco structures were chosen in preference to others because of the high proportion of masonry damage among Salmon damage claims. It was generally necessary to select residential structures for those in close proximity to the site because of a general lack of other types of buildings. In cities and towns, however, commercial, institutional, or public structures were preferred because of the greater ease of access for repeated close-interval condition surveying and monitoring prior to the event.

The last two weeks of October and the first week in November 1966 were spent by two members of JAB conducting a detailed condition survey of 19 selected structures in the test site area. The existing condition of these structures was photographed and written reports were made on their observed material weaknesses. Monitoring gauges were installed on various structures where permission by owners was granted and where existing damage to building materials was apparent.

On November 28, 1966, 17 members of JAB rendezvoused in Hattiesburg, to participate in the project activities. Each of the previously selected structures was assigned to one of the participants for monitoring during the event. Time prior to the event was spent in familiarization with the assigned structure and conducting of a preshot condition survey.

On the morning of the event observers were dispersed to their respective locations prior to shot time to orient themselves for the event and to operate strong motion instruments installed by the USC&GS. Everything went as scheduled. Only slight motion was felt in a few close-in areas.

Strong motion accelerographs recorded ground motion near residential structures 1.5 to 5.0 miles from GZ. Each accelerograph contains 3 components each of Carder displacement meters and USC&GS accelerometers. However, none of the displacement meters was sensitive enough to record measurable motion. NGC-21 velocity meters were employed near major structures from the Baxterville Post Office to the Lumberton State Bank and the Hattiesburg Southernaire Motel.

Peak recorded horizontal accelerations at the residential structures ranged from 0.0013 g at the Dobson residence to 0.00064 g at the Ready residence. Structures to the NW of GZ received comparatively less motion than the others.

The Baxterville High School experienced a peak recorded horizontal velocity of 0.014 cm/sec while the Post Office Station recorded 0.010 cm/sec. The Bass Memorial Academy near Purvis and the Marion Center High School near Colombia received 0.00089 and 0.00033 cm/sec respectively. The Southernaire Motel station in Hattiesburg recorded a peak of 0.004 cm/sec.

No damage was observed in any of the monitored structures. JAB participants returned to their respective home offices by December 4.

CHAPTER V

ENGINEERING, CONSTRUCTION AND SUPPORT

5.1 ENGINEERING AND CONSTRUCTION

The project site was located in an area overlying the Tatum Salt Dome and consisted of portions of Sections 11, 12, 13, and 14, Township 2N, Range 16W, St. Stephens Principal Meridian, in Lamar County, Mississippi. The nearest large town is Hattiesburg, Mississippi, approximately 23 air miles NE of the site. The Administrative offices used by the USAEC, the Architect-Engineers, Technical Program Agencies, and the Support Contractor were located in Hattiesburg.

5.1.1 Preliminary Work

Major activities in preparation for the Sterling test involved the rehabilitation of the facilities used in the Salmon test, among which were the following:

(1) Station 1A Emplacement Hole.
(2) Postshot Hole No. 1.
(3) Postshot Hole No. 2.
(4) Instrument Hole No. E-13.
(5) Instrument Hole No. E-14B.
(6) Salmon Event Test Director's Manned Station (TDMS), and relocation of the Salmon Event CP to a site adjacent to the TDMS.
(7) Existing device assembly area.
(8) Existing Sandia recording park.
(9) HE storage bunkers.
(10) Existing area power and lighting systems.
(11) Existing scientific cable facilities.

The following new facilities were provided:

(1) Station 4 - a hole drilled for use in an HE calibration test which was conducted November 17, 1966.
(2) A GZ recording park.
(3) Additional scientific cable facilities.

5.1.2 Engineering Services

Fenix & Scisson, Inc. (F&S) provided Titles I, II, and III engineering services for drilling and mining activities listed in paragraph 5.1.1 and described in paragraph 5.1.3. This organization also designed the concrete pad for Station 1A. F&S provided 24-hour inspection service with a crew of inspectors under the direction of a Chief Field Inspector. F&S prepared 10 drawings and 23 documents which included contract specifications, drilling programs, and technical reports.

Holmes & Narver, Inc. (H&N) provided architect-engineering and field engineering and inspection services related to surface construction, and prepared construction status reports. Survey services were provided by a local engineering firm, as required, on an H&N purchase order. H&N was responsible for Titles I, II, and III engineering for all surface facilities including scientific and power cabling, but excluding the concrete pads for drill holes.

The H&N Las Vegas Office produced 19 new drawings, and the field office provided 10 new drawings. All drawings were brought into as-built status. H&N also maintained the record library of engineering data.

5.1.3 Construction

Big Chief Drilling Company, operating under AEC Prime contracts, completed the following work:

(1) Station 1A Emplacement Hole (N.537,357.91; E.269,541.55)

The Salmon Emplacement Hole had been cased with 29-inch ID casing to 899 feet, 20-inch ID casing to 2202 feet and 8-5/8 inch OD casing to 2651 feet. Big Chief removed the 8-5/8 inch OD casing, and then reamed the hole with an 18-inch shoe. Later, Big Chief assisted with the emplacement of the device and performed the stemming operations.

(2) Postshot Hole No. 1 (PS-1) (N.537,365.30; E.269,536.42)

This hole had been drilled into the cavity at a depth of 2661 feet, and cased with 9-5/8 inch casing to a depth of 2250 feet. Big Chief reopened this hole into the cavity in preparation for emplacement of instrumentation by the Deep Well Service Co. Grouting of instruments in this hole and PS-2 was difficult to accomplish. Obtaining a seal at the intersection of the hole and the cavity, and placement of salt matching grout were the problem areas.

(3) Postshot Hole No. 2 (PS-2) (N.537,461.43; E.269,537.00)

This hole had been drilled near the cavity to a depth of 3024 feet and cased with 11-3/4 inch casing to a depth of 2101 feet. Big Chief reopened this hole in preparation for emplacement of instrumentation by Mohon Brothers.

(4) Station 4--HE Emplacement Hole (N.536,278.54; E.269,167.48)

This hole was drilled to a depth of 2717 feet, with 20-inch casing to 2198 feet. The hole was 12-1/4 inches in diameter. It was used for the calibration shot. Big Chief also assisted in emplacement of the HE materials.

Prairie Drilling Company was awarded an AEC contract to redrill Instrument Hole No. E-14B (N.537,124.66; E.269,034.59). This hole had been drilled to 3959 feet, cased with 11-3/4 inch OD casing to 1627 feet and plugged back with cement below 1075 feet. Prairie Drilling Company removed the pumping equipment which had been installed for the USGS hydrological testing program and drilled a new 10-5/8 inch diameter hole to 2800 feet for emplacement of instrumentation by Mohon Brothers under a separate contract.

Mohon Brothers was awarded an AEC contract to redrill instrument Hole E-13 (N.537,047.75; E.268,098.71). This hole had been drilled to 2871 feet, and was cased to 938 feet with 16-inch casing and to 1561 feet with 11-3/4 inch casing. The Contractor also removed cable bundles from the hole and placed the instrumentation.

Reynolds Electrical and Engineering Co., Inc. (REECo) served as support contractor on this project and completed the following items of construction:

(1) Modification to Skid IV - Added partitions, electrical, air conditioning. (One bid received and rejected as being too high.)

(2) Installation of scientific cabling.

(3) Installation of secondary electrical lines at the Recording Park.

(4) Relocation of secondary electrical lines, poles, and lights from the old CP to the new CP.

(5) Erection of two TV towers.

(6) Interchange of electrical equipment at several substations.

(7) Station 4 grading and planking.

(8) HE emplacement at Station 4

REECo also arranged by negotiated subcontract for the construction of the following items:

(1) Rehabilitation of Station 1A Site.

(2) Fencing and Helicopter Pad.

(3) GZ Recording Park

(4) LRL Storage Building

5.2 SUPPORT

5.2.1 REECo Support

REECo provided logistical support, construction support, and on-site radiological support services. Logistical services included the following:

(1) Establishment and maintenance of communications--telephone, teletype, and radio services.

(2) Maintenance of office and warehouse facilities.

(3) Control, maintenance, and dispatch of vehicles.

(4) Supply functions such as procurement, expediting, traffic control, freight handling, and warehousing.

(5) Administrative services such as subcontract administration, personnel support for Visitors' Bureau, Observers' program, evacuation program, AEC Claims Office, medical station, fire protection, industrial safety, and industrial guard services.

(6) Demobilization.

REECo construction support was provided in response to work orders issued by H&N. REECo provided direct support for all "buck slip" orders in which direct costs were limited to $300; and REECo also performed construction entailing greater expense when it was not advantageous to award the work to another contractor.

Radiological safety support is discussed in detail in Chapter 4, paragraph 4.2.1.

5.2.2 F&S Support

F&S maintained surveillance of underground activities and prepared a daily progress report. The project office activities were supervised by an Engineer as Senior Site Representative, and the engineering staff was reinforced with field trips by a Project Engineer from the Central Engineering Staff at the Tulsa Office.

5.2.3 H&N Support

Project activities were accomplished by a Senior Site Representative who supervised the inspection and survey crews. When the need arose this organization was temporarily supplemented by members from the Las Vegas Office and the Nevada Test Site.

H&N administered a work order system, patterned after NTS procedures, for construction or services which could not be conveniently procured under contractural arrangement. Work orders were usually issued to satisfy specific requirements of a technical agency. In each case, H&N prepared an estimate of total costs, exclusive of A-E costs, and the AEC approved the expenditure before release to REECo for execution. When feasible, REECo negotiated a subcontract for the work; otherwise, REECo forces performed the work.

H&N provided inspection services for surface construction including roads, trailer parks, power and lighting, concrete pads, shelters, scientific cabling, and equipment installations.

H&N also supervised the survey activities for the layout of facilities, topographic mapping, and the design work performed under the engineering service subcontract.

CHAPTER VI

COSTS

PROJECT STERLING COST REPORT - NOVEMBER 30, 1967

WORK FEATURE NUMBER	DESCRIPTION	PERFORMING CONTRACTOR	COSTS INCURRED THROUGH NOVEMBER 30, 1967
01	ARPA Funded		
	Field Construction		
01	Site Preparation	REECo	$ 16,518.19
02	Zero Station	Big Chief	437,192.29
		Prairie Drilling	66,026.26
		REECo	49,788.63
	Total		$ 553,007.18
03	Instrument Locations	REECo	86,911.74
05	Zero Station Cabling	REECo	681.77
07	Technical Structures	REECo	32,834.92
08	Instrument Cabling	REECo	10,938.13
11	Emplacement & Buttonup	REECo	80,434.79
12	Reentry & Recovery	REECo	-0-
18	Other Office Facilities	REECo	835.49
25	Restricted Access Fence	REECo	6,693.29
34	Airstrip	REECo	962.15
75	Field Support	REECo	25,843.13
90	Architect/Engineer Functions	F&S	105,395.67
		H&N	52,473.88
	Total		$ 157,869.55
	Total-Field Construction		$ 973,530.33
02	Technical Support		
	Technical Support	WES	$ 22,386.98
	Diagnostic Support	EG&G	46,778.83
	Total		$ 69,165.81
01	Hydro-Geo-Meteor-Seismic & Other	USGS	$ 53,241.49
		Environ. Res.	10,146.73
		USPHS	102,699.00
		ARFRO-ESSA	27,596.71
		Isotopes	8,094.74
		Blume	20,810.00
		USC&GS	89,193.96
		REECo	2,625.10
		USBM	5,429.06
		Gen'l Adj. Bureau	1,899.78
	Total		$ 321,736.57

WORK FEATURE NUMBER	DESCRIPTION	PERFORMING CONTRACTOR	COSTS INCURRED THROUGH NOVEMBER 30, 1967
02	Technical Support (Cont.)		
02	Scientific Photography	REECo	$ 7,417.26
04	Timing & Firing	EG&G	60,815.49*
05	Rad Safety & Studies	REECo	89,168.11
07	Indemnification & Claims	REECo	157.44
10	Prep. of Proj. Mgr's. Report	REECo	1,732.79
	Total-Technical Support		$ 550,193.47
03	Logistical Support		
	Miscellaneous Support	REECo	$ 712.26
01	Motor Vehicles	REECo	78,115.84
02	Telephone & Radio	REECo	58,794.46
03	Supplies & Materials	REECo	8,020.43
04	Shop Services, Reproduction	REECo	4,139.45
05	Personnel Assistance	REECo	14,747.11
06	Transportation of Items	REECo	10,531.96
07	Security	WSI	38,343.70
08	Aircraft	DASA	17,261.00
		REECo	82.39
	Total		$ 17,343.39
09	Public Info, Observers, & Visitor Prog.	REECo	812.71
	Total-Logistical Support		$ 231,561.31
04	Maintenance & Operation		
01	Utilities	REECo	$ 11,389.83
02	Buildings & Trailers, M&O	REECo	21,023.89
03	Buildings & Trailers, Other	REECo	5,969.33
04	Roads, Grounds, Fencing, & Lighting	REECo	20,753.11
07	Health, Medicine, & Safety	REECo	6,744.21
08	Plant Protection	REECo	43,403.65
09	Supply, Storage, & Warehousing	REECo	14,854.19
10	Project & Site Office	AEC-ORO Couriers	625.00
		REECo	101,897.86
			$ 102,522.86
	Total-Maintenance & Operation		$ 226,661.07
	Less: Costs for Continuing Maintenance & Operation-Hattiesburg Site- Transferred to ARPA Order 394		(189,000.00)
	Subtotal ARPA Funded Costs		$ 1,792,946.18
	Total Costs Through November 30, 1967		$ 1,732,130.69

* *AEC Funded - Not included in ARPA Fund Total*

CHAPTER VII

CLASSIFICATION AND SECURITY

7.1 CLASSIFICATION

The position of Classification Advisor for Project Sterling was filled on a continuous basis by the NVOO Classification Officer.

Basic classification guidance for Project Sterling was in accordance with

NVOO memorandum of July 26, 1962, subject:
"Classification Guidance for the Seismic Improvement Program,"

NVOO memorandum of August 17, 1966, subject:
"Classification Guidance - Project Sterling,"

CG-WT-1
"AEC-DOD General Classification Guide for Continental Test Operations" which supplements the

Joint US/UK Nuclear Weapons Classification Guide (CG-W-1).

There were no major classification problems of an unusual nature in connection with Project Sterling inasmuch as visual access to the exterior of the device canister was unclassified. Accordingly, uncleared personnel were permitted to be present during the down-hole operation. Such visual access, however, has to be reviewed on a case-by-case basis and could pose a serious security problem at off-site locations where numbers of cleared personnel are limited.

7.2 SECURITY

7.2.1 Responsibilities and Organization

The Director, Security Division, NVOO, appointed a Chief of Security, Project Sterling, who was responsible for all facets of the security program. The AEC security interest at Project Sterling consisted of receipting, handling, storing, transmitting, and safeguarding documents and materials classified up to and including "Secret Restricted Data." The security program was activated on October 14, 1966, and terminated on December 8, 1966.

Control of access to the general area and property protection activity at the Project Sterling Site was accomplished through the use of a "Q" access authorized (AA) unarmed watchman service supplied by REECo. These watchmen also served as backup to the guard force during calibration events and the test detonation, and are providing limited services in support of the postshot program.

During the operational phase of the program, Wackenhut Services, Inc. (WSI), of Coral Gables, Fla., a prime contractor for security services to NVOO, furnished armed guards for the Hattiesburg Project Office (HPO) and Sterling

Site security interests. Security areas were established at the following site locations: Device Storage Area; Diagnostic Trailer Compound; Ground Zero; Test Director's Manned Station, which included the Sterling cryptographic and communications facilities; and the Test Manager's Control Point. Materials, documents and cryptographic equipment classified up to and including "Secret Restricted Data" were authorized in these areas on an "as required" basis.

The "Buddy System," or two-man concept, was used for protection of the device when determined necessary by the LRL Test Director.

The south wing of the HPO was established as a limited security area where storage and work with Secret documents was authorized. Access to the area was controlled by WSI, which also operated the Badge Office adjacent to the security area. During normal working hours, a dutch door with an electronically activated locking device was used by the guard to prevent entry to the area until examination of badge credentials was effected. During normal nonoperating hours, all classified matter was secured in approved repositories and guard coverage was extended for security as well as plant protection, the PBX operation, locator service, and badging capability.

Other security services provided by the guard force included escorting of classified test devices and component materials at the site; motor patrols to assist in security safeguards, emergency plans, property protection, and relief for security stations; and periodic checks of buildings, storage locations, office trailers and areas of security interest. Under the direction of the Chief of Security, and in compliance and conjunction with the "Test Manager's Operations Plan and Schedule of Events," the guard force also performed air and ground sweeps over heavily wooded and swampy terrain and established road and muster controls for clearing areas for calibration events and for the detonation area on D-Day. The guard force was augmented with local watchman personnel during area sweeps and mustering operations. This augmentation proved successful from both operational and economic viewpoints. Helicopters used for air sweeps over the wooded and swampy terrain saved time and effort in checking areas inaccessible to motor vehicles.

Due to the temporary nature of the security areas and interests, chain link fences were not used to provide security protection.

Temporary barriers of a combination of four strands of barbed wire or hog wire were used to designate security area boundaries and these boundaries were supplemented with fixed point security protection afforded by a combination of administrative controls, temporary floodlighting during hours of darkness, and 24-hour guard coverage. Sight barriers or storage containers shielded classified objects from view of uncleared or unauthorized persons working in contiguous areas.

7.2.2 Device Movement and Shipment Security

The movement of the test device to the Sterling Site was the responsibility of the Manager, ALOO. The Manager, NVOO, was responsible for accepting custody of the device at the Sterling Site. This responsibility was redelegated to the Chief of Security, who accepted custody of the device and test components from ALOO couriers. Device and test component shipment was accomplished by courier-operated government vans. The Armed Forces Courier Service was used to transport classified spare parts and assembly tools from LRL, Livermore, California, to the Chief of Security who accepted custody in Jackson, Mississippi, and provided escort to the Sterling Site. Final assembly was accomplished in the Device Assembly Building in the GZ Area.

The Armed Forces Courier service also delivered classified cryptographic equipment to the Chief of Security, who accepted custody in Jackson and provided escort to the Sterling Site.

Classified spare parts and assembly tools were returned to LRL, Livermore, by REA Protective Signature Service. Cryptographic equipment was returned to NVOO by SROO and ALOO couriers.

7.2.3 Clearances

Clearance information was processed to the Chief of Security by the use of Badge Request Forms, or Form AEC-277. These forms were signed by an authorized individual of the requesting agency who sent sample signatures to the Security Office. Security clearance information stated on the form was verified for access to Defense Information or certified for access to Restricted Data, as applicable, through the requester's normal AEC, DOD or other government agency channels, prior to the form being accepted for badge preparation.

7.2.4 Pass and Badge Office

A Pass and Badge Office was activated at the Project Office in Hattiesburg on October 24, 1966. The office was in operation a minimum of 12 hours per day, 6 days per week, and the capability for badging 24 hours per day existed as a result of the guard coverage of the HPO. Special Sterling badge inserts were used which were color-coded for type and level of clearances, as well as numerically coded for area access and type of classified information authorized. After personnel processing was completed, the photo-identification badge system was placed into effect on October 25, 1966 and remained in effect until D + 2, December 5, 1966 at which time the Pass and Badge Office was deactivated. A total of 972 Project Sterling badges were prepared and issued.

7.2.5 Security Education

The limited period of the classified aspects of Project Sterling made it not feasible or practical to undertake a formal security education program for the varied participating agencies and organizations. At 120 days prior to the detonation, the NVOO-Security Plan draft was transmitted to major participants for comment. Ninety days prior to detonation, the final "Security Plan" was distributed to all participants. The "Security Plan" constituted the security operating policies and set forth the security rules and regulations applicable to all Project Sterling personnel. The Project Security Office was established on October 14, 1966, to furnish additional information and day-to-day guidance on security matters. On-site security education was presented to participants in the form of posters, lectures, discussions, and various publications.

CHAPTER VIII

PUBLIC INFORMATION

Project Sterling was first made public on July 12, 1966, with a simultaneous information issuance in Washington, Hattiesburg, and Las Vegas. Just prior to the announcement, NVOO officials met with Mississippi Governor Paul Johnson and explained the project to him. Governor Johnson volunteered the fullest cooperation of his office and various state agencies, including the Mississippi State Highway Patrol.

After the meeting with the governor, the NVOO officials met with Hattiesburg civic and business leaders at the William Carey College in Hattiesburg. The meeting was arranged through and by Mr. Henry Pyne, manager of the Hattiesburg Chamber of Commerce, at the request of the Project Site Manager. Project Sterling was explained to the group, which included Mayor Paul Grady, who volunteered to assist in any way possible.

That evening, the same NVOO group met with about 200 residents living around the Tatum Salt Dome and explained the project to them. Once assured that ground shock was not likely to be felt outside the test site and that the Project Salmon damage claim procedures would be used, the local residents accepted the project.

Until the announcement of the opening of the Joint AEC-DOD Office of Information in Hattiesburg on November 12, 1966, only routine announcements, such as contract awards, were issued. The Joint Office of Information was opened at 106 Buschman Street, and the news media and public were invited to make any inquiry they wished about the project.

The Joint Office of Information was manned by an AEC Information Officer from NVOO, who was responsible to the Project Manager, and a public information officer borrowed from TC/DASA, Nevada Branch. The JOI was responsible for the operation of the Visitors Bureau, which made motel reservations for program personnel and official visitors, and helped make travel arrangements.

On November 15, 1966, a joint information announcement was issued in Washington, Hattiesburg, and Las Vegas, which set the planned Sterling detonation date (November 29), invited residents living around the Tatum Salt Dome to a second public meeting at the Baxterville School auditorium (on the evening of November 17), and announced LRL's Technical Symposium on Project Sterling and the theory of decoupling for invited scientists and educators (held in Hattiesburg on November 16). Salt dome area residents were also invited to attend the Baxterville meeting through invitations mailed to householders from USPHS census lists.

Measures to insure public safety during the experiment were explained at the second Baxterville meeting and the Project Sterling booklet was distributed. (Some 1200 fact books were subsequently distributed to Mississippi schools, colleges, libraries, and interested persons.) The meeting was attended by about 100 persons, about half the number that attended the first Baxterville meeting for Project Sterling.

Other information announcements issued by the JOI during the week of the second Baxterville meeting were announcement of the 2-ton chemical high explosive calibration shot; an invitation to news media to attend a Project Sterling briefing and to be present for the detonation; a report of the Baxterville meeting; and an announcement that the calibration shot had been successfully fired.

On November 23, a JOI announcement said the planned detonation date of November 29 "has been postponed for at least a few days," and that the postponement was "caused by technical difficulties." In response to inquiries, oral explanations (failure of an electric motor in the device cooling unit) were given to local news media. After the motor was replaced and the device lowered into the cavity, the JOI issued an announcement setting December 5 as the planned detonation date.

On December 2, the JOI announced that the planned detonation had been moved ahead to 0600 Saturday, December 3, 1966, because of a cooling system failure; they also announced that the news media briefing scheduled for the day before the previous shot date of December 5, had been cancelled.

On Saturday, December 3, the JOI issued its last information announcement, that the shot had been fired successfully. Official and news media observers, about 11 news media and 19 others, were at the Sterling observer site, which had been established about 1-1/2 miles from SGZ. They were briefed by an AEC Information Officer from headquarters, who received his information on shot day activities from the AEC-JOI Information Officer in the Sterling CP via a hotline telephone. After the detonation, the news media and official observers were briefed in the CP briefing trailer by the AEC Test Manager, the LRL Test Director, and LRL's Scientific Advisor to the AEC.

The JOI was closed on Sunday, December 4, after oral replies to inquiries seeking results of decoupling had been answered. The oral response was that signals had been recorded at Sterling seismic stations as far away as 60 miles, but that the data would have to be analyzed before any preliminary results could be announced. Thereafter, queries regarding decoupling were referred to the DOD News Room at the Pentagon.

After the NVOO Information Officer returned to Las Vegas, he received a telephone inquiry on Monday, December 5, regarding the results of the experiment from a newsman *(Business Week)* who had missed the detonation because the shot date was advanced. The newsman asked if any radiation escaped. He was told that radiation had been recorded near the surface from the timing and firing cables, that the seepage appeared to be confined to the cables; that sensitive instruments 500 feet away gave no indication of radiation, and the seepage was stopped by cutting the cables and encasing them in cement. These answers had been prepared for use in response to inquiry only after the seepage occurred. There were no other inquiries regarding radiation.

On January 6, 1967, the DOD issued a news release announcing the preliminary results of the experiment, principally: "There has been experimental verification of the decoupling theory with a nuclear explosion."

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

9.1.1 Engineering and Construction

(1) Nuclear device emplacement holes can be constructed to withstand the shock of detonation under conditions similar to those encountered in Project Dribble.

(2) It is technically feasible and economically advantageous to clean out and reuse an emplacement hole under conditions similar to those encountered in Project Dribble and Project Sterling.

(3) Improved pack-off techniques are required to insure reliable device emplacement and instrumentation grouting in holes entering a dry cavity.

(4) Unproven grouting techniques should not be used on instrument holes entering a dry cavity where a marginal seal may be destroyed.

(5) It is difficult to obtain reasonable construction bids from small firms in the southeastern U. S. with existing contracting procedures, mainly because these contractors lack the accounting and legal staff to confidently handle a government contract.

(6) Freezing of criteria at an appropriate time during the construction phase is an effective way to eliminate costly midconstruction changes and to assure meeting construction schedules.

9.1.2 Safety

(1) No damage of the oil or gas wells was observed either by on-the-spot inspection or examination of photographs.

(2) No damage was reported by the producing or pipeline companies.

(3) Although complete results are not yet available, it appears highly unlikely that hazardous concentrations of radionuclides entered the ground-water system as consequence of this event.

(4) Results of the postshot surveillance (water sampling and analysis) programs conducted by several agencies are expected to show that essentially all explosion-related radionuclides were confined within the salt mass of Tatum Dome.

(5) The Sterling detonation produced no increase in streamflow of Half Moon Creek or Lower Little Creek, in contrast to the Salmon Event.

(6) As predicted, the Sterling detonation was satisfactorily contained.

9.1.3 Organization and Funding

(1) The project organization developed for Project Sterling, reflecting the joint AEC/Laboratory effort and overall responsibilities, functioned exceptionally well.

(2) The AEC/NVOO funding, the reimbursable arrangements with ARPA for Sterling funding, and the funding for claims were handled satisfactorily during and after the operation.

9.1.4 Public Information

(1) It was apparent that the comparatively low yield of Project Sterling and the fact that it was the second underground nuclear experiment in the area made public acceptance of the project much less difficult to achieve. Those two facts also lessened public interest in the event, so much so that only one request to visit the site prior to the event was received by the Joint Office of Information.

(2) Prompt and candid response to inquiries kept the news media and general public fully informed about the experiment, thereby preventing undue and probably erroneous speculation about what caused delays and the subsequent advancement of the shot day.

9.1.5 Operations

(1) No problems were encountered that were not satisfactorily solved in time to meet the scheduled program dates. All agencies concerned with coordination of operational activities of the project worked diligently and efficiently to accomplish assigned tasks.

(2) Various agencies, both public and private, in the State of Mississippi are to be commended for their cooperation and support of the program. These include the Governor's Office, Mississippi Highway Patrol, County Sheriffs, Southern Railway System, officials of the City of Hattiesburg and also all those residents inconvenienced by leaving their homes for the detonation period.

9.1.6 Security

(1) Previous off-NTS detonations used guard force personnel experienced in guard force and testing activities. This project utilized first-echelon experienced supervision from NTS and guard personnel (including second-echelon supervision) from other locations who were not experienced in testing activities or adequately experienced in guard force activities. The use of inexperienced and/or untrained guard force personnel occasioned an extraordinary amount of extra duty hours by supervisory personnel.

In addition to the foregoing personnel, local personnel were used to augment the guard force during area sweeps and mustering operations. This combination of personnel from other than NTS and the limited augmentation with local personnel effected a substantial cost savings, but did not adversely affect the satisfactory accomplishment of the security mission.

(2) In the interests of economy, and due to the temporary nature of the project, in-place or old materials remaining from Salmon were used for temporary security fencing. In some instances, due to space limitations created by swampy or forested terrain, fencing was in closer proximity to operating structures than was desirable from a security viewpoint. The clearing or filling of such areas to provide the desirable space between fencing and structures would not have improved security commensurate with the large expenditure of funds that would have been required.

9.2 RECOMMENDATIONS

9.2.1 Engineering and Construction

(1) When it is probable that an emplacement hole will be reused, this should be made known so that the option to design for total eventual usage will be available.

(2) Engineering construction or support requirements which involve long lead time materials, such as electrical and radio equipment, should be programmed into early criteria.

(3) Instrument hole grouting criteria should be made available early enough so that an unproven but necessary technique can be field-tested without endangering the hole or the scheduled detonation date.

9.2.2 Public Information

It is recommended that insofar as national security permits, all future off-site events be conducted as openly as possible, including full disclosure of current facts.

9.2.3 Operations

(1) The Sterling Event emphasized the need for complete long range planning in all phases of a project; an example is the USGS seismic station support requirements which appeared very late in the program and required crash action to meet scheduled dates.

(2) Other examples of the need for advance planning were (1) the sudden requirement for personnel to be at some USC&GS seismic stations located in the closed area, and (2) requests by personnel of J. A. Blume and Associates, Inc., to visit seismic stations in the closed area after H - 1 hour.

(3) Air support requirements from DOD should be reevaluated to determine if reductions can be made in members of ground personnel fielded at off-site project locations.

(4) Participants should have knowledgeable on-site representation during the last two or three weeks of the operational phase to provide a continuous liaison.

(5) Portable generating plants, if used, should be placed far enough away from the CP complex to reduce the noise level.

9.2.4 Security

(1) First- and second-echelon guard force supervision should be experienced in nuclear testing activities.

(2) Other guard force personnel should meet the minimum requirements for qualification and training specified in the AEC and NVOO Manual Chapters and as deemed necessary by the NVOO Security Division.

(3) Local personnel, if available, should be used to augment the guard force during muster and sweep operations.

(4) Temporary security areas continue to be surrounded by inexpensive fencing; however, such fencing should be placed an adequate distance from operating structures as specified by Security, and should be in a good state of repair.

(5) An adequate number of suitable security signs should be available for posting at required locations to clearly identify security areas.

APPENDIX A

LIST OF TECHNICAL AND SAFETY PROGRAM REPORTS

The following technical and safety program reports are being issued by the Division of Technical Information Extension, USAEC, Oak Ridge, Tennessee:

SAFETY REPORTS

AGENCY	REPORT NO.	SUBJECT OR TITLE
ERC	VUF-1035	Analyses of Ground Motion and Containment, Sterling Event
USPHS	VUF-1036	Off-site Surveillance for the Sterling Event
ESSA/ARFRO	VUF-1037	Weather & Radiation Predictions for the Sterling Event
REECo	VUF-1038	On-site Health & Safety, Sterling Event
FAA	VUF-1039	Federal Aviation Agency Airspace Advisory, Sterling Event
H-NSC	VUF-1040	Hydrologic Safety Evaluation, Sterling Event
USBM	VUF-1041	Pre- and Postshot Safety Inspections of Oil and Gas Facilities near Sterling Event
USGS	VUF-1042	Well Aquifer Response to the Sterling Event, Tatum Dome
USGS	VUF-1043	Chemical and Radio-Chemical Quality of Water Following the Sterling Event

TECHNICAL REPORTS

AGENCY	REPORT NO.	SUBJECT OR TITLE
LRL, SC	VUF-3025	Subsurface Seismic Measurements, Sterling Event
USC&GS, USGS, Geo Tech, LRL	VUF-3026	Surface Seismic Measurements, Sterling Event
TI	VUF-3027	Radioactive Gas Analysis, Sterling Event
II	VUF-3028	Detection of Radionuclides, Sterling Event

3

APPENDIX B

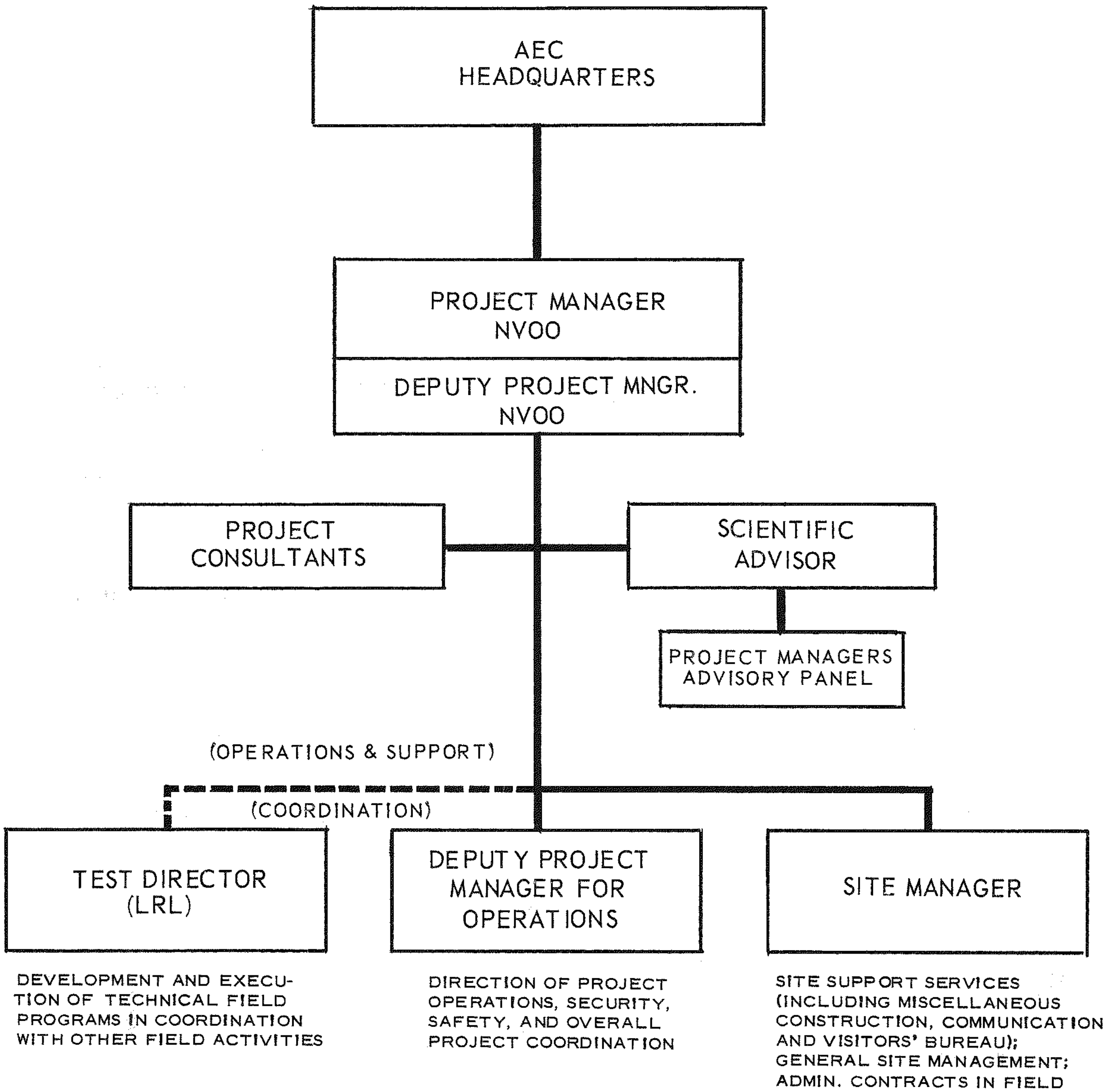
AEC-WASHINGTON AUTHORIZATION AND GUIDANCE FOR CONDUCT OF PROJECT STERLING

Following is the text of the teletype from the Director, DMA, USAEC, Washington, D.C., to the Manager, NVOO, DTG 282020Z, reference symbol MA:T: ALR-329-1:

"This message constitutes your authority to execute Sterling in Station 1A in the Tatum Salt Dome."

APPENDIX C

PROJECT STERLING ORGANIZATION



APPENDIX D

APPOINTMENTS TO PROJECT STERLING ORGANIZATION

Project Manager, NVOO	J. E. Reeves
Deputy Project Manager, NVOO	R. H. Thalgott
Scientific Advisor, LRL	H. L. Reynolds
Test Director, LRL	W. R. Woodruff
Deputy Project Manager for Operations, NVOO	R. H. Shaw
Site Manager, NVOO	L. J. Yelinek

NVOO Program Directors:

Safety	D. H. Edwards, Dir. Safety Evaluation Division
Engineering, Construction, & Support	W. D. Smith, Dir. Engineering & Construction Div.
Operations	W. W. Allaire, Dir. Project Operations Division
Security	W. R. Adair, Dir. Security Division
Public Information	H. G. Vermillion, Dir. Office of Public Information
DMA Liaison Officer	Lt. Col. A. L. Romine Test Branch, DMA