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PROJECT GASBUGGY

MANAGER'S REPORT

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DATE 4/13/72

NOVEMBER 1971

UNITED STATES ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE

Las Vegas, Nevada

R3709

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PROJECT GASBUGGY

MANAGER'S REPORT

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NOVEMBER 1971

UNITED STATES ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE
Las Vegas, Nevada

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PREFACE

The Gasbuggy experiment, detonated December 10, 1967, was the first nuclear detonation designed to stimulate an underground, low productivity, natural gas reservoir.

The project was part of the Atomic Energy Commission's (AEC) Plowshare Program for developing peaceful applications of nuclear explosives and was sponsored jointly by the El Paso Natural Gas Company (EPNG), the Department of the Interior, and the AEC. Costs in this regard were borne by both the Government and EPNG. The total cost was approximately \$5,640,000 with 60 percent (\$3,371,000) borne by the Government and 40 percent (\$2,269,000) borne by EPNG.

The site agreed upon for the experiment was an EPNG lease in the San Juan Basin of northwestern New Mexico (see Figure 1), approximately 55 air miles east of Farmington, New Mexico. The experiment involved the detonation of a 29 kiloton, contained nuclear explosive at a depth of 4,240 feet, in the Lewis shale, just below the base of the natural gas-bearing Pictured Cliffs sandstone.

The primary purpose of the Gasbuggy experiment was to determine if nuclear stimulation would release gas that presently cannot be economically produced from underground reservoirs by conventional methods.

This report is concerned with the administration, operational planning, safety, engineering, construction, and logistics performed by the AEC's Nevada Operations Office (NVOO) in support of the technical and scientific experiments conducted under Project Gasbuggy through the postshot reentry of the emplacement hole and the production testing phase of the project.

This report includes a summary of the technical and scientific purposes of the experiment and such accounts of the field tests as were available at the time of publication. Detailed information concerning the technical and safety aspects of Project Gasbuggy can be found in the Gasbuggy technical and safety program reports listed in a document titled "Reports Available in Plowshare Open File," NVO-86, which may be obtained from the USAEC's Nevada Operations Office, Classification and Technical Information Division, Las Vegas, Nevada (see Appendix D).

Figure 1 Aerial View of Project Gasbuggy Area

ABBREVIATIONS

Abbreviations used in this report for the agencies and contractors that participated in Project Gasbuggy are listed below.

AEC	Atomic Energy Commission
AFSWC	Air Force Special Weapons Center
ALOO	AEC Albuquerque Operations Office
ARL	Air Resources Laboratory
ARPA	Advanced Research Projects Agency
DASA	Defense Atomic Support Agency
DOD	Department of Defense
DPNE	Division of Peaceful Nuclear Explosives
EG&G	EG&G, Inc.
EIC	Eberline Instrument Corporation
EPNG	El Paso Natural Gas Company
ERC	Environmental Research Corporation
ESSA	Environmental Sciences Service Administration
FAA	Federal Aviation Agency
F&S	Fenix & Scission, Inc.
H&N	Holmes & Narver, Inc.
TI	Teledyne Isotopes, Inc.
JAB	John A. Blume & Associates
LASL	Los Alamos Scientific Laboratory
LRL	Lawrence Radiation Laboratory (Now Lawrence Livermore Lab. - LLL)
NATS	Nevada Aerial Tracking System
NVOO	Nevada Operations Office
REEC	Reynolds Electrical & Engineering Co., Inc.
SAN	AEC San Francisco Operations Office

ABBREVIATIONS (Cont'd.)

SL	Sandia Laboratories (formerly Sandia Corporation)
SWRHL	Southwest Radiological Health Laboratory, USPHS*
USAF	U. S. Air Force
USBM	U.S. Bureau of Mines
USBR	U. S. Bureau of Reclamation
USC&GS	U. S. Coast & Geodetic Survey**
USGS	U. S. Geological Survey
USPHS	U. S. Public Health Service
WES	Waterways Experiment Station
WSI	Wackenhut Services, Inc.

*Transferred to the Environmental Protection Agency (EPA) on December 2, 1970, SWRHL is now known as EPA/WERL (Western Environmental Research Laboratory).

**Now known as the National Oceanic and Atmospheric Administration/National Oceanic Survey (NOAA/NOS).

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CHAPTER I

PLANNING, AUTHORITIES, AND ORGANIZATION

1.1 BACKGROUND

As early as 1958, El Paso Natural Gas Company (EPNG) investigated the application of nuclear explosive stimulation to a gas reservoir by initiating correspondence with the University of California, Lawrence Radiation Laboratory (LRL), Livermore, in connection with the Pinedale Unit Area, covering approximately 92,000 acres in Sublette County, Wyoming. However, EPNG did not propose a field test at that time.

A study was initiated by the AEC San Francisco Operations Office (SAN), EPNG, and the U. S. Bureau of Mines (USBM), utilizing accepted technology of the industry, performing the necessary calculations, and making the engineering evaluations for such a project. EPNG furnished the geologic data and ownership and location information, while LRL provided consulting services pertaining to effects of nuclear explosions and to resulting radioactivity in the gas.

On June 17, 1965, Mr. Howard Boyd, Chairman of the Board, EPNG, presented the feasibility study dated May 14, 1965, to the AEC, suggesting nuclear explosive stimulation of a natural gas reservoir and proposing that the experiment be jointly conducted.

On June 24, 1965, the Division of Peaceful Nuclear Explosives, USAEC, requested a comprehensive review and evaluation of the proposed project. This review was undertaken in the summer of 1965 by LRL. A report on the review was distributed on July 30, 1965, to EPNG, USBM, and the AEC, recommending that Gasbuggy be conducted.

Following a 6-month period of relative inactivity, the Gasbuggy concept was reexamined. An updated Technical Concept was distributed on October 17, 1966. EPNG proposed to make available to the AEC the EPNG gas lease on Federal land for use as a site for a nuclear experiment and offered technical assistance in the design and execution of an experiment.

On January 31, 1967, Contract No. AT(04-3)-711 was signed by AEC/HQ, the Department of the Interior, and EPNG. On February 9, 1967, the Manager, NVOO, was authorized by the General Manager, AEC, to act as the authorized representative of the Contracting Officer for the administration of the contract.

On February 11, 1967, EPNG began drilling the first preshot test well, GB-1, which was completed on March 17, to total depth of 4,306 feet. On April 9, EPNG began drilling the second test well, GB-2, which was completed on May 5, to a total depth of 4,248 feet. Gas reservoir tests in conjunction with GB-1, and EPNG Well 10-36, were conducted.

On April 5, 1967, the AEC accepted the site for the execution of Project Gasbuggy based on the recommendations of (a) the NVOO staff as to the acceptability of the site from overall safety and operational considerations, and (b) LRL, EPNG, and USBM as to site suitability for conduct of project technical programs.

On June 25, 1967, drilling was begun on emplacement hole GB-E.

Authorization for the execution of the Gasbuggy detonation was received from DPNE on November 29, 1967.

The original readiness date of October 18, 1967, was delayed by construction difficulties with the emplacement hole. A new readiness date of December 6, 1967, was established, but later delayed to December 10, 1967, due to technical difficulties.

Reentry drilling in hole GB-ER ("R" indicating the same hole has been reentered) was begun on December 13, 1967. On January 10, 1968, at a depth of 3,907 feet (333 feet above the detonation point), communication with the chimney was established.

The Gasbuggy site initial reentry was completed by January 31, 1968, and the site placed on a standby status with gas sampling continuing at monthly intervals. Production testing and reservoir evaluation were tentatively planned to begin within 6 to 9 months, depending upon results of the radiochemistry analysis and the availability of funds.

A 15-day production test was begun June 28, 1968. This test was conducted to determine bottomhole temperatures and pressures and to determine build-up times after flowing the well at 5 million cubic feet per day (5 MMcf/D). Following this test, the well was shut in and remained so until long-term production testing was initiated in November 1968.

On November 4, 1968, a long-term production testing program of Well GB-ER was begun. The test program consisted of three 30-day production tests at successively lower (and constant) chimney pressures followed by a 7-month production test at a still lower pressure. A final pressure blowdown was begun October 28, 1969, and terminated on November 14, 1969. At this time, GB-ER was shut in for long-term pressure build-up.

Other field activities during the above time interval included the following:

(1) Reentry of Preshot Test Well GB-2

During June 1968, GB-2R was completed to 4,224 feet with production tubing landed at that depth in open hole. The open hole apparently collapsed, pinched the tubing, and prevented the use of the hole for production testing.

(2) Reentry of Well 10-36 (Preshot Production Well)

During October 1968, stemming material was removed from the 5 1/2-inch casing to a depth of 3,612 feet where casing damage prevented further penetration. The well was then completed in the Ojo Alamo sandstone formation as an aquifer monitor well.

(3) Well GB-3

During August and September 1969, GB-3 was drilled to a depth of 4,800 feet to investigate changes in the Ojo Alamo and Pictured Cliffs formations and in the underlying shale. An extensive coring program utilizing logs and natural flow gauges was used in defining reservoir characteristics.

1.2 OBJECTIVES

The specific objectives of Project Gasbuggy were (a) to measure the change in gas production rates caused by the nuclear explosion and determine, to the extent possible, the mechanisms responsible for these changes; (b) to determine the gas quality with regard to radioactive contamination, and to evaluate various techniques suggested for reducing this contamination; (c) to continue the development of a predictive capability for shock and seismic damage to gas field equipment and other structures, both public and private; and (d) to develop technical engineering knowledge for industrial applications of nuclear explosives for gas field stimulation.

This project was carried out in three phases. The first phase consisted principally of (a) drilling and testing two test wells to confirm site acceptability and establish preshot geological, hydrological, and reservoir characteristics, and (b) starting appropriate safety programs. The second phase included carrying out the safety, operational, construction, and support programs related to the conduct of nuclear operations. The preshot activities were concluded by the detonation. The third phase included postshot drilling operations and extensive postshot evaluations of reservoir conditions, geological characteristics, and gas quality.

1.3 SITE INVESTIGATION AND EVALUATION

1.3.1 Criteria

The criteria for selecting a reservoir stimulation test site for possible utilization of a nuclear device are as follows:

- (1) A low permeability depletion-drive reservoir in which conventional stimulative methods are inadequate.
- (2) A reservoir having gas-bearing formations sufficiently thick to effectively utilize the anticipated effects of the proposed nuclear explosion.
- (3) A reservoir sufficiently deep to confine the explosion, but not so deep as to result in excessive emplacement and testing expenses.
- (4) A site reasonably remote from habitation but easily accessible.
- (5) Sufficient drilling in the surrounding area to provide adequate production and subsurface data, yet not so highly developed as to result in heavy liability for possible damage to existing wells and surface field facilities.
- (6) Uniformity of leasehold ownership and/or withdrawal from leasing of unleased lands adjacent to the test site.

1.3.2 Location of the Site

The site selected was in the SW 1/4 Sec. 36, T29N, R4W, Rio Arriba County, New Mexico, on the eastern side of the San Juan Basin, a structural feature of the Colorado Plateau Province located in northwestern New Mexico and southwestern Colorado.

The site was both remote and uninhabited, yet readily accessible by paved highway. There was no appreciable ground or surface water in the immediate area. The nearest sizeable town was Farmington, New Mexico, 55 air miles to the west of the site, with a population of 23,000. The nearest community was Dulce, New Mexico, approximately 20 miles to the northeast, with a population of about 500. There were no houses or buildings within a 5-mile radius of the site.

The test site was within the Carson National Forest and adjacent to the Jicarilla Apache Indian Reservation. The existing oil and gas leases for the lands in the immediate area of the test location are held by EPNG. (See Figures 2 and 3.)

The area surrounding the site contains mesas, canyons, and the usual bench-type topography generally associated with these surface features. Elevations range from 6,800 to 7,500 feet in the general area and from 7,000 to 7,200 feet in the immediate test area. The San Juan River, at its nearest point, is about 20 miles from the test site and the Navajo Dam is about 23 miles away.

Figure 2 Project Gasbuggy Area Map

Figure 3 Project Gasbuggy Ground Zero-Plot Plan

1.3.3 Locations for GB-E, GB-1, and GB-2

To avoid the possibility of encountering a major joint or fracture zone with the Gasbuggy experiment, it was considered prudent to avoid the valley immediately to the northeast of EPNG Well 10-36. The emplacement hole was located about 434 feet south from Well 10-36 at the approximate coordinates of N 2, 067, 450, and E 219, 050*. Exploratory hole GB-1 was located approximately 188 feet N 57° W of hole GB-E. Exploratory hole GB-2 was located 300 feet east of hole GB-E.

1.3.4 Gasbuggy Preshot Hole, GB-1

The critical parameters investigated for GB-1 were:

- (1) The amount, mobility, and location of water in the Ojo Alamo and lower formations.
- (2) The geologic detail of the reservoir formations.
- (3) The amount, location, and flow behavior of gas in the various formations.

1.3.5 Gasbuggy Preshot Hole, GB-2

Preshot hole GB-2 was drilled after hole GB-1 was completed, the objectives of GB-1 attained, and the acceptability of the site proven.

The purposes of GB-2 were:

- (1) To confirm data obtained in GB-1 regarding subsurface geology, hydrology, and gas presence and to obtain information about the variation of these quantities with horizontal distance.
- (2) To serve as a monitor well during the production experiments to be performed in GB-1.

1.4 ORGANIZATION RESPONSIBILITY

1.4.1 U. S. Atomic Energy Commission

The Division of Peaceful Nuclear Explosives (DPNE) was responsible for the direction of AEC Plowshare programmatic activities, general policy development and guidance, Headquarters' coordination, and AEC project-related funding requirements.

The Nevada Operations Office was responsible for the construction of the emplacement hole, all surface construction and support, the overall field management, safety, security, and nuclear materials management; and for administering AEC responsibilities delegated to the Manager, NVOO, by the Contracting Officer under the provisions of the contract between the Government and EPNG.

The San Francisco Operations Office was responsible for the development of joint feasibility studies of potential uses of nuclear explosives for industrial purposes, such as Project Gasbuggy; for providing appropriate assistance to NVOO in the areas of technical reporting, classification, patents, and copyrights; and for assisting DPNE in financial management.

* New Mexico State Grid Coordinates

1.4.2 El Paso Natural Gas Company

EPNG was responsible for providing (a) use of the project site, (b) company experience, knowledge, and guidance relating to natural gas reservoir characteristics and production techniques, (c) construction and funding for two preshot test wells, (d) testing of the two preshot wells in accordance with the technical program developed by EPNG, LRL and the USBM, and (e) other items of surface construction and logistical support at Company expense as identified in the contract between the Government and EPNG.

1.4.3 Department of the Interior, U. S. Bureau of Mines

The U. S. Bureau of Mines was responsible for the direction and development of the reservoir evaluation portion of the Technical Program in cooperation with EPNG and LRL, and for evaluating the preshot and postshot conditions of mines and wells in the vicinity of the experiment for safety-related purposes. The USBM was also responsible for coordinating activities that involved other agencies within the Department of the Interior, and for serving as liaison representative for the Department in matters regarding Project Gasbuggy.

1.4.4 Lawrence Radiation Laboratory

LRL provided the nuclear explosive and was responsible for the design and development of all three phases of the Technical Program in cooperation with EPNG and USBM. The Laboratory provided a Test Director (who had overall technical and technical operational responsibility) and a staff to coordinate, direct, and execute the Technical Program. The Test Director was responsible to the AEC for the collection of technical data from all experimental phases and for assuring that data were reported in a timely fashion consistent with the agreed to Project Gasbuggy Technical and Safety Reporting Plan. EPNG, USBM, and LRL were responsible for the design of measurements and experiments that comprised the Technical Program and for interpreting the results.

1.5 REFERENCES

- (1) Project Gasbuggy - Feasibility Study, prepared jointly by EPNG, USBM, and AEC, dated May 14, 1965, included the background, objectives, and concept of field operations for a nuclear stimulation experiment.
- (2) Letter, Chairman of the Board, EPNG, to Chairman, AEC, dated June 17, 1965, proposed the joint conduct of Project Gasbuggy.
- (3) Letter, Associate Director, LRL, to Director, DPNE, dated July 30, 1965, recommended that Gasbuggy be conducted and transmitted the Technical Director's concept for Gasbuggy.
- (4) Memorandum, Manager, NVOO, to Director, DPNE, dated August 13, 1965, transmitted the Project Manager's concept for Gasbuggy.
- (5) TWX, Director, DPNE, to Director, Office of Programs and Plans, NVOO, dated September 28, 1965, approved initiation of appropriate activities of the Project Manager's Organization for Gasbuggy.
- (6) LRL's Project Gasbuggy Technical Concept, dated October 17, 1966.

- (7) TWX, Director, DPNE, to Manager, NVOO, dated November 7, 1966, authorized continuation of the appropriate elements of the Project Manager's Organization for Gasbuggy and approved field studies required to complete the total project plan.
- (8) TWX, Director, DPNE, to Manager, NVOO, dated November 28, 1966, authorized the start of activities in support of the Safety Program.
- (9) Memorandum, Manager, NVOO, to Director, DPNE, dated December 2, 1966, transmitted the Project Manager's Plan for Project Gasbuggy.
- (10) Letter, Associate Director, LRL, to Director, DPNE, dated December 5, 1966, transmitted the Test Director's Operational Plan for Project Gasbuggy.
- (11) Project Gasbuggy Contract - Contract AT(04-3)-711, dated January 31, 1967.
- (12) TWX, Director, DPNE, to Director, LRL, and Managers, NVOO and SAN, dated February 2, 1967, authorized preparations for the execution of Project Gasbuggy.
- (13) Memorandum, General Manager, AEC, to Manager, NVOO, dated February 9, 1967, assigned Project Gasbuggy Contract AT(04-3)-711 to Manager, NVOO, for administration.
- (14) Project Gasbuggy Planning Directive, dated February 1967, issued by NVOO.
- (15) Memorandum, Manager, NVOO, to Manager, SAN, dated March 14, 1967, outlined proposal for administration of the Government's responsibilities under the Gasbuggy contract, and requested SAN's assistance in administering classification, technical report plan, patents, and copyrights.
- (16) Memorandum of Understanding, dated March 23, 1967, between Region 3 of the U. S. Forest Service, Department of Agriculture and NVOO in connection with Project Gasbuggy in Carson National Forest.
- (17) TWX, Test Director, LRL, to Assistant Manager for Plans and Budgets, NVOO, dated April 4, 1967: Determination by LRL, EPNG, and USBM that Gasbuggy site was technically acceptable.
- (18) TWX, Manager, NVOO, to Director of Exploration, EPNG, dated April 5, 1967: AEC acceptance of Gasbuggy site.
- (19) Memorandum, Manager, SAN, to Manager, NVOO, dated April 7, 1967, provided SAN's concurrence in assisting NVOO in administering specific functions of the Gasbuggy contract.
- (20) Project Gasbuggy Field Public Information Plan, dated May 23, 1967.
- (21) Project Gasbuggy Program Information Plan (Preliminary), issued by DPNE, March 24, 1967.
- (22) Memorandum, Classification Officer, SAN, to Director, DPNE, and others, dated July 7, 1967: Project Gasbuggy Classification Guide.
- (23) Project Gasbuggy Technical and Safety Reporting Plan, dated August 18, 1967, issued by SAN.

- (24) Project Gasbuggy Planning and Program Directive, dated August 1967, issued by NVOO.
- (25) TWX, Director, DPNE, to Manager, NVOO, dated October 12, 1967, advised of Presidential approval for the conduct of Project Gasbuggy.
- (26) Project Gasbuggy Operations Order NV-OpO-2-67, dated October 16, 1967, issued by NVOO.
- (27) TWX, Director, DPNE, to Manager, NVOO, dated November 29, 1967, authorized the execution of Project Gasbuggy (Appendix B).
- (28) Memorandum "Yield of Gasbuggy Explosive," Dr. Fred Holzer, January 5, 1970.

1.6 BOARDS AND PANELS

1.6.1 Project Review Panel

A Project Review Panel was established for Project Gasbuggy and was responsible to the Project Manager. This Panel, periodically through the completion of Phase III, monitored overall project progress and costs and sought solution of significant, unresolved matters which were between the Program Director and the Test Director.

The Panel was guided by policy agreements formed at the headquarters level of the participating organizations as to interorganization division of responsibility for funding and field operations, and other concepts on which field planning was based.

The Project Review Panel consisted of the following:

R. E. Miller, NVOO	Chairman
W. R. Woodruff, LRL	Member
D. N. Canfield, EPNG	Member
W. W. Allaire, NVOO	Member
R. H. Shaw, NVOO	Alt. Member
W. D. Smith, Jr., NVOO	Member

The Project Review Panel made the following major recommendations to the Project Manager, NVOO, during Project Gasbuggy:

April 11, 1967

- (1) Recommended that the revised project schedule targeted for a mid-October readiness date be adopted and supported by the Project Organization.
- (2) Suggested that SAN prepare an approach for the Technical Information Plan for coordination with the other participants by May 1, 1967.
- (3) Recommended that the current cost estimate (prepared by NVOO) of \$2,560,000 for Gasbuggy be accepted subject to critical review by the Project Organization while recognizing that an overrun situation may exist.

- (4) Reconfirmed the acceptability of the Gasbuggy site for conducting the experiment based on available safety, technical, and operational considerations which supported that conclusion.
- (5) Recommended that approval to procure cable be obtained so preparation could advance on schedule inasmuch as the cable had to be custom made and tested due to the severe downhole environment to which the cable would be subjected.

June 28, 1967

- (1) Recommended that the Project Organization continue to support an October 18, 1967, readiness date.
- (2) Recommended that the new cost estimate (prepared by NVOO) of \$2,345,000 be accepted while recognizing that no contingency was included for any operational or weather delays that might occur, and that the scope of the postshot drilling program could not be firmed up until the general results of the detonation were known. The revised estimate represented a total reduction of \$215,000 from the estimate submitted on April 11, 1965.

The \$215,000 reduction was achieved as a result of the deletion of requirements for the instrumentation of GB-2, device yield diagnostics associated with GB-E, and scientific photography; significant reductions in the estimates were also made in the areas of claims investigations, logistical support, and maintenance and operations.

August 15, 1967

- (1) Recommended that execution readiness be rescheduled if the drilling of emplacement hole GB-E was not completed by September 1, or, if on or before September 1, it was determined that the mid-to-late October execution date could not be met. Because the hunting season extended into the first part of November, the earliest date identified for possible rescheduling of project readiness was November 14.
- (2) Recommended that preparations for Gasbuggy execution continue recognizing that (a) the current total estimate for NVOO effort exceeded the \$2.3 million programmatic limitation by about \$97,000, which represented an increase of \$52,300 since the June 28 Review Panel meeting, and (b) the estimate for the postshot program, being reestimated based on definitive criteria, could result in a substantial increase.
- (3) Suggested that DPNE be advised of the status of the project schedule and cost estimates.

September 18, 1967

- (1) Recommended that, based on the present progress of field operations and assuming no conflict with other AEC tests, the date of November 14, 1967, be targeted for Project Gasbuggy readiness.
- (2) Proposed that DPNE be advised that the overall Gasbuggy estimate exceeded the NVOO program limitation by \$403,900, which represented an increase of \$306,600 since the August 15 Review Panel meeting.

The increase of \$306,600 was attributed principally to (a) the increase from \$245,000 to \$465,000 in the estimate for postshot drilling based on detailed criteria, (b) the increase in special items and materials furnished by the Government for emplacement hole drilling, and (c) additional costs expected to be incurred because of the stretch out of project activities due to the postponement of project readiness from mid-October to mid-November.

- (3) Recommended that DPNE be advised that it would be inappropriate to begin emplacement operations prior to completing contractual arrangements for postshot drilling, because the technical program called for sample collection as soon as possible following detonation.

1.6.2 Scientific Advisory Panel

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

Dr. H. L. Reynolds, LRL	Chairman
Mr. P. W. Allen, ESSA-ARL	Member
Mr. F. D. Cluff, AEC/NVOO	Member
Dr. C. S. Maupin, REEC	Member
Mr. J. R. McBride, USPHS	Member
Dr. R. Maxwell, AEC/Washington	Member

The Panel met five times; the first two meetings were held in Las Vegas, Nevada, at AEC/NVOO on September 13 and September 15, 1967. The following topics were discussed:

- (1) Applicable radiation levels for onsite and offsite personnel were to be dictated by AEC Manual Chapter 0524. The NTS requirements of 12-hour residence time within the borders would apply to Gasbuggy.
- (2) Radiation standards for postshot freeing of gas would be established when further study had given a better understanding of the conditions of the natural gas.
- (3) The release model for Gasbuggy would be: one-half of the rare gases would be released in a 24-hour period through a hole approximately 1-foot in diameter extending from the cavity to the surface. It was also assumed that 0.03 percent (1,000 curies) of the total ^{131}I produced would be released.
- (4) The number of people and cows within the 50-mile radius of Gasbuggy.

The third and fourth meetings were held at the El Paso Natural Gas Company main office in Farmington on December 8 and 9, 1967. R. H. Thalgott, NVOO, opened the meeting on the 8th, outlining the purpose of readiness briefings and introducing panel members. W. R. Woodruff, LRL, Gasbuggy Test Director, gave a detailed review of the experiment.

The 48-hour and 24-hour weather predictions by R. Armstrong, ARL-LV, were optimistic, with a forecast of no precipitation and favorable wind trajectories. R. J. Sinsabaugh's outline of area control was complete, as set forth in "INSTRUCTIONS FOR GASBUGGY" (Appendix E). It included the participating aircraft, an outline of the helicopter sweep from ground zero (GZ), state road blocks, and the precautions taken at the Jicarilla Apache Indian Reservation.

J. Morrell's fallout synopsis was hypothesized on the maximum credible accident. He presented detailed briefing charts which also included concentrations of people and cows.

The final briefing, at 8:00 a.m., December 10, at the Gasbuggy CP, covered a favorable weather forecast and a comprehensive area control.

1.6.3 Test Evaluation Panel (TEP)

The Test Evaluation Panel consisted of:

R. H. Thalgott, NVOO	Chairman
W. W. Allaire, NVOO	Vice Chairman
W. E. Ogle, LASL	Member
R. H. Goeckermann, LRL	Member
H. L. Reynolds, LRL	Member
B. F. Murphy, SL	Member
O. R. Placak, USPHS	Member
J. R. McBride, USPHS	Member
P. W. Allen, ESSA-ARL	Member
Col. J. J. Neuer, DASA	Member
C. S. Maupin, REECO	Consultant
P. J. Mudra, NVOO	Executive Secretary

Containment plans for Project Gasbuggy were first reviewed by the Test Evaluation Panel during its meeting of June 7, 1967. After considerable discussion of the plans, it was concluded that categorization should be deferred until a later meeting because the emplacement hole had not yet been drilled.

During this meeting, however, LRL proposed remedial cementing work to holes GB-1 and GB-2. The Panel approved this proposal.

The second review of Gasbuggy data by the Panel took place on August 2, 1967. Emplacement hole drilling was only halfway completed and no remedial action had been taken on the GB-1 and GB-2 holes. The Panel voted to place Gasbuggy in a conditional category.

The third review of Gasbuggy took place at the TEP meeting of September 13, 1967. Remedial cementing work on GB-1 and GB-2 was discussed at length. The Panel voted to continue Gasbuggy in the conditional category due to the lack of a completed emplacement hole.

Gasbuggy was briefly discussed by the Panel during its meeting of October 31, 1967. Inasmuch as there were no additional data submitted on the emplacement hole at the meeting, the Panel continued the conditional categorization.

The fourth and final, full review of Gasbuggy by the Panel took place on November 15, 1967. Additional information concerning the recementing of GB-1 and GB-2 was presented. The hole history for the newly completed emplacement hole was presented along with associated geology and changes in the stemming plan. Following the presentation of all data, the Panel voted to remove the qualification of conditional.

Subsequent to the November 15 meeting, members of the Panel were notified of a modification to the Gasbuggy stemming plan by teletype 00A:PJM-846, "Thalgott to Distribution," dated November 24, 1967. The modification involved adding 650 feet of sand and 50 feet of polymer to the upper 700 feet of hole. After reviewing this information, all Panel members or their alternates voted to continue Gasbuggy in Category B.

In concurrence with the findings of the Test Evaluation Panel, the Manager, NVOO, first requested execution authority for Gasbuggy from the DPNE in a memorandum, dated November 20, 1967. This request was reiterated in a teletype, dated November 30, 1967, in which DPNE was also advised that after reviewing the data on the November 24, 1967, stemming change, the Panel had reaffirmed its Category B for Gasbuggy. Execution authority was granted by DPNE by teletype, dated November 29, 1967.

CHAPTER II

SCIENTIFIC ACCOUNT

2.1 SCIENTIFIC MEASUREMENTS - TECHNICAL PROGRAM

The purpose of the Gasbuggy experiment was to determine the extent a low permeability natural gas formation could be stimulated by an underground nuclear detonation and to identify the detonation-associated effects which cause the stimulation. Specifically, the experiment was designed to achieve these objectives:

- (1) To measure the changes in the deliverability and ultimate recovery of the gas, and, insofar as possible, to identify the changes responsible.
- (2) To measure any radioactivity of the gas, to study the thermodynamics and chemical reactions of the mixture of gaseous nuclear explosive products and methane, and to evaluate any necessary control measures.
- (3) To measure and evaluate the generation and propagation of seismic energy within the San Juan Basin as part of a continuing study of ground motion and its effect on structures.

2.1.1 Preshot Program (USBM/EPNG/LRL)

The preshot program utilized exploratory holes GB-1 and GB-2, drilled and completed preshot, and an existing EPNG gas production well designated as Well 10-36. These holes were located approximately 190, 300, and 430 feet respectively from the planned explosive-emplacement hole, GB-E. Figure 4 shows the location of these holes in plan view.

The field program involved measurements of the gas-flow properties from the area of the experiment, a detailed geologic and geophysical exploration program, hydrologic test and evaluation, and determination and evaluation of reservoir characteristics.

Preshot program work included measurements of physical properties of the rock most strongly affected by the explosion, computation of dynamic shock effects, assessment of the expected gas quality, gas-flow computation, and evaluation of ground shock and other hazards.

2.1.2 Operational Phase Program

This phase covered all major surface construction; drilling of the GB-E emplacement hole and the ARPA Add-On Program subsurface measurements hole, GB-D; instrumentation and explosive emplacement; stemming; execution; recovery of prompt data; and concluding the surface reentry.

Figure 4 Plat of Wells, Gasbuggy Test Area

A. Subsurface Phenomenological Measurements - LRL

The subsurface measurements were to establish the validity of the theoretical calculations used to predict the Gasbuggy phenomenology, and to aid in the interpretation of related results of other experiments associated with the test. Particularly, details of chimney dynamics and fracturing processes may be valuable in interpreting the results of the gas stimulation measurements, and may be used to develop new models and theories to describe the mechanisms important to the gas stimulation processes.

To accomplish these objectives, a number of instruments to measure shock velocity, peak hydrodynamic pressure, chimney dimensions, and fracture radius were installed in emplacement hole GB-E and about 188 feet away, in the instrument hole GB-1. (See Figure 5.)

Figure 5 Subsurface Instrumentation, Project Gasbuggy

Data were recorded on both magnetic tape and cathode ray oscilloscopes. The magnetic tape was the primary recording facility for the time-of-arrival (TOA) data with the oscilloscope recording furnishing a backup; peak pressure data were recorded on oscilloscopes only. The fracture data were recorded on magnetic tape with a counter-printer operating as an auxiliary recording system and, since the time of chimney collapse could not be predicted, a counter-printer with long recording times was utilized to record the chimney dynamics data.

1. Shock Wave Time-of-Arrival

Shock wave and TOA measurements provided data concerning the location of the shock front as a function of time. These data can be used to calculate shock wave velocities for the hydrodynamic region and to calculate the bulk elastic wave velocity in the elastic region.

The slifer system and TOA string supplied the major portion of the data. Three slifer systems were emplaced for the Gasbuggy test; two units in hole GB-E and one in GB-1. TOA strings were emplaced approximately parallel to the slifer system in holes GB-E and GB-1. (See Figure 5.)

The slifer consisted of a Collpitts electronic oscillator and a long coaxial cable. The cable and oscillator were emplaced so the advancing shock wave would crush and short the cable, decreasing its electrical length, and thereby producing a change in the oscillator frequency. The magnitude of frequency change used in conjunction with the emplacement survey provided the location of the shock wave at any specified time. The ends of the resonance cables in each hole began at about the level of the shot horizon and extended vertically upwards for 175 feet at which point they were attached to the oscillators.

The TOA strings were used to obtain time-of-arrival data in the region of low stress levels. They consisted of lead zirconate titanate ceramic cylinders spaced at several locations in a long coaxial cable. These strings were emplaced so that the outgoing shock would impinge on the lead cylinders and create a measurable electric charge, the onset of which would indicate the presence of the shock wave at that particular spatial location.

2. Peak Hydrodynamic Pressure

This experiment was performed to verify and normalize the theoretical calculations and, in conjunction with the measured shock wave velocity, to calculate the hydrodynamic energy output of the nuclear explosive.

Peak pressure gages were emplaced in hole GB-E at a range of about 10 meters from the detonation center. Two gages were used to record pressures in the 100 to 300 kilobar range.

The peak pressure transducers were 2-inch diameter shells of lucite, plated on the inner and outer surface to facilitate signal acquisition. The passage of a strong shock wave through the wall of the lucite shell induced a measurable surface charge on plated electrodes.

3. Chimney Dynamics

The objective of this experiment was to determine the final height of the chimney, time of collapse, and history of the gross material motion in a dynamically forming chimney. For this experiment, two transducer units were emplaced in hole GB-E.

The central components of the collapse transducers, designated the acronym, "cliper," consisting of long coaxial cables of known electrical length emplaced in the hole and passing vertically upward through the expected chimney volume. The hole was then filled with grout to secure a firm bond between the cable and the surrounding rock, thereby constraining the cable above the cavity to terminate always at the roof of the chimney as it formed.

Postshot electrical length measurements of the transducer cable and correlation with preshot calibration factors and emplacement surveys provided the relationship between the measured travel time and the position of the chimney roof.

4. Instrumentation

a. Fractures

The location and number of fractures created in the region immediately surrounding the explosive source were two important parameters controlling the success of the Gasbuggy experiment.

To obtain these data, two transducer-cables constituting a modified version of the cliper system were emplaced in hole GB-1, providing a sensitivity to fractures occurring in the region between radii of 40 and 300 meters.

b. Geophone Date - LRL

In order to ascertain the approximate time after the detonation at which the cavity collapsed and the chimney formed, as well as for reasons of establishing safe time for area reentry, three geophones were placed just below the ground surface at distances of 2,600, 4,200, and 8,400 feet from surface zero.

c. Surface Accelerations and Velocities - LRL

A seismic array consisting of five stations on or near the Navajo Dam, about 38 km west of the site, and two stations on and near the El Vado Dam, about 42 km east of the site, were installed to record surface velocities at the crests and the downstream toes of these dams. (See Figure 6.)

The instruments, canisterized and buried a few feet beneath the surface, consisted of one-cycle coil velocity geophones positioned to measure three orthogonal components of velocity.

Recording of signals was accomplished with portable four-channel magnetic recorders. Five of the stations, four at the Navajo Dam and one at El Vado Dam, had two recorders to record a separate gain. The remainder of the stations recorded at a single gain.

Figure 6 LLL Seismic Station Instrumentation at El Vado Dam

d. Reservoir Pressures (USBM/EPNG)

Records of surface pressure from six wells nearest the detonation were recorded. These wells had been shut in for about 1 month prior to the detonation. Some days before detonation, three of the wells were also equipped with bottomhole pressure gages.

e. Wellhead Investigations (USBM/EPNG)

A number of gas production wells in the vicinity of surface zero were subjected to detailed preshot and postshot examinations for the purpose of determining shock-induced displacement or leakage in wellhead equipment.

f. Department of Defense Sponsored Programs (ARPA)

A number of noninterference experiments funded directly by DOD were added onto Gasbuggy under the sponsorship of the Advanced Research Projects Agency. The Test Director's organization provided coordination and scheduling data for the participation of these programs. These programs included:

(1) Ground Motion Measurements - SL

A program of ground motion measurements designed and conducted by SL to define the seismic source by measuring radial particle velocity at four depths in hole GB-D, located 1,500 feet away from the Gasbuggy shot hole, was added to the project. This program of measurements included, in addition to the seismic source instrumentation, six surface-motion stations installed at horizontal ranges between 100 and 8,400 feet from surface zero.

The seismic source experiment consisted of four ground motion stations installed in hole GB-D at depths of 4,100, 4,600, 3,600, and 3,250 feet. (See Figure 7.) Each gage station included three orthogonally-oriented accelerometers and particle-velocity gages recording vertical, horizontal radial, and horizontal tangential components of motion. In addition to recording individual components of motion, output of the vertical and horizontal radial velocity gages were added vectorially along the true radius from the shot point of each gage station to give a radial vector velocity record. These radial velocities were further integrated to radial displacements; and these were again integrated to produce reduced displacement potentials, which have been found useful in correlating seismic source and teleseismic records.

Surface motion stations were located at horizontal ranges of 100, 434, 1,495, 2,643, 4,229, and 8,387 feet from surface zero. These ranges were chosen for proximity either to points of interest or to points which were a distance from surface zero of one and two times shot depth. All but one surface station included three accelerometers and three velocity gages oriented to respond to vertical, horizontal radial, and horizontal tangential motion; the

Figure 7 Gasbuggy Ground Motion Stations

exception was the station nearest surface zero, where only vertical and horizontal radial gages were installed with dual vertical accelerometers to provide extended dynamic range.

All gages included variable reluctance transducer elements which modulated a constant-voltage 3-kHz carrier. Gage output was transmitted by hardwire to a recording trailer at a range of about 2,800 feet where the signals were amplified, demodulated, and recorded through voltage-controlled oscillators as frequency modulated signals on magnetic tape.

(2) Surface Seismic Motion - USGS

The U. S. Geological Survey, Office of Earthquake Research, made recordings along five lines radiating from the Gasbuggy GZ (Figure 8) primarily to determine the azimuthal effects upon the upper mantle first arrival (Pn phase). Data were obtained from a total of 29 stations. All stations recorded the outputs of Electro-Tech, Model EV-17, velocity seismometers (natural period 1 second) with appropriate filters and amplifiers. Twenty-five stations recorded on magnetic tape and four provided photographic records only.

Figure 8 USGS Recording Stations for the Gasbuggy Test

(3) Long-Range Seismic Measurements (LRSM) - Geotech,
A Teledyne Company

The LRSM program operated 15 mobile seismological observatories and six portable seismograph systems during Gasbuggy. The primary sites occupied by the LRSM teams are shown in Figure 9. Other vans located in Canada were: Mould Bay, NWT; Schefferville, Quebec; Whitehorse, Yukon; and Prince George, BC.

The LRSM effort was directed toward profiles to the north, northwest, and west from 500 to 1,500 km distance from the Gasbuggy site in a coordinated program with the USGS and the U. S. Coast and Geodetic Survey (USC&GS). The data collected by the LRSM teams are summarized as Geotech Technical Report No. 68-7.

Figure 9 Locations of Gasbuggy Seismic Stations

(4) Botanical Techniques for Onsite Inspection - USGS

The USGS, Branch of Geochemical Census, participated in Project Gasbuggy with the objective of identifying plant and/or plant-related sensors of the Gasbuggy underground nuclear detonation and to further develop onsite inspection techniques in accord with the intent of the On-Site Inspection Office of the ARPA-DOD.

Preshot and postshot studies of the plant species and communities at the site were conducted to determine plant reaction to, and recovery from, disruption by shock and to correlate the degree of damage and time of recovery with magnitude of shock and distance from the source of the shock. The selection of stations and subsequent observations were primarily concentrated within a 1-mile radius of SGZ.

About 2 dozen observation points were selected upon the completion of the postshot studies. These are indicated on Figure 10. During the preshot reconnaissance the following 14 sites were marked, photographed and studied as potential shock targets: Nos. 1 and 2 at SGZ; No. 5 at the 1/4 mile perimeter; Nos. 6, 7, and 10 at the 1/2 mile perimeter; Nos. 14, 15, 16, and 22 at the 1-mile perimeter; No. 17, 1-1/2 miles from SGZ, Nos. 18 and 23 at 2 miles from SGZ; and a single supplementary station 5 miles northeast of SGZ.

Figure 10 Selected Shock Damage Study Sites

Fresh and preserved samples of the algae, *Spirogyra* and *Closterium*, were collected 2 days postshot from the impoundments Leandro Tank at SGZ and Laguna Seca, about a mile west. These were sent for study by botanists of the USGS subcontract agency, the Fredric Burk Foundation Research Center, San Francisco, California.

Further postshot study of the site was proposed to record (a) the persistence of the immediate shock effects on especially sensitive targets; (b) the indirect influence of ground shock and rock displacement on subsequent growth of plants that had been dormant during the test, and (c) the ability of vegetation to obliterate surficial evidence related to the Gasbuggy program.

(5) Detection of Radionuclides - Isotopes, Inc., A Teledyne Company

Isotopes, Inc., Westwood Laboratories, measured the produced dispersion and diffusion rate of gaseous radionuclides in soil near GB-E and up to 6,000 feet from GB-E, as well as in the air. None of the measurements were timed for coincidence with detonation zero time.

Measurements consisted of data obtained by radioassay of samples collected by mobile high-pressure compressors which pumped air from the atmosphere and from below the soil atmosphere interface from each of 16 sampling locations, consisting of 6-inch diameter auger-drilled holes with 20-foot void chambers isolated from the atmosphere by a 30-foot cement column. (See Figure 11.) A 1-inch plastic pipe, valved at the surface, penetrated the cement to provide access to the soil gas diffusing into the chamber.

DEPTHS AND LOCATION OF ISOTOPES' DRILL HOLES (Dh) AT GASBUGGY SITE

Figure 11 Survey Description of Sample Station Locations

All station holes were of 50-foot depth except Dh-1, Dh-6, and Dh-10 which were drilled to less than 50 feet because of hardrock intersections; Dh-7 due to wet clay being encountered; and Dh-12 and Dh-13 were completed to 25 feet rather than 50 feet to minimize collapse loss at zero time.

Additionally, some samples were collected of the small volume of gases passing across the soil atmosphere boundary. The flux measuring device consisted of a measured area of surface isolated by an aluminum box cemented onto the ground. Nitrogen carrier gas was flowed through the box at a regulated rate, and a compressor pumped soil gas plus carrier gas into a pressurized vessel.

All station holes functioned after the detonation, and some 350 postshot samples were collected for analysis by Isotopes, Inc.

g. Yield Measurements (LRL)

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

2.1.3 Postshot Exploration (USBM/EPNG/LRL)

The major fulfillment of the objectives of Project Gasbuggy hinged upon the accomplishment of the postshot program; specifically, the objective of determining the deliverability and productivity of the stimulated reservoir, the identification of the mechanisms responsible for the observed changes, as well as the evaluation of the concentration of radioactive nuclides in the gas, and possible control measures critically dependent on the successful completion of the postshot program.

A. Initial Explorations

The LRL, in collaboration with USBM and EPNG, initially engaged in postshot exploration of the chimney and the surrounding fractured region through geophysical, chemical, and radiochemical investigations in the redrilled explosive emplacement hole (identified as GB-ER), and in the redrilled preshot hole (identified as GB-2R) which was offset about 300 feet from GB-E. Gas production testing, by flowing the gas, was done to assess in a preliminary way, the effects of nuclear stimulation. Flowing the gas involved its being flared at the top of a 10-meter stack. The gas stream was continuously monitored between the wellhead and the stack for the presence of hazardous levels of radioactivity.

By the end of calendar year 1969, some 90 gas samples had been taken during and after the flow tests, to permit detailed laboratory investigation of radionuclide concentrations and to verify the total release numbers. Of the total gas samples withdrawn for laboratory analysis, only two were taken from later drilled holes, because essentially no radioactivity was found in samples from these later holes. Those later drilled holes are discussed in the text that follows. Surface and bottom-hole gas samples were collected in evacuated bottles, and shipped to the LRL at Livermore. Results of the gas sampling activity were then used to interpret possible hazards from the gas produced from the Gasbuggy chimney, to evaluate the chemical reactions that had taken place, and identify the need to control the quality of the gas withdrawn at future times. Periodic gas sampling is to continue for an indeterminate time. Some water samples were also obtained and analyzed.

B. Other Explorations

Later in the postshot explorations, additional holes were drilled into the stimulated region, to determine the extent of the affected region, and establish the change of those physical characteristics which affect gas production. The additional holes drilled were a sidetracking of GB-2R, drilling of a new hole, GB-3, about 200 feet NE of GB-E, and reentering the preexisting gas well 10-36. (Figure 4.) Samples and logs of these additional holes were provided to the LRL at Livermore, where the substance of the LRL evaluation, computer calculations, comparison with preshot predictions and characteristics, and ultimate reporting, took place.

Sampling, logging, reservoir pressure buildup, and withdrawal measurements of these additional holes were used in evaluating changes in reservoir performance, the extent of fracturing and its frequency, chimney definition, evaluating water influx to the chimney, changes in aquifer permeability and hydraulic communications between aquifer and reservoir, and for acquiring additional samples for both chemical and radiochemical analysis.

2.1.4 Reservoir Evaluation (USBM)

A. Preshot Tests

To supplement reservoir and production data available from the eight original field wells in the Gasbuggy test area (Figure 12), two preshot wells, GB-1 and GB-2, were drilled. These wells provided detailed reservoir and production characteristics for use in determining the suitability of the site for the Gasbuggy experiment and for comparison with postshot characteristics. Figure 4 shows locations of preshot test wells and postshot well GB-3.

Figure 12 Gasbuggy Test Area

The gas-bearing Pictured Cliffs sandstone, the object of this stimulation test, was cored using gas as the circulating fluid in both wells. Essentially, all the core was recovered. Cores were described, gamma ray scanned, photographed, and analyzed for density, porosity, permeability, liquid saturations, and total water at 2-foot intervals. Reservoir properties are summarized in Table 1. During coring operations, the rate of gas production was measured each time a core was pulled. These natural gages were desired to indicate zones of significant production and to aid in profiling the producing section.

TABLE 1
AVERAGE RESERVOIR PROPERTIES AT GASBUGGY SITE

	GAS-SATURATED SAND WITH 60% OR LESS WATER SATURATION			TOTAL GAS-SATURATED SAND		
	PRESHOT		POSTSHOT	PRESHOT		POSTSHOT
	GB-1	GB-2	GB-3	GB-1	GB-2	GB-3
Porosity, percent	11.2	12.4	10.6	9.6	10.6	9.1
Gas Saturation, percent	52.0	52.7	55.5	42.5	41.8	41.4
Permeability, millidarcys	0.14	0.19	0.15	0.10	0.15	0.10
Thickness, feet	156	149	143	254	255	255
Temperature, °F	130	130	---	130	130	---
Pressure, psia	1,050	---	---	1,050	---	---
Gas-in-Place, MMcf/160 acres	4,152	4,912	4,192	5,504	6,064	5,152
Gas volumes expressed at 15.025 psia and 60°F.						

Before casing was set above the producing sand in the test wells (while the holes contained mud), the following logs were run: Electrical Survey, Dual Induction-Laterolog, Temperature, Dipmeter, Density, Sidewall Neutron Porosity, Sonic, Variable Density Sonic, and Caliper. After reaching total depth, the following logs were run in the gas filled holes: Compensated Formation Density, Gamma Ray, Induction, Flowing Temperature, Flowmeter, and Directional Survey. Borehole photographs were made in GB-2. In addition, the following logs were run when preparations were being made for stemming: Flowmeter, Caliper, Borehole photographs (dry hole logs), 3-D Velocity and Caliper (in the mud filled holes), and in GB-1 only, Electrical Survey, Compensated Formation Density, Borehole Compensated Sonic, Dual Induction-Laterolog, Nuclear Cement Top Locater, Cement Bond, and Temperature (all in mud).

After logs had been run in the gas-drilled wells, tubing was installed and the wells were completed for production testing. To obtain a continuous measurement of bottomhole pressures during production tests, a surface recording bottomhole pressure gage was run in each well on a wire line.

For GB-1, after an initial pressure buildup test, a series of four 6-hour isochronal tests (with the fourth test continuing for 24 hours) was conducted. The flow rate was held constant throughout each test. The well was then shut in for pressure buildup. A second series of four 6-hour isochronal tests (with the fourth test continuing for 30 days) was then conducted. Following a pressure buildup period, a drawdown test was run with a constant rate maintained at the sandface. The well was

again shut in for buildup after which a standard New Mexico potential test was run. Pressure in Well No. 10-36 was monitored during tests of GB-1 and it was determined that there was communication between the wells.

The productivity of GB-2 was too low for isochronal production tests.

No water was produced during production tests; however, a small volume of condensate that had collected in the tubing during production of GB-1 was produced during the latter part of the test period.

The data obtained from GB-1 and GB-2 show the Pictured Cliffs gas sand at this location to be relatively homogeneous with very low permeability. Productivity also is very low except where fracture systems intersect a wellbore. GB-2 produced only 5 Mcf/D at essentially no back pressure. GB-1, with two fracture intervals present, produced about 100 Mcf/D under similar conditions. Such a dependence on fractures for production is common in this type of reservoir and, because production is largely controlled by fractures, rigorous analysis based on standard radial flow equations is not possible.

B. Postshot Production Tests

After the explosive emplacement hole, GB-E, was reentered and completed as gas well GB-ER, brief production tests were run before the well was shut in January 17, 1968, for pressure buildup. Bottomhole pressure (BHP) was measured at 3,790 feet, 126 feet above the top of the Pictured Cliffs formation; BHP increased gradually from about 950 to 1,067 pounds per square inch gauge (psig) when production was resumed on June 28, 1968. This BHP was 84 psi higher than that measured preshot in test well GB-1 and approximately 160 psi lower than pressures measured initially in nearby field wells 13 years ago.

A 15-day production test begun June 28, consisted of flowing GB-ER at 5 million cubic feet per day (5MMcf/D, where M= 1,000) for 6 days, during which time BHP dropped to 906 psig at 248° F bottomhole temperature (BHT); then the well was shut in for 24 hours. During this shut-in period, the BHP rose to 917 psig and BHT declined to 174° F. Production testing was resumed for 5 days at 5 MMcf/D, resulting in 780 psig BHP and 247° F BHT. The production rate was lowered to 750 Mcf/D, and at the end of 4 days the BHP had increased 16 psi. The well was then shut in and remained so until testing was resumed November 4, 1968, except for one brief production period for collecting gas samples. Figure 13 shows BHP and production rate versus time.

A series of three 30-day production tests on GB-ER, each at successively lower (and constant) chimney pressure, followed by a 7-month production period at a still lower pressure, was begun November 4, 1968. Having built up to 950 psig BHP at that time, GB-ER was blown down to 884 psig BHP, and based on past performance, an 850-Mcf/D rate was set. It was necessary to lower the producing rate three times in attempting to maintain constant BHP, and the final rate was 350 Mcf/D. Following the first 30-day period, the BHP was lowered from 854 to 706 psig by producing 5 MMcf/D for 5 days, then the rate was set at 600 Mcf/D. The rate was lowered to 500 Mcf/D toward the end of the 30-day period; however, the pressure continued to decline, and final BHP was 687 psig. The BHP was then reduced to 506 psig by producing at about 4 MMcf/D for 7 days. The initial 650-Mcf/D rate for the last 30-day test had to be decreased four times to 400 Mcf/D, with the final pressure being 496 psig.

Figure 13 Project Gasbuggy Production Performance, June 1968 - March 1969

For the 7-month test, which was begun March 19, 1969, blowdown to 264 psig BHP was accomplished, and a 500-Mcf/D rate was selected to maintain constant pressure. The rate was gradually decreased to 160 Mcf/D by June 26, 1969. An increasing pressure then dictated raising the production rate to 175 Mcf/D on August 3, 1969. This rate was maintained until October 4, 1969, when the rate was decreased to 160 Mcf/D. Further rate adjustments were unnecessary.

A final pressure drawdown for this test series was begun October 28, 1969, and was terminated November 14, with 125 psig BHP. GB-ER is shut in for a long-term pressure-buildup test. Figure 14 shows data for this series.

Figure 14 Project Gasbuggy Production Performance, March - November 1969

C. Review of Work on Other Wells

Preshot test well GB-2 was reentered in June 1968. A 6-1/4-inch hole was gas-drilled to 4,600 feet after sidetracking out of a window milled in 7-inch casing at 3,691 feet. Sidetracking was necessary because casing damage at 3,812 feet prevented further progress. Logs were run and the well, GB-2R, was completed with production tubing landed in the uncased hole at 4,224 feet. The open hole apparently collapsed around the bottom of the tubing and sealed it off sufficiently to prevent use of the well for production tests. Production tests that were made during drilling of the sidetracked hole and a flowmeter survey that was run after reaching total depth indicated that productivity has been improved by the detonation; however, very little connection with the chimney was evidenced. BHP of GB-2R versus time is shown in Figures 13 and 14.

Well No. 10, located 436 feet northwest of GB-ER, was reentered in October 1968. Stemming material was cleaned out of the 5-1/2-inch casing to a 3,612-foot depth (about 300 feet above the top of the Pictured Cliffs gas sand), where damaged casing prevented further penetration. The well then was completed in the Ojo Alamo sand as an aquifer monitor well.

Well GB-3 was drilled in August and September 1969 during GB-ER production testing to investigate changes in Ojo Alamo and Pictured Cliffs formations and in the underlying shale to a 4,800-foot depth. An extensive coring program, utilizing logs and natural-flow gauges was used in defining reservoir characteristics, which were similar to preshot conditions in nearby well GB-1 (see Figure 4 for well locations) except that GB-3 core showed more fractures and was generally more fragmented on removal from the core barrel. Average values of the gas reservoir properties found in GB-3 are listed in Table 1.

Gas production was first encountered during coring at a 3,871-foot depth immediately above the Pictured Cliffs sand. The production reached a maximum rate of 54 Mcf/D at a 4,058-foot depth, about the middle of the Pictured Cliffs. The production rate was less than expected and showed a lack of open fracture communication with the chimney, as had GB-2R. After completion, the BHP in GB-3 built up in approximately 1 month to 445 psig, while chimney pressure remained at 256 psig. During the final blowdown of GB-ER to 125 psig BHP, GB-3 BHP declined to 426 psig. No experiment-related radioactivity was detected in GB-3 cores or produced fluids. The well is being used to monitor reservoir pressure.

D. Evaluation

In analyzing the behavior of the chimney well, the open-flow potentials (theoretical producing rate at zero psig backpressure) that were indicated from backpressure curves, constructed from data obtained near the end of each constant BHP test, were examined. The open-flow potentials are as follows:

	Approx. open flow potential, Mcf/D
July 1968: Short-Term test	2,800
December 1968: End of first 30-day test	930
January 1969: End of second 30-day test	840
February 1969: End of third 30-day test	500
July - October 1969: Last half of 7-month test	170

The marked decline in open-flow potential makes it clear that short test periods in the early life of a well in this type of reservoir do not reflect true long-term productivity. During the 7-month test, the BHP and production rate were stabilized; consequently production-rate data from the test were considered to be adequate for comparison with preshot productivity data from field wells, which have been producing for about 10 years. Table 2 gives production history of the original field wells. The GB-ER 160-Mcf/D production rate was obtained with a 232-psig surface backpressure. At a 500-psig surface pressure, which corresponds to the field gas-gathering line pressure, GB-ER should produce

TABLE 2
CHOZA MESA PICTURED CLIFFS FIELD PRODUCTION HISTORY

WELL	28-4 No. 6	28-4 No. 7	29-4 No. 2	29-4 No. 4	29-4 No. 10	29-4 No. 16	INDIAN A-2	INDIAN E-1
Location, Section-Township-Range	11-28-4	12-28-4	35-29-4	35-29-4	36-29-4	36-29-4	30-29-3	31-29-3
Initial Potential, Mcf/D	3,182	1,058	6,928	801	1,348	635	5,709	20,200
Open-Flow Potential, Mcf/D	-----	-----	-----	-----	1,403	647	7,984	-----
Annual Production, MMcf:								
1955	1.7	4.3	----	----	----	----	----	138.8
1956	11.0	----	144.6	9.2	----	----	----	37.2
1957	----	----	89.3	4.1	2.3	----	----	----
1958	18.6	6.1	84.2	2.6	12.5	----	131.7	63.4
1959	12.1	5.0	60.2	6.0	9.0	5.7	108.9	23.8
1960	12.4	4.3	42.7	4.5	8.2	3.9	68.6	23.3
1961	11.9	4.8	44.9	4.4	8.5	4.3	53.8	8.7
1962	10.3	3.1	39.5	2.9	9.3	3.1	47.7	10.5
1963	10.6	3.9	39.0	2.2	7.5	3.6	32.7	11.7
1964	10.0	4.1	24.2	2.4	6.6	4.2	17.1	5.7
1965	8.1	4.8	33.0	1.7	8.6	3.7	26.3	8.8
1966	5.8	4.1	30.1	2.3	8.4	2.9	34.6	6.7
Cumulative Production, 1-1-67, MMcf	112.5	44.5	631.7	42.3	80.9	31.4	521.4	338.6
1966 New Mexico State Test, Mcf/D	20	14	112	8	22	4	¹ / ₂ 219	27
¹ / ₁₉₆₅ test								

135 Mcf/D. After the initial flush production period, the five field wells nearest the test site produced at an average rate of 11 to 30 Mcf/D. Well 10-36, only 436 feet from GB-ER, produced an average of 22 Mcf/D. Therefore, the Gasbuggy postshot well produces at 6 to 7 times the rate of the average of these five field wells, which were hydraulically fractured when completed. Three field wells, Nos. A-2, and E-1, were not included in the comparison because they are farther from GB-ER; also, natural fracture systems encountered in these three wells gave them much higher productivity than is believed representative of the test area.

In comparing postshot productivity with that of the preshot test wells, the 30-day production tests of GB-1 provided the most reliable data of all the preshot tests. Although 30 days is not enough time to obtain a stabilized producing rate, the 125-Mcf/D openflow potential for GB-1 indicated at the end of the 30-day test should be comparable with that of GB-ER after producing for an equal time under similar conditions. As previously stated, the open-flow potential of GB-ER after the first 30-day test was 930 Mcf/D, a 7.4-fold increase.

GB-ER has produced approximately 284 MMcf of gas (213 MMcf of hydrocarbons) and, based on preliminary estimates of projected performance, should produce 900 MMcf in 20 years, which would amount to about 19 percent of the gas originally in place under 160 acres (a normal producing unit area for the field). With Well 10-36 having produced 81 MMcf

in 10 years, total recovery in 20 years for a well at that location (10-36 is no longer completed in the Pictured Cliffs sand) can be estimated with fair confidence. The 20-year production for Well 10-36 is estimated at 170 MMcf maximum, which is slightly more than twice the 10-year volume; an anticipated gathering-line pressure reduction would increase producing rates. Therefore, GB-ER is expected to produce at least 5 times the estimated production from a conventionally completed well in the area.

Pressure behavior during blowdown periods of the recent tests confirms a 2.5-million-cubic-foot void volume. This volume is equivalent to the void volume of a resultant chimney from a nuclear-created cavity with an 80- to 85-foot radius, depending on volume in fractures emanating from the chimney. As mentioned previously, drillback data from GB-2 and GB-3, both within 300 feet of GB-E, show little increase in productivity and indicate a smaller radius of effective fracturing than was anticipated.

Initially 52 percent of the chimney gas was hydrocarbons, instead of the usual 99 percent in gas from field wells. This decrease resulted from dilution by CO₂ and H₂, which were byproducts of the detonation. As expected, fresh gas entering the chimney increased the hydrocarbon content by flushing CO₂ and H₂ from the chimney. On November 14, 1969, when GB-ER was shut in, the hydrocarbon content of the produced gas had increased to 88 percent, while radioactivity in the gas had decreased by over a factor of 10 as a result of this chimney flushing. Gas composition was determined during production tests. Table 3 shows representative analyses at various times.

TABLE 3
GAS COMPOSITION (Mol. Percent) GB-ER

COMPONENT	PRE-SHOT	SHORT-TERM PRODUCTION TEST, JUNE 1968	BLOWDOWN PRIOR TO FIRST 30-DAY PRODUCTION TEST, NOVEMBER 1968	BLOWDOWN PRIOR TO EXTENDED PRODUCTION TEST, FEBRUARY 1969	BLOWDOWN AT END OF EXTENDED PRODUCTION TEST, NOVEMBER 1969
Carbon Dioxide	0.29	35.60	24.27	16.37	8.89
Hydrogen	---	12.03	10.11	6.38	2.35
Hydrogen Sulfide	---	0.11	0.02	0.04	0.02
Nitrogen	0.59	0.51	0.80	0.65	0.54
Methane	85.36	45.45	56.35	65.66	73.24
Ethane	7.40	4.83	5.30	6.03	7.20
Propane	4.00	0.95	1.93	2.86	4.41
I-Butane	0.75	0.19	0.39	0.58	0.86
N-Butane	0.94	0.16	0.41	0.69	1.18
I-Pentane	0.29	0.05	0.12	0.22	0.39
N-Pentane	0.20	0.03	0.08	0.16	0.29
Hexane	0.18	0.09	0.22	0.36	0.63
Heating value (Btu/cu. ft.)	1178	588	790	938	1112
Specific Gravity	0.673	0.890	0.808	0.776	0.768

The production tests, as of publication of this report, have resulted in a cumulative production of 213 million cubic feet of hydrocarbons, and gas recovery in 20 years is estimated to be 900 million cubic feet which would be an increase by a factor of 5 over that expected from hydraulically fractured wells in this low permeability area. At the end of production tests the flow rate was 160 thousand cubic feet per day. In addition, the Gasbuggy chimney is capable of storing 150 million cubic feet of gas, which at the higher flow rates clearly demonstrates the potential use of such cavities for gas storage.

2.2 ONSITE SAFETY MEASUREMENTS

The Project Manager retained overall responsibility for Project Gasbuggy. However, during a period of time determined jointly by the Project Manager and Test Director when execution of onsite radiological functions had direct bearing on the success or failure of the scientific program, control of radiological and nuclear detonation 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 onsite safety criteria. The Test Director was delegated responsibility beginning on the day the nuclear explosive arrived and continuing through the period of GB-ER drilling and initial gas sampling until it was determined that no postshot radiological hazard existed. During the detonation and immediate data recovery period, the Test Director operated a trailer containing the readout of the remote area monitoring system (RAMS) units, geophone, zero site wind information and closed circuit TV of the ground zero area. RAMS, wind, and geophone data were transmitted to the Project Manager and Scientific Advisory panel as input relating to the on and offsite safety.

During the GB-ER and GB-2R reentry drilling and gas sampling period, the Test Director operated radiation monitoring detectors on the drilling return and effluent vent lines. Readout of these monitors in a trailer operated by the Test Director was continuous. Routine site surveys and sampling were conducted utilizing the Project Manager's onsite rad-safe organization. The results of all monitoring and sampling were transmitted to the Project Manager as input relating to the on- and offsite safety.

2.2.1 Onsite Safety

Prior to detonation, a postshot surface ground zero reentry plan was prepared by the Test Director. All reentries into the onsite 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 Gasbuggy detonation, a postshot radiation safety survey of the onsite area was conducted to apprise the Test Director of rad-safe conditions to be expected by recovery parties. In addition, each recovery/reentry party was accompanied by a qualified rad-safe monitor while in the data recovery areas. During this period and the GB-ER drilling, the Test Director exercised control over all personnel entering the onsite area. LRL Hazards Control and the Project Manager's onsite rad-safe organization provided qualified monitors for the recovery parties and drilling operation, and conducted the initial postshot and continuing radiation surveys of the experimental area during the drilling and sampling operation.

2.2.2 Remote Area Monitoring System - EIC 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, two RAMS placed at 277 feet and 2,975 feet downhole were operated. All units had a continuous readout in the Test Director's trailer.

2.2.3 Geophone Listening - LRL

An array of postshot listening devices was installed at 3 locations on the surface for detection of underground disturbances immediately following the detonation. This information was continuously recorded in the Test Director's trailer.

2.2.4 Air Samplers - EIC

An array of air samplers was operated around the zero location for monitoring airborne radioactivity. The samples were collected and analyzed after the initial reentry.

2.2.5 Surface Television Monitoring - H&N

Closed circuit television was operated to observe GZ at shot time.

2.2.6 Surface Photography - LRL

Zero time photography consisted of one fixed camera location with motion and timelapse photography for the purpose of effluent history documentation in the event of a release.

2.2.7 Surface Ground Zero Site Weather - ESSA

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

2.3 TEST DIRECTOR'S STAFF

2.3.1 Administrative and Technical Support

A. Field Services (LRL)

This group was responsible for daily and long-range operational coordination of the various programs and technical support groups involved. This included collection and consolidation of all requirements for items such as transportation, communications, office and warehouse space, 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 for preparing schedules, reports, and correspondence deemed necessary by the Test Director.

B. Field Test Logistics (LRL)

Onsite warehousing and shipping services were not operated as a total project support function, as this was provided through the AEC Surface Construction Contract. Technical agencies were provided these services as requested. Temporary storage at the experimental site was also arranged. At the conclusion of the program, facilities and assistance were available for packaging and shipment of material from the site.

C. Hazard Control (LRL)

LRL's Hazards Control provided a staff representative responsible to the Test Director for the onsite safety program utilizing the organization of the Project Manager in establishing and enforcing onsite safety criteria.

D. Photography (LRL)

Installation and remote operation of a fixed camera station was accomplished for zero time motion pictures of SGZ to document any effluent release.

E. Classification Guidance (LRL)

The plans for Gasbuggy were reviewed by the AEC and LRL Classification Offices. Classification guidance for Project Gasbuggy was issued by the AEC-San (San Francisco Operations Office) on September 19, 1967, Ref: A-40979, classified SRD-1. This guidance provided the basis for answering classification questions concerning Project Gasbuggy.

F. Security (LRL)

The LRL Security Department provided a staff representative responsible to the Test Director for the development of the technical program onsite security interests as applicable to the Project Gasbuggy On-Site Security Plan issued and implemented by the Project Manager. The LRL security representative was also responsible for causing the establishment of the Gasbuggy technical program classified mailing facility, verification of LRL clearances to the onsite area and assuring LRL onsite compliance with internal Laboratory security procedures regarding classified document matters.

2.3.2 Engineering Support

A. Explosive Systems Engineer (LRL)

LRL provided an Explosive Systems Engineer who assumed the responsibility for all nuclear explosive related 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 Gasbuggy explosive. All signals originated from the timing and firing trailer located at the CP. In general, signals to experimenters onsite were provided by hardwire and signals to experiments offsite via radio.

C. Engineering and Construction (LRL)

This section was responsible to the Test Director for the development of all engineering and construction criteria for the technical program. In the early planning stages the section developed the scientific engineering design criteria, coordinated the actual design and review, and approved all contract documents. During the construction period, the section served in a liaison capacity between the USAEC and the 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 construction crafts was coordinated and provided 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 and overseeing its installation.

F. Grouting Services (WES)

Waterways Experiment Station (WES) provided technical support to the Test Director in the grouting of all holes. While actual emplacement of grout was accomplished by AEC contractors, WES provided the designs and tests of the mixtures used. Its laboratory design of these mixtures was in accordance with needs specified by the Test Director. WES personnel in the field furnished surveillance over the 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.

2.4 EMPLACEMENT HOLE (Figure 15)

The Gasbuggy nuclear explosive was emplaced in hole GB-E, a 4,350-foot drilled hole cased from surface to 4,325 feet with 18-1/4-inch ID steel casing. The explosive canister was lowered on 7-inch, OD casing, to a depth of 4,240 feet (Working Point). The emplacement hole was stemmed with cement, sand, and polymer to the surface.

Figure 15 GB-E Emplacement of Nuclear Explosive before Rig Moved over the Hole

2.5 SUPPORTING FACILITIES

2.5.1 Control Point (CP) (Figure 16)

The Gasbuggy CP consisted of an area of about two acres located 2-1/4 miles southwest of the emplacement hole, GB-E. All operational phase functions were conducted from this area. This included timing and firing, postshot RAMS, closed circuit TV, geophone readout/record data, and the D-Day assembly of all zero time operational personnel, except those exempted by the Test Director. The CP area, graded and stabilized, accommodated about 20 trailers and had the necessary utilities for the proper functioning of all project activities at this location.

Figure 16 CP on D-Day

2.5.2 Recording Trailer Park (RTP) (Figure 17)

The Gasbuggy RTP consisted of a 10,000-square foot cleared area located 2,500 feet SW of emplacement hole GB-E. LRL facilities at this location recorded signals from instrumentation emplaced in GB-E and GB-1. SL facilities at this location recorded material motion data from hole GB-D and the shallow subsurface array of instruments.

Figure 17 RTP with Emplacement Rig at Left Center

2.5.3 Explosive Assembly Area (Figure 18)

The final installation of the explosive into the environmental canister was done in a temporary wooden structure located approximately 250 feet from the GB-E hole. This structure also served as a junction point for the surface and downhole cables associated with the explosive and housed the surface electronics required for detonating the explosive.

2.5.4 Scientific Cable

Instrument and timing and firing cables of various types and sizes were installed as necessary between the CP, the various holes and surface instruments, and recording facilities.

Figure 18 Nuclear Explosive Package Being Removed from Red Shack to Go to Emplacement Hole

CHAPTER III

OPERATIONS COORDINATION

The operational period for Project Gasbuggy began October 16, 1967. The Operations Coordination Center (OCC) was activated under the supervision of the AEC Chief Coordinator from the Project Operations Division, NVOO, for the Project Manager, and staffed by personnel of the Operations Coordination Center from NTS. During the period of activation, the OCC was the focal point for receiving and disseminating information on operational activities, including coordination of operational effort of the participating agencies.

The OCC also prepared, coordinated, and issued area control plans and the Project Manager's Special Instructions and Schedule of Events for Project Gasbuggy. The OCC was deactivated on D+2. A NVOO Project Operations representative remained onsite through reentry drilling operations and gas sampling at GB-ER.

3.1 OPERATIONS COORDINATION CENTER

The Operations Coordination Center was activated on October 16, 1967, and operated on a one-shift basis until December 5, 1967, when 24-hour operations began. Operations Coordinators were on standby at Farmington for the overnight hours and on call to all agencies in case operational assistance was required. The OCC was deactivated at 4:00 p.m. on December 12, 1967; however, the trailer was retained as an office for the staff of the AEC Deputy Project Manager for Operations during postshot activities. An original force of two OCC personnel arrived on October 16, 1967. The two men began establishing an office in the OCC trailer at the CP and conducting road and area surveys to select and mark roadblock locations for area control purposes. Two additional men arrived onsite November 27, 1967, to assist in executing control plans during the test.

3.2 AIR OPERATIONS

Arrangements for operational aircraft support from military sources were made by the Project Operations Division, NVOO. Requests for aircraft operational missions from user and support agencies were submitted to the Director, Project Operations Division, NVOO. During the operational period, aircraft requirements were coordinated through the OCC at the site.

The Air Operations Plan was prepared and issued by the Nuclear Group of AFSWC. Aircraft control was exercised from a mobile AOC located 2-1/2 miles west of SGZ near the CP.

With the approval of the Federal Aviation Agency (FAA), the airspace within a 15-mile radius of GZ to an altitude of 20,000 feet MSL was closed D-Day, except for aircraft participating in the test. The FAA office in Denver, Colorado, issued Notice to Airmen (NOTAMS) for airspace restrictions.

No FAA representative was at Gasbuggy on D-Day; however, through prior arrangements with the Denver FAA office, communications were maintained between the CP and the control tower at the Farmington Municipal Airport by telephone and radio. Net 1 (AEC Net) facilities had been temporarily installed at the tower for this purpose.

On D-Day, aircraft participating or on standby totalled six, of which two were helicopters. Another two of the six, the Nevada Aerial Tracking System (NATS) aircraft and an EPA Turbo-Beech, were on standby at McCarran Airport in Las Vegas, Nevada. Four aircraft staged out of Farmington Municipal Airport and were airborne during H-Hour. A USAF C-47 and an EPA Turbo-Beech were airborne for cloud tracking and sampling missions if, and as, required. The two helicopters performed photo and other missions as directed by the Project Manager, utilizing the Gasbuggy landing pad to load and unload personnel and equipment.

3.3 REAL ESTATE

The major item of real estate at Project Gasbuggy was Section 36, Township 29 North, Range 4 West. This section in the Carson National Forest was withdrawn from Public Land Use for the Gasbuggy program by agreement with the U. S. Forest Service under Contract No. AT(26-1)-305, dated March 23, 1967. In Section 36 are located the emplacement hole (GB-E), two instrument holes (GB-1 and GB-2), the ground zero trailer complex, and the ARPA detection hole (GB-D). The agreement also allowed AEC utilization of other Carson National Forest lands as coordinated with the Forest Service Rangers at the Gobernador Ranger Station. Under this agreement other portions of the Carson National Forest Lands were used for the CP complex, Recording Trailer Park, helicopter tie down pad, Official Visitor Area, cableways, two CCTV and photographic camera sites, and access roads. Arrangements were made and/or permits obtained for the installation of 34 USC&GS seismic stations surrounding the site, ranging from 820 meters from ground zero to points as far as Farmington, New Mexico. The LRL established seismic stations at the Navajo and El Vado Dams. Permits were also obtained for the erection of three weather towers at or near the site and the construction, operation, and maintenance of three repeater stations for the radio communications network.

Office space in Farmington, New Mexico, for the AEC and other agencies, was provided by leasing several offices in the Petroleum Plaza Building. In addition, the USPHS obtained office and laboratory space in the San Juan County Public Health Building in Farmington.

Arrangements for real estate for construction purposes were made by the Engineering and Construction Division, NVOO.

Real estate requirements for operational purposes were submitted to the Director, Project Operations Division, NVOO. After review and coordination by the Project Operations Division, the requests were processed through appropriate NVOO channels.

3.4 WELFARE OF AREA RESIDENTS

3.4.1 General

No plans were made for preshot evacuation of offsite residents. In the unlikely event postshot evacuation was required, plans were prepared for the care, housing, and transportation of possible evacuees. The AEC Site Manager was requested by the Deputy Project Manager for Operations to be prepared to furnish facilities for water supply in case of damaged water systems, power and light, and temporary housing.

These facilities were not actually on standby, but arrangements were made with sources of supply for immediate acquisition if necessary.

3.4.2 Transportation

Transportation was available to assist in moving residents if such actions were required.

3.4.3 Medical

A doctor, first aid assistance, and an ambulance were available to provide emergency service to residents and others if required. These facilities were stationed at the Official Visitor Area.

3.5 OPERATIONAL ACTIVITIES AND ASSOCIATED PROBLEMS

3.5.1 Unsatisfactory Communications Between Agencies and OCC

Delays by participants in notifying the OCC of construction problems affecting the overall program and schedule and impending official visits resulted in poor coordination of site activities and reporting of actual situations.

3.5.2 Communication Facilities

Certain deficiencies in communication facilities, including both telephones and radios, resulted in some operational problems. Some agencies tended to excessive use of the limited outside telephones until time restrictions were imposed. Maintaining radios, both base stations and mobile, in a state of operational readiness was a continuing checkout and repair problem.

3.5.3 Road Survey

The preshot survey, staking and mapping of the numerous roads within a 10-mile radius area from GZ were satisfactorily completed to meet the revised shot schedule. The limited number of OCC personnel deployed to the site necessitated some overtime work to cover the extensive geographical area involving very rough terrain.

3.5.4 Office Space in Town

Because of limited funds for the project, no office space in Farmington was allocated for the AEC Deputy Project Manager for Operations and staff. A desk in the Site Manager's Office was available when not occupied by others. This caused some inconvenience when the Operations staff were required to perform duties at Farmington.

3.5.5 Seismic Station Noise Controls

The LRL requested that vehicle traffic on the road traversing the downstream face of the Navajo Dam be stopped from about H-10 minutes to H+10 minutes. LRL had established seismic stations at the dam and any traffic on this road at shot time would tend to generate noise which would obliterate seismic signals received from the detonation. This request was coordinated with the New Mexico State Police who arranged for the road closure during the specified time period.

3.5.6 Area Closed to Hunting

The deer hunting season in the Carson National Forest and adjacent Jicarilla Apache Indian Reservation was declared open October 28, 1967, through November 12, 1967. To protect Gasbuggy personnel and facilities from stray bullets, arrangements were made with the U. S. Forest Service to close a portion of the Carson National Forest in the vicinity of GZ, the Recording Trailer Park, the CP, and the helicopter tie down pad. The area was posted with "Closed-to-Hunting" and "No Trespassing" signs. Announcements of the closure were made to public via commercial radio, television, and local newspapers. Access was allowed through the closed area on posted roads so hunters could cross from one open area to another without having to travel many miles out of their way.

Recognition was made of potential area control problems during the special deer hunt on the Jicarilla Apache Indian Reservation beginning December 9, 1967. On D-Day, December 10, 1967, the Indian Police closed the area within the 5-mile radius of SGZ to entry of hunters. No problems were encountered.

3.6 ANALYSIS OF SCHEDULE

3.6.1 Project Manager's Special Instructions and Schedule of Events

The Project Manager's Special Instructions and Schedule of Events was published on November 28, 1967, after coordination with the LRL Test Director. (Appendix E).

3.6.2 Original D-Day

D-Day was originally set for October 18, 1967. Delay in completion of the emplacement hole because of drilling difficulties resulted in rescheduling to November 14, 1967.

Construction difficulties during the cementing of the emplacement hole casing resulted in setting a new tentative readiness date of December 6, 1967. Technical difficulties were encountered with a downhole cabling system resulting in the loss of several diagnostic circuits and the refrigeration system. The cable system problem resulted in several more days' delay and a new readiness date of December 10, 1967, was established. A preliminary readiness briefing held December 8, 1967, at 8:00 p.m., in the Conference Room of the El Paso Natural Gas Company main office in Farmington, New Mexico, confirmed the state of technical and operational readiness to meet the December 10 date.

3.6.3 Readiness Briefing - December 9, 1967 - 9:00 p.m.

At this briefing, H-Hour was set for 11:00 a.m., December 10, 1967. Muster of the 2-mile radius area around GZ began at 12 midnight, December 9, 1967. All offsite roadblocks were in position by 7:15 a.m., December 10.

3.6.4 Test Execution

The explosive was detonated at 12:30 p.m. The delay from 11:00 a.m. to 12:30 p.m. was due to waiting for winds to change trajectory slightly. Offsite roadblocks were released at 4:00 p.m. and all areas were opened at 5:25 p.m. except the GZ area. The Security station at GZ was deactivated at 8:30 a.m. on December 11, 1967.

3.6.5 Roadblock and Evacuation Procedures

There was no preshot evacuation of residents in the Gasbuggy area. No permanent dwellings were within the 5-mile radius of GZ. In the event postshot evacuation was required, the USPHS was prepared to move residents and others from the affected areas; however, the requirement for postshot evacuation did not arise. The establishment and readjustment of roadblocks on the 5-mile perimeter closed area and downwind sector beyond 5-miles were the responsibility of the Operations Coordination Center.

The area surrounding Gasbuggy GZ was divided into three zones for control purposes during the critical period of several hours before and after the shot:

- (1) Zone A was the area within an irregular periphery of about 2-miles radius from GZ. No personnel were permitted within this area. Roadblocks controlling Zone A were manned by WSI (AEC Contractor) guards stationed on access roads in the vicinity of the CP.

- (2) Zone B was the area between Zone A and an irregular periphery of about 5-miles radius from GZ. Project participants at the CP, helicopter pad, and guard stations were within this zone. Roadblocks controlling this area were manned by civil authorities.
- (3) Zone C, a truncated downwind sector between the 5-mile perimeter and the 10-mile perimeter, was established by the Project Manager for control if circumstances developed that were hazardous to offsite personnel. Roadblocks controlling Zone C were to be manned by civil authorities. At detonation time, no requirement arose to set up controls around this zone.

Roadblock locations on the 5- and 10-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 two perimeters were also selected, numbered, and staked. In addition, because of the numerous roads and jeep trails in the area, road intersections from GZ to the 10-mile perimeter were numbered and staked to facilitate roadblock and other project personnel to proceed to their assignments without undue delay and to help them identify their location. Roadblock stations and intersection numbers were marked on area maps which were distributed to the various concerned agencies.

3.6.6 Cooperation of Local and State Authorities

During Gasbuggy planning, briefings were held for the Governor of New Mexico and the Jicarilla Apache Tribal Council. Upon activation of the OCC, the District Commander, Farmington-Aztec, District 10, New Mexico State Police, and the Chief, Jicarilla Apache Tribal Police, were contacted and brought up-to-date on the progress of the project. From this time on they were kept informed of delays and changes in schedules. Both agencies participated at the CP in signal and full-power, full-frequency timing and firing dry runs to check radio frequencies and ensure noninterference at shot time. As both agencies intended to use radios in vehicles to maintain communications with their roadblock and control personnel on D-Day, their mobile radios were operated during the dry runs. Several days prior to D-Day, the State Police District Commander and the Jicarilla Apache Tribal Police Chief were given sets of area maps and briefed on roadblock locations and duties of roadblock personnel.

Both State and Tribal Police participated in readiness briefings. They in turn briefed their personnel. On the morning of D-Day, the two organizations were met at predetermined locations on State Highway 17 by representatives of the Operations Coordination Center. As all the roadblock personnel were not familiar with the roadblock locations, they were escorted to their stations by the OCC representatives.

The police organizations provided their own transportation and communications system on their normal frequency. The State Police District Commander and the Jicarilla Apache Tribal Police Chief were at the OCC during the test to relay necessary instructions to the roadblock personnel. Excellent cooperation was received from both police agencies. Their efforts, willingness, and efficiency contributed greatly to the successful culmination of Project Gasbuggy.

A total of nine roadblocks were manned, four by the State Police, four by the Tribal Police and one jointly (at the junction of State Route 17 and the main access road to the Gasbuggy site). The State Police controlled entry to the Official Visitor Area and also held three officers in reserve at this location for emergency purposes. In addition to manning roadblocks selected by the AEC, the Tribal Police set up several of their own stations on certain main roads outside the 5-mile perimeter. These were primarily advisory stations to alert travelers of road closures and advise the use of alternate bypass routes. In case of emergency, these advisory

station personnel could be called on for assistance. OCC personnel were stationed at several strategic roadblocks to assist in clearing project personnel through to the CP and to be available for timely relocation of roadblock positions in case of emergency.

In an effort to keep the number of people at the CP to an absolute minimum, all agencies submitted to the OCC lists of essential personnel required to be present through H-Hour. These lists were closely reviewed by the AEC Deputy Project Manager for Operations. Other personnel, such as later reentry and recovery groups and support types required on standby in case of facility breakdowns prior to H-Hour, were stationed at a "standby support area" at a State Police roadblock on the access road, west of the CP, about 4-1/2 miles from GZ. Communications and transportation were available for quick reactions if necessary.

State Route 17, which crossed a portion of the northwest sector of the 5-mile controlled area, was closed at 9:00 a.m. on D-Day from approximately 3 miles east of Gobernador Camp to a point about 3 miles east of the junction of Route 17 and the main access road to the Gasbuggy site. Roadblocks were established at these points which also served as public visitor sites for those visitors and residents not authorized in the Official Visitor Area. Official visitors and newsmen arriving late were escorted to the Official Visitor Site up to H-1 1/2 hours, at which time all traffic stopped. Route 17 was opened to traffic at 1:00 p.m. after the State Patrol had surveyed the road to assure it was not blocked by falling rock. A road patrol unit was stationed at the Official Visitor Area if needed to clear debris from the highway. It was not required.

3.6.7 Support to Official Visitor Program

Support furnished to the AEC/EPNG Official Visitors Program included escort through controlled areas, radio communications, helicopter lift of high ranking officials, and coordination of shot day events.

3.7 CLAIMS

To accurately evaluate possible complaints and/or claims of damage from the Gasbuggy detonation, preshot surveys were made of selected structures by John A. Blume and Associates, Structural Response Engineers. Seismic recording stations were installed by the USC&GS at various selected locations surrounding the shot point as well as the seismic stations established by the LRL at Navajo and El Vado Dams. Arrangements were made with the General Adjustment Bureau to have personnel in the area to investigate any complaints of damage.

3.8 POSTSHOT REENTRY (GB-ER)

Reentry of the Gasbuggy emplacement hole began on December 13, 1967. Sand removal from the 7-inch emplacement casing was begun. A representative of the Project Operations Division was onsite throughout the reentry program which was completed on January 16, 1968.

3.9 GASBUGGY GAS SAMPLES

Authorization to furnish Gasbuggy gas samples to interested parties was obtained through publication of a notice in the Federal Register on March 13, 1969. Purchases are handled in accordance with a single party sales agreement, including all substantive provisions, with payment called for at time of delivery. A charge of \$60 per container, holding approximately 7,950 milliliters (.28 cu. ft.) of gas, for delivery at the AEC's project site, Rio Arriba County, New Mexico, with an additional charge of \$10 per container, payable in advance, for delivery FOB by commercial carrier in either Santa Fe or Albuquerque, New Mexico, has been established. All requests for Gasbuggy samples have to be in writing to the Manager, NVOO.

On March 26, 1969, the Test Manager, NVOO, was assigned responsibility for administering the sale of the samples. Eberline Instrument Corporation was instructed on May 22, 1969, to prepare samples as requested.

There were six inquiries about buying samples prior to the time of the samples' availability. As of March 1971, only two purchases have resulted.

On January 29, 1971, SWRHL requested approval for the Radiological Research Program to obtain approximately 6,000 cubic feet of gas from the GB-E well at the Project Gasbuggy site for use in their research study "Project Moonbuggy." The objective of this study is to determine the equilibrium tritium to protium (T/P) ratio in the body water of swine living in a trailer heated with an open flame nonvented gas heater burning natural gas from the Project Gasbuggy cavity as part of their "Evaluation of Products Resulting from the Peaceful Uses of Nuclear Explosives" program. Approval was granted on February 8, 1971.

CHAPTER IV

SAFETY PROGRAM

4.1 WEATHER AND SURFACE RADIATION PREDICTIONS

ESSA's Air Resources Laboratory (ESSA-ARL), was responsible for providing:

- (1) Meteorological data and weather forecasting services in support of the Test Director's Program and the Operational Safety Plan.
- (2) Predictions of the dispersion of any radioactive effluent which might result from the device detonation or be released during postshot reentry into the emplacement hole and subsequent gas flow testing programs.

Meteorological support personnel were released by the Project Manager upon completion of the GB-E reentry program in January 1968.

During GB-2R reentry and gas flow tests conducted in June and July 1968, ESSA-ARL personnel returned to the site to provide local surface and winds aloft observations. Weather and radiation forecasts were available by telephone on request from the duty forecaster at NTS. Upon completion of the gas flow testing program in July 1968, all meteorological support for Project Gasbuggy was terminated.

- (3) Postshot analyses, records, and reports as required.

A site climatology, based upon available data from proximate established weather stations, was prepared and distributed as an input to project planning. Local surface wind data obtained from three onsite mechanical wind stations, erected some months before the test phase, were studied to determine local terrain effects.

A completely equipped weather observing and forecasting facility was established at the Gasbuggy CP. Local surface and upper air observations were supplemented with large scale data obtained from National Weather Facsimile and Teletype circuits for around-the-clock operations commencing about 10 days prior to the scheduled execution date. Daily forecasts were issued for site operations and in support of aircraft operations.

Forecasts of meteorological parameters pertinent to safety considerations, estimates of total external gamma exposure produced by passage of the potential effluent cloud, and estimates of inhalation and ingestion doses from a possible ^{131}I release were presented to the Project Manager and his Advisory Panel, in both formal and informal briefings, prior to detonation.

Local area winds and weather conditions on D-Day were documented through surface and upper air observations at the site and winds aloft observations at three offsite pilot balloon locations which bracketed the site at distances of about 50 miles.

Weather conditions were nearly ideal on D-Day. Sky cover consisted of a few high, thin clouds; and a stable layer at about 8,500 feet MSL limited vertical mixing to the first 1,500 feet above the surface. Light westerly winds throughout the mixing layer were producing trajectories toward the east. (See Figure 19.)

Figure 19 GB-E Preshot D-Day with Weather Balloons to Indicate Surface Wind Direction

Meteorological support was continued through the postshot period. Although levels of support varied according to the operational situation, 24-hour weather and radiation forecasting and observing services were maintained during all periods of potential release hazard.

Meteorological support personnel were released by the Project Manager upon completion of the GB-E reentry program.

4.2 RADIOLOGICAL SAFETY

4.2.1 Onsite Radiological Safety

Eberline Instrument Corporation (EIC) was assigned by AEC/NVOO under Contract AT(26-1)-294 to support the Project Manager and the Test Director with radiation monitoring and medical services at Project Gasbuggy.

Radiation monitoring support included the following activities:

- (1) Installation and operation of the Remote Area Monitoring System (RAMS) and air samplers around surface ground zero (SGZ) for effluent documentation and hazards evaluation.
- (2) Around-the-clock site surveillance by certified radiation monitors.
- (3) Environmental sampling.
- (4) Operation of an onsite radiological measurements trailer to detect the presence of any possible radioactive material in air, gas, water, soil, snow, drilling fluids, vegetation, and other samples.
- (5) Radiation area access control.
- (6) Personnel dosimetry including urine bioassay.
- (7) Instrument maintenance and calibration.
- (8) Control of radioactive sources and contaminated materials and equipment.
- (9) A capability to respond to radiation incidents of an emergency nature.

A. Effluent Documentation

RAMS detectors were installed to encircle SGZ at 250 and 450 feet from the emplacement hole (Figure 20). Specially packaged shock resistant detectors were placed at SGZ and two downhole locations, at depths of 300 and 2,900 feet, to give an early indication of any movement of radioactive materials from the emplacement depth up toward the surface.

Figure 20 Project Gasbuggy RAMS Array at SGZ on Shot Day

A sample of the gas leaking up the cables was collected in an evacuated flask through a charcoal prefilter and analyzed by gamma spectrometry at 7:45 a.m., December 11, 1967. The only radioactive material present in the charcoal and the flask were inert noble gases. The results obtained from these laboratory measurements are tabulated below:

Radionuclide	pCi/cc
Xe - 135	28.7
Kr - 88	110
Kr - 85m	308
Total Iodine	<0.1

Air samplers located on the two arcs around SGZ, were started at approximately 7:00 a.m., December 10, 1967. The filters and charcoal cartridges were removed from these samplers at approximately 8:00 p.m. the same day. These first filters and cartridges were counted within 2 hours after removal from the air samplers. The air sampler at the CP was not in the downwind pattern from SGZ, and this sample was used as a control. Analyses of air samples collected at SGZ and the CP showed no fresh fission products.

Twenty-four hour air samples were collected daily from 7:00 a.m., December 10, 1967, until after the drillback and gas sampling operations were completed on January 17, 1968. These samples were counted soon after collection and again after radon daughters had decayed. They indicated that airborne radioactivity around SGZ never varied significantly from normal background levels. Drilling samples also indicated no greater than normal background levels.

The conversion of total gamma emission from the charcoal cartridge to μCi was based on the assumption that all of the gamma emission was from ^{131}I . However, the activity in the charcoal for samples taken from the drill rig was identified as ^{133}Xe . None of the samples collected at Project Gasbuggy contained enough ^{131}I to be identified as such by gamma spectrometry.

During postshot drilling and gas sampling operations, evacuated flask samples were taken directly from the wellhead, the high pressure containment system, the cellar under the drill rig, and from the bottom of the reentry hole (GB-ER). None of these samples contained any radioactive material except the noble gases xenon and krypton.

Charcoal cartridge samples were collected at points in front of and behind the filter bank in the vent line system during the sampling phase of the operation. These samples did not contain ^{131}I in detectable concentrations (less than 6×10^{-5} pCi/cc).

B. Site Surveillance

Onsite operations began on October 11, 1967, with the arrival of the first of five trailers and a few radiation monitoring personnel. On November 21, 1967, with the arrival of the nuclear explosive, a conservative program of around-the-clock surveillance of SGZ was initiated. This was continued until January 19, 1968, when postshot drilling, sampling, and testing were completed. No above background levels of radiation were detected in any of the work areas during this period except during radiography and well-logging operations which were controlled to

avoid any unnecessary radiation exposure. A postoperational survey on January 24, 1968, indicated that radiation levels onsite were nominally in the background range of 0.01 to 0.04 mR/hr with a maximum reading of 0.10 mR/hr at the outside surface of the 2-7/8-inch diameter wellhead pipe that penetrated the chimney.

C. Environmental Sampling

Samples of water, soil, and vegetation were collected and analyzed to establish the preshot radiological condition of the site. A similar set of samples will be collected when the production testing is completed for comparison with preshot sample results.

During the postshot drilling program, water from GB-ER, moisture from the air; water from Cedar Springs, Leandro Lake, and Laguna Seca; drinking water from onsite taps; and snow samples were analyzed for total alpha, total beta, and tritium. Most of the samples contained only background levels of contamination; however, there were a few exceptions.

A snow sample, from a recently deposited top snow only, was collected at the CP on December 29, 1967, and indicated the presence of nonvolatile fission products. These were identified as primarily ^{147}Nd , ^{141}Ce , ^{99}Mo , and ^{143}Ce . Between December 29, 1967, and January 3, 1968, the nonvolatile beta emitters present in the sample decreased by a factor of two which would tend to indicate that the radioactive material did not originate at Project Gasbuggy. Mixed fission products from Project Gasbuggy would have a much longer half-life than 5 days at this time. A similar snow sample was collected in Santa Fe, New Mexico, December 31, 1967. This sample contained the same gamma emitters in approximately the same concentration as the sample collected at the CP on December 29. The contamination, therefore, did not originate at Project Gasbuggy.

A sample of water collected from the 3,000-foot depth in GB-ER on January 2, 1968, contained tritium at a concentration of $(1.6 \pm 0.3)10^{-4}$ $\mu\text{Ci/ml}$. Another sample collected from the same location on January 6, 1968, contained $(6.0 \pm 0.4)10^{-4}$ $\mu\text{Ci/ml}$. Water collected directly from the drill stem on January 10, 1968, contained $(30 \pm 1)10^{-4}$ $\mu\text{Ci/ml}$. Ice removed from the top of GB-ER on January 16, 1968, contained $(25 \pm 0.7)10^{-4}$ $\mu\text{Ci/ml}$. These tritium levels were very low, near the lower limit of EIC detection capability, and did not represent a hazard to onsite personnel. None of the water samples from GB-ER contained detectable amounts of other beta emitters except ^{133}Xe .

D. Radiological Measurements

A trailer equipped with sensitive electronic counting equipment was used for rapid onsite assay of samples. A multi-channel pulse height analyzer was used along with a 3-inch diameter by 3-inch thick NaI(Tl) detector to identify gamma emitting radionuclides. A gas flow proportional counter was used to determine alpha and beta emitting radionuclides. A liquid scintillation counter was used to determine tritium. At critical times, this facility was operated around-the-clock. At other times it was manned on the day shift only.

E. Radiation Area Access Control

Prior to D-Day, radiation areas existed for short periods of time during radiography and well-logging operations. These areas were controlled by ropes, signs, and radiation monitors as required. Personnel working with sealed radioactive sources were required to wear film badges.

On D-Day, personnel who were assigned to reentry parties were fitted for and issued respiratory protective equipment, anticontamination clothing (anti-C), and dosimeters. A typical kit included coveralls, plastic tote boots, cotton gloves, hood, two self-reading dosimeters, a full face mask with a filter cartridge for removal of particulates and organic vapors, and a film dosimeter.

Thirty-five of these kits were issued prior to H-Hour. Each reentry party was issued duplicate sets of high and low range radiation measuring instruments.

Four EIC monitors were actively involved in prompt, postshot reentry operations to recover film and other records of the test. Nine others were outfitted for reentry and were in standby status if needed. Five persons were involved in monitoring, relaying, and recording the radiation levels near SGZ as indicated by the RAMS. Additional personnel were assigned to standby at roadblocks and visitor areas as a precautionary measure.

RAMS surveillance and routine radiation surveys at SGZ continued through the first 24-hours postshot. Radioactive gas was detected leaking up the cables at H+5 hours, first by downhole RAMS readings and later by direct instrument survey of the cables. This led to the cable cutting and sealing operations which prevented any significant release of the radioactive gas in accordance with designed capability.

Before postshot drilling began, the Access Control Trailer was moved to the SGZ. The area around SGZ which represented a potential radiation area was enclosed by a rope barrier and appropriate signs. Entry into this area was through the Access Control Trailer, which served as an issue and check-in point for anti-C clothing, dosimeters, and instruments. EIC personnel carried on a continuous monitoring program throughout the postshot drilling period. This included air sampling for radioactive materials and periodic surveys to determine radiation levels and to detect the existence of toxic gases or explosive mixtures. During critical stages of the drilling operation, a monitor, equipped with portable radiation and explosive mixture instrumentation, was stationed on the drill platform.

When the postshot drilling was completed, the drill rig and drill pipe were dismantled, and these items were surveyed for radioactive contamination before being released. The wellhead and the surrounding area were fenced and locked to prevent tampering by unauthorized personnel. Radiation levels outside this enclosure were at their preoperational background levels.

F. Personnel Dosimetry

Film badges were issued to 298 individuals at Project Gasbuggy. In no case did any individual receive an exposure above 10 percent of the limits specified in the operational plan.

Urine samples from 38 individuals, including those most directly involved in the postshot drilling operations, were analyzed for radioactive material. A summary of the results are tabulated below:

No. of Samples	Assay for	Maximum Concentration
38	Tritium	$(2.5 \pm 0.7)10^{-5} \mu\text{Ci/ml}$
22	Gamma emitters	$(3 \pm 3)10^{-6} \mu\text{Ci/ml}$

All results indicated no positive exposure above background.

Ten thermoluminescent dosimeters (TLD) were placed at various locations within the site boundary for a week preshot. Ten others were placed for the period D-1 through D+5. All of these indicated a total exposure of less than 20 mrad, the limit of detectability.

G. Instrument Maintenance and Calibration

The following portable instruments were provided for radiation monitoring at Project Gasbuggy:

Quantity	Type
13	Beta - gamma survey meter, Eberline Model E-400, 0-200 mR/hr
8	Beta - gamma survey meter, Eberline Model E-500B, 0-200 mR/hr
20	Gamma Dose Rate Meter, Victoreen Model Radector 500, 0.01 - 1000 R/hr
5	Personnel Radiation Monitor with Audio Warning, Electro-Neutronics Model PRM-2, 0.1 mR/hr and up
75	Pocket Dosimeter, Victoreen Model 541A, 0-200 mR (gamma)
50	Pocket Dosimeter, Bendix Model 866, 0 - 1R (gamma)
8	Alpha Survey Meter, Eberline Model PAC-4G, 0 - 5000,000 CPM

The above instruments, the RAMS, the equipment in the Radiological Measurements Trailer, the portal monitor in the Access Control Trailer and effluent monitoring equipment provided by LRL were maintained using a trailer facility designed and equipped for this purpose. All equipment was fully calibrated in Santa Fe prior to shipment to the project site. Additional field calibration was provided using a 100 mCi/ ^{137}Cs source.

4.2.2 Onsite Radiological Safety (Production Testing Phase)

During the production testing phase of Project Gasbuggy, Eberline Instrument Corporation (EIC) provided onsite radiological safety support to AEC/NVOO under Contract AT(26-1)-294. Medical services were not required during this phase. From January 25, 1968, until June 11, 1968, there was no drilling or production testing and radiological safety support was limited to periodic radiation measure-

ments at the wellhead. Limited production tests were conducted in June and July 1968 and then the well was shut in until November 4, 1968, when production testing began again. These production tests continued until November 14, 1969. Monitoring support services were also provided during the reentry of GB-3, from August 13, 1969, to September 23, 1969.

A. Monitoring of Gas During Flaring

Tritium and ^{85}Kr were the primary radionuclides from the detonation that were found in the gas or liquids during production tests in June and July 1968, and the series of tests which began in November 1968.

A System to Analyze Low Levels of Krypton and Tritium (STALLKAT) was designed and built by LRL. This system was designed so that the gas flowed through two chambers at a flow rate of approximately 1.8 liters per minute. The tritium chamber had a volume of 15.9 cm^3 and contained a $\text{CaF}_2(\text{Eu})$ scintillation detector 0.010 inches thick x 1.75 inches in diameter. The krypton chamber had a volume of 3,665 cm^3 and contained a $\text{CaF}_2(\text{Eu})$ scintillation detector 0.030 inches thick x 1.75 inches in diameter. The signals from the detectors were amplified and pulse height selected by single channel analyzers. The tritium detector was kept at a temperature of -10°C by a refrigeration system. A scaler and a count rate meter were driven by the analyzer output. The scaler output drove a printer. The entire system was calibrated using standard krypton and tritium gas supplied by LRL. Frequent gas samples taken to LRL for analysis verified the calibration of this on-line system. The limit of detection for the STALLKAT was $2 \times 10^{-5} \mu\text{Ci/cc}$ for tritium and $1.3 \times 10^{-7} \mu\text{Ci/cc}$ for ^{85}Kr .

The STALLKAT employed a bulk liquid trap, a particulate filter and a desiccant moisture trap before the detectors. Although the pre-filter and traps had no effect upon the monitoring of krypton, these traps remove tritiated distillate (oil and water) from the gas prior to the gas flowing to the detectors. In order to determine the tritium content of the vapor which was not seen by the on-line detectors, freeze-out samples were collected and analyzed for tritium.

The STALLKAT was used during all production tests through November 1969.

B. Management of Tritiated Liquid Wastes

Water and some oil were carried up the tubing with the gas in the emplacement-reentry well (GB-ER) when the velocity of the gas was sufficient to carry up the water. Most of this liquid was removed by two bulk liquid separators and was stored in a metal tank until analyzed for radioactive material.

The limited tests in June and July 1968, produced 1,440 gallons of water. This water was placed in 36 55-gallon drums, gelled, and sent to the Nevada Test Site (NTS) for disposal. These 36 drums contained a total of 7.2 Ci of tritium. Five 55-gallon drums with HTO in dirt containing a total of 0.1 Ci of tritium and one 55-gallon drum with 0.03 Ci of tritium in assorted wastes were also shipped to NTS. For the subsequent series of tests, 118,440 gallons of water were separated. The bulk of this water was produced during three rapid draw-down periods at high flow rates designed to reduce the downhole pressure.

The disposal of this quantity of water by forming a gel in barrels and transporting the barrels to a waste disposal site would have been too costly. The water produced would have required approximately 2,725 barrels to be prepared and shipped. The tritium contained in the separated water also constituted only about 5 to 10 percent of the tritium released by burning the gas.

A steam/spray system was designed to vaporize the water into the flame at the top of the flare stack. Two pipes with nozzles were attached at the top of the flare stack and the liquids were sprayed directly into the gas being flared. When the flow rate of the gas was approximately 2 MMcf/D or greater, the water was completely vaporized. With lower flow rates, the water was first passed through a steam generator and then introduced into the gas flare as steam. The objective in both cases was to completely vaporize the water.

EPNG conducted, on a variable schedule, downhole pressure and temperature bomb runs on the GB-ER well. The bomb was lowered to 3,790 feet for the measurements. Liquid (water and oil) and sludge entered the bomb through a small hole. The composition of the liquid varied from day to day. The amount of liquid collected was highly variable.

The liquid was removed from the bomb and assayed for tritium by liquid scintillation spectrometry. In some cases much less than a milliliter of liquid was obtained and the samples were not analyzed. Many of the samples were so highly colored by sludge that extreme quenching precluded accurate analysis without extensive sample pretreatment. Centrifuging and distillation were performed when sample volume permitted.

C. Exposure Documentation

Routine radiation surveys were made with portable beta-gamma instruments. Although no external radiation hazards were detected, film badges were issued to onsite personnel. Dry ice and acetone cold traps were used to collect samples of moisture from the air. Urine samples were collected at least weekly from onsite personnel. These air moisture and urine samples were analyzed for tritium by liquid scintillation spectrometry.

D. Waste Liquids

The first rapid decrease in pressure from 870 psi to 700 psi lasted 6 days at a flow rate of 5 MMcf/D. During this period, 5,172 gallons of water were produced. The next reduction, a month later at the same flow rate, from 700 psi to 500 psi downhole pressure, lasted 9 days and 18,500 gallons of water were produced. The third reduction of downhole pressure, from 500 psi to 260 psi, lasted 24 days and 76,441 gallons of water were produced. During this period, the well was flared wide open and flow rates gradually decreased from 3.42 MMcf/D on February 18, 1969, to 0.95 MMcf/D on March 14, 1969. Water production reached 220 gallons per hour during portions of this period and the well was shut in several times because water production exceeded maximum disposal capability with existing equipment and storage facilities. A 6-month production test, maintaining a constant downhole pressure of 260 psi, commenced March 14, 1969. The flow rate decreased gradually to a flow rate of 300 Mcf/D. A total of 119,880 gallons of liquid waste were handled including the 1,440 gallons sent to NTS.

During the steam/spray operations, samples of liquid were routinely collected from the waste liquid storage tank for tritium analysis. The samples were analyzed for tritium by liquid scintillation spectrometry.

E. Moisture Freeze-Out Samples

Filtration and desiccant traps were necessary on the STALLKAT to remove moisture and oil vapor from the gas to prevent accumulation in the detector system. Since the STALLKAT did not detect the tritium in this vapor, freeze-out samples of vapor in the gas were taken using dry ice acetone traps after the bulk liquid separators. The volume of liquid thus obtained from a known volume of gas was measured. The liquid was analyzed by liquid scintillation spectrometry for tritium and the amount of tritium released by this mechanism was calculated. This quantity of tritium was added to the amount detected by the STALLKAT and the tritium in any waste water was steam/sprayed to obtain total tritium release for the day.

Freeze-out samples were also collected from the gas before it passed through the bulk liquid separators. The concentration of tritium in these samples sometimes differed significantly from the concentration in samples collected after the separators. The reason for this difference was not determined; however, the fact that the concentrations before and after, differed significantly in some cases is not surprising when the nature of this liquid is considered. Condensate samples were a mixture of oil and water and the efficiency of the separators was not necessarily the same for both. Since the tritium in the vapor fraction after the separators is the only tritium not measured by other systems, this was the only fraction which needed to be measured for inclusion in the total tritium release estimate. For this reason, collection of freeze-out samples before the separators was discontinued on April 3, 1969. The tritium in the vapor phase after the bulk liquid separators represented only a very small fraction of the total tritium released.

F. Liquids from GB-ER Bomb Runs

Liquid samples obtained during temperature and pressure bomb runs were analyzed for gross alpha, beta, and gamma activity in addition to a tritium determination. No evidence of any radioactivity above natural background other than tritium was found. The results had nothing to do with tritium release calculations but did indicate concentrations of tritium in liquids in the GB-ER well at the time of each bomb run.

G. Gas Monitoring Results

The total tritium released during the June and July 1968, tests were based on the analysis of gas samples by LRL. The total ^{85}Kr released during this period was based on STALLKAT readings.

The tritium released during the tests that began in November 1968, was composed of three parts; tritium in the gas monitored by the STALLKAT, tritium in the waste water monitored by liquid scintillation spectrometry of water samples taken during the steam/spray operation, and the tritium in the vapor phase as monitored by liquid scintillation spectrometry of freeze-out samples collected after the bulk liquid separation. The ^{85}Kr results for this period are based on STALLKAT readings. Through November 1969, 2,432 curies of tritium and 364 curies of ^{85}Kr were released to the environment.

H. Personnel Exposure

Film badges worn by onsite personnel indicated no positive external radiation exposure (all less than 30 mrem).

Air moisture samples collected during the period December 16, 1968, through November 14, 1969, indicated only very low concentrations of HTO in air. Measured concentrations were several orders of magnitude below the concentration guides for controlled and uncontrolled areas.

Concentrations of tritium in urine were all background (less than 4×10^{-4} $\mu\text{Ci/ml}$) indicating no significant uptake of tritium.

4.2.3 Offsite Radiological Safety

The Southwestern Radiological Health Laboratory (SWRHL) of the USPHS was responsible to the AEC Project Manager for providing appropriate environmental surveillance which included:

- (1) Maintaining a comprehensive record of background environmental radioactivity in the offsite area during the operational period.
- (2) Documenting the type and extent of any offsite environmental radiological contamination resulting from the experiment.
- (3) Assuring continuous protection of public health and safety during the operational period by determining potential exposures and performing suitable protective measures when directed by the Project Manager.
- (4) Conducting a continuous program of personal contacts in the surrounding communities to develop and maintain local confidence that public safety was being guarded throughout the project period.
- (5) Reporting any offsite area incidents or complaints attributed to project operations to the Project Manager and assisting in the investigation of such matters as directed.

A. Radiological Safety Criteria

The radiological safety criteria for offsite populations are those established in Section II (A) of AEC Manual, Appendix 0524.

B. Operational Procedures

1. Personnel

Personnel responsible for the offsite radiological safety program were assigned from SWRHL. These 17 people helped by 10 state health officials from New Mexico and 3 from Colorado, assigned to the USPHS for the Gasbuggy operation. In addition, 2 New Mexico state laboratory personnel stationed in Farmington were available to perform analyses of any offsite samples. A Jicarilla Apache Indian interpreter was also with USPHS personnel.

2. Preshot Census

A detailed human population and milk cow census was taken to a distance of 100 miles from ground zero. Additional census information was collected out to a maximum distance of 140 miles. Location surveys were also made of all mining and tunneling operations within 50 miles of ground zero. No special action regarding surveillance or inspection of these operations was requested of the USPHS by the AEC Project Manager during or after the test.

3. Community Relations

The USPHS Project Officer and state health officials made visits to officials in surrounding communities, answering questions, distributing printed information, and making themselves available for any future questions. Several talks were given by the Project Officer to local organizations.

4. Medical Activities

The SWRHL Medical Advisor was assigned to Farmington for period before, during, and after the test. Liaison was established with physicians in the area and arrangements were made with local facilities to aid the USPHS in any offsite emergencies during test operations.

5. Veterinary Activities

A SWRHL Veterinary Officer was assigned to Farmington during test operations. His responsibility was to establish contact with local and state veterinary officials, to investigate any possible domestic livestock or wildlife claims, and to take countermeasures if a release of radioactivity occurred.

6. Surveillance Program

a. Aerial Monitoring

A USPHS Turbo-Beach with four USPHS crew members and a USAF C-47 with an USPHS two-man monitoring team provided aerial monitoring on the day of the test.

b. Ground Monitoring

Prior to the day of the test, field personnel spent 2 days in classroom instruction and 6 days in field orientation. Field personnel were required to learn the location of all offsite residents within 30 miles of ground zero, and to take background radiation readings. Of the 30 personnel assigned to the USPHS effort on shot day, 21 were in the field including 15 monitors, four zone supervisors, and the Medical and Veterinary Officers. All field personnel were equipped with a Model NE-148 Baird Atomic Scintillator, an E-500B Geiger-Mueller survey instrument, a Victoreen Radector II, and environmental sampling equipment and supplies. The Acting Director, SWRHL, the USPHS radio net coordinator, and the USPHS Project Officer were located in the Operations Coordination Center.

c. Dosimetry

Fifty stations for both thermoluminescent dosimeters (TLD) and film badges were established in an approximate 8-mile radius network surrounding the site. Additional TLD's were available to supplement the basic network had a venting occurred. All USPHS personnel wore TLD's during the test.

d. Air Sampling

Thirty-six air sampling stations ranging from 10 to 300 miles from ground zero were utilized for the test. They collected background information for 13 days prior to shot day and operated for 3 days after the shot. Eleven of the stations ranging from 10 to 60 miles from ground zero continued operation through the drillback period.

e. Milk Sampling

Fifty-two pershot milk samples, Grade A dairies and family milk cows, were taken and analyzed for background information. Samples were taken from 22 locations ranging from 15 to 150 miles from ground zero. An additional 25 milk samples were collected postshot.

f. Water Sampling

Seventy-seven preshot water samples and 26 postshot samples were collected and analyzed. Samples were taken from 34 locations ranging from 1 mile to 150 miles from ground zero.

g. Vegetation Sampling

Thirty-five vegetation samples were taken at 31 air sampling stations before the shot. No samples were taken postshot since no radiation was detected offsite and the area was covered by 1 to 3 feet of snow. Samples were taken during flaring operations. (See paragraph 4.2.4.)

h. Laboratory Analysis

Milk, water, and air samples were analyzed at SWRHL. A field laboratory was set up in Farmington which was used to analyze the vegetation samples and to read the TLD's.

i. Natural Gas Analysis

The USPHS initiated an independent analysis of the natural gas taken from wells within 5 miles of the GB-E well (ground zero). This program began in September 1967.

j. Human Dose Assessment

The permanent whole body counting facility was available in Las Vegas. In addition the USPHS mobile thyroid counting trailer was on standby in Las Vegas ready for movement to New Mexico at the direction of the Project Manager.

k. Emergency Action Procedures

A complete emergency action procedure for the care and handling of the offsite civilian population was established for use in the event of any significant release of radioactivity. No evacuation of civilian population was required before, during, or after the test.

7. Results

No fresh fission products were found in any milk, water, air or vegetation samples. The TLD's and film badges in the network and the TLD's worn by personnel showed no exposure above background. No radiation was observed by monitors in the offsite area following the test.

8. Postshot Drilling Activities

SWRHL provided five monitors for 19 days in December 1967, and January 1968, during drillback operations. No radiation above background or fresh fission products were detected in the offsite area during or after the drillback period.

4.2.4 Offsite Radiological Safety (Production Testing Phase)

SWRHL also provided offsite radiological surveillance for the GB-2R Phase I and Production Testing Phase Programs of Project Gasbuggy.

A. GB-2R Phase I Program

The surveillance provided during the redrill and flaring operations of the GB-2R Phase I program consisted of:

1. Operating a daily air sampling network of 10 stations ranging from 5 to 50 miles from the site.
2. Establishing TLD stations within 6 miles of the site.
3. Monitoring for radioactivity around the site with survey instruments.
4. Collecting special air samples during the flaring operation with molecular sieve and cryogenic sampling systems.
5. Collecting water, vegetation, and soil samples after completion of testing operations.

The monitoring and dosimetry operations showed no increase in radioactivity above background in the offsite area, and no fission products were detected in daily air samples and surface water samples. Tritium concentrations above background were found in the special air samples collected during flaring operations and in vegetation and soil samples.

The background tritium concentration for air was 6 pCi/ml H_2O , or 41 pCi/m³ air. Six special air samples were collected during both daytime and nighttime "drainage" wind conditions 0.3 miles from the flare. These six samples indicated tritium concentrations ranging from 4 to 675 pCi/ml H_2O , with an average of 130 pCi/ml. This corresponds to a range of 28 to 1,200 pCi/m³ air with an average of 280 pCi/m³ air. The highest atmospheric concentration of tritium detected was less than 2 percent of the offsite Radiation Concentration Guide (RCG) for tritium (67,000 pCi/m³ of air).

Vegetation and soil samples were collected from 11 stations within 2 miles of the flare. Twenty-two vegetation samples were collected in which tritium concentrations ranged from 1.6 to 4.1 pCi/ml H_2O with an average of 2.6 pCi/ml H_2O . Ten soil samples were collected and their tritium concentrations ranged from 1.8 to 15.7 pCi/ml H_2O with an average of 5.8 pCi/ml H_2O . No levels of tritium or other isotopes were detected which would represent a hazard to people or livestock in the offsite area.

B. Production Testing Phase

Surveillance provided during the flaring operations of the production testing phase consisted of monthly trips to the site by three or four SWRHL personnel to collect environmental samples. The surveillance consisted of:

1. Collecting special air samples for tritium in atmospheric moisture.
2. Collecting snow, vegetation, and soil samples on three trips.

3. Collecting cryogenic samples with an aircraft during September and October 1969.

There were 86 atmospheric moisture samples collected during the production flaring, and 31 of these samples collected from within 13 miles of the site showed tritium levels greater than background. The highest level of atmospheric tritium was found in the samples collected within 0.3 miles from the site in November 1968, just after production flaring was begun. One of these samples contained tritium levels of 116 pCi/ml H_2O , or 500 pCi/m³ air. This is less than 1 percent of the off-site RCG. Levels of tritium in the atmosphere continued to decrease after mid-1969, only occasional atmospheric samples contained levels of tritium above background.

Four cryogenic air samples were collected in the flaring plume with and aircraft in September and October 1969. These samples contained tritium from 10 to 17 pCi/m³ air. None of these samples contained radioisotopes of xenon. The September samples contained no radioisotopes of krypton, while the October samples indicated levels of 350 and 450 pCi/m³ air for radioisotopes of krypton.

Twelve snow samples were collected from 0.3 to 1.3 miles from the flare during January and February 1969. All of these samples contained tritium at or near background levels. Several vegetation and soil samples were collected within 2.2 miles of the site in November 1968 which contained tritium above background levels.

Tritium concentrations in vegetation ranged from 4.1 to 36 pCi/ml H_2O and soil ranged from <0.8 to 7.1 pCi/ml H_2O . A second set of vegetation and soil samples was collected in July 1969 from the same area. The levels in these samples were lower, with vegetation ranging from 3.4 to 8.4 pCi/ml H_2O and soil from 0.9 to 2.0 pCi/ml H_2O . The last set of vegetation and soil samples was collected in October 1969, with tritium levels in all samples at background.

No levels of tritium or other isotopes were detected which would present a hazard to people or livestock in the offsite area.

4.3 MEDICAL SERVICES

Medical support for Project Gasbuggy was designed to utilize local facilities as much as possible. Professional supervision was provided by NEMCO Research and Analysis, Inc., under subcontract to EIC. Arrangements were made with the San Juan Hospital in Farmington, New Mexico, for any hospitalization that might be required and with Farmington physicians for their support as required.

The onsite medical aid station was opened on October 16, 1967, with one technician providing day shift coverage, 5 days a week. As requirements and the site population increased, medical personnel increased to four technicians who provided around-the-clock coverage, 7 days a week. A doctor was onsite at shot time to augment medical capability.

On shot day, a second aid station manned by a doctor, a registered nurse, and the EIC Medical Services Manager was established at the Official Observer Area.

On December 11, 1967, medical support was reduced to three technicians who provided medical services as required until January 19, 1968.

A total of 110 patients were seen during the period of medical coverage for this operation. Of this number, 23 were occupational and 87 were nonoccupational

4.4 GROUND MOTION

4.4.1 Predictions

Preliminary predictions of ground motion were prepared by ERC and submitted by letter April 4, 1967. Revised predictions were submitted by letter on May 18, 1967, following a change in the location of the proposed site. These preliminary predictions included a table providing distances to pertinent ground motions of 1 g, 0.1 g, 0.001 g, 10 cm/sec, and 1 cm/sec. Experience in other areas indicated that significant energy focusing, from either channeling or up-dip wedging from the test, was unlikely.

On June 28 and 29, 1967, representatives from ERC, JAB, LRL, USC&GS, and NVOO participated in a reconnaissance of the area to determine the final locations of proposed instrument stations. Other reconnaissance trips to the area were conducted by ERC in conjunction with the USBM to evaluate possible adverse effects from ground motion on slopes, dams, and tunnels.

On September 19, 1967, Dr. Roland F. Beers of ERC presented a paper entitled "Predications of Ground Motion and Subsurface Effects," at the Project Gasbuggy Preshot Technical Symposium in Farmington, New Mexico.

ERC submitted final seismic prediations on November 1, 1967, in Report NVO-1163-124, "Summary Report of Predictions, Gasbuggy Event." These final seismic predictions were made using empirical equations derived by analyses of selected NTS data. The equations have been used successfully to predict ground motions for many tests in a variety of geologic media.

Predications of peak acceleration, displacement, and velocity were made for surrounding communities and selected points of interest. The predicted distances to 0.1 g and 0.001 g acceleration were 10.9 km and 109 km, respectively. No towns existed within the predicted distance to 0.1 g acceleration. Several close-in gas wells were expected to receive ground motion higher than 1.0 g acceleration. Damage to these wells was predicted to range from slight to heavy.

A representative of ERC was at the site at shot time to observe effects of ground motion on slopes, dams, and tunnels. Rock falls occurred as predicted along Route 17. The estimated ground motion where these rock falls occurred (approximately 7.5 km from GZ) was: acceleration 0.87 g, displacement 1.4 cm, and velocity 5.4 cm/sec. No damage to tunnels or dams was observed or reported.

4.4.2 Ground Motion Instrumentation Stations

The Special Projects Party of USC&GS operated 36 seismograph stations in the distance range of from 0.752 km to 89.955 km. An 89 percent station operation success was obtained using three different seismograph systems: the USC&GS strong-motion accelerograph; the National Geophysical Type 21 velocity seismograph (NGC-21); and the seismic correlated amplifier transducer tape recorder, Mark I (SCATT-1), velocity system.

Table 4 gives the station pertinent data, and Figure 22 is a map showing the general locations of the stations. Ten stations (Stations 1-10) had accelerographs, measuring displacement and acceleration, and 26 stations (Stations 11-37) had velocity seismographs. Station 18 was deleted. All stations measured ground motion. Three of the stations (Stations 15, 16, and 32) not only measured the ground level motion but also the motion at roof level of the structures occupied.

TABLE 4

USC & GS SEISMIC STATION DATA - PROJECT GASBUGGY

2 DECEMBER, 1967

GB-E, SZ: N 2,067,376.14

E 218,956.33

ORIGIN TIME: 1930:00.136 GMT

GB-E, S.Z: N 36°40'40.4141''

W 107°12'30.2540''

STATION	LOCATION	DISTANCE to GB-E (Surface & Slant Dist.)	COORDINATES				BEARING FROM STATION	TYPE OF INSTRU.	NUMBER OF CHANNELS	ORIENTA- TION OF SEIS.	PARA- METERS	TYPE OF RECORD	STATION REMARKS (medium, nearest structure, etc.)
			GEODETIC (Scaled) (degrees)		N. M. ST. (Surveyed) (feet)								
		(Km)	Latitude	Longitude	North	East							
1.	Gaswell 4 SJ 29-4	1.350 1.883			2,070,222	215,567	S49°58'E	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	AL; : EPNG Well #4
2.	Gaswell 16 SJ 29-4	1.180 1.767			2,070,308	221,489	S40°49'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; EPNG Well #16
3.	Gaswell 6 SJ 28-4	0.752 1.514			2,065,604	217,238	N44°8'E	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; EPNG Well #6
4.	Gaswell 7 SJ 28-4	1.191 1.774			2,065,471	222,370	N60°51'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; EPNG Well #7
5.	Gaswell 11-31, S. of Munoz Canyon	9.890 9.983	36°37.00'	107°17.35'			N46°48'E	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; EPNG Well #11-31
6.	East of GB-E	4.260 4.272	36°41.28'	107°09.76'			S74°22'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; Ranch East of GB-E
7.	Southeast of Va- queros Ranger Sta.	7.709 7.819	36°44.05'	107°09.55'			S34°56'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; Northeast of GB-E
8.	Southeast of GB-E	11.521 11.604	36°35.09'	107°09.07'			N26°26'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; Compañero Creek
9.	La Jara Ranch(R2W- T29N) Rt. 537	20.042 20.086	36°44.55'	106°59.95'			S68°58'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	AL; Near La Jara Lake
10.	Jicarilla Motor Pool Dulce, New Mexico	34.020 34.089			2,160,293	281,056	S33°45'W	Accell.	6	Z, R, T	Accel & Displ.	Photo. Paper	HR; Highway Dept. Maintenance Shop
11.	Northeast of GB-E	19.987	36°49.90'	107°05.55'			S31°45'W	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; Northeast of GB-E
12.	S. of Boulder Lake	28.129	36°42.03'	106°53.71'			S84°50'W	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; East of GB-E
13.	Lowry Camp, NW of Doswell Camp (R6W-T27N)	25.429	36°34.25'	107°27.60'			N62°12'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; Pump House
14.	Gobernador, N.M. (R5W-T29N)	16.480			2,077,007	165,692	S79°45'E	Scatt-1	6	Z, R, T	Velocity	Mag. Tapes (2)	HR & AL; EPNG Residence #30 (2 Scatt-1 units) (all seis. outside)
15.	Jicarilla Agency Dulce, New Mexico	35.590			2,164,082	284,480	S34°07'W	Scatt-1	6	Axis of Structure	Velocity	Mag. Tape	DI-A, (AL) point surveyed outside of structure (seis., attic & gr.)
16.	Dulce School	35.390			2,163,187	284,495	S34°22'W	Scatt-1	6	Axis of Structure	Velocity	Mag. Tape	DB-1, (AL) point surveyed, outside of structure (seis., roof & gr.)

TABLE 4 (Cont'd.)
USC & GS SEISMIC STATION DATA - PROJECT GASBUGGY
2 DECEMBER, 1967

STATION	LOCATION	DISTANCE to GB-E (Surface & Slant Dist.)	COORDINATES				BEARING FROM STATION	TYPE OF INSTRU.	NUMBER OF CHANNELS	ORIENTA- TION OF SEIS.	PARA- METERS	TYPE OF RECORD	STATION REMARKS (medium, nearest structure, etc.)
			GEODETIC (Scaled) (degrees)		N. M. ST. (Surveyed) (feet)								
		(Km)	Latitude	Longitude	North	East							
17. 18.	Lumberton, N.M. Deleted – instru- ment moved to priority Sta. #35	40.561	36°54.66'	106°51.53'			S50°20'W	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; St. Francis Church
19. 20.	Chama, N.M. Tierra Amarilla, N.M.	61.760 54.271	36°54.45' 36°41.88'	106°34.70' 106°36.11'			S65°37'W S87°38'W	Scatt-1 Scatt-1	3 3	Z, R, T Z, R, T	Velocity Velocity	Mag. Tape Mag. Tape	AL; Foster Hotel AL; Arriba County Courthouse
21.	Cuba, N.M. (R1W-T21N)	76.270	36°01.25'	106°57.50'			N17°07'W	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; Three Story Elem. Catholic School
22.	Lindrith, N.M. (R2W-T24N)	43.998	36°18.25'	107°02.63'			N19°36'W	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; Elem. School Gymnasium
23.	Blanco on Rt. 17	55.182	36°43.45'	107°49.40'			S84°38'E	NGC 21	6	Z, R, T	Velocity	Mag. Tape & Photo paper	HR & AL; St. Rose Church (all seis. outside)
24.	Aztec Ruins Nat'l. Monument	72.807	36°50.18'	107°59.98'			S76°00'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; Southwest area (Patio)
25.	Lybrook Ind. Mis- sion (R7W-T23N)	59.009	36°14.13'	107°34.45'			N33°41'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; LDS Church
26.	New Navajo Hsng. Area (R9W-T29N)	65.447	36°24.08'	107°51.25'			N62°03'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; Multi-purpose bldg., (Gym, Aud.)
27.	Bayfield, Colo.	70.034	37°13.50'	107°36.00'			S29°57'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; Bayfield Ranger Sta.
28.	Bloomfield, N.M. (R11W-T29N) on Rt. 17 & 44	68.629	36°42.95'	107°58.50'			S86°28'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; High School Maintenance Shop
29.	Navajo City on Rt. 17 (R7W-T30N)	35.932	36°45.12'	107°36.00'			S76°45'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; Boat Storage (metal) Bldg.
30.	Aztec, N.M. on Rt. 50 (R11W-T30N)	71.772	36°49.38'	107°59.50'			S77°01'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; Police Station
31.	Farmington, N.M.	88.356	36°44.45'	108°11.58'			S85°27'E	NGC 21	6	Z, R, T	Velocity	Mag. Tape & Photo paper	AL & HR; Petroleum Plaza Bldg., 3535 E. 30th (all seis. outside)
32.	Farmington, N.M.	89.674	36°43.73'	108°12.60'			S84°34'E	Scatt-1	6	Axis of Structure	Velocity	Mag. Tapes (2)	AL; Avery Hotel (302 W. Main) (2 units) (seis., roof & gr.)
33.	Durango, Colo.	89.955	37°17.00'	107°52.80'			S41°39'E	Scatt-1	6	Z, R, T	Velocity	Mag. Tape	HR; 2705 W. 2nd Ave. AL (all seis. outside)

TABLE 4 (Cont'd.)
 USC & GS SEISMIC STATION DATA - PROJECT GASBUGGY
 2 DECEMBER, 1967

STATION	LOCATION	DISTANCE to GB-E (Surface & Slant Dist.)	COORDINATES				BEARING FROM STATION	TYPE OF INSTRU.	NUMBER OF CHANNELS	ORIENTA- TION OF SEIS.	PARA- METERS	TYPE OF RECORD	STATION REMARKS (medium, nearest structure, etc.)
			GEODETIC (Scaled) (degrees)		N. M. ST. (Surveyed) (feet)								
		(Km)	Latitude	Longitude	North	East							
34.	Pagosa Springs, Colo.	68.199	37°16.13'	106°59.95'			S15°52'W	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; Archuleta County Courthouse
35.	Tunnel #2 (Manzan- ares Mesa) N.M.	42.228	36°42.26'	107°40.80'			S86°26'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	HR; Navajo (3 Mi.) Indian irrigation project
36.	EPNG Blanco Pump Station	67.491	36°44.03'	107°57.63'			S84°44'E	Scatt-1	3	Z, R, T	Velocity	Mag. Tape	AL; Subsiding Area of E PNG Blanco Pump Sta- tion, NE of Bloomfield
37.	Observer's Point (5 miles N. of GZ)	9.10	36°45.63'	107°12.13'			S 2°30'W	Scatt-1	3	Z, R, T	Velocity	CEC Data flash 58 paper	HR, housed in a Ford Econoline van
								EV 301	1	R	Displ.	Paper	All seis. outside near van

NOTE: Bottom figures where given in Distance column are slant distance.

Abbreviations:

Accel = Acceleration
 Accell. = Accelerograph
 AL = Alluvium
 Displ. = Displacement
 E. = East
 gr. = ground

GB-E = Gasbuggy surface Zero
 EPNG = El Paso Natural Gas
 HR = hard rock
 Mag. = magnetic
 N. = North
 Photo. = photographic

R = radial component
 Seis. = seismometer
 S. = South
 T = transverse component
 W. = West
 Z = vertical component

Figure 22 General Locations of Seismograph Stations

4.5 CONTAINMENT AND STEMMING

ERC's predictions of containment, adequacy of the stemming plan, and close-in phenomena were presented in Report NVO-1163-124 (November 1, 1967). Methods used to calculate these predictions have been successfully used for numerous NTS tests.

The device, executed in a shale media at a scaled depth of burial of 1,350 ft/kt $\frac{1}{3}$, was overlain by impermeable shales and sandstones. In the past, tests of comparable yield and significantly less scaled depth of burial have been satisfactorily contained. However, complications with installation and stemming of the device developed. Water entered the emplacement hole casing through the casing cementing tool at a depth of approximately 3,600 feet. The device canister had been designed and hydrostatically tested. It was concluded that containment and related phenomena would not be significantly affected by wet hole emplacement of the device. Therefore, it was predicted that the Gasbuggy test with a maximum yield of 31 kt, would be contained.

The predictions ERC made for close-in phenomena are listed in Table 5.

TABLE 5
PREDICTIONS OF CLOSE-IN PHENOMENA - GASBUGGY TEST

YIELD (kt)	CAVITY RADIUS (ft)	CHIMNEY HEIGHT (ft)	RADIUS OF CRACKING (ft)	RADIUS OF RADIOACTIVITY ABOVE W.P. (ft)	RADIUS OF RADIOACTIVITY BELOW W.P. (ft)
26	72-96	315-491	415-460	160-204	98-125
31	76-102	332-521	440-490	166-212	102-131

Hazards from radioactive containment were not anticipated because the predicted radius of radioactivity was not expected to intersect any known aquifers. Preliminary reports of postshot investigations indicate observed cavity radius and chimney height are within ERC's predicted range. As predicted, the Gasbuggy shot was contained.

4.6 HYDROLOGICAL AND GEOLOGICAL INVESTIGATIONS

The U. S. Geological Survey, Water Resources Division, investigated resources in the vicinity of the Gasbuggy site. Geological studies made previously by the Geological Survey and other organizations in the eastern part of the San Juan Basin were considered adequate and were used for evaluating the site. Hydrological investigations were made to evaluate the general ground water hydrology in the vicinity of the site and to evaluate the potential for ground water inflow to the rubble chimney. Also, wells and springs were investigated to check for effects from the detonation.

4.6.1 Geologic Setting

The Project Gasbuggy site was in the eastern part of the San Juan Basin, a large structural feature principally in northwestern New Mexico. The basin is about 180 miles long and 135 miles wide. Surface drainage from the basin is mainly to the west and northwest in the San Juan River and its tributaries.

Nonmarine sedimentary rocks, consisting of alternating sandstone and shale of Early Tertiary age, cover the central part of the basin. Marine and nonmarine sandstone and shale of Late Cretaceous age underlie and encircle the outcrops of Tertiary rocks. Older Mesozoic and Paleozoic sedimentary rocks underlie and encircle the outcrops of the Cretaceous rocks. Small intrusive plugs and dikes are scattered throughout the eastern part of the basin. All the rocks from the emplacement depth upward crop out along the San Juan River or its tributaries between the Gasbuggy site and a point a few miles west of Farmington, New Mexico.

The stratigraphic units that were of particular interest to Project Gasbuggy, in ascending order, are the Lewis shale, the Pictured Cliffs sandstone, the Fruitland Formation, the Kirtland shale and the Ojo Alamo sandstone. These are the units that would have definitely or possibly affected the technical feasibility and hydrologic safety.

4.6.2 Hydraulic Testing

The Ojo Alamo sandstone was the only stratigraphic unit within the zone of possible shot-produced fracturing that was expected to yield significant quantities of water. Hydraulic tests of this formation were made in both the GB-1 and the GB-2 test holes. Tests of underlying formations confirmed the lack of free water in them.

Hole GB-1 was hydraulically tested in two stages. The upper zone (3,475 to 3,575 feet) was tested two times by swabbing at a rate of 5.3 gallons per minute (gpm). At the end of the swabbing period, the water level was about 2,700 feet during the first test and 3,000 feet during the second test. The specific capacity for the upper zone was 0.003 gpm per foot of drawdown, and the transmissibility was 0.412 gallons per day (gpd) per foot, or 0.0226 darcy foot. The lower zone (3,575 to 3,654 feet) was tested two times by swabbing at a rate of 14 and 13 gpm, respectively. At the end of the swabbing periods, the water level was 2,300 and 2,350 feet, respectively. The specific capacity of the lower zone was 0.016 gpm per foot of drawdown. The transmissibility was 2.64 gpd per foot, or 0.144 darcy foot. The static water level was estimated to be about 1,000 feet, based on projection of the water-level recovery curves. The field specific conductance of the water was 9,000 micromhos at the end of the swabbing periods.

In hole GB-2, the entire interval of Ojo Alamo sandstone was tested as a unit. The specific capacity of the interval was 0.026 gpm per foot of drawdown, and the transmissibility was 2.85 gpd per foot, or 0.156 darcy foot. The static water level was estimated to be about 1,000 feet. The field specific conductance of the water withdrawn was 9,000 micromhos.

Samples of water were collected from each of the swabbing tests and chemically analyzed.

4.6.3 Well and Spring Investigation

All known wells and springs within a 5-mile radius of ground zero and selected wells and springs between the 5- and 10-mile radius were inspected preshot. The 13 wells visited ranged in depth from 54 to 229 feet, and most were completed in valley alluvium. The wells are used primarily for stock-water supplies, and they generally yield 1 to 3 gpm. The field specific conductance of the water ranged from 700 to 2,600 micromhos.

Twenty-three springs, which discharge from sandstones of Tertiary age, were examined. Some were seeps with little or no visible flow when visited. Others yielded from less than 1 gpm to a little more than 8 gpm. Field specific conductance of the water ranged from 370 to 2,300 micromhos.

4.6.4 Response of Wells and Springs to Gasbuggy Test

Measurements were made in five wells and five springs 2 days before the test and some were measured again in a few hours after the test. Two of the springs and one well were equipped with recording instruments during the test. Long-term changes in water levels in wells were insignificant. The recorder in a well 3.1 miles northeast of ground zero showed a water-level rise of 0.75 foot and a series of oscillations of 0.2-foot magnitude for 3 seconds. About 6 seconds after the first pulse, the water returned to the preshot level.

Changes in spring discharge were too small for measurement. The recorder on one spring, 5.1 miles northwest of ground zero showed a very small response. The increased flow of a fraction of a gallon per minute was evident for 4 days.

No complaints of well or spring damage have been received.

4.6.5 Ground Water Velocity

Ground water velocity in the Ojo Alamo sandstone was estimated on the basis of permeability determined from hydraulic tests in holes GB-1 and GB-2, porosity determined from laboratory analyses of core, and the average water-level gradient from the Gasbuggy site to outcrops of the Ojo Alamo sandstone near Farmington, New Mexico. The computed velocity was 0.0001 foot per day or 0.04 foot per year.

4.7 HYDROLOGIC CONTAMINATION

In support of the Safety Program for Project Gasbuggy, the Palo Alto Laboratories of Isotopes, Inc. performed field, laboratory, and office studies in order to:

- (1) Predict the temporal-spatial distribution of all Project Gasbuggy explosion-related radioactivity in water; and
- (2) Construct a worse than credible model of radiocontaminants in water distribution relative to public water safety.

Mathematical models were constructed incorporating available hydrologic, geologic and laboratory data on radionuclide retardation. The model studies indicated that even under worse than credible conditions, explosion-related radioactivity in water would be confined to the immediate explosion environment.

Twenty-two preshot water samples for radioassay were collected from points at varying distances from the Gasbuggy SGZ. Three "close-in" postshot samples were collected for radioassay comparison and indicated no perceptible change in the concentration of natural radioactivity in the water.

4.8 STRUCTURAL RESPONSE

The participation by John A. Blume & Associates (JAB) in the safety program for Project Gasbuggy included preshot reconnaissance of the general area within a radius of 100 km from ground zero, condition surveys of selected structures, overflights of the region of predicted strong ground motion, observation and monitoring at 16 locations during the shot, recommendations for USC&GS accelerometer and velocity instrument locations, and postshot condition surveys.

4.8.1 Field Investigations

On January 22, 1966, a small earthquake caused minor damage in Dulce and Lumberton, New Mexico. Since Project Gasbuggy was in the planning stage at that time, it was believed desirable to gather all available data on the behavior of structures in the region subjected to seismic motion. An investigation was made and report NVO-99-10, "Report on Structural Damage in Lumberton and Dulce, New Mexico, Caused by the Earthquake of January 22, 1966," was submitted by JAB in March 1966. This report was used as a basis for later condition surveys in the area.

During the summer and fall of 1967 after the project had been authorized and was moving toward execution, a number of additional field investigations were conducted as follows: During April 1967, a preliminary reconnaissance was made of the major population centers surrounding ground zero. During May 1967, the immediate vicinity of ground zero and close-in regions were resurveyed to conform with NVOO's request for an inventory of all structures in the region of strong ground motion. In the company of personnel from ERC, USC&GS, AEC/NVOO, LRL, and

USGS, all instrument locations were visited during July 1967 for purposes of establishing complete agreement between agencies as to siting and orientation of instruments. Condition surveys and preparation of detailed reports pertaining to the structural and architectural condition of 31 representative structures began in July 1967 and continued through August 1967. The structures selected were in locations within the 100 km radius of ground zero and were deemed to be typical structures which could have been particularly vulnerable to ground motion. Aerial reconnaissance surveys to affirm the complete adequacy and coverage necessary for the safety program were conducted utilizing USPHS aircraft during September, October, and November and consisted of fly overs and photography of the project area.

For test participation, 16 observers were assigned to various locations surrounding the site. These observers conducted preshot surveys of all condition-surveyed structures prior to the test and immediately after the test and in addition provided perceptibility observations. Postshot condition surveys were conducted immediately after the test by the same teams that had conducted the preshot condition survey.

4.8.2 Damage Predictions

Damage predictions were made using two separate procedures. The first was an engineering estimate based on experience with damage from earthquakes and underground nuclear tests, a first hand knowledge of the structures involved, and utilizing ERC-predicted ground motion peak amplitudes and response spectra. This method yielded an estimate of about \$20,000 total damage expected.

A second prediction was made using a detailed computerized procedure entitled the Spectral Matrix Method (SMM) for damage prediction. This technique uses a predicted ground motion response spectrum as input and takes into account the variable dynamic response of the various kinds of buildings involved and their condition and vulnerability. Ground condition influences and construction quality are considered as well as probabilistic effects. Using this method, a prediction of about \$35,000 in damage cost was forecast.

4.8.3 Test Observations

During the test, strongly perceptible motion was noted by observers in Dulce and at closer locations with occasional areas of strong perception in isolated locations as far away as Aztec, about 70 km west of the shot point. Detailed investigations by the postshot condition survey team showed that no significant changes had occurred in any of the surveyed structures, and consequently no damage was caused to them by the Gasbuggy ground motion.

4.8.4 Complaint Investigations

On December 10, a rancher, approximately 18 miles southeast of ground zero, complained of cracking in his ranch house walls. The complaint was made within an hour after the test and was investigated by two engineers, an architect, and an engineering geologist from JAB. Findings were that the cracks were all old; some reworking was credible but no new damage was believed to have been caused. An adjuster from the General Adjustment Bureau, Inc. (GAB) following his investigation on December 11, denied the rancher's complaint of damage as not having been caused by ground motion arising from the detonation of Project Gasbuggy. Claim Form AEC-369 was left with the rancher with instructions to mail the completed form to AEC/NVOO, Las Vegas, Nevada. Although the rancher indicated he would pursue his complaint, the claim form was never filed.

A second complaint from a rancher approximately 25 miles southwest of ground zero was investigated. The rancher complained of cracking in his ranch house walls. The complaint was investigated by an engineer and it was found that the cracks were primarily in the stone walls of the ranch house and were caused by settlement. While it was considered possible that some aggravation of existing cracks had occurred due to ground motion, it was felt that any damage caused by such aggravation would be negligible. The rancher filed claim form AEC-369 for a substantial amount under date of July 22, 1968. Subsequent investigations by GAB adjusters and JAB engineers resulted in a lesser offer to the rancher in settlement of his claim. This offer of settlement had not been accepted by the rancher as of May 31, 1971.

A third complaint was received on June 25, 1968, from a third rancher who complained of cracks in exterior walls, foundation walls, and concrete steps. This ranch property is located about 16 miles northwest of the Gasbuggy SGZ. Subsequent investigations by the GAB adjusters and JAB engineers resulted in a determination that the damages complained of were not caused by ground motion from detonation of Project Gasbuggy. The complainant was so advised on September 13, 1968, by an adjuster of the GAB. It was indicated by the complainant that the complaint would be pursued, and, accordingly claim form AEC-369 was presented to them for completion and filing. The claim form has never been filed.

4.9 MINES AND GAS WELLS

The U. S. Bureau of Mines (USBM) was assigned responsibility for the structural condition survey of mines, tunnels, gas wells, and related facilities at Project Gasbuggy.

A preshot inventory of all underground workings within a 50-mile radius of ground zero was made. Two tunnels of the U. S. Bureau of Reclamation (USBR), Navajo Irrigation Project; three tunnels of the San Juan-Chama Water Diversion Project (USBR); and a small producing coal mine near Monero, New Mexico, were examined and photographed in detail both preshot and postshot.

An inventory was made of gas wells and facilities to a radius of 10 miles from ground zero. Within 5 miles of ground zero, all wells and facilities were examined and photographed in detail, both preshot and postshot. Six of the seven close-in Pictured Cliffs gas wells, at distances between 2,650 and 6,750 feet, were monitored for pressure changes. Three wells had subsurface recording bottomhole pressure gages installed near the bottom of the tubing, and three wells had gages recording casing and tubing pressures at the surface.

Neither the mine nor any of the tunnels examined exhibited postshot damage. No surface damage was sustained by any of the gas wells nor by the test wells near ground zero. No subsurface damage was evident beyond the test well cluster. At the seven Pictured Cliffs wells, some of the separator-dehydrators and meter houses had moved between 1 to 3 inches from their original positions and some cracking of the ground around the wellheads was observed. However, the function of these surface facilities was not impaired. The surface pressure recorders at the wellheads continued to operate after detonation, as did the bottomhole pressure instruments. No change in pressure was recorded for any of the wells nor were radioactivity or other problems encountered in retrieving downhole pressure instruments.

CHAPTER V

ENGINEERING, CONSTRUCTION, AND SUPPORT

5.1 ENGINEERING AND CONSTRUCTION

5.1.1 Engineering and Procurement Services

Fenix & Scission, Inc., (F&S) provided Titles I, II, and III engineering services for all drilling and other subsurface construction work for both the preshot and postshot activity.

Specifically, F&S prepared plans and specifications for six contracts which were awarded for drilling, casing, instrumentation, device emplacement stemming and allied cementing, logging and well surveying services. Additionally, F&S prepared the following: specifications for purchase of GB-E and GB-D well casing, device emplacement casing and other long-lead and specialized procurement items; operational programs for drilling, casing, welding, cementing, reentry drilling and stemming consistent with the approved criteria; official cost estimates and special studies and reports; and provided 24-hour inspection service for the field activities described above.

Reynolds Electrical & Engineering Company, Inc., (REECO) provided procurement services for the surface conductor pipe, well casings, and other specialized and long-lead wellhead and specialized procurement items associated with subsurface work. Eight purchase orders were issued for procurement of these items.

Holmes & Narver, Inc., (H&N) provided Titles I, II, and III engineering services for all surface facilities, construction, and support except those facilities constructed by EPNG as stated in Section 5.1.2 A and B.

Additionally, H&N prepared plans and specifications and procured all special scientific wire and cable; the closed circuit TV system and subcontracted for communication installation and maintenance services, field surveying, drayage, and other services and materials.

Approximately 70 H&N purchase orders were issued for services and materials, and three service subcontracts for surveying, communications, and transcold maintenance. A total of 26 drawings were prepared for the AEC prime surface construction contract and were revised to an as-built status.

Limited Architect/Engineering (A-E) management functions were provided by the H&N Las Vegas Office consisting of the procurement activities, engineering support, and disbursement of funds for all AEC prime contracts, REECO purchase orders, and H&N subcontracts and purchase orders in support of construction and the Project Office.

5.1.2 Construction (Figures 23 through 34)

The major construction activities in preparation for the Gasbuggy test and the postshot reentry activities included, but were not limited to, the following:

Figure 23 Drilling Emplacement Hole (GB-E)

Figure 24 Workover Rig Stemming EPNG Well 10-36

Figure 25 Device Emplacement Rig and Crane

Figure 26 High Pressure Recirculation System

Figure 27 Decontamination Facility

Figure 28 Reentry GB-E Filter Bank and Exhaust Stack

Figure 29 GB-1 Wellhead

Figure 30 GB-2 Wellhead

Figure 31 EPNG 10-36 Wellhead

Figure 32 Cable Reel Racks with Cables for GB-E and GB-1

Figure 33 Control Point (Security Area)

Figure 34 Assembly Building (Red Shack) at Left

A. Preshot Construction

1. Drilling - El Paso Natural Gas Company
 - Drilling and testing GB-1.
 - Drilling and testing GB-2.
2. Drilling, Instrumentation, Device Emplacement, and Stemming - AEC
 - Drilling, device emplacement, and stemming GB-E.
 - Drilling, instrumenting, and stemming GB-D (seismic detection hole).
 - Instrumenting and stemming GB-1.
 - Stemming GB-2.
 - Stemming 10-36.

B. Surface Construction - El Paso Natural Gas Company

- Constructing an all-weather access road between Route 17 and ground zero (GZ).
- Grading, stabilizing, and leveling areas for facilities at GZ, Recording Trailer Park (RTP), Control Point (CP), and Official Observer Area.
- Furnishing and operating generators at GZ and CP.
- Installing fuel and water storage tanks, installing primary electric system, installing water distribution system and sewerage system at GZ and CP.
- Installing and connecting Government-furnished trailers.
- Constructing and maintaining minimal roads and trails.
- Performing rollup and cleanup onsite.

C. Surface Construction - AEC

- Constructing device assembly building complex (including adjoining guard shack).
- Constructing CP guard shack.
- Constructing balloon inflation shelter.
- Constructing cable reel racks.
- Constructing TV camera towers.
- Constructing helicopter landing pads.

- Installing geophone stations.
- Installing security and perimeter fences.
- Installing scientific wire cable and terminal boards.

D. Postshot Construction and Research Development

1. Drilling - AEC

- Reentry drilling GB-E.
- Reentry drilling GB-2.

2. Surface - AEC

- Installing high-pressure natural-recirculation system, rad-safety decontamination facility, rollup of Government assets, and secure facility.

5.1.3 Construction Contracts, AEC Prime

AEC Prime construction contracts included:

(1) Surface Construction Contract

Western States Construction Company - Contract AT(26-1)-330

(2) Drilling Contracts

Signal Drilling Company - Contract AT(26-1)-318

- Drilling and casing GB-E.

Brinkerhoff Drilling Company - Contract AT(26-1)-338

- Drilling and casing GB-D.
- Emplacing device and stemming GB-E. Reentry drilling GB-ER.

Aztec Well Service Company - Contract AT(26-1)-347

- Emplacing instruments and stemming GB-D.
- Emplacing instruments and stemming GB-1.
- Stemming GB-2 and 10-36.

Loffland Brothers Company - Contract AT(26-1)-392

- Postshot drilling and reentry, GB-2 (GB-2R).

(3) Well Service Contracts

Halliburton Company - Contract AT(26-1)-336

- Cementing casing GB-D and GB-E.
- Stemming GB-D, EG-E, GB-1, GB-2, and 10-36.

Sperry-Sun Well Service Company - Contract AT(26-1)-332

- Directional Surveying of GB-E, GB-D, and 10-36.

Schlumberger Well Services - Contract AT(26-1)-334

- Logging all holes.

Birdwell (call out services)

- Logging all wells.

Construction work performed under the above listed drilling contracts consisted of the following:

A. Emplacement Hold GB-E

GB-E was drilled in two phases to a total depth of 4,350 feet. The first pass was with a 13-3/4-inch drill bit and the last pass to open the hole to the 28-inch design diameter. Drilling mud was used as a circulation medium for all drilling.

The emplacement hole was cased with 20-inch OD, J-55 casing to 4,324 feet. The bottom 1,934 feet of the casing weighed 160 pounds per foot with 0.735-inch wall thickness and the remainder of the casing weighed 133 pounds per foot with 0.635-inch wall thickness.

The bottom 1,434 feet of casing was reinforced with 1-1/2 x 4-inch stiffener rings; 245 feet with stiffener rings on 5-foot centers and 1,187 feet with stiffener rings on 6-foot centers.

The 1,434 feet of the casing which was reinforced with stiffener rings was a combination of threaded and coupled and butt welded. The remaining 2,892 feet were threaded and coupled.

Casing cementing was accomplished in three stages through a float shoe at 4,324 feet, a float collar at 4,290 feet, and DV cementing tools at 3,500 feet and 1,800 feet. The device was emplaced on a 7-inch N-80 casing, weighing 26 pounds per foot with slotted casing joints positioned to provide intervals consistent with the cementing and sand stemming placement.

The emplacement hole was stemmed with cement from the top of the canister assembly at 4,228 to 3,032 feet in three stages, with sand to 2,528 feet and cement to 1,474 feet in two stages, with sand to 50 feet and with a polymer material to the surface.

B. Seismic Detection Hole GB-D

GB-D was drilled to a depth of 4,725 feet; 26-inch diameter hole and cased with 20-inch conductor pipe from surface to 29 feet, 17 1/2-inch diameter hole and cased with 13 3/8-inch casing to 482 feet and open hole 12 1/4-inch diameter to total depth. Mud was used as a circulating medium during drilling.

The four instrument packages were emplaced on wire rope, cemented in place with seven stages of medium matching grout and with mud from 3,106 feet to the surface.

C. Test Well GB-1

Instrument packages were run on steel and fiber-glass tubing, cemented to 2,612 feet and stemmed with mud to the surface.

D. Test Well GB-2

Stemmed with cement from total depth of 4,248 to 2,988 and with mud to the surface.

E. Existing Well 10-36

Sand stemmed from total depth of 4,210 feet through the perforated section of 5 1/2-inch OD casing to a bridge plug at 3,880 feet, cement stemmed to 2,941 feet and mud stemmed to the surface.

F. Reentry Drilling GB-ER

Reentry was made through 7-inch OD device emplacement casing using both gas and mud as circulating media to the defined cavity entry at 3,907 feet where the 20-inch OD casing was parted.

G. Reentry Drilling GB-2 (GB-2R)

At GB-2R, preshot stemming was circulated out of 7-inch OD casing with water to the top of the cement plug at 2,988 feet. Cement was drilled out from 2,988 feet to 3,692 feet. The shot induced casing collapse or offset (evidenced at 3,692 feet). Water was unloaded from casing and drilled cement using 4 3/4-inch bit with gas to 3,812 feet.

A bridge plug was set at 3,700 feet and a whipstock was set at 2.5 degrees from 3,678 feet to 3,698 feet. A window was milled in the 7-inch casing with 6 1/4-inch spud mill. A 6 1/4-inch hole was drilled ahead using gas to 4,600 feet. Induction, formation density, caliper, gamma ray, temperature logs, and a directional survey were run. A Laval camera was also run. "Y" type tubing head was installed and 2 3/8-inch OD tubing was run to 4,224 feet. The tubing was perforated between 4,198 and 4,201 feet.

5.2 CONSTRUCTION AND SUPPORT

Project facilities identified in user criteria and logistics support criteria, which were not provided by EPNG as stated in 5.1.2 A and B, were constructed by the surface construction contractor under unit price items, including installation of all scientific wire and cable.

Craftsmen were furnished at a unit price per hour to accomplish those construction activities which were not defined in criteria and/or logistics support requirements or which were identified but could not be defined adequately to bid on a unit price basis. Work in these categories was performed on the basis of specific field authorization.

5.2.1 F&S Support

Surveillance of underground drilling and oil well services was furnished on a 24-hour basis. The field staff consisting of a site representative, a field engineer, and three drilling specialists was reinforced by the project engineer and Las Vegas Office staff.

5.2.2 H&N Support

H&N project activities were accomplished in the field by a senior site representative who had responsibility for limited H&N Architect-Engineering management activities which consisted of field engineering and inspection, administration of the Project Office, supervision of the AEC prime support contractor and the H&N subcontractor, and logistical services.

Logistical services included the following:

- A. Establishment and maintenance of communications, telephone, teletype and radio services.
- B. Operation and maintenance of the Project Office.
- C. Control, maintenance and dispatch of motor vehicles.
- D. Supply functions such as procurement, expediting, and freight handling.
- E. Administrative services such as subcontract administration and support for participating agencies.
- F. Demobilization.

5.3 COMMUNICATIONS

The original planning for communications provided for VHF radio, telephone, closed circuit TV, and weather service. The design goal was to furnish a low cost, temporary system of reliable communications. This approach implied a minimum coverage system due to the rugged terrain and unpopulated nature of the project site location.

In order to obtain the low cost feature, equipment furnished from Government assets was used wherever possible and local labor was utilized for installation and maintenance. To supervise and coordinate communications activities, one H&N engineer was provided.

The VHF mobile radio planning consisted of three high band networks and one low band network as follows:

<u>Net</u>	<u>User</u>	<u>Mobile</u>	<u>Fixed</u>	<u>Portable</u>	<u>Repeater</u>	<u>Description</u>
1	AEC Operations, Security and Construction	30	12	12	2	High Band Repeated
2	Technical Agencies	38	17	18	2	High Band Repeated
3	Public Information Office		2			Point-to-Point
4	Offsite Safety	30	6		3	Low Band Repeated
Totals		98	37	30	7	

The onsite telephones system consisted of two services with nationwide access and one local service. The detail on these systems are as follows:

INSTRUMENTS

<u>Item</u>	<u>Lines</u>	<u>CP</u>	<u>RTP</u>	<u>GZ</u>	<u>Supplier</u>
Nationwide Dial Service	5	13			Mountain States Telephone & Telegraph Company
Nationwide Radio	2			2	Contact, Inc.
Onsite PABX	26	24	4	5	Government-Furnished Equipment
Totals	33	37	4	7	

Other services provided for communications were a closed circuit TV system and three weather services.

The CCTV system consisted of two GZ cameras and six monitors. A tone control system was utilized to remote control the cameras from the CP. The RF carrier was transmitted by cable from GZ to the CP.

The weather services were furnished via the telephone microwave facility. Services provided were National Facsimile and Weather Services "A" and "C".

Project Gasbuggy communications were intended as a low cost, yet reliable, system. The low cost was imposed by budget restrictions and necessarily implied minimum coverage. Basically, the methods of implementing this low cost system were to utilize existing assets and local labor support wherever possible. To that end, Nets 1, 2, and 3 radio equipment and an automatic PBX for local telephone service were borrowed from the Hattiesburg, Mississippi, site.

The planned radio systems for Gasbuggy consisted of three high-band and one low-band VHF networks. Nets 1 and 2 were to provide service to the AEC and LRL. These nets were to cover CP, RTP, GZ, and approximately 60 percent of the road between Farmington and the job site. Net 3 was to provide point-to-point service for the PIO; and Net 4, the low-band net for USPHS, rad-safe, ESSA-ARL, and USC&GS, was to provide 70 percent coverage of a 100 mile radius of ground zero.

Actual coverage obtained was influenced by two developments that occurred after the preliminary proposals for radio service were accepted: (a) the need for portable radio coverage at the site by LRL and Security and the need for more comprehensive coverage for AEC Operations which necessitated installation of Nets 1 and 2 onsite repeaters at the CP; (b) the "add on" program of seismic station actuation signals via Net 4 cut down on road coverage obtained from the initial Net 1 repeater station on Caviness Mountain in Southern Colorado. Final results indicated that approximately 50 percent coverage for Net 2 and 40 percent coverage for Net 1 was obtained. The above figures are for mobile transmitting from along the road. A 60 percent figure was obtained easily for the repeater talking back to the road. Expressed differently, if a mobile on Nets 1 and 2 could hit the repeater, the coverage would easily be 60 percent of the road; but the mobile could hit the repeater only 50 percent of the time for Net 2 and 40 percent of the time for Net 1. The initial setup of Nets 1 and 2, (prior to the seismic tone modification to Net 4) did give the designed 60 percent coverage.

Originally, for Nets 1 and 2, the transmit antennas were low on the tower at Caviness Mountain and the receive antennas were on top. This configuration gave the desired coverage. However, upon installing the tone system link receiver, the Net 1 repeater transmit frequency of 167.825 MHz desensitized the tone receiver which was receiving on 168.450 MHz. Thus, since FPFF had been finalized and a new frequency for the link could not be installed, it was necessary to reconfigure the transmit and receive antenna design at the repeater site by interchanging the Net 1 and Net 2 receive antennas. This change basically cut down coverage to the final levels specified above. The problem would have been easily solved had more tower space been available.

The Net 4 system was also affected by the tone system introduction. In order to complete the Net 4 system modification for tones, it was necessary to jury-rig Net 4 repeater sites using old base stations from NTS. In order to get the proper levels to key the seismic stations, it was necessary to over-modulate the Net 4 repeater system, thus distorting Net 4 audio.

With the passing of the shock wave by the CP, the onsite telephone PBX and Net 3 failed. The PBX failed because the relay rack was upset, and somewhere in the system a short was introduced. This failure was due to a structural failure of the rack. The Net 3 failure could have been rectified in 10 minutes had the communications technician been notified of the trouble. This notification did not come until 2 hours after shot time when Net 3 was no longer needed.

CHAPTER VI

COSTS

The following chapter contains tabulations of costs incurred in relation to Project Gasbuggy. These figures, compiled by NVOO, are the most current available.

Table 6 is a cost information summary which the Division of Peaceful Nuclear Explosives is using in response to inquiries concerning Gasbuggy costs.

TABLE 6
HISTORY OF PROJECT GASBUGGY COST ESTIMATES
(In Thousands)

	AEC	EPNG	ESTIMATED COST	COST SHARING (AEC/EPNG)
Original Estimate	\$3,700	\$1,000	\$4,700	79-21%
Revised Estimate Following JCAE FY 1967 Authorization Hearings	3,200	1,500	4,700	68-32%
Revised Estimate Developed on Basis of Final Contract	2,775	1,925	4,700	60-40%
Current Estimate through Comple- tion of Project Activities (In- cludes 10 months of Production Tests)	3,371	2,269	5,640	60-40% ^{1/}

^{1/}U. S. Government Estimate. Does not include cost of special nuclear materials.

CURRENT BREAKDOWN OF PROJECT GASBUGGY TOTAL ESTIMATED COST
(In Thousands)

	AEC	EPNG	TOTAL
Field Construction	\$1,505 (NV)	\$1,261	\$2,766
Technical Support	651 (NV)	50	701
Logistical Support	245 (NV)	263	508
Maintenance and Operations	232 (NV)	120	352
NV Total:	\$2,633		
Technical Program	738 (LRL)	575	1,313
TOTAL	\$3,371	\$2,269	\$5,640

6.1 NVOO COST SUMMARY THROUGH FY 1970

FIELD CONSTRUCTION	FISCAL YEAR 1967 (09-04-03-8801)	FISCAL YEAR 1968		FISCAL YEAR 1969 (09-04-03-8802)	FISCAL YEAR 1970 (09-04-03-8802)	TOTAL
		7/1/67-1/31/68 (09-04-03-8801)	2/1/68-6/30/68 (09-04-03-8802)			
H&N-OCTD						
Site Preparation	\$ 2,000.00	\$ 338.06				\$ 2,338.06
Zero Station	88,748.36	600,950.72				689,699.08
Instrument Locations		38,355.08				38,355.08
Zero Station Cabling		124,992.74				124,992.74
Tech. Structure-Test Related		34,556.70				34,556.70
Instrument Cabling	25,210.45					25,210.45
Utilities-Test Related		5,471.72				5,471.72
Prep. for & Emplacement & Button-up		144,279.37				144,279.37
Postshot Recovery-Drilling		137,334.82	\$ 58,703.80	\$ 468.65	\$ 26.52	196,533.79
Postshot-General Construction		13,936.43				13,936.43
Field Support/Minor Construction		17,109.86	205.50			17,315.36
Engineering and Design	46,719.66	60,469.68	8,118.18	1,232.12		116,539.64
GB Variances			584.17	(17,319.55)	(10,832.76)	(27,568.14)
F&S						
Engineering and Design	23,006.38	98,282.39	17,560.27	4,479.37		143,328.41
Subtotal - Field Construction	\$185,684.85	\$1,276,077.57	\$ 85,171.92	\$ (11,139.41)	\$ (10,806.24)	\$1,524,988.69
TECHNICAL SUPPORT						
EG&G Hydro, Geol, Meteor, & Seismic		\$ 17,679.00				\$ 17,679.00
II " " " " "	\$ 1,966.36	8,179.74				10,146.10
ERC " " " " "	4,369.92	12,644.06	\$ 7,680.82	\$ 991.64		25,686.44
USC&GS " " " " "		35,403.82	(2,211.23)			33,192.59
ESSA-ARL " " " " "	5,998.18	38,077.56	2,239.76	1,542.52		47,858.02
USGS " " " " "		6,000.00	1,000.00	497.04	3,732.26	11,229.30
USBM " " " " "		9,900.00				9,900.00
WES Engineering Studies	5,861.03	10,647.00				16,508.03
JAB Structural Response Studies	3,916.00	33,685.00				37,601.00
EG&G Timing and Firing		61,113.00				61,113.00
USPHS Radiological Safety & Studies	37,369.00	66,496.00	9,054.00	25,767.00	15,692.00	154,378.00
EIC Radiological Safety & Studies	11,000.00	135,561.52	8,554.41	93,966.98	40,199.78	289,282.69
H&N-OCTD Scientific Photography		632.12				632.12
Subtotal - Technical Support	\$ 70,480.49	\$ 436,018.82	\$ 26,317.76	\$122,765.18	\$ 59,624.04	\$ 715,206.29

NVOO COST SUMMARY (Continued)

LOGISTICAL SUPPORT	FISCAL YEAR 1967 (09-04-03-8801)	FISCAL YEAR 1968		FISCAL YEAR 1969 (09-04-03-8802)	FISCAL YEAR 1970 (09-04-03-8802)	TOTAL
		7/1/67-1/31/68 (09-04-03-8801)	2/1/68-6/30/68 (09-04-03-8802)			
H&N-OCTD						
Motor Vehicles	\$ 2,799.95	\$ 64,379.15	\$ 2,802.50	\$ 838.89	\$	\$ 70,820.49
Telephone and Radio	1,970.69	63,902.98	4,807.61	2,517.86		73,199.14
Supplies and Materials	373.33	5,178.84	200.15	(25.16)		5,727.16
Shop Services, Reproduction, etc.		419.67				419.67
Personnel Assistance	752.18	12,248.43				13,000.61
Transportation of Things		14,909.65	2,502.71	4,678.16		22,090.52
Public Info, Observation, Visit		500.00				500.00
WSI Security		58,644.94	35.90			58,680.84
DASA-Aircraft		5,401.00				5,401.00
REECO-Logistic Support				751.88	338.52	1,090.40
Subtotal - Logistical Support	\$ 5,896.15	\$ 225,584.66	\$ 10,348.87	\$ 8,761.63	\$ 338.52	\$ 250,929.83
MAINTENANCE AND OPERATIONS						
H&N-OCTD						
Utilities	\$	\$ 9,024.87	\$	\$	\$	\$ 9,024.87
Buildings and Trailers - M&O	431.00	1,982.00				2,413.00
Buildings and Trailers - Other	5,673.17	10,227.61				15,900.78
Project and Site Offices	8,035.47	48,019.68				56,055.15
Postshot M&O/Site			16,286.15	9,265.65		25,551.80
Postshot M&O/Las Vegas			743.61	225.62		969.23
Health, Medicine and Safety		4,438.30				4,438.30
EIC - Health, Medicine and Safety		21,853.84				21,853.84
Subtotal - Maintenance & Operations	\$ 14,139.64	\$ 95,546.30	\$ 17,029.76	\$ 9,491.27	\$	\$ 136,206.97
TOTAL AT 6/30/70	\$276,201.13	\$2,033,227.35	\$138,868.31	\$129,878.67	\$ 49,156.32	\$2,627,331.78

H&N-OCTD costs include Prime Construction contracts which were assigned to them for payment.

Not included above is \$3,911.85 incurred by H&N-OCTD for "Aerial Mapping" which was charged to 09-01-03-8145 in FY-1967 as well as \$6,004.00 incurred by USPHS for "Gasbuggy Gas Surveillance" which was charged to 09-01-03-8175 in FY-1970.

6.2 SUMMARY OF THE HARD CORE COSTS OF PROJECT GASBUGGY

Total Cost	\$5,640,000*
Total Hard Core Cost.	2,931,101

FUNCTION	COST
a. Site Preparation	\$449,630
b. Emplacement Hole	738,160
c. Cabling	62,323
d. Emplacement and Button Up	188,600
e. Explosive Operations	524,205
f. Site Characteristic - Analysis and Documentation	184,810
g. Operational Safety	199,923
h. Reentry Drilling	260,450
i. Logistical Support and Maintenance	215,000
j. Operational Support	23,000
k. Industrial Safety	26,000
l. Security	59,000
m. Project Management	-0-

*Government estimate; does not include cost of special nuclear materials.

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
FUNCTION: SITE PREPARATION		Total: \$449,630	
Access Road to Site	Ten Miles of two-lane paved road.	\$140,000	Provided by State of New Mexico, AEC cost estimate.
Onsite Access Roads, Cable-Ways, and Trails	Construct, improve, and maintain.	71,000	Provided by EPNG, AEC cost estimate.
Site Clearing and Grading	Ground zero, control point, and work areas.	32,000	Provided by EPNG, AEC cost estimate.
Facilities	Helicopter pad.	1,118	
	Bituminous stabilizing.	1,512	
Engineering Services	Includes planning, estimating, design surveys, and inspection for surface construction, facilities, and electrical work.	84,000	Of the \$107,188 engineering costs approximately \$84,000 are considered hard core costs.
Field Effort		Man/hours (est.)	
	Project Engineering	374	\$12 (avg.)
	System Design	763	"
	Design Engineering	90	"
	Field Inspection	25	"
	Cable Design	1	"
	Communications Design	30	"
	Field Support	1,703	"
	Total Man/hours	2,986	
	Direct Labor		\$19,733
	Penalty		400
	Survey Subcontract		8,389
	Other		6,122
	Overhead		13,081
	Total		\$47,725
Headquarters Effort		Man/hours (est.)	
	Engineering Management	16	\$9.5 (avg.)
	Product Engineering	1,078	"

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
Engineering	Estimating	661 \$9.5 (avg.)	
Services (Cont'd.)	Special Studies	22 "	
	Civil Engineering	237 "	
	Electrical Engineering	113 "	
	Mechanical Engineering	51 "	
	Structural Engineering	255 "	
	Technical Studies	20 "	
	Reports	232 "	
	Systems Design	888 "	
	Cable Design	65 "	
	Communications	22 "	
	Technical Coordination	16 "	
	Field Support	124 "	
	High Pressure Systems	- 63 "	
	Total Man/hours	3,737	
	Direct Labor	\$30,277	
	Penalty	954	
	Material	157	
	Other	3,249	
	Overhead	19,531	
	Total	\$54,168	
	Planning Direction		
	Direct Labor	\$ 2,929	
	Material	40	
	Other	357	
	Overhead	1,969	
	Total	\$ 5,295	
	Summary of Engineering Services Costs:		
	Field	\$ 47,725	
	Headquarters	59,463	
	Total	\$107,188	

For consistency the 63 man/hours of engineering spent on the high pressure system have been deleted from the total effort. This effort belongs in the postshot analyses phase not covered in this cost breakdown.

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
Utilities	Electric power generators, service, and maintenance; fuel and water plus storage tanks for same.	\$104,000	Provided by EPNG, AEC cost estimate.
Field Support	Minor construction and miscellaneous materials.	16,000	

FUNCTION: EMPLACEMENT HOLE

Total: \$738,160

Engineering	Direction of drilling operations, 45.3 man/mths.	\$ 91,000	Includes reentry effort.
Drilling Operations	Drill hole 28" x 4,300'; 18½" ID casing set to total depth and annulus.	412,748	Costs increased primarily because of problems resulting from parted casing.

Drilling Breakdown

Item	Quantity/Rate	Cost
1. Mobilization	\$ 51,482	\$
2. Linear Footage (LF) Operations		
a. drill 36" hole (0' to 50')	49 LF/\$134	6,566
b. drill 28" hole (50' to 4350')	4,300 LF/\$26.54	112,858
3. Install 30" ID Casing (0' to 50')	49 LF/\$80	3,920
4. Government Directed Hourly Rate		
a. with drill pipe	336 hrs/\$83.35	30,485
b. without drill pipe	463 hrs/\$83.35	38,570
c. install 20" OD casing	20 hrs/\$81.35	9,762
5. Special Items & Services		137,715
6. Demobilization		17,540
7. Cleanup of Mud Pit Area		3,850

As casing was delivered without threads, installation required field welding of casing at joints, increasing costs of operations substantially.

Cementing Services		\$ 26,152	Costs increased due to problem resulting from parted casing.
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Materials	Casing, drilling components, etc.	\$168,074	
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Item	Quantity/Rate	Cost
1. 30" OD Casing	60 ft/\$	\$ 1,980
2. 20" OD Casing	4,400 ft/\$	151,608
3. Drilling Components		
a. stage collars (upper & lower)		13,761
b. basket cement		273
c. centralizers		452

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
Logging Services		\$ 40,761	Increased due to difficulties with parted casing.
	Gyroscopic Survey.	\$ 8,180	
	Callout Logging.	32,006	
FUNCTION: CABLING		Total: \$62,323	
Timing & Firing Cabling and Installation		\$ 54,727	Downhole cable special ordered to withstand environment.
	Materials		
	Item	Quantity/Rate	Cost
	1. Downhole 51C Cable	4,700 LF/\$6.36	\$ 29,907
	2. Surface 50 pr #19 fm GE to RTP	3,200 LF/\$0.67	2,144
	3. Surface 50 pr #19 fm RTP to CP	9,500 LF/\$0.67	6,365
	Total Cable		\$ 36,416
	4. Terminations & Backboards		4,807
	5. Cable Reel Rack		2,318
	Total Materials		\$ 45,541
	Installation		
	Item	Quantity/Rate	Cost
	1. Downhole		\$ 7,453
	2. Surface fm GE to RTP		422
	3. Surface fm RTP to CP		1,311
	Total Installation		\$ 9,186
Other Cabling and Installation	Geophone Cabling and Installation	\$ 7,596	
	Item	Quantity/Rate	Cost
	1. Station #1 2C #18	2,000 LF/\$0.025	\$ 50
	Cbl. Installation		129
	2. Station #2 2C #18	1,500 LF/\$0.025	38
	Cbl. Installation		97
	3. Station #3 2C #18	1,000 LF/\$0.025	25
	Cbl. Installation		64
	Total		\$ 403

Reel more elaborate than required for timing & firing function because of number of other cables downhole.

Exclusive of emplacement rig costs.

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
	TV Cabling and Installation		
	Item	Quantity/Rate	Cost
	1. TV Cable	1,950 LF/\$0.173	\$ 3,374
	Installation		3,409
	Total		\$ 6,783
	RAMS		
	Item	Quantity/Rate	Cost
	1. 16 pr. #19 Cbl.	1,200 LF/\$0.25	\$ 300
	Installation		110
	Total		\$ 410
FUNCTION: EMPLACEMENT & BUTTON UP		Total: \$188,600	
Emplacement	Item	Cost	\$107,249 LRL supervision costs recorded under explosive operation.
	1. Rig costs, lowering operations	\$ 65,187	
	2. Materials - 7" OD casing	28,450	
	stabilizers	4,416	
	wellhead equipment	4,538	
	3. Logging	4,031	
	4. Surface Facilities - Perimeter Fence	627	
Stemming	Item		
	1. Place medium matching grout in 7" pipe and 20" OD casing to 4,150'. Place filler grout fm 4,150' to 3,000'. Place construction sand fm 3,000' to 50' in the OD casing and to the surface in the 7" casing.	\$ 30,351	
	2. Spot resilient plug in annulus (between 20" OD casing and 7" casing) from 50' to surface.		
Engineering	Design of stemming grout mixture, supervision of mixing operation (13 man/months).	\$ 11,000	
Inspection	Laboratory review and approval of Gasbuggy experiment preparation and emplacement (1.2 man/years).	\$ 40,000	
FUNCTION: EXPLOSIVE OPERATIONS		Total: \$524,205	
Test Director and Staff	Test Direction and Explosive Design (2 man/years).	\$ 60,000	

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
Nuclear Explosive	26 kt Design Yield Arming and Firing Services	\$395,000	This charge taken from AEC Policy Statement dated May 1964.
Logistics	7 Man/Years	\$ 23,000	
Field Services	1 Man/Year	\$ 33,000	
Technical Structures		\$ 13,205	
	Item	Cost	
	1. Assembly Building Complex	\$ 5,865	
	2. TV Camera Towers (2)	1,354	
	3. Electrical Grounding System	1,168	
	4. Guard Shack	1,030	
	5. Security Fencing	3,788	

FUNCTION: SITE CHARACTERISTIC ANALYSIS AND DOCUMENTATION

Total: \$184,810

Seismic Effect on Structures	Item	Cost	\$100,000
	1. Ground Motion - Prediction and Evaluation	\$ 17,000	
	2. Structural Response	38,000	
	3. Mine and Well Surveys	10,000	
	4. Seismic Instrumentation	35,000	
Hydrology	Evaluation of Possible Ground Water Contamination		\$ 16,000
Containment	Item	Quantity/Rate	Cost
	1. Geological & Hydrological Studies	.4 mnyr/\$	\$ 14,000
	2. Explosive Eval.	1.0 mnyr/\$	33,000
Population Surveys			\$ 8,315
Climatology Studies	Item	Cost	\$ 13,495
	1. Salaries	\$ 8,859	
	2. Travel and Per Diem	2,872	
	3. Climatology Studies	1,000	
	4. G & A 6 percent	764	

PROJECT: GASBUGGY

TASK	DESCRIPTION		COST	REMARKS
FUNCTION: OPERATIONAL SAFETY			Total: \$199,923	
Ground Motion	Item	Quantity/Rate	Cost	
	1. Geophone Recording	.25 mnyr/\$	\$ 8,250	
	2. Geophone Stations (3 @ \$46 each)	3/\$46	138	
				\$ 8,388
Onsite Rad-Safety	Item	Quantity/Rate	Cost	
	1. Supervision	.1 mnyr/\$	\$ 4,000	
	2. Monitoring		60,000	
	3. Rad-Safe Facility		5,171	
				\$ 69,171
Offsite Rad-Safety	Operations			\$122,364
	Item	Quantity/Rate	Cost	
	1. Ground Monitoring		\$ 25,687	
	a. Planning Field	80 mndy/\$45		
	Lab	30 mndy/\$45		
	b. Field Prep.	370 mndy/\$45		
	c. Event Prep.	60 mndy/\$45		
	d. Caretaker Status	30 mndy/\$45		
	2. Environmental Sampling		13,408	
	a. Air	1,120 mndy/\$6		
	b. Milk	75 mndy/\$10		
	c. Water –			
	Predet.	76 mndy/\$10		
	Postdet.	25 mndy/\$10		
	d. Vegetation	31 mndy/\$50		
	e. All Other		3,378	
				At the time of detonation the USPHS had a staff of 30 in the field to monitor the detonation plus one doctor and one veterinarian. This force was supplemented by 25 people from the State Public Health Service, the costs of which are not included here.
				Fifty thermoluminescent dosimeter stations were set up and 400 residents were provided with dosimeters.
				SEE ATTACHED PRESLOT LIST OF EQUIPMENT.

PRESHOT LIST OF EQUIPMENT UTILIZED FOR OFFSITE RADIOLOGICAL SAFETY PROGRAM

A. FIELD EQUIPMENT

Portable Instruments

E-500-B	\$ 565 each
Scintillator	925 each
Radector	400 each
Background Radiation Monitor Recorder	800 each
Gelman Air Sampler	240 each

NOTE: Each field person should have two of each type of portable instruments. Air samplers and radiation recorders would have to be in sufficient numbers to adequately define the situation. A rough rule of thumb would be four of each for each field person.

B. LABORATORY EQUIPMENT

Low Beta Counting System	\$15,000 each
400-Channel Analyzer System with Shield and Necessary Components	19,000 each
Cryogenic Sampler	600 each
Associated Miscellaneous Hardware for Above Equipment	1,000

NOTE: A minimum of two of each system listed above is required.

C. DOSIMETRY EQUIPMENT

Thermoluminescent Dosimeters (TLD)	\$ 28 each
TLD Readers	6,960 each
Electric Annealing Furnace	820 each

NOTE: Several hundred TLD's are required to adequately document a field operation.

OTHER REQUIREMENTS

A. SERVICES OR EQUIPMENT REQUIRED WHICH CAN BE OBTAINED THROUGH CONTRACT OR OTHER SOURCES

Vehicles (Pick-Ups)
 Mobile Two-Way Radios
 Whole Body Counting System
 Automatic Data Processing Equipment for Information Retrieval
 Medical and Veterinary Services
 Electronic Maintenance Repair
 Aircraft Equipped with Monitoring Equipment for Cloud Tracking in
 Case of Accidental Release

B. LABORATORY ANALYSIS COSTS (INCLUDING LABOR)

Cryogenic Samples	\$ 275 each
Natural Gas Samples	250 each
Molecular Sieve Samples	100 each
Environmental Samples (Soil and Vegetation)	50 each
Milk - Gamma Scan	10 each
⁹⁰ Sr Analysis	10 each
Water - Gamma Scan	10 each
Air Sample (Including Operator and Utility Costs)	6 each

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
	Item	Quantity/Rate	Cost
			(Cont'd from page 95)
	3. Aircraft Opns.	48 mndy/\$45	\$ 9,299
	4. Whole Body Counting		120
	5. Medical Services		304
	6. Veterinary Services		36
	7. Program Planning		27,331
	8. Public Relations		4,983
	9. Rpts. Prep.		211
	10. Training		1,353
	11. Support		12,101
	12. Special Studies		971
	13. Lab Rent		8,800
	Total Operations		\$104,604
	Estimated Hard Core Costs		\$ 88,000
	Meteorological Support		
	1. Operational Phase (D-60 - D+2)		
	Salaries and Overtime		\$ 15,603
	Travel and Per Diem		3,838
	Expendables k		2,176
	Common Services - 6 percent		1,297
			\$ 22,915
	2. Postevent Phase (D+2 - Present)		
	Salaries and Overtime		\$ 8,458
	Travel and Per Diem		2,343
	Common Services - 6 percent		648
			\$ 11,449
	Total Meterological Support		\$ 34,364
	FUNCTION: REENTRY DRILLING		Total: \$260,450
Drilling	Item	Cost	\$131,400
Operations	1. Drill Back into 7" Casing	\$117,227	
	2. Cementing Operations	5,052	
	3. Logging	9,121	

Of the \$104,604, it is estimated that \$88,000 were hard core costs.

Extended work week to minimize manning levels.

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
Onsite Rad-Safety	LRL Supervision – Effort involved a 168 hour work-week requiring a crew of 11 people for one month: Senior Monitor Instrument & Junior Monitor Repairman Senior Health Physicist Utility Man Monitoring	\$ 36,000 70,000	\$106,000
Offsite Rad-Safety	Item 1. Ground Monitoring 2. Environmental Sampling 3. Aircraft Operation 4. Program Planning 5. Public Relations 6. Briefings 7. Report Preparation 8. Support 9. Special Studies	Cost \$ 3,437 16,432 167 1,319 999 30 373 253 40	\$ 23,050

FUNCTION: LOGISTICAL SUPPORT AND MAINTENANCE

Total: \$215,000

Vehicles	Lease and rental for project personnel.	\$ 37,000	
Communications	Radio and telephone; weather teletype services.	\$ 59,000	
Supplies and Materials	Includes shop services; reproduction, etc.	\$ 6,000	
Project Offices	Staff; offices, furniture, and office equipment rental in Farmington.	\$ 69,000	
Shipping	Transportation of equipment, supplies, etc.	\$ 15,000	
Warehousing	Storage of materials and supplies in Farmington.	\$ 6,000	Provided by EPNG. AEC cost estimate.
Trailers: Rental and Moving	For offices, safety programs, etc., at site.	\$ 14,000	
Site Maintenance	Janitorial services, repairs, general labor, etc. for project site work areas and trailers.	\$ 9,000	

PROJECT: GASBUGGY

TASK	DESCRIPTION	COST	REMARKS
FUNCTION: OPERATIONAL SUPPORT		Total: \$23,000	
Operations Coordination Center	Staff for AEC operations coordination at Control Point.	\$ 18,000	
Aircraft Support	To support security and safety surveillance patrols and photo mission at shot time.	\$ 5,000	This cost is for personnel transportation and per diem expenses only.
FUNCTION: INDUSTRIAL SAFETY		Total: \$26,000	
	First aid trailer, medical services, fire protection, etc.		
FUNCTION: SECURITY		Total: \$59,000	
	Includes protection of classified materials and area control at hazardous times.		
FUNCTION: PROJECT MANAGEMENT		Total:	
	AEC Test Manager and AEC staff functions related to overall planning, management, and execution of project.		No direct costs to Gasbuggy; AEC personnel costs are budgeted and accounted for as a basic cost of managing all AEC programs.

CHAPTER VII

CLASSIFICATION AND SECURITY

7.1 CLASSIFICATION

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

Basic classification guidance for Project Gasbuggy was in accordance with the Project Gasbuggy Classification Guide developed by the San Francisco Operations Office and dated September 19, 1967. This guidance supplemented the Classification Guide for the Peaceful Application of Nuclear Explosives (CG-PNE-1). An unclassified version of the guide was also prepared and distributed for general use.

There were no major classification problems involved in connection with Project Gasbuggy.

7.2 SECURITY

7.2.1 Organization and Mission

The Director, Security Division, NVOO, appointed a Chief of Security, Project Gasbuggy, who was responsible for all facets of the security program. The AEC security interest consisted of receipting, handling, storing, transmitting, and safeguarding documents and material classified up to and including Secret--Restricted Data (SRD) Special Nuclear material. The operational security program was activated on October 9, 1967, and terminated on December 13, 1967.

During the security operational phase of the program, Wackenhut Services, Inc., (WSI) of Coral Gables, Florida, a prime contractor for security services to NVOO, furnished armed guards for the Gasbuggy site security interests and for local movement of classified matter. Security areas were established at the following locations: Device Storage and Assembly Area, Recording Trailer Park, GZ, and the Control Point. Materials and documents classified up to and including Secret--Restricted Data (SRD) were authorized in these areas on an "as required" basis.

The "buddy system" or two-man concept, was utilized for protection of the device upon arrival and until detonation.

The OCC and Security trailers were established as limited security areas where storage and/or work with SRD documents was authorized, when and as required. During normal non-operating hours all classified matter was secured in containers approved by security, and guard coverage was extended for security as well as plant protection and safety functions.

Other security services provided by the guard force included escorting classified test devices, component materials and equipment at the site; motor patrols to assist in security safeguards, emergency plans, property protection, and relief for security station; 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 aerial and ground sweeps over mountainous and wooded terrain and established road and muster controls for clearing areas for operational tests and for the detonation area, on D-Day. The guard force was augmented with members of the Jicarilla Apache Tribal Police, members of the State of New Mexico Police, and members of the San Juan County Sheriff's Office during area sweeps and roadblock controls on D-Day. This augmentation, from operational and economic viewpoints, was successful. Helicopters used for air sweeps over the precipitous mountain and wooded terrain saved time and effort in checking areas inaccessible to motor vehicles and virtually inaccessible to foot patrols.

Because of the temporary nature of the security interest and areas, security-approved permanent type chain link fencing was not utilized to surround security areas and provide security protection. Temporary barriers of a combination of hog wire, topped with barbed wire, were used to designate security area boundaries. Such boundaries were supplemented with fixed point security protection afforded by a combination of administrative controls including signs, interior and exterior floodlighting during hours of darkness, 24-hour guard control of access at points of entry/exit, and frequent interior/exterior patrols. Storage containers and/or sight barriers shielded classified objects and operations from observation by uncleared and unauthorized personnel employed in contiguous areas.

Due to the remote location of the site and the fact that there were no approved classified storage facilities in Farmington, New Mexico, the guard force provided armed escort service for the movement of classified documents and materials between the site and Farmington. Such documents and/or material were received at, or dispatched from, Farmington via Registered Mail or Air Express Armed Surveillance Service.

7.2.2 Shipment and Device Movement

The movement of the device to the site was the responsibility of the Manager, ALOO. The Manager, NVOO, was responsible for accepting custody of the device at the site. This latter responsibility was delegated to the Chief of Security, who accepted custody of the device and associated components from ALOO couriers. The device and associated components shipment was accomplished utilizing courier-operated Government vans equipped with special conveniences designed to afford such shipments maximum safety and security protection. Carco Air Services and SAN couriers were utilized to transport other classified matter to the Chief of Security at Farmington, New Mexico, or at the site. Shipments accepted in Farmington were provided armed escort to the site. Final assembly of the device was accomplished under extremely limited "buddy system" controls in the Device Storage and Assembly Area Building (the Red Shack) in the ground zero fenced exclusion area.

Classified spare parts, assembly tools, and other classified matter were returned to SL in Albuquerque, New Mexico, or SL and LRL facilities in Livermore, California, by SAN couriers.

Classified "back-up" material was transported from the Gasbuggy site to the Rocky Flats AEC Office by SAN couriers.

SS Nuclear Material Accountability Facility NAB at the 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. Completed documents were returned to NAB at the NTS for appropriate disposition.

7.2.3 Postshot Security Interest and Controls

The only classified interest currently at Project Gasbuggy is the radioactive debris in the puddle at the bottom of the cavity. This debris is classified Secret--Restricted Data until analyzed and is protected by approximately 4,000 feet of overburden. All activities at the Gasbuggy site involving downhole gas sampling (excluding current surface gas sampling) or entry into the cavity will be coordinated with the NVOO Operations Support Division.

A Security Plan for Gasbuggy postshot operations has been published detailing controls for the period, postshot to cavity entry. A Security Plan will be published when needed, detailing controls for cavity entry operations and protection of puddle debris.

7.2.4 Clearances and Identification Office

Clearance information was processed by the Chief of Security by the use of various agency certification forms, Badge Request Forms, or Forms AEC 277. Forms were signed by authorized individuals of the requesting agency who provided sample signatures through security channels 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 or DOD channel prior to the form being accepted as authority for issuance of identification media.

An Identification/Security Office was activated at the site on October 9, 1967, and was deactivated on December 12, 1967. The Security Office was in operation 24 hours per day, 7 days per week and the capability for issuing identification media existed as a result of supervisory guard coverage. Special Gasbuggy identification nonphotographic badges were prefabricated at the NTS for issue at the Project. These badges were color-coded for type and level of clearance, as well as numerically coded for area access and type of classified information authorized. In addition to the special identification media used exclusively for Gasbuggy, NTS Photographic Security Badges were recognized for access to security areas and classified information, as required, if the NTS badge was such that it would afford similar levels of access and information at the NTS. Use of this dual type badge system commenced on October 11, 1967, and terminated on December 12, 1967, at which time the Identification/Security Office was deactivated. The dual type badge system proved economical. In excess of 65 percent of the Gasbuggy participants, who required identification media, utilized NTS Security Badges which had been issued for use at NTS and the majority are still in use or valid for use at NTS.

7.2.5 Security Education

The limited period during which the classified aspects of Project Gasbuggy applied made it neither feasible nor practical to undertake an onsite formal security education program for the various participating agencies and organizations. Five months prior to the detonation, a NVOO-prepared draft Security Plan was transmitted to major participants for comment. Ninety days prior to detonation, the final Security Plan was distributed to all participants for information and guidance. The Security Plan constituted the security operation policies and set forth the security rules and regulations applicable to all Project Gasbuggy personnel. The Gasbuggy Security Office was established on October 9, 1967, to furnish additional information and day-to-day guidance on security matters. Onsite security education was presented to participants in the form of posters, signs, lectures, discussions, radio net announcements, and various publications.

CHAPTER VIII

PUBLIC INFORMATION

8.1 PUBLIC INFORMATION PLAN

Formal Gasbuggy information policy and program negotiations between the NVOO Office of Public Information and El Paso Natural Gas Company public relations officials began after the announcement of June 14, 1965, of the joint SAN, EPNG, USBM feasibility study that recommended the experiment be conducted. From the beginning, USBM information personnel indicated that their role in the project would be limited. Consequently, USBM participated to a minor degree in the project's information policy formation and program execution.

(See Appendix D for copies of the items mentioned in this chapter.)

A first draft Project Gasbuggy Public Information Plan was submitted by NVOO to EPNG for discussion on October 6, 1965. The value of the plan was questioned by EPNG personnel, but a public information plan was finally agreed upon by all participating organizations and distributed to participants on May 23, 1967.

A Joint Office of Information (JOI) made up of representatives from NVOO, SAN, EPNG, and USBM was established by the plan to carry out public information activities for the project, including information announcements, public meetings, preparation of a fact book, a visitor program, and the establishment of a field information office during the operational phase of the experiment. Two significant agreements were made under the plan:

- (1) All previously issued information could be used by all participating organizations as desired without repetitive coordination.
- (2) Each organization would have primary responsibility for originating issuances related to its particular role and capability, with the AEC specifically reserving the sole responsibility for information actions related to nuclear operations and nuclear safety.

8.2 INFORMATION ANNOUNCEMENTS

Prior to reaching agreement on the information plan, information announcements were coordinated between EPNG and NVOO information personnel on a case by case basis. This evolved into an effective routine of established channels that continued to function under the formal plan.

Significant information announcements issued before the plan was put into effect included the announcement of contract negotiations between the Government and EPNG on December 1, 1966; the contract signing by the AEC, Department of the Interior, and EPNG on January 31, 1967; and confirmation of the suitability of proposed Gasbuggy site on April 6, 1967. Others were routine construction contract announcements and announcements of public meetings.

Beginning on July 6, 1967, all announcements were issued under a Project Gasbuggy Joint Office of Information title. Significant announcements included plans for an official visitor program and the technical symposium, issued on August 4; the note to editors and correspondents explaining procedures for news coverage on D-Day and prior to detonation, issued on October 24; a second invitation to news media to cover the event, issued on November 27; announcement of operational road closures issued on December 1; announcement of the Gasbuggy briefing for news media and invited visitors, issued on December 8; announcement of the detonation on December 10, 1967; and announcement of the preliminary results on January 25, 1968. Other announcements concerned project delays and rescheduling (made on September 5, October 30, November 6 and 22, and December 3, 1967), contract awards, and construction progress.

8.3 PUBLIC MEETINGS

The NVOO Office of Information planned (and coordinated with EPNG) or participated in these meetings: county and state health officials in Farmington on April 6; Jicarilla Apache Tribal Council at Dulce, New Mexico on April 7; New Mexico Governor David Cargo at the Gasbuggy site on April 20, and a public meeting in Farmington on May 25, 1967. The purpose of the meetings, which included EPNG, LRL, and USPHS (except for the Governor's meeting) was to explain the project and to allay any fears the various groups might have. USBM participated in only the Farmington public meeting, which primarily concerned safety aspects of the project.

The NVOO Office of Public Information did not participate in the planning or conduct of the Gasbuggy Technical Symposium held in Farmington on September 19, 1967. Under the Technical Information Plan for the project, the symposium was arranged and conducted by LRL, USBM and EPNG. As planned, the symposium was only for persons from the scientific and industrial communities. However, the symposium attracted a number of newsmen, and NVOO and Headquarters information officers made impromptu arrangements for them.

A visit to the site for symposium attendees the day after the symposium required explanations of Gasbuggy operations and safety. This explanation was given at the CP by a NVOO information officer.

8.4 NEWS MEDIA VISITS

News media visits to the Gasbuggy site and briefings were conducted or arranged by the Joint Office of Information, which opened in Farmington early in October. With project delays, the JOI was staffed on alternate weeks by NVOO and EPNG information officers until the final three weeks before detonation when both information officers staffed the office. They were joined by a USBM information officer some 10 days before detonation. The information officers escorted newsmen to the site, including NBC-TV crews, a correspondent from the San Francisco Chronicle, five Japanese citizens, and others.

8.5 OFFICIAL VISITOR PROGRAM

The NVOO Office of Information and EPNG planned the official visitor program jointly, but EPNG, acting with the JOI plan, made most of the arrangements and funded the program, including bus transportation from Albuquerque, housing and feeding at the visitor site, issuing invitations from a master list compiled from lists submitted by each participating organization, and notifying invitees of project delays and subsequent changes in the visitor program, displays and exhibits, and D-1 briefing arrangements. Visitor site toll telephones for newsmen were provided by the telephone company. The AEC provided communication between the CP and visitor site. EPNG provided visitor site first aid facilities, and the AEC provided contract medical personnel. Some 300 persons attended the D-1 briefing in Albuquerque (chosen for availability of housing and transportation). Some 500 visitors attended the D-Day program.

8.6 PHOTOGRAPHY

The AEC and EPNG jointly funded the Gasbuggy motion picture, with SAN administering the contract and coordinating the script with EPNG, NVOO, LRL, and Headquarters. EPNG provided some of the still pictures services at the site, using its own personnel, and SAN provided the remainder. Airborne motion picture photography of SGZ at zero time (for news media distribution) was provided by NVOO. Stills were provided by EPNG.

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

This chapter contains comments, conclusions, and recommendations submitted by the El Paso Natural Gas Company (9.1) and those reached by the NVOO staff (9.2).

9.1 EL PASO NATURAL GAS COMPANY

9.1.1 General

By current standards EPNG's participation in the Gasbuggy experiment must be regarded as somewhat unique, rather than a model for industrial participation in subsequent Plowshare projects. As the first joint Government-industry Plowshare experiment, the procedure and administration were, of necessity, most sensitive to the internal policy and practices of the AEC and its contractors. Precedent was understandably lacking in many areas. The approach taken was to carefully delineate the responsibilities of the individual participants in the contractual agreement between the AEC, Department of the Interior, and EPNG. Subsequent Government-industry projects appear to be oriented towards limiting the Government's technical and scientific responsibilities and, correspondingly, enlarging those to be assumed by industry. The following comments, conclusions and recommendations are offered in this context.

The technical responsibilities of the participants remained relatively constant for the feasibility study, project design, project execution, and technical reporting phases. The objective was to place responsibility upon the project participant having experience and competency in a given area, and to minimize duplication of effort. Generally speaking, EPNG's input to the feasibility study involved information on environmental conditions, geology, reservoir analysis, petroleum engineering and flow rate predictions with the cooperation of the USBM on appropriate topics. EPNG was also responsible for coordinating, editing and publishing the feasibility study report. The AEC, through its contractors, primarily LRL, furnished predictions and underground phenomenology, seismic effects, hydrology, and radiochemistry. NVOO was responsible for project administration and formulation and implementation of the safety program.

To a large extent, project design responsibility paralleled the preparation of a feasibility study and, in turn, project execution involved a similar division of effort. EPNG provided site preparation, support facilities, and the drilling, coring, and production testing of the two preshot test wells. Following analysis of the data obtained from the preshot wells and a determination of site acceptability by the AEC, the AEC's role was one of primary responsibility for the planning and execution of the nuclear detonation.

Such determinations as the appropriate yield of the explosive; selection of the explosive; drilling, cementing and casing programs for the emplacement hole; site acceptance; and the safety program were the exclusive responsibility of the AEC and its contractors. Similarly, the detonation phase of the experiment was necessarily a primary AEC responsibility.

Technical reporting responsibilities were assigned to the participant assigned the particular project function.

The efforts of the participants reflected the dictates of the Project Gasbuggy Agreement. Therefore, the effort can be characterized as highly compartmentalized and complex in terms of the coordination required.

9.1.2 Conclusions and Recommendations

Complete appreciation for the manner in which Gasbuggy operations were performed, up to and including detonation, develops largely in retrospect. Therefore, project performance can now be examined most usefully from two viewpoints; namely, the carrying out of assigned tasks to accomplish a safe experiment, and the broader consideration of developing the ultimate objectives of the Plowshare Program, which in turn, requires the corresponding development of industrial technical competency.

The Project Manager succeeded in coordinating the required physical operations within the prescribed time frame and the only notable delay, postponement of the shot date, was the result of conditions beyond his direct control. However, the method of operation contributed little toward the industrial partner developing the depth of technical and scientific competency that would justify increased responsibility in subsequent Plowshare activities.

This latter objective was not accorded high priority. The transition to increased industrial responsibility, while the technology evolves from the early experimental stage to economic application, was then viewed as a very gradual process. Much of the difficulty rests with existing AEC classification and information policies. There is also the further impediment of policy to the effect that an industrial participant should not be permitted to develop a significant competitive advantage through project participation.

While it must be assumed that a number of experiments will be required to refine this technology to the point where great confidence can be placed on physical effects predictions and economic forecasts, profitable experience can be gained only through access to technical information that currently exists and that continues to be developed. From EPNG's point of view, there is a need to make known the methods used to make predictions relating to subsurface phenomenology, seismic effects, and resulting radioactivity, as well as a need to understand the pertinent safety criteria. However, much of the data and many of the computer codes and other calculational techniques that have been developed are not available to industry. This is also true of many of the criteria relating to safety considerations. If industry is to gain the capability to plan nuclear stimulation projects, either inhouse competency must be developed, reliance placed on contractual relationships with the AEC's technical contractors, or an approach must be taken that is a combination of the two. Each of these alternatives requires that adequate data be made available through as yet undeveloped reporting channels, or through revision of classification policy. This would be a departure from Gasbuggy experience where, for example, results of effects predictions made by AEC contractors were reported but much of the methodology and data utilized were not.

Representation at technical and safety review panel meetings would have been more helpful. It is important not only to obtain the criteria upon which to plan and make predictions, but to develop an understanding of the reasons for these criteria. Conversely, the industrial partner can make valuable contributions to the AEC effort. In many areas the industrial partner has developed highly refined knowledge and experience which would be pertinent, such as in the design of the well program for the emplacement hole.

The AEC required detailed information relating to the full spectrum of EPNG's operations to design Project Gasbuggy as a meaningful experiment. In addition to furnishing requested data, there was extensive discussion between representatives of the Government's participating organizations and EPNG personnel which was unrestricted from the industry side. It is clear that additional tests will have to be conducted to develop the technology of nuclear stimulation of natural gas reservoirs and to test the feasibility of other applications, such as recovery of minerals, in situ oil shale retorting, underground storage and water management. Achieving the Plowshare Program objectives of both Government and industry in the presence of budget restrictions requires that the industrial partner be provided sufficient information with which to plan, evaluate, and execute on a much broader scale than experienced in this first test. Essentially there is a need to provide industrial participants the opportunity of free discussion with AEC representatives to the same extent that AEC representatives enjoy when developing information about the EPNG's operations.

The recognized organizational approach is the joint committee format which is workable and logical. The committee, composed of representatives from each of the participating organizations, should be responsible for project definition. The modification recommended is that the scope of industry's participation be broadened to include interaction on all technical and safety matters, except, of course, discussion of explosive design and fabrication where national security becomes an issue. It is recognized that even with the limitations related to explosives, this approach will require revision of present classification guidelines. However, unless industry can develop confidence in its ability to evaluate both economic and technical feasibility, as well as participate in interpreting safety criteria, there will be less than complete commitment by private business to fund the number of experiments that will be required to properly evaluate the various applications under consideration.

Structure of the joint Government-industry organization conducting a project is considerably less important than the level of communication permitted among its members. Organizational refinement cannot, of itself, satisfy industry's need for pertinent information. Revision of existing classification restrictions will also serve to eliminate present concerns relating to preferential access to data by individual industrial participants.

9.2 NVOO

9.2.1 Operations

No problems were encountered that were not satisfactorily solved in time to meet the scheduled project execution date. Participating agencies concerned with operational activities coordinated their efforts, worked diligently and efficiently to accomplish the tasks necessary for the success of the project.

9.2.2 Public Information

The success of the public information and official visitor program depended upon a high degree of cooperation between AEC and EPNG. When agreement was reached on the general objectives and operation of the program, channels of cooperation and methods of execution had already evolved. They functioned quite well although non-AEC participants were reluctant to be candid about the nuclear and ground safety program.

9.2.3 Organization and Funding

- (1) The project organization developed for Project Gasbuggy reflecting the overall responsibilities functioned exceptionally well.
- (2) The AEC/NVOO funding was handled satisfactorily during the operation with the exception that there were no contingency funds available for the project which made the operation cumbersome at times.

PROJECT GASBUGGY ORGANIZATION CHART

PROJECT GASBUGGY PERSONNEL ASSIGNMENTS

Appointment to Project Gasbuggy Organization

Project Manager	James E. Reeves	NVOO
Deputy Project Manager	Robert H. Thalgott	NVOO
Scientific Advisor	Harry L. Reynolds	LRL
Test Director	Wayne R. Woodruff	LRL
Deputy Project Manager for Operations	William W. Allaire	NVOO
Alternate Deputy Project Manager for Operations	Rollin H. Shaw	NVOO
EPNG Site Coordinator	Darrel N. Canfield	EPNG
Site Manager	Leonard J. Yelinek	NVOO

NVOO Program Directors

Engineering, Construction, and Support	William D. Smith, Jr., Director Engineering & Construction Division
Safety	Donald H. Edwards, Director Safety Evaluation Division
Operations	William W. Allaire, Director Project Operations Division
Security	William R. Adair, Director Security Division
Information	Henry G. Vermillion, Director Office of Public Information

Project Policy Group

Manager, NVOO	James E. Reeves, Chairman
Director, Exploration, EPNG	Sam Smith
Associate Director, LRL	Glenn C. Werth
Director, Petroleum Research, USBM	J. Wade Watkins

Project Review Panel

Assistant Manager for Plans and Budgets, NVOO	Robert E. Miller, Chairman
Project Gasbuggy Test Director, LRL	Wayne R. Woodruff
EPNG Site Coordinator	Darrel N. Canfield
Deputy Project Manager for Operations, NVOO	William W. Allaire
Director, Engineering and Construction Division, NVOO	Rollin H. Shaw, Alternate William D. Smith, Jr.

Joint Office of Information

Director	Henry G. Vermillion	NVOO
Associate Director	B. Marshall Willis	EPNG
Member	Robert O. Swenarton	USBM
Member	Rodney L. Southwick	SAN

Technical Information Coordinating Group

Chairman	John F. Philip	SAN
Member	Sam Smith	EPNG
Alternate	Harry Gevertz	EPNG
Member	J. Wade Watkins	USBM
Alternate	C. J. Wilhelm	USBM
Member	Robert E. Miller	NVOO
Alternate	Robert R. Loux	NVOO
Member	Glenn C. Werth	LRL
Alternate	Gary H. Higgins	LRL
Executive Secretary and Alternate	Ernest D. Campbell	SAN
DPNE Liaison Officer	Carl R. Gerber	
	Raymond M. Richardson, Alternate	
SAN Liaison Officer	Ernest D. Campbell	
Classification Advisor	Richard H. Johnston, Jr.	
	Classification Officer	NVOO

APPENDIX B

PUBLIC ANNOUNCEMENTS

NV-65-52

UNITED STATES
ATOMIC ENERGY COMMISSION
Nevada Operations Office
P.O. Box 1676
Las Vegas, Nevada

June 14, 1965

Office of Information
2753 South Highland Drive
Telephone: 734-3011, Ext. 3851

ADVANCE: HOLD FOR RELEASE
FOR USE AFTER 8:30 A.M. PDT
WEDNESDAY, JUNE 16, 1965

Underground nuclear explosions in low permeability natural gas fields, principally in the Rocky Mountain area, may increase their total gas production about seven times the amounts now attainable, according to a feasibility study submitted to the El Paso Natural Gas Company, the U.S. Atomic Energy Commission and the U.S. Bureau of Mines.

The study was conducted by staff personnel of the company, the AEC's San Francisco Operations Office, and the Bureau of Mines. The AEC's Lawrence Radiation Laboratory, at Livermore, California, provided technical assistance.

The study team investigated the use of nuclear explosives to fracture "tight" gas-bearing formations to improve recovery and production rates from natural gas fields. The study concluded that this is feasible and recommends that an experimental nuclear detonation, designed to be contained underground, be conducted by the AEC at a site in the San Juan Basin of New Mexico, about 55 air miles east of Farmington. The company stated today that it plans to submit to the Commission a proposal for jointly conducting such an experiment. If authorized, the experiment would represent the first government-industry use of a nuclear explosive for industrial purposes anywhere in the world.

The study, called "Gasbuggy," is a part of the Commission's Plowshare program to develop industrial and scientific uses for nuclear explosives.

The Gasbuggy study covers the preliminary design of an underground nuclear explosion to fracture gas-bearing strata in fields where large quantities of gas are presently unrecoverable because of low permeability of the rock formations. The study team concluded that in such "tight" gas-bearing formations, the nuclear explosion could be expected to create extensive fracture systems that would permit gas to flow more freely into wells. Present fracturing methods cannot sufficiently increase the flow through many of these formations.

The study indicates that the Pictured Cliffs formation in the San Juan Basin of New Mexico appears attractive for an experiment with a 10-kiloton (10,000 tons TNT equivalent) explosive about 4,000 feet underground. Preliminary cost estimates for such an experiment are about \$3,000,000 exclusive of the nuclear explosive.

(more)

June 14, 1965

Extensive studies would be made by the AEC to assure safety of the experiment.

The study stated the blast would vaporize the rock around it and create a subterranean chamber deep below the surface. Then the roof of the chamber would fall in, and a "collapse zone," or area of broken rock, would form above it to a height of about 350 feet and a width of about 130 feet. This would, in effect, create a large storage chamber into which gas would flow through innumerable fractures extending in all directions.

Later, a re-entry hole would be drilled into the top of the chamber to obtain production data and to gather samples of the gas.

Information gained from the experiment would be evaluated to help determine whether nuclear stimulation could be commercially useful. Gathering and evaluating data may require as much as three years after detonation of the explosive.

Preparatory field work could begin within a month or so after a decision has been made to go ahead, but the actual experiment could not take place for at least a year.

Basically, nuclear stimulation is expected to produce the same results as conventional stimulation, but greatly magnified. In conventional stimulation, after a well is drilled into a gas-bearing sandstone formation the rock is fractured (cracked) with a fluid under high pressure or by the now seldom used method of exploding nitroglycerin to enable the gas to move more readily through the rock to the well.

A nitroglycerin detonation uses 1,000 to 2,500 quarts. The proposed Gasbuggy nuclear explosive would equal five million quarts of nitroglycerin

El Paso Natural Gas Company is one of the nation's largest natural gas transmission firms, supplying gas on a wholesale basis to eleven western states: Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming. It has 35.6 trillion cubic feet of natural gas reserves dedicated to the service of this area, the largest volume of gas dedicated by a pipeline to the service of any area in the country.

NV-66-137

UNITED STATES
ATOMIC ENERGY COMMISSION
Nevada Operations Office
P.O. Box 1676
Las Vegas, Nevada

December 1, 1966

Office of Information
2753 South Highland Drive
Telephone: 734-3011, Ext. 3851

FOR IMMEDIATE RELEASE

The Atomic Energy Commission has authorized the negotiation of a contract with the El Paso Natural Gas Company (EPNG) to conduct a proposed government-industry project called "Gasbuggy" to determine whether or not nuclear explosives can be used to increase natural gas production. The action follows an extensive review of the proposed project by the AEC and Department of the Interior agencies, particularly the U.S. Bureau of Mines (USBM) which will represent Interior in the negotiations and also be a participant in the project. Preparations for the experiment could be completed by the late spring or early summer of 1967.

The contract negotiations stem from a proposal by the company to the AEC in June 1965, that a nuclear explosive be detonated deep underground at a site in the San Juan Basin of New Mexico, 55 air miles east of Farmington. EPNG's proposal followed an 18-month feasibility study by the company, the USBM and the AEC; with technical assistance from the AEC's Lawrence Radiation Laboratory at Livermore, California. The study team investigated the proposed use of nuclear explosives to fracture "tight" gas-bearing formations to improve gas recovery and production. The study concluded that the concept is feasible and recommended that a nuclear experiment be conducted at the San Juan Basin site.

The study outlined an experiment with a nuclear explosion at a depth of about 4,000 feet. The current tentative design concept envisages about a 20 kiloton explosion. The depth tentatively chosen is related to the depth of the gas-bearing formations and their geology and is more than adequate to contain the explosion.

NV-67-9

UNITED STATES
ATOMIC ENERGY COMMISSION
Nevada Operations Office
P.O. Box 1676
Las Vegas, Nevada

January 31, 1967

Office of Information
2753 South Highland Drive
Telephone: 734-3011, Ext. 3851

FOR IMMEDIATE RELEASE

An agreement providing for the nation's first experiment using a nuclear explosion in an effort to stimulate natural gas production, was signed today by the Department of the Interior, the Atomic Energy Commission, and El Paso Natural Gas Company.

The agreement was signed in Washington on behalf of the government by Secretary of the Interior Stewart L. Udall and Chairman Glenn T. Seaborg of the AEC. It was signed for El Paso Natural Gas Company by Howard Boyd, Chairman of the Board.

The experiment, Project Gasbuggy, will be conducted at a site 55 air miles east of Farmington, New Mexico. The contained underground nuclear explosion would occur in a low permeability -- or "tight" -- gas-producing formation (the Pictured Cliffs Formation). It could be carried out in seven to nine months provided detailed geological, hydrological and other safety and technical studies confirm the suitability of the present site. El Paso Natural plans to start drilling the first of two test wells at the site immediately.

If a successful nuclear fracturing technique can be developed as a result of Project Gasbuggy, it may find widespread applications in similar "tight" formations in the United States, principally in the Rocky Mountain region. The Bureau of Mines has estimated that the technique could add 317 trillion cubic feet of natural gas to the nation's proved reserves, more than doubling the present supply. During 1965, the nation's proved reserves were 286.5 trillion cubic feet. It is estimated that Project Gasbuggy will cost about \$4,700,000.

The AEC, through its Nevada Operations Office at Las Vegas, will manage the field project and will have control and responsibility for all nuclear aspects of the project, including public safety. The Lawrence Radiation Laboratory, Livermore, California, operated for the AEC by the University of California, is responsible for developing and executing the technical program in cooperation with El Paso Natural and the Department of the Interior's Bureau of Mines.

El Paso Natural has granted the government use of all its operating rights in 160 acres from the surface to 500 feet below the base of the Pictured Cliffs Formation, with complete control until the government

(more)

January 31, 1967

returns the rights to the company. It is making available its experience and knowledge of natural gas reservoir characteristics and production techniques, in addition to drilling the two test wells and providing for other construction and support services.

The Interior Department's Bureau of Mines will evaluate the reservoir in advance of the experiment. Geologic and hydrologic data will be provided by the Interior's Geologic Survey. El Paso Natural will provide additional geologic data and participate in these studies with Interior.

Today's agreement grew out of a study by the AEC, the Bureau of Mines, and El Paso Natural. The study concluded that the effects of a contained underground nuclear explosion could substantially increase the recovery of natural gas from a low-permeability formation. Subsequently, in June 1965, El Paso Natural proposed to the AEC that Project Gasbuggy be carried out as a joint experiment.

The explosion will vaporize the rock around it and create a subterranean chamber deep below the surface. Then the roof of the chamber is expected to fall in, creating a "chimney" or area of broken rock. This would be a large area into which gas would flow through explosion-created fractures which extend in all directions.

A re-entry well will be drilled into the "chimney" to gather samples of the gas. From this and other wells, information will be obtained to measure the amount of gas produced and to determine reservoir characteristics. Information gained from Gasbuggy will be the first step toward evaluating whether nuclear stimulation would be commercially useful. Final evaluation of the project may not be completed for several years after the explosion.

Basically, nuclear stimulation is expected to produce results similar to conventional stimulation, but on a greatly magnified basis. In conventional stimulation, after a well is drilled into a gas-bearing sandstone formation, the rock is fractured with a fluid under high pressure or by the now seldom used method of exploding nitroglycerin to enable the gas to move more readily through the rock to the well.

Preliminary estimates indicate that the detonation of about a 20-kiloton nuclear explosive (equivalent to 20,000 tons of TNT) at 4,200 feet underground would fracture the sandstone gas reservoir sufficiently to release about seven times the amount of gas now recoverable at the present site.

El Paso Natural Gas Company is one of the nation's largest natural gas transmission firms, supplying gas on a wholesale basis to 11 western states.

NOTE TO EDITORS AND CORRESPONDENTS: This announcement is being issued simultaneously by El Paso Natural Gas Company and the Commission's offices in Albuquerque, New Mexico; Grand Junction, Colorado; Las Vegas, Nevada; and Berkeley, California.

NV-67-42

UNITED STATES
ATOMIC ENERGY COMMISSION
Nevada Operations Office
P.O. Box 1676
Las Vegas, Nevada

April 6, 1967

Office of Information
2753 South Highland Drive
Telephone: 734-3011, Ext. 3851

FOR IMMEDIATE RELEASE

Information gained from the first sampling hole at the Project Gasbuggy site east of Farmington, New Mexico, has confirmed the suitability of the site for an underground nuclear detonation intended to stimulate natural gas production, project officials announced today.

The officials are Project Manager James E. Reeves, who is Manager of the U.S. Atomic Energy Commission's Nevada Operations Office, Sam Smith, Director of Exploration for El Paso Natural Gas Company, and Wade Watkins, Director of Petroleum Research, U.S. Bureau of Mines of the Department of the Interior.

Project Gasbuggy is a joint industry-government experiment to determine if an underground nuclear explosion can stimulate production of natural gas from tight geologic formations. Scheduled for late 1967, the project calls for a 20-kiloton nuclear explosion 4,200 feet underground. The experiment is a cooperative venture of the AEC, El Paso Natural Gas Company, and the Department of the Interior.

The site is in a remote area of northwestern New Mexico, about 55 air miles east of Farmington. It is in Rio Arriba County, in the southwest quarter of Section 36, Township 29 North, Range 4 West.

The location was identified in late 1963, during the Project Gasbuggy feasibility study, substantially on the basis of the subsurface geology and its remoteness. The appropriateness of the location has been further substantiated through analysis of electrical logs, hydrologic tests, cores, and other tests and logs.

The data obtained were studied thoroughly by representatives of the Bureau of Mines, El Paso Natural, the Nevada Operations Office of the Atomic Energy Commission, and the Lawrence Radiation Laboratory of Livermore, California, which is in charge of the technical program for Project Gasbuggy for the AEC.

A second pre-detonation sampling hole is to be drilled by El Paso Natural to provide additional information concerning the reservoir characteristics at the site.

Both of the pre-detonation holes will be tested for gas producing capabilities for purposes of comparison with production after the explosion.

(more)

April 6, 1967

Both of the pre-detonation holes are being drilled by El Paso Natural Gas Company. Also scheduled for drilling, by the Atomic Energy Commission, is an emplacement hole through which the nuclear device will be lowered into position, and a post-detonation re-entry hole, for withdrawing gas samples and probably for production testing.

(This announcement is also being issued by AEC offices in Albuquerque, N.M. and Berkeley, California, and by El Paso Natural Gas Company in El Paso, Texas and Farmington, New Mexico.)

JOI-67-6

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

August 4, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Nevada Operations Office
Office of Information
P. O. Box 1676
Las Vegas, Nevada 89101
Telephone: 734-3011, Ext. 3851

(NOTE: This was issued in the Farmington area only.)

Project Gasbuggy, the experiment designed to test whether or not nuclear explosives can increase recovery and deliverability of gas from a tight formation, has attracted scores of scientists, engineers and technicians to Farmington, New Mexico. The number is expected to increase dramatically in late September and early October, officials of the Joint Office of Information for Project Gasbuggy said today.

The experiment will be conducted at a site about 55 air miles east of Farmington, New Mexico. It is a joint venture of the U.S. Atomic Energy Commission, El Paso Natural Gas Company and the Bureau of Mines of the U.S. Department of the Interior. Scheduled detonation date is October 18.

Initial groups from the three organizations are already housed in Farmington, nearest sizable community to the detonation site. A total of nearly 250 government and contractor employees are scheduled to arrive and be housed in Farmington during the three weeks prior to the detonation day. A number of these people will probably remain in Farmington for varying periods to assist in evaluation of data resulting from the experiment.

Inasmuch as interest in the experiment has been widespread, plans are being made for an official visitor program on the day of the detonation for gas, oil, government and news representatives. Farmington housing facilities will be fully utilized by the city's normal number of visitors plus the staff for Gasbuggy. Most of the official visitors, expected to number between 400 and 1000 persons will have to be quartered in Albuquerque, New Mexico and brought by bus to the detonation area.

It is planned to hold a briefing for the visitors in Albuquerque on the day prior to the detonation, but the bulk of activities connected with Project Gasbuggy will center in Farmington and near the detonation site.

JOI-67-7

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

August 4, 1967

U.S. ATOMIC ENERGY COMMISSION - EL PASO NATURAL GAS COMPANY
U.S. BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Nevada Operations Office
Office of Information
P. O. Box 1676
Las Vegas, Nevada 89101
Telephone: 734-3011, Ext. 3851

FOR IMMEDIATE RELEASE

The U.S. Atomic Energy Commission, El Paso Natural Gas Company, and the U.S. Department of the Interior are developing plans to have news media representatives, interested U.S. and foreign government, technical, and industry officials, and representatives of the International Atomic Energy Agency be present for the Project Gasbuggy underground nuclear explosion and related briefings.

Project Gasbuggy is a \$4.7 million joint government-industry experiment to determine if nuclear explosives detonated deep underground can stimulate natural gas production by fracturing rock in which gas is tightly confined.

The 26-kiloton underground nuclear explosion, part of AEC's Plowshare Program to develop civilian uses of nuclear explosives, now is planned for mid-October in a remote part of the San Juan Basin about 55 air miles east of Farmington, New Mexico. A special area for official visitors and news media representatives has been identified along New Mexico Route 17, some five miles from the point on the earth's surface directly above the detonation point some 4,240 feet underground. There are not expected to be any observable effects from the explosion aside from possible ground motion.

Due to operational considerations, there are no plans for visitors to tour the site immediately following the explosion.

On September 19, approximately one month before the explosion, a technical symposium on Project Gasbuggy will be held at Farmington, New Mexico for members of the scientific and industrial community and representatives of foreign governments and the International Atomic Energy Agency who are interested in the technical aspects of this project. Following the symposium a tour of the Gasbuggy site is scheduled on September 20 for those who are interested.

Procedures by which interested U.S. and foreign news media representatives may be accredited to be present for the explosion and briefings are expected to be announced about September 1.

(more)

JOI-67-7

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August 4, 1967

Detailed plans for the technical symposium and visitor program will be sent to government representatives, state and local officials, representatives of the oil and gas industry and others who are interested in Project Gasbuggy well in advance of the technical symposium and the detonation.

Plans also are being developed to set aside two areas in the same general vicinity as the official visitor area for all other persons interested in listening to the pre-detonation countdown. These plans will be announced well in advance of the detonation date.

JOI-67-10

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

September 5, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Nevada Operations Office
Office of Information
P. O. Box 1676
Las Vegas, Nevada 89101
Telephone: 734-3011, Ext. 3851

FOR IMMEDIATE RELEASE

The deep underground nuclear detonation planned near Farmington, New Mexico, the central feature of the Project Gasbuggy experiment, has been rescheduled to November 14. The detonation was previously planned for October 18.

However, the technical symposium for members of the scientific and industrial community interested in the project's technical aspects will be held in Farmington on September 19 as scheduled. The visitor program planned for the day of detonation with briefings for visitors and newsmen on the day before have, of course, been rescheduled.

Project Gasbuggy is a joint experiment of El Paso Natural Gas Company, the Atomic Energy Commission, and the Department of the Interior to determine if a nuclear explosive can be used to increase natural gas production from a low permeability reservoir.

The date for the detonation has been changed because drilling difficulties will delay readiness of the hole in which the nuclear device will be emplaced. The 28-inch diameter emplacement hole is to be drilled to a total depth of 4,350 feet. On September 5, it was down to a depth of 3,415 feet.

JOI-67-11

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

October 24, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Nevada Operations Office
Office of Information
P. O. Box 1676
Las Vegas, Nevada 89101
Telephone: 734-3011, Ext. 3851

NOTE TO EDITORS AND CORRESPONDENTS:

The Atomic Energy Commission, El Paso Natural Gas Company and the Department of the Interior invite accredited news media representatives to attend a briefing and to be present for an underground nuclear detonation experiment planned for November 14, 1967, near Farmington, New Mexico. The experiment is part of AEC's Plowshare Program to develop peaceful uses of nuclear explosives.

Called Project Gasbuggy, the experiment calls for detonation of a 26-kiloton nuclear explosive, 4,240 feet underground in a natural gas bearing formation of low productivity. The explosion is designed to fracture large volumes of rock in which the gas is tightly held. This fracturing is expected to stimulate the production and ultimate recovery of the natural gas.

Project Gasbuggy, located in a remote area of the San Juan Basin some 85 road miles from Farmington, New Mexico, is the first joint Government-industry experiment in the AEC's Plowshare Program. The experiment will cost an estimated \$4.7 million.

In addition to news media representatives, several hundred government and industry officials will be invited to the briefing in Albuquerque, New Mexico, and to be present for the detonation. A tentative schedule of events is attached.

Delays or Postponements

It is anticipated that the attached schedule will be followed. However, weather or technical difficulties may delay the experiment for several hours or postpone it for several days or even weeks. If possible, news media representatives and official visitors will be notified in advance of any delay of 24 hours or more. Determination of the effects of the Gasbuggy explosion will depend upon data that may require a substantial period of time to obtain and evaluate.

(more)

October 24, 1967

Registration

News media representatives and official visitors should register at the Albuquerque Civic Auditorium, 600 Elm NE, to receive their badges for visitor site access and bus boarding, and to receive the Project Gasbuggy information kits. Registration will be from 2 p.m. to 6:30 p.m. on November 13, which is the day before the scheduled detonation. From 7 p.m. to 11 p.m., registration will be at the White-Winrock Motor Hotel on Interstate 40.

The Briefing

The briefing by personnel representing the organizations participating in Project Gasbuggy will be held at the Albuquerque Civic Auditorium from 4 p.m. to 6 p.m. on November 13. There will be a question and answer period after the briefing.

Transportation to Visitor Site

Invited visitors and news media representatives will be transported without charge by special buses to the observer site early in the morning of detonation day. The trip is 176 miles one way and will take about four hours. Buses will depart promptly at 5:15 a.m. from these points in Albuquerque:

White-Winrock Motor Hotel, Interstate 40
Downtown Motor Hotel, 717 Central NW
Sheraton-Western Skies Motor Hotel, 13400 Central SE
Holiday Inn, 12901 Central NE
Sundowner Motor Hotel, 6101 Central NE
Desert Inn Motor Hotel, 918 Central SW

The buses will return to Albuquerque after a post-shot briefing at the visitor site.

The Visitor Site

The Official Visitor Site is located just off New Mexico Route 17 about five miles northwest of the area where the underground nuclear explosion will take place. There is no line of sight to the detonation area because of intervening hills. It is unlikely that there will be any noticeable effects from the explosion at the visitor site aside from ground motion, which is likely to be felt by most visitors.

The Closed Area

The Official Visitor Site will be within the area near the Gasbuggy site that will be closed to the public at detonation time. News media

(more)

October 24, 1967

representatives wishing to provide their own transportation to the Official Visitor Site must park their vehicles outside the road blocks on New Mexico Route 17. Shuttle transportation from the road blocks to the official visitor site will be available.

Only authorized vehicles and aircraft will be permitted inside the closed area, but news media representatives with heavy camera or communication equipment that cannot be carried on foot may seek authorization to bring a vehicle into the visitor area. This authorization should be requested in a letter seeking accreditation (see page 4). That letter should specify the kind of equipment to be brought in, including radio or other broadcast frequencies, if any. Frequencies that may interfere with test site communications will not be permitted in the area.

Visits to the Detonation Site

News media representatives, including photographers, who wish to visit the Gasbuggy detonation site and its facilities before detonation day may do so by writing or telephoning: David F. Miller or Joseph T. Arnett, Project Gasbuggy Joint Office of Information, Petroleum Plaza Building, 3535 East 30th Street, Farmington, New Mexico 87401, telephone 505-327-9656. The Joint Office of Information will open in Farmington on October 25, 1967. Visits to the site may be made after the Joint Office of Information opens except for periods when operations or safety require exclusion. After the detonation, it will not be possible to visit the detonation site for at least several hours.

Communications

The nearest communities with telephone service are Dulce on the Jicarilla Apache Indian Reservation about 15 miles northeast on New Mexico Route 17, and Blanco about 35 miles west on New Mexico Route 17. Few of these telephones are available to the public.

Climate

It is suggested that visitors be prepared for cold weather on detonation day. The average temperature in November is 37 with average daytime temperatures in the low 50's. Precipitation is infrequent, but visitors should be prepared for rain or snow.

Housing in Albuquerque

Visitors will be housed at their own expense in Albuquerque, New Mexico, the closest point where sufficient housing and mass transportation are available. Rooms can be reserved through the Greater Albuquerque Chamber of Commerce Reservation Service, 400 Elm NE, Albuquerque, New Mexico

(more)

October 24, 1967

87102, telephone 505-243-2201. Space has been reserved in several establishments; but reservations will be made by the reservation service on a first-come, first-served basis.

Transportation to Albuquerque

Albuquerque's modern, all-weather airport is served by four airlines: Continental, Trans-Texas, Frontier, and Trans-World. The city is located on the main line of the Santa Fe Railway, and is at the junction of Interstate Highways 25 and 40 (U.S. Highways 85 and 66).

Accreditation for Newsmen

Accreditation for U.S. news media representatives will require a statement from the publication or other medium giving the name and title of its representative or representatives. The letter should be submitted to: Project Gasbuggy Joint Office of Information, P.O. Box 1492, El Paso, Texas 79999.

Accreditation for Foreign Newsmen

Accreditation for foreign news media representatives will require a statement from the publication or other medium giving the name and title of its representative or representatives. The letter should be submitted to: John A. Harris, Jr., Director, Division of Public Information, Attention: Frank L. Ingram, U.S. Atomic Energy Commission, Washington, D.C. 20545.

Deadline for Accreditation

Letters seeking accreditation should be mailed by Wednesday, November 1, 1967. In addition to the business address and phone number, the letter should list the home address and telephone number of the person seeking accreditation to facilitate notification in case of delays or postponements.

Attachment:
Schedule of Events.

Schedule of Events

October 24, 1967

PROJECT GASBUGGY

Monday, November 13, 1967

D-Day Minus One

2:00 p.m. to 6:30 p.m.	Registration at Albuquerque Civic Auditorium.
7:00 p.m. to 11:00 p.m.	Registration at White-Winrock Motor Hotel.
4:00 p.m. to 6:00 p.m.	Briefing and press conference at Albuquerque Civic Auditorium by Project Gasbuggy representatives. (High level AEC, EPNG, and Interior officials may be introduced at briefing and speak at D-Day program.)

Tuesday, November 14, 1967

D-Day

4:00 a.m.	Breakfast.
5:00 a.m.	Board buses at pickup points.
5:15 a.m.	Buses depart for Official Visitor Site.
9:00 to 9:30 a.m.	Buses arrive at visitor site. (A large tent will be erected at site. Coffee and sweet rolls will be available. There will be exhibits.)
9:45 a.m.	Program
10:45 a.m.	Announcer picks up countdown.
11:00 a.m.	Detonation.
11:30 a.m.	Post-detonation briefing by Project Manager if possible.
12:00 noon	Board buses for return to Albuquerque.
12:15 p.m.	Buses leave visitor site. Box lunches will be distributed on buses.
4:15 p.m.	Arrival at pickup points in Albuquerque. Program ends.

JOI-67-12

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

October 30, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Nevada Operations Office
Office of Information
P.O. Box 1676
Las Vegas, Nevada 89101
Telephone: 734-3011, Ext. 3851

Construction difficulties encountered with the final stages of preparation of the Project Gasbuggy emplacement hole will result in a delay of the planned November 14 detonation date for the 26-kiloton underground nuclear explosive gas stimulation experiment.

The length of the delay depends upon the time required to seal water leaks in the hole, but preliminary estimates indicate that there will be at least a one week delay.

Project Gasbuggy is a joint experiment of the Atomic Energy Commission, El Paso Natural Gas Company, and the U.S. Department of the Interior. It is the first joint government-industry experiment in the AEC's Plowshare Program to develop peaceful uses for nuclear explosives. The experiment seeks to determine whether or not fracturing large volumes of gas bearing rock with a deep underground nuclear explosion will stimulate the production and ultimate recovery of natural gas in formations where the gas is not presently economically recoverable.

JOI-67-13

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

November 6, 1967

USED ONLY AS RESPONSE TO INQUIRY

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Field Information Office
Petroleum Plaza Building, Room 100
3535 East 30th
Farmington, New Mexico 87401
Telephone: 327-9656

GASBUGGY POSTPONEMENT

Detonation of a nuclear explosive deep underground in Northwestern New Mexico, part of the Project Gasbuggy natural gas reservoir stimulation experiment, has been postponed at least until the first week in December.

Preliminary estimates last week indicated difficulties with emplacement hole construction would delay the detonation at least one week. Detonation of the 26-kiloton nuclear explosive some 4,200 feet underground had been planned for November 14.

No new detonation schedule will be set until completion of emplacement hole surveys (logging), now underway, and evaluation of whatever remedial construction the surveys may indicate is necessary.

Project Gasbuggy is a joint experiment of the U.S. Atomic Energy Commission, El Paso Natural Gas Company, and the U.S. Department of the Interior. It is the first joint Government-industry experiment in the AEC's Plowshare Program to develop peaceful uses for nuclear explosives.

JOI-67-13

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

November 22, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Nevada Operations Office
Office of Information
P. O. Box 14100
Las Vegas, Nevada 89114
Telephone: 734-3011, Ext. 3851

The Project Gasbuggy underground nuclear detonation readiness date has been rescheduled for Wednesday, December 6, 1967. The 26-kiloton explosion is part of an experiment being conducted near Farmington, New Mexico, to study the technical and economic feasibility of stimulating natural gas production and ultimate recovery from formations of low permeability.

The previously planned ready date for the Gasbuggy detonation was November 14. It was delayed by water entering the emplacement hole, and by subsequent emplacement hole surveys to determine that the cementing around the emplacement hole casing was satisfactory.

Project Gasbuggy is a joint experiment of the U.S. Atomic Energy Commission, El Paso Natural Gas Company, and the Department of the Interior.

JOI-67-14

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

November 27, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Petroleum Plaza Building, Room 100
3535 East 30th
Farmington, New Mexico 87401
Telephone: 505-327-9656

NOTE TO EDITORS AND CORRESPONDENTS:

On October 24, 1967, the Atomic Energy Commission, El Paso Natural Gas Company, and The Department of the Interior invited accredited news media representatives to attend a briefing and be present for an underground nuclear detonation experiment then planned for November 14 near Farmington, New Mexico. This is a re-invitation based on a currently planned date of December 6, 1967, for the detonation, which will be part of the Project Gasbuggy experiment in the Plowshare Program to develop peaceful uses for nuclear explosives. Postponements and delays still are possible, and every effort will be made to notify those who plan to participate.

THE SCHEDULE

Newsmen and official visitors will be briefed in the Albuquerque Civic Auditorium from 4 p.m. until approximately 6 p.m. on December 5, or on event day minus one if there are further postponements. All visitors, including newsmen, will be transported without charge by special buses to the visitor site, 176 miles from Albuquerque, the morning of December 6, 1967. Departure will be promptly at 5:15 a.m. from these points in Albuquerque:

White-Winrock Motor Hotel, Interstate 40
Downtown Motor Hotel, 717 Central NW
Sheraton-Western Skies Motor Hotel, 13400 Central SE
Holiday Inn, 12901 Central NE
Sundowner Motor Hotel, 6101 Central NE
Desert Inn Motor Hotel, 918 Central SW

Return to Albuquerque will be shortly after the detonation.

NEWS MEDIA ACCREDITATION

Accreditation for U.S. Newsmen will require a statement from the employing organization giving the name and title of its representative or representatives. The wire or letter should be submitted to:

November 27, 1967

Project Gasbuggy Joint Office of Information
P. O. Box 1492
El Paso, Texas 79999

with duplicate to:

Project Gasbuggy Joint Office of Information
P. O. Box Q
Farmington, New Mexico 87401

Promptness is necessary; the wires or letter must be received by December 1, 1967. In addition to the business address and phone number, the wire or letter should list the home address and phone number of the person seeking accreditation so notification may be made readily in case of delays or postponements.

SPECIAL TRANSPORTATION

Those desiring to transport heavy camera or communications equipment to the Visitor Site in their own vehicle should request authorization in the accreditation wire or letter. Otherwise, no permission will be given.

WEATHER

It may be anticipated that weather can be very cold at the site so dress should be planned for very low temperatures.

HOUSING AND CREDENTIALS

The requirements for accreditation also will serve as a requirement for us to reserve hotel or motel accommodations in Albuquerque for the nights of December 5 and 6 unless otherwise specified. Badges and other necessary materials will be waiting at the hotel or motel. If you do not wish accommodations reserved, please so instruct, and materials may be picked up at the briefing session at the Civic Auditorium. Materials not picked up at the Civic Auditorium may be obtained at the White-Winrock Hotel just off Interstate 40 in Albuquerque after 7 p.m. on December 5, 1967.

JOI-67-15

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

December 1, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Petroleum Plaza Building, Room 100
3535 East 30th
Telephone: 505-327-9656
Farmington, New Mexico 87401

New Mexico Route 17 between the old Gobernador Town Site and a point three miles west of John Mills Lake on the Jicarilla Apache Reservation will be closed to through traffic at 9 a.m. for at least three hours on Wednesday, December 6.

The road closure is part of the Atomic Energy Commission's operational control of the area around the Project Gasbuggy site. Project Gasbuggy is an experiment that calls for the December 6th detonation of a 26-kiloton nuclear explosive 4,240 feet underground. The explosion is expected to break up large volumes of natural gas bearing rock, which may increase natural gas production and ultimate recovery.

Route 17 will be closed in cooperation with the New Mexico State Police and the Jicarilla Apache Tribal Police. The road will be reopened after the detonation (now scheduled for 11 a.m.) when Gasbuggy Deputy Project Manager Robert H. Thalgott determines that closure is no longer needed, possibly one hour after detonation.

Visitor sites, open to the public, will be established at both road blocks on Route 17. The 30-minute detonation countdown, scheduled to start at 10:30 a.m., will be broadcast over a public address system and a limited number of Project Gasbuggy booklets will be made available to the public at both sites.

In addition to the road closure, an area about five miles in radius around the Gasbuggy site will be closed to all persons except authorized project personnel from 5 a.m. on December 6th until the area is declared open by Mr. Thalgott. The closed area encompasses part of the Carson National Forest, in which the Gasbuggy site lies, and part of the Jicarilla Apache Reservation.

Air space 15 miles in radius from the Gasbuggy site up to 20,000 feet above sea level will be closed to all except authorized aircraft from midnight, December 5, until declared open by the Federal Aviation Administration.

(more)

December 1, 1967

No radio, radio-telephone, telecasts or other use of the air waves in the area are authorized. The only exceptions will be for those persons at the Public and Official Visitor Sites who have had their equipment checked for non-interference with scientific signals. No transmission is authorized during the ten minute period beginning five minutes before detonation time and ending five minutes after detonation.

Released December 1 to:
(with map)

The Daily Sentinal, Grand Junction
Durango Herald
Santa Fe New Mexican
UPI - Ken Englade
Albuquerque Journal
AP, Albuquerque - Jake Booher
The Free Press, Colorado Springs
H. G. Vermillion
Arch Napier
Harry Willett
Katy Woolston, Albuquerque Tribune
Larry Calloway, UPI, Santa Fe
Farmington Daily Times

JOI-67-16

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

December 3, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Petroleum Plaza Building, Room 100
3535 East 30th
Farmington, New Mexico 87401
Telephone: 505-327-9656

The Project Gasbuggy nuclear detonation near Farmington, New Mexico, has been postponed at least two days past the previously scheduled date of Wednesday, December 6. The delay is caused by technical difficulties with electrical cables. Project personnel at the site are analyzing the problem and seeking possible remedies.

Because the problems at the site are unresolved, it is not possible to announce a new date at this time.

The official visitor program, including a briefing scheduled in Albuquerque December 5, has been postponed also.

JOI-67-18

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

December 8, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Petroleum Plaza Building, Room 100
3535 East 30th
Farmington, New Mexico 87401
Telephone: 505-327-9656

FOR IMMEDIATE RELEASE

A briefing on Project Gasbuggy for news media and invited visitors will be held from 4 to 6 p.m. at the Albuquerque Civic Auditorium on Saturday, December 9.

Project Gasbuggy is a test of the feasibility of using nuclear explosives to fracture large volumes of natural gas bearing rock, which is expected to increase production and ultimate recovery of natural gas in tight gas bearing formations. The Project, the first industrial application of nuclear explosives, is a cooperative venture of the El Paso Natural Gas Company, the Atomic Energy Commission, and the Department of the Interior. The 26-kiloton Gasbuggy detonation is scheduled to take place 4,240 feet underground at 11 a.m., Sunday, December 10, some 55 air miles east of Farmington, New Mexico.

New Mexico Lt. Governor Lee Francis is scheduled to deliver the welcoming address at the session that will feature speakers from the Gasbuggy organizations. Among the speakers are: Dr. Gerald F. Tape, AEC Commissioner, who will make the opening remarks; H.F. Steen, President, El Paso Natural Gas Company; Robert H. Thalgott, Deputy Project Manager for Gasbuggy and Assistant Manager for Operations of the AEC's Nevada Operations Office, and Wade Watkins, Director of Petroleum Research, Bureau of Mines, the Department of Interior.

Some 300 top level executives from Government and industry are expected to attend the briefing in Albuquerque. They will travel by chartered bus to the Gasbuggy Official Visitor Site for a detonation day program, on December 10. The Official Visitor Site, open only to invited guests and newsmen, is located on New Mexico Route 17 about 57 miles east of Farmington.

Visitor sites, open to the public, will be established at road blocks on New Mexico Route 17. The 30-minute detonation countdown, scheduled to start at 10:30 a.m., will be broadcast over a public address system and a limited number of Project Gasbuggy booklets will be made available to the public at both sites.

Among these expected to attend are members of the Joint Congressional Committee on Atomic Energy: Representative Chet Holifield, California, Vice-Chairman; Senator Wallace F. Bennett, Utah; Representative

(more)

December 8, 1967

Melvin Price, Illinois; and Representative Tom Morris, New Mexico. Other members of Congress expected to attend are Senator Joseph M. Montoya and Representative E.S. Johnny Walker, both of New Mexico.

Among the topics to be discussed at the briefing are "Concepts Behind Gasbuggy and How the Project Began" by Mr. Steen; "AEC Testing Experience and Gasbuggy Safety and Operations," Mr. Thalgott, and "Potential Applications of Gasbuggy-type Explosives," Mr. Watkins.

Other speakers include: Dr. Glenn Werth, Associate Director of the Lawrence Radiation Laboratory, which is providing technical support for the project, who will discuss "The State of Technical Readiness and the Technical Program;" Carl Gerber, representing the AEC's Division of Peaceful Explosives, who will discuss the "AEC's Plowshare Program," of which Gasbuggy is a part, and Marshall Willis, Director of Public Relations for El Paso Natural Gas Company, who will discuss "What to Expect on D-Day." Henry G. Vermillion, Director of the Project Gasbuggy Joint Office of Information, will be the briefing moderator.

There will be a question and answer period for newsmen after the briefing.

JOI-67-19

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

December 10, 1967

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Petroleum Plaza Building, Room 100
3535 East 30th
Farmington, New Mexico 87401
Telephone: 505-327-9656

The U.S. Atomic Energy Commission detonated a nuclear explosive deep underground in northwestern New Mexico this afternoon in a natural gas reservoir stimulation experiment.

Called Project Gasbuggy, the explosive was fired 4,240 feet beneath the surface at 12:30 p.m. some 55 air miles east of Farmington. There was no release of radioactivity and no report of damage from ground shock resulting from the detonation. Radiation and health safety experts will continue to monitor the experimental area. As a precaution, prior to the detonation, pipelines taking gas from wells in the five-mile radius around the site were physically cut apart from the El Paso Natural Gas Company system.

The nuclear explosive had a design yield of 26 kilotons (equivalent to 26,000 tons of TNT). The explosion was designed to create a cavity 160 feet in diameter, which then would collapse forming a zone (or chimney) of shattered and broken rock 160 feet in diameter and about 350 feet high--roughly the size of a one-half block square, 35-story building more than 3,500 feet underground through a "tight" gas-bearing formation.

Today's detonation was but one phase of the Project Gasbuggy experiment. The principal objective is to assess the extent of natural gas reservoir stimulation. This will involve an extensive program over the next several months of analysing gas flowing into the well bore from the chimney, the reasons for any increase in potential production, and testing to determine radioactivity in the gas.

Gasbuggy is a joint project of the Atomic Energy Commission, the El Paso Natural Gas Company, and the Bureau of Mines, U.S. Department of the Interior.

Initial drilling into the zone of broken rock is expected to begin Monday to collect samples for preliminary analysis. No substantial information is expected for several weeks or months.

JOI-68-20
NV-68-5

UNITED STATES
ATOMIC ENERGY COMMISSION
Nevada Operations Office
P.O. Box 14100
Las Vegas, Nevada

January 10, 1968

Office of Information
2753 South Highland Drive
Telephone: 734-3011, Ext. 3851

FOR IMMEDIATE RELEASE

Drillers early this morning penetrated the Project Gasbuggy chimney, the zone of broken rock formed in a natural gas bearing sandstone formation by the deep underground nuclear detonation near Farmington, New Mexico, on December 10, 1967.

The detonation with a design yield of 26 kilotons was part of the experiment to determine if nuclear explosives can be used to stimulate production and ultimate recovery of natural gas from formations where the gas is not presently recoverable economically by conventional means.

Re-entry drilling indicates a chimney top at 3907 feet below the surface. The detonation occurred at 4,240 feet below ground. This places the chimney height at 333 feet.

Gas samples taken from the chimney will undergo detailed radiochemistry analysis at the Lawrence Radiation Laboratory (LRL) at Livermore, California, to determine exactly what nuclides are present and in what amounts. The analysis will take several months.

Production testing to see if the rock fracturing did increase the flow of natural gas into the fractured zone is expected to begin in six to nine months, depending upon the results of the detailed radiochemistry analysis.

Project Gasbuggy is the first joint government-industry experiment in the AEC's Plowshare Program to develop peaceful uses for nuclear explosives. Project participants are the El Paso Natural Gas Company, the AEC, and the Bureau of Mines of the U.S. Department of the Interior. The Gasbuggy technical program is under the direction of LRL, which is operated by the University of California for the AEC.

JOI-21

PROJECT GASBUGGY
JOINT OFFICE OF INFORMATION

January 25, 1968

U.S. Atomic Energy Commission - El Paso Natural Gas Company
U.S. Bureau of Mines, Department of the Interior

Nevada Operations Office
Office of Information
Las Vegas, Nevada
Telephone: 734-3011, Ext. 3851

The Atomic Energy Commission, together with El Paso Natural Gas Company and the U.S. Department of the Interior, released today preliminary technical data obtained from Project Gasbuggy. Gasbuggy is the first joint government-industry experiment in the AEC's Plowshare Program to develop peaceful uses of nuclear explosives.

The detonation occurred on December 10, 1967, near Farmington, New Mexico. Limited analyses of seismic data analyzed to date indicate that the explosion released approximately 26 kilotons of energy.

The specific objective of Gasbuggy is to obtain data to help determine whether nuclear explosives can be used to stimulate the production and ultimate recovery of natural gas from formations where the gas is not presently economically recoverable by conventional means. The experiment is being conducted jointly by the El Paso Natural Gas Company, the Bureau of Mines of the Department of the Interior, and the Atomic Energy Commission. The technical program is under the direction of the Lawrence Radiation Laboratory (LRL) at Livermore, California, operated for the AEC by the University of California. Final results of Gasbuggy are not expected to be known for about one to two years, although much information and data will be obtained and reported during this period.

Re-entry drilling was completed on January 10, 1968, and indicates that a chimney of broken rock was formed as expected. The top of this chimney is 3,907 feet below the surface of the ground which gives a chimney height of 333 feet. A pre-shot calculation had indicated that a layer of coal, located 334 feet above the explosion point might stop the formation of the chimney at that height. The agreement between that calculation and the actual chimney height is considered to be remarkably good. The fact that the chimney height was so close to that expected gives increased confidence that other pre-shot calculations such as the 78-foot chimney radius may be also approximately correct. Other measurements indicated that the chimney was formed by collapse within a minute after the explosion.

At the time of the explosion, instruments indicated that fractures in the rock around the chimney extended out to about 440 feet. The pre-shot prediction of the extent of such fracturing was about 390 feet.

(more)

The chimney formation and the extent of fracturing are important since the rate at which natural gas flows into a well is determined by the permeability of the rock and the pressure of the gas within the rock. Thus, the size of the chimney of broken rock and the extent of fractures extending outward from it determine the increase in recoverable gas. Measurements of gas pressure in the Gasbuggy reservoir prior to the detonation revealed a reservoir pressure of about 1,050 pounds per square inch. The gas pressure, measured after the explosion, currently is 833 pounds per square inch at the surface which indicates pressures in the chimney now to be about 950 pounds per square inch. The lower pressure results from the fact that the explosion created about two million cubic feet of void space between the broken rock in the chimney into which gas can flow. As gas enters the chimney, the pressure within the chimney increases and is expected to approach the original levels within a few months. One of the objectives of the Gasbuggy experiment is to determine the rate at which gas re-enters the chimney, and this can be measured, in part, by the rate of pressure increase. These data further will be refined by removing gas collected in the chimney and again measuring the rate at which gas re-enters the chimney. Such determination will be part of the continuing post-shot program.

Predictions made before the Gasbuggy explosion indicated that several radionuclides would be present in the gas after the explosion -- including krypton-85, iodine-131, xenon-133, and tritium. Measurements to determine the amount of tritium are important in assessing the public health and safety aspects of this experiment. Rough measurements of samples of gas collected to date at the Gasbuggy site have demonstrated the presence of xenon-133. The short radioactive half-life of xenon-133, about five days, means that it would not be of significance in future applications.

The on-site instruments used for these radioactivity measurements are designed primarily to assure the health and safety of workers at the site. They are not designed to perform detailed analyses to identify very small quantities of krypton or tritium. Samples of natural gas have been flown to LRL at Livermore, California, for detailed analyses, to investigate the presence of these and other nuclides. The results of these analyses are not expected to be known for some time, but will be reported when available.

Scientists working on the project point out that the most important information to be obtained from the Gasbuggy experiment -- on radioactivity, gas flow increases related to fracturing, gas pressure, and gas production testing -- will be gathered and analyzed over the next year or more, after which it will be possible to draw firm conclusions about the results of the experiment.

APPENDIX C

INSTRUCTIONS FOR GASBUGGY

November 28, 1967

INSTRUCTIONS FOR GASBUGGY

I EVENT, TIME AND DATE

The Gasbuggy event is scheduled for 1100 hours on 6 December 1967.*

II LOCATION

The nuclear event will take place in the Carson National Forest, Rio Arriba County, New Mexico, Hole GB-E

New Mexico State Grid Coordinates:

N. 2,067,376.74

E. 218,956.53

Geographic Coordinates:

N. $36^{\circ} 40' 40.4141''$

W. $107^{\circ} 12' 30.2540''$

III PROJECT MANAGER'S READINESS BRIEFINGS

A. Briefings will be held in the EPNG San Juan Division Office Building Conference Room (Near Elks Club) in Farmington as follows:

1. D-2 Days, 1600 hours
2. D-1 Days, 2100 hours

B. Contractor and Agency Representatives attending the readiness briefings will notify their personnel of the area control plan and any safety precautions recommended by the Project Manager's Advisory Panel and insure that their respective personnel not directly connected with the event are notified to leave the controlled area prior to the final sweep, as indicated in the area control procedures.

IV AREA CONTROL PROCEDURES

The following plan is scheduled for presentation at the D-1 Day readiness briefing. The plan presented will be dependent upon the predicted weather forecast. Modifications may be made by the Project Manager's Advisory Panel prior to H-hour.

*Actual firing date was 12:30 MST,
10 December 1967

A. H-12 Hours

1. WSI will establish Muster Station just north of the CP on U.S.F.S. Road 314.
2. Establish control stations on the perimeter of the area at two (2) mile radius from GZ.
 - a. Junction of the Gasbuggy Site access (J-10) and La Jara Canyon (J-16) roads.
 - b. Junction of J-10 and U.S.F.S. Road No. 357.
 - c. Junction of Piedra Blanca Canyon Road and U.S.F.S. Road No. 357.
 - d. U.S.F.S. Road No. 431
3. All other roads and trails into the area within a 2 mile radius of GZ will be barricaded.
4. Control and muster the area within a two mile radius of GZ.
5. Contractors and agencies are responsible for having all non-event personnel out of the closed area prior to start of the final sweep.

B. H-6 Hours

1. Final sweep of the area within two (2) miles of GZ. Only personnel as listed in the Schedule of Events will be permitted in the area unless specifically authorized.
2. New Mexico State Police and Jicarilla Apache Tribal Police will establish road blocks on the perimeter of the area 5 miles from GZ, excluding through traffic on State Highway 17. Barricades will be erected on the secondary roads and trails.
3. Establish controls on the downwind sector out to 10 miles as required by the Project Manager.

C. Daylight

Two helicopters will start air sweeps out to a 5 mile radius from GZ. Any personnel, vehicles or encampments, observed in this area will be reported to OCC.

D. H-3 Hours

All personnel at the CP including the helicopter pad will be issued stay-in badges. All personnel not on stay-in list must clear the five mile radius closed area. Those that wish may proceed to the Official Visitor Area on State Highway 17 via the west access road. All agencies must submit names of their personnel that will use the Official Visitor Area to the Project Gasbuggy Public Information Office. WSI road blocks will move out to the 5 mile perimeter.

E. H-2 Hours

Established road blocks on State Highway 17 at: (1) Gobernador Ruins and (2) Approximately two miles west of John Mills Lake.

V MUSTER

- A. All personnel entering or exiting the area within a two (2) mile radius of GZ and the CP area are required to stop at the muster or control station for issuance or return of their muster or stay-in badges.
- B. Contractors and agencies will have all of their personnel not connected with this event out of the closed area prior to the start of the final sweep.
- C. AEC Security will notify OCC when the area is clear for arming and prior to firing.

VI RESPONSIBILITY

- A. The Test Director is responsible to the Project Manager for the radiological and criticality safety within a radius of 3500 feet around GZ and for all technical buildings and facilities in accordance with the applicable provisions of Part 0500 of the AEC Manual.
- B. Device Safety and Security Procedures in the GZ area and T & F Control Trailer will be in accordance with AEC Manual Chapter 0560.
- C. When permission to arm is granted OCC will verify that the Buddy System is in effect on the T & F Trailer.

VII DELAYS

Delays will be announced from the Project Manager's Office and will be referenced from the originally scheduled shot time.

VIII REENTRY

All post shot reentry will be staged at the CP Muster Station and will report to the reentry staging area one hour prior to H-Hour. Reentry will start by Direction of The Project Manager, all reentries will be coordinated with the Test Director. The person in charge of each party will give the Security Guard at the Muster Station the item number as listed in the Schedule of Events, name of personnel, and the name of the monitor for the party.

IX RADIOLOGICAL SAFETY

A. Manned Stations

All ground and aircraft manned station personnel remaining inside or over the closed area through H-Hour must have the required RAD/SAFE protective clothing and/or equipment available and be accompanied by a qualified RAD/SAFE monitor. These personnel must be familiar with evacuation routes and procedures and remain in radio contact with OCC through appropriate communications. Exceptions to be made by the Project Manager with the concurrence of the Test Director.

B. Reentry Personnel

Parties entering contaminated, or potentially contaminated areas, must be accompanied by a qualified RAD/SAFE monitor.

C. Arrangements for RAD/SAFE monitors may be made with RAD/SAFE prior to the event or the laboratory may use its own qualified RAD/SAFE monitors.

X EVACUATION

A. The Test Director will determine the necessity for evacuating from any station, those technical personnel whose presence may affect the success or failure of the experiment.

B. The Project Manager will determine the necessity for evacuation of all onsite and offsite areas. USPHS personnel in conjunction with local law enforcement officers will evacuate the areas determined by the Project Manager.

XI VISITORS

A. The Official Visitor Area for official visitors and invitees will be located on State Highway 17, approximately 5-1/2 air miles north of GZ, just west of the Gasbuggy access road junction. This area may be used by project personnel not required at the Gasbuggy Site on D-Day. Prior to D-Day, agencies must submit names of their personnel to AEC/PIO for access to this area. Time for occupancy prior to H-2 hours.

- B. Public Visitor Areas will be located on State Highway 17 at the New Mexico State Police and Jicarilla Apache Tribal Police road blocks. Radio count down will be provided.

XII COMMUNICATIONS

- A. At H-3 hours all radio traffic will be limited to operational traffic connected with the event and emergency traffic.
- B. At H-5 minutes radio silence will be maintained on all nets except for operational control and emergency traffic. This will remain in effect until announced that normal traffic may resume.
- C. The radio nets are assigned as follows:

Net 1	AEC, WSI, H&N
Net 2	Technical Programs
Net 3	PIO
Net 4	USPHS, EIC, USC&GS, ESSA

XIII AIR SPACE CONTROL

With concurrence of FAA, the air space, 15 mile radius from GZ to 20,000 feet MSL, will be closed from H-12 hours until declared open by the Project Manager after detonation. Additional air space closure may be requested if circumstances warrant. Only event related aircraft will be allowed in the closed air space.

XIV REPORTS

- A. The Technical Programs will keep the Project Manager informed of the status of their respective programs through the Test Director.
- B. The Technical Programs will furnish preliminary results to the Project Manager through the Test Director for inclusion in the H+30 min. report.
- C. Any available scientific results will be reported to the Project Manager through the Test Director for inclusion in the H+6 hour report.

XV MANNED STATIONS

<u>AGENCY</u>	<u>LOCATION</u>	<u>COMM</u>	<u>VEHICLES</u>	<u>PERSONNEL</u>
LLL PHOTO	Upwind - (Distance to be determined at Readiness Briefing)	Yuletide Freq	UH-IF Helicopter	Three LLL Personnel to be named. Monitor USAF Crew
PIO PHOTO	Upwind - (Distance to be determined at Readiness Briefing)	Yuletide Freq	UH-IF Helicopter	J. Feierbacher C. Trussel or C. Reeves Monitor USAF Crew

XVI AIRCRAFT PARTICIPATING

<u>TYPE</u>	<u>ORGANIZATION</u>	<u>MISSION</u>
Turbo-Beech	USPHS	Cloud Tracking & Sampling
Turbo-Beech	USPHS	Cloud Sampling on standby at Las Vegas, Nevada
UHIF (Manned Station)	LLL/USAF	LLL Photo*
UHIF (Manned Station)	PM/USAF	PIO Photo*
Martin 404	EG&G/NATS	Cloud Tracking On standby at Las Vegas, Nevada

*Will be used for security safety sweep from daylight until approximately H-2 Hours.

All aircraft will maintain radio contact with Yuletide control on UHF-255.8.

XVII CCTV

The closed circuit TV cameras are located:

Camera #1, 2000' East, and #2, 3000' North, of GZ.

XVIII ABBREVIATIONS

AEC	-	Atomic Energy Commission
CP	-	Control Point
DPNE	-	Division of Peaceful Nuclear Explosives
EIC	-	Eberline Instrument Corporation
EPNG	-	El Paso Natural Gas Company
ESSA/ARL	-	Environmental Science Service Administration/ Air Resources Laboratory
FAA	-	Federal Aviation Administration
F&S	-	Fenix and Scisson
GZ	-	Ground Zero
ISO	-	Isotopes Inc.
H&N	-	Holmes & Narver, Inc.
LLL	-	Lawrence Livermore Laboratory
OCC	-	Operation Coordination Center
PIO	-	Public Information Office
PM	-	Project Manager
RTP	-	Recording Trailer Park
SC	-	Sandia Corporation
TD	-	Test Director
USAF	-	U. S. Air Force
USBM	-	U. S. Bureau of Mines
USC&GS	-	U. S. Coast and Geodetic Survey
USFS	-	U. S. Forest Service
USGS	-	U. S. Geological Survey
USPHS	-	U. S. Public Health Service
WR	-	When Released
WSI	-	Wackenhut Services Inc.

General Location Map

Schedule of Events - Gasbuggy

D-Day

<u>ITEM</u>	<u>HOURL</u>	<u>AGENCY</u>	<u>EVENT</u>																																							
1	0001 to H-3	SEISMIC USC&GS	Check seismic stations within a two (2) mile radius of GZ. <table><tr><th><u>Station #</u></th><th><u>Gaswell #</u></th><th><u>Location</u></th></tr><tr><td>#1</td><td>6SJ28-4</td><td>RTP</td></tr><tr><td>#2</td><td>7SJ28-4</td><td>3600' SE</td></tr><tr><td>#3</td><td>16SJ29-4</td><td>4000' NNE</td></tr><tr><td>#4</td><td>4SJ29-4</td><td>5000' NW</td></tr></table> Frank Risavich Nick Yates Russ Forshee Net 4	<u>Station #</u>	<u>Gaswell #</u>	<u>Location</u>	#1	6SJ28-4	RTP	#2	7SJ28-4	3600' SE	#3	16SJ29-4	4000' NNE	#4	4SJ29-4	5000' NW																								
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2	0001 to H-5	SEISMIC USC&GS	Check seismic stations as required located outside a two mile radius from GZ. Personnel must be clear of the area within a five mile radius of GZ prior to H-5 hours. <table><tr><th><u>Station #</u></th><th><u>Distance from GZ</u></th><th><u>Location</u></th></tr><tr><td>5</td><td>36,000'</td><td>S45°W</td></tr><tr><td>6</td><td>14,700'</td><td>N82°E</td></tr><tr><td>7</td><td>22,900'</td><td>N30°E</td></tr><tr><td>8</td><td>33,400'</td><td>S26°E</td></tr><tr><td>9</td><td>55,700'</td><td>N78°E</td></tr><tr><td>10</td><td>111,500'</td><td>Jicarilla Motor Pool</td></tr><tr><td>11</td><td>65,600'</td><td>N30°E</td></tr><tr><td>12</td><td>94,100'</td><td>N85°E</td></tr><tr><td>13</td><td>95,100'</td><td>Lowry Camp</td></tr><tr><td>14</td><td>41,500'</td><td>Gobernador</td></tr><tr><td>15</td><td>111,500'</td><td>Jicarilla Agency</td></tr><tr><td>16</td><td>111,500'</td><td>Dulce School</td></tr></table> Frank Risavich Nick Yates Russ Forshee Net 4	<u>Station #</u>	<u>Distance from GZ</u>	<u>Location</u>	5	36,000'	S45°W	6	14,700'	N82°E	7	22,900'	N30°E	8	33,400'	S26°E	9	55,700'	N78°E	10	111,500'	Jicarilla Motor Pool	11	65,600'	N30°E	12	94,100'	N85°E	13	95,100'	Lowry Camp	14	41,500'	Gobernador	15	111,500'	Jicarilla Agency	16	111,500'	Dulce School
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3	0001 to H-3	CCTV H&N	Check closed circuit TV cameras located: <table><tr><td>No. 1</td><td>and</td><td>No. 2</td></tr><tr><td>2000' East</td><td></td><td>3000' North of GZ</td></tr></table> W. Coplin D. Nagata Net 1	No. 1	and	No. 2	2000' East		3000' North of GZ																																	
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ITEM	HOURL	AGENCY	EVENT
4	0001 to H-3	LRL	<p>Check equipment at remote camera station located approximately 2,000' East of SGZ.</p> <p>T. Oliver</p> <p>Net 2</p>
5	0001 to H-3	LRL	<p>Check recording system at Trailer 68 in RTP approximately 3,000' SSW of SGZ.</p> <p>R. Rossman (in charge) N. Bailey J. Stellar D. Statler D. Larson K. Bear C. Sisemore</p> <p>Net 2</p>
6	0001 to H-3	SC	<p>Check recording system at Trailer B-3 in RTP approximately 3,000' SSW of SGZ.</p> <p>K. Kimball (in charge) D. List W. Perret C. Eisenhower C. Csinnjinni B. C. Benjamin H. Przystas</p> <p>Net 2</p>
7	0001 to H-3	Isotopes, Inc.	<p>Check approximately ten shallow auger holes located in the muster area at varying distances and direction from SGZ.</p> <p>M. Gardner D. Churchfield</p> <p>Net 2</p>
8	0001 to H-3	LRL/SC/ EG&G	<p>The following personnel, at the Red Shack Assembly area compound, engaged in nuclear explosive systems activities.</p> <p>A. W. Lundberg (in charge) R. Burton, SC O. Whitt, EG&G H. E. Brown, LRL L. Hake, SC J. Brewer, EG&G D. Myers J. Fuqua, SC J. Magruder, EG&G P. House V. Black, SC H. Pouliot, SC J. Martinell, SC</p> <p>Net 2</p>

ITEM	HOUR	AGENCY	EVENT
9	0001 to H-3	As specified	<p>The following engineering, construction and support personnel, with equipment, will need access to the muster area to work as directed by L. Ballou, LRL</p> <p>LRL: L. Ballou, S. Serocki, M. Peterson, L. Lininger</p> <p>EPNG: M. Castille, plus one other</p> <p>F&S: R. Gatliff, M. Haslet, H. Sullivan, O. Alexander, B. Thompson</p> <p>H&N: P. Noblitt, W. Coplin, S. Turner, plus three others</p> <p>WESTERN STATES CONST: M. Fricke, R. Funk, plus ten others</p> <p>FOUR STATES COMM: W. Payne</p> <p>Net 2</p>
10	H-6 Hrs.	PM STATE AND TRIBAL POLICE	<p>Activate New Mexico State and Jicarilla Apache Tribal Police roadblocks on the five mile arc excluding through traffic on Highway 17.</p> <p>State and Tribal Police radio freq.</p>
11	H-6 to H-5 Hrs.	SAFETY EBERLINE	<p>Check RAMS equipment located in the muster area at distances out to 500' from SGZ.</p> <p>J. R. Curtis, EIC (in charge)</p> <p>Net 4</p>
12	H-5 to H-3 Hrs.	SAFETY LRL	<p>Check safety monitoring systems located in the muster area at distances out to 2500' from SGZ.</p> <p>W. Silver, LRL (in charge)</p> <p>Nets 2 and 4</p>
13	H-5 1/2 to H-3 Hrs.	SAFETY EBERLINE	<p>Start air samplers located in the muster area at distances out to 500' from SGZ.</p> <p>R. May, EIC (in charge)</p> <p>Net 4</p>

ITEM	HOURL	AGENCY	EVENT
14	H-4 1/2 Hrs.	LRL/SC/EG&G	Arming party at Red Shack. A. W. Lundberg, LRL (in charge) L. Hake, SC J. Brewer, EG&G J. Fuqua, SC O. Whitt, EG&G *P. House, LRL *H. Brown, LRL *D. Myers, LRL *To depart the vicinity of GZ before final arming commences and return to the CP. Net 2
15	H-4 to H-3 Hrs.	SAFETY EBERLINE	Check air sampler equipment operation in the muster area at distances out to 500' from SGZ. G. Phillips, EIC (in charge) Net 4
16	Daylight	PM/WSI	Security will accomplish air safety sweep of closed and controlled area. Aircraft will not fly over GZ area. Two UH-1F helicopters will be used. Both will return to helicopter pad to refuel and be on station for LRL and PIO photo missions prior to H-30 minutes. Two WSI USAF Crew Yuletide freq or Net 1 and 2
17	H-3	ALL	Radio silence will be maintained on all nets except for operational control and emergency traffic.
18	H-3	WSI	Security will issue stay-in badges to all personnel in the CP area including the helicopter pad. Personnel not required may proceed to the Visitor Areas on Highway 17 via the west side access road.
19	To be announced	AEC PM	A readiness briefing will be conducted in the AEC/PM conference trailer at the CP.
20	H-2 Hrs.	LRL	Test Director request permission to arm.
21	H-2 Hrs.	AEC/PM	Project Manager gives permission to arm.

ITEM	HOURL	AGENCY	EVENT
22	H-2 Hrs.	ARMING PARTY	Design arming. Report to Project Manager when arming is complete and departing area.
23	H-2 Hrs.	PM STATE & TRIBAL POLICE	Activate New Mexico State and Jicarilla Apache Tribal Police roadblocks on Highway 17 at Gobernador Ruins and two miles west of John Mills Lake. Highway 17 will be swept clear between the roadblocks. State and Tribal Police radio freq.
24	H-1	USAF/LRL/ EIC	Following personnel, in Anti-C clothing, standby at the helicopter tiedown area prepared to perform airborne photo and/or surveillance missions: L. Ballou (in charge) R. Jaeger, Motion Pictures D. Lombard, Still pictures C. W. Childers, Monitor PILOT CO-PILOT ALTERNATES: M. Peterson or S. Serocki (in charge) H. Benhard, Motion Pictures K. Way, Still pictures J. Foster, Monitor Net 2 and AOC Hot Line Phone
25	H-1 Hr.	EG&G NATS	NATS aircraft and crew will be alerted and on standby at McCarran Field, Las Vegas, Nevada, at H-Hour to be called into the area for cloud tracking as required by the Project Manager. Martin 404 Yuletide freq and Net 4
26	H-1 Hr After arming party departs area	SECURITY	Security will report to the Project Manager through the Operations Coordination Center that the closed area is clear, except for manned stations.
27	H-30 min.	EG&G	Countdown required on all nets. Radio silence during countdown announcements

ITEM	HOURL	AGENCY	EVENT
28	H-30 Manned Station	USAF/LRL	<p>UH-IF Helicopter depart tiedown area to perform airborne photo mission, and to remain in orbital position upwind at position to be determined at readiness briefing until ordered to perform photo and/or surveillance activities.</p> <p>L. Ballou, LRL (in charge) R. Jaeger, Motion Pictures</p> <p>PILOT D. Lombard, Still Pictures C. W. Childers, Monitor CO-PILOT</p> <p>ALTERNATES:</p> <p>M. Peterson or S. Serocki, LRL (in charge) H. Benhard, Motion Pictures K. Way, Still Pictures J. Foster, Monitor</p> <p>Yuletide freq and Net 2</p>
29	H-30 Manned Station	PM/PIO/ USAF	<p>UH-IF Helicopter will be on station upwind at position to be determined at readiness briefing until ordered to perform photo and/or surveillance missions.</p> <p>J. Feierbacher USAF Crew C. Trussel Monitor or C. Reeves</p> <p>Yuletide freq and Net 1 or 2</p>
30	H-30 Min.	USPHS	<p>USPHS Turbo-Beech will orbit outside the closed area to be used for cloud tracking and sampling as requested by the Project Manager.</p> <p>USPHS Crew</p> <p>Yuletide Freq and Net 4</p>
31	H-15 Min.	PM STATE POLICE	<p>New Mexico State Police will close State Highway 511 across the down stream face of the Navajo Dam.</p>
32	H-5 Min.	EG&G	<p>Announce on all nets radio silence except for emergency traffic.</p>

ITEM	HOUR	AGENCY	EVENT
33	H-1 Min.	SEISMIC USC&GS/EG&G	USC&GS requires following tone and voice announcement on Net. 4 H-1 Min - Voice tone announcement H-5 Sec - "JK" Tone
34	H-Hour 1100 Hours	ALL	Zero Time
35	H-plus 5 Min	LRL	Camera Function: Photo station 2000' East GZ. (1) 24 PPs, Color (10 minutes available film) - 10 sec. camera start, plus 5 min. camera stop (unless directed to continue by TD). Five min. of film remaining to be used at the discretion of TD. (2) Time lapse, 1 exposure ea. 5 sec., Black & white (50 min. available film) -2 min. camera start, plus 48 min. camera stop.
36	When approved by Project Manager	PM	The Project Manager will announce that recovery operations may begin as scheduled. The Test Director will be notified. All reentries and recoveries will be in accordance with the Test Director's published reentry and recovery plan.
37	WR by TD	LRL/EIC	The following personnel, in Anti-C clothing, will conduct the initial radiological survey of the SGZ and RTP, as directed by the Test Director. Results will be reported on Net 2 radio as soon as taken. These personnel will then be available to furnish monitoring support to recovery parties as required. Time in area about two hours. Party #1 M. Chew, LRL (in charge) Balance to be named. Party #2 F. McMillen, LRL (in charge) Balance to be named. Two vehicles, Net 2 and 4 radios 6 Monitors furnished by LRL/EIC

<u>ITEM</u>	<u>HOURL</u>	<u>AGENCY</u>	<u>EVENT</u>
38	WR by TD	LRL	<p>The Test Director's party will conduct a preliminary survey of the GZ area.</p> <p>W. R. Woodruff (in charge) L. Ballou or Alternate L. Lininger or Alternate A. Lundberg or Alternate</p> <p>Net 2 and 4</p> <p>Monitors in area furnished by LRL/EIC</p>
39	WR by TD	LRL	<p>Following personnel, in Anti-C clothing, recover film from recording Trailer 63 in RTP approximately 3,000' SSW of SGZ. Time in area about 15 minutes.</p> <p>R. Rossman (in charge) D. Statler K. Bear</p> <p>Net 2</p> <p>Monitors at RTP furnished by LRL/EIC</p>
40	WR by TD	SC	<p>Following personnel, in Anti-C clothing, recover film and tape from Trailer B-3 in RTP approximately 3,000' SSW of SGZ. Time in area about 5 minutes.</p> <p>K. Kimball (in charge) D. B. List</p> <p>Net 2</p> <p>Monitors at RTP furnished by LRL/EIC</p>
41	WR by TD	LRL	<p>Following personnel, in Anti-C clothing, recover film from remote camera station located approximately 2,000' East of SGZ.</p> <p>T. Oliver (in charge)</p> <p>Net 2</p>
42	WR by TD	USBM	<p>Photograph various wells and installations in the muster area.</p> <p>C. Atkinson D. Ward D. Sears Monitors as required.</p>

<u>ITEM</u>	<u>HOUR</u>	<u>AGENCY</u>	<u>EVENT</u>
43	WR by TD	ISOTOPES, INC.	<p>Check approximately 10 shallow auger holes located in the muster area at varying distances and direction from SGZ.</p> <p>M. Gardner D. Churchfield</p> <p>Net 2 One Monitor furnished by EIC</p>
44	WR by TD	As specified	<p>The following engineering, construction and support personnel, in Anti-C clothing, standing by with equipment, will reenter the muster area to perform work as directed by L. Ballou, LRL, in charge.</p> <p>LRL: L. Ballou H&N: P. Noblitt EIC: Monitor EPNG: M. Castille WESTERN STATES CONST: M. Fricke F&S: R. Gatliff One Monitor furnished by EIC</p>
45	WR by PM	PM	<p>After survey and recovery operations are underway, the Project Manager, with concurrence of the Test Director, will designate when the closed areas and roads may be opened.</p>

APPENDIX D

TECHNICAL AND SAFETY PROGRAM REPORTS EXPECTED FROM PARTICIPANTS IN PROJECT GASBUGGY

A. TECHNICAL REPORTS - (already issued)

Authoring Organization	Report No.	Report Title
EPNG/AEC/USBM/LLL	PNE-1000	Project Gasbuggy (Feas. Study Rpt.)
LLL	PNE-1001	Pre-Shot Summary
LLL	PNE-1003	Preliminary Post-Shot Summary
EPNG	PNE-G-9	Drilling & Testing Operations
LLL	PNE-G-10	Gas Quality Investigation Program Status Rpt.
LLL	PNE-G-11	Post-Shot Geologic Investigation
USBM/EPNG	PNE-G-13	Status of Reservoir Evaluation

B. TECHNICAL REPORTS - (to be prepared)

SL	PNE-1002	Free-Field & Surface Ground Motions
LLL	--	Prediction & Results of Dynamic Effects
LLL	--	Analysis & Interpretation of Gaseous Radioactivities
LLL	--	The Gasbuggy Seismic Source
LLL	--	Response of the Navajo and El Vado Dams
EPNG/USBM/LLL	--	Reservoir Geology
EPNG/USBM	--	Post-Shot Flow Tests
EPNG/USBM	--	Reservoir Analysis

C. SAFETY REPORTS - (already issued)

NVOO	PNE-G-12	Operational Safety Aspects
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D. SAFETY REPORTS - (to be prepared)

EIC	PNE-1006	Onsite Radiological Safety
USPHS	PNE-1007	Offsite Radiological Surveillance
ESSA/ARFRO	PNE-1008	Weather and Radiation Predictions
TI	PNE-1009	Ground Water Safety Evaluation
ERC	PNE-1010	Analysis of Ground Motion & Containment
USBM (BuMines)	PNE-1011	Mine & Well Safety
JAB	PNE-1012	Structural Response
USGS	PNE-1013	Geology & Hydrology
USC&GS	PNE-1014	Seismic Measurements

E. PLOWSHARE OPEN FILE REPORTS

A significant compilation of scientific and technical information has resulted from Project Gasbuggy, a part of the U. S. Atomic Energy Commission's (AEC) Plowshare Program to develop peaceful uses for nuclear explosives. The fundamental concept in such underground engineering applications is to use the energy of a deeply buried nuclear explosive to increase the permeability and porosity of rock thereby stimulating the flow of natural gas.

The "Reports Available in Plowshare Open File" document lists those publications concerning Gasbuggy that have been placed in the Plowshare Open Files by the Nevada Operations Office of the AEC. All of the publications are available to the scientific, technical, and industrial communities. Also listed in the document are certain other publications concerning the AEC's safety programs for underground nuclear detonations which may be of particular interest.

The publications described in the Open File document may be purchased at the following locations:

U. S. Atomic Energy Commission
Division of Technical Information
Extension
P. O. Box 62
Oak Ridge, Tennessee 37831
(Check should be payable to
National Cash Register)

National Technical Information
Service
U. S. Department of Commerce
Springfield, Virginia 22151

In addition, these publications are readily available for public inspection in full size copy at the following locations:

U. S. Bureau of Mines
Bartlesville Petroleum Research
Center
Virginia and Cudahy Streets
Bartlesville, Oklahoma 74003
Attn: Open File

University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, Nevada 89109
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