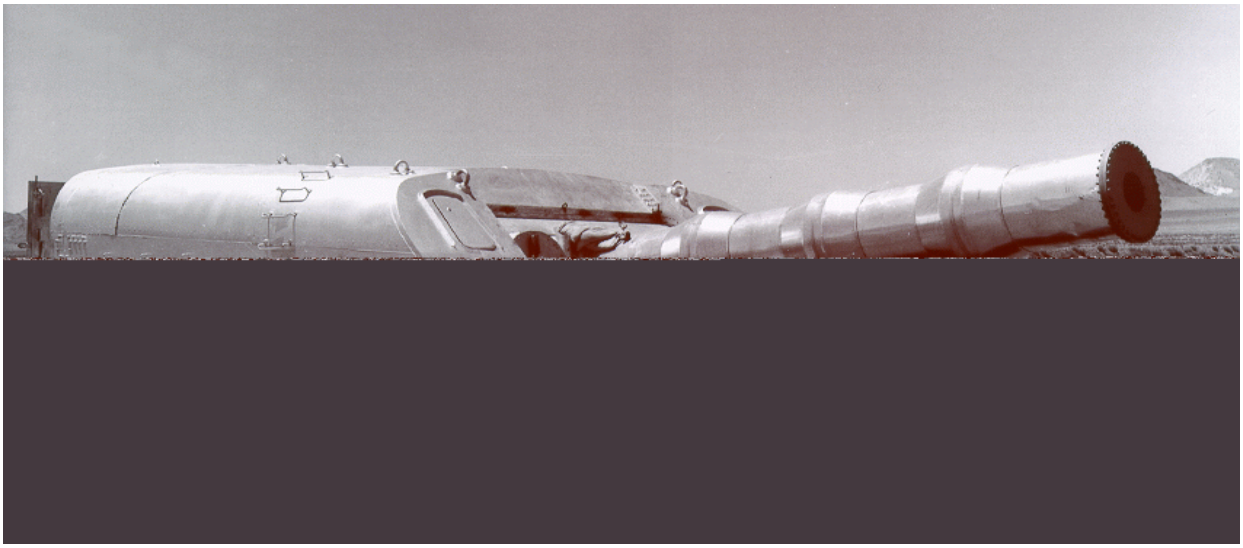

NEVADA TEST SITE GUIDE

DOE/NV-715 Rev 1
March 2005

National Nuclear Security Administration
Nevada Site Office

Foreword

In August 1999, after several months of research, the *Guide to Frenchman Flat* was published to dispel some of the myths and factual errors that clouded the events that took place in Frenchman Flat, and to provide a standard reference to Nevada Test Site visitors to describe the artifacts that remain from the 14 atmospheric tests conducted in Frenchman Flat between 1951 and 1962.

The *Nevada Test Site Guide* expands on the information previously published in the *Guide to Frenchman Flat.* While the new guide does not cover all the events that have occurred at the Nevada Test Site, it does contain photographs and articles on past atmospheric and underground tests, and other events and programs that play a very important role in the nation=s security and defense.

As a living document, it is hoped that in future years the guide will gradually be expanded until all of the Nevada Test Site information is contained within its pages; until that time, information about many other programs conducted at the Nevada Test Site can be found at www.nv.doe.gov .

Front Cover Photographs

Located in Area 2, this gun turret was removed from a U.S. Navy Heavy Cruiser. It was developed by Lawrence Livermore Radiation Laboratory for line-of-sight diagnostics. Basically, the turret could be used on multiple atmospheric nuclear tests by rotating it and adjusting the elevation to aim at the tower cab. This eliminated the need of constructing new line-of-sight equipment for each test.

Aerial view of Yucca Flat looking south. In the foreground is Sedan Crater. Measuring 320 feet in depth, it is the deepest crater on the Nevada Test Site.

Nevada Test Site Guide

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The Nevada Test Site Guide is published for the employees of the U.S. Department of Energy=s National Nuclear Security Administration Nevada Site Office (NNSA/NSO), its contractors, and members of the public. Forward all inquires and correspondence to NNSA/NSO Public Affairs, P.O. Box 98518, Las Vegas, Nevada, 89193-8518.
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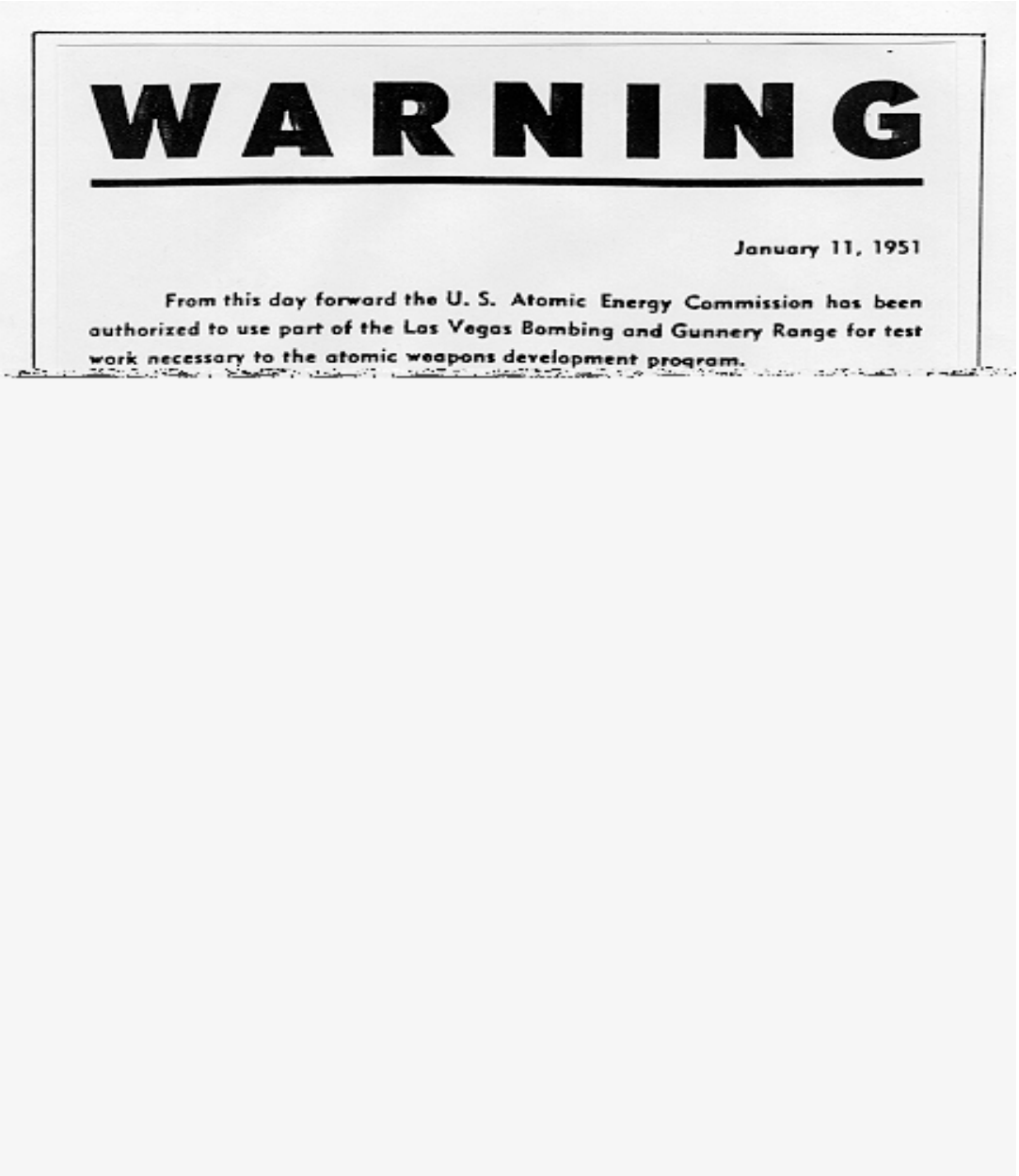
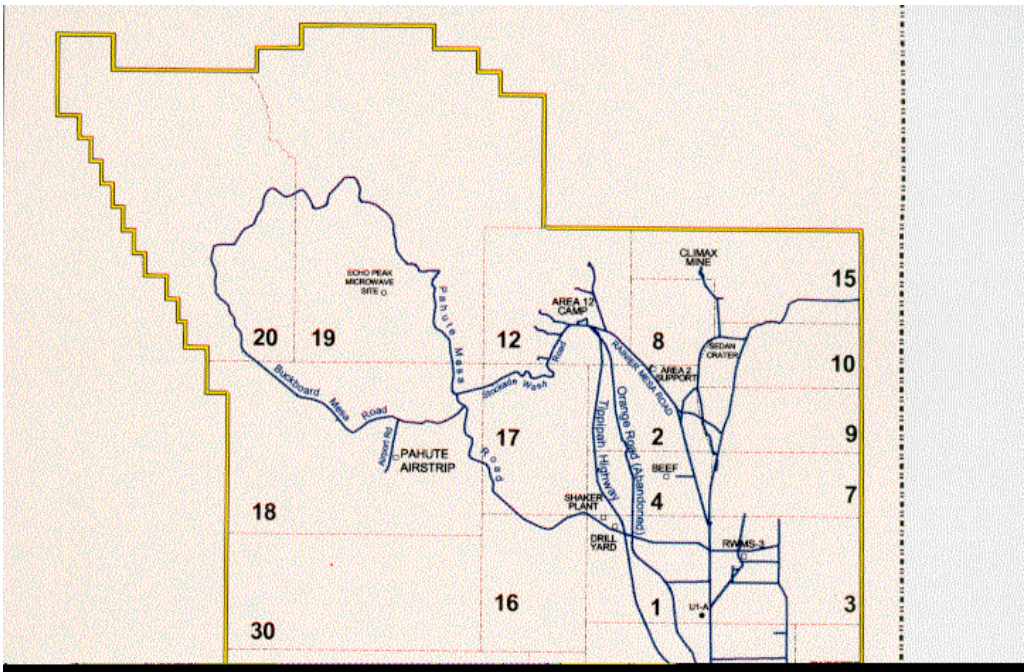


WARNING

January 11, 1951

From this day forward the U. S. Atomic Energy Commission has been authorized to use part of the Las Vegas Bombing and Gunnery Range for test work necessary to the atomic weapons development program.

This U.S. Atomic Energy handbill was distributed 16 days before the first nuclear device was detonated at the Nevada Proving Ground, now the Nevada Test Site.



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Nevada Test Site

The Nevada Test Site occupies about 1,375 square miles in southeastern Nye County, Nevada.

Aerial view of Frenchman Lake shows the remains of structures that were subjected to a series of atmospheric tests from January 1951 through July 1962.

Nuclear Tests Conducted at Frenchman Flat

The first atmospheric nuclear test at the Nevada Test Site took place on Area 5 of Frenchman Flat on January 27, 1951. The one-kiloton device called *Able* was dropped from an Air Force B-50 bomber. A total of 14 atmospheric tests took place on Area 5 of Frenchman Flat between 1951 and 1962.

The majority of the tests conducted on Frenchman Flat were weapons-related tests. The largest detonation was the 37-kiloton Priscilla device, which was detonated on June 24, 1957, while suspended from a balloon.

Industrial buildings, above-ground and below-ground community shelters, a railroad bridge, and a bank vault were exposed to several nuclear detonations from varying distances.

Frenchman Flat was selected for its flat terrain, which permitted good photography of the detonations and resulting fireballs.

Five underground nuclear weapons tests were also conducted on Area 5 of Frenchman Flat between 1965 and 1968.

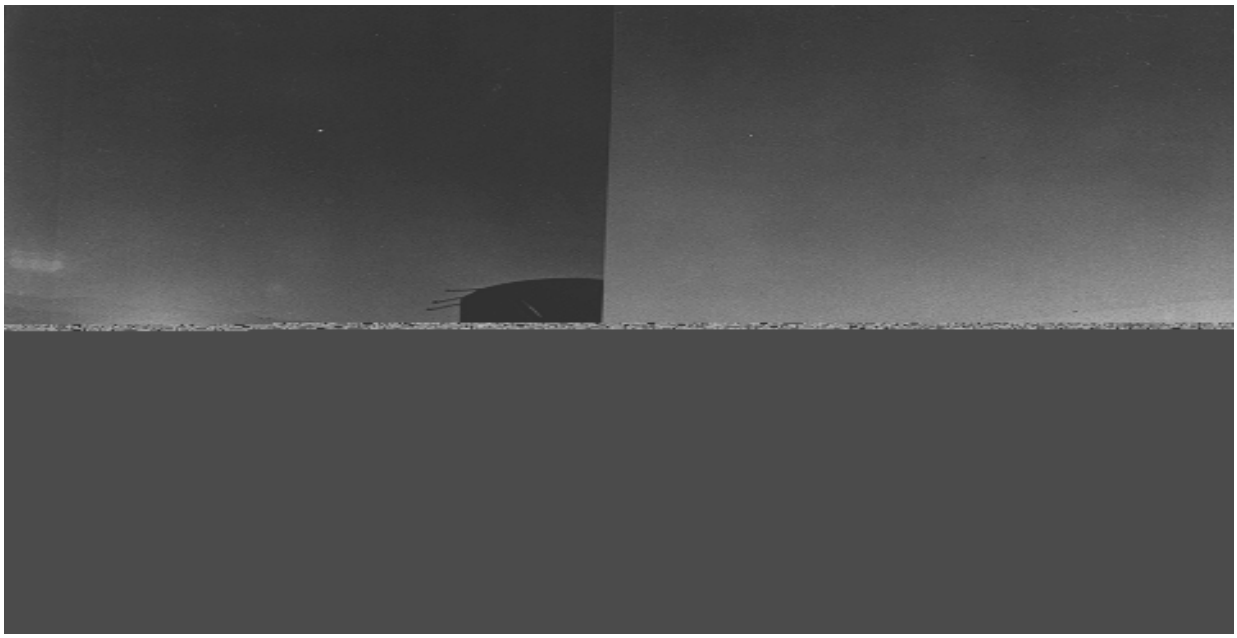
Frenchman Flat is about 75 miles northwest of Las Vegas. The 123-square mile dry lake bed is typical of great basin geology and is one of two such areas on the Nevada Test Site.

Ranger Series

Each test in this series consisted of an air-drop from a B-50 bomber belonging to the 4925th Special Weapons Group, Kirtland Air Force Base, Albuquerque, New Mexico.

Date	Name	Type	Yield
January 27, 1951	*Able*	Airdrop	1 kt

Airdropped from a B-50 bomber at 19,700 feet and detonated at 1,060 feet. This was the fourth atomic device to be airdropped. The preceding air drops were the 1945 combat bombings of Hiroshima (August 5) and Nagasaki (August 9) in Japan, followed by the June 30, 1946, 21-kt *Able* test at Bikini Atoll. *Able* was the first atomic device to be detonated at the Nevada Proving Grounds (Nevada Test Site).



Baker, an 8-kiloton device dropped from a B-50 bomber on January 28, 1951.

January 28, 1951	*Baker*	Airdrop	8 kt

Airdropped from a B-50 bomber at 19,700 feet and detonated at 1,080 feet.

February 1, 1951	*Easy*	Airdrop	1 kt

Airdropped from a B-50 bomber at 19,700 feet and detonated at 1,080 feet.

February 2, 1951 *Baker-2* Airdrop 8 kt

Airdropped from a B-50 bomber at 19,700 feet and detonated at 1,100 feet.

February 6, 1951 *Fox* Airdrop 22 kt

Airdropped from a B-50 bomber at 29,700 feet and detonated at 1,435 feet.

Tumbler--Snapper Series

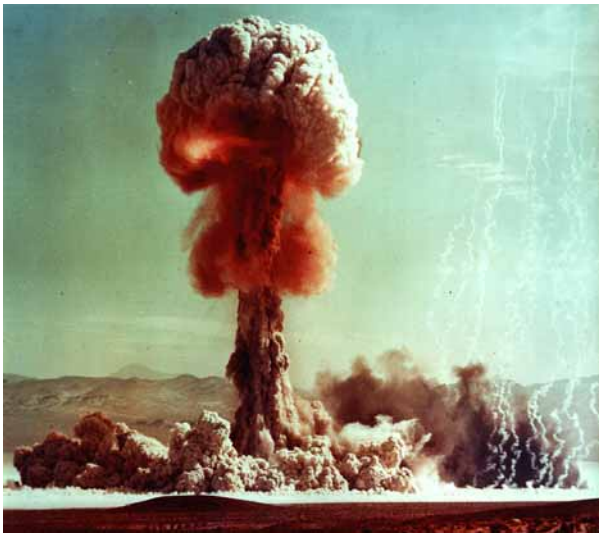
April 1, 1952 *Able* Airdrop 1 kt

Airdropped from a B-50 bomber at 22,135 feet and detonated at 793 feet.
Test series was for blast measurements, structure stress, biomedical, thermal measurements and effects, and long range detection of atomic blasts. Other blast tests were conduced in Areas 1, 3, 7, 9, and 10 at the Nevada Test Site.

Upshot--Knothole Series

May 8, 1953 *Encore* Airdrop 27 kt

Airdropped from B-50 bomber at 22,000 feet and detonated at 2,423 feet.
Tested reinforced structures and military fortifications (22 foxholes of various designs).



Grable, May 25, 1953

Priscilla, June 24, 1957

The 280 mm cannon that fired the first and last nuclear projectile at the Nevada Test Site is silhouetted against a mushroom cloud, the result of the 15-kiloton Grable test on May 25, 1953.

May 25, 1953 *Grable* Airburst 15 kt

Grable tested the strength of open-deck, single-track railroad bridges. Sixteen items of rolling stock were placed on small track sections. Army tanks, automobiles, boxcars, and a diesel locomotive were placed 285 to 1,246 feet from ground zero.

Two 280 mm cannons were emplaced for this test. Between May 15 and 25, several different conventional high-explosive practice rounds were fired. The actual atomic shell was fired by remote control and detonated 524 feet above Frenchman Flat. The cannon that fired the atomic shell is now on display at the U.S. Army Artillery Museum, Fort Sill, Lawton, Oklahoma. Three other cannons are on display at the National Atomic Museum, Albuquerque, New Mexico; Fort Riley, Kansas; and Aberdeen Proving Grounds, Maryland.

Teapot Series

April 15, 1955	*MET*	400-ft tower	22 kt

MET (Military Effects Test) consisted of shielding studies. Twenty structures were built in eight groups located at distances of 186, 213, and 260 feet from Ground Zero. Included were gun emplacements, seven shelters, two bunkers and two domes.

Also tested were various items of engineering equipment and cargo containers. In addition, American, Russian, and Chinese protective clothing designed to combat the effects of thermal radiation was tested. Mannequins fitted with chemical warfare gas capes were placed at each of three test stations established at 5,094 feet, 8,091feet, and 11,055 feet from ground zero.

Plumbbob Series

Date	**Name**	**Type**	**Yield**
June 24, 1957	*Priscilla*	700-ft. Balloon	37 kt

Numerous structures were tested, including shelters of French and German design, and a bank vault built to the specifications of the Mosler Safe Company, San Francisco. *Priscilla* was a weapons-related test.

Operation Hardtack II

October 15, 1958	*Hamilton*	50-ft Wood Tower	1.2 tons

Weapons-related. Measured and evaluated damage to jeeps, M-48 tanks, and M-59 Armored Personnel Carriers 90 meters from ground zero.

October 22, 1958.	*Wrangell*	1,500-ft. Balloon	115 tons

Weapons-related. Tested equipment for measuring flash and electromagnetic impulses.

October 26, 1958.	*Sanford*	1,500-ft Balloon	4.9 kt

Weapons-related. Diagnostic experiments.

Operation Storax

July 14, 1962	*Small Boy*	10-ft. Tower	Less than 20 kt

Weapons-effects test to provide information on electromagnetic pulse effects.

Small Boy was the last atmospheric test to be conducted at Frenchman Flat. The last atmospheric test to be conducted at the Nevada Test Site was *Little Feller I* on July 17, 1962.

Underground Tests

Operation Whetstone

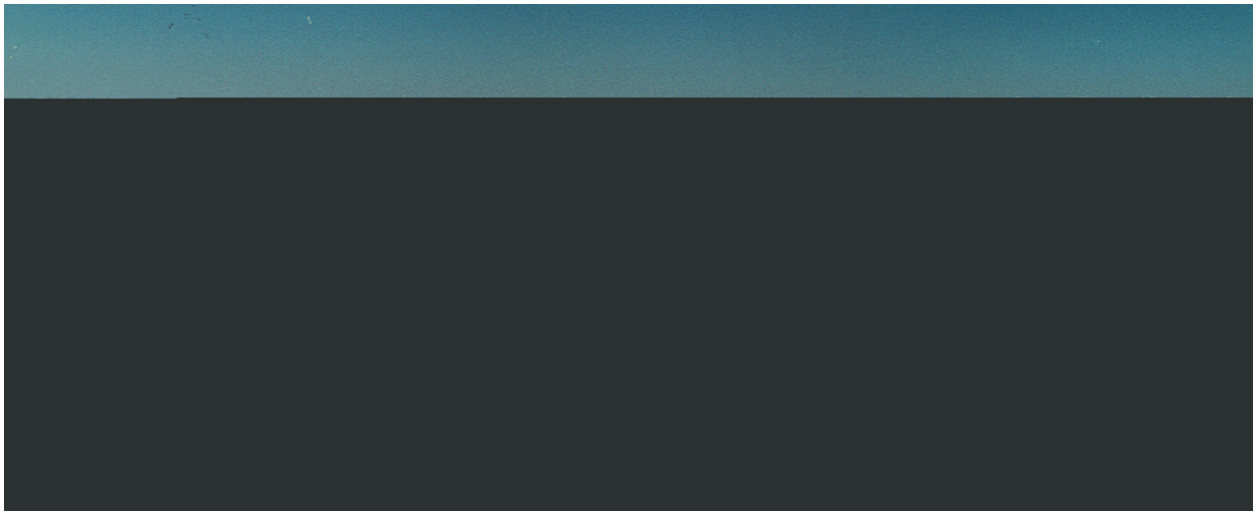
Date	Name	Type	Yield
February 18, 1965	*Wishbone*	Shaft	Less 20 kt
May 14, 1965	*Cambric*	Shaft	750 tons
June 16, 1965	*Diluted Waters*	Shaft	Less 20 kt

Operation Latchkey

September 12, 1966	*Derringer*	Shaft	7.8 kt

Operation Crosstie

March 25, 1968	*Milk Shake*	Shaft	Less 20 kt



These wooden bleachers were not always empty. From 1951 to 1962, VIPs observed the detonation of 14 atmospheric tests on Area 5 of Frenchman Flat.

VIP Bleachers *located to the left and right of the Mercury Highway, north of Gate 200.*

Located seven miles from Frenchman Flat. A host of politicians, military leaders, and distinguished VIPs observed the detonation of 14 atmospheric tests in Area 5 from these wooden benches.

Grable Cannon Site *located to the right of Mercury Highway about one mile north of Gate 200.*

On May 25, 1953, a 15-kiloton artillery projectile was fired by remote control from a 280 mm cannon by members of a gun battery from A Battery, 867th Field Artillery Battalion, Fort Sill, Oklahoma. The shell exploded 524 feet above Frenchman Flat. More than 2,500 military personnel and 700 observers participated in the test. It was witnessed by hundreds of high-ranking Armed Forces officers and over a hundred members of Congress. Included in the list of observers was Secretary of National Defense Charles E. Wilson and designated Chairman of the Joint Chiefs of Staff Admiral Arthur W. Radford. Prior to the actual firing, two cannons conducted a test by firing several different conventional artillery shells. The original cannon is now on display at the Fort Sill Artillery Museum, Lawton, Oklahoma. Three others can be found at the National Atomic Museum, Albuquerque, New Mexico; Fort Riley, Kansas; and the Aberdeen Proving Grounds, Maryland.

Short Pole Road *located on 5-01Road.*

The 5-01 Road was once called "Short Pole Road." Along this road in the 1950s, telephone poles were approximately 12 feet high. Due to an oversight by an Army Signal Unit, it did not send enough poles. Workers cut the poles in half to have enough poles to string the lines.

Gravel Gertie as it looked on shot day, November 20, 1982.

Gravel Gertie, as it looks today.

Gravel Gertie Site *located on 5-01Road.*

The association of nuclear material with explosive material has always posed a safety problem. In the case of an accidental conventional explosion, one would have to contend with blast damage; in addition, there would be the possibility of uranium or plutonium contamination.

In order to minimize contamination in the event of such an accident, Sandia National Laboratories designed a special structure known as the "Gravel Gertie." In 1957, three full-scale mock-ups of this structure were built and tested at the Nevada Test Site, followed by a fourth test in 1982 using 423 pounds of high explosive.

The distinctive feature of the Gravel Gertie structure, which was designed by Mason Hanger Silas-Mason Co., Inc., is the 15-foot gravel covering which was used instead of a solid conventional roof. The gravel was supported by steel cables which were strung from reinforced two-foot-thick concrete walls through a central steel spider support. Layers of steel wire mesh were used in addition to contain the gravel. In the event of a detonation, in association with nuclear materials uranium or plutonium within the structure, the gravel would be lifted and then fall back, filtering most of the nuclear material from the escaping gases in the process, thus preventing the escape of radioactive particles into the atmosphere.

The white poles around the bunker contained instrumentation to measure releases of the surrogate materials used in the test. In addition, five large balloons were attached by cable around the bunker for wind direction, and the top of the cell was painted red for photographic purposes. Today, there are seven Gravel Gertie cells in use at the Pantex Plant, Amarillo, Texas, and five have been incorporated into the Device Assembly Facility *(Article, Page 33*).

HAZMAT (Hazardous Material Spill Center) *located at Frenchman Flat.*

The $7.9 million *HAZMAT Spill Center* was completed in 1986. The first test was conducted on August 4, 1986, for *Amoco Oil Company*. It was one of six conducted that year for *Amoco* to gather data for selecting and validating models for predicting the movement of hydrofluoric acid vapors in the atmosphere.

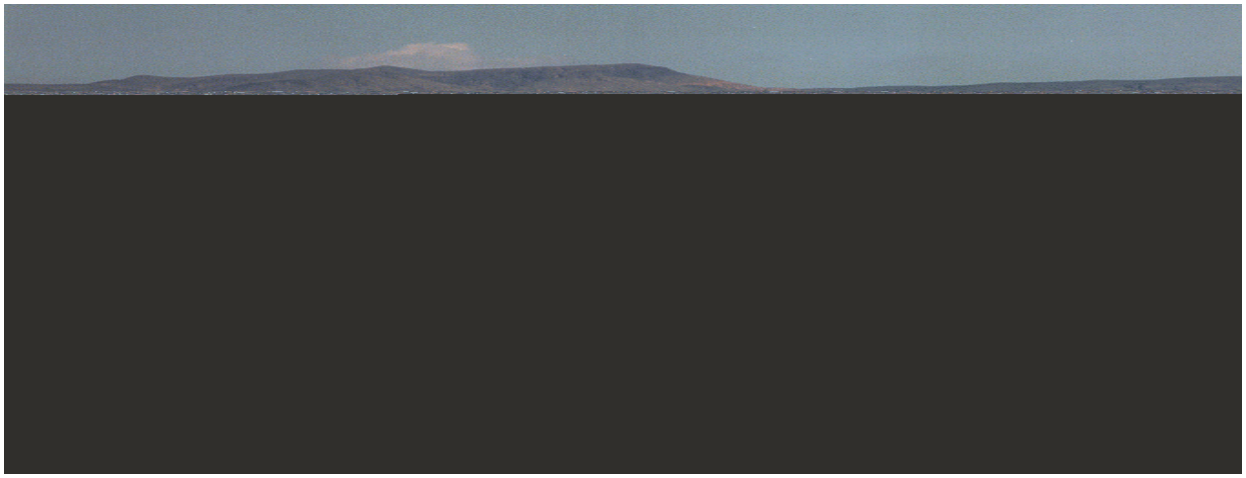
In addition to *Amoco*, other customers have included *Mobil Oil, Allied Signal, Gas Research Corporation, Chubb National Foam Inc., ANSUL Corporation, Silicone Health Council, Dow Chemical, DuPont Speciality Chemicals, Desert Research Institute, Western Research Institute, Lawrence Livermore National Laboratory, Environmental Protection Agency,* and the *U.S. Department of Defense.*

Congress directed the U.S. Department of Energy to construct the Spill Center and develop agreements for governmental agencies and industry to conduct tests there on a user-fee basis.

Tests are directed at:

- Understanding the physics of spill dispersion.
- Minimizing spill effects.
- Clean-up technology and procedures.
- Mitigating spill effects, as well as training personnel in how to negotiate a spill or release of materials.
- Testing encapsulated suits for emergency responders.

Aerial View of the HAZMAT Spill Center.



HAZMAT Spill Center wind tunnel in operation.

The facility consists of a control building *(located one mile west of the Spill Center)* housing data acquisition and recording instruments, a command and control computer, and support personnel. The test area consists of a tank farm, spill pans, and various tanks used for storage of the test chemicals. Two 12-inch diameter insulated lines and one six-inch diameter insulated line extend 500 feet from the tank farm to a point where fluids are spilled for testing. Cryogenic fluids are placed in one or both of the 28,000-gallon dewar storage tanks.

Cool liquid is pressure-forced from the tank(s) to the spill area through one or more of the 500-foot long pipes. Noncryogenic liquids (such as ammonia and chlorine) are transported as liquids and placed in a 26,000-gallon tank until forced through the spill lines. Spill rate and duration, as well as test condition parameter checks, occur under computer control from the control building. About 700 channels of data originating at remotely located sensors are recorded.

Chemicals tested have included hydrofluoric acids, silicon tetrachloride, gaseous chlorine, sulfur dioxide, liquefied natural gas, propane, and fuming acids, to name just a few.

Other points of interest include:

- A wind tunnel, built at a cost of $1.2 million by a consortium of users and manufacturers of the facility. It is 96 feet long, 16 feet high and 8 feet wide. Scientists are able to control the temperature and humidity effects on chemicals.
- The large concrete pads are used for tests on the effects of certain types of foams on hazardous materials.
- Safety suit testing facility.

Tests occur year-round, however, weather conditions April through September are usually the most favorable.

The HAZMAT Spill Center was re-designated as the Nonproliferation Test and Evaluation Complex in 2005.

Atmospheric Test Relics

AThere is no evil in the atom, only in men=s souls.@
Adlai Stevenson, September 18, 1952

Frenchman Flat is home to a large number of aboveBground and belowBground structures that were exposed to nuclear blasts during the period of atmospheric testing. *Operation Upshot-Knothole* and *Operation Plumbbob* were operations where many different structures were tested. In some cases such as the *Encore* and *Grable* tests, structures were subjected to more than one blast. Mines, parked aircraft, railroad equipment, field fortifications, and military vehicles were also subjected to the tests in Frenchman Flat, in addition to the 80 other atmospheric tests that were conducted in Yucca Flat.

For the 1953 *Upshot-Knothole* series *Encore* and *Grable* tests, the soil was stabilized to minimize dust clouds and to improve motion picture photography. About 700,000 square yards of two-inch thick sand-cement mat was laid 2,000 to 12,000 feet from the ground zeros. In addition, 3,000 square yards of the area was sprayed with sodium silicate to stabilize the mounded-over portions of the buried structures.

It should be noted that the Federal Civil Defense Agency, the U.S. Department of Agriculture, the U.S. Forest Service, and the U.S. Army, Navy, and Air Force, in conjunction with the Armed Forces Special Weapons Project, were sponsors of the tests.

Pig Pens -- Several wire mesh holding pens designed to hold pigs were used to test fabrics and materials exposed to the heat generated by nuclear explosions.

Several pig pens collectively named the *Pork Sheraton* were home to 1,200 swine in 1957. The pens were located near Burma Road, to the left of the Mercury Highway. The Cheshire, Hampshire and Landrace sows were especially bred for the military and were purchased from farmers in the Trimble, Missouri, area. The swine were, at that time, considered the most pampered pigs in America, costing about 25 1956-dollars a head. During their stay at the *Pork Sheraton*, they received highly-specialized care.

The project director for the test was Lt. Col. Gerald M. McDonnel of the U.S. Army Medical Corps. For the *Encore* test, 55 pigs were used. Forty-four of the anesthetized animals were dressed in clothing of various materials and exposed in eight pens located 2,310 to 9,075 feet west southwest of ground zero. The remaining 11 pigs were placed at three stations in cylindrical aluminum containers with fabric-covered portholes.

Swine which underwent medical care experiments during Operation Plumbbob are photographed at the Pork Sheraton pig pens at Frenchman Flat by Lookout Mountain Laboratory cameramen.

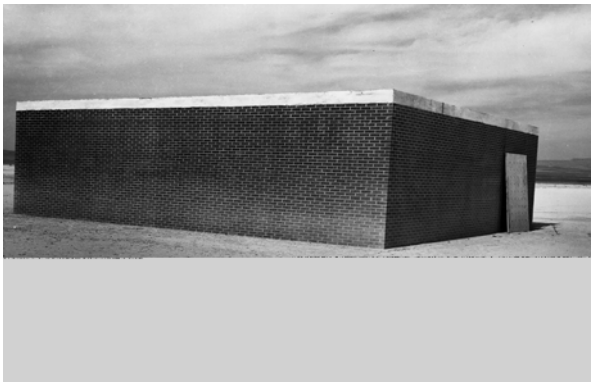
\

For the *Priscilla* test, medical personnel from Walter Reed Army Hospital used 719 pigs to investigate the effects of nuclear detonations on pigs in an attempt to define more specifically the effects on humans. The pigs were placed at 11 stations located 2,607 to 9,405 feet from ground zero.

A 25-pound shoat is removed from an aluminum barrel by SSgt Nathaniel Morgan, 47th Field Hospital, Fort Sam Houston, Texas. The containers were positioned at various distances from ground zero to measure radiation doses.

One of several pig enclosures at Frenchman Flat.

For the Encore test, 11 pigs were placed in cylindrical aluminum containers with fabric-covered portholes. Altogether there were three stations located on Frenchman Flat.



Windowless modular structure before the Priscilla test.

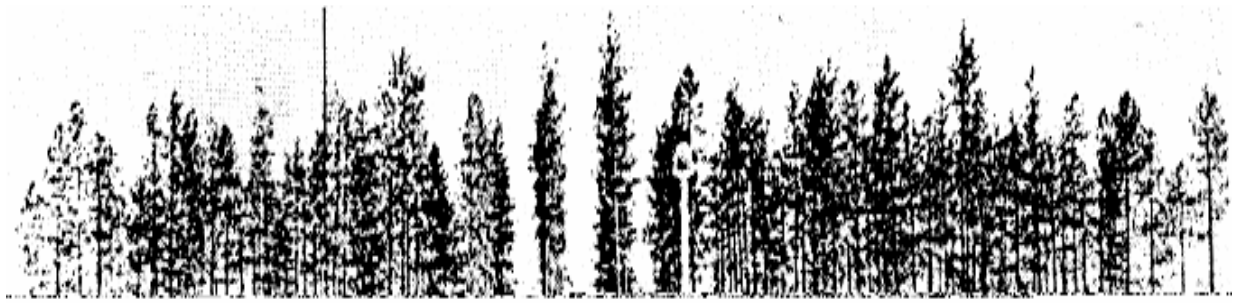
Windowless modular structure after the test. Notice the displacement of the wall.

Windowless Modular Structure -- This brick masonry structure (shelter) was built for the June 24, 1957, *Priscilla* test. The walls of the 32-foot by 28-foot building consist of two layers of brick with reinforcing steel in the center, forming a thickness of 10 inches. The flat roof is reinforced concrete. The blast from the nuclear test displaced the wall facing ground zero (east side) about one-quarter of an inch.

One of the industrial buildings (motels) shortly after it was exposed to the 1953 Encore test.

Industrial Buildings -- Test structures, nicknamed *Motels*. These were built to test various construction techniques and materials for *Blast Effects Upon Curtain Walls and Partitions of Masonry and other Materials*.

Eight-inch and twelve-inch reinforced and unreinforced concrete and cinder block panels were used to build the walls, which were designed to survive overpressures of 1 to 5 pounds per square inch. The front test walls (west) were strung with gauges and measured an overpressure of 20 pounds per square inch from the tests. In addition, standard commercial materials were used to build doors. Anti-blast valves (round objects on wall) were tested for shelter ventilation openings. The buildings were built for the May 8, 1953, *Encore* test, and were later modified for the June 24, 1957, *Priscilla* test.



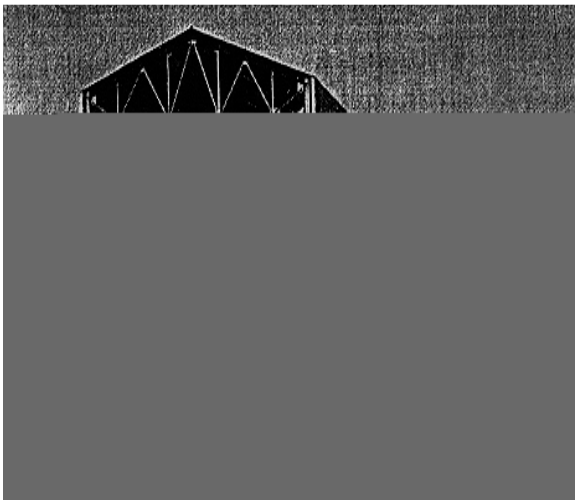
Artists rendering of the Ponderosa Pine grove prior to the Encore test in 1953.

Coniferous Tree Stands -- The U.S. Department of Agriculture and U.S. Forest Service, in conjunction with the U.S. Department of the Army, placed 145 Ponderosa Pines in a grove covering 160 x 320 feet, 6,500 feet from the *Encore* ground zero. The trees were subjected to 0.52 pounds per square inch of overpressure. Average tree height was 51 feet and the average tree base diameter was 15 inches. The trees were taken from forest reserves near the test site and were used to study the effects of a nuclear explosion over a forested area. The trees were cemented into concrete blocks eight days before the May 8, 1953, *Encore* test. Additional trees were positioned in two lines ranging from about 5,000 to 8,052 feet from ground zero.

Three of five boiler plate cylinders exposed to the Encore test.

This 20-foot cylinder was located 6,280 feet from the Encore ground zero

Metal Cylinders -- Five 3/8-inch boiler plate cylinders were exposed to the *Encore* and *Grable* tests at two locations 3,927 and 4,818 feet from ground zero. The large 20-foot cylinder was located 6,280 feet from ground zero. Thirty air pressure and 10 strain gauges were placed on the cylinders. Purpose was to gain knowledge of blast effects on cylindrical structures. An overpressure reading of 4.6 pounds per square inch was recorded.



A drag type Butler building prior to the April 1955 MET (Military Effects Test).

The same building as it looks today.

Full-Scale Industrial Buildings -- Also called Butler (hanger) buildings. Four structures were built for the *Met (Military Effects Test)* test. Two were of the drag type: the roofing and siding were fragile/breakable corrugated asbestos sheets. Two were of the semi-drag type: buildings with reinforced concrete side walls and corrugated asbestos roofing. All four had the same steel frames: 30 feet in overhead height and spans of 40 feet. The two drag type buildings were located 3,600 and 4,350 feet from ground zero, and the two semi-drag structures were 5,000 and 5,750 feet from ground zero. The four buildings were modified for the 1957 *Priscilla* test.

Open Frames Structures (Railroad Trestles) -- The U.S. Army=s 412th Engineer Construction Battalion erected five structures which duplicated the center sections of open-deck, single-track truss railroad bridges for the *Encore* and *Grable* shots. The structures were built for *Testing the Loading of Truss Systems Common to Open Frames Structures,* and were subjected to 22 pounds per square inch of overpressure. The trestles were positioned between 2,211and 2,343 feet northwest of ground zero. Strain gauges were placed on the foundations of the structures. All of the remains have been removed except for the remaining structure, which was severely damaged. The middle two steel beams were subjected to 450 pounds per square inch of dynamic overpressure (the air pressure behind the shock front of the blast wave).

Four open frames structures are readied for the Encore test. The single-track railway bridge at the far left still remains today, minus its upper framework. The structure was 2,200 feet from the Encore ground zero.

Open frames structure today.

Open frames structure after the Encore test.

Entrance to the underground garage/shelter as it appeared in 1957.

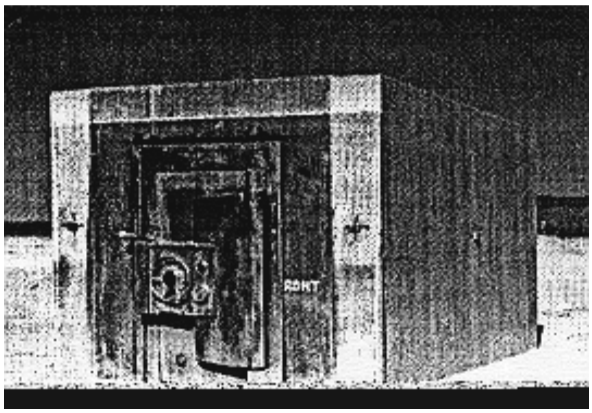
Garage/Shelter -- Underground dual-purpose garage and mass shelter, built for the Federal Civil Defense Administration at a cost of $200,000. The shelter was constructed under three feet of earth with a reinforced concrete roof slab two feet, six inches thick, and the huge room measures about 90-feet square. A four-foot-thick reinforced 100-ton concrete blast door was also installed. The garage was subjected to 30 pounds per square inch of overpressure.

Garage/shelter entrance as it appears today.

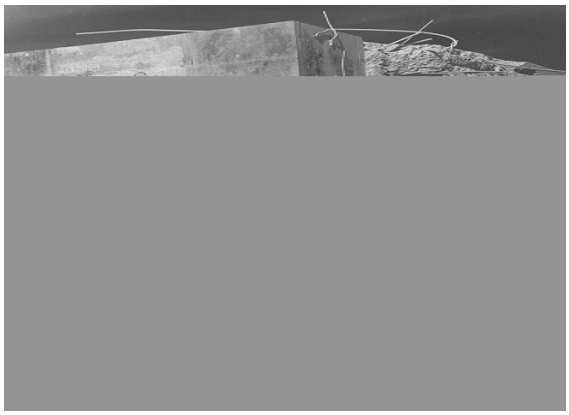
Interior view of the 90-feet square dual-purpose garage and mass shelter.

Mosler bank vault. Bottom left photo shows the vault prior to the 1957 Priscilla test. The above and bottom right photo show the effect of the blast on the vault directly after the test.

Bank Vault -- The *Mosler Safe Company*, San Francisco, California, designed a 12 foot by 8 foot by 8 foot reinforced concrete vault with a standard 10-inch thick safe door modified to resist high intensity loads. The steel door was mounted on a steel box frame weighing 14½ tons. It was designed as part of the *Response of Protective Vaults to Blast Loading* program. The vault was located for testing at a side-on overpressure of 75 pounds per square inch. The actual overpressure it received from the *Priscilla* test on June 24, 1957, was 70 pounds per square inch. Trim on the steel door facing ground zero was loosened by the blast, but the operation of the massive steel door (since removed) was not impaired. The safe was part of a Civil Defense project to protect vital records and valuables.

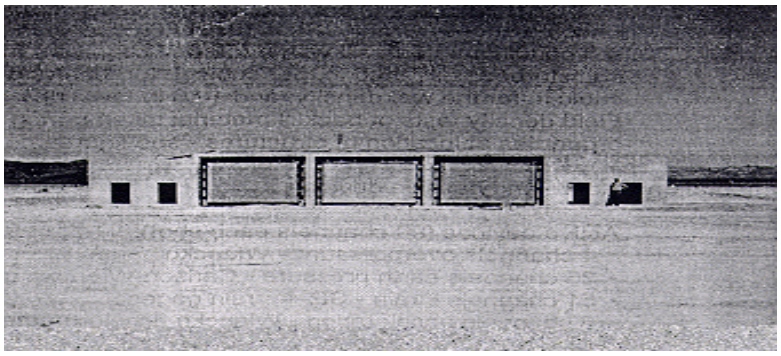


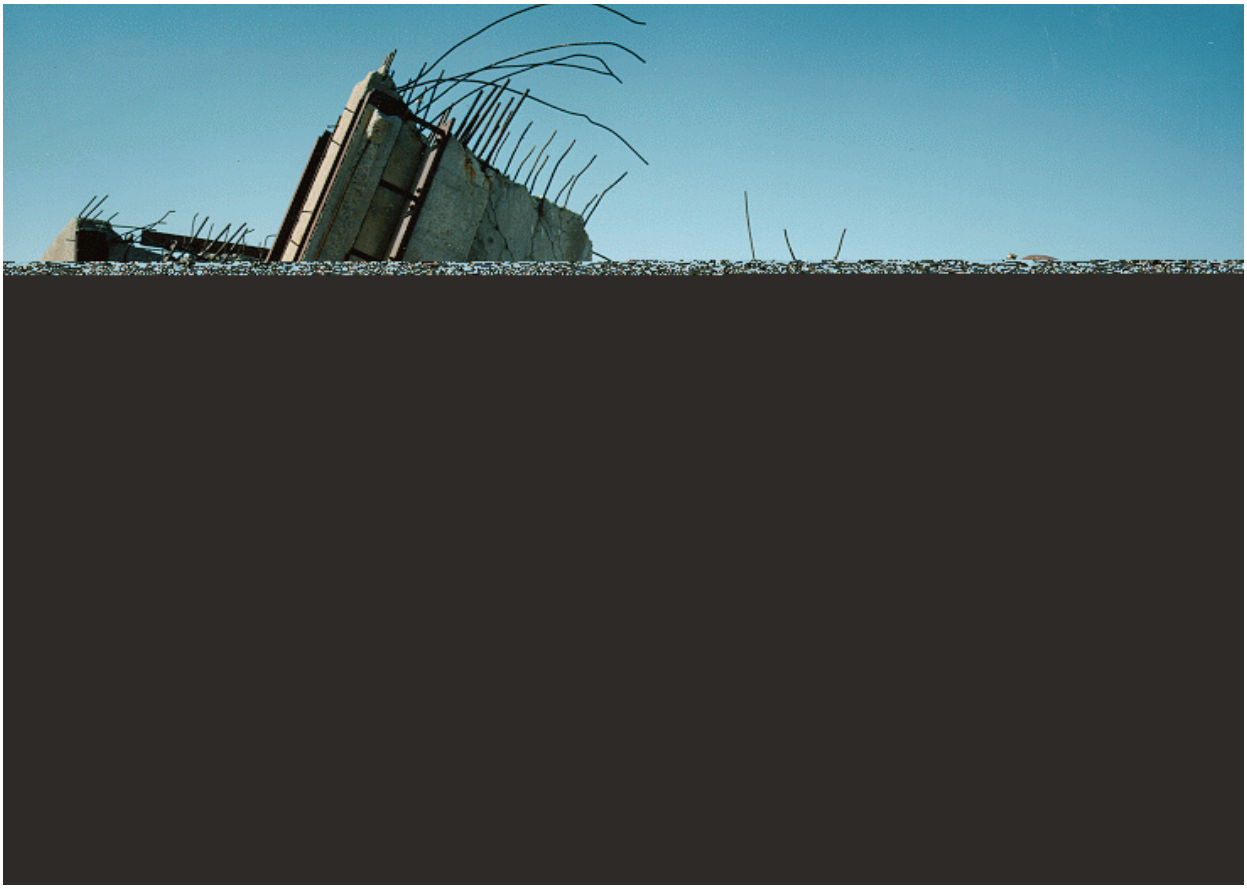
Before



After

Before the blast . . .

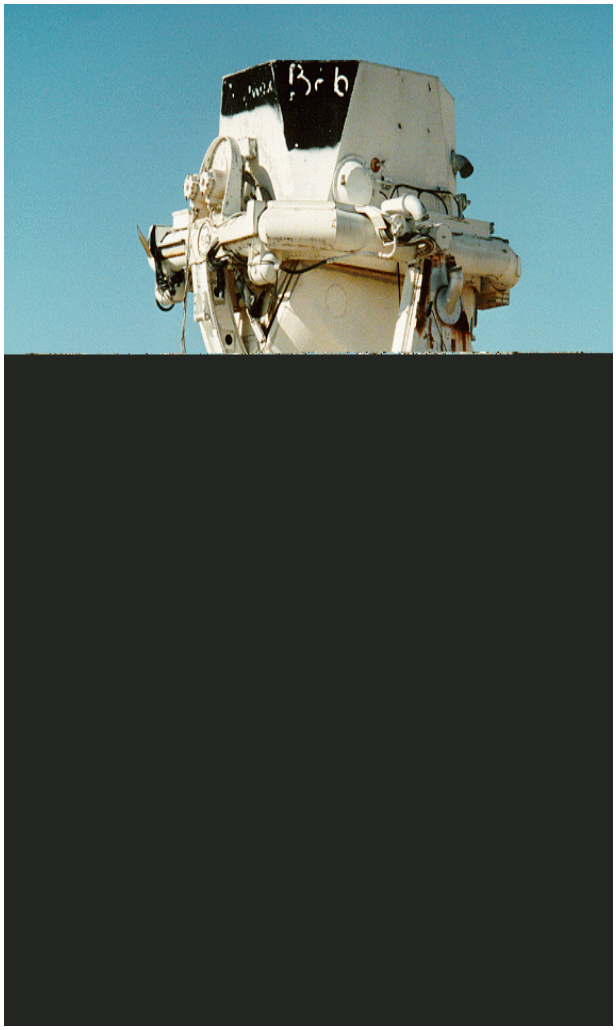




. . . and after

'Before' and 'after' views of one of several concrete structures that were exposed to the 1957 Priscilla test.

Concrete Structure -- Located northeast of the railroad trestle, this structure was designed for *Tests on Response of Wall and Roof Panels and the Transmission of Load to Supporting Structure.* The concrete structure, which consisted of several reinforced concrete test cells that supported wall and roof panels, was previously subjected to the blasts from the 1953 *Encore* and *Grable* tests.



Isolated from the sea

Gun Direction Tower B Originally used at Yucca Flat during atmospheric testing; later, it was moved to Frenchman Flat. Collimating detectors (systems) were placed inside the tower to collect data for diagnostic purposes, which required precise positioning for direct line of sight.

Hot spot

***MET (Military Effects Test)* Ground Zero** Shown is one of three steel anchors that held the guide wires to support a 500-foot tower for the *MET* test. In the background can be seen the concrete pad on which the tower was placed prior to the April 15, 1955, 22-kiloton test.

Entrance to one of the concrete domed shelters as it appeared in 1957.

A collapsed six-inch thick concrete dome.

Domed shelters B Ten concrete and two aluminum shelters and their blast doors were tested to withstand various blast forces. The 50-feet diameter concrete domed shelters were two-feet thick (still intact) and six-inches thick (partially collapsed). The domes were subjected to 70 and 40 pounds per square inch of overpressure, respectively. The aluminum domes (both crushed) were 20 feet in diameter and one-inch and one-half-inch thick. The shelters were designed and built by American Machine and Foundry Company for the national shelter program and were subjected to the *Priscilla* test. Instrumentation was conducted by Ballistic Research Laboratories and the Armor Research Foundation.

One of two collapsed aluminum shelters.

One of nine shelters sponsored by the former West German government. The main room had a capacity of 25 people. At the left foreground is the location for the stairwell and main blast door. The shelter measured 9 feet by 21 feet by 7 2 feet. The walls and roof were two feet thick.

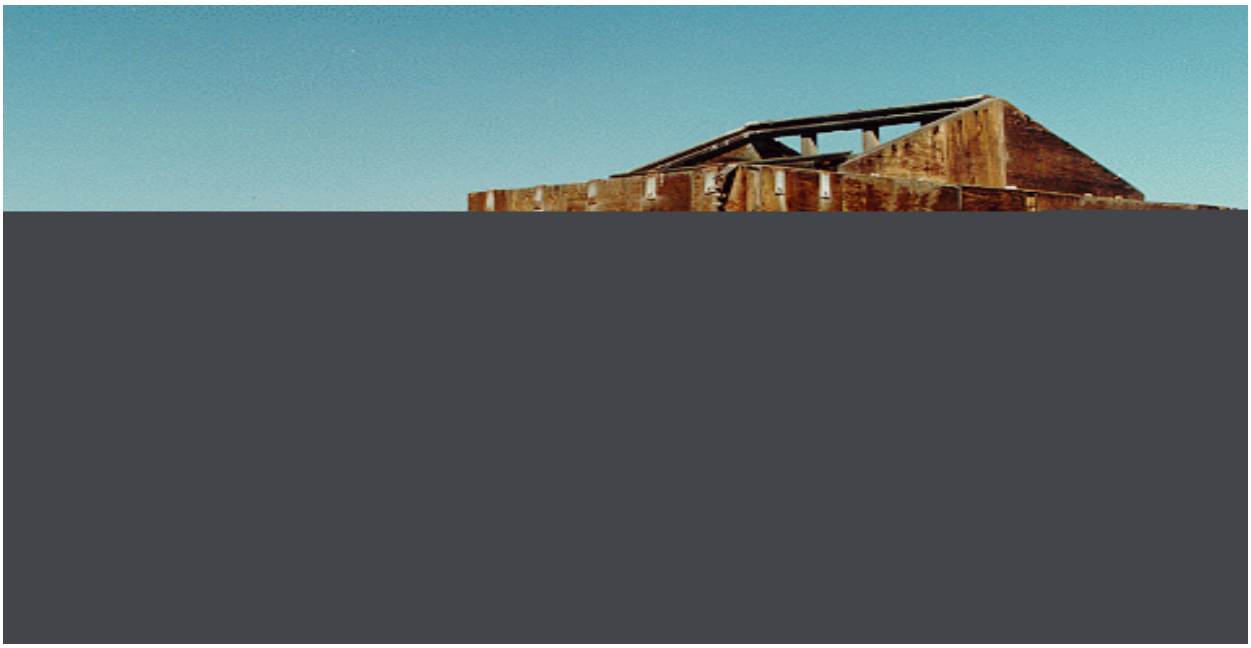
Community Shelters -- The Federal Civilian Defense Administration sponsored tests on 14 French and German designed and financed shelters which cost from $1,500 to $3,000 to build. The shelters were subjected to overpressures ranging from 75 psi to 200 psi during the *Encore* and *Priscilla* tests. Because they were more elaborately designed than comparable American structures, they were exposed to higher overpressures.

Launch site

This reinforced concrete structure was used to hoist nuclear devices attached to helium-filled balloons. The balloons were capable of lifting upwards of two-and-a-half tons to an altitude of 1,500 feet.

These three window frames bear bleak testimony to the force of the atom. Glass fragments still litter the desert landscape from the 1957 Priscilla test.

Freestanding Windows -- Several groups of window frames were erected at varying distances from the *Priscilla* ground zero. They tested the effects of atmospheric blast on different window designs and glazing thickness.



Glass House -- Located to the south of the Hazardous Materials Spill Center Control Room, this structure was built to determine the blast effects on glazing and window construction, and to assess the problem of flying glass, from the February 1, 1951, *Easy* test.

Other Sites of Interest

Standing guard: although a variety of military equipment was exposed to the ravages of the atom in Frenchman Lake, this M-47 tank is a relative newcomer to the area.

U.S. Army Tank -- This M-47 tank was used as a target for testing armor-piercing artillery rounds (depleted-uranium tipped) in Area 5.

Sugar Bunker *located to the left of 5-01 (Short Pole) Road.*

The bunker was used for various experiments during the voluntary nuclear testing moratorium (October 31, 1958 - September 15, 1961) implemented by President Dwight D. Eisenhower.

Cambric Research Site *located to the west of 5-01 (Short Pole) Road, south of 5-07 Road.*

A 750-ton underground nuclear test named *Cambric* was conducted in alluvium (sand and gravel) at this site on May 14, 1965. A companion test, *Cheshire*, was conducted on Pahute Mesa volcanics on February 14, 1976. Both were conducted for special studies into the movement of groundwater. For the *Cambric* test, scientists drilled a well 300 feet from the ground zero and, during a period of 16 years, pumped four billion gallons of water to force radioactive elements to move out of the cavity made by the *Cambric* test. It took two years of continuous pumping to move tritium 300 feet from the cavity to the well. Although 98 percent of the tritium concentration was in the *Cambric* cavity, the maximum level ever detected at the sample well was less than a tenth of a percent. Radioactive elements such as strontium-90, cesium-137, plutonium, and uranium were never detected during pumping activities.

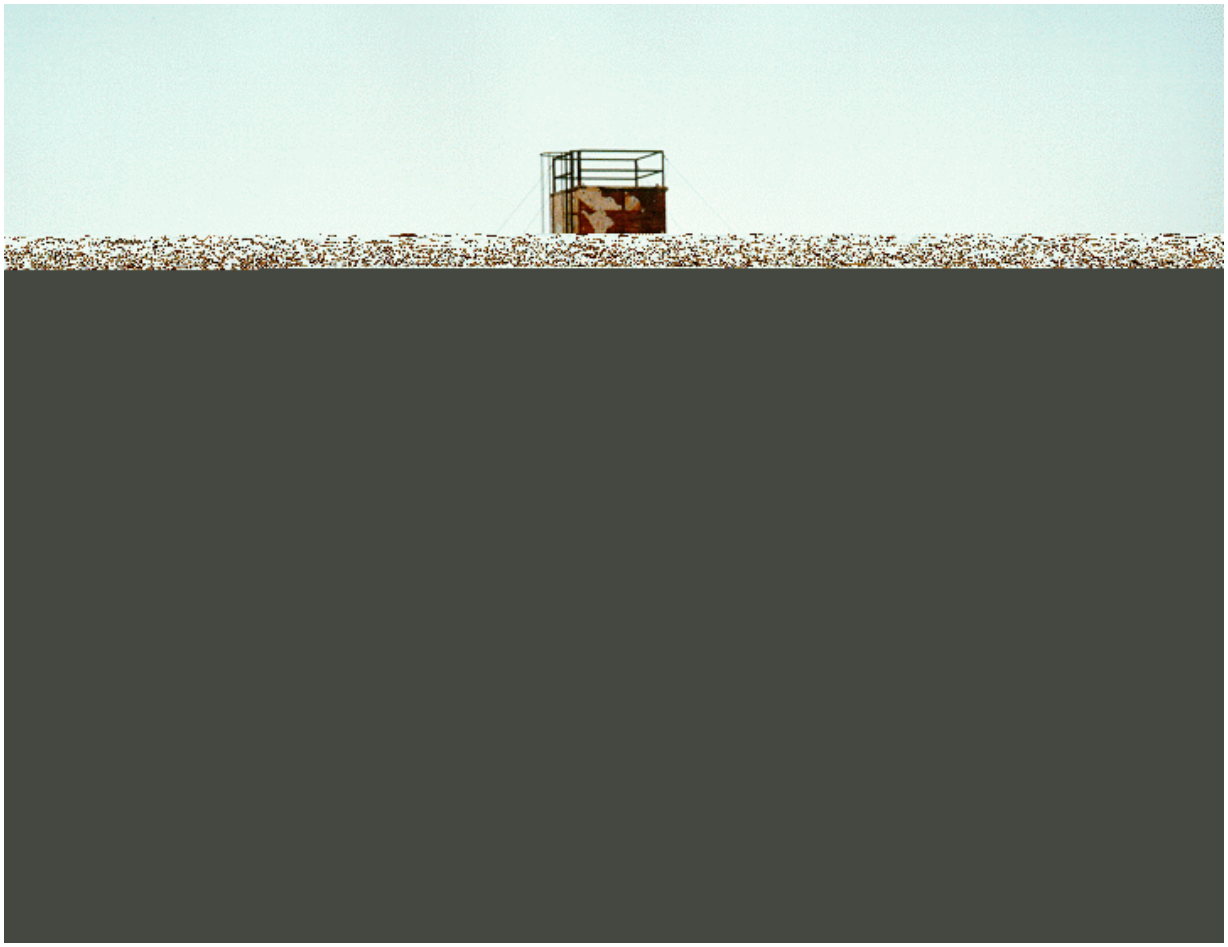
FACE (Free Air Carbon Dioxide Enrichment) Facility *located east of 5-01 (Short Pole) Road.*

FACE (Free Air Carbon Dioxide Enrichment) Facility

This state-of-the-art facility uses FACE technology developed by scientists to create 21ST- century atmospheric conditions in an otherwise natural environment 24 hours a day, 365 days a year.

Facility and students from Nevada=s three research institutions (University of Nevada, Las Vegas; University of Nevada, Reno; Desert Research Institute) and scientists from all over the world are using the facility to study the impact of rising atmospheric carbon dioxide on the desert, the dominant terrestrial ecosystem on Earth.

Ship of the Desert *located in the northeastern part of Frenchman Flat.*



This structure containing experiments was placed above the Diagonal Line underground test. A line-of-site pipe extended from where the nuclear device had been buried underground into a experimental chamber within this housing. At the time of the detonation, fast-acting closure doors prevented the explosive debris from the less-than-20-kiloton test from entering the experimental chamber.

Atmospheric Test Vehicle Graveyard

Located on the western edge of Area 5

Several automobiles and military vehicles are located in this area. The odometers have been melted and traces of melted trinatite still remain on the vehicles. It is not known which test they were exposed to, however, the automobiles were probably used at one of the Civil Effects tests, i.e., Annie or Apple-2.

Area 5 Radioactive Waste Management Site *located on 5-01 Road.*

The Area 5 Radioactive Waste Management Site is where low-level radioactive wastes are managed and disposed. Activities include the disposal of low-level radioactive waste, the storage and disposal of mixed low-level radioactive waste, the storage of transuranic wastes, and the storage of non-radioactive hazardous waste. The water table is approximately 800 feet below ground surface.

Aerial view of the Area 5 Radioactive Waste Management Site.

Low-Level Wastes -- These are generally only slightly radioactive and usually do not require shielding or heat removal. The wastes are packaged in metal or wooden boxes or steel drums. Historically, about 56-percent of the low level waste has come from off-site generators.

Mixed Waste -- The Nevada Test Site has 280,000 cubic feet of mixed waste disposed of in a shallow burial pit. It is called mixed waste because it contains amounts of both hazardous and radioactive materials. The waste in the past was shipped primarily from DOE's Rocky Flats Plant, near Denver, Colorado, but receipts from Rocky Flats were halted in 1990. At the present time, the NTS is allowed only to dispose of mixed waste that is generated through activities that are on or related to the NTS, and the waste must meet all land disposal restrictions.

Transuranic Waste -- These wastes are contaminated with radioactive isotopes having an atomic number greater than uranium (above 92). They are defined as wastes contaminated with alpha-emitting radionuclides with half-lives greater than 20 years and concentrations exceeding 100 nanocuries per gram of waste. Approximately 22,000 cubic feet of TRU waste is stored in 1,637 steel drums and 58 metal boxes inside a covered building on an impervious asphalt pad. The waste must be characterized and will then be shipped to the DOE=s Waste Isolation Pilot Plant in New Mexico for disposal.

Hazardous Waste -- Constructed in 1990, the Hazardous Waste Storage Unit provides a state-approved temporary (less than 1 year) storage area where hazardous wastes are prepared for shipment to licensed commercial facilities for recycling, incineration, or disposal when appropriate. Hazardous wastes are non-radioactive materials such as paints, chemicals, fuels, and other items that must be disposed of properly.

Greater Confinement Disposal -- Low-level radioactive wastes that required remote handling or contained highly mobile isotopes, such as tritium, were placed in deep bore holes 120 feet below the desert surface. However, since 1989, greater confinement disposal has not been practiced at the Nevada Test Site. The existing boreholes are being studied to determine the best method for closure or remediation.

A typical low-level radioactive waste storage pit.

Device Assembly Facility (DAF) *located to the west of Mercury Highway in Area 6.*

Design work for the DAF began in 1984, after Congress authorized the $100-million project to replace aging assembly facilities at the Nevada Test Site. Construction began in 1988 and was completed in 1990. Installation of sophisticated safety and handling equipment continued into late 1995. On September 1998, the DAF began operations.

Device Assembly Facility

For decades, nuclear weapons testing was the primary mission of the Nevada Test Site. The Nevada Operations Office (now Site Office) was charged with conducting the nation=s nuclear testing program in a safe, secure, and efficient manner, in full compliance with federal and state regulations and DOE orders and directives. These operations have included assembly, disassembly or modification, staging, transportation, maintenance, repair, retrofit, testing, and surveillance.

The 100,000-square-foot nuclear explosive Device Assembly Facility, located in Area 6 of the Nevada Test Site, is a state-of-the-art national asset. As a valuable part of the DOE complex, this facility is a vital resource for maintaining the nation=s nuclear stockpile.

The structures within the DAF are designated as buildings rather than rooms, as each is a distinct structure separated from the other buildings by earthen embankments. Except for the office area, the entire DAF is constructed with noncombustible materials. The main facility is covered with a minimum of five feet of compacted earth. Safety systems include fire detection and suppression, chemical detection, separated and filtered ventilation, special electrical grounding, personnel air supplies, automatic room isolation, and a system of loudspeakers, alarms, and warning lights. Blast doors are interlocked so that one door must be closed before the other can be opened. The DAF is a collection of 30 individual steel-reinforced buildings connected by a rectangular racetrack corridor.

Most isolated of the operational buildings are five assembly Acells@ for activities involving uncaged conventional high explosives and special nuclear material. Four high bays and three assembly bays provide facilities for less hazardous operations. Five staging bunkers provide ample space for the interim storage of nuclear components and high explosives. Finally, all materials packages arrive or depart the DAF through either of two shipping or receiving bays.

Atmospheric Vehicle Graveyard *located at the south end of Yucca Flat in Area 6.*

Several rusted military vehicles and automobiles are located in this area. All of the vehicles have bullet holes, inflicted as a result of small arms fire from Nevada Test Site security personnel. Several retired Nevada Test Site workers have stated the vehicles were exposed to atmospheric nuclear tests in Yucca Flat.

Military armored personnel carrier in Area 6.

Built in 1951, the Control Point overlooks Frenchman and Yucca Flat in Area 6.

Control Point *located on the west side of Mercury Highway in Area 6.*

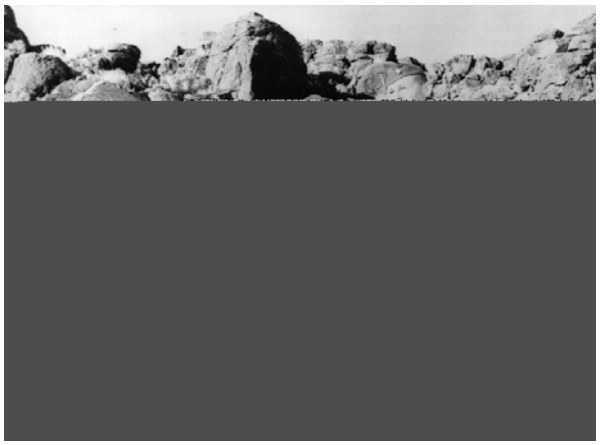
From 1951 until the end of nuclear testing in 1992, the Control Point was the principal command and firing control point for 100 atmospheric and 828 underground tests which were conducted at the Nevada Test Site. The Control Point is a reinforced-concrete single-story building with a basement. Gross floor area is 31,600 square feet. The building has a cafeteria capable of seating 32 persons. All the structures in this area were designed to withstand an increase in atmospheric pressure of 0.6 pounds per square inch, in anticipation of the wind blast effects from atmospheric detonations.

Yucca Air Strip *located on the east side of Yucca Flat in Area 6.*

Originally built by the Army Air Corps (U.S. Air Force) as part of the Nellis Bombing and Gunnery Range, prior to the establishment of the Nevada Proving Grounds (Nevada Test Site) by President Harry S. Truman in December 1950. The wooden building at the northwest end of the runway is believed to have been used as a control/advisory tower.

News Nob *located on the east side of Mercury Highway in Area 6.*

A craggy knoll of rock just across from the Control Point has its own place in the history of the Nevada Test Site. On April 22, 1952, it was established as a good point for news photographers and cameramen to watch and film the airdrop and detonation of *Charlie* (named *Big Shot* by the journalists), a 31-kiloton atmospheric test at Yucca Flat.



Two soldiers look toward Yucca Flat from News Nob.

Whether during the day or in the pre-dawn hours, news photographers and recorders of history averted their eyes while shutters remained open to capture the tremendous power of a nuclear explosion at Yucca Flat.

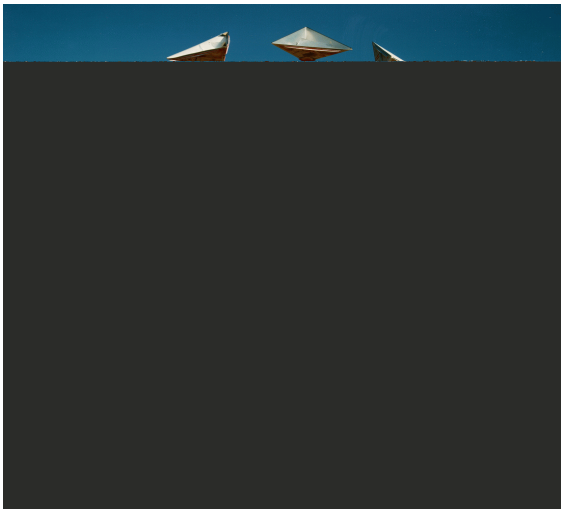
The original sign naming the rocky outcrop *News Nob* was a weather-beaten board with a door knob from an outdoor privy attached. The name *News Nob* was painted in yellow. Later, the board was replaced with a more conventional sign. A newer sign still stands today. Reporters witnessing tests from this vantage point included such famous national newsmen as Bob Considine, *New York Times,* and Walter Cronkite, *CBS News.* The original benches where the reporters sat and witnessed the tests still remain today. While no records have been kept on the number of journalists who have visited the Nevada Test Site, it would not be exaggerating to say that, during the atmospheric testing days, it was one of the most photographed and heavily-reported areas in the world.

This weather-beaten News Nob sign has been replaced by a newer sign.

One of three camera towers built by Sandia National Laboratories to photograph inert bomb (non-nuclear) drops at Yucca Lake in Area 6.

Camera Towers *located in the center of Yucca Flat dry lake bed.*

Sandia National Laboratories built three wooden camera towers and placed them outside a 3,000-foot-diameter target circle on the Flat for night-time "inert" bomb drops. The purpose of the tests, conducted between 1954 and 1956, was to test contact bomb fusing. Just before the bomb impacted, each of the three cameras shutters would capture images of a flash bulb attached to the bomb that had been set to fire when the contact fuse operated, just before the bomb hit the lake surface.



Lone Sentinel of the Desert

Reflector Tower *located in the center of Yucca Flat dry lake bed.*

Used as a radar target by maneuvering aircraft during "inert" contact fusing bomb drops at Yucca Flat. Sandia National Laboratories conducted the tests on the lake bed from 1954 to 1956.

Fortune Training Tower *located to the west of Tweezer Road in Area 6.*

The *Fortune Training Tower* was erected to train personnel in the procedures to prepare for underground nuclear tests. The tower contains a model rack and emplacement assembly, such as those that were lowered into drilled shafts for a typical underground test.

Weather Station *located at the northwest corner of Yucca Lake.*

Intermittent weather observations began at what became the Yucca Flat Weather Observatory on October 1, 1956, when U.S. Weather Bureau personnel started taking observations for eight-hour periods, daily. On May 1, 1957, the station was manned by U.S. Air Force personnel in support of Operation Plumbbob. On October 1, 1957, operations were returned to U.S. Weather Bureau personnel. The station was closed from April 29 to August 16, 1959, and from May 25, 1960, to December 17, 1961. A 24-hour observations program then began with full surface and upper-air measurements to provide key meteorological information to support the underground nuclear testing program. The station was closed when the meteorological observatory was moved in May, 1978, to its current location at Desert Rock Airport.

Electronic Pulse Tower (EMP)
Located about one mile from the junction of Mercury Highway and Tippapah Highway. Turn left at the first dirt road. The EMP is located about 800 yards from the highway in Area 6 .

The antenna tower was constructed to collect electromagnetic pulse data. It may have been built to gather data from the *Johnnie Boy* underground and *Little Feller I* and *Little Feller II* atmospheric tests.

Airborne Response Team (ART) Hanger
located at the northeast corner of Yucca Lake.

The ART hanger was used to station a Messerschmitt helicopter and members of the Wackenhut Services, Inc., Airborne Response Team (ART), so they could quickly respond to any security incident on the Nevada Test Site, e.g., infiltrators attempting to halt underground nuclear tests. The ART program ended on July 24, 1991, with the tragic crash of the helicopter and the loss of the two pilots and three ART Wackenhut Security Officers.

Joint Test Organization
Forward Area Support Facilities
located to the left of Tweezer Road in Area 6.

This forward area support facility provides support to the U.S. Department of Energy-s Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratories, and the Defense Threat Reduction Agency. The facility consists of several administrative buildings and craft shops, as well as storage space for mothballed laboratory recording trailers and other items of equipment that would be required to conduct an underground nuclear test, if so ordered by the President of the United States.

Back to the Past – This original Atomic Energy Commission entrance portal once graced the entrance to the Nevada Test Site. Today it is located within the Forward Area Support Facility, Tweezer Road, in Area 6.

Heavy Equipment Yard *located to the west of Yucca Lake in Area 6.*

This support facility is operated for the U.S. Department of Energy by Bechtel Nevada. The Heavy Equipment Yard has several support facilities where mechanics, welders, electricians, carpenters, and other crafts people service and repair heavy equipment, e.g., front lift loaders, cranes, bulldozers, drilling equipment, and other types of equipment.

Explosive Ordnance Disposal Unit – Restricted Entry
Located in the Massachusetts Mountains (elevation 4,350 feet) to the right of Mercury Highway in Area 11.

The site was opened on May 12, 1964, for the open burning and detonation of explosive ordnance wastes. In 1988, the practice of open burning was discontinued. In May 1995, a Hazardous Waste Operations Permit was issued to allow for the thermal treatment of waste explosives at the site.

The Explosive Ordnance Disposal Unit is operated by trained and certified Bechtel Nevada personnel. The 20-acre site consists of a graded detonation pit surrounded by an earthen pad and ancillary equipment, including a bunker, electric shot box, and electric wire. To support activities at the site, three explosive storage magazines are located adjacent to the unit. One of the magazines is designated as a satellite accumulation area for waste explosives prior to treatment. The two other magazines are used for the storage of detonation materials and explosives. Waste explosives are generated from the Defense Threat Reduction Agency, contractor operations, the Wackenhut Services Inc. Nevada Test Site security firing range, and resident national laboratories. The site can store 4,130 pounds of waste annually and has the capacity to dispose of 200 pounds of explosives per hour.

Tweezer Facility B This facility has a centrifuge which was used by Los Alamos National Laboratory to prepare stockpile nuclear devices for underground tests.

Technical Facility B Built in 1962 by Los Alamos National Laboratory as its nuclear device assembly facility. In the early 1980s the laboratory joined with Lawrence Livermore National Laboratory at a joint facility in Area 27, which was used until underground nuclear testing ended with the signing of October 2, 1992, nuclear testing moratorium. The facility could also have been used to dismantle damaged nuclear weapons (*Broken Arrows*), however, this was not the main function of the facility.

Plutonium Valley B Between November 1955 and January 1956, Los Alamos National Laboratory conducted *Project 56*, a series of four safety experiment tests, one with uranium and three with plutonium, all devices fully encased. The detonation of the high-explosive charges dispersed plutonium in the test area. In 1981, attempts were made to vacuum up the soil and to remove the plutonium. The cleanup was not successful; as a result, alpha contamination (see *Appendix* for *Alpha*) is still present. Today, the area is used for radiation safety training exercises.

U1a Complex

U1a Complex *located on 1-02 Road in Area 1.*

U1a is an underground experimental complex managed for the National Nuclear Security Administration by the Los Alamos National Laboratory. The complex is designed to contain subcritical experiments in a safe and secure environment in an underground laboratory of horizontal tunnels and small experiment alcoves mined at the base of a vertical shaft approximately 960 feet beneath the surface. The complex also consists of several above-ground support facilities.

In 1988, a 1,460-foot horizontal tunnel was mined south at the 962-foot level of the shaft. In September 1990, the *Ledoux* nuclear test was conducted in the shaft. Mining for the expanded complex began in early 1993 with the excavation of an 1,100-foot tunnel connecting the U1a shaft to a new 108-inch drilled shaft (U1g).

Apple-2 Ground Zero *located about one mile south of Pahute Mesa Road in Area 1.*

This 29-kiloton test was detonated from the top of a 500-foot tower on May 5, 1955. 6,600 feet to the east are the remains of a wooden two-story house. Another house made of brick is located 8,000 feet from ground zero. To the south of these two houses are two single-story houses which can be reached by using *1-04 Road*.

The test was part of *Operation Teapot,* and the houses were built for *Operation Cue (see Appendix, Film Listing*), a Civil Defense exercise. At the time of the test the two houses and three other bungalows, built to different building codes, were part of a small town. Other structures, e.g., electrical power systems, radio broadcasting station, weigh station, propane tank farm, and electrical transformer were also built for the test. In addition, automobiles, fire equipment, food supplies, and other items were used for the test. Observers watched the detonation from Mine Mountain, 14,784 feet southwest of the ground zero. After the test it was dubbed *Survival Town*. Debris from the destroyed structures has since been removed.

Apple-2 wooden house

Structural Response Towers *located between the two Apple 2 houses in Area 1.*

These two four-story concrete skeletons were constructed by *Holmes & Narver* for the specific purpose of structural response investigations. The frameworks allowed engineers to study stress response characteristics which could be generally applied to high-rise buildings. This information was used in conjunction with studies and readings taken from Las Vegas high-rise buildings when they were subjected to shockwaves caused from underground tests.

Drill Yard *located at the junction of Pahute Mesa Road and Tippapah Highway in Area 1.*

This area contains drill equipment used to bore large diameter shafts for underground tests. During the period 1961 to 1992, a total of 1.5 million feet (280 miles) of 36-inch-diameter holes were drilled at the Nevada Test Site.

Big Hole drilling (holes larger than 36 inches in diameter) was essential for the nation=s nuclear testing program. Holes as deep as a mile were drilled to accommodate large diagnostic packages. Some diagnostic packages were as long as 200 feet. To prevent the package with the test experiments from binding or catching on the sides of the hole, it had to be drilled straight. This was achieved with a drilling assembly weight **(*photo at left*)** of 160,000 pounds. 10,000 pounds was supported by the bit and 150,000 pounds was suspended by the drill pipe to keep the hole straight.

See Appendix for details about big-hole drilling methods, equipment, and preparations to conduct underground tests.

Shaker Plant *located on Pahute Mesa Road to the rear of the drill yard in Area 1.*

This facility supplied gravel and sand to back-fill the drilled shafts that had been prepared for underground nuclear tests.

Annie houses in Area 3 just prior to their destruction.

Annie Ground Zero *located near 3-08 Road between Mercury Highway and Orange Blossom Road.*

Annie was conducted for the Federal Civil Defense Administration (FCDA) on March 17, 1953. It was also named *Shamrock* by those in attendance, as it was detonated on St. Patrick=s Day.

The test was also called *Operation Doorstep* by some of the more than 600 Civil Defense observers and media that witnessed the explosion, a name that was later used in a FCDA report on the test.

Two colonial two-story homes were erected in Area 3 of the Nevada Test Site and placed 3,500 and 7,500 feet from a 300-foot tower that held a 16-kiloton device.

The test had three main objectives: First, determine what would happen to a typical American home exposed to an atomic blast. Second, study the protection provided by eight different outdoor underground home-type shelters. Third, determine the amount of protection afforded to passengers in cars and the effect a nuclear blast would have on the operation of these vehicles.

The passenger cars (1936 to 1953 models) were donated through the Automobile Manufactures- Association -- General Motors, Ford, Chrysler and American Motors; in addition, three U.S. Post Office vehicles were used. Gas and oil for the cars was donated by Standard Oil Company. Mannequins were donated by L.A. Darling Co., Bronson, Michigan, and clothing for the mannequins was obtained from J.C. Penny Co. Because of limited funds, the houses were furnished mostly with government furniture and furniture donated by American Van Lines. No electrical wiring, plumbing, heating, or gas piping was installed. The interiors were plastered but not painted. The wood trim, doors, and floors were also left unfinished.

To help in the prevention of fire, both houses were given white exterior finishes and windows facing the explosion were equipped with aluminum Venetian blinds. This was done to help reflect as much of the thermal energy generated from the explosion as possible.

Each basement included one lean-to shelter and one corner-room shelter. The building materials used to erect the shelters cost, respectively, $40 and $95 each.

The house at 3,500 feet from the blast was 90 to 95 percent destroyed. Its destruction was recorded by an automatic camera, the results of which have been widely publicized on film and in a set of eight photos that captured the implosion of the house. The house at 7,500 feet was badly damaged. Both houses were later demolished and the site cleaned.

In addition to the two houses, eight underground shelters were tested at various distances from the houses to determine resistance to various blast pressures and the amount of protection a shelter would provide from radiation exposure.

Two single shelters were located 1,250 feet and 1,450 feet from the detonation. Five shelters were located 1,800 feet from the tower. The last shelter was positioned at 3,500 feet from the detonation. All the shelters contained mannequins.

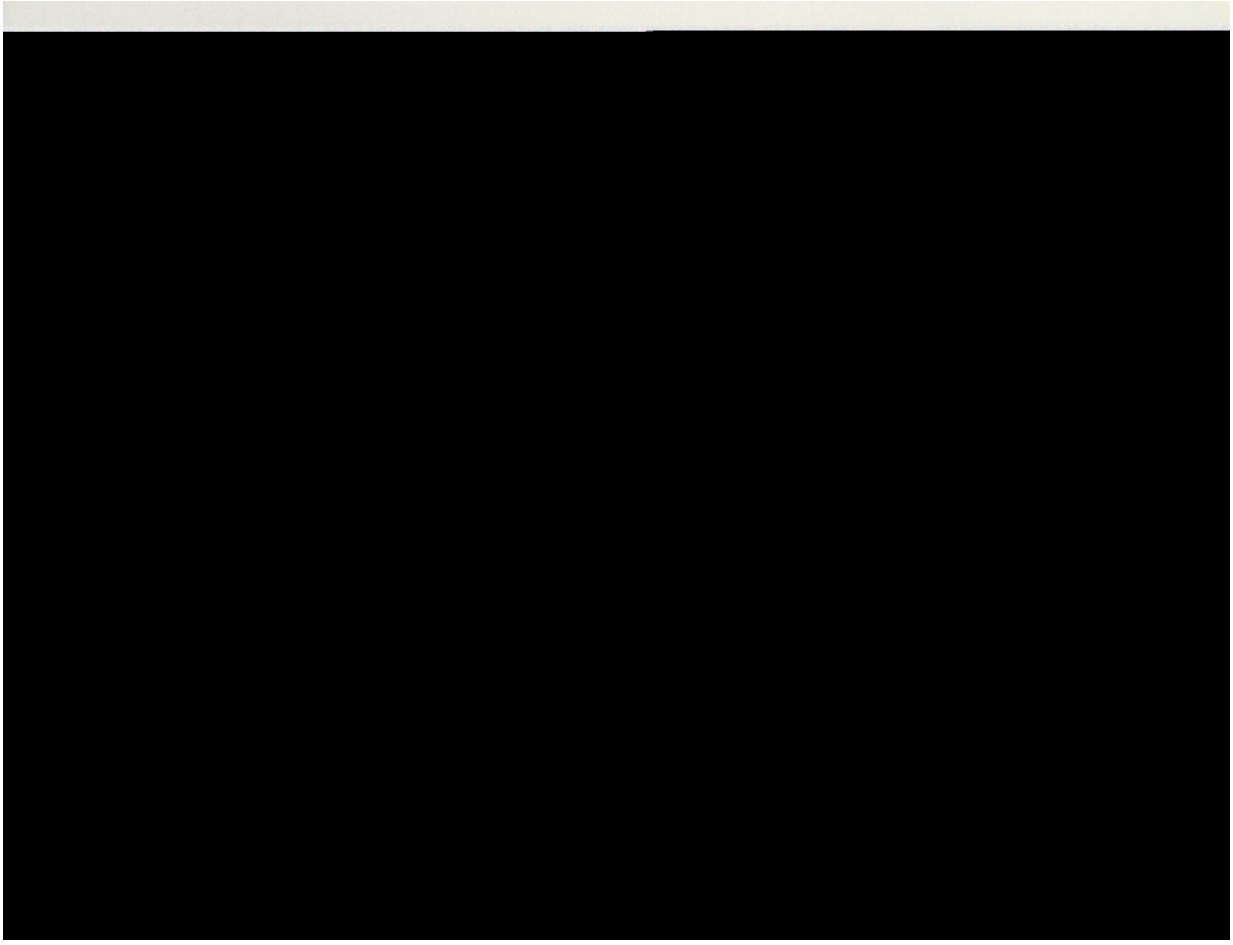
Two weeks after the Annie test, J.C. Penney Co. displayed the mannequins in its store located on Fremont Street. Before and after photographs appeared in the April 3, 1953, edition of the Las Vegas Review Journal, with the following statement:

> ". . . These mannequins could have been real people, in fact, they could have been you. Volunteer now for the Civil Defense. J.C. Penney was happy to donate the clothing to the Federal Civil Defense Administration for the test. L.A. Darling Co. is to be complimented for donating the fifty mannequins which are now on display for your inspection."

Bilby Ground Zero *located about 1,000 feet to the right of Angle Road in Area 3.*

Bilby provides a good first-hand opportunity to see a circular subsidence crater up close. Craters were formed by the collapse of underground spherical cavities that were formed deep underground by nuclear explosions. The earth collapsed as the gases inside the test cavity cooled and the pressure was lost. The collapse then progressed to the surface, which resulted in the crater formation.

Bilby was a 249-kiloton test detonated on September 13, 1963. It was one of the larger detonations on Yucca Flat and the first underground test to be felt by a large number of Las Vegans. It was fired 2,400 feet underground in volcanic rock. A crater 1,800 feet wide and 80 feet deep resulted.



Huron King Test Chamber *located to the right of 3-08 Road in Area 3.*

The *Huron King* test chamber contained a communications satellite and other space-related experiments, and simulated a space environment. It was used for a rare type of Vertical Line of Sight underground test conducted by the Defense Nuclear Agency, forerunner of the Defense Threat Reduction Agency. The device, which was less than 20 kilotons, was detonated on June 24, 1980.

Radioactive Waste Management Site (RWMS) *located to the right of 3-300 Road in Area3.*

The Area 3 RWMS is located approximately 30 miles north of the main access gate in the Yucca Flat basin, a closed basin where all surface drainage terminates in a playa lake at the south end of the basin. The water table is 1,600 feet beneath this facility.

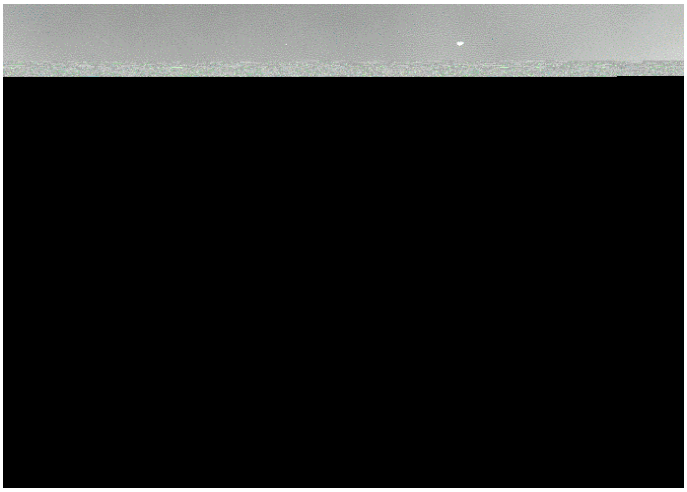
The Area 3 RWMS covers 120 acres and uses subsidence craters formed from underground testing of nuclear weapons for the disposal of packaged and unpackaged bulk low-level radioactive waste.

Aerial view of the U3 craters showing the containers of waste.

The Area 3 RWMS includes a total of seven craters representing four cells designated for disposal operations. One disposal cell, formed from a pair of craters known as U3bl, has been closed. Another disposal cell, formed from a pair of craters (U3ah/at) and a single crater (U3bh), has been developed and is operational. The current inventory of disposed waste at the Area 3 RWMS is approximately 12.6 million cubic feet. Open capacity available in the two developed cells is estimated to be approximately 7.8 million cubic feet. The two remaining craters, which at the present time are assumed to be individual cells, represent an estimated combined available future capacity of 7.2 million cubic feet. The total estimated capacity of the Area 3 RWMS is 15 million cubic feet.

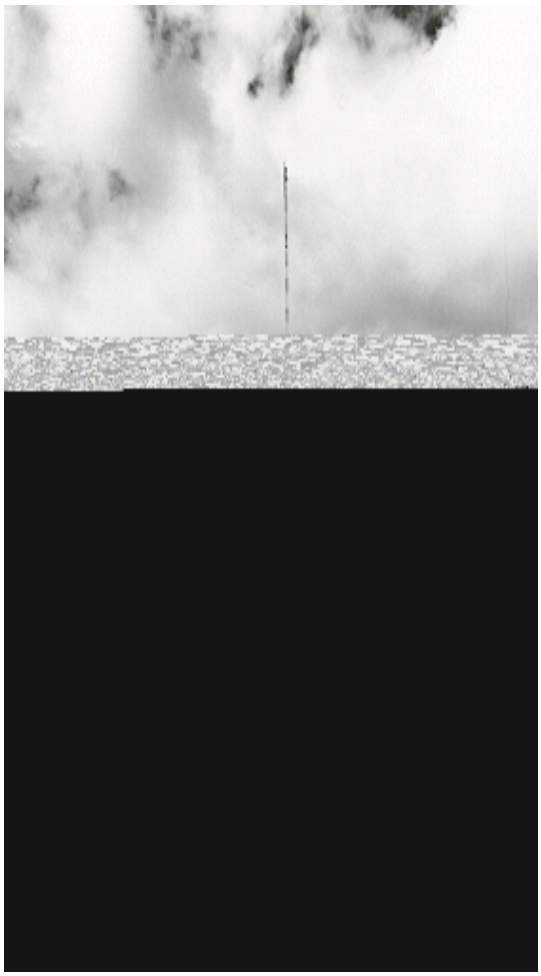
Apple-1 Ground Zero *located to the right of 4-04Road in Area 4.*

More than 600 troops deployed from Camp Desert Rock to participate in the *Apple-1* test. The 14-kiloton device was detonated from a 500-foot tower on March 29, 1955. The troops witnessed the test from trenches about 10,000 feet southwest of ground zero.



Japanese Village
Located to the right of 4-04 Road in Area 4.

Using authentic architectural drawings, several simulated light-framed Japanese houses (see top and right photos) were built in this area in 1962. They were used in conjunction with the joint U.S./Japanese Atomic Bomb Casualty Commission as part of a research project to estimate radiation doses received by survivors of the Hiroshima and Nagasaki atom bomb blasts. The houses were built on skids, which allowed them to be moved to different testing areas.



BREN Tower

The 1,537-foot steel-tower Bare Reactor Experiment Nevada (BREN), now located in Area 25, was erected in Area 4. A small unshielded reactor was mounted on a hoist car and moved to various heights up and down the tower. The houses at the bottom of the tower were them bombarded with various intensities of radiation from the reactor. Scientists wanted to know what kind of protection the houses provided from the radiation emitted from atomic weapons.

The concrete pad for the BREN Tower is located in the northwest corner of the Big Explosives Experimental Facility.

See *Appendix* for *BREN Tower (Bare Reactor Experiment Nevada).*

Japanese Village as it appears today.

BEEF (Big Explosives Experimental Facility) *located at the end of 4-04 Road in Area 4.*

BEEF, showing the blast berm, which defects blasts from high explosive detonations on the firing table to the front of the berm.

BEEF (Big Explosives Experimental Facility) *located at the end of Road 4-04 in Area 4.*

The BEEF is a hydrodynamic testing facility. The facility consists of a control bunker, camera bunker, gravel firing table, and associated control and diagnostic systems. In 1995, the facility safely detonated conventional high-explosive experiments up to 7,000 pounds in size to ensure that the 4-300 bunker would provide a safe working environment for personnel who would be required to carry out sophisticated diagnostics, such as high speed optics and x-ray photography.

The gathered information will play a large role in accumulating data to support the Stockpile Stewardship Management program. Lawrence Livermore National Laboratory converted the bunkers, at the site in 1955, into a state-of-the-art control and diagnostic facility. Lawrence Livermore National Laboratory conducts explosive tests at the facility, including hydrodynamic shock wave tests, applications of shaped-charge technology, and development of advanced high explosives technologies. Los Alamos National Laboratory conducts explosively driven pulsed power experiments.

Buried Objects Detection Facility
Located in Area 4, opposite the BEEF Facility. Take Road 4-04 and turn left at first dirt road.

The *Buried Objects Detection Facility* is a unique facility operated by Lawrence Livermore National Laboratory to evaluate new mine detection hardware.

Aerial view, looking northeast, of the Mine Detection Facility in Area 4.

The *Buried Objects Detection Facility* was established to help in the detection and neutralization of anti-tank mines, which, along with anti-personnel mines, are high on every humanitarian organizations-s priority list. The goal of the facility is to provide experimenters with an area where they can evaluate possible solutions to the detection of anti-tank mines.

The facility is available to military and civilian research efforts for detection and the characterization of various buried objects, including spheres, drums, and pipes, but specifically anti-tank mines. All of the mines and other structures are precisely mapped and characterized. For personnel safety, the mines are all defused; however, for detection purposes, all contain their original main explosive.

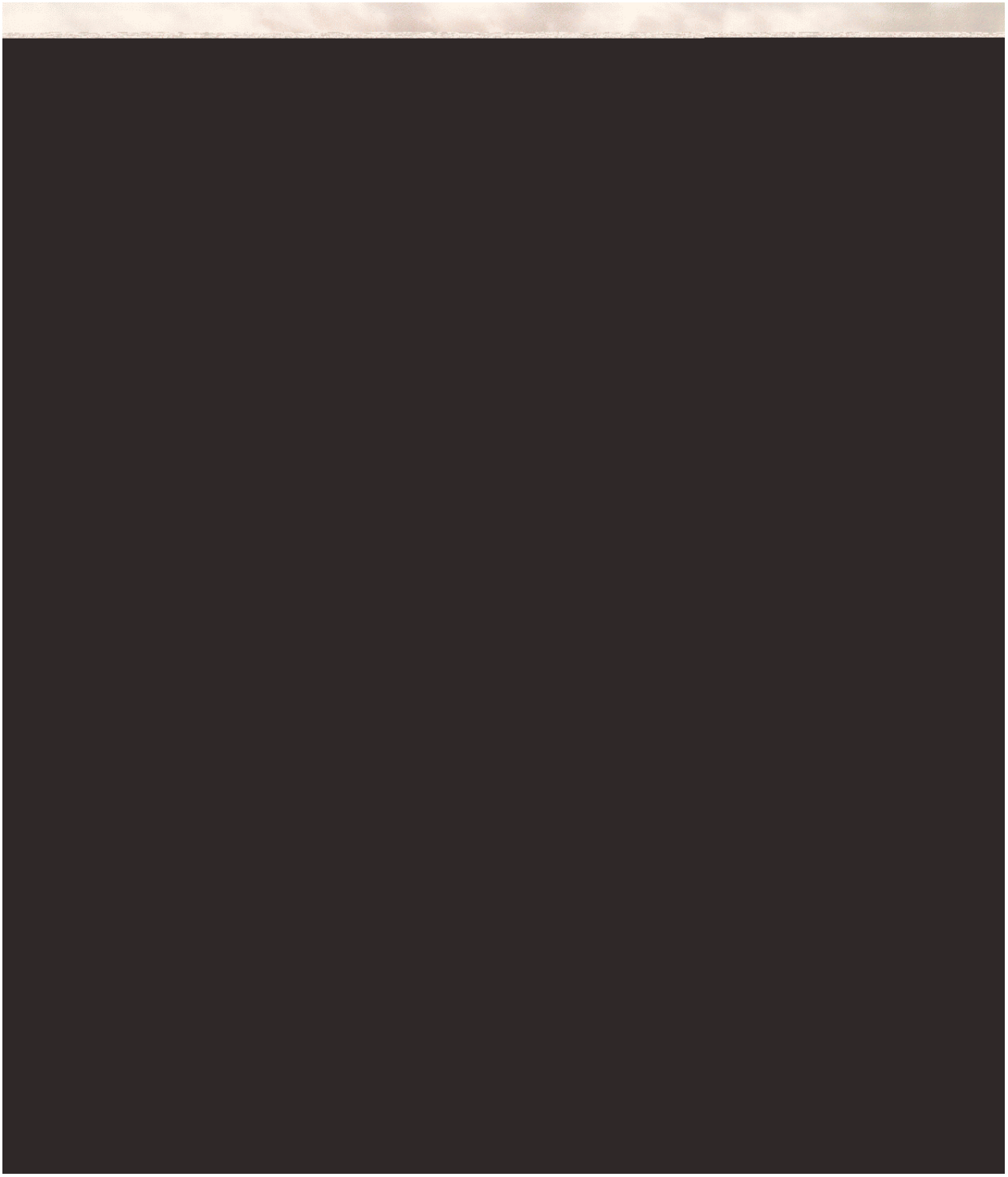
The facility covers over 100 acres, of which 30 acres are in a secure enclosed area. The secure area contains 296 mines, 276 of which are available to experimenters to use for uniform calibration of their detection instruments, while the characteristics of the other 20 are kept from the experimenters. These 20 then become the actual search objects.

The area is typical of the high desert geology and soil conditions prominent at the Nevada Test Site, and the earth has been undisturbed since the mines were introduced to the area in 1993 and 1994.

This photograph showing the early stage of Boltzman was captured in three-millionths of a second.

***Boltzmann* Ground Zero** *located about two miles to the east of Icecap ground zero in Area 7.*

Boltzmann, a 12-kiloton tower test, was detonated on May 28, 1957. It was the first test of the *Plumbbob Series.*



Icecap

Diagnostic cables snake their way across the desert landscape towards the Icecap tower in the background, which houses the diagnostic cannister. ***(See article page 53.)***

Icecap Ground Zero *located east of Mercury Highway, about six miles north of CP-1, in Area 9.*

One of three ground zeros planned for 1993 (the others were *Gabbs* in Area 2 and *Greenwater* in Area 19) that still remain in place.

Icecap was a planned Los Alamos National Laboratory underground nuclear test, scheduled for the spring of 1993; however, all operations ceased with the announcement of the testing moratorium. The tower is 152-feet tall. Inside, a 500,000 pound diagnostic cannister is suspended from the top of the tower. The test was to have been in the 20-to-150-kiloton range and would have been conducted 1,557 feet underground.

A Ringer crane, safety rated to lift 750,000 pounds (equivalent to a fully-laden 747 airliner), would have lowered the diagnostic cannister down the shaft. The crane was dismantled in May 1999 and transported to Lawrence Livermore National Laboratory for use in constructing the National Ignition Facility.

Calibration Gun Turret *located on 2-04 Road behind Bunker 2-300 in Area 2.*

This gun turret was removed from a pre-1940s scrapped U.S. Navy heavy cruiser. The old steel used to forge the turret was selected because it had not been contaminated by radioactive fallout, thereby ensuring accurate calibrations. The turret, with its 45-inch diameter barrel, was connected with buried coaxial cables to the nearby instrument block house (presently being used by Sandia National Laboratories) which relayed information from the *Whitney, Shasta, Diablo,* and *Smoky* atmospheric tests that were detonated in Yucca Flat during the 1950s.

Navy gun turret, adapted to take calibration readings from the Whitney, Shasta, Diablo, and Smoky tests.

Hood Ground Zero
Located to the south of Papoose Lake Road; turn right onto 9-01 Road from Mercury Highway.

Hood, with a yield of 74 kilotons, was suspended from a balloon and detonated in Area 9 on July 5, 1957, at an altitude of 1,500 feet. It was the largest atmospheric device detonated at the Nevada Test Site. About 2,200 Marines from the Fourth Marine Corps Provisional Atomic Exercise Brigade participated in the test. The Marine exercise had several objectives, including the training of personnel in the effects and employment of nuclear weapons, the formulation of tactics and techniques relative to nuclear war, and passive defense measures against the effects of nuclear weapons.

Hood, the highest yield atmospheric test to be conducted at the Nevada Test Site.

Kuchen *located to the east of Gabbs.*

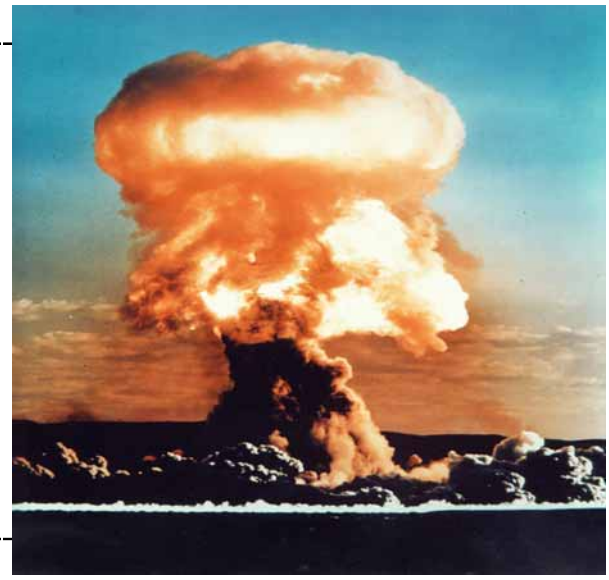
Kuchen was a high-explosive experiment conducted in Area 9 on August 10, 1995. This non-nuclear experiment was part of a routine series of activities in which high explosives were detonated for the purpose of carrying out the Presidential-mandated mission of maintaining a capability to resume underground nuclear weapons tests. The experiment incorporated an exercise to test readiness of equipment, communications, procedures, and personnel.

The experiment included the detonation of 110 pounds of high explosives. The test sponsor, Lawrence Livermore National Laboratory, also used the detonation of small explosive charges to evaluate seismic signatures which may become instrumental in future diagnostic work related to nonproliferation and arms control.

Owens, Wheeler, Charleston, and Morgan Balloon Tests Ground Zero
Located to the south of Papoose Lake Road; turn right onto 9-01 Road from Mercury Highway.

These four balloon tests were fired in Area 9 of Yucca Flat between July 25 and October 7, 1957.

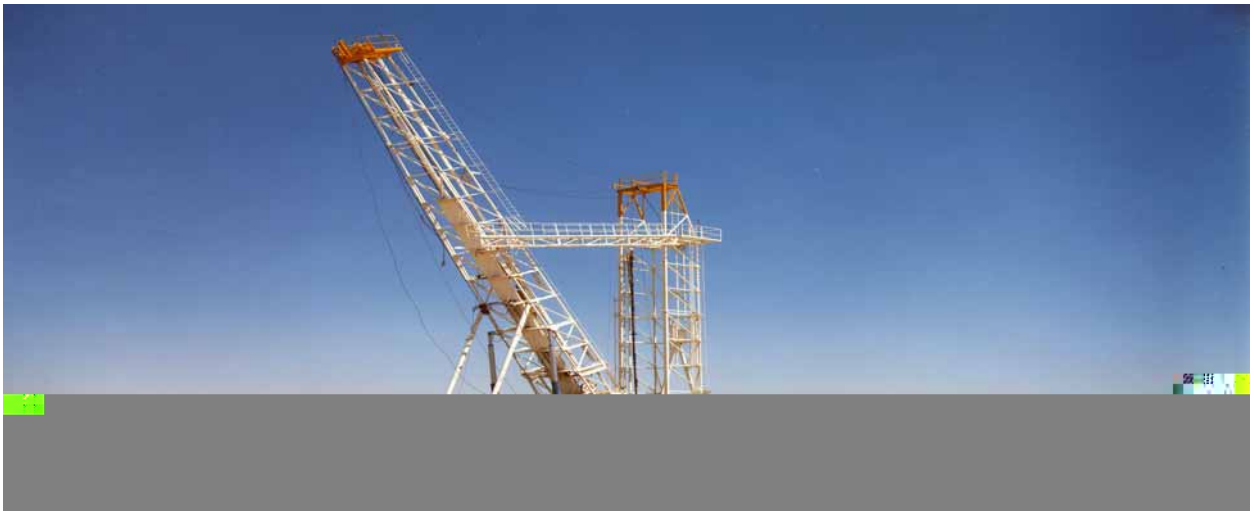
Photo at the right is the 9.7-kiloton Owens test, detonated on July 25, 1957.



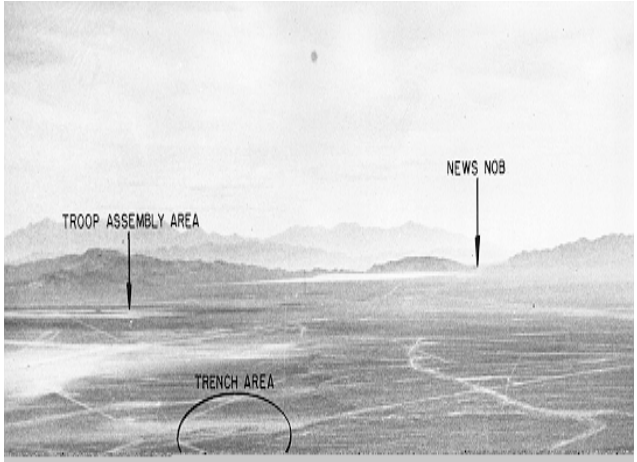
Drill-back Training Area *located to the east of the Gabbs ground zero in Area 9.*

Drill-backs were conducted to obtain a complete picture of a nuclear device's performance. Results of all the prompt diagnostic experiments were correlated with the radiochemical analysis of the test debris.

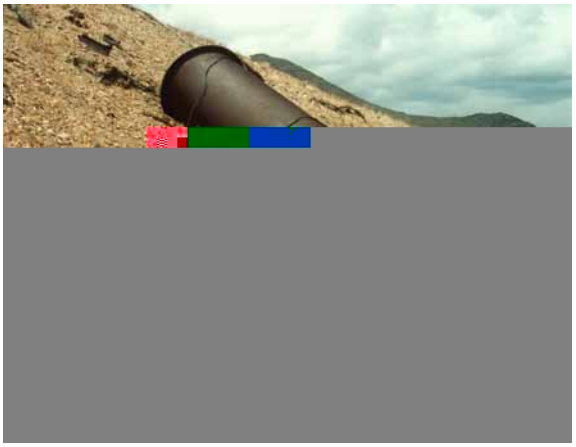
As soon as it was safe, drillers would set up a post-shot drill rig to recover samples. Once the angled hole was drilled through to the radioactive debris in the bottom of the collapsed cavity, radiochemists and drilling engineers would conduct tests to determine the areas richest in radioactive elements.



Drill-back rig.



View from the top of the Smoky 700-foot tower, looking south.

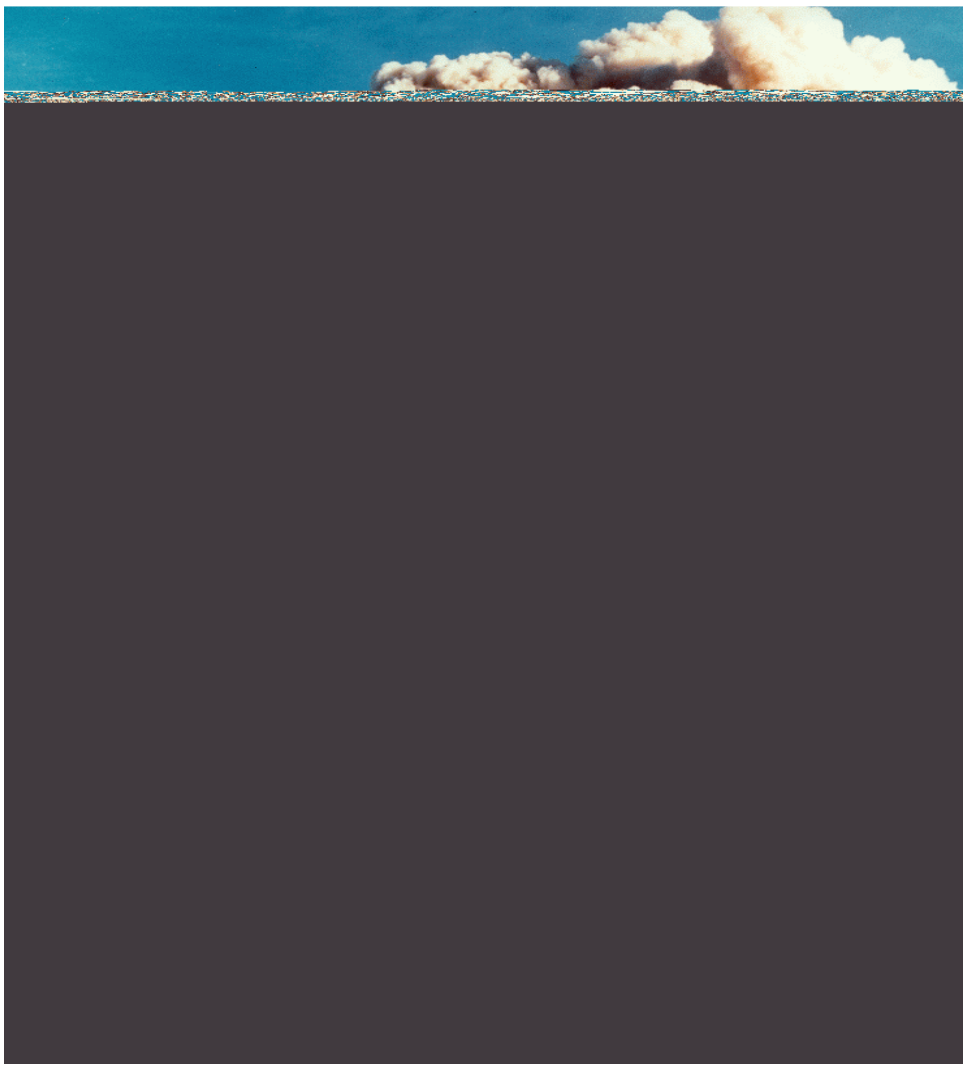


Smoky ground zero today.

Smoky* Ground Zero** B ***Located opposite Sedan crater in Area 2. Because debris from the site has not been removed, the site is still contaminated and remains off-limits. It is the last pristine atmospheric ground zero site on the test site.

Smoky, with a yield of 44 kilotons, was detonated on August 31, 1957, from a 700-foot tower. The main purpose was to test a particular nuclear device. It also afforded an opportunity for 700 troops and a platoon of Canadian soldiers to participate in a troop exercise.

Smoky was a study for hill and dale effects (blast removed top soil) and also studied the blast effects produced on missiles, and on two unmanned M-48 tanks. One tank was located 1,231 feet from ground zero, and was rolled over on its top and suffered extensive damage. The other tank at 2,800 feet from ground zero was essentially undamaged. Military and civilian personnel observed the test from News Nob.



Baneberry* Ground Zero *B Site is located to the right of Rainier Highway, just south of 8-01 Road in Area 8.

The *Baneberry* underground nuclear test of 10 kilotons was detonated on December 18, 1970. Everything proceeded normally until about three minutes after the detonation, when radioactivity started to be released from a fissure about 300 feet from the emplacement hole. The release continued even after the surface collapsed and formed a crater 16 minutes after the detonation. Although the venting rate steadily decreased with time, the visible vapor continued to be seen 24 hours after the detonation.

The venting was attributed to a combination of high water content at a shallow depth and a geologic fault in a small area around the *Baneberry* ground zero. Radioactivity released from the detonation produced some exposure to personnel onsite and offsite; however, safety procedures instituted following the detonation successfully ensured that radiation exposures were below established safety standards.

Gabbs* B *Located to the east of 2-04 Road in Area 2.

Gabbs was a planned Lawrence Livermore National Laboratory underground nuclear test scheduled for an early 1993 detonation. Like *Icecap*, the test was canceled with the announcement of the nuclear testing moratorium in 1992.

Unlike *Icecap*, *Gabbs* does not house a diagnostic cannister inside the prefabricated tower.

Looking south, the large crater in the foreground is Sedan. (See Sedan article, page 59.)

Sedan Crater *located near Circle Road, just past 10-01 Road in Area 10.*

Sedan Crater was formed when the Atomic Energy Commission (AEC) conducted an excavation experiment on July 6, 1962, using a 104-kiloton thermonuclear device.

The test was one of 27 conducted under the Atomic Energy Commission *Plowshare Program* to develop peaceful uses for nuclear explosives for industrial applications.

The explosion displaced about 12 million tons of earth, creating a crater 1,280 feet in diameter and 320 feet deep. The force of the detonation released seismic energy equivalent to an earthquake with a magnitude of 4.75 on the Richter Scale.

On April 1, 1995, the Director of the National Park Service announced that *Sedan Crater* had been entered into the *National Register of Historic Places*.

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Ess *located about a mile south of Sedan in Area 10.*

Ess was an atomic demolition test detonated on March 23, 1955. The one-kiloton device was buried 67 feet below the surface. Fifteen structures of various steel and concrete designs were built in an arc around the ground zero (remains are still in place). The resulting explosion created a crater 290 feet in diameter and 96 feet deep.

U.S. Environmental Protection Agency (EPA) Farm
No longer in existence. Once located on 10-02 Road in Area 15.

For 15 years, the U.S. Environmental Protection Agency managed a unique 36-acre experimental farm for the U.S. Department of Energy and its predecessor agencies.

Construction of the farm began in 1964. The land was cleared of desert vegetation, a 5,400-foot water well was rehabilitated, a one-million-gallon reservoir was built, and the first crops were planted.

During the next two years, dairy facilities were added, including several large open paddocks, individual shaded stalls, and a combination milking barn/main laboratory building.

Extensive plant and soil studies evaluated the uptake of pollutants in farm-grown vegetables and from the forage eaten by a diary herd of some 30 Holstein cows. Scientists also studied horses, pigs, goats, and chickens.

The U.S. Environmental Protection Agency also managed a herd of 100 Hereford beef cattle. Four of the animals, including *Big Sam*, gained fame as *fistulated steers* (animals with surgical openings in their sides). The steers were part of a special research project and served as biological samplers of the forage consumed by the rest of the herd as it ranged over the northeast corner of the test site.

The farm was closed in 1981 because no more useful data was being obtained. The researchers found no disease or tissue damage in the cattle due to radiation exposure. Radiation levels that were detected in the tissue samples were well within accepted Federal standards.

A U.S. Environmental Protection Agency employee prepares to take a food sample from Big Sam. Four of these Herefords, including Big Sam, gained fame as "fistulated steers" (animals with surgical openings in their sides).

Hard Hat and Pile Driver Ground Zero *located at the end of 10-02Road.*

In the early 1960s, two weapons effects tests were conducted by the Defense Nuclear Agency (forerunner of the Defense Threat Reduction Agency) in "*A*" tunnel, 1,400 feet below the surface in Area 15.

The first test was *Hard Hat* on February 15, 1962. The 5.7-kiloton detonation was conducted about 900 feet below the surface. On June 2, 1966, *Pile Driver*, a 62-kiloton test, was conducted about 1,400 feet below the surface. Information from the *Pile Driver* test was used in designing hardened missile silos and the North American Air Defense Command (NORAD) facility in Colorado Springs.

Spent Fuel Test (Climax Mine) *located at the end of 10-02 Road in Area 10.*

In January 1978, it was proposed that the U.S. Department of Energy's Lawrence Livermore National Laboratory conduct a test to demonstrate that nuclear reactor spent fuel, a highly radioactive material, could be safely and reliably packaged, transported, stored in a geologic repository, and then retrieved.

By 1980, two new tunnels had been mined and 11 spent fuel canisters from the Turkey Point Nuclear Power Station, Dade County, Florida, were lowered into steel-lined boreholes, and a 5,000-pound concrete plug was placed on top of each one. During the next three years over 500 thermocouples recorded a complete temperature history of the facility.

E-Tunnel *located off of the Stockade Wash Road in Area 12, west of the Area 12 Camp.*

On June 17, 1965, *Tiny Tot*, a weapons-effects test of less than 20 kilotons, was conducted within this tunnel complex by the Defense Nuclear Agency, forerunner of the Defense Threat Reduction Agency.

Appendix

Subcritical Experiments:

These are scientific experiments to obtain technical information in support of the U.S. Department of Energy's responsibility to maintain the safety and reliability of the U.S. nuclear weapons stockpile without nuclear testing. They involve chemical high explosives to generate high pressures that are applied to nuclear weapon materials, such as plutonium. The configuration and quantities of explosives and nuclear materials are such that no nuclear explosion takes place; thus, the experiments are consistent with the Comprehensive Test Ban Treaty. They are called "subcritical" because no critical mass is formed, i.e., no self-sustaining nuclear fission chain reaction will occur. Scientific data is obtained on the behavior of nuclear weapon materials by the use of complex, high-speed measurement instruments.

Types of Radiation:

Alpha B Radioactive alpha particles can be shielded by a sheet of paper or by human skin. But if these sub-atomic particles are inhaled, ingested, or if they enter the body through a cut in the skin, they can be very harmful. Alpha particles can cause damage to the lungs if inhaled.

Beta B Radioactive beta particles cannot be stopped by a sheet of paper. Some beta particles can be stopped by human skin, but some need a thicker shield (like wood) to stop them. Just like alpha particles, beta particles can also cause serious damage if they enter the body. For example, if ingested, some radionuclides that emit beta particles could be absorbed into the bones and cause damage.

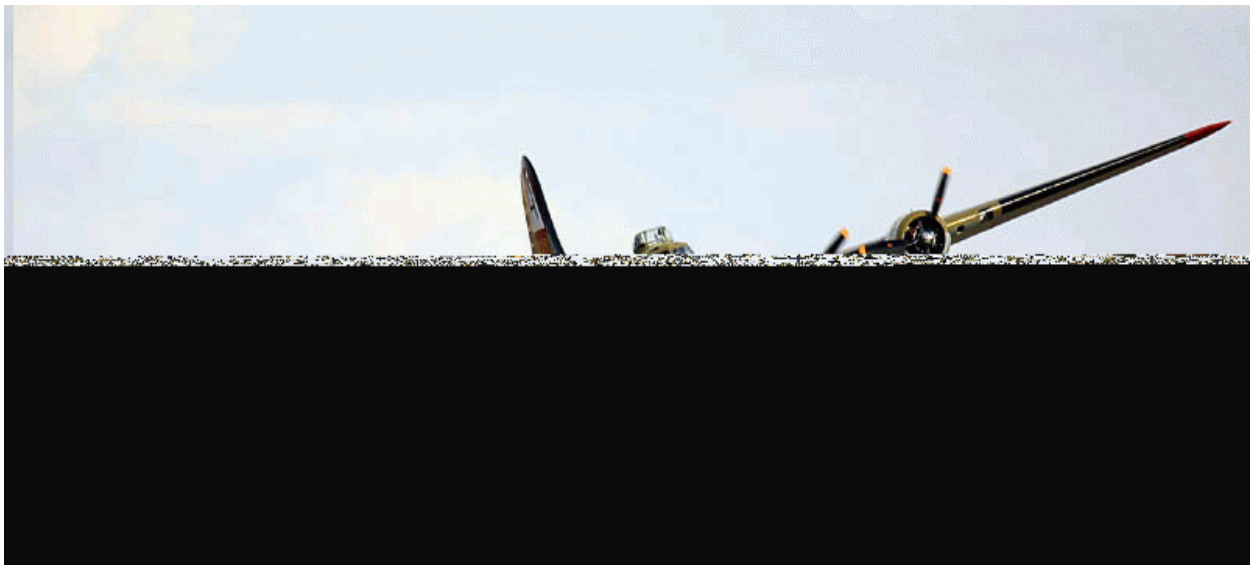
Gamma B Gamma rays are the most penetrating. Gamma rays usually accompany beta and some alpha rays. To protect against gamma rays, a shield at least as thick as a concrete wall would be required. This type of radiation will cause severe damage to the internal organs. X-rays fall into this category, but they are less penetrating than gamma rays.

***Yucca Lady*:**

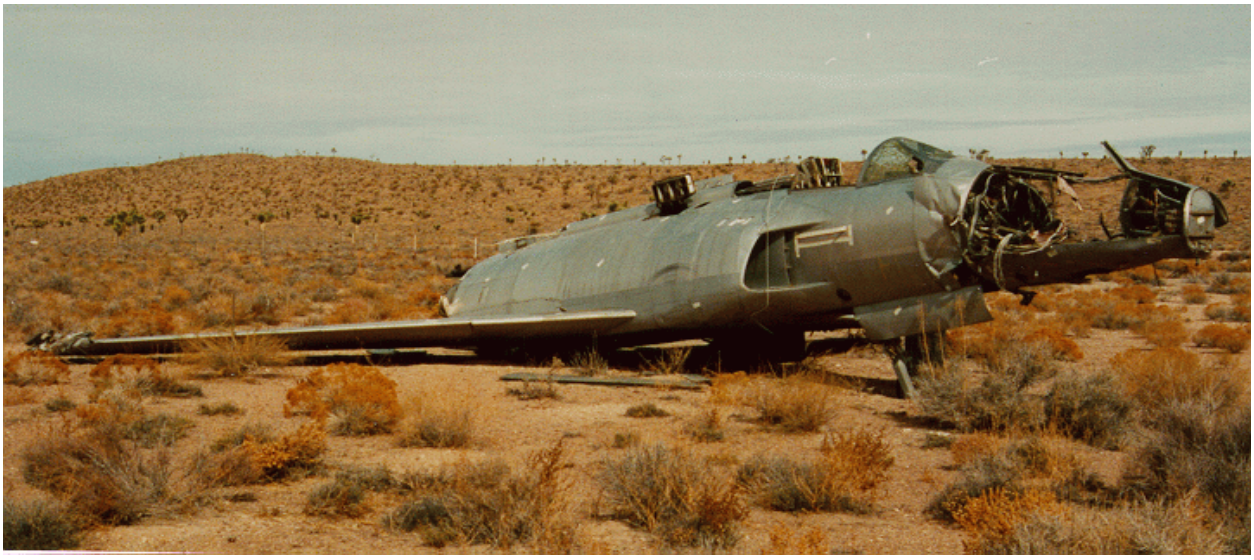
On May 14, 1965, the *Yucca Lady*, which was subjected to three atmospheric tests, was rebuilt and flown off a hot desert airstrip at the Nevada Test Site. Today the *Yucca Lady*, a World War II B-17G Flying Fortress, is owned by the Collings Foundation, Stowe, Massachusetts, who renamed it *Nine-O-Nine*, after a famous WW II B-17 bomber. Today it appears at air shows across the country. Of the original 12,726 produced, only about 15 can still fly.

Yucca Lady before its restoration.

The *Yucca Lady* by all accounts should have ended up as scrap in 1952, after being exposed along with 28 other aircraft to the blast from three atmospheric nuclear tests during *Operation Tumbler Snapper -- Vulnerability of Parked Aircraft to Atomic Bombs*. In January 1965, when all contamination had decayed off the B-17, it was offered as part of an 800-ton lot in a salvage sale. In March 1965, arrangements were made for a partial restoration to fly the aircraft out of the Nevada Test Site. For the next 20 years, the B-17 was used to fight forest fires, until she was purchased by the Collings Foundation in 1986.



Renamed Nine-O-Nine, the original Yucca Lady is still flying.



Lockheed XF-90 (46-688):

This *XF-90*, a *Lockheed* experimental aircraft, was also exposed to the same tests as the *Yucca Lady*. The *XF-90*, of which only two were ever built, is the sole surviving example of Clarence (Kelly) Johnson=s *Lockheed Skunk Works* second design. The first was the *XP-80*, which later went into production as the *F-80 Shooting Star*. The Skunk Works went on to design the *U-2*, *SR-71 (Blackbird)* and the *F-117 Stealth* fighter. Historically, the *XF-90* boasts several significant features: it was one of the first to employ an ejection seat; it had a fully adjustable tail, and was the first to use fowler flaps to improve air flow over the ailerons. It was also the first to use wingtip drop tanks on sweptback wings, and the first to employ an afterburner. Today the broken aircraft rests in two parts in Plutonium Valley; its counterpart was destroyed during structural testing in Ohio. Plans call for the aircraft to be dismantled, decontaminated, and to be placed on display at the U.S. Air Force Museum, Wright-Patterson Air Force Base, Ohio.

Preparations to Conduct an Underground Nuclear Test:

Drilling time for the emplacement hole (shaft) usually took three to twelve weeks of around-the-clock work, depending on the hole=s location, depth and diameter. Typical depths ranged from 600 to 2,200 feet, and a typical diameter hole ranged from 74 to 120 inches.

The most important part of the nuclear test was the *rack* or *diagnostic canister*, which housed the nuclear device, diagnostic instruments, and the downhole components of the timing and firing hardware. The rack was lowered into a prepared hole (shaft), and then covered with stemming materials to prevent any radioactive debris and gases from escaping to the surface. Coaxial cables -- as many as 200 -- would be connected to recorders located inside trailers that were positioned several hundred feet from the surface ground zero.

Technicians and engineers would then set up a timing station at the *Red Shack*, where arming and firing signals would be received and sent downhole. As many as 20 dry runs would be conducted to ensure that the instruments in the recording stations and the diagnostic systems would all operate properly.

Signal cables are laid out at a former test location on Yucca Flat.

To prevent unauthorized detonation of a device, an arm-enable code, which was used to unlock the arming system remotely, was chosen and set by two laboratory engineers just before final cable connections were made at the *Red Shack.*

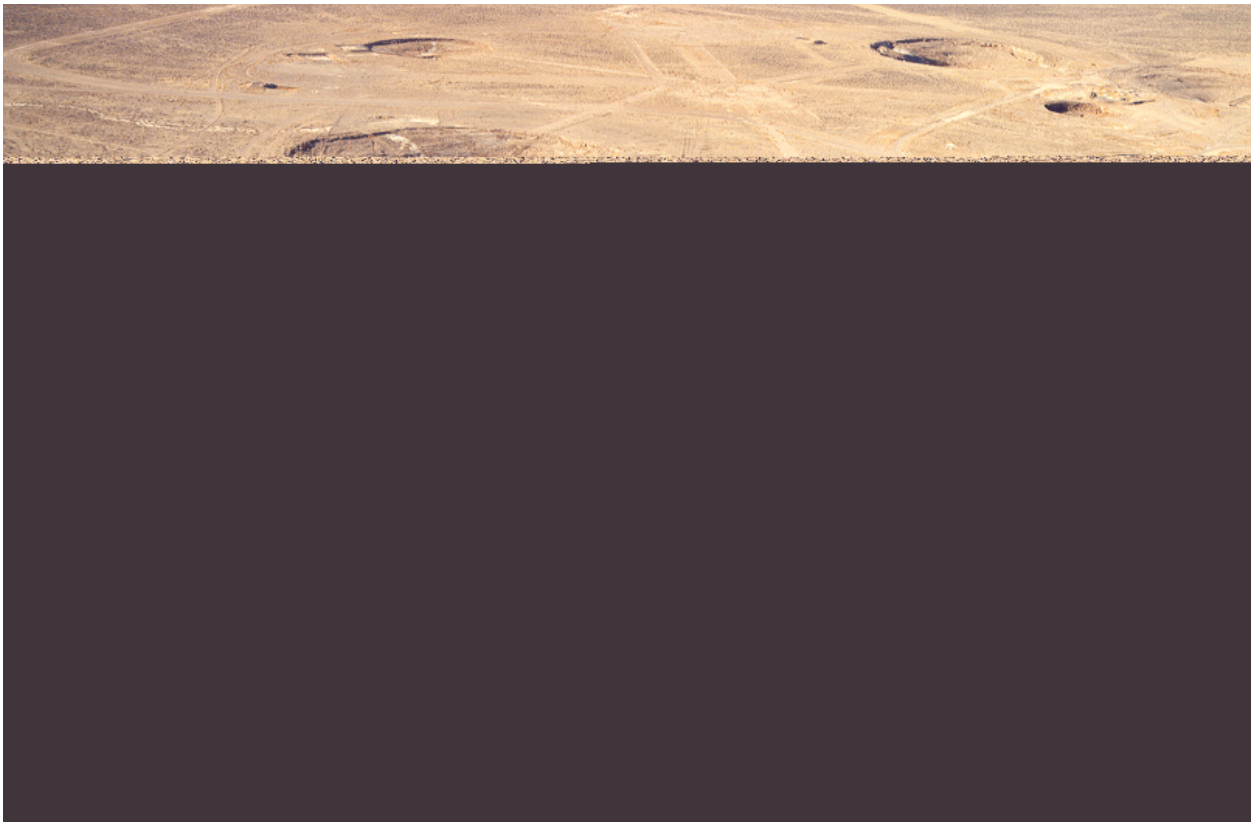
Contrary to popular belief, manually pushing a *red* button did not set off the detonation. Signals were sent to the Red Shack by an automatic sequencer that typically cycled through its program in 10 to 15 minutes. The sequencer sent the control signals that completed the arming process and activated the recording equipment at the diagnostic stations. A *fire* signal was then sent and the device was detonated.

An underground nuclear test occurred over a very short interval. All of the underground nuclear tests conducted at the Nevada Test Site were fired in less than one minute.

Subsidence Craters:

These were formed after underground nuclear tests. However, not all tests resulted in the formation of a crater. Cratering would sometimes occur within minutes, hours, or weeks. In some instances, no crater formed, which resulted in the area being roped off and posted as a "potential crater area."

The hundreds of craters in Yucca Flat resulted from the detonation of buried nuclear devices and the vaporizing of the surrounding rock, which created a cavity from 100 to 2,000 feet in diameter, depending on the geology and size of the nuclear device. As the pressure decreased in the cavity, the ceiling materials at the top of the cavity collapsed into the formed chamber. When the collapse reached the surface, it created a crater.



Most subsidences leave saucer-shaped craters varying in diameter and depth, depending on the yield, depth of burial, and geology. This is the north end of Yucca Flat. Most tests were conducted in this valley.

Icecap Diagnostic Mock Rack Data:

Inside the *Icecap* tower is a 1/16-scale model of a typical Los Alamos National Laboratory diagnostic rack. The rack contains a mock nuclear device and a suite of physics experiments. A typical tower has a floor every 15 feet, with an interior stairwell and exterior elevator. The tower is equipped with air conditioning and heating units.

The base of the rack is where the nuclear device would be housed. Once the device was in place, it was lowered into a large canister, lowered and bolted to a thick metal plate called a lid. The cannister served to protect the device and its many sensitive instruments.

The lid's main purpose was to serve as a junction point for the many *line of sight* (LOS) pipes that channel the radiation -- gamma rays, x-rays, and neutrons emitted from the fusion reactions -- into the many detectors located along the length of the rack. The LOS pipes on the model are represented by the many colored pipes that run the length of the model rack. Often, instead of terminating directly in to the lid, the LOS pipes terminate into what is called a *top hat*. The *top hats* are represented by the opaque blocks between the lid and the end of the LOS pipes.

The following information is for use in conjunction with the Icecap Diagnostic Cannister Model.

The **RED** sections of the LOS pipes represent brass collimators. The collimators define the radiation beams in the LOS pipes before they reach the detectors. Proper alignment of the LOS pipes was critical to the success of the experiments, and the task of individually aligning each stack of collimators with the aiming point was one of the most time-consuming parts of fielding a rack.

The WHITE LOS pipes represent reaction history lines-of-sight. The detectors in these pipes, represented by the black blocks, are known as alpha detectors. These measure the reaction multiplication rate in the fissioning or fissioning systems in the cannister.

The **GREEN** LOS pipes represent THREX lines-of-sight. THREX packages are **THR**eshold x-ray **EX**periments. In a THREX package, a set of solid-state detectors records proton recoils from a thin foil that is exposed to a neutron beam. These experiments are used to derive temperatures.

The two **ORANGE** LOS pipes that run vertically the length of the rack are PINEX (Pinhole Imaging Neutron Experiment) pipes, for taking pictures of the pit from neutrons. The **RED** section in each pipe represents the pinhole assembly. The pinhole focuses a beam of x-rays, gamma rays, or neutrons onto a fluoroscope. The fluoroscope is located in the television box represented by the large **GRAY** box at the top of the rack. The fluoroscopes provide an image of the exploding device. The images are transmitted uphole by television cameras.

The **BLUE** LOS pipes represent line-of-sight for NUEX pipes. The NUEX (Neutron Experiment) experiments derive the device yield from time-resolved measurements of neutron output.

The **YELLOW** pipes represent line-of-sight SMATs detectors. SMAT detectors were high-bandwidth-laser-modulated and laser-transmitted reaction history experiments.

The short **ORANGE** line-of-sight that runs up the left hand side of the rack is a TOMEX (**TOM**ographic Reconstruction **EX**periment). The TOMEX looked at various planes of an image of the exploding device that is recorded onto a streak camera. Cylindrical lens condense the sections of the image into a fiber optical cable, which transmits the image uphole to a recording trailer.

Drill Yard Technical Facts:

CIRCULATION SYSTEM: Method used to remove cuttings from downhole.
B A dual string drill pipe (13+3/8-inch outer with a 7-inch inner string) was used.
B Fluid is pumped down the annular area (between the inner and outer drill pipes) and drawn out of the inner string.

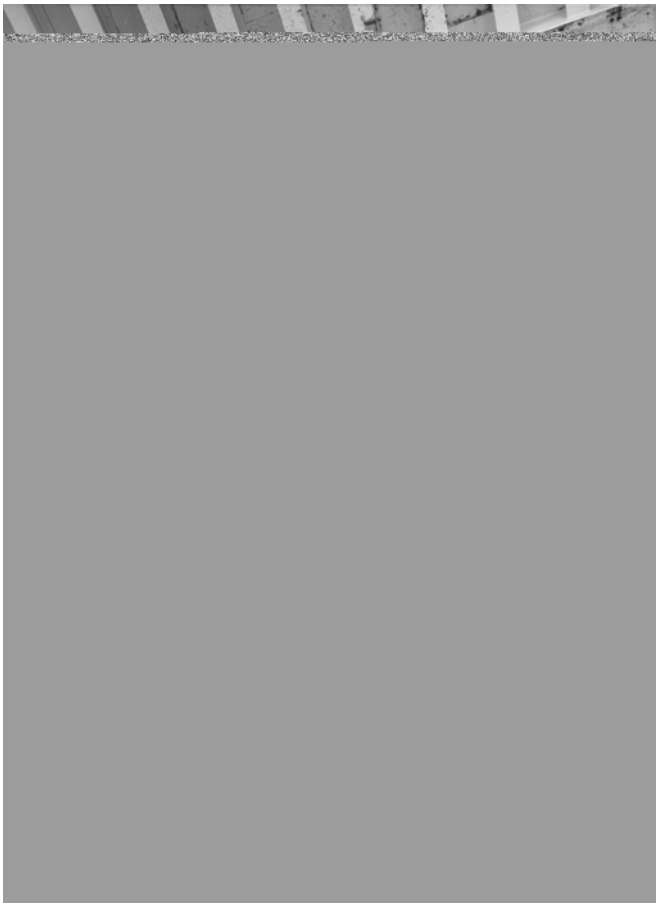
DRILL BITS: Item used to cut or break the rock
B Sizes ranged from 144 inches (12 feet) to 36 inches (3 feet) in diameter.
B The 108-inch drill bit bodies cost about $350,000 each.

96-INCH BITS:
B For every foot drilled, 50 cubic feet of dirt had to be excavated.
B To dress a bit with new cutter cost about $60,000.
B To dress a bit with a retip cutter cost about $8,000.
B Cutters could be retipped as many as 8 times.
B After the bit was dressed, it could be used for another 80 to 120 hours.

CASING ELEVATOR: Used to pick up casings and lower it into them into the hole. Casings ranged from 146 inches to 38 inches in diameter.

FISHING MAGNET: Used when junk (lost cutter, junk, etc.) was lost in a hole. Worked well when a good surface-to-surface contact could be made.

DUAL STRING DRILL PIPE: Pipe used in supporting the drilling assembly and in transporting fluid and cuttings. 13+3/8-inch outter with a 7-inch inner string.



View of a flat-bottom bit and cutters

DOUGHNUT WEIGHTS: Stacked on the mandrel to add weight to the drilling assembly. This weight is required to drill big holes.
B 90-inch weights weighed 27,500 pounds each.
B Usually drilled with 8-10 weights stacked on top of each other. This gave a total assembly (drill bit, mandrel and weights) weight of 450,000 pounds.

BIG GRABS: Used to remove the drilling assembly when the drill pipe had twisted off (broken in two) in the hole.

KELLY: Used to transmit the rotating motion from the rig motors to the drill pipe; hence the drill bit.

HOLE: It cost an average of $1.5 million to drill a big hole during the 1980s. Holes ranged in depth from 500 to 2,600 feet.

***BREN* Tower (Bare Reactor Experiment Nevada).**

The *BREN* Tower was dismantled and moved from Area 4, Yucca Flat, to Area 25, Jackass Flat, in 1966. The 1,527-foot tower (Empire State Building: 1,454 feet) was originally erected in 1962.

It consists of 51 thirty-foot sections of high-tensile steel. Each cross-section is a triangle measuring 10 feet per side, and the tower is the same size from bottom to top. Its total weight is 345 tons. It is guyed with five and one-half miles of steel cables designed to withstand winds greater than 120 miles per hour. It is equipped with an outside hoist for lifting scientific equipment and a two-person elevator inside the tower, which operates at a speed of 100 feet per minute (about 15 minutes to reach the top.)

BREN Tower got its name from the initials of the 1962 experiment for which it was constructed: Bare Reactor Experiment Nevada. *BREN* was a major project of the Civil Effects Test Operation of the Atomic Energy Commission=s Division of Biology and Medicine, which was conducted in Area 4 primarily to develop a means of estimating accurately the radiation doses received by selected survivors of Hiroshima and Nagasaki.

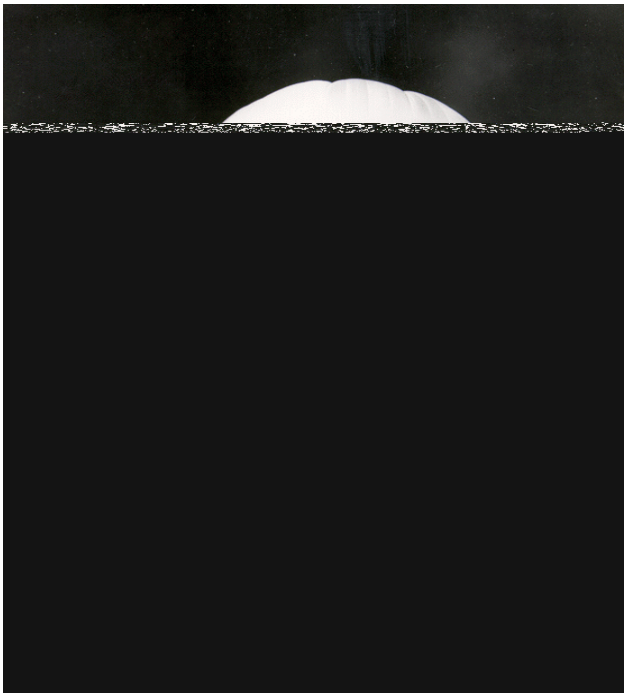
A small unshielded (bare) reactor was mounted on the hoist car for moving to various levels up and down the tower. Simulated Japanese houses were built near the base of the tower and were bombarded with various intensities of radiation.

Atmospheric Test Bunkers:

These massive underground bunkers, or blockhouses, were built of concrete and steel and were covered with a thick mound of earth, which was stabilized in place with an asphalt coating. Depending on the type of design, the bunkers could cost from $100,000 to $600,000 in the 1950s.

Recording instruments inside the bunkers were used to record the blast, heat, neutron or gamma radiation. In addition, high-speed cameras recorded the detonation and resulting mushroom cloud. Several bunkers were built in Yucca Flat.

The bunkers protected instruments against the resulting blast and radiation. Without this protection, the intense radiation fields accompanying the nuclear blast would have fogged the photographic film in the high-speed cameras, ionized the gasses in the many electronic tubes, and caused other severe damage.



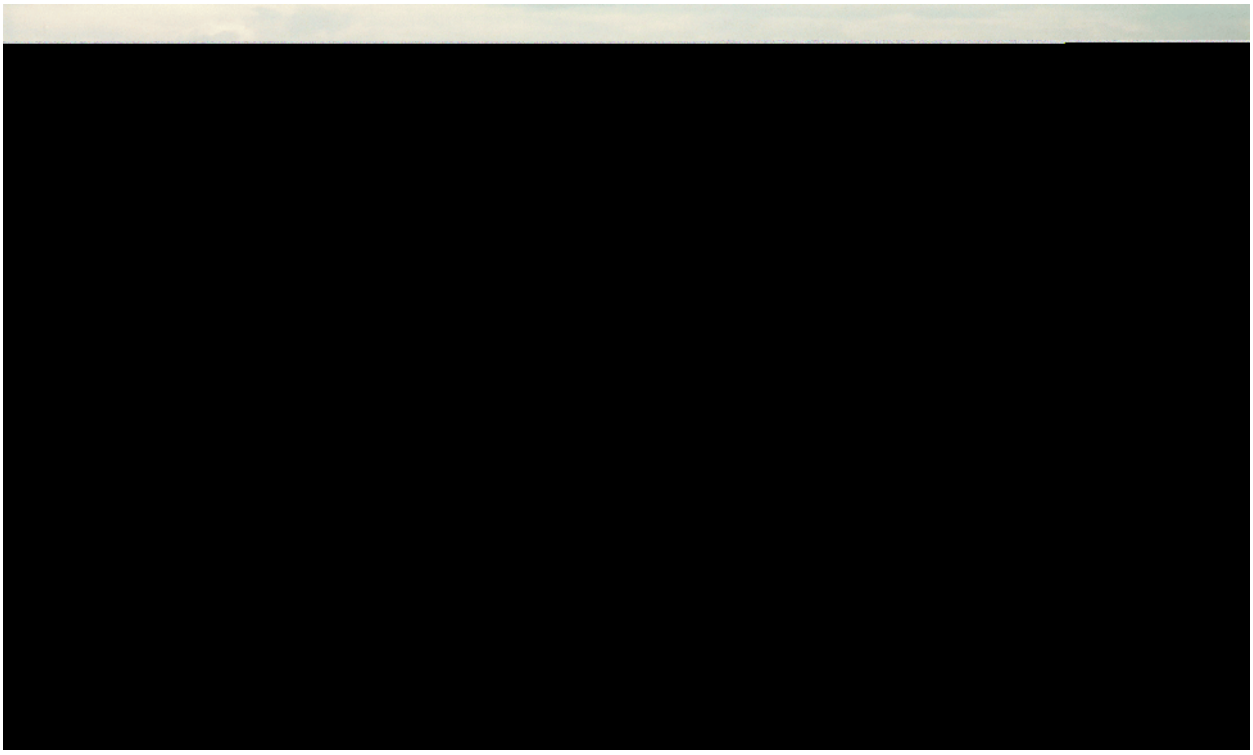
Balloon Tests:

Sandia National Laboratories began experiments at the Nevada Test Site in January of 1957 to determine the adequacy of safety controls, stability, and handling procedures. The field tests proved that the balloon rigging would prevent the balloon from escaping and that, in the event of high winds, the balloon could be brought down immediately by activating a safety device which would burn a hole in the top of the balloon, thereby releasing helium.

Two balloon sizes were designed. They measured 67 feet and 75 feet in diameter. The smaller balloon could lift a one-ton device to 1,500 feet. The larger could lift about two-and-a-half tons to the same altitude. The balloons were anchored with a main vertical cable and three guy cables; all were operated by remote-controlled winches located in heavily shielded bunkers.

The balloon winches were operated from the Control Point, where an operator sitting at a console was able to control the tension of the control cables. In addition, the operator had two television monitors which pictured the balloon's precise location.

Balloons significantly reduced the amount of surface materials drawn into the radioactive cloud and later deposited as fallout.



Yucca Flat Lake Bed:

The lake bed is one of several geologically interesting dry lake beds that can be found in southern Nevada. Runoff from rains and snows washed sediment from the mountain sides into deep valleys, gradually filling depressions in the valleys with alkaline sediment. Hundreds of feet deep, the sediment then formed a uniformly level surface.

Yucca Flat is about 10 by 20 miles in size, and during the atmospheric testing program (1951-1962), ten test sites were laid out. These developed sites consisted of instrumentation towers and underground instrumentation bunkers. Rocket launchers were also used to put up trails of smoke that was useful in making measurements. Areas were also developed for air drops, tower, surface, tunnel, and balloon tests.

Test Site Area Numbers:

Each time a test area was designated it was assigned a number, i.e., Mississippi = Area 93; Tonopah = Area 52; Alaska = Area 59; Central Nevada = 58; etc. Nevada Test Site Areas that changed were: 401, which became Area 26; 410 became Area 27; Area 28 went away; Area 25 and Area 27 were expanded. The early area assignments were randomly made (to avoid a set pattern) by the Atomic Energy Commission=s (AEC) Albuquerque Operations Office, before the Nevada Operations Office was established.

The Atomic Energy Commission used the area numbering system to assign each nuclear weapons test a unique number that allowed anyone "in the know" to know where a test would be conducted. The same system is still used today and a Master Log has been maintained of every nuclear test conducted at the Nevada Test Site. In addition, the area numbers were originally used for timekeeping purposes by the Nevada Operations Office contractor, Reynolds Electrical and Engineering, Inc. The area numbers were also used in the issuing of personnel dosimeters.

Nevada Test Site Important Dates:

Date	**Code Name**	**Yield Kilotons**	**Significance**
January 27, 1951	*Able*	1	First test at the NTS.
July 5, 1957	*Hood*	74	Highest yield atmospheric test at the Nevada Test Site.
August 10, 1957	*Saturn*	0	First tunnel test.
September 19, 1957	*Rainier*	1.7	First detonation contained underground.
October 31, 1958			Moratorium begins.
September 1, 1961			Soviets resume testing. Moratorium ends.
September 15, 1961	*Antler*	2.6	U.S. resumes testing.
March 1, 1962	*Pampas*	9.5	First joint U.S.-U.K. test.
July 6, 1962	*Sedan*	104	First Plowshare test at the Nevada Test Site.
July 17, 1962	*Little Feller I*	Less than 20	Last atmospheric test at the NTS.
April 26, 1968	*Boxcar*	1.3 Megaton	Largest underground test at the NTS.
March 31, 1976			U.S. and U.S.S.R agree to limit underground tests to 150 kt. *Treaty signed in Moscow July 3, 1974, ratified December 8, 1990.*
May 12, 1976	*Mighty Epic*	Less than 20	First 150-kt limit test.
August 17, 1988	*Kearsarge*	100 to 150	Joint U.S.-USSR verification experiment.
September 18, 1992	*Hunters Trophy*	Less than 20	Last tunnel test.
September 23, 1992	*Divider*	Less than 20	Last underground test.
October 2, 1992			Moratorium begins.

Naming nuclear tests:

From the beginning of the Atomic Age, starting with Trinity B the world=s first atomic test in 1945 B and the two combat drops of atomic weapons on Japan, which were named after Sir Winston Churchill (Fat Man) and President Theodore Roosevelt (Little Boy), names were assigned to nuclear tests. Wartime secrecy made this necessary for military operations. Similarly, the actual nuclear weapon or device was classified. That made it necessary for scientists and test planners to assign innocuous code words or nicknames to planned tests.

Early tests used the military phonetic alphabet (Able, Baker, Charlie, etc). As the pace of testing increased, more imaginative names were used. They included rivers, mountains, famous scientists, small mammals, fish, birds, vehicles, cocktails, automobiles, trees, cheeses, wines, fabrics, tools, nautical terms, colors, and ghost towns.

Although the selection of names by Los Alamos and Livermore National Laboratories may seem somewhat whimsical, there was a formal procedure by which the names were selected by the two laboratories. After appropriate in-house screening for inappropriate or previously used or rejected names, the new names were submitted to Headquarters, U.S. Department of Energy in Washington. There, further screening and coordination with other government agencies was conducted. Ultimately, an approved list was returned to the laboratories.

Today, the same procedure is used in selecting names for subcritical experiments, e.g., musical instruments, movies, and horses.

Availability of Historical Films:

Due to recent declassification efforts, more than 95 films that cover the years 1945 through 1976 are available for purchase from U.S. Department of Energy=s Nuclear Testing Archive.

Videos are available in four formats: VHS (NTSC), BetaCam SP (NTSC), and international versions VHS (PAL) and VHS (SECAM). *BetaCam PAL or SECAM formats are not available.* Costs: VHS (NTSC) - $15 each; BetaCam SP 30 minutes or more - $150 each, less than 30 minutes - $120 each; VHS (PAL) and VHS (SECAM) - $50 each.

Shipping and handling varies depending on the quantity ordered. Please call, write, or send an e-mail and a cost estimate will be provided. International orders have a $30 surcharge. In addition, the recipient is responsible for any import/export fees. All prices are in U.S. dollars. Payment options are cash (in person), check, or money order. Credit cards are not accepted. To order, send a check or money order, **payable to Bechtel Nevada**, along with a list of desired videos and formats to:

Via U.S. Postal Service or Express Mail (UPS, FedEx).
U.S. Department of Energy, National Nuclear Security Administration, Nevada Site Office, Nuclear Testing Archive, Bechtel Nevada, P.O. Box 98518, Las Vegas, NV 89193-8521. Feel free to call the Archive at 702-794-5121, fax: 702-794-5198, or send e-mail to cic@nv.doe.gov with any questions or comments.

Film Listing

Nuclear Testing Review, 25 min, Color, Overview of Operation Dominic failures, A-7 carrier aircraft launch.
Trinity 1945, 12 min, 1945, Color, Sanitized, Silent.
Project Crossroads, 41:30 min, 1946, Black & White
Operation Sandstone, 20 min, 1948, Color, Overview.
EGG in Operation Sandstone, 15:40 min, 1948, Color.
USAF Participation in Operation Sandstone, 30 min, 1948, Black & White.
U.S. Army Engineers on Operation Sandstone, 20 min,1948, Black & White.
Blast Measurement Group in Operation Sandstone, 18:35 min, 1948, Color.
Navy's Part in Operation Sandstone, 41:30 min, 1948, Black & White.
Operation Greenhouse, 22 min, 1951, Pacific, Color.
Operation Buster/Jangle, 17 min, 1951, Nevada, Color, Sanitized.
Operation Tumbler/Snapper, 47 min, 1952, Nevada, Color, Sanitized.
Operation Ivy, 62:30 min, 1952, Pacific, Color, Sanitized.
Operation Castle, 20 min, 1954, Color, Sanitized.
Damage and Destruction, 17 min, No date given, Black & White/Color, Sanitized, Silent.
Operation Upshot/Knothole, 35:45 min, 1953, Color, Sanitized.
Operation Upshot/Knothole, Project 5.2, Atomic Weapons Effects on B-50 Aircraft, 19 min, 1953, Black & White, Silent.
Operation Teapot, Military Effects Studies, 30 min, 1955, Color, Sanitized.
Operation Wigwam, Commander's Report, 35:45 min, 1955, Color.
Operation Redwing, 25:45 min, 1956, Black & White, Sanitized.
Military Effects on Operation Redwing, 31:30 min, 1956, Color, Sanitized.
Operation Plumbbob, 22 min, 1957, Black & White, Sanitized.
Operation Plumbbob, Military Effects Studies, 31:45 min, 1957, Black & White, Sanitized.
Operation Hardtack, Military Effects Studies, Part One - Basic Effects, Structures and Material, 26 min, 1958, Black & White.
Operation Hardtack, Military Effects Studies, Part Two - High Altitude Studies, 24:45 min, 1958, Black & White, Sanitized.
Operation Hardtack, Military Effects Studies, Part Three - Underwater Tests, 18:40 min, 1958, Black & White, Sanitized.
Operation Hardtack, Military Effects Studies, Part Four - Sub-Kiloton Effects, 33:50 min, 1958, Black & White, Sanitized, Silent.
Report of Chief, AFSWP to ARPA - Operation Argus, 44:40 min, 1958, South Atlantic, Color, Sanitized.
Vela Uniform Participation in Operation Nougat and Gnome, 21:30 min, 1961-1962, Black & White.
Dominic Fireballs, Pacific Testing 1962, Christmas Island Area, 43:40 min, 1962, Color, Silent, (long-distance aerial views only).
Project Sedan, 7 min, 1962, Color, poor original, great film.
SADM Delivery by Parachutist/ Swimmer (Special Atomic Demolition Munition), 9:45 min, no date given, Black & White, no explosions.
The U.S. Army Presents MF20 9811, Ivy Flats Film Report, 17:35 min, 1962, Black & White.
Operation Doorstep 10 min, and ***Operation Cue***, 16 min. ***1953 Annie Event*** and ***1955 Apple-2 Event***, Color, Civil Defense Films, Nevada (two films on one video).
Project Gnome, 29:13 min, and ***Plowshare*** 28:22 min, 1968 and 1973, Black & White/Color.
Nuclear Evacuation, Excavation with Nuclear Explosives, 8:45 min, and ***Plowshare***, 28:22 min, 1968 and 1973, Black & White/Color.

Project Rulison, 7:28 min, 1969, Colorado, Color.
The Warm Coat, 14 min, 1969-1969, Otter relocation from Amchitka, Alaska, no explosions.
The Amchitka Program, 24:11 min, 1970, Alaska, Color.
Project Long Shot, 13:15 min, 1965, Alaska, Black & White.
The Milrow Event, 27:30 min, 1969, Alaska, Color.
Project Cannikin Review, 13 min, 1971, Alaska, Color, Sanitized.
Atomic Blasts, Operations Greenhouse through Upshot-Knothole, 29:22 min, 1951-1953, Color, Silent.
Pacific Nuclear Tests, 21:15 min, 1962, Color, Sanitized
U.S. Navy Training Film – ASSROC Weapons System – Introduction, 20:30 min, 1963, Black & White.
Naval Atomic Weapons Vulnerability Program, 21:15 min, late 1950s, Black & White, Sanitized.
Composite No. 1 – Swordfish, Sailor Hat (Conventional Test), ASROC, SUBROC, 17:45 min, various dates, Color, Sanitized.
U.S Navy Training Film – Delivery of Atomic Weapons by Light Carrier Aircraft, 18:20 min, no date, Black & White.
U.S. Navy Presents Nuclear Effects at Sea, 20:30 min, 1976, Black & White, Sanitized.
The Defense Atomic Support Group, Agency Presents Technical Training Film Bulletin Number 45, Part II – TALOS Missile Handling, Cruiser Installation, 13 min, no date, Black & White, Sanitized.
U.S. Navy Training Film – Torpedo MK 45 (Nuclear) Systems Description, 13 min, 1962, Black & White/Color.
Armed Forces Special Weapons Project Presents United States Air Force Atomic Bomb Delivery Aircraft (Piloted), 17:30 min, 1950-1957, Black & White/Color, Sanitized.
Armed Forces Special Weapons Project Presents Atomic Guided Missiles, 11:50 min, 1955, Black & White/Color, Sanitized.
Produced by the Defense Nuclear Agency, Meeting the Terrorist Threat, , 7:30 min, early 1970s, Color.
Hybla Fair, 15;15 min, 1974, Black & White/Color, Sanitized.
Federal Civil Defense Administration Presents Let's Face It, 13:25 min, no date, Color.
Produced by the Defense Nuclear Agency, Enewetok Cleanup, 13:15 min, no date, Color.
Excerpts From Operations Hardtack, 17:30 min, 1958, Color, Silent.
U.S. Navy Training Film – Mark 43 and Mark 57 Weapons – Shipboard Handling, Including Aircraft Loading, 20:25 min, 1963, Black & White, Sanitized.
The Unitd States Army Presents TF9 3370, Technical Proficiency Inspection, 23:50 min, 1963, Black &White, Sanitized.
Exercise Desert Rock, 27:51 min, 1951, Black & White.
Operation Dominic Nuclear Tests, 26:23 min, 1962, Black & White, Sanitized.
Starfish Prime Event Interim Report By Commander JTF-8; Fishbowl Aural Sequences; Dominic On Fishbowl Phenomenon; Fishbowl XR Summary, 61:25 min, 1962, Silent, Black & White/ Color, Sanitized (four films on one video).
Operation Fishbowl – High Altitude Weapons Effects, 28:10 min, Black & White, Sanitized.
JTF-8 Presents Operation Dominic, Christmas Island; EG&G Operation Dominic Scientific Photography, Bluestone Event, 22:29 min, 1962, Black & White, Sanitized.
JTF-8 Presents Operation Dominic: Johnston Island, 19:23 min, 1962,Black & White, Sanitized.
High-Altitude Nuclear Weapon Effects Part One – Phenomenology, 20:53 min, 1963, Color, Sanitized.
High-Altitude Nuclear Weapon Effects Part Two – Systems Interference, 16:29 min, 1963, Color, Sanitized

Atomic Weapons Orientation Part One - Organization for Atomic Energy ,17:50 min, and ***Atomic Weapons Orientation Part Two - Basic Atomic Weapons,*** 12:10 min, 1961 and 1965, Black & White/Color, Sanitized (two films on one video).

Atomic Weapons Orientation Part Three - Special Weapons Orientation: Weapons Family, 7:30 min, and ***Atomic Weapons Orientation Part Four - Atomic Weapons Support Operations,*** 12:20 min, 1961, Black & White/Color, Sanitized (two films on one video).

Atomic Weapons Orientation Part Five - Effects of Atomic Weapons, 15:25min, and ***Atomic Weapons Orientation Part Six - A Special Weapon Orientation***: ***The Thermonuclear Weapon,*** 29:50 min, 1964, Black & White/Color, Sanitized (two films on one video).

Tonopah Test Range: An Outdoor Laboratory Facility, 12:27 min, 1964, Color.

Developing and Producing the B-61, 26:29 min, 1970s, Color, Sanitized.

Trinity Historical Footage, 11:15 min, 1945, Color, Sanitized.

Atomic Proving Ground, The Story of Operation Sandstone, 73:50 min, 1948, Black & White.

Radiological Safety on Operation Sandstone, 25:45 min, 1948, Black & White.

The Armed Forces Special Weapons Project Presents Technical Report: Tumbler-Snapper, 12:50 min, 1953, Black & White, Sanitized.

Operation Tumbler: A Photographic Study of Blast and Thermal Effects, 22:20 min, 1952, Color.

Atomic Weapons Tests: Tumbler-Snapper Through Upshot-Knothole, 30:30 min, 1952-1953, Color, Sanitized

Operation Teapot – Military Effects Studies, 31 min, 1955, Color.

The First Twenty-Five Years (Los Alamos), 28 min, 1973, Black & White/Color.

U.S. Air Force Training Film TF5973, Broken Arrow Procedures for an EOD Detachment, 17 min, 1967, Color.

B-52 Accident, Yuba City, CA (Broken Arrow), 14:55 min, 1961, Black & White, Sanitized, Silent

Nuclear Weapon Accident Responses – Thule, Greenland and Palomares, Spain (Broken Arrow), 40:24 min, 1968 & 1966, Color, Sanitized, Silent (two films on one video).

Atomic Explosions, the Story of Five Atomic Bombs (Reels 1-6), 59:17 min, 1945-1946, Black & White.

Atomic Explosions, the Story of Five Atomic Bombs (Reels 7-12), 59:52 min, 1945-1946, Black & White.

Atomic Explosions, the Story of Five Atomic Bombs (Reels 13-18), 61:44 min, 1945-1946, Black & White.

Dominic Sunset, 3:30 min, 1962, Color, Silent.

Joint Task Force Three Presents Operation Greenhouse, 79:30 min, 1951, Color, Sanitized.

Atomic Weapons Tests, Trinity Through Buster-Jangle, 22:59 min, 1945-1951, Color, Sanitized.

Additional films available from the Nuclear Testing Archive:

Target Nevada, 13:30 min, 1953, Color.

Atomic Weapons Tests, Trinity through Buster-Jangle, 22:59 min, 1945-1951, Color, Sanitized.

The Basic Physics of an Atomic Bomb, 19:45 min, no date given, Color.

Nuclear Effects During SAC Delivery Missions, 30:50 min, 1960, Color, Sanitized.

Edward Teller - An Early Time, 28 min, 1979, Black & White/Color.

Nevada Test Site - The First 50 Years, 28:21 min, 2001, Color.

Resources

Robert M. Anders, *Energy History Series B The Office of Military Application*, DOE/OSE-0003, August 1980.

Nevada Test Site Organization: Background Information on Nevada Nuclear Tests, May 1, 1957.

William Gray Johnson, Barbara A. Holz and Robert Jones, *A Cold War Battlefield: Frenchman Flat Historic District*, DE-AC08-00NV13609-01, August 2000.

Abby A. Johnson, *A History of the Nuclear Test Personnel Review Program, 1978-1986*, DNA604F, 1986.

Sandia National Laboratories, *Tonopah Test Range*, SAND96-0375 UC-700, March 1996.

Frederick C. Worman, *Anatomy of the Nevada Test Site*, University of California, Los Alamos National Laboratory, March 1965.

Operation Hardtack 1958, DNA-6026F, December 3, 1982.

Shots Encore to Climax May 8 - June 1953, DNA 6018-F.82

Operation Hardtack 1958, DNA-6026F, December 3, 1982.

Shots Encore to Climax May 8 - June 1953, DNA 6018-F.

Completion Report Operation Plumbbob, Holmes and Narver Inc., July 17, 1972.

Operation Teapot 1955, DNA 6009F, November 23, 1981.

Ralph E. Reisler, *Archival of Structural Experimental Data*, DNA-TR-97, November 18, 1997.

M. Sharirli, D.G. Rose, *Gravel Gertie: Full Scale Test Summary*, LA-UR-96-2290, June 27, 1996.

Samuel Glasstone & Philip Dolan, *The Effects of Nuclear Weapons*, U.S. Department of Defense, Third Edition, 1977.

NTS News, *The Yucca Lady*, May 21, 1965.

Significant Peaceful Nuclear Explosion Events and Related Activities, U.S. Atomic Energy Commission, June 1973.

Operation Ranger, DNA, 6022F, July 27, 1982.

Five-Year Summary Report of an Experimental Dairy Herd Maintained on the Nevada Test Site 1971 through 1975, U.S. Environmental Protection Agency, EMSL-LV-0539-9, June 1977.

Nevada Nuclear Waste Storage Investigations, U.S. Department of Energy, November 1980.

Baneberry Summary Report, U.S. Atomic Energy Commission, May 1971.

Alice. L. Buck, *A History of the Atomic Energy Commission*, U.S. Department of Energy, August 1982.

Major Marshall B. Jones, *A Chronological History of Nuclear Readiness*, no date.

A. Costandina Titus, *A-Bombs in the Backyard*, Las Vegas Sun, July 1951.

United States Nuclear Tests, July 1945 through September 1992, DOE/NV-209-Rev-15, December 2000.

Nuclear Civil Effects: Bare Reactor Experiment Nevada (BREN), January - December 1961.

NOTES

For more information, write, or call
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