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U. S. DEPARTMENT OF THE INTERIOR

Preliminary Evaluation of the Seismicity, Geology, and Hydrology of the Northern Sand Springs Range, Churchill County, Nevada, as a Possible Site for Project Shoal

By
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July 1961

This report is preliminary and has not been edited for conformity with Geological Survey format and nomenclature

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NUCLEAR EXPLOSIONS—PEACEFUL APPLICATIONS

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PRELIMINARY EVALUATION OF THE SEISMICITY, GEOLOGY, AND HYDROLOGY OF THE NORTHERN SAND SPRINGS RANGE, CHURCHILL COUNTY, NEVADA, AS A POSSIBLE SITE FOR PROJECT SHOAL

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Prepared on behalf of the Albuquerque Operations Office,

U. S. Atomic Energy Commission

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INTRODUCTION

Project Shoal is an experiment designed to compare the seismic energy produced by an underground explosion with that produced by a shallow-focus natural earthquake. The Shoal experiment is one of a series of experiments in the Vela Uniform program, a comprehensive research program under the direction of the Advance Research Projects Agency to improve techniques of detecting underground nuclear explosions.

The Geological Survey was requested by the Albuquerque Operations Office, U.S. Atomic Energy Commission, to evaluate the northern Sand Springs Range, Churchill County, Nev., as a possible site for Project Shoal, in terms of the seismicity, climate, topography, geology, and hydrology. This report presents preliminary data from library research and a brief field examination of the area.

The requirements for a suitable site for the Shoal experiment are based on technical criteria furnished by the Air Force Technical Applications Center. These were first stated in a letter dated August 29, 1960, from the Defense Atomic Support Agency to the

Albuquerque Operations Office of the Atomic Energy Commission. The requirements have been modified by subsequent discussion and at the present time are as follows:

1. Geologic medium shall be like that of the Logan (tuff) or of Lollipop (granite) tests in an area of simple geologic structure.

2. Surface relief should be less than one-tenth wave length at one cycle per second within a radius equal to emplacement depth.

3. Emplacement depth is to be 1,500 feet if in granite and 1,350 feet if in tuff.

4. Site shall be in a currently active seismic area where there is a recent history of strong shallow-focus earthquakes.

5. Preferred time for the event is spring, summer, or fall, to avoid winter storms.

6. Technical operations will require a central working area around ground zero, extending outward for a radial distance of half a mile. Bedrock outcrops for installation of several seismograph stations will be required within the working area.

7. Two half-acre areas, separated by a distance of a quarter of a mile, will be required for each off-site seismographic station. Bedrock outcrops, which will be used for seismograph vaults, will be required in one of the areas. The other area will provide a location for a recording shelter, generator, and vehicle storage.

8. The shot location within the chosen active seismic area is not critical, nor is the depth of overburden, although several bedrock outcrops will be required within a radius of 1,500 feet of ground zero.

9. Strong motion measurements and intermediate range measurements will be similar to those programmed for Lollipop. Approximately 40 temporary seismograph stations will be used in linear and azimuthal patterns at distances ranging from 200 to 4,000 kilometers.

The northern Sand Springs Range was selected as a possible site for the Shoal experiment as a result of extensive library and field study of seismic areas in all of the Western States (Twenhofel, Black, and Balsinger, 1961). This study disclosed that the region east of Fallon, Nev., is seismically more active than any other area in the Western States outside of California. Because of population density and evaluation of public relations problems in using sites in California, the Albuquerque Operations Office of the Atomic Energy Commission has recommended the northern Sand Springs Range for further geologic exploration.

There is no tuff known within the active seismic area east of Fallon, and the only known body of granite of sufficient size and of sufficiently low topographic relief is in the northern Sand Springs Range.

This report summarizes to date (June 1961) the known information on the Sand Springs Range as it pertains to the Shoal experiment.

LOCATION

The possible site for the Shoal experiment is in the northern portion of the Sand Springs Range, Churchill County, Nev., about 5 miles south of U. S. Highway 50. (See fig. 1.) The approximate location of ground zero is in the SW¼ sec. 34, T. 16 N., R. 32 E. Fallon, the nearest community, is about 28 miles to the northwest.

The site is near the top of the northern Sand Springs Range within an upland drainage basin of relatively subdued relief compared to the steep slopes on the sides of the Sand Springs Range. (See figs. 4-9,)

SEISMICITY

The Sand Springs Range and adjoining areas are within an active earthquake region. (See fig. 2.) The epicenters of past earthquakes are centered about the Sand Springs Range, the Stillwater Range to the north, and Fairview Valley and Dixie Valley to the east and northeast. Within this region 200 earthquakes were recorded in the years 1945-59. Of these, five were of Richter magnitude greater than 6, 40 were of Richter magnitude 4.5 to 6, and 142 were of Richter magnitude 3.5 to 4.5; 13 were of undetermined magnitude. (See fig. 3.)

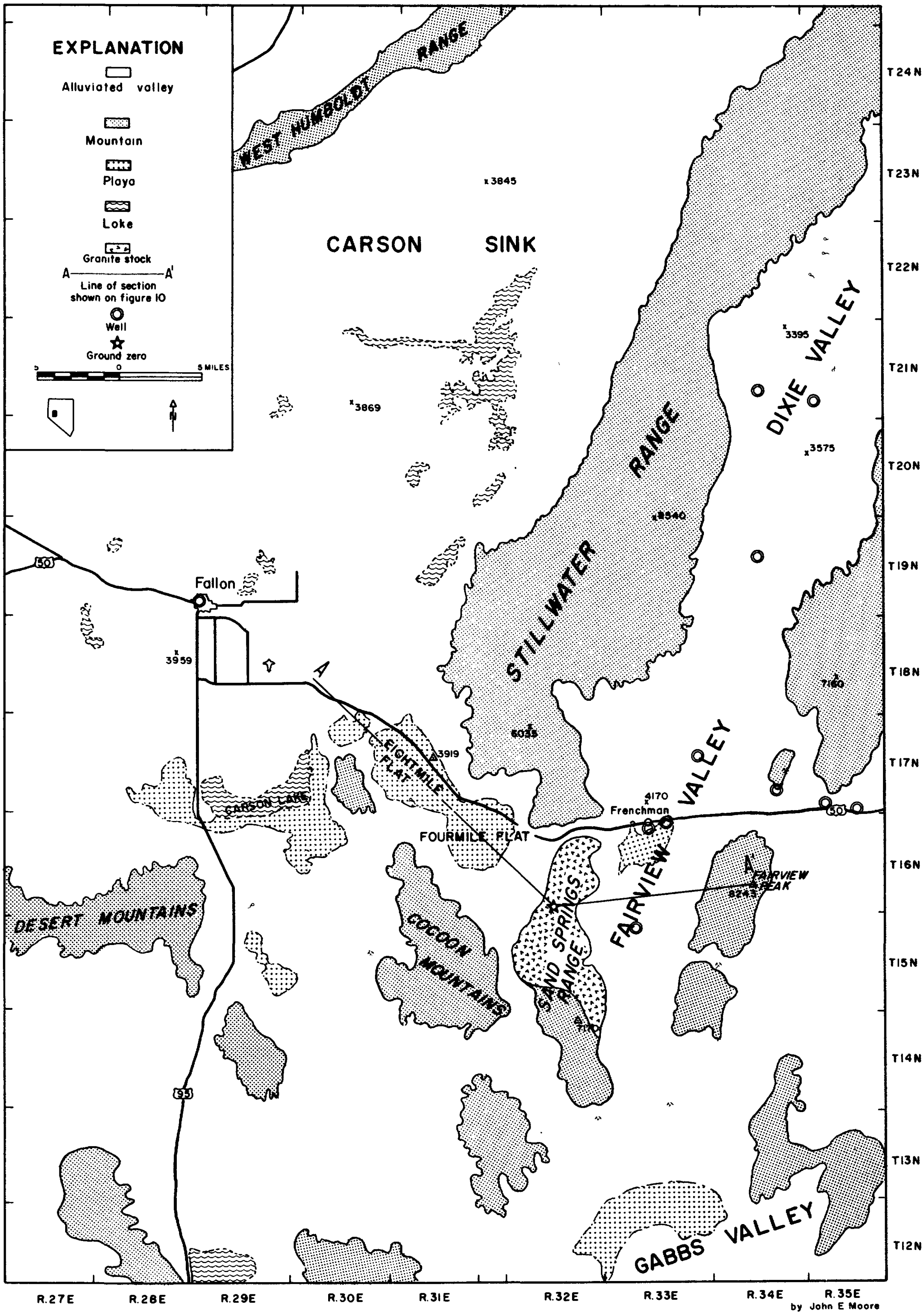
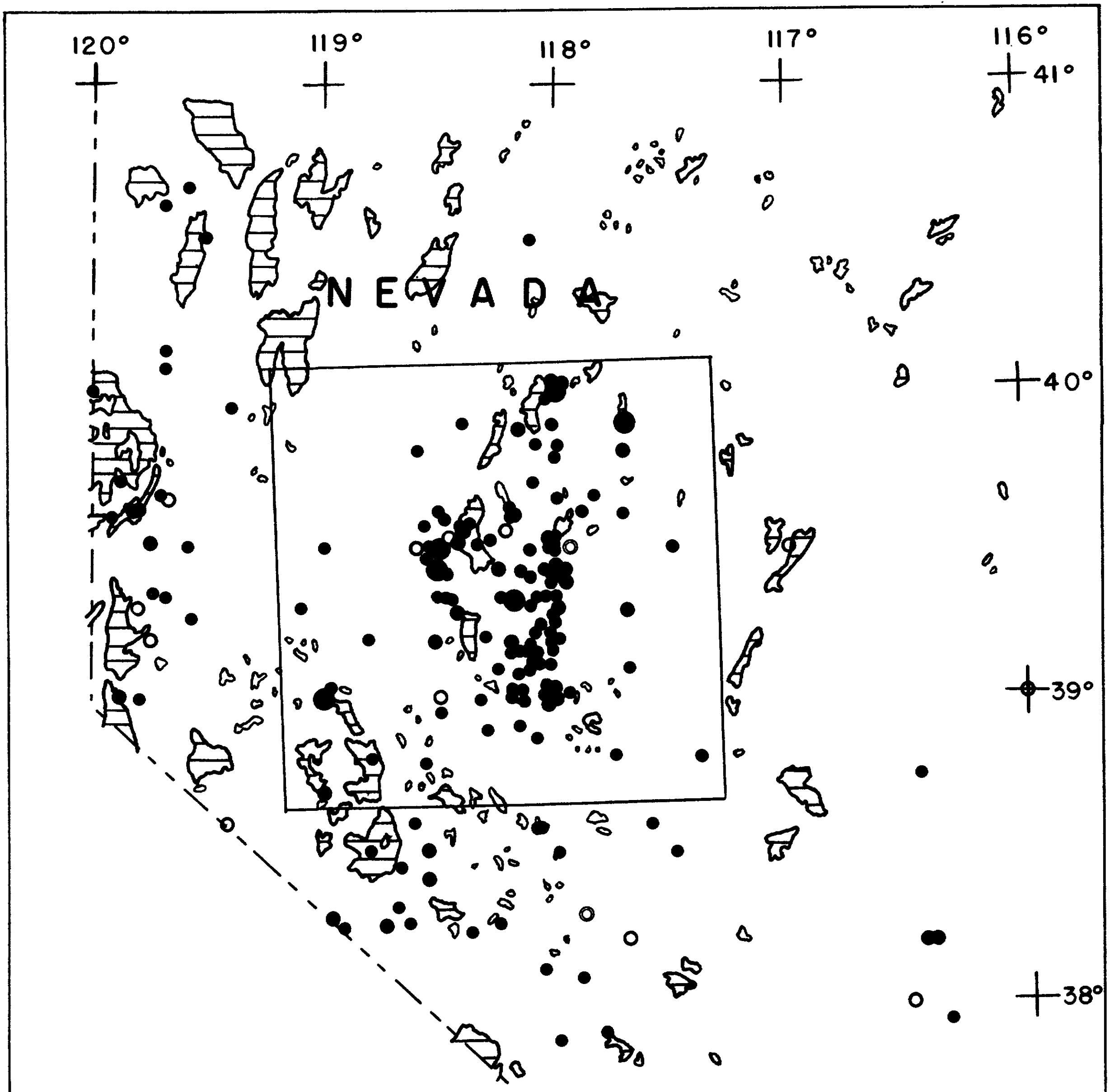


FIGURE 1. - SAND SPRINGS RANGE AND VICINITY, CHURCHILL COUNTY, NEVADA



EXPLANATION

- Earthquake epicenter, Richter magnitude 3.5 - <4.5
- Earthquake epicenter, Richter magnitude 4.5 - 6.0
- Earthquake epicenter, Richter magnitude >6.0
- Earthquake epicenter, magnitude unknown

Granitic rocks

100-mile square, selected to include granitic rocks and concentration of epicenters

Figure 2.-Granitic rocks and earthquake epicenters, 1945-59, western Nevada

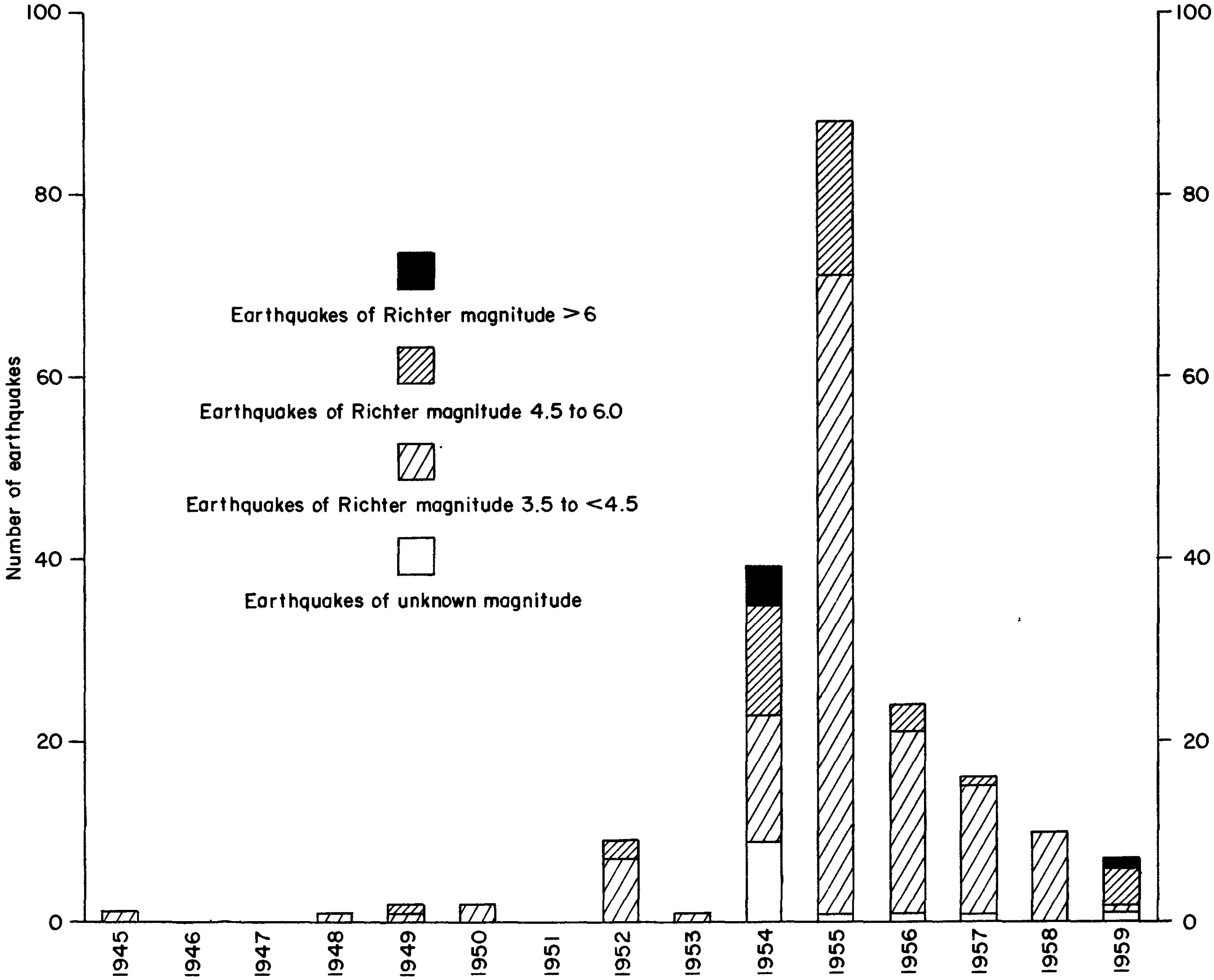


Figure 3.-Frequency of earthquakes, 1945-59, in the Fallon area, Nevada

During the period 1945-51, the earthquake activity in the region was low. The activity was extremely great in 1954-55 (about 125 earthquakes in these 2 years) and has decreased steadily and significantly to a low of seven earthquakes in 1959.

CLIMATE

The Sand Springs Range is within the arid Basin-and-Range region of Nevada. The nearest weather station is at Fallon, 28 miles northwest, at an altitude of about 3,965 feet compared to peak altitudes of 5,600 feet in the northern Sand Springs Range. The average annual rainfall at Fallon for the last 55 years is 4.95 inches; the mean annual temperature at Fallon for the past 47 years is 51°F, the average January temperature is 29.8°F, and the average July temperature is 73.1°F. Temperature extremes range from -25°F to 106°F. Because of the higher altitude of the Sand Springs Range the precipitation at the site may be expected to be somewhat greater than at Fallon, probably 7 to 8 inches per year, and the temperature slightly lower. Climatic conditions at the Sand Springs Range probably are similar to those of the higher parts of the Nevada Test Site. Year-around operations, only slightly inconvenienced by weather conditions, are possible.

TOPOGRAPHY

The Sand Springs Range trends north-south and is steep sided, but for a distance of 7 miles southward from U. S. Highway 50 the top of the range is a broad, eastward-tilted and somewhat dissected erosional surface averaging 2½ miles in width. This surface is 1,000 to 1,300 feet above the floors of the adjoining valleys (see figs. 4-6), and granite crops out or is covered by thin residual soil over this entire upland area. (See fig. 7.)

The potential site is near the center of a sagebrush and grass-covered upland topographic basin (see fig. 7) that drains southeast and east into the southern end of Fairview Valley. Proposed ground zero is at an altitude of about 5,200 feet; within a circle of 1-mile radius about ground zero, altitudes range from 4,800 to 5,600 feet. Within a radius of half a mile the range in altitude is from 5,000 to 5,400 feet.

The only topographic maps of the area are the AMS Reno sheet (1960) and the USGS Carson Sink quadrangle sheet (1908), both at a scale of 1:250,000 (1 inch equals 4 miles). Lack of detailed topographic maps precludes precise analysis of the topography of the site.

GEOLOGY

Bedrock in the northern Sand Springs Range principally is a granite body about 3 to 5 miles wide in an east-west direction and 10 to 13 miles long in a north-south direction. (See fig. 1.) The shape of the granite stock is not well known as the area has not been geologically mapped. The shape of the granite shown on figure 1 is based on a brief ground and aerial reconnaissance and should be considered as a sketch map of uncertain reliability. The granitic body is buried on the east and west sides by the alluvium in Fairview Valley and Fourmile Flat, respectively, Presumably, large faults along the sides of the Range separate the Range from the bordering lowlands. (See fig. 10.)

The bordering valleys are deeply filled with alluvial debris from the nearby mountains. A gravity survey along U. S. Highway 50 through the area indicates that the alluvium in Fairview Valley is 5,000 feet thick and on Fourmile Flat is 2,000 feet thick (Thompson, 1959). (See fig. 10.)

The granite generally is coarse grained but variable in texture and composition. (See fig. 8.) Details of these variations are not known. Numerous dikes, faults, and fractures transect the granite body, but their extent, distribution, frequency, and continuity are not known. From cursory field examination it is thought that homogeneous granite sufficiently extensive to accommodate the Shoal experiment can be found.

Figure 4.--Fourmile Flat looking east toward northern Sand Springs Range and southern Stillwater Range.

Figure 5.--Northern Sand Springs Range viewed from Fourmile Flat, looking east.

Figure 6.--Northern Sand Springs Range viewed from Fairview Valley, looking west.

Figure 7.--Top of northern Sand Springs Range. Ground Zero is to right of center near the stream. View looking north.

Figure 8.--Road leading to top of northern Sand Springs Range. Exposure of granite stock in background.

Figure 9.--Fourmile Flat viewed from northern Sand Springs Range, looking west.

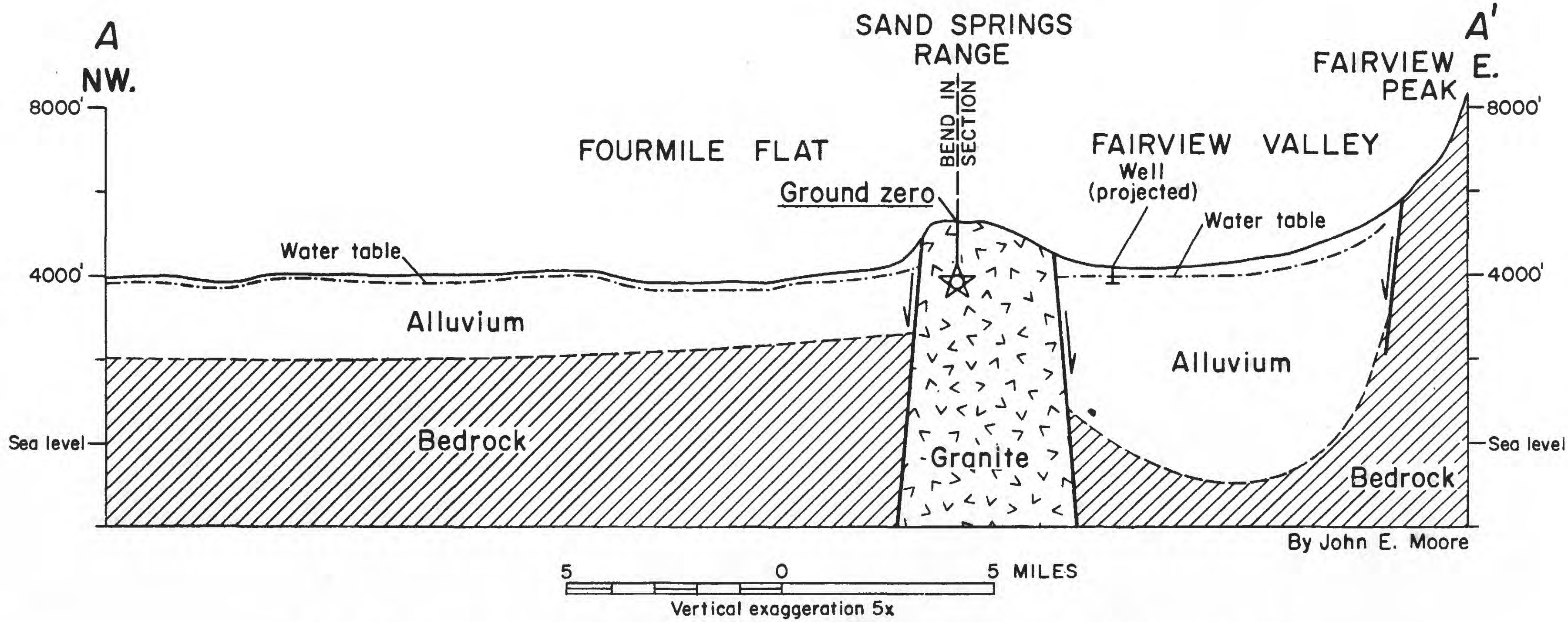


Figure 10.-Cross section from Fallon across northern Sand Springs Range to Fairview Peak.
(Showing assumed geologic and hydrologic conditions.)

There are numerous granite outcrops at the site and much of the area is covered by residual soil generally less than 10 feet thick.

HYDROLOGY

The hydrologic evaluation of the Sand Springs Range and vicinity is based on two days of field study (March 23-24, 1961) and on information obtained from Omar J. Loeltz and his staff at the Ground Water Branch district office, U. S. Geological Survey, in Carson City, Nev.

Surface water and ground water

The northern portion of the Sand Springs Range is drained by streams that are ephemeral or intermittent. (See fig. 1.) The streams discharge into Fourmile Flat and Fairview-Dixie Valleys, both topograpically closed drainage basins. Both basins are sparsely populated. Fallon, the closest large center of population, is in the Carson River Sink area and does not receive surface water from the Sand Springs Range.

Ground water occurs in the valley alluvium as both unconfined and confined water (Zones, 1957). It may also be present in fractures in the Sand Springs granite stock. The alluvial aquifers are recharged principally by snow-melt from the adjoining mountain ranges.

At this site we are concerned with four ground-water areas as they relate to possible contamination: Fallon, Fourmile Flat, Fairview-Dixie Valleys, and the northern Sand Springs Range. Records of selected wells in the vicinity of the Sand Springs Range are summarized on table 1 of this report and their locations are shown on figure 1. The wells are identified by a numbering system based on the network of surveys by the General Land Office. This numbering system is also used to locate the well in the township, range, and section. The first two numerals of the number designate the township, the second two separated from the first two by a slash in the range, and the next one or two numerals separated by a dash is the section. The section has been divided into four 160-acre tracts, each of which has been assigned a letter. Beginning with the northeast quarter, the letters have been assigned in a counterclockwise direction. Thus the northeast quarter is "A," the northwest quarter "B," the southwest quarter "C," and the southeast "D." The second letter designates the quarter of the quarter section. The first well recorded is designated by the numeral 1, the second 2, and so forth.

Fallon

Fallon is a town of 3,500 and the water use is approximately 550,000 gallons per day. The principal water supply for Fallon is obtained from two wells that penetrate a cavernous volcanic aquifer at a depth of 448-521 feet. (See table 1.) Additional small water supplies for irrigation, stock and domestic use are drawn from shallow wells in the alluvialfill. These wells have low yields and the water is highly mineralized. The elevation of the water table in the Fallon area is approximately 3,930 feet above sea level (33 feet below land surface).

Table 1. Records of selected wells in the vicinity of the Sand Springs Range

Well number	Location	Depth (feet)	Aquifer	[a]Altitude (feet)	Water level below land surface (feet)	Water table altitude (feet)	Remarks
15/33-5BA1	Fairview Valley-	364	Alluvium-----	4295	340	3955	Stock well, Q <2gpm.
16/33-2DC1	---do----------	441	---do--------	4170	220	3950	Stock well.
16/33-3CB1	---do----------	280	---do--------	4170	220	3950	Domestic well, sodium bicarbonate water.
17/34-18CA1	---do----------	362	---do---------	4235	340	3895	Stock well.
17/34-26D1	---do----------	---	---do---------	4340	205	4135	Mine shaft.
17/35-32DC1	---do----------	99	---do---------	4470	58	4412	Unused well.
17/35-34CC1	---do----------	---	---do---------	4524	24	4500	Stock well.
19/29-32CD1	Town of Fallon--	506	Volcanic rock--	3960	33	3927	Public supply, volcanic rock 448-506. Q = 2000 gpm, drawdown 6 ft.
19/29-32CD2	---do----------	521	---do---------	3960	33	3927	Public supply, volcanic rock 455-521, Q = 1000 gpm, drawdown 3 in.
19/34-15CC1	Dixie Valley----	---	Alluvium------	3850	319	3531	Stock well.
21/34-27DC1	---do----------	---	---do---------	3530	28	3502	Unused well.
21/35-31D1	---do----------	---	---do---------	3477	35	3442	Stock well.

[a]Altitudes determined by altimeter or estimated from topographic quadrangle maps

Fourmile Flat

The ground-water hydrology of Fourmile Flat and adjacent Eightmile Flat is not known. From incomplete evidence it is presumed that the water-table altitude is less than 3,900 feet above sea level and is at relatively shallow depths.

Fairview-Dixie Valleys

The population in Fairview-Dixie Valleys is sparse. Water for domestic purposes is obtained from wells and the pumpage from them is very small.

The elevation of the water table in eastern Fairview Valley is approximately 4,500 feet above sea level (30 to 60 feet below land surface), and in central and southern parts of the valley it is approximately 4,000 feet above sea level (220 to 340 feet below land surface). Ground water, as shown by available water-level measurements, moves northward from Fairview Valley to Dixie Valley, where the water table is approximately 3,440 feet above sea level. The water table in Fairview Valley is almost flat, and it steepens abruptly between Fairview and Dixie Valleys. In the central part of Dixie Valley ground-water gradients are again flat and most of the ground water is discharged by evaporation and transpiration. The rate of ground-water movement in these valleys probably ranges from several feet a day to several feet a year (Zones, 1957). It is remotely possible that a small amount of ground water may move southward (Gabbs Valley) or westward from Fairview Valley.

Northern Sand Springs Range

The ground-water hydrology of the granite and associated flank sediments in the northern Sand Springs Range is unknown. Ground water may be present in fractures in the upper part of the granite stock. This ground water probably moves in the same general direction as does the surface water. In order to determine the direction of water movement in the stock, water-level altitudes should be taken in test holes that tap water solely in the granite.

Evaluation of possible contamination of water

The proposed shot chamber will be at most 270 feet lower than the water table in both Fourmile Flat and Fairview-Dixie Valleys, at an altitude of 3,700 feet above sea level. (See fig. 10.) Should the ground water system in Fourmile Flat and Fairview-Dixie Valleys be interconnected through the Sand Springs Range, the detonation point will be below the water table.

Ground-water movement from the Sand Springs Range probably parallels the surface drainage, but travels more slowly. The risk of possible contamination of either surface-water or ground-water supplies at this site does not appear to be great. Since the ground water possibly may move from Fourmile Flat and adjacent Eightmile Flat toward Fallon, the major concern should be the possibility of contaminating the ground-water supply of Fallon.

Availability of water for experiment

For operations at this site a water supply is thought to be available about 4 miles east of the proposed ground zero in the alluvium of Fairview Valley where two wells now produce water for stock and domestic purposes at depths of 200 and 340 feet. A 6-inch well (15/35-5BA1) 5 miles east of ground zero has a total depth of 364 feet and penetrates 24 feet of aquifer. (See table 1.) It produces a few gallons a minute for stock purposes, but might be capable of producing more if required. A 12-inch well penetrating 110 feet of aquifer probably would provide the water necessary for site operations. At present there is no large supply closer than Fallon where water might be purchased.

FURTHER INVESTIGATIONS

Hydrologic studies

The following hydrologic studies are recommended for a better evaluation of this site:

A. Well and spring inventory: To define the regional ground-water conditions in terms of the depth below land surface, and configuration of the water table, and to establish the current demand for and use of ground water.

1. An inventory of wells and springs should be made to cover an area having a radius of approximately 40 miles

from ground zero. This inventory should include the Fourmile Flat area, Fairview-Dixie Valley, the Sand Springs Range and Fallon. Only a partial representative inventory is needed in the Fallon area because of the large number of small domestic wells.

B. Test drilling: To determine the rate of movement of ground water and slope of the water table in Fourmile-Eightmile Flat and Fairview Valley, the occurrence of ground water in the northern Sand Springs Range granite stock, and to establish a network of observation wells and radiochemical monitoring points.

1. Fourmile-Eightmile Flat - Approximately ten test holes should be drilled. One or more of these holes should be at least 600 feet deep but the remainder need only be deep enough to penetrate 20-50 feet below the water table (30-100 feet).

2. Fairview Valley - About four test holes should be drilled deep enough to penetrate 20-50 feet below the water table (300-400 feet).

3. Ground zero - Exploratory drilling to 1,500 feet (shot chamber depth) to determine the frequency and orientation of fractures in the granite and the occurrence of water. If water is found, bailing or pumping tests should be made.

4. Northern Sand Springs Range - Several test holes should be drilled in the vicinity of ground zero to locate ground

water, if any, in the upper portion of the granite stock. It is estimated that the ground water would be most likely found within 100 feet of land surface. These holes should be drilled after the ground-zero deep hole is completed.

5. Additional test drilling will depend on the results of the exploratory drilling outlined above.

C. Chemical and radiochemical analyses - The background radioactivity of the water should be determined so that future changes, if any, can be recognized.

1. Samples of water should be collected from a selected number of wells and springs for chemical and radiochemical analysis.

2. Samples of water should be collected from all exploratory test holes and test wells for chemical and radiochemical analysis.

Geologic studies

The following geologic studies are recommended to evaluate the site in terms of the size and shape of the granite stock and the homogeneity of the granite medium within 2,000 feet of the detonation point.

A. Surface geologic mapping: To define the rock types, dikes, fractures, and faults within a radius of 1 mile from suggested ground zero. The mapping scale should be 1 inch equals 500 feet.

B. Reconnaissance geologic mapping: To determine the size and shape of the granite stock and the position, size, and number of faults bounding and traversing the stock.

C. Aeromagnetic survey: To provide data on the size and shape of the granite stock at depth.

D. Gravity survey: To provide data on the configuration of the granite stock buried beneath alluvium and the number and position of bounding faults.

E. Exploratory drilling: To determine the characteristics and extent of fracturing of the granite at and surrounding the detonation point.

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