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Hydrological/Geological Studies

Book 1

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Project Proposal - Evaluation of Tritium and Other Radionuclides in Groundwater in the Areas Surrounding the Sites of Projects Shoal, Dribble, Gnome, Gasbuggy, and Rulison

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PROJECT PROPOSAL
EVALUATION OF TRITIUM AND OTHER RADIONUCLIDES IN GROUNDWATER IN THE AREAS SURROUNDING THE SITES OF PROJECTS SHOAL, DRIBBLE, GNOME, GASBUGGY, AND RULISON

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I. Proposal

It is proposed that a project be initiated to provide for the analysis of groundwater (used for domestic purposes) for tritium and long-lived radionuclides in the areas of Projects Shoal, Dribble, Gnome, Gasbuggy, and Rulison in order to ascertain the safety of such water on the basis of radiological health considerations and to assist in verification of long-range predictions. It is intended that the project will be conducted as part of the routine activities of the Milk, Food, and Water Surveillance Unit of the Environmental Surveillance Program. Data derived from the proposed sampling program will be used for comparative purposes and would be provided to appropriate state and local health authorities.

II. Justification

A. Background

Although the majority of all U. S. underground nuclear detonations have been conducted within the confines of the Nevada Test Site, other sites have been used from time to time for projects of a special nature. One of these sites, the Sand Springs Test Site near Fallon, Nevada, was the location chosen for Project Shoal, an event held in 1963 as part of the Vela Uniform program, which involves the detection of underground nuclear detonations. Another Vela Uniform study, Project Dribble, has involved tests in the Tatum Salt Dome near Hattiesburg, Mississippi. The Plowshare program, set up to explore the peaceful uses of nuclear explosives, has utilized several test sites in the western states. Project Gnome, a Plowshare event, was detonated in a deep salt formation near Carlsbad, New Mexico. A project of somewhat different nature was Gasbuggy, a detonation in a

deep gas-bearing formation held in 1967 near Farmington, New Mexico. Project Rulison, quite similar in nature to Project Gasbuggy, was detonated a short distance from Grand Valley, Colorado, in 1969.

For all of these projects, the U. S. Public Health Service Southwestern Radiological Health Laboratory (SWRHL) was responsible for the determination of off-site radiological contamination of air, water, milk, and food. As soon as it was established that no radioactivity had been released to the environment, however, environmental sampling and monitoring were curtailed. No continuing routine water sampling network, such as exists around the Nevada Test Site, was instituted at these sites due to the nature of the tests and the one-time use of the site. Some special sampling on a long-term basis (longer than five years), although of a very limited nature, has been carried on. Water sampling, for instance, was carried on at the Project Shoal site in cooperation with the Desert Research Institute at Reno, Nevada, until July 1968.

The persistence in the environment of certain long-lived radionuclides associated with nuclear detonations and the public health significance of these nuclides have been well documented. Research on the behavior of these nuclides, such as tritium, has pointed up the advisability of systematic monitoring of groundwater supplies surrounding nuclear detonation sites in order to document the levels of activity present, and to assist in verification of predictions. Such a program of surveillance has been instituted for the area surrounding the Nevada Test Site, and has provided much useful information. It is suggested that similar programs, but of a much smaller scale, be set up for the sites in Colorado, Mississippi, New Mexico, and northern Nevada.

B. Scope

1. Project Shoal - Fallon, Nevada

Planning for Project Shoal involved comprehensive studies of the

groundwater in the Sand Springs area and included a program of short term surveillance conducted by SWRHL (see Figure 1) and a program of long range surveillance conducted by the Desert Research Institute (DRI) of Reno, Nevada (1). Before the Shoal event was detonated, plans were made for the DRI to take water level measurements at inventoried water points, to perform chemical analysis of water samples from selected water points, and to monitor the post-shot re-entry hole for water level measurements on an intensified basis during the two fiscal years folloring the event, and on a reduced basis for five years following FY 1964.

Assistance with chemical analysis was provided by Hazelton Nuclear Science Corp. (now Isotopes, Inc., Palo Alto, California) and radiological analyses were performed by SWRHL. No tritium analyses were performed on the samples taken as part of the intensive sampling program carried on in 1964. Between 1965 and 1968, samples were taken on a yearly basis from the area surrounding the site, and tritium analyses were performed on the samples taken after 1966. A map of the site area indicating the sampling points is presented in Figure 2.

Since the detonation point for Project Shoal is considerably below the water table (at least 270 feet), and since the groundwater movement is fairly slow, ranging from several feet per day to several feet per year, the risk of possible contamination of either surface water or groundwater supplies is rather remote. Considering the possibility that groundwater may move from Fourmile Flat and adjacent Eightmile Flat (shown in Figure 2) toward Fallon, the major interest is the possibility of radiological contamination of the groundwater supply of Fallon (2).

It is proposed that a new sampling program be set up at the Shoal site, with all sampling formerly handled by the DRI becoming the responsibility of SWRHL. Samples would be taken from the same areas covered by the DRI program. A total of four samples would be collected

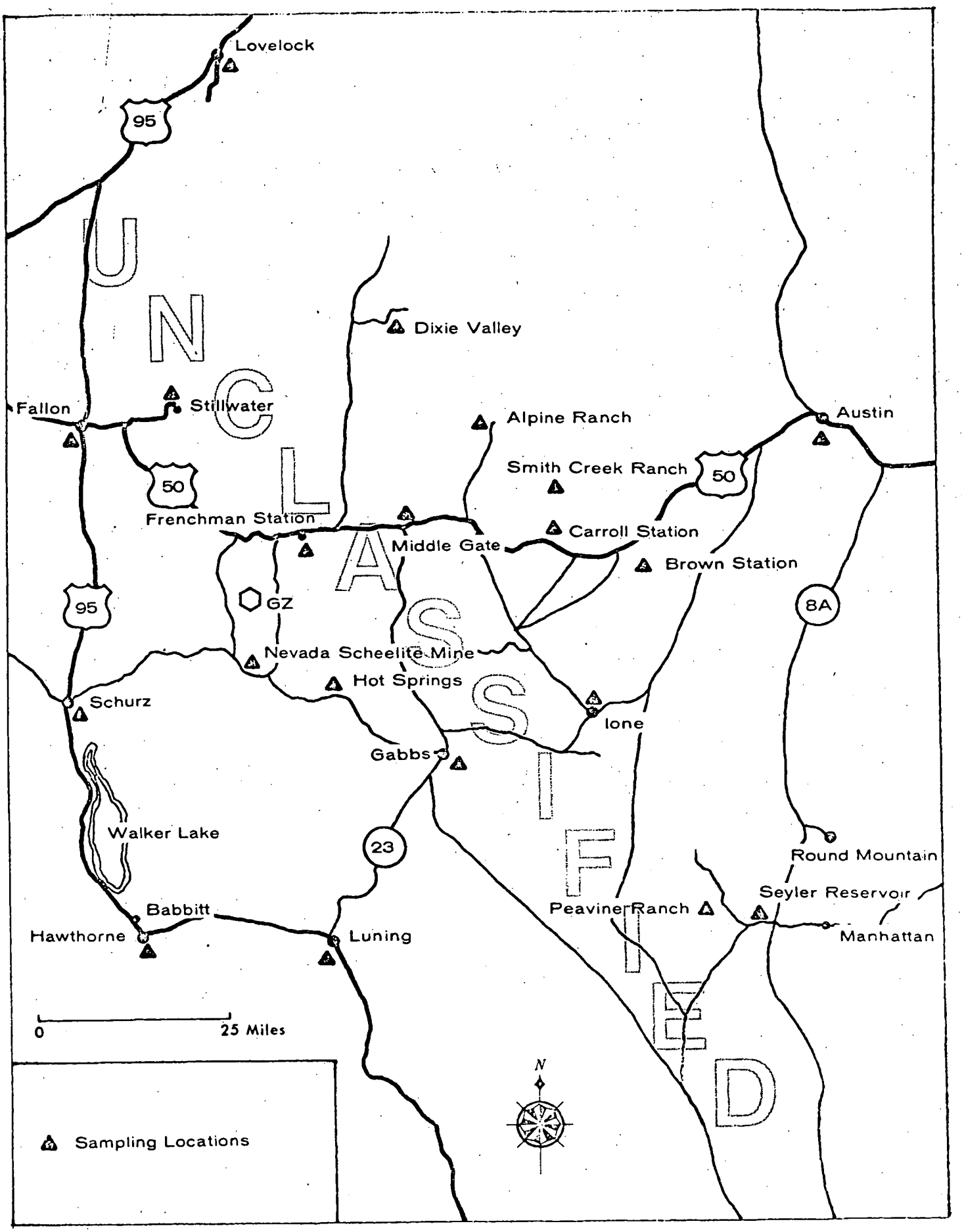

Figure 1 Sampling Locations During Project Shoal

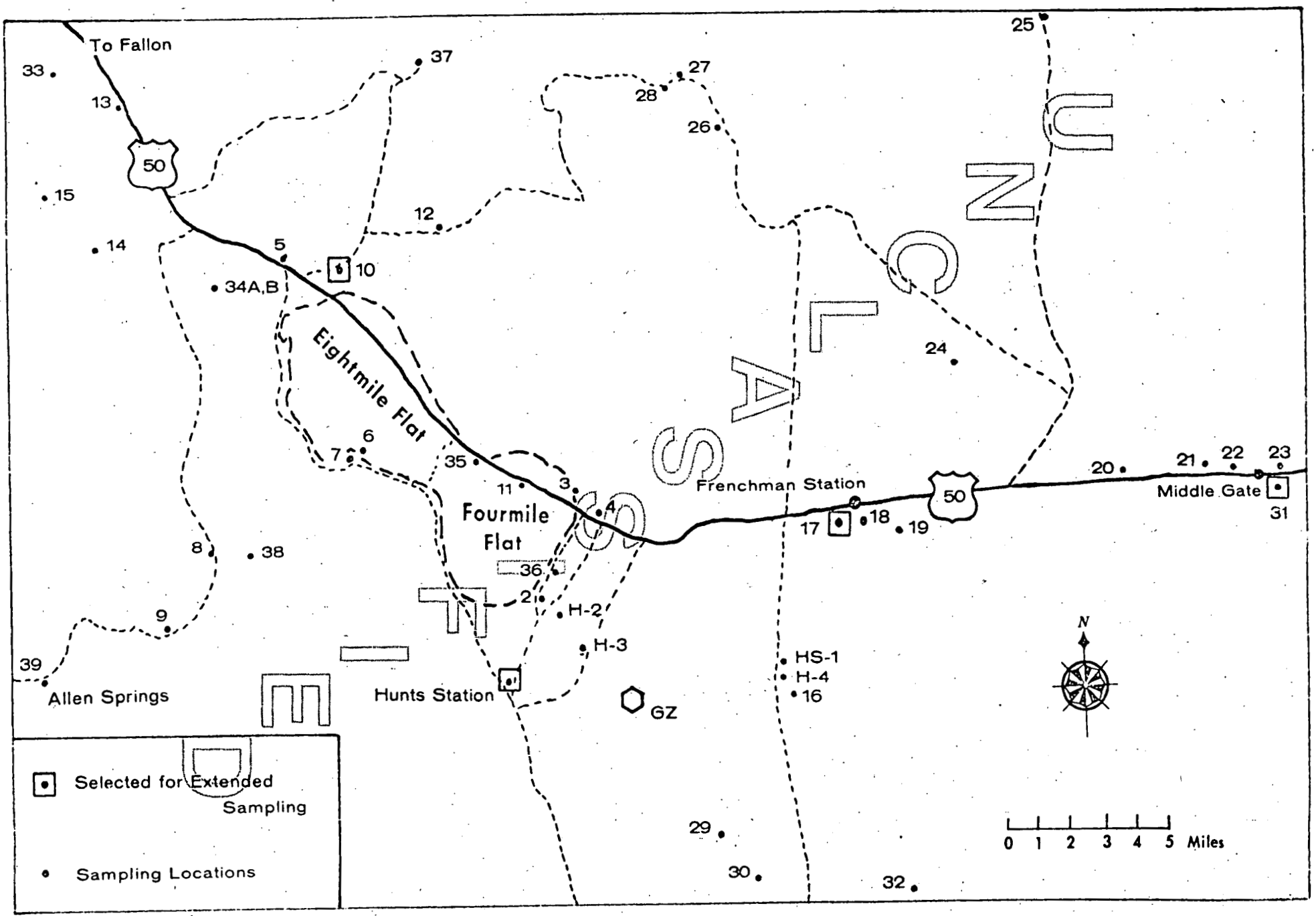

Figure 2 Sampling Locations Used by Desert Research Institute

each year, all from wells where there is human consumption of the water. All samples would be analyzed for significant gamma emitters, tritium, and strontium-90.

2. Project Dribble - Hattiesburg, Mississippi

Project Dribble involved two separate nuclear detonations: The Salmon Event, conducted on October 24, 1964, and the Sterling Event, held on December 3, 1966. Both detonations were set off in a salt formation known as the Tatum Salt Dome, approximately 19 miles southwest of Hattiesburg, Mississippi. Information on the geologic and hydrologic conditions at the site was supplied by the U. S. Geological Survey (USGS). A total of five aquifers were identified as lying above the salt dome. The Cook Mountain limestone at a depth of approximately 2,600 feet at Tatum dome is the shallowest aquifer (designated aquifer 5) containing brine. This aquifer is used for the disposal of brine in the vicinity of the Baxterville oil field a few miles southwest of Tatum dome.

The injection of brine has caused a rise in head in this aquifer at Tatum dome and apparently has reversed the flow of brine to the northeast. Thick intervening clay beds, however, probably will prevent much movement of brine into overlying fresh water aquifers.

The deepest fresh water aquifer (designated aquifer 4) is in limestone beds at a depth of 2,000 feet in the vicinity of Tatum dome. The yield of the aquifer is small and the aquifer is not presently utilized for water supply, since large yields can be obtained from wells in shallower sands. This aquifer is discontinuous over Tatum dome but may be hydraulically connected with the caprock.

The overlying sands and clay beds contain several sand units that will yield large amounts of water to wells. In the Tatum dome area, the principal sand units have been designated aquifers 1, 2, and 3, the deepest being aquifer 3. These aquifers in turn have been subdivided into a and b units. Aquifer 2a has the highest permeability.

These sands, in a general way, form one hydrologic system that is extensive over the general region. Large scale regional pumping from this hydrologic system has detered the original regional hydraulic gradient which was south-southwest and has affected the hydraulic gradient in the vicinity of Tatum dome. The result has been to make the hydraulic gradient more gentle in the vicinity of Tatum dome but there is evidence that the direction of movement of water has been reversed in some of the sand units.

USGS concludes that on the remote chance that radioactivity might excape from the salt stock in which the nuclear devices were detonated, the activity would most likely enter the caprock, the overlying sands of aquifer 3, or aquifers 4 and 5 on the flank. Computed values of the rate of movement of water in aquifers 3, 4, and 5 indicate the movement will be less than 10 feet per year. This slow rate of movement coupled with the high exchange capacity of the material comprising the aquifers leads to the conclusion that the off-site contamination potential is small to nil. The highest rate of movement, about 160 feet per year, was computed for aquifer 2a. It is unlikely that radioactivity would be released into this aquifer, several hundred feet above the caprock (3).

As part of its off-site radiological safety program, SWRHL sampled water at 47 locations for the Salmon Event and 37 locations for the Sterling Event. These locations represented public and private water supplies as well as surface streams. Twenty-four of the sampling locations for the Salmon Event were wells; eleven wells were sampled for the Sterling Event. These locations are shown in Figure 3. Those wells selected for extended sampling are also indicated in Figure 3. A total of seven locations were selected which surround ground zero. Due to the numerous aquifers at the site and the uncertainty regarding the direction of flow, it is considered that this number of stations is needed to provide an adequate appraisal of groundwater safety in the off-site area (4) (5). All samples would receive the same analyses as those from the other sites.

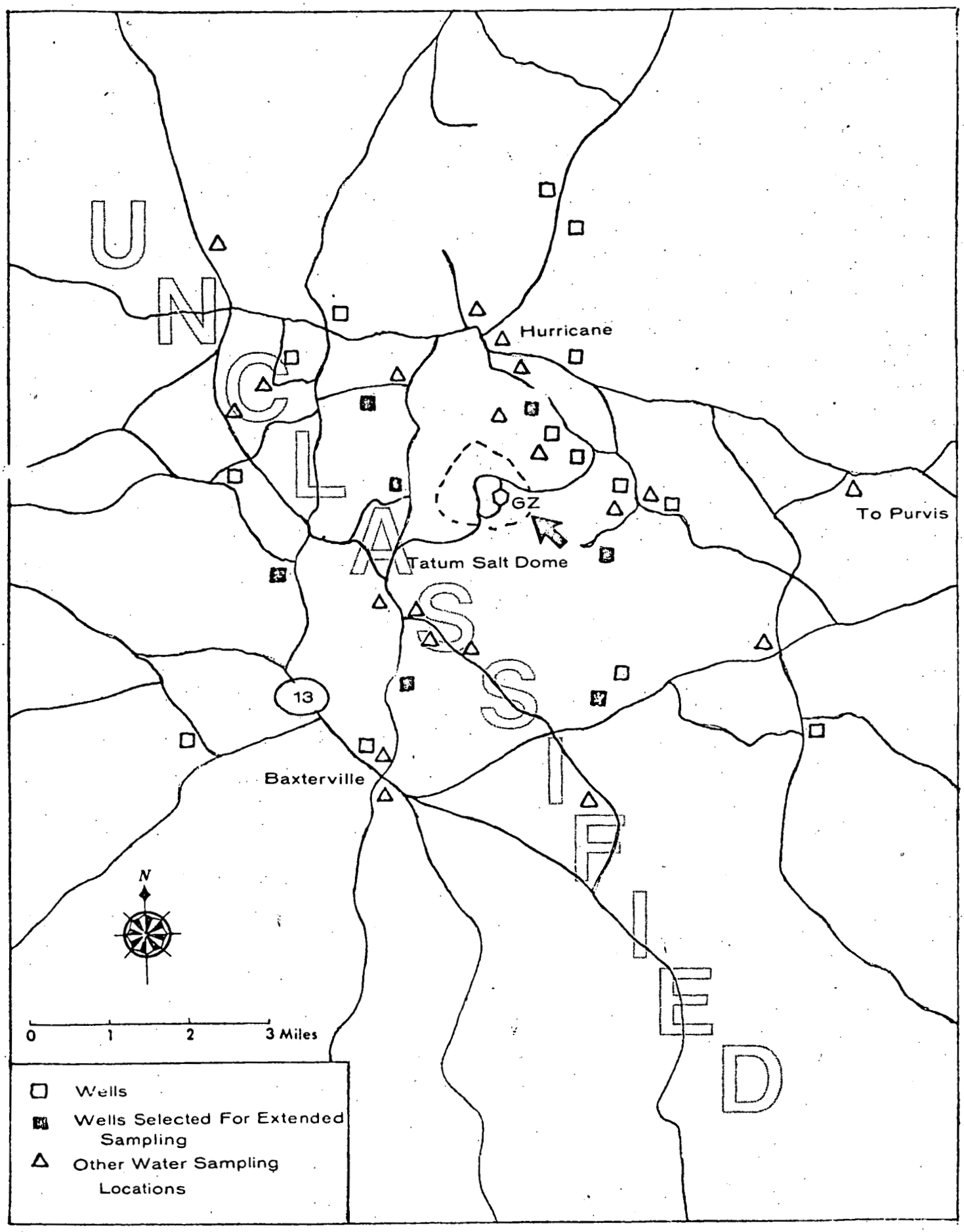

Figure 3 Sampling Locations For Project Dribble

3. Project Gnome - Carlsbad, New Mexico

As part of the Atomic Energy Commission's (AEC) public safety program, USGS investigated 10 privately-owned water wells within a 5-mile radius of the Gnome test site. These wells were used primarily for livestock water; however, the water from two wells was also used for human consumption (6). A map of the test site area showing the location of these wells is presented in Figure 4. Those locations sampled by SWRHL during the project operational period are shown in Figure 5 (7).

Pre-shot investigations of the geology and groundwater conditions at the Project Gnome site and surrounding area had determined that only one aquifer is present at the site. It is about 500 feet below the land surface, about 200 feet above the salt bed in which the device was detonated, and about 700 feet above the shot point (8). This aquifer is about 30 feet thick, and contains water with about 75 feet of artesian pressure head. The water moves westward from the shot point at a rate of about 1/2 foot per day (9).

Due to the extremely slow rate of transport in the aquifer under consideration and the scarcity of wells in the direction of groundwater flow from the detonation point, it is proposed that the number of samples be limited to two per year. The wells from which these samples would be collected are identified as numbers 9 and 10 on Figure 4. One well is approximately 194 feet deep and the other about 450 feet deep. Only one of the wells, No. 9, is used to supply water for domestic consumption. All samples would be subjected to the routine analysis procedure.

4. Project Gasbuggy - Farmington, New Mexico

USGS, as part of its participation in the safety program of the AEC, inventoried the wells and springs in the vicinity of Project Gasbuggy during June 1967. All known wells and springs within a 5-mile radius of ground zero were located and inspected. Readily accessible wells and springs between the 5- and 10-mile radius were also inventoried. The locations of these wells and springs are shown in Figure 6 (10).

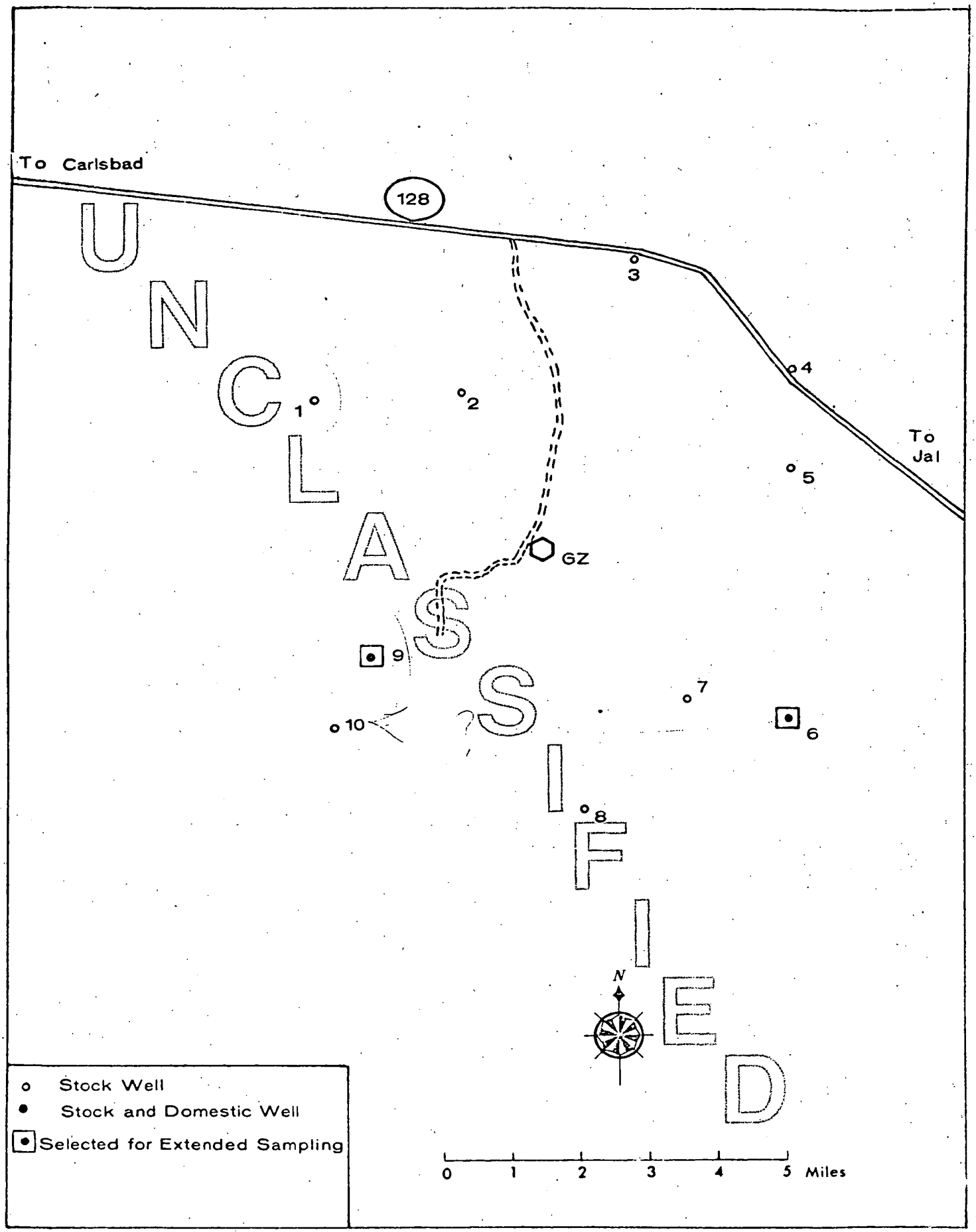

Figure 4 Wells Inventoried for Project Gnome

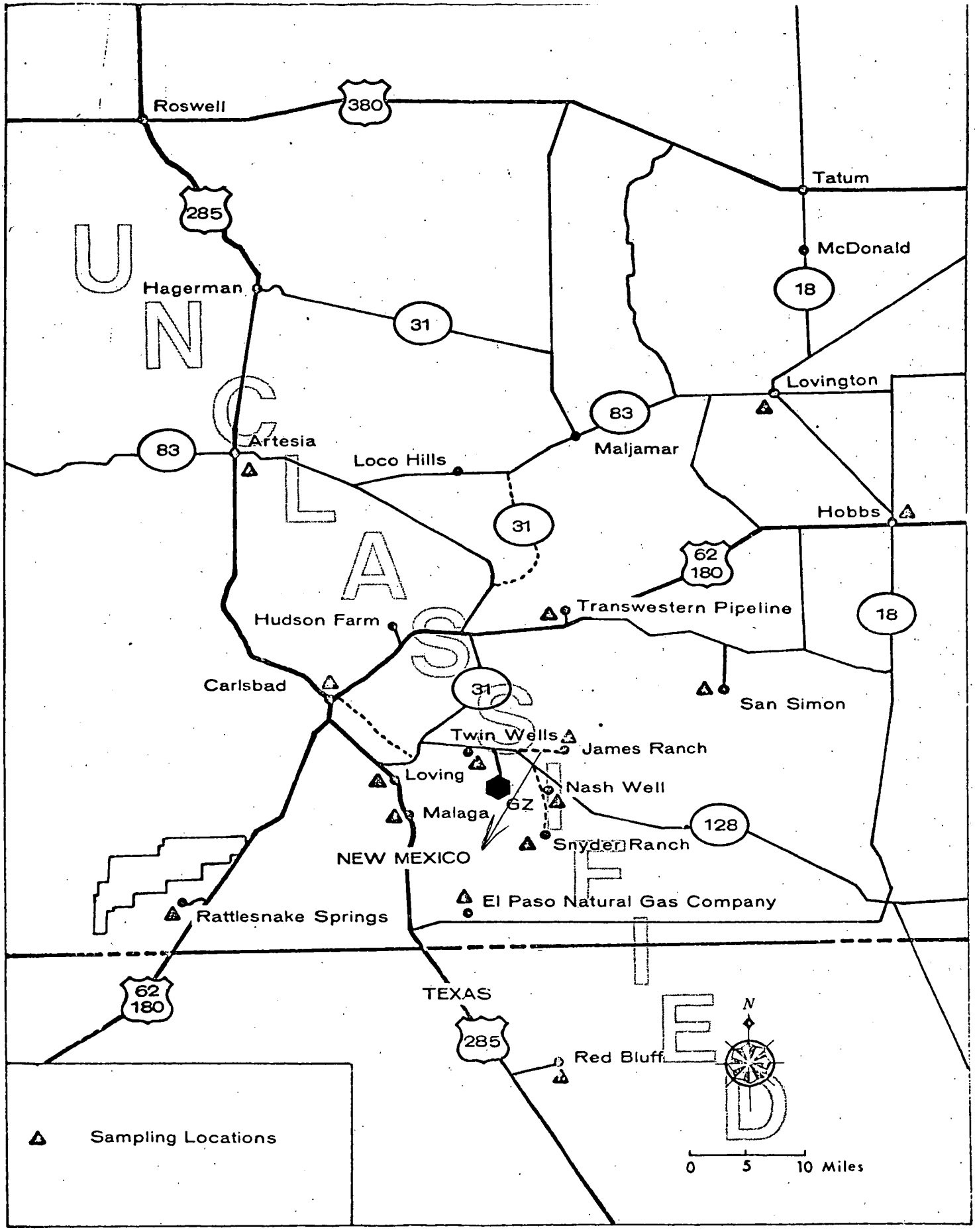

Figure 5 Sampling Locations During Project Gnome

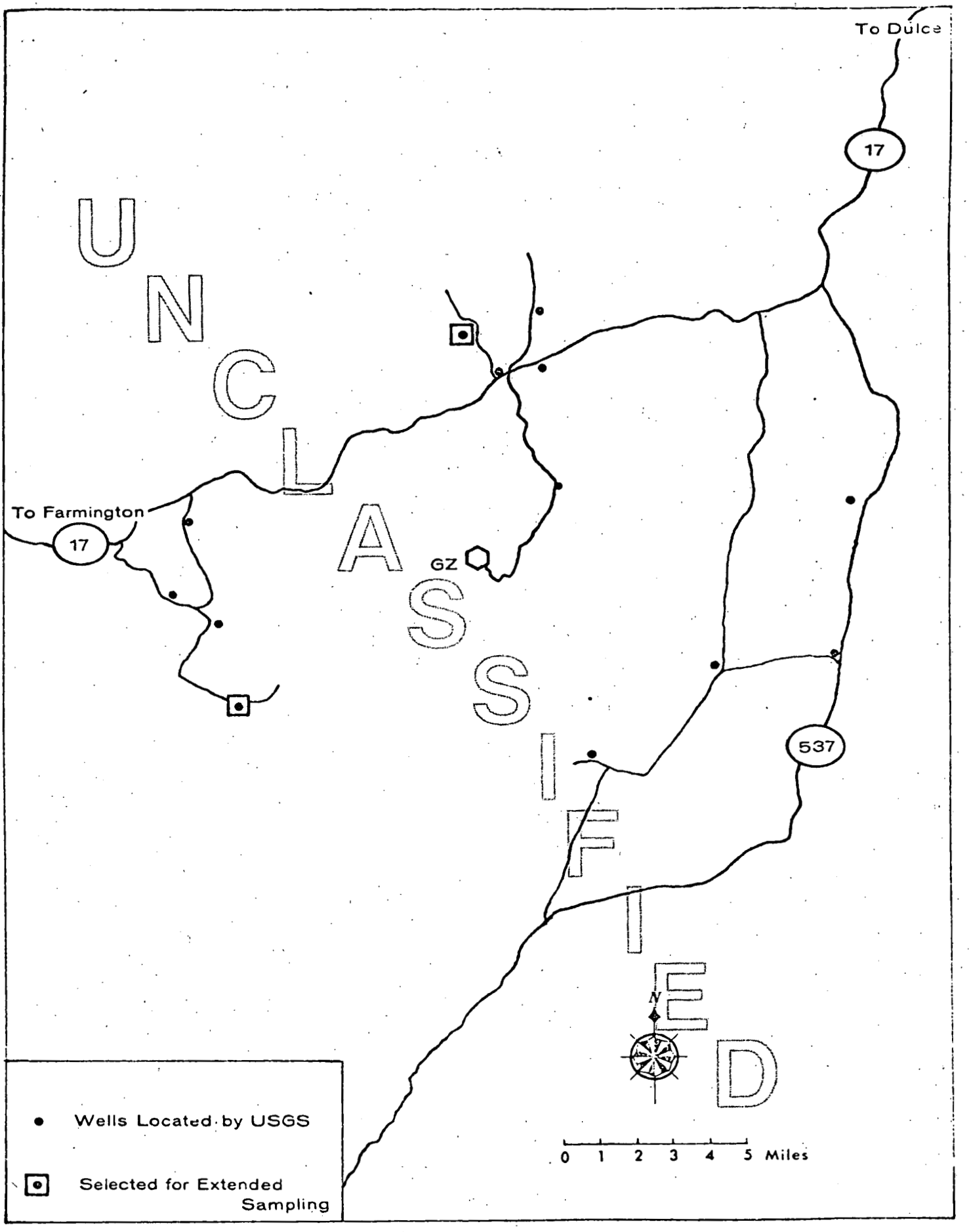

Figure 6 Wells In The Vicinity Of Project Gasbuggy

During the period of planning and execution of the Gasbuggy event, SWRHL provided radiological safety support. Water sampling coverage during the pre-shot and post-shot periods was provided by a network of thirty-four sampling stations, shown in Figure 7. Six of the network locations were municipal water systems located approximately 120 miles from ground zero. Eighty-one samples were collected during the operation. No samples were analyzed for tritium content (11).

The direction of groundwater movement in the San Juan Basin is well known. The major discharge point for water moving in the Ojo Alamo Sandstone probably is the San Juan River, 50 miles northwest of the test site. An estimate of the rate of groundwater movement has been computed by using known, or assumed, values for the permeability and porosity of the aquifer and for the hydraulic gradient of the water in the aquifer. By using this method, USGS has calculated that the average rate of movement of groundwater in the Ojo Alamo Sandstone across the basin is about 0.0001 foot per day or 0.04 foot per year (12).

P Pearson on EP or other holes into nearby Ojo Alamo.

Since the rate of groundwater movement at the Gasbuggy site is extremely slow, and since no water wells that tap any of the formations associated with the nuclear experiment were found within the 10-mile radius, it is extremely unlikely that any groundwater contaminated by the detonation will ever be discovered in wells used for stock or domestic uses. It may be desirable, however, to collect samples at the Gasbuggy site for documentation and public relations purposes. It is proposed therefore that samples be taken from two locations near the site which are indicated in Figure 6. One well is of unknown depth and the other is 175 feet deep. The proposed sampling schedule would provide for samples to be collected on a once per year basis from the wells indicated, and analyzed in the same manner as the samples from the other sites.

5. Project Rulison - Grand Valley, Colorado

Prior to the detonation of Project Rulison an in-depth study was made of the groundwater and surface water supplies in the vicinity of ground zero by USGS. In the months immediately preceding the detonation a

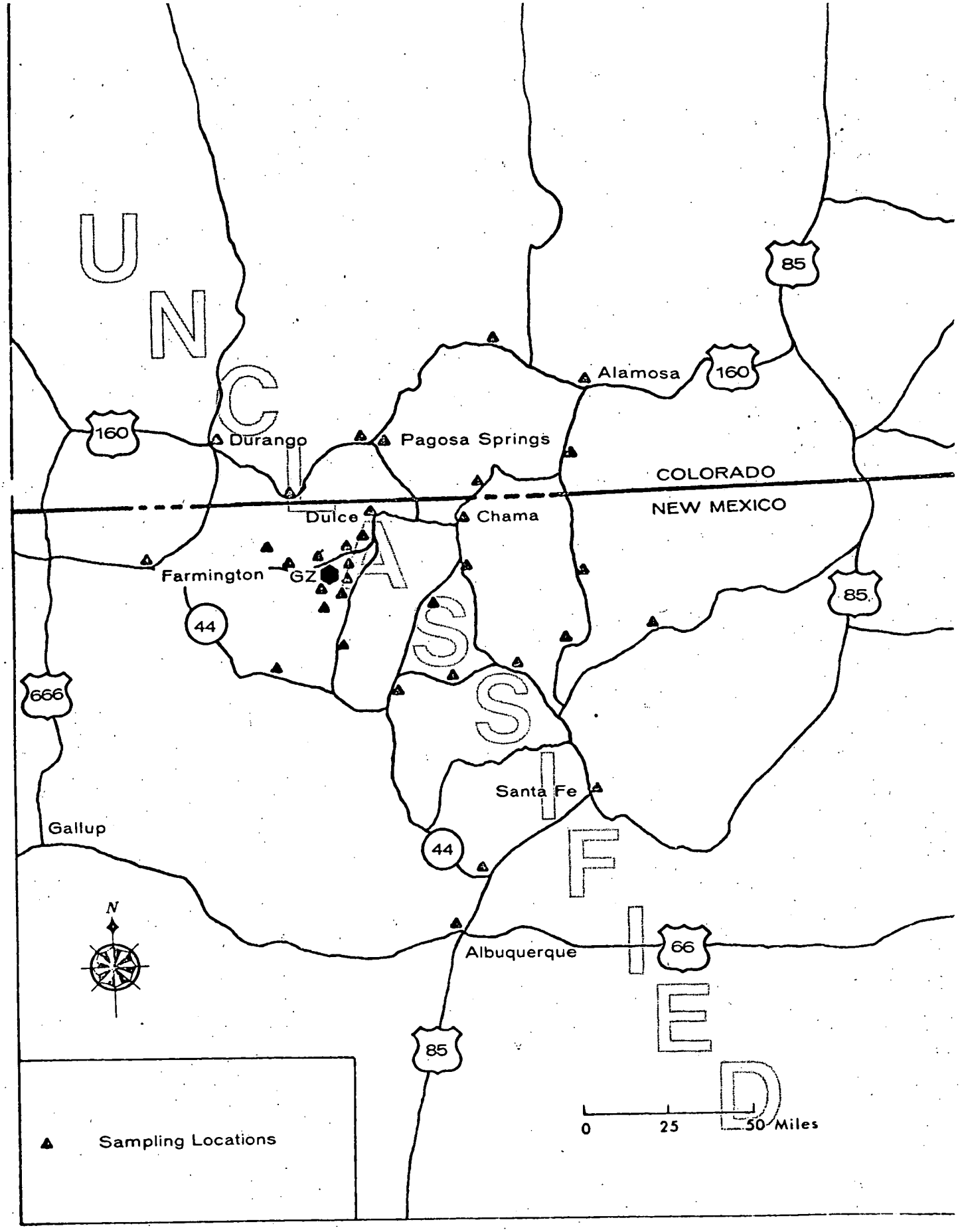

Figure 7 Sampling Locations During Project Gasbuggy

network of water sampling stations was set up by personnel of SWRHL. Several wells were included in this network. A map showing the location of the stations in the network is shown in Figure 8.

USGS investigations have determined that the groundwater resources in the Rulison area are confined primarily to alluvium and terrace deposits. The underlying bedrock formations are generally impermeable and yield little or no water. A small amount of water was found in a sandstone lens during the drilling of an experimental well, but later tests of this zone and other zones thought to contain water showed no measurable water production. Sufficient water is available from shallow wells in alluvium and terrace deposits or from cisterns or ponds which are supplied by creeks and springs so that there is no need to depend on deep water sources in the area (13).

Although the potential for groundwater contamination in the Rulison area is extremely slight, due to the depth of placement of the device and use of water close to the surface, a sampling program at the site may be desirable for the same reasons that were outlined in connection with Project Gasbuggy. It is proposed that two samples be collected yearly from wells in the direction of groundwater flow from the detonation point. Both of the wells which would be sampled are household supplies. (See Figure 9).

III. Estimated Project Cost and Procedures

Since this project will involve only one sampling per year for each source (a total of seventeen samples), there will be no need for additional equipment or personnel. It is contemplated that the samples from the Fallon, Nevada, area will be collected by the monitor assigned to the Tonopah route. Samples from Colorado, Mississippi, and New Mexico may be collected by personnel from SWRHL, local PHS facilities, or health departments. As mentioned previously, all samples would be analyzed for tritium, strontium-90, and significant gamma emitters.

The estimated costs for this sampling program, based upon the assumption

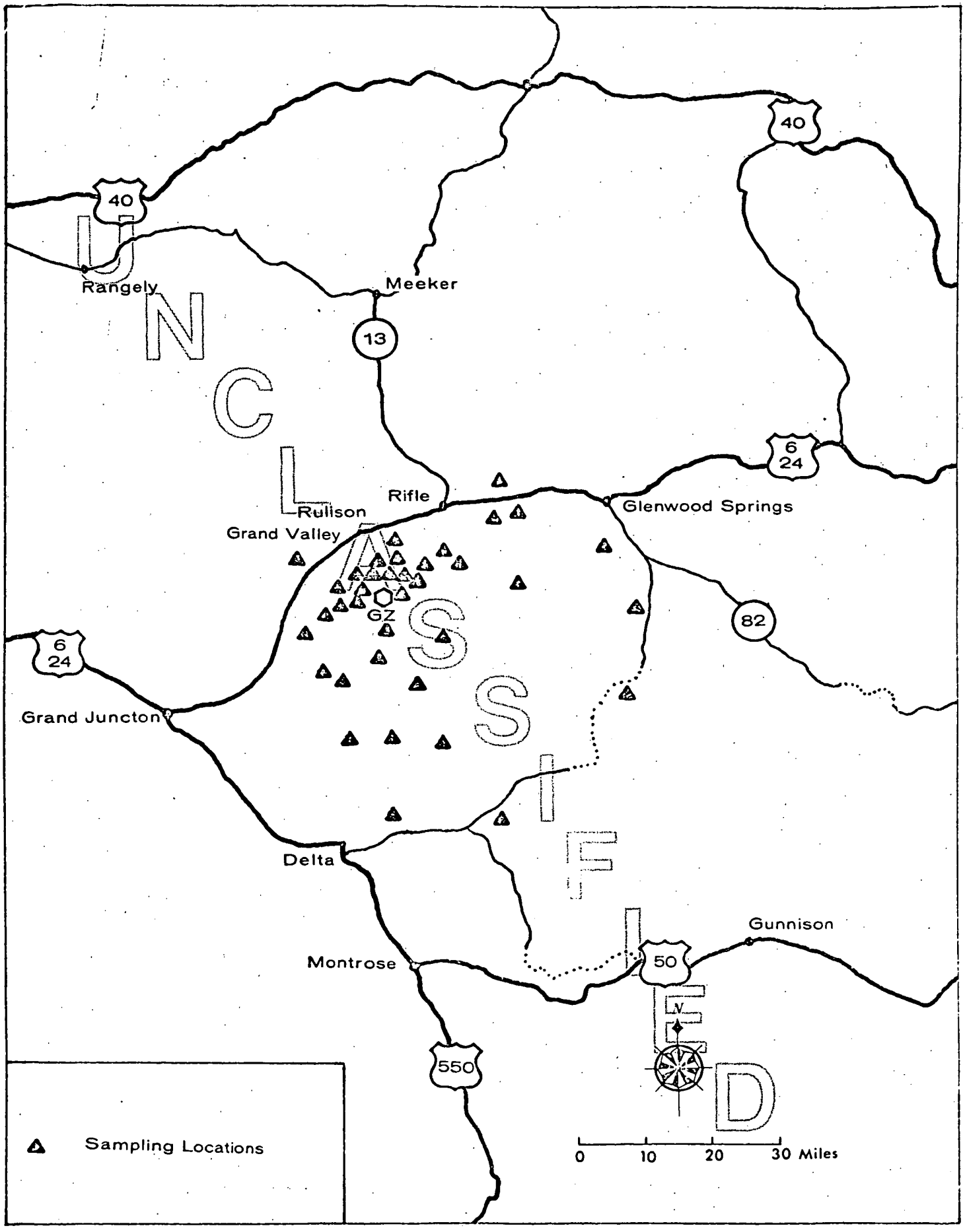

Figure 8 Sampling Locations During Project Rulison

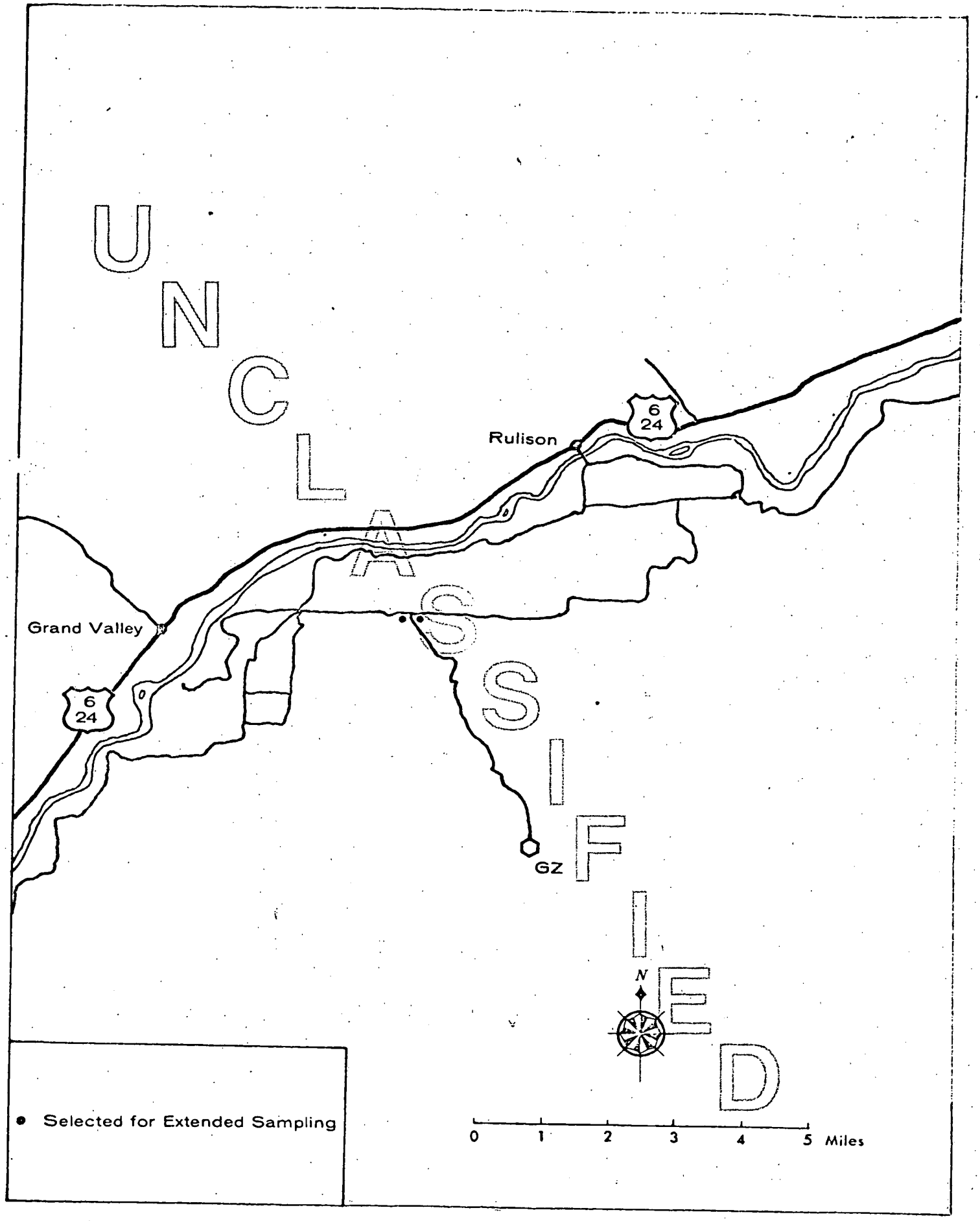

Figure 9 Selected Sampling Locations for Project Rulison

that all sampling will be handled by personnel from SWRHL or the Southeastern Radiological Health Laboratory (SERHL), are shown below. If the support of local health departments can be enlisted for the collection of samples, program costs can be reduced. Regardless of the availability of such support, PHS personnel will need to visit the various off-site areas to establish the actual locations to be used for sampling. Efforts will be made during the start-up of the program to gain the assistance of local public health personnel in the collection of future samples.

PROJECT START-UP - Estimated Total Cost	$1000.00

COLLECTION

Fallon Sampling Run	
1. Salary GS-5 (1 day)	$ 30.00
2. Per diem	$ 25.00
3. Vehicle mileage	$ 20.00
Total	$ 75.00
Colorado and New Mexico Sampling Run	
1. Salary GS-5 (3 1/2 days)	$ 90.00
2. Salary GS-11 (3 1/2 days)	$ 180.00
3. Per diem	$ 175.00
4. Aircraft Fuel	$ 100.00
5. Aircraft maintenance & support	$ 200.00
6. Vehicle Rental	$ 60.00
Total	$ 805.00
Mississippi Sampling Run *	
1. Salary GS-5 (2 days)	$ 60.00
2. Per diem	$ 50.00
3. Vehicle Rental	$ 50.00
Total	$ 160.00

* To be handled by personnel from the Southeastern Radiological Health Laboratory (SERHL), Montgomery, Alabama.

Sample Analysis	
Gamma Scan	$ 170.00
Tritium	$ 170.00
Strontium-90	$ 170.00
Total	$ 510.00
Administration and Supervision	$1200.00
Collection Total Estimated Costs	$2750.00

According to this estimate, first year costs would total $3750, while annual costs thereafter would be $2750.

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