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Annual Water Sampling and Analysis Calendar Year 1996:

RULISON Test Site Area
RIO BLANCO Test Site Area
FAULTLESS Test Site Area
SHOAL Test Site Area
GASBUGGY Test Site Area
GNOME Test Site Area

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by

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ABSTRACT

In this report the annual water sampling for the Long-Term Hydrological Monitoring Program (LTHMP) conducted during 1996 by the Environmental Protection Agency's (EPA's) Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE), Office of Radiation and Indoor Air will be described. This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site (NTS) and at former test sites in Colorado, Nevada, and New Mexico. The LTHMP program is designed to detect any radioactivity that may be related to previous nuclear testing activities. Although tritium initially seeped from two of the offsite tests, the tritium levels in wells at both these sites are decreasing and were well below the National Primary Drinking Water Regulation levels.

The analytical results are given and all samples were analyzed for the presence of gamma-ray emitting radionuclides, none was detected above the minimum detectable activity.

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
DOE	Department of Energy
RSL	Radiation Sciences Laboratory
EPA	Environmental Protection Agency
DCG	Derived Concentration Guide
g	gram
$^{3}H+$	Enriched Tritium
^{3}H	Tritium
HpGe	high purity germanium gamma detector
keV	kilo electron volts = thousand electron volts
kg	kilogram, 1000 grams
kt	kiloton (TNT equivalent)
LTHMP	Long-Term Hydrological Monitoring Program
L	liter
m	meter
min	minute
MDC	minimum detectable concentration
MeV	million electron volts
mL	milliliter = one thousandth of a liter
ORIA	Office of Radiation and Indoor Air
pCi/L	picocuries per liter = 10^{-12} curies per liter = 1/1,000,000,000,000 curies per liter
PHS	U.S. Public Health Service
R&IE	Radiation and Indoor Environments National Laboratory
SGZ	surface ground zero
USGS	U.S. Geological Survey

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1.0 INTRODUCTION

Under an IAG with the U.S. Department of Energy (DOE), the Radiation and Indoor Environments National Laboratory (R&IE), formerly Radiation and Sciences Laboratory (RSL), Office of Radiation and Indoor Air (ORIA), of the U.S. Environmental Protection Agency (EPA) located in Las Vegas, NV, conducts a Long-Term Hydrological Monitoring Program (LTHMP) to measure radioactivity concentrations in water sources near the sites of underground nuclear explosions. The results of the LTHMP provide assurance that radioactive materials from the tests have not migrated into drinking water supplies. This report presents the results for the samples collected in March and June of 1996 around the following test site areas:

- Project RULISON Test Site, Garfield County, Colorado
- Project RIO BLANCO Test Site, Rio Blanco County, Colorado
- Project FAULTLESS Test Site, Nye County, Nevada
- Project SHOAL Test Site, Churchill County, Nevada
- Project GASBUGGY Test Site, Rio Arriba County, New Mexico
- Project GNOME Test Site, Eddy County, New Mexico

2.0 Sample Analysis Procedures

The procedures for the analysis of samples collected for this report were described by Johns, et al. (1979) and are summarized below (see Appendix for Typical MDA Values for Gamma Spectroscopy). These include gamma spectral analysis and radiochemical analysis for tritium. The procedures were based on standard methodology for given analytical procedures. Two methods for tritium analysis were performed: conventional and electrolytic enrichment. The samples are initially analyzed by the conventional method. If the tritium result is less than 700 pCi/L, selected samples are analyzed by the electrolytic enrichment method which lowers the minimum detectable concentration (MDC) from approximately 300 pCi/L to 5 pCi/L. An upper level of 700 pCi/L has been established for the tritium enrichment method. Sample cross contamination becomes a problem at higher ranges.

For wells with operating pumps, the samples are collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling unit is used. With this unit it is possible to collect three-liter samples from wells as deep as 1,800 meters (5,900 ft). At the normal sample collection sites, the pH, conductivity, water temperature, and sampling depth is measured and recorded when the sample is collected.

The first time samples are collected from a well, ^{3}H, $^{89,90}Sr$, $^{238,\ 239+240}Pu$, and uranium isotopes are determined. At least one of the one gallon samples from each site is analyzed by gamma spectrometry. In late 1995, it was decided that only 25% of tritium samples collected would be analyzed by the enrichment method. Sampling locations in a position to show migration are usually selected.

Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Sample Size	Approximate Detection Limit[a]
HpGe Gamma[b]	HpGe detector calibrated at 0.5 keV/ channel (0.04 to 2 MeV range) individual detector. Efficiencies ranging from 15 to 35%.	100	Radionuclide concentration quantified from gamma spectral data by online computer program.	3.5L	See Table in Appendix.
^{3}H	Automatic liquid scintillation counter	300	Sample prepared by distillation.	5 to 10 mL	300 to 700 pCi/L
3H+ Enrichment	Automatic liquid scintillation counter	300	Sample concentrated by electrolysis followed by distillation.	250 mL	5 pCi/L

[a] The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE 1981).

[b] Gamma spectrometry using a high purity intrinsic germanium (HpGe) detector.

2.1 Sampling at Project RULISON, Colorado

History

Cosponsored by the AEC and Austral Oil Company under the Plowshare Program, Project RULISON was designed to stimulate natural gas recovery in the Mesa Verde formation. The test, conducted near Grand Valley, Colorado on September 10, 1969, consisted of a 40-kt nuclear explosive emplaced at a depth of 2,568 m (8,425 ft). Production testing began in 1970 and was completed in April 1971. Cleanup was initiated in 1972 and the wells were plugged in 1976. Some surface contamination resulted from decontamination of drilling equipment and fallout from gas flaring. Contaminated soil was removed during the cleanup operations.

Sampling was conducted in June 1996, with collection of eight samples out of nine wells in the area of Grand Valley and Rulison, Colorado. The spring 300 yards from SGZ was dry. Routine sampling locations are shown in Figure 1. Sampling included the Grand Valley municipal drinking water supply springs, water supply wells for five local ranches, and three sites in the vicinity of SGZ, including one test well, a surface-discharge spring which was dry and a surface sampling location on Battlement Creek. Seven new monitoring wells were completed at the RULISON Site in 1995. These wells will be added to the Long-Term Hydrological Monitoring Program. The EPA was sampling these wells for BTEX, THP diesel, and RCRA metals. The samples were sent to Quanterra Laboratory in Missouri. After the samples were analyzed, the results were sent to IT Corp, where the report of those measurements are compiled for DOE.

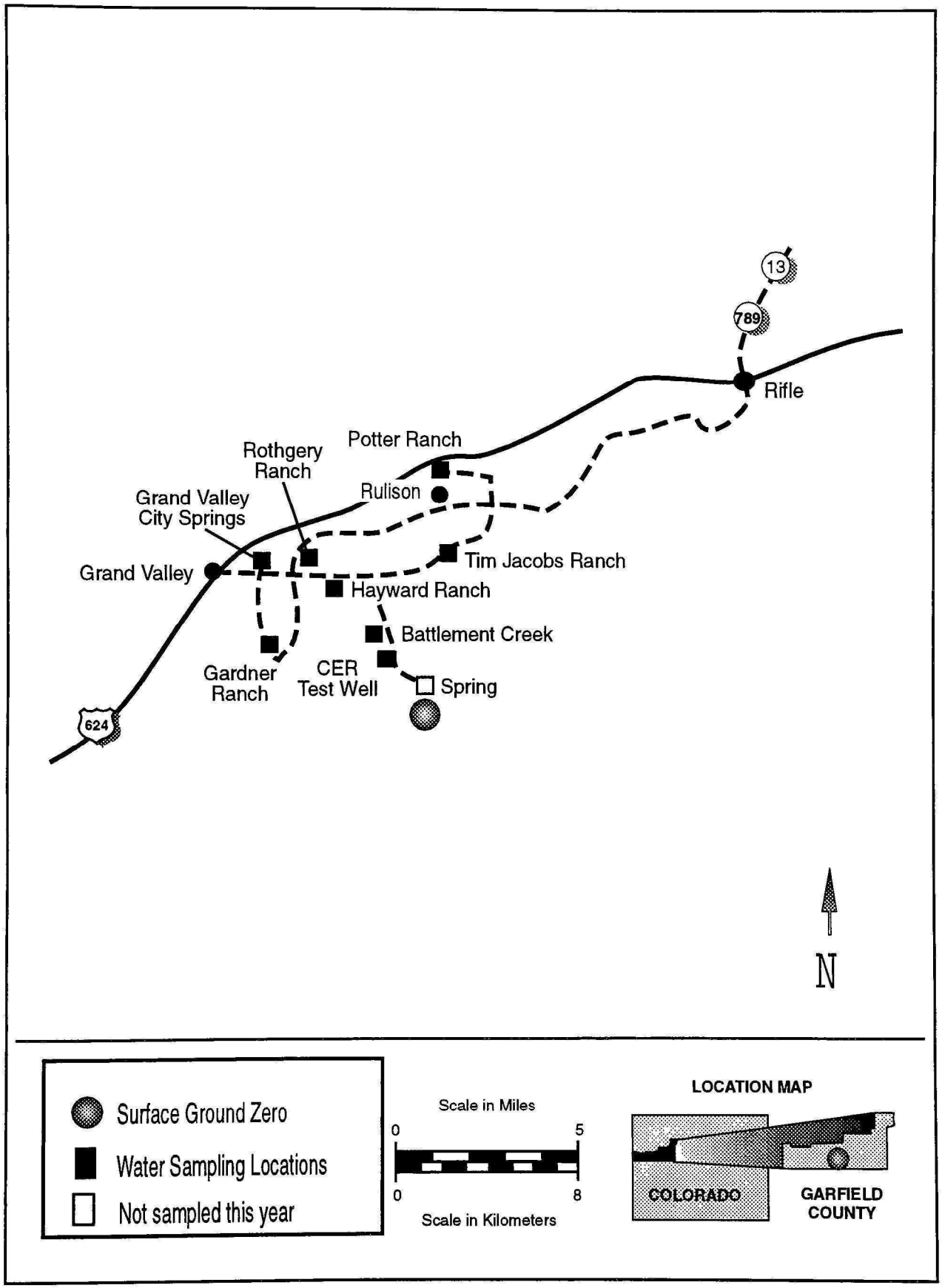

Figure 1. RULISON Site sampling locations for June 1996.

2.1.1 Water Analysis Results

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. All of the remaining sampling sites show detectable levels of tritium, which have generally exhibited a stable or decreasing trend over the last two decades. The range of tritium activity in 1996 was from 242 ± 140 pCi/L at Battlement Creek, to 112 ± 6.9 pCi/L at Lee Hayward Ranch (see Table 1). All values were less than one percent of the DCG. The detectable tritium activities were probably a result of the high natural background in the area. This was supported by the Desert Research Institute analysis, which indicated that most of the sampling locations were shallow, drawing water from the surficial aquifer which was unlikely to become contaminated by any radionuclides arising from the Project RULISON cavity (Chapman and Hokett, 1991).

Table 1. Analysis Results for Water Samples Collected in June 1996.

RULISON Site							
Sample Location	Collection Date 1996	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium pCi/L ± 2 SD	(MDC)	Gamma Spectrometry pCi/L	(MDC)
Battlement Creek	6/04/96			242 ± 140	(224)	ND	(5.7)
City Springs	6/05/96			<MDC	(244)	ND	(5.9)
Albert Gardner	6/04/96			242 ± 140	(224)	ND	(4.3)
CER Test Well	6/04/96	75 ± 4.7	(5.9)			ND	(5.4)
Lee Hayward Rn.	6/04/96	112 ± 6.9	(8.6)			ND	(6.1)
Potter Ranch	6/04/96			<MDC	(244)	ND	(5.9)
Wayne & Debra Rothgery	6/04/96			<MDC	(244)	ND	(5.6)
Tim Jacobs	6/04/96			242 ± 140	(224)	ND	(5.5)
Spring 300 yds N. of GZ	6/07/96			No Sample Spring Dry			

(<MDC) Indicate samples are below the MDC.
ND Non-detected, no gamma radionuclides detected above MDC.

2.1.2 Conclusions

Tritium concentrations in water samples collected onsite and offsite are consistent with those of past studies at the RULISON Test Site.

All samples were analyzed for presence of gamma-ray emitting radionuclides. None were detected above the MDC.

2.2 Sampling at Project RIO BLANCO, Colorado

History

Project RIO BLANCO a joint government-industry test designed to stimulate natural gas flow was conducted under the Plowshare Program. The test was conducted on May 17, 1973 at a location between Rifle and Meeker Colorado. Three explosives with a total yield of 99 kt were emplaced at 1,780-, 1,920-, and 2,040-m (5,840-, 6,299-, and 6,693-ft) depths in the Ft. Union and Mesa Verde formations. Production testing continued until 1976 when cleanup and restoration activities were completed. Tritiated water produced during testing was injected to 1,710 m (5,610 ft) in a nearby gas well.

Sampling was conducted in June 1996. Sampling locations are shown in Figure 2. Only 13 of the 14 routine wells were sampled. No sample was collected from Brennan Windmill because the windmill was inoperable. The bottle containing the sample taken from CER #1 was broken in transit. The routine sampling locations included three springs and six surface wells. Three of the wells are located near the cavity and at least two of the wells (Wells RB-D-01 and RB-D-03) were suitable for monitoring because they were down gradient and would indicate possible migration of radioactivity from the cavity.

2.2.1 Water Analysis Results

Gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any offsite samples. Three of the eleven samples collected were above the MDC for tritium (see Table 2, page 7).

2.2.2 Conclusions

Tritium concentrations in water samples collected onsite and offsite are consistent with those of past studies at the RIO BLANCO Site.

No radioactive materials attributable to the RIO BLANCO test were detected in samples collected in the offsite areas during June 1996. The tritium concentrations are well below 20,000 pCi/L level defined in the EPA National Primary Drinking Water Regulations (40CFR141). All samples were analyzed for presence of gamma-ray emitting radionuclides.

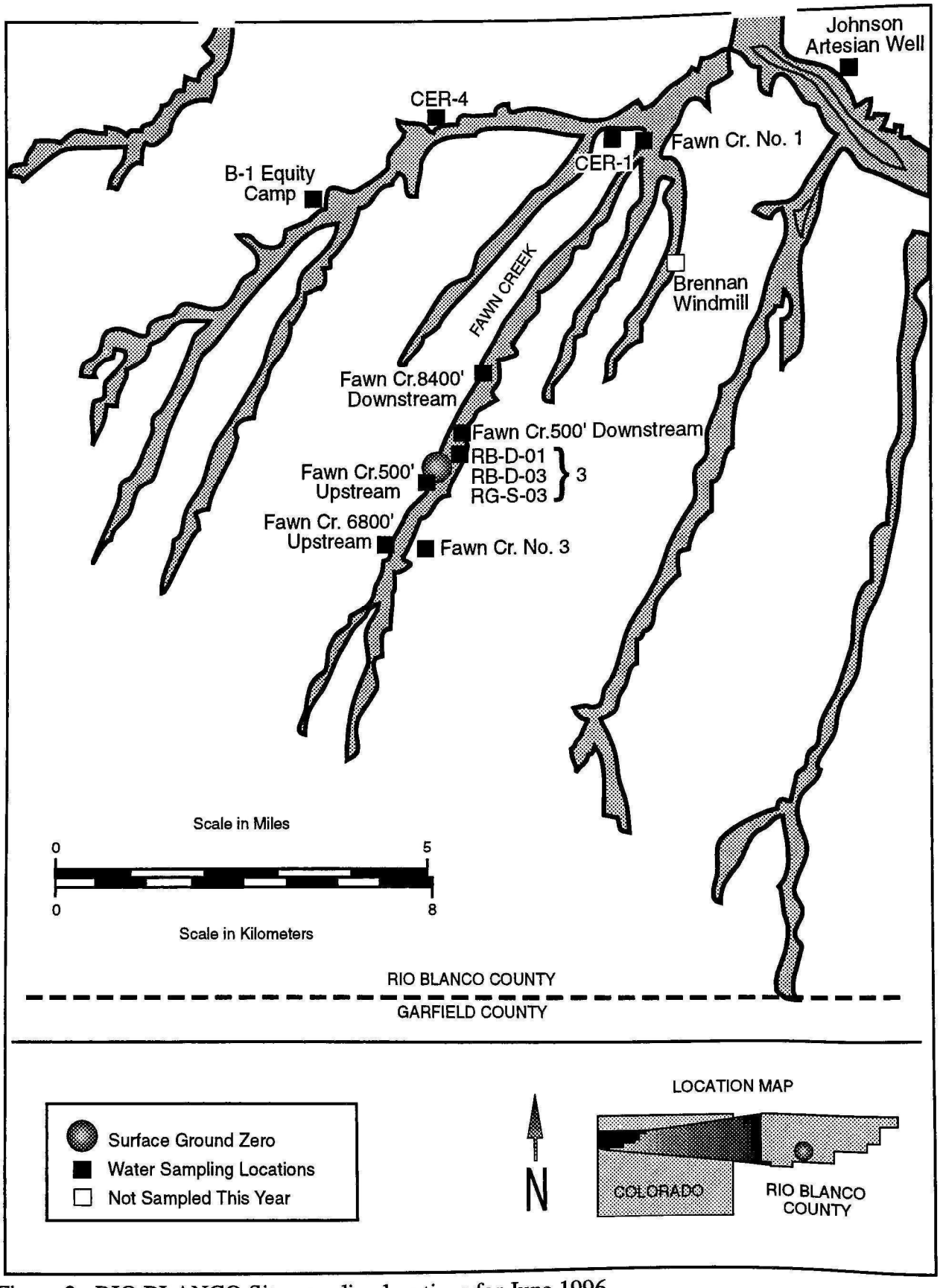

Figure 2. RIO BLANCO Site sampling locations for June 1996.

Table 2. Analysis Results for Water Samples Collected in June 1996.

RIO BLANCO Site							
Sample Location	Collection Date 1996	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium pCi/L ± 2 SD	(MDC)	Gamma Spectrometry pCi/L	(MDC)
B-1 Equity Camp	6/06/96	47 ± 5.2	(7.2)			ND	(5.5)
Brennan Windmill	6/06/96					No Sample inoperable	
CER #1 Black Sulpher	6/06/96					Sample lost in transit	
CER #4 Black Sulpher	6/06/96	46 ± 4.7	(6.4)			ND	(5.2)
Fawn Creek #1	6/06/96			<MDC	(224)	ND	(5.2)
Fawn Creek #3	6/06/96			<MDC	(224)	ND	(5.6)
Fawn Creek 500' Upstream	6/06/96			<MDC	(224)	ND	(7.9)
Fawn Creek 6800' Upstream	6/06/96			<MDC	(224)	ND	(7.0)
Fawn Creek 500' Downstream	6/06/96			<MDC	(224)	ND	(7.0)
Fawn Creek 8400' Downstream	6/06/96	32 ± 4.9	(7.0)			ND	(6.3)
Johnson Artesian Well	6/06/96			<MDC	(224)	ND	(5.5)
Well RB-D-01	6/07/96	<MDC	(6.5)			ND	(5.2)
Well RB-D-03	6/06/96			<MDC	(224)	ND	(6.2)
Well RB-S-03	6/07/96			<MDC	(224)	ND	(6.8)

(<MDC) Indicates sample are below the MDC.
ND Non-detected, no gamma radionuclides detected above MDC.

2.3 Sampling at Project FAULTLESS, Nevada

History

Project FAULTLESS was a "calibration test" conducted on January 19, 1968, in a sparsely populated area near Blue Jay Maintenance Station, Nevada. The test had a yield of less than 1 Mt and was designed to test the behavior of seismic waves and to determine the usefulness of the site for high-yield tests. The emplacement depth was 975 m (3,200 ft). A surface crater was formed,

but as an irregular block along local faults rather than as a saucer-shaped depression. The area is characterized by basin and range topography, with alluvium overlying tuffaceous sediments. The working point of the test was in tuff. The groundwater flow is generally from the highlands to the valley and through the valley to Twin Springs Ranch and Railroad Valley (Chapman and Hokett, 1991).

Sampling was conducted on March 6 - 7, 1996. Sampling locations are shown in Figure 3. Routine sampling locations include one spring and five wells of varying depths. The Bias Well was not sampled because the ranch was closed and at the Six Mile Well because the pump was removed. A new sampling location was established to replace the shallow wells at Bias Ranch and the Six Mile Well. The site C complex is a very deep well and is approximately twenty miles from SGZ.

At least two wells (HTH-1 and HTH-2) are positioned to intercept migration from the test cavity, should it occur (Chapman and Hokett, 1991). All samples yielded negligible gamma activity. Tritium concentrations were less than the MDC and less than 0.01 percent of the DCG (shown in the Table on page 9). These results were all consistent with results obtained in previous years. The consistently below-MDC results for tritium indicate that, to date, migration into the sampled wells has not taken place and no event-related radioactivity has entered area drinking water supplies.

2.3.1 Water Analysis Results

All gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any offsite samples. All tritium results were below the MDC (see Table 3, page 10).

2.3.2 Conclusions

Tritium concentrations of water samples collected onsite and offsite are consistent with those of past studies at the FAULTLESS Site.

All samples were analyzed for presence of gamma-ray emitting radionuclides. None were detected above the MDC.

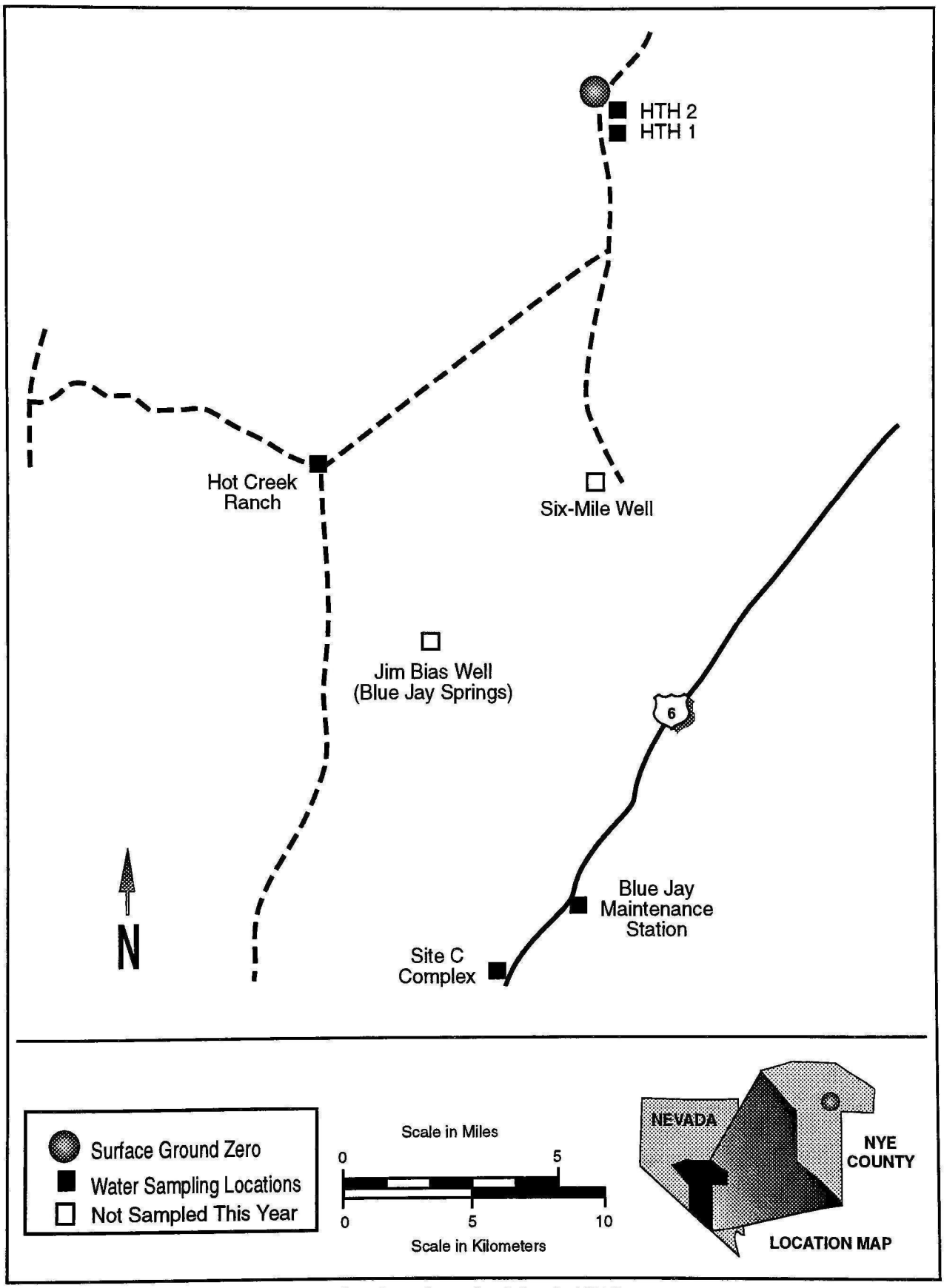

Figure 3. FAULTLESS Site sampling locations for March 1996.

Table 3. Analysis Results for Water Samples Collected in March 1996.

FAULTLESS Site							
Sample Location	Collection Date 1996	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium pCi/L ± 2 SD	(MDC)	Gamma Spectrometry pCi/L	(MDC)
Hot Creek Ranch Spring	3/06/96			<MDC	(216)	ND	(5.6)
Blue Jay Maint Station	3/06/96			<MDC	(216)	ND	(6.9)
Well HTH-1	3/03-07/96	<MDC	(216)			ND	(7.5)
Well HTH-2	3/03-07/96	<MDC	(216)			ND	(6.3)
Site C Base Camp	3/03-07/96			<MDC	(216)	ND	(6.0)

(<MDC) Indicates results are less than MDC.
ND Non-detected, no gamma radionuclides detected above MDC.

2.4 Sampling at Project SHOAL, Nevada

History

Project SHOAL, a 12-kt nuclear test emplaced at 365 m (1,204 ft), was conducted on October 26, 1963, in a sparsely populated area near Frenchman Station, Nevada, 28 miles southeast of Fallon, Nevada. The test, a part of the Vela Uniform Program, was designed to investigate detection of a nuclear detonation in an active earthquake zone. The working point was in granite and no surface crater was created. The effluent released during drillback was detected onsite only and consisted of 110 curies of ^{131}Xe and ^{133}Xe, and less than 1.0 curie of ^{131}I.

Samples were collected in March 1996. The sampling locations are shown in Figure 4. Only five of the seven routine wells were sampled. No sample was collected from Spring Windmill because the pump was removed. No sample was collected from Well H-2 because the well was locked and no key was available to EPA. The routine sampling locations include one spring, one windmill, and five wells of varying depths. At least one location, Well HS-1, should intercept radioactivity migration from the test cavity, should it occur (Chapman and Hokett, 1991).

2.4.1 Water Analysis Results

All gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any offsite samples. All tritium results were below the MDC (see Table 4, page 12).

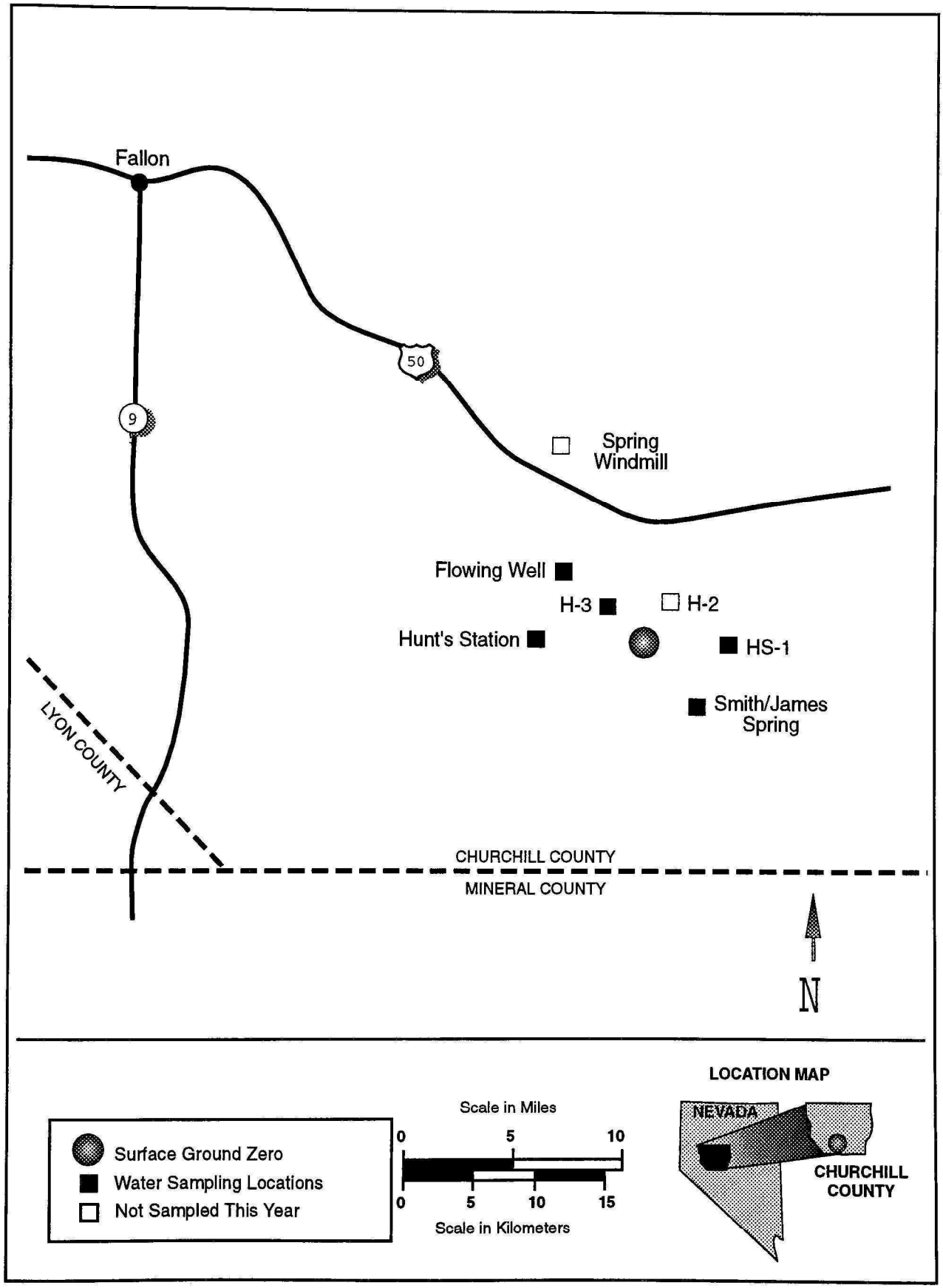

Figure 4. SHOAL Site sampling locations for March 1996.

2.4.2 Conclusions

No radioactive materials attributable to the SHOAL nuclear test were detected in samples collected in the offsite areas during March of 1996. Tritium, when detected, is compared to the National Primary Drinking Water Regulations (40CFR141) which list tritium at 20,000 pCi/L for human consumption.

All samples were analyzed for presence of gamma-ray emitting radionuclides. None were detected above the MDC.

Table 4. Analysis Results for Water Samples Collected in March 1996.

SHOAL Site							
Sample Location	Collection Date 1996	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium pCi/L ± 2 SD	(MDC)	Gamma Spectrometry pCi/L	(MDC)
Hunts Station	3/04/96			<MDC	(216)	ND	(6.4)
Smith James Sps.	3/04/96			<MDC	(216)	ND	(5.4)
Spring Windmill	3/04/96					No Pump	
Flowing Well	3/04/96			<MDC	(216)	ND	(5.6)
Well 2						Well locked	
Well H-3	3/04/96	<MDC	(5.1)			ND	(6.3)
Well HS-1	3/05/96	<MDC	(6.0)			ND	(6.6)

(<MDC) Indicates results are less than MDC.
ND Non-detected, no gamma radionuclides detected above MDC.

2.5 Sampling at Project GASBUGGY, New Mexico

History

Project GASBUGGY was a Plowshare Program test co-sponsored by the U.S. Government and El Paso Natural Gas Co. Conducted near Gobernador, New Mexico on December 10, 1967, the test was designed to stimulate a low productivity natural gas reservoir. A nuclear explosive with a 29-kt yield was emplaced at a depth of 1,290 m (4,240 ft). Production testing was completed in 1976 and restoration activities were completed in July 1978.

The principal aquifers near the test site are the Ojo Alamo Sandstone, an aquifer containing non-potable water located above the test cavity, the San Jose formation and Nacimiento formation,

both surficial aquifers containing potable water. The flow regime of the San Juan Basin is not well known, although it is likely that the Ojo Alamo Sandstone discharges to the San Juan River 50 miles northwest of the Gasbuggy site. Hydrologic gradients in the vicinity are downward, but upward gas migration is possible (Chapman and Hokett, 1991).

Annual sampling at Project GASBUGGY was completed during June 1996. Only ten samples were collected at the Truckee sampling locations (see Figure 5). The Bixler Ranch has been sealed up and is inaccessible at this time. The pond north of Well 30.3.32.343N was dry.

2.5.1 Water Analysis Results

The three springs sampling sites yielded tritium activities of 26 ± 4.3 pCi/L for Bubbling Springs, Cedar Springs 43 ± 4.0 pCi/L, and 54 ± 6.2 pCi/L for Cave Springs, which was less than 0.2 percent of the DCG and similar to the range seen in previous years. Tritium samples from the three shallow wells were all below the MDC (see Table 5, page 15).

Well EPNG 10-36 yielded tritium activities between 100 and 560 pCi/L in each year since 1984, except in 1987. The sample collected in 1996, yielded a tritium activity of 133 ± 5.2 pCi/L. The migration mechanism and route is not currently known, although an analysis by Desert Research Institute indicated two feasible routes, one through the Printed Cliffs sandstones and the other one through the OJO Alamo sandstone. One of the principle aquifers in the region (Chapman 1991) in either case, fractures extending from the cavity may be the primary or a contributing mechanism.

All gamma-ray spectral analysis results indicated that no man-made gamma-ray emitting radionuclides were present in any offsite samples.

2.5.2 Conclusions

Tritium concentrations of water samples collected onsite and offsite are consistent with those of past studies at the GASBUGGY Site.

Well EPNG 10-36, a gas well located 132 m (435 ft) northwest of the test cavity with a sampling depth of approximately 1,100 m (3,600 ft), has yielded tritium activities between 100 and 560 pCi/L in each year since 1984, except 1987. The proximity of the well to the test cavity suggests the possibility that the activity increases may indicate migration from the test cavity. The sample collected in June yielded a tritium activity of 133 ± 5.2 pCi/L (MDC 5.2) . All samples were analyzed for presence of gamma-ray emitting radionuclides.

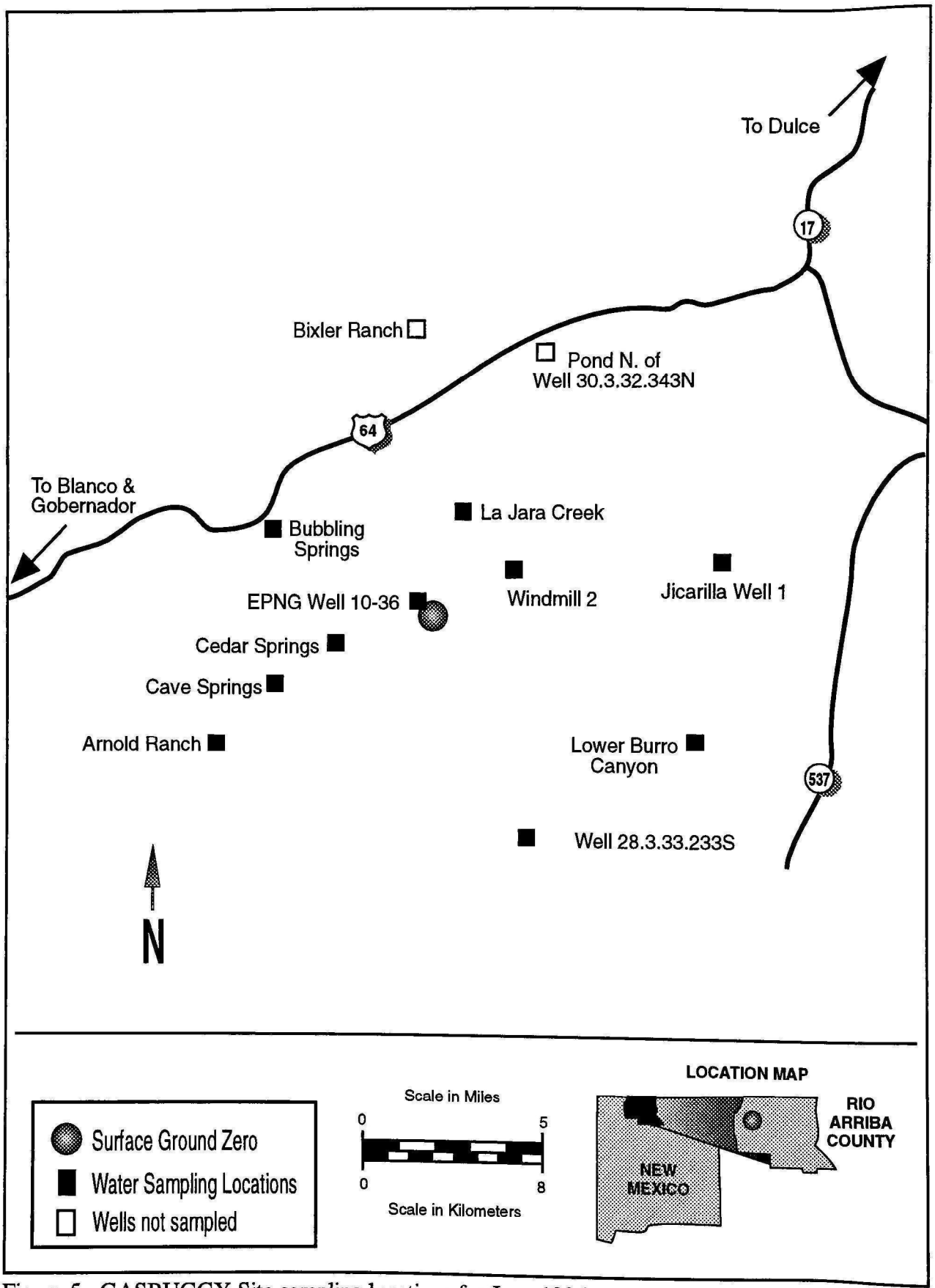

Figure 5. GASBUGGY Site sampling locations for June 1996.

Table 5. Analysis Results for Water Samples Collected in June 1996.

GASBUGGY Site							
Sample Location	Collection Date 1996	Enriched Tritium pCi/L ± 2 SD	(MDC)	Tritium pCi/L ± 2 SD	(MDC)	Gamma Spectrometry pCi/L	(MDC)
Arnold Ranch	6/10/96			<MDC	(224)	ND	(6.1)
Bixler Ranch	6/09/96					No Sample Ranch Closed	
Bubbling Springs	6/09/96	26 ± 4.3	(6.2)			ND	(6.4)
Cave Springs	6/09/96	54 ± 6.2	(8.5)			ND	(7.6)
Cedar Springs	6/09/96	43 ± 4.0	(5.6)			ND	(5.3)
La Jara Creek	6/10/96			<MDC	(224)	ND	(5.8)
Lower Burro Canyon	6/10/96			<MDC	(224)	ND	(5.8)
Pond N. of Well 30.3.32.343	6/10/96					No Sample Pond Dry	
Well EPNG-10-36	6/09/96	133 ± 5.2	(5.2)			ND	(5.1)
Jicarilla Well 1	6/09/96			<MDC	(224)	ND	(5.6)
Well 28.3.33.233 (South)	6/09/96			<MDC	(224)	ND	(6.0)
Well 30.3.32.343 (North)	6/10/96					No Sample Windmill Inoperable	
Windmill #2	6/10/96			<MDC	(224)	ND	(6.0)

(<MDC) Indicates results are less than MDC.
ND Non-detected, no gamma radionuclides detected above MDC.

2.6 Sampling at Project GNOME, New Mexico

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test conducted in a salt formation. The explosive yield was slightly-more-than 3-kt was emplaced at a depth of 1,216 ft in the Salado salt formation. Oil and gas are produced from the geologic units below the working point. The overlying Rustler formation contains three water-bearing zones: brine located at the boundary of the Rustler and Salado formations, the Culebra Dolomite which is used for domestic and stock supplies, and the Magenta Dolomite which is above the zone of saturation (Chapman and Hokett, 1991). The ground water flow is generally to the west and southwest.

Radioactive gases were accidentally vented following the test. In 1963, USGS conducted a tracer study involving injection of 20 Ci tritium, 10 Ci ^{137}Cs, 10 Ci ^{90}Sr, and 4 Ci ^{131}I in the Culebra Dolomite zone; wells USGS 4 and 8 were used for this tracer study. During remediation activities in 1968-69, contaminated material was placed in the test cavity and shaft up to within 7 ft of the surface. More material was slurried into the cavity and drifts in 1979. A potential exists for discharge of this slurry to the Culebra Dolomite and to rustler-Salado brine. This potential may increase as the salt around the cavity will compress, forcing contamination upward and distorting and cracking the concrete stem and grout.

Annual sampling at Project GNOME was completed during June 1996. The routine sampling sites, depicted in Figure 6, include nine monitoring wells in the vicinity of surface GZ, the municipal supplies at Loving and Carlsbad, New Mexico, and the Pecos River Pumping Station well. No detectable tritium activity was detected in the Carlsbad municipal supply or the Pecos River Pumping Station well. An analysis by Desert Research Institute (Chapman and Hokett, 1991) indicates that this sampling location, on the opposite side of the Pecos River from the Project GNOME site, is not connected hydrologically to the site and, therefore, cannot become contaminated by Project GNOME radionuclides.

2.6.1 Water Analysis Results

Tritium results greater than the MDC were detected in water samples from two of the nine sampling locations in the immediate vicinity of GZ. Tritium activities in wells DD-1, LRL-7, USGS-4, and USGS-8 ranged from $5.32E^{+03} \pm 214$ to $6.79E^{+07}$ pCi/L in Well DD-1. Well DD-1 is the test cavity, Well LRL-7 samples a sidedrift, and wells USGS-4 and -8 were used in the radionuclide tracer study conducted by the USGS. Wells PH-6 and PH-8 had concentrations of 33.0 ± 4.7 and 7.8 ± 2.9 pCi/L, which are consistent or below those of surface water. No tritium was detected in the remaining Project GNOME samples, including Well USGS-1, which is possibly positioned to best detect nuclide migration from the test cavity, should it occur (Chapman and Hokett, 1991). In addition to tritium, ^{137}Cs concentrations of $1.29E^{+05} \pm 7.07E^{+04}$ pCi/L to 6.8 ± 1.2 pCi/L were observed in samples from wells DD-1, LRL-7, and USGS-8, while ^{90}Sr activity ranging from $1.04E^{+04} \pm 143$ pCi/L to $3.98E^{+03} \pm 23$ pCi/L was detected in wells DD-1, USGS-4 and USGS-8. Samples from these four wells were analyzed for plutonium isotopes and results were less than the MDC in all cases (see Table 6, page 18). Of the wells analyzed for the presence of ^{90}Sr, three had concentrations exceeding the MDC values. The three wells were USGS-4 ($3.53E^{+03} \pm 23$), USGS-8 ($3.98E^{+03} \pm 23$), and DD-1 ($1.04E^{+04} \pm 1.43E^{+03}$) pCi/L, respectively. The samples from wells DD-1, LRL-7, and USGS-4 indicate a decreasing trend for all detectable radionuclides when compared to results of previous years.

2.6.2 Conclusion

No radioactive materials attributable to the GNOME Test were detected in samples collected in the offsite areas during June of 1996. The tritium concentrations are well below 20,000 pCi/L level defined in the EPA National Primary Drinking Water Regulations (40CFR141).

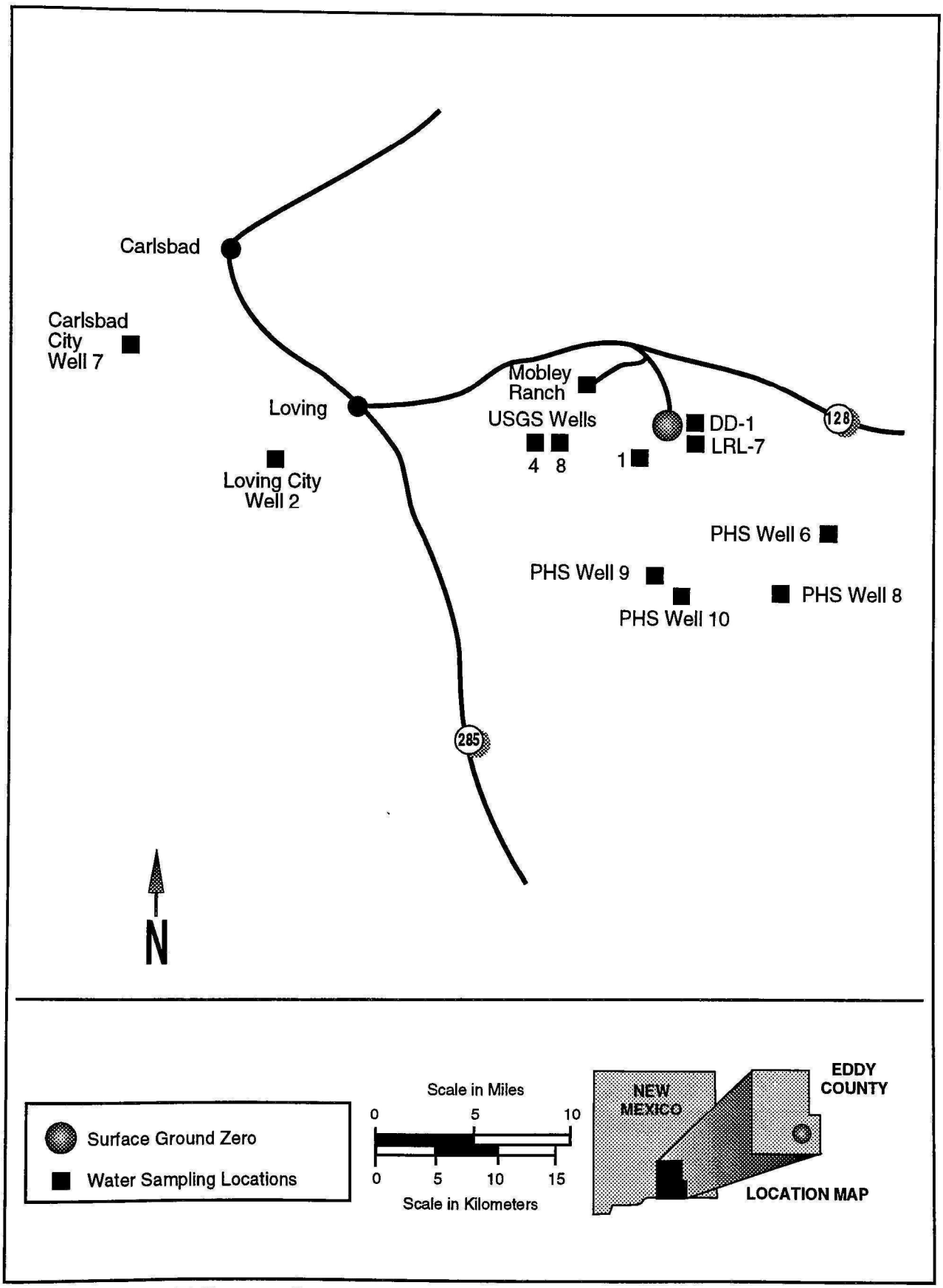

Figure 6. GNOME Site sampling locations for June 1996.

Table 6. Tritium Results for Water Samples Collected in June 1996.

GNOME Site				
Sample Location	Collection Date 1996	Enriched Tritium pCi/L ± 2 SD (MDC)	Tritium pCi/L ± 2 SD (MDC)	Gamma Spectrometry (MDC)
Well 7 City	6/13/96		<MDC (224)	ND
Well 2 City	6/13/96		<MDC (224)	ND
PHS 6	6/14/96	33 ± 4.7 (6.9)		ND
PHS 8	6/14/96	7.8 ± 2.9 (4.5)		ND
PHS 9	6/14/96		<MDC (224)	ND
PHS 10	6/14/96		<MDC (244)	ND
USGS Well 1	6/13/96	<MDC (5.9)		ND
USGS Well 4	6/15/96		$9.04E^{+04} \pm 6.4\ E^{+02}$ (224)	ND
Well USGS 8	6/15/96		$7.65E^{+04} \pm 6.4E^{+02}$ (224)	Cs-137 6.8 ± 1.2 (2.5)
J. Mobley Ranch	6/14/96	<MDC (4.8)		ND
Well DD-1	6/15/96		$6.79E^{+07} \pm 6.06E^{+05}$ (223)	Cs-137 $7.29E^{+05} \pm 3.19E^{+03}$
LRL-7	6/15/96		$5.32E^{+03} \pm 214$ (224)	Cs-137 $1.03E^{+02} \pm 15$ (2.5)

(<MDC) Indicates results are less than MDC (enriched and conventional method).
ND Non-detected, no gamma radionuclides detected above MDC.

REFERENCES

Chapman & Hockett, 1991. *Evaluation of Groundwater Monitoring at Offsite Nuclear Test Areas,* Las Vegas, NV, Desert Research Institute, University of Nevada System, Report DOE/NV/10845-07.

Code of Federal Regulations, Vol. 41, title 40, Part 141, July 9, 1976, *National Interim Primary Drinking Water Regulations.*

A Guide for Environmental Radiological Surveillance at U.S. Dept. of Energy Installations, July 1981, Office of Operational Safety Report. Las Vegas, NV: U.S. Department of Energy; DOE/EP-0023.

Johns, F., et al. 1979. *Radiochemical and Analytical Procedures for Analysis of Environmental Samples.* Las Vegas, NV: U.S. Environmental Protection Agency; EMSL-LV-0539-17-1979.

Offsite Environmental Monitoring Report Radiation Monitoring Around Nuclear Test Areas, Calendar Year 1992. EPA 600/R-94/209.

GLOSSARY OF TERMS

Background Radiation

The radiation in man's environment, including cosmic rays and radiation from naturally-occurring and man-made radioactive elements, both outside and inside the bodies of humans and animals. The usually quoted average individual exposure from background radiation is 125 millirem per year in mid-latitudes at sea level.

Curie (Ci)

The basic unit used to describe the rate of radioactive disintegration. The curie is equal to 37 billion disintegrations per second, which is the equivalent of 1 gram of radium. Named for Marie and Pierre Curie who discovered radium in 1898. One microcurie (μCi) is 0.000001 Ci.

Isotope

Atoms of the same element with different numbers of neutrons in the nuclei. Thus ^{12}C, ^{13}C, and ^{14}C are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but have different physical properties (for example ^{12}C and ^{13}C are stable, ^{14}C is radioactive).

Enrichment Method

A method of electrolytic concentration that increases the sensitivity of the analysis of tritium in water. This method is used if the tritium concentration is less than 700 pCi/L.

Minimum Detectable Concentration (MDC)

The smallest amount of radioactivity that can be reliably detected with a probability of Type I and Type II errors at 5 percent each (DOE 1981).

Offsite

Areas exclusive of the immediate RULISON Test Site Area.

Type I Error

The statistical error of accepting the presence of radioactivity when none is present. Sometimes called alpha error.

Type II Error

The statistical error of failing to recognize the presence of radioactivity when it is present. Sometimes called beta error.

Appendix

Typical MDA Values for Gamma Spectroscopy
(100 minute count time)

Geometry*	Marinelli	Model	430G
Matrix	Water	Density	1.0 g/ml
Volume	3.5 liter	Units	pCi/L
Isotope	MDA	Isotope	MDA
		Ru-106	4.76E+01
Be-7	4.56E+01	Sn-113	8.32E+00
K-40	4.92E+01	Sb-125	1.65E+01
Cr-51	5.88E+01	I-131	8.28E+00
Mn-54	4.55E+01	Ba-133	9.16E+00
Co-57	9.65E+00	Cs-134	6.12E+00
Co-58	4.71E+00	Cs-137	6.43E+00
Fe-59	1.07E+01	Ce-144	7.59E+01
Co-60	5.38E+00	Eu-152	2.86E+01
Zn-65	1.24E+01	Ra-226	1.58E+01
Nb-95	5.64E+00	U-235	1.01E+02
Zr-95	9.06E+00	Am-241	6.60E+01

Disclaimer

The MDA's provided are for background matrix samples presumed to contain no known analytes and no decay time. All MDA's provided here are for one specific *Germanium detector and the geometry of interest. The MDA's in no way should be used as a source of reference for determing MDA's for any other type of detector. All Gamma spectroscopy MDA's will vary with different types of shielding, geometries, counting times and decay time of sample.